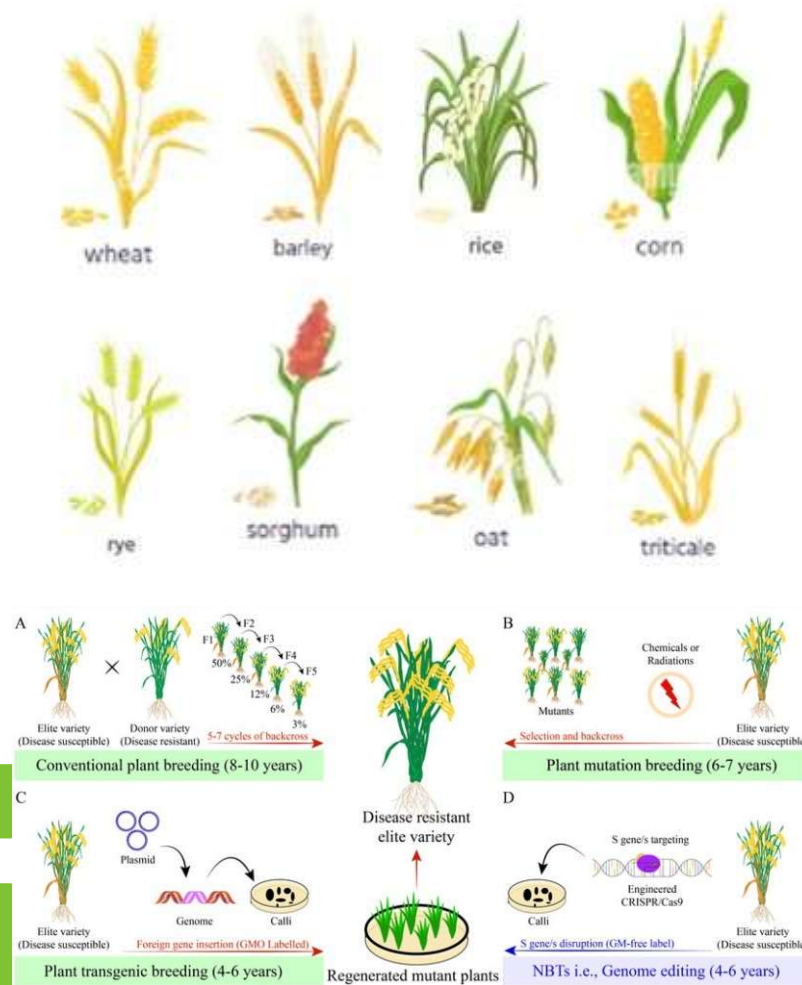


M.E.Ashurov, G. A.Narmatova, M.Makhammatova

BREEDING AND SEED PRODUCTION OF GRAIN CROPS

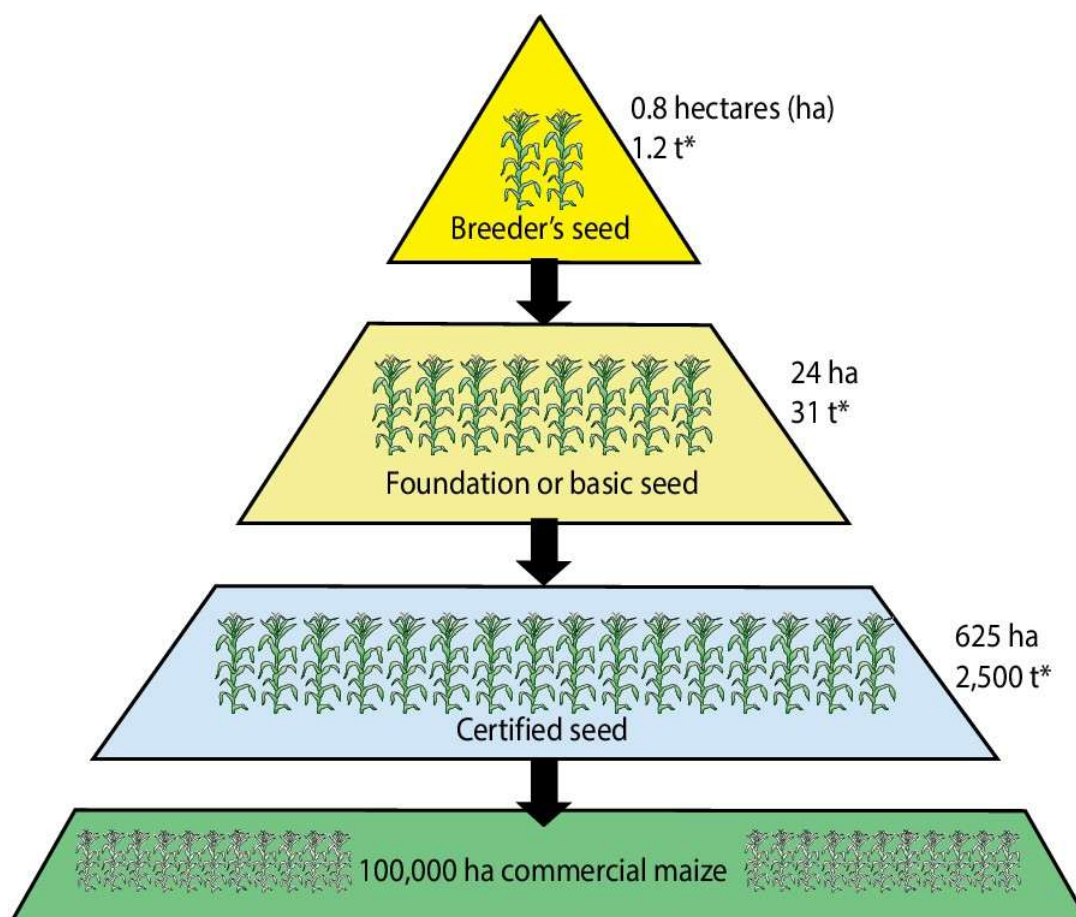
TEXTBOOK



M.E. Ashurov, G.A. Narmatova, M. Makhammatova

BREEDING AND SEED PRODUCTION OF GRAIN CROPS

Textbook



Taskent – 2025

UDC 633:631.52:631.531(075.8)

LBC 41.3ya72

A84

Ashurov M.E. and others.

Breeding and seed production of grain crops. The textbook./ M.E. Ashurov, G.A. Narmatova, M. Makhammatova. – T.: Tashkent: “Impress media” publishing house, 2025. – 506 p.

The textbook “**Breeding and seed production of grain crops**” is targeted to use for bachelor students of agricultural educational establishments.

It also can be used by masters, research assistants, teachers and grain crop breeders

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The textbook has been permitted to publish by the order of the Tashkent State Agrarian University under № 1-9-6\530 on December 27, 2024 on the base of decision of PD №60, of the President of the Republic of Uzbekistan on December 24, 2021.

ISBN 978-9910-05-084-8

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INTRODUCTION

Grain crops in Uzbekistan have a basic importance in the social economy and agricultural strategy of the republic.

Depending on annual planting area and production, grain crops are ranked in the following order: wheat, barley, rice, corn, rye, sorghum, oats, and triticale. Among them, wheat, barley, rice, corn, and sorghum have historically had longer periods of cultivation and development in the territory of our republic. During the cultivation period, they were subjected to adaptation to specific local soil-climatic conditions and differentiated into biotypes depending on growing conditions (natural selection) and the selection of local peasants. Their locally adopted variety and diversities should meet almost all the requirements of the local population.

The soil-climatic condition of the Republic of Uzbekistan is characterized by its variation regarding agricultural regions located in the southern and northern geographic latitudes, altitudes, and soils.

The soil content where the grain crops are cultivated alters on the vast plains, slopes, and mountains of the republic. Grey-brown, takyr, meadow, and swamp soils are widely spread on the plain zones that are used in agriculture. Meadow soils within them are used mostly. Agricultural products are produced by moistening and irrigating the soil in cultivated fields. Farming on such soils is carried out in the valleys of such rivers as Norin, Syrdarya, Karadarya, and Surkhandarya.

Watering meadow soils are enriched with humus and differ in the content of feeding elements. The average level of soil in these places is about 1.5–2.5 meters. Areas with soil salinization require conducting soil melioration measurements. Otherwise, the soil salinization will increase, and the land will become unusable. Farming is carried out on the takyr, gray-brown soils of the desert zone. But, because of the heavy melioration conditions (vulnerability to salinization, plastering, compaction, and washout), they are used to a lesser extent. The soils of the desert zone spread primarily in the following regions: Navoiy, Bukhara, Samarkand, Sukhandarya, Kashkadarya, and Karakalpakstan Republic.

Typical and light gray soils are also the most fertile soils in the high mountain districts. Such soils are broadly distributed and fertile in the valley of Fergana, in the districts of Tashkent, Samarkand, Jizzakh, Syrdarya, Kashkadarya, and Surkhandarya.

The climate of Uzbekistan is sharply continental. It expresses in sharp amplitudes day and night, summer and winter temperatures. Nature is dried, with less atmospheric precipitation and lowered relative air moisture. Days in the summer last for 15 hours; in the winter, they last less than nine.

January is the coldest month in which the temperature falls to -8°C of frost and lower; in the far south, in the district of Termez City, it will be warmer. July is the hot month in the mountain districts—July and August. At this period, the average temperature on the plain and slopes consists of 25–30 degrees; in the south (Termez and Sherabad), it reaches up to 41–42 degrees.

The annual amount of precipitation does not exceed 200–300 millimeters on the majority of the territory. There are a few lakes in the republic. Aral is the biggest of them, and it is called the sea. To our great regret, its level was lowered by 12–14 meters. The above-mentioned rivers are not able to provide for all cultivating fields in the republic.

Therefore, growing grain crops and obtaining sustainable productivity annually are accompanied by some of the risks caused by listed natural stresses and their consequences. It needs continuously improving the genetic potential of grown varieties of grain crops or importing foreign varieties from countries where the natural conditions are worse than ours and have advanced plant breeding and seed production systems.

However, it has universally been proven that locally, the creation of new varieties by using native and foreign accessions is the best way to address any regional challenges in the countries' agriculture. That is why our government is permanently concerned with evolving contemporary Scientific Research Institutes (SRI) with their remote field experimental stations and regional branches. This was more notable after the country's independence in 1991. On the government's initiatives today, functioning SRIs for all grain crops and their regional networks occupy all soil-climatic conditions of the republic.

Plant breeders, scientists, and seed producers of grain crops' SRIs relying on the government's support and under the guidance of the government's laws: "About achievements of plant breeding" and "About seed production" are being achieved with comparatively considerable outcomes. In cooperation with colleagues from international agricultural centers and from agrarian developed countries around the world, they

practice innovative technical means and plant breeding and seed production methods (look at the first and second title pages).

Today, our republic has become a country, fully secured by its own grain supply. The locally created varieties of grain crops, based on their productivity and product quality, are competitive with internationally recognized standard varieties. They highly adopted to the conditions of regions to plant. Resistant to agricultural diseases and pests. Grain and other products of local varieties developed by our breeders and seed producers meet nationally accepted standards, requirements, and demands of national consumers and the food industry.

Part I. Breeding and seed production of grain crops in Uzbekistan

The food products derived from wheat, triticale, barley, rice, corn, oats, and ray have a great demand among the people and industry of Uzbekistan, and farmers in our republic are eager to plant and get bumper crops of high quality. Consequently, our government representatives and scientists devoted to grain plant breeding and their seed production are the major initiators and creators of the new and high-producing grain crop varieties adopted to local and regional conditions of the republic in order to meet the growing requirements of our nation and industry for grain and their products.

Grain production in our republic has an annual growth dynamic (table 1).

Table 1. Grain production dynamics in the Republic of Uzbekistan

Crop years	Area, in hectares	An average yield in tons	Total crop, in tons
1991	770 000	1.2	900 000
1995	1 372 000	1.9	2 382 000
2000	1 182 000	2.7	3 140 000
2010	1 375 000	4.4	more than 6 000 000

According to social information, grain crop production in 2021 was 4 724 000 tons, and 4 634 000 tons, or 98.1% of that, was made of grain from cereal crops.

The earlier data for 2022 show that in this year, 6 371 000 tons of cereal grain were produced, which was 104.6% more than in 2021.

The latest data from the statistics agency (January–June 2023) stated that 5.4 million tons of grain have been produced. And there was note that this index is 7.3% higher than this period of 2022. The leaders in grain production across the regions are: Ferghana (more than 12%; Surkhandarya – 11.8%; Kashkadarya – 11.3%; Andijan – 9.0%; Samarkand – 8.3%; Jizzakh – 8.2% and the Republic of Karakalpak – 2.1%.

It was especially highlighted that the average grain crop productivity has been achieved at 5.0 tons. A number of leading farms are getting 7.0–8.0 and more tons of grain per hectare. A future increase

in grain production is mainly hoped to be solved by increasing productivity, working out introgressed crop growing technologies, and introducing them into production.

Since 2005 the area planted to grain crops has been stabilized and we can list them according to the size of the cropping area: 1. Wheat - 1428.3 thousand; 2. Barley-64.4 thousand; 3. Rice-47.8 thousand; 4. Maize-13.6 thousand; 5. Rye 7 thousand; 6. Sorghum-2.8 thousand; 7. Oat-1.5 thousand (2006).

Chapter 1. History of plant breeding and seed production of grain crops in Uzbekistan

The government of Uzbekistan, since the adoption of independence for the republic in 1991, has started wide-scale reforms in the economy, which have also embraced agriculture. Locally, production of grain and reproduction of grain products seemed to be one of the strategic trends for the streamline, independent country. Subsequently, substantial renovations were needed in the plant breeding of grain crops and their seed production. So, the Scientific Research Institute on Cereal and Bean Plants in the Irrigating Lands (the SRICBPIL) has been established by the initiative of I.A. Karimov, the first president of the Republic of Uzbekistan, and the resolution No. 413 of the Minister Chamber of the Republic of Uzbekistan on August 25, 1997. Its branches in all regions have been set up by resolution No. 344 of the Minister Chamber on August 7, 1998.

It was registered again in the state register by the name "Scientific Research Institute of Grain and Bean Crops (the SRIGBC)" on the basis of resolution No. PR-2125 of the President of the Republic of Uzbekistan "About perfection the activity of the Scientific-Production Center of Agriculture of Uzbekistan (Uz.SPCA)" dated on February 10, 2014, order No. 33 of the Ministry of Water and Agriculture of the Republic of Uzbekistan dated on February 13, 2014, and order No. 6 of the Scientific-Production Center of Agriculture of Uzbekistan dated on February 14, 2014.

The SRIGBC has been formed at Uz.SPCA and is considered the legal successor of the SRICBPIL, Kashkadarya Scientific Research Institute on the Plant Breeding and Seed Production of Cereal Crops (the Kashkadarya SRIPBSPCC), Uzbek Scientific Research Institute of Rice Growing (Uz.SRIRG), and Corn Scientific Experimental Station of Uzbekistan (Uz.CSES).

So, the history of plant breeding and seed production of grain crops in Uzbekistan launched its development with the establishment of these scientific research institutions:

*The SRICBPIL (Scientific Research Institute on Cereal and Bean Plants in the Irrigating Lands)

*Uz.SRIRG - Uzbek Scientific Research Institute of Rice;

*The Kashkadarya SRIPBSPCC - Kashkadarya Scientific Research Institute on the Plant Breeding and Seed production of Cereal Crops;

* The SRIGBC - Scientific Research Institute of Grain and Bean Crops and

*Uz.CSES - Corn Scientific Experimental Station of Uzbekistan.

By, looking through their individual formation, goals, and achieved outcomes, we can get solid information about the history of plant breeding and seed production of grain crops in Uzbekistan. The SRICBPIL is the oldest one among them.

1. The Scientific Research Institute on Cereal and Bean Plants in the Irrigating Lands (the SRICBPIL). Its history begins with the Zarafshon experimental field, which was formed in 1913 near Kattakorgan city in the Samarkand region. Professor V.S. Maligin guided the first experiments on rain-fed agriculture with his four scientific staffs.

Since 1925, this scientific institution has changed into the Kattakorgan Experimental Station. N.V. Karpov was its director. The number of scientific staff increased to 10. This station has become a single scientific station in central Asia to conduct research on the botanic and biological properties, plant breeding, seed production, and agro-practices of crops being grown in the rain-fed areas. And many new varieties of cereal and other agricultural crops were released at the station. The seed production works were begun, and definite works have been implemented into practice based on the study of the scientific basis of rain-fed agriculture.

In 1932, Kattakorgan experimental station was moved to Gallaral (Djizzakh region) and transformed into Milyutin experimental station. The number of scientific staff has reached 20. It was guided by N.V. Karpov, S.L. Tulaykov, and G.F. Sokolov in different successive years. Its basic points were formed in Kamashi (Kashkadarya region), Kurapatkin, Kattakurgan (Samarkand region), Zarkent (Tashkent region), and Bakhmal (Djizzakh region). Many new varieties of rain-fed crops have been developed in this period, and the physical and agro-chemical properties of soil in rain-fed areas and agro-practices of cereal and other crops have started to be deeply studied. Special tree zones have been built up to defend soil in rain-fed areas from wind erosion. New bean, oil-bearing, and forage crop species were selected for rain-

fed areas and worked out their agro-practices. The laboratory on plant protection has led effective activities.

In 1957, Malyutin State Plant Breeding Station was transformed into the Scientific Research Institute of Rainfed Agriculture of Uzbekistan (Uz.SRIRFA). The institute was guided by Sh.M. Muminov, A.I. Kovalov, and G.A. Atabaev in different successive years. The new laboratories and departments were established. Numerous new varieties were developed and put into seed production. Deeply and scientifically substantiated crop rotation systems and agro-technologies for crops. Studied the scientific basis of the resistance to cold and drought of rain-fed areas' crops in the physiology laboratory. The nutrient substances of the soil have been studied in the agro-chemical laboratory, and the physical and water features of the soil were determined in the agro-physics laboratory. Wide-scale scientific works have been implemented in the basic Kattakurgan, Bakhmal, and Gobdin points of the institute.

A postgraduate course was established in the institute to improve the specialists' skills. Close cooperation has been organised with a number of foreign scientific institutes.

In 1976, Uz.SRIRFA was transformed into the Cereal Growing Scientific Research Institute of Uzbekistan (Uz.CGSRI). The institute was guided by M.O. Amanov in 1978–1983 and S.Kh. Odilov in 1983–1986. The number of scientific staff has reached up to 80. Three of them were doctors of the sciences, and thirty were philosophy doctors in agriculture.

Scientific research on cereal growing and especially cereal growing in irrigated areas was broadened. These fields were provided with experienced staff and the necessary laboratory tools. During this period, 24 new cereal crop varieties were developed, seed production farms were also provided with an adequate volume of super-elite seeds for reproduction, crop rotation systems were perfected, and the new agro-practise innovations were tested.

In 1989, Uz.CGSRI was transformed into the "Galla" Scientific Production Association ("Galla" SPA). The state elite seed-producing farms of Gallaaral in the Gallaaral district, Oltin Bashoq, and K Marks in the Kamashi district, and basic points, were included in the structure of this association. Q.E. Eshmirzaev in 1986–1997 and A.A. Amanov in 1997–1998 guided this scientific establishment. The possibilities to create new varieties, perfect agro-technologies, form systems for the

production of high-reproduction seeds and introduce them into production have been widened.

Since 1997 up to 2014, as we specially noted at the beginning of composing this history on the plant breeding and seed production of grain crops, it has been renewed into the "Gallaarol Branch" of the Scientific Research Institute for Cereal and Bean Plants ("Gallaarol Branch" of the SRICBP). This branch was guided by S.E. Rustamov, T.M. Urinbaev, Kh.T. Odilov, and R.E. Siddikov in successive years. During this period, more than 50 varieties of agricultural crops and 31 wheat varieties were released and recommended for production. Their initial seeds have been produced. The methods to get high yields out of cereal crops in the irrigated lands have been worked out. So, in short, the registered name, Scientific Research Institute on the Rain-fed Area (the SRIRFA in 1997), was again renamed in 2014 to Gallaaral Scientific, Experiment Station of Scientific Research Institute for Grain and Bean Crops (Gallaarol SESSRIGBC, photo 1).

The main objects of the station are: the creation of new varieties of agricultural crops; conducting thorough research on the crop varieties and their hybrids; and the development of varieties of cereal, grain crops, bean grains, forage, oil-bearing, and vegetable crops adopted to local conditions with high productivity and product quality. Perfection of intensive production technology of selected varieties on the base of ecological variety testing, results and recommend to agricultural production; engage with preliminary seed production of registered varieties and hybrids; on the base of corresponding agreement to provide seed producing farms with high generation seeds and to work with them in cooperation; introduction of new systems of crop rotation into experimental plots of experiment station and their administrative departments and to conduct experiments in the expanding of scientifically substantiated ones; to implement different experimental tests; development of seed production of forage crops; production of high grade seeds of varieties and hybrids as well as perfection of their seed production.

Scientific trends of the station:

- *Plant breeding of agricultural crops;
- *Seed production of agricultural crops;
- *Production technologies of agricultural crops;
- *Physiology of plants, agro-chemistry and soil science.



Photo 1. Headquarters of Gallaaral Scientific – Experiment Station of Scientific Research Institute for Grain and Bean Crops located in the Gallaaral district of Djizzakh region.

At present, the station has 77 staff, and 24 of them are scientific staff. 15 of them have scientific degrees, and one of them is a Doctor of Science. And 14 of them have Doctor of Philosophy in agricultural sciences.

During the 2007–2019 years, 44 scientific research projects dealing with the actual problems in the sphere of the above-mentioned scientific trends were carried out by the scientific staff of the station. Today, the station continues its close scientific and practical cooperation with Tashkent State Agrarian University, the National University of Uzbekistan, ICARDA, SIMMIT, Krasnodar Agrarian Scientific Research Station, and the Kazakh Scientific Research Institute for Plant Growing and Farming.

2. **Uzbek Scientific Research Institute of Rice (Uz.SRIRG).** This institute is the coordinating scientific center on rice growing in Central Asia (photo 2).

Its history begins in 1926, when it was a department of rice growing in a Turkistan agricultural experiment station named after R.R. Shreder at the structure of the Uzbekistan Agriculture and Water Resources Ministry. Since 1932, it has been the Rice Growing Station of Uzbekistan (Uz.ROS), in 1958, the Rice and other irrigating grain crop department of SoysNIKHI, and in 1967, the Rice Growing Scientific Research Institute of Uzbekistan (Uz. RGSRI). In 2017, it was again built up by the decision No. PF-5094 of the President of the Republic of Uzbekistan.



Photo 2. The Uzbek Scientific Research Institute of Rice is located in the O'rtachirchik district of the Tashkent region.

Scientists and rice breeders of the institute lead their activities on 218.4 hectares of land and has its regional branches in Karakalpakstan (since 1967), Andijan (since 1994), and Khorezm (since 1997).

Scientific-research aspects of the Uz.SRIRG are:

*Creation of high-yielding, early, middle, and late-ripening, resistant to biotic and abiotic stresses, high-tech rice varieties designated to grow in different agro-climates of Uzbekistan with intensive and resource-saving technologies;

*Renewing varieties of rice and soya cultivating in the Republic, implementation of strain changing, and carrying out preliminary seed production;

*Working out and extension into production of leading intensive production agro-techniques to lower investment expenditure and enhance productivity of rice areas;

*Working out new technological methods to use mineral fertilisers and other agro-chemical means in the aim of maximal use of the rice and soya varieties' potential and recommending them for production;

*Working out of the application system with less harmful pesticides on the environment to fight against weeds, pests, and diseases of rice and recommend them for production;

*Creating new varieties of soya and mung bean and working out cultivation agro-practises as well as perfection;

*Mechanization of rice cultivation and its perfection

The institute has made great achievements in the development of rice varieties and working out their local growing technologies in Uzbekistan. Only in the years of Uzbekistan's independence has it created about 30 new rice, soya, and mung bean varieties. They are:

-resistant to diseases, pests, shadding, and lodging rice varieties: Avangard, Lazurniy, Istikbol, Istiklol, Bugdoy boshqoq, Ok kiltik, Mustakillik, Iskandar, Guljahon, Ilgor, Sitara, Marvarid, Navbahor, Tursunboy, Ahmad sholi, Tarona, and Tantana;

-soya varieties: Uzbek-6, Orzu, Nafis, Parvoz, Sevinch, and Madad;

-mung bean varieties: Navroz, Radost, and Kakhrabo.

Annually, seed producers of the institute are able to produce high-progeny seeds of rice (250 tonnes) and soy plant (30 tonnes) varieties and let them be planted in the production areas of farmers. The demand of clusters, farmers, and individual peasant landholders is constantly growing for the seeds of new rice and soya varieties created by the scientists of the institute. 90–95% of the land under rice plantations belongs to the rice varieties developed by the breeders of this institute. Their agropractices—planting term and seed norm, optimal norm of fertilisation, and term—were worked out. Worked out the measurements for the complex control of diseases, pests, and weeds in rice. At this, they produced: Bozogran, A-klinn, Namuna Super, Totariks, Totaris, Sapa nominal, Vi-klinn, B-klinn plus, Simfoniya plyus, Clipper, Bozagran gold, A-Zagran, and Turan star herbicides; Archer-bio,

Amistar-top, and Tric-Mancozeb fungicides against diseases; and Tayshin against wood.

New prospects of the institute:

- *Organization of ecological variety testing plots for introduced and local soya varieties in the institute, in its Khorezm branch, as well as in the experimental study areas;

- *Organization of an exhibition field on the establishment of seed production of the new developed rice variety Tarona in the "TSP Rice" cluster areas of Kuyichirchik district of the Tashkent region and to conduct an annual "Field Day" with the participation of rice farmers and cluster employers;

- *Creation of new varieties of rice, soy, and mung bean from bean crops adopted to different soils and climatic regions of the republic. Working out their growing technologies, arranging the preliminary seed production of crops, and holding authority over growing varieties.

3. Kashkadarya Scientific Research Institute on the Plant Breeding and Seed Production of Cereal Crops, the Kashkadarya SRIPBSPCC. The Kashkadarya SRIPBSPCC was set up by the resolution of the Ministry of the Republic of Uzbekistan "About measurements on the further reinforcement and development of the scientific base of cereal growing and cotton growing in the Kashkadarya region" No 209, dated September 16, 2008.

The following activities were marked as the major objects of the Kashkadarya SRIPBSPCC:

- *The creation of new competitive hard and soft wheat varieties with high quality indexes and resistance to diseases and pests;

- *Selection of foreign and local varieties adaptable to the natural climatic conditions of the region and preparation of recommendations on their extension;

- *Organisation of initial seed production systems to develop cereal grain crop varieties;

- *Working out advanced agrotechnologies for the maintain of high yields out of cereal crops in conditions of water scarcity and drought.

The institute leads its activities with the support of the Uzbekistan agriculture scientific-production centre and Kashkadarya regional governance. In this point of view, the institute was secured with 62 scientific research staff and 1000 hectares of land along the three zones of the region (namely 300 hectares from irrigated areas and 700 hectares from rain-fed areas).

In the subsequent years, the institute has undergone some changes in its name: in 2014, its name became "Kashkadarya Branch of Grain and Bean Crops Scientific Research Institute (the KBGBCSRI), and in 2021, it became "Southern Farming Scientific Research Institute (the SFSRI, photo 3).

The scientists-breeders of this institute, in their years of activity, have developed soft wheat varieties: Yaksart, Turkiston, Gozgon, Hazrati Bashir, Elomon, Hisorak, Bunyodkor, Shams, Janub gavhari, Gallakor, Kesh-2016, Shukrona, Ravon, Farovon, Barkhayot, Sarbon, Yuksalish, Nasafiy, Farovon-2, Turon, and Oksaroy soft wheat varieties; Langar, Zilol, Nasaf, Nafis, Musaffo and Hilol hard wheat varieties; Vaho", Sulton, Chinkurgon and Kamashi barley varieties; Obod - chick pea variety.

Today, the institute faces the challenges of creating new competitive varieties of grain, bean, oil-bearing, and forage crops; developing preliminary seed production for agricultural crops; working out and recommending the production of advanced techniques and intensive technologies by taking into account regional soil and climatic conditions.

4. Scientific Research Institute of Grain and Bean Crops (SRIGBC). It was mentioned above that this institute is younger, and it began its activity in 1997 at the initiative of the first president, I.A. Karimov (photo 4).

Laboratory of plant breeding, seed production, and growing agrotechnologies of grain crops, laboratory of plant breeding, seed production, and growing agrotechnologies of bean crops, physiology of plants, laboratory of grain quality and biochemistry, laboratory of plant protection and agrochemistry, laboratory of plant breeding of forage crops, seed production, and agrotechnologies, testing laboratories for starting agro-practices for rice varieties, and line samples introduced from abroad are functioning in the SRIGBC.

Kashkadarya branch as well as Gallaarol, Tashkent rice, grain, and bean crops, plant breeding and seed production of corn, Namangan, Fergana, Samarkand Syrdarya, Surkhandarya, Bukhara, Navoiy, Khorezm regions, and Karakalpakstan Republic scientific research stations are involved in the structure of this institute. Currently, Central, Istiklol, Tashkent, Bakhmal, Kasbi, and Kamashi experimental plots are also involved in their scientific research activities.



Photo 3. The administrative building of Southern Farming Scientific Research Institute located in Karshi city of Kashkadarya region.

The main scientific research trends of the institute are:

- *Creation of new varieties of cereal, rice, corn, and bean grain crops, deepening the work on hybrids and lines of crops;
- *Creation of high-quality, productive, and adoptive varieties of cereal, rice, corn, bean grain, oil-bearing, and forage crops to local conditions; perfection of intensive growing technologies for selected varieties on the basis of ecological variety testing and recommendation to production;
- *Engaging with preliminary seed production of varieties and hybrids of registered and marked varieties as prospective ones, providing the seed producing farms with high seed generations on the basis of corresponding agreements, and working with them in cooperation;
- *Extension of scientifically evidenced crop rotation systems in the plots of the institute and its local points conducting field experiments only in crop-rotated plots;
- *Cooperation between foreign institutes is set up. On the basis of bilateral agreements, the best varieties, hybrids, and lines of cereal, rice,

corn, bean grain, hybrids, and forage lines of crops were introduced and tested. The best ones are selected and resistered for production.



Photo 4. Scientific Research Institute of Grain and Bean Crops located in the Andijan district of Andijan region.

*To extend widely effective and save technologies.

The five high-priority plant breeding objects of the institute are:

1. Recommend into production the best varieties through ecological testing of introduced foreign varieties and lines;
2. Creation of extremely early-ripening and early-ripening varieties;
3. Creation of intensive types with high productivity, water and nutrient savings, resistance to diseases, and semi-dwarf and dwarf varieties;
4. Creation of strong wheat varieties with high productivity in irrigated conditions;
5. Selection of highly productive and super-quality hard wheat varieties in the irrigated areas and creation of their new varieties

Additionally, the institute works on and develops plant breeding projects with such crops as:

- *Creation of early-ripening, resistant-to-disease soya varieties;
- * Creation of winter kitchen chickpea varieties resistant to the disease Achaxitos;
- *Creation of winter lentil varieties, working out investment-saving growing technologies;

*Selection of the best varieties and hybrids, adopted to local conditions from introduced foreign bean grain crops, on the basis of ecological test results.

The achievements of the SRIGBC in its past years the scientific staff of the institute has established bilateral cooperation ties between scientific research institutes around the world to further strengthen and rise to the world level of scientific research in the plant breeding of cereal crops. More than 5 000 genefund collection varieties and samples of cereal crops differing from each other on their geographic origin and biologic-economic traits were collected from leading scientific research institutes in Russia, Kazakhstan, France, and Serbia. They were studied and evaluated comprehensively, selected the best varieties and samples with desirable indexes, and are being used as the initial sources in the plant breeding of cereal crops.

Annually, 450–500 simple, complicated, and backcross combination methods are carried out to create new varieties among varieties and lines based on their remote origin, biologic and economic traits, high productivity, resistance to diseases, and high grain quality.

Chillaki, Andijan-4, Bobur, Matonat, Yulduz, Yogdu, Jaykhun, Yaksart, Turkistan, Elomon, Gazgon, Khazrati Bashir, Bunyodkor, and Khissorak varieties belong to eritrospermum species diversity of winter soft wheat; varieties of Mars-1 belong to ferrugineum species diversity. Andijan-1, Andijan-2, Durdona, Asr, Davr, Sokhibkor, and Qoradarya belong to the species of Lyutessence diversity; Omad and Shodlik belong to Grekium species diversity; hard wheat varieties: Kakhrobo, Sadaf, Olmos, Mingchinor, Makus-3, Marvarid have been developed in a short period of time by the breeder scientists of the institute and its branches as well as in scientific experiment stations and were recommended to plant across regions of the republic. Except this, varieties of soft wheat: Sokhibkor, Khamkor, Khumo, Zafar, Billur, Vodiy, Uzbek-1, Osiyo, Tarakkiyat, Kras-An, Start, Iftikhor, Nihol, Yubiley-15, Islakhat, Ustoz, Komolot, Sanam, Samo, fazo, Asati, Baraka, Aziz, Umid, Uzbekistan-25, Barkhayot, Farovan, Zumrad, Shams, Istiklol and hard wheat varieties: Langar, are passing through different soil-climatic condition tests in the republic.

Varieties of soya: Oltintoj, Oyjamol, Tumaris, Baraka, Ustaz MM-60, Dustlik, Uzbekistan-2, Uzbekistan-6, Nafis, Orzu, Parvoz; varieties of winter kitchen chick pea: Polvon, Zumrad; kitchen chick pea varieties: Jakhongir, Iroda-96, Lazzat, Yulduz; mung bean varieties:

Kakhrabo, Navroz, Radost; winter varieties of lentil: Darmon, Sarbon, Oltin don; winter pea varieties: Osiyo-2001, Jasur-98; winter china variety: Gafur were developed by the breeder scientists in the field of bean crop breeding.

Varieties of rice: Avangard, Alanga, Guljakhon, Ilgor, Istikbol, Iskandar, Lazurniy, Mustakillik, Nukus-70; corn hybrids: Uzbekistan-601, Uzbekistan-420, Uzbekistan-400, Karasuv-350, Uzbekistan-300; sorghum varieties: Daylet, Karabash of Kandlik sorghum, Shirin-91, Dragana were selected again in the local conditions by our breeder scientists with scientific cooperation, worked out their local agro-practices.

Today the scientists of the institute have a close cooperation with scientists of Krasnodar SRI named after P.P. Lukyanenko in the Russian Federation, "Uga-Vostok" Saratov SRI of Agriculture, Serbian state Noviy Sad field vegetation SRI, Krasnodar oil bearing crops SRI named after V.S. Pustovoit, International ICARDA, Simmut, and "Soya complex" enterprises of Krasnodar in order to provide winter and spring wheat varieties with high productivity and quality, adopted to different soil and climatic conditions of the republic.

Introduced early ripening winter soft wheat varieties: Esaul, Kuma, Starshina, Rapsodiya, NS-40S; middle ripening: Kroshka, Krasnodarskaya-99, Tanya, Pamyat, Nota, Grom, Sila, Vassa, Pervitsa, Gratsiya, Zimnitsa, Kalim, Lebed; middle late ripening: Moskvich, Vostorg, Uka into state registered with recommendation to plant in the result of the state variety trial commission.

Furthermore, testing works are being conducted above new perspectives on nearly 20 early-ripening, high quality and productive winter soft varieties: Irishka, Lastochka, Afina, Unpa, Ayvina, Vershina, Tabor, Brigada, Proskovya, Kuren, Adel, Aleekseyich, Bezostaya-100, Stan, Belena, Vekha and Gurt to isolate varieties promising their high productivity in the future in our regions.

Moreover, barley varieties: Skiper, Komander, Kompast, Novosadskiy 525, Novosadskiy 565, Sprinter, Platon; varieties of triticale: Serey, Khleborob, and Tit with high grain quality and productivity indexes, resistant to environmental stresses; and new early-ripening varieties of soya out of bean crops: Slaviya, Sparta, Selektora 201, Apleta, Amiga, Avanta, Vilana, Selekt 302, Merkur, Viktoriya, and Tayfun are under testing in different plots of the institute.

5. Corn Scientific Experimental Station of Uzbekistan (Uz.CSES). This scientific-experimental station on corn breeding and seed production (photo 5) was set up in 2007 on the basis of the department of corn breeding and seed production of corn and sorghum, which existed before in the structure of the scientific-production firm "Erkin". 35 hectares of land, including irrigated fields, a corn grain reprocessing shop, a laboratory building, and other year-round supporting techniques, were allocated to the station. In 2014, the station entered the structure of the Scientific-Research Institute of Grain and Grain-Bean Crops in the Irrigated Lands.

During 2007–2020, the scientists of the station have developed varieties and hybrids of corn: Uzbekistan 400 DR, Uzbekistan 300 MV, Kelajak 100, Esdalik 80; varieties of sorghum: Daulet, Korabosh, Azamat, Massino, Ozodlik; African millet variety: Khashaki 1; varieties of triticale: Toyimli, Armug'on 60. And these varieties and hybrids are being grown in the republic on an area of 2.5–3.0 thousand hectares.

Current research of the scientific staff of the station covers the creation of rapid-growing, middle-ripening varieties and hybrids with high productivity of grain and green mass out of corn, sorghum, african millet, forage beet, raygrass, triticale, oat, raps, and vika and their preliminary seed production, working out of cultivation technology, elaborating on the scientific basis of introduced seedlings, and reprocessing obtained products.

The station has international relations with the Agriculture Scientific Research Institute of Krasnodar, a Russian SRI of plants, and has built up close cooperation with its Kuban and Uzbek branches (at present, the SRI of Plant Genetic Resources). The work of creating high-lisinole and drought-resistant hybrids has been related to these institutes.

Cooperative work with Ukraine corn SRI has helped in the creation of a series of early-ripening hybrids to use in the summer after harvest sowings.

The plant breeders at the station are conducting plant breeding over hundreds of commercialized hybrids of corn introduced from the USA, Serbia, Hungary, Russia, Kazakhstan, China, and Korea to adopt them in local conditions.



Photo 5. Central building of the Uz.CSES located in the district of Zangiota, the Tashkent region.

A series of samples were taken from the rich collection of all Russian SRI of plant Growing, ICARDA, IKBA, ICRISAT and studied as the quality of initial material. Work on the organisation of seed production for forage crops in different regions of the country was initiated with the assistance of ICBA and ICARDA.

Work on the seed production and extension of triticale into production is implemented in the framework of the Corea-Uzbek project.

Table 2. Determine cereal grain seed sowing rates in the irrigating areas.

Weight of 1000 seeds gr.	4.0 million seeds in kg.	4.5 million seeds in kg.	5.0 million seeds in kg.	5.5 million seeds in kg.	6.0 million seeds in kg.
40.0	160.0	180.0	200.0	220.0	240.0
40.5	162.0	182.0	202.5	222.8	243.0
41.0	164.0	184.5	205.0	225.5	246.0
41.5	166.0	186.0	207.5	228.3	249.0
42.0	168.0	189.0	210.0	231.0	252.0

42.5	170.0	191.3	212.5	233.8	255.0
43.0	172.0	193.5	215.0	236.5	258.0
43.5	174.0	195.8	217.5	239.3	261.0
44.0	176.0	198.0	220.0	242.0	264.0
44.5	178.0	200.3	222.5	244.8	267.0
45.0	180.0	202.5	225.0	247.5	270.0
45.5	182.0	204.8	227.5	250.3	273.0
46.0	184.0	207.0	230.0	253.0	276.0

Grain seed production data for 2023 shows that production of seed stock grain in our republic is led by 335 farmers, clusters in 127 agriculture districts, SRIs, and elite seed production farms governed by the Seed Production Development Center. The area of 96.8 000 hectares will be allocated to produce 300 000 tons of high-generation planting seed (seed stock). At this point, 5 000 hectares are needed to produce 15.7 000 tons of original seed stock from the reproduction nursery, 35.1 000 hectares to produce 109.8 000 tons of elite seed stock, and 56.7 000 hectares to produce R-1 seed stocks.

The table 2 to determine the seed sowing rate was recommended throughout the regions of the republic.

Part II. Breeding and seed production of wheat.

Chapter 1. Wheat varieties and their characteristics

1.1. The morphology of wheat and its ear. It presents in the field as an annual that grows erectly from 30 to 120 cm (figure 1). The roots have a fibrous habit. Stems are cylindrical, with distinct nodes and internodes. They are swollen and hollow. Usually, there are six internodes on the stem, and the sixth is the spike-bearing one. Leaves are simple, with alternate leaves arranged on both sides of the stem and a long, linear lamina with a leaf sheath covering the internodes. The two halves of lamina are unequal and present a tendency to twist.

The inflorescence of wheat is called a head, spike, or ear. Generally, 15-20 spikelets are formed on the rachis in a zigzag shape. Spikelets form two glumes, which may end as an awn (lemma). Each spikelet consists of two to five florets (Figure 2) attached alternatively on opposite sides of a short central axis called the rachilla and is covered by two sterile (empty) glumes. The lemma is broad with a sharp tip or awn, while the palea is thin. Usually, the lower lemmas are fertile and the top ones are sterile.

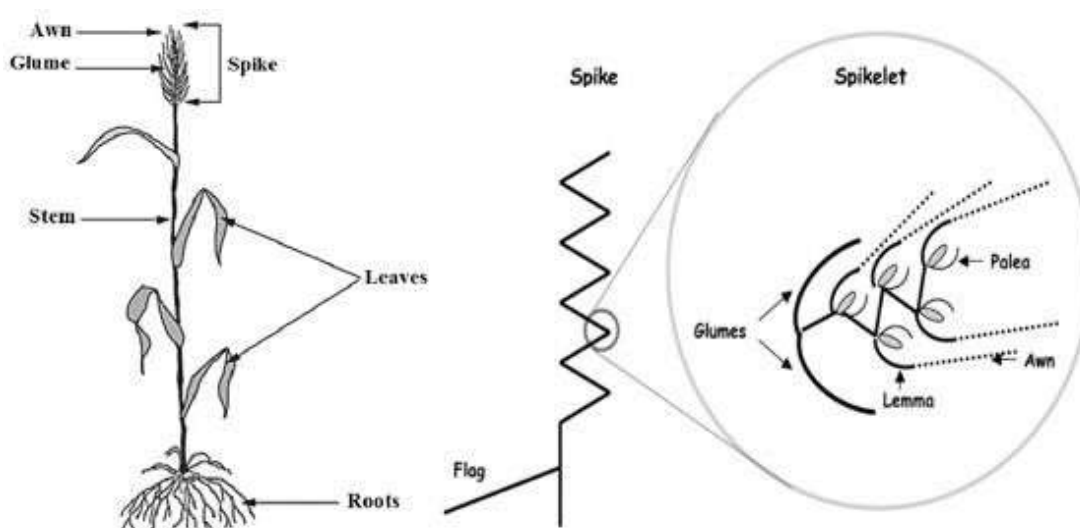


Figure 1 and 2. **The morphology of wheat plant (presented by Tehmina Saleem Khan) and structure of a spike.**

The construction of wheat flowers is distinct for its special habit, and they do not have petals or sepals (figure 3, 4). Each female flower of wheat has an ovary from which two stiles form, ending with two feathery stigmas. The male flower has three stamens with thin filaments

that turn gold or green in color. They have superior ovary. Usually, wheat flowers are characterised as self-pollinators.

The wheat grain is a single-seeded fruit in which the embryo and endosperm are surrounded by fused outer layers: the inner and outer pericarps and testa (seed coat), nucellar epidermis with aleyrone, and hyaline layers (accounting for about 8% of the grain).

Today, the following two species of wheat have a broad extension in the zone of cultivation:

*Soft wheat, or common wheat (*Triticum aestivum* L.), which is also known as bread wheat, It is remarkable for its high content of protein and gluten. The endosperm of grain is hard or soft.

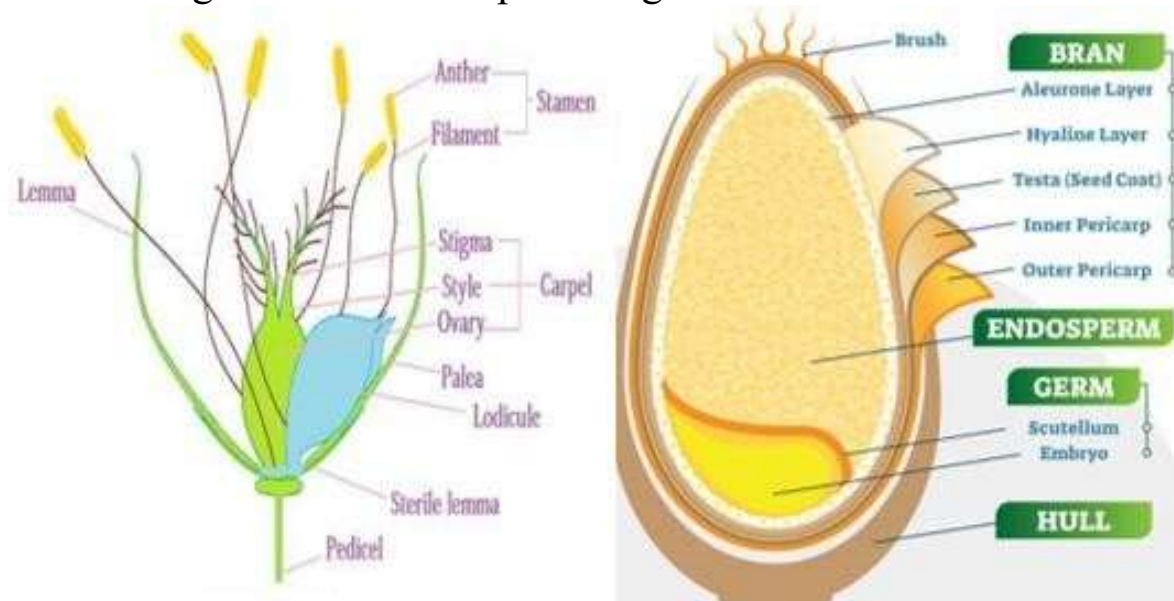


Figure 3, 4. Structure of wheat flower and grain.

1.2. Types of wheat, cultivation, and importance of wheat in the world and in Uzbekistan.

*Hard wheat (*Triticum durum* L.), or “noodles” cereals, is known for its special hardness of grain, high content of protein, saturated yellowish colour, pleasant odour, as well as splendid bread-baking dignities.

It must be especially emphasised that the annual production of wheat durum amounts to 25 to 30 million tonnes, which is 4% of total world wheat production. To increase its share This is one of the problems standing.

Growing wheat varieties are classified depending upon the following parameters: seed sowing, grain hardness, grain quality, and flour class (table 3).

1.3. **Wheat varieties** are divided into two groups based on their terms of sowing:

1. Winter wheat or common wheat Usually, the sowing of winter wheat seeds is carried out in the September and October months, and the harvest is carried out in the months of June, July, and August, depending on the regions and varieties of the world. Most of the winter wheat varieties are guessed uncial, owing to requirements for vernalization. Vernalization is a necessary requirement for the initiation of the blooming process, during which seedlings are exposed to the prolonged effect of a lowered temperature. This is a heritable trait that prevents the early development of the flower meristem of winter wheat and its damage by cold. The reaction of plants to vernalization depends on two factors: the effect of temperature and the duration of the vernalization period. Vernalization completes when the plant meristem has reached the stage of spring vegetation.

Three temperature ranges are distinguished, which took part in the process of vernalization:

*Minimal, it is usually the temperature of -1.3 to -4°C, process of vernalization does not occur at a lower temperature than them;

*Optimal, an average of 3 to 10°C is the most efficient, with the top at 4.9.

*Maximal, above which the process of vernalization has ceased.

Table 3. Parameters to divide of growing wheat varieties.

Terms of sowing	Grain hardness	Grain quality	Flour class
Winter	Hard	1 group	General designation
Spring	Soft	2 group	Bread
	Durum	3 group	Flour with loosening substance
		4 group	Confectionery
			Semolina
			Durum

Source: Cakmak et al. 1996.

Research states that a distinct line reaction of vernalization was observed at temperatures between 0 and 8°C. It is accepted that the influence of optimal temperature during the 50 days is necessary for the quality vernalization of winter wheat. This period is termed efficient days due to the saturation of the vernalization reaction.

2.Spring common wheat. The difference between this and winter wheat is that spring wheat doesn't require exposure to a lowered temperature (vernalization) to initiate blooming. Spring wheat is planted in the months of January and February, and the crop is beginning to be harvested in the month of August. The duration of the vegetation period ranges from 120 to 180 days, depending on the climatic conditions. Usually, the effect of temperature fluctuation in the range of 7°C to 18°C for 5–15 days is enough to start the blooming of spring wheat.

1.4. Wheat classification based on grain hardness. Below is the classification of wheat based on the structure of the endosperm, which may be hard or soft:

Hard wheat. Hard wheat is marked by its increased protein content. Well suited to get bread grades of flour. Starch grains are hard and do not crumble up in the process of milling.

Soft wheat. Soft wheat has soft endosperm, and starch grains are well ground up during milling. It is used in the baking of beading, sponges, and biscuits.

Wheat durum. Wheat with a hard grain of dark colour, rich in gluten. It is used to bake bread and produce noodles. This kind of wheat is grown preferably in the south of Russia, in north Africa, and in the north of the central part of North America.

1.5. Classification of the grain quality Wheat, depending on the grain quality, can be divided into the following groups:

I group. This group of wheat varieties has superior indexes of milling and baking characteristics. The price of flour out of the 1st group will be higher than the mean, owing to its correspondence with the requirement for quality (13% of protein content, a number of fallings on Hagbergu (HFN) of 250, and a specific gravity of 76 kg).

II group. This group contains different varieties of wheat in its structure, not all of which have potential to be used in bread baking. Some of the varieties are not hard enough in comparison with the I

group; others are too soft; and the third is fully fit for professional production of flour.

III group. This group comprises soft wheat varieties, ideal to produce biscuits, confections, and other flour varieties, where the main requirements are soft milling characteristics, a lowered level of protein content, good release of flour and strain, but not elastic gluten.

IV group. These wheat varieties are grown mainly for forage designation.

1.6. The classification of wheat depends on the flour quality. Wheat from each group is used to make flour for the bread baking industry. The flour of general designation is the most widely applicable of all flour types. This flour is taken from a finely milled part of wheat grain, which is termed endosperm. Flour of general designation is produced out of a combination of hard and soft wheat varieties and used in various baking applications, such as bread from yeasted dough, cake, dried biscuits, and buns.

Bread flour is used in the industrial making of bread-bun products. In spite of the similarity with the flour of general designation, bread flour differs with a higher content of gluten.

Flour with loosening addition – this type of flour is the flour containing salt and addition. Usually, this kind of flour is used to make sponges and biscuits.

Confectionary flour – flour of fine milling, grinded out of soft wheat varieties with a lower protein content. They are used to making all kinds of baking, such as cakes, biscuits, sponges, and others. Confectionary flour has a higher percentage of starch and a lower percentage of protein than bread flour.

Semolina – this is an endosperm wheat durum from rude milling.

Wheat durum: this is a hard wheat variety that has a high protein content. This makes it ideal for making high-quality noodles and kuskus.

Durum – it is a by-product of producing semolins. As a rule, this flour is enriched by four vitamin groups: V and iron and is used to make noodle soup.

1.7. Botanic classification of wheat. The genus *Triticum* encompasses 22 wheat species. Two of them, the species of hard (*T. durum* L. $n=14$, $2n=28$) and soft (*T. aestivum* L. $n=21$, $2n=42$) wheat are grown in the most areas of the world, and the largest part of those areas contain soft or common wheat plantations. Variety characteristics of grown varieties are worsened as a consequence of successive plantings

in the agricultural industry. The lowering of variety characteristics causes a decrease in crop yields and spoils the product's quality. That is why the selection of identical plants and the propagation of their seeds were foreseen in the process of wheat breeding and seed production. Because only the high-grade wheat variety is able to demonstrate its own hereditary and farm-value traits and attributes in the industry.

1.8. Growing importance in the world and in Uzbekistan. Grain crops are planted on 14% out of the world's agricultural lands, and grain makes up 50% of the food product trade. Despite this, there is a great demand for wheat products. The world trend shows that today over the world, annually, 760 million tonnes of wheat grain are produced, and it is expected to increase up to 850 million tonnes by 2030. Of course, this is closely related to the increasing world population rather than industry demand. So, wheat is an extraordinarily important food crop in the agriculture of the world. About the current top world wheat grain producing countries based on their production volume, we can know from the data in the table presented below (table 4).

Table 4. Eleven top wheat grain producing countries of the world.

Countries		Production (tons)	Production per person (kg)	Acreage (ha)	Yield (kg/ha)
	China	131.696.392	94.483	24.348.396	5.408.8
	India	93.500.000	69.96	30.230.000	3.093
	Russia	73.294.568	499.02	27.312.777	2.683.5
	USA	62.859.050	191.781	17.761.840	3.539
	Canada	30.486.700	819.235	9.261.840	3.291.7
	France	29.504.454	438.422	5.562.553	5.304.1
	Ukraine	26.098.830	617.521	6.205.800	4.205.6
	Pakistan	26.005.213	128.82	9.143.097	2.844.2
	Germany	24.563.800	195.668	3.201.700	7.640.9
	Australia	22.274.514	889.223	11.282.202	1.974.3
	Turkey	20.600.000	254.917	7.609.868	2.707

Usually, the wheat grain has protein and gluten in its form, which have a significant role in the provision of food products. Protein and

gluten in the structure of grain are the main indexes of wheat grain quality. Scientists state that gluten, as a biochemical substance, determines the extensibility and elasticity of dough, noodles, and baked bread. The biochemical structure of wheat grain is very variable. Structural components like protein, gluten, microelements, vitamins, pigments, and enzymes easily vary under climate, soil, applied fertilisers, agro-practices and sown varieties.

According to the world standard requirements, the protein content in the structure of wheat grain should not be less than 13.5%. The amount of protein in it defines the fitness of this grain to use in what kind of product production. For example, baking bread requires 14-15% protein content, while preparing noodles requires 17-18%.

Wheat grain remains the main protein source that provides 50 percent of a man's daily food ration.

In general, wheat grown in the rain-fed conditions of Uzbekistan is able to accumulate a lot of quality protein and gluten under high sun rays at an efficient temperature. The fitness of wheat flour to bake bread is determined by the amount and quality of gluten, which influence volume, porousness, and stickiness.

The world wheat grain in the crop year 2021 was made of 724 million tonnes, and 6.6 million tonnes of this was the share of Uzbekistan. This crop was harvested as the result of growing wheat varieties throughout the republic. According to the State Register on the recommended crops to plant in the regions of Uzbekistan, we can see the list of wheat diversities and varieties planted in 2022 (table 5).

Table 5. Wheat diversities and varieties recommended for planting in the territory of the Republic of Uzbekistan

Name of varieties	Order № of originator	Code of the country	Registered year	Recommended regions to plant
1. Winter soft wheat (<i>Triticum aestivum</i> L.).				
Alekseyich	62	RF	2020	1-13 (Irr.)
Andijan 2	62, 434	Uz	2003	1-13 (Irr.)
Andijan 4	434	Uz	2004	2,4,7,9,10,12 (Irr.)
Antonina	62	RF	2020	1-13 (Irr.)

Amangul	492	Uz	2021	1 (Irr.)
Asr	434	Uz	2013	1-13 (Irr.)
Bardosh	9	Uz	2015	8,10, -12 (Irr.)
Bakhmal 97	5	Uz	2012	4,5,8,9 (Rainf)
Bezostaya-100	62	RF	2020	1-13 (Irr.)
Bobur	434	Uz	2006	1-13 (Irr.)
Bograt	62	RF	2021	2,7,12 (Irr.)
Brigada	62	RF	2021	2,7,12 (Irr.)
Bunyodkor	315	Uz	2020	3,5,9 (Irr.)
Vassa	62	RF	2016	1-13
Velena	62	RF	2021	2,7,12 (Irr.)
Vekha	62	RF	2022	3,9,13 (Irr.)
Gratsiya	62	RF	2013	1-13 (Irr.)
Grom	62	RF	2013	1-13 (Irr.)
Gurt	62	RF	2020	1-13 (Irr.)
Davr	434	Uz	2019	1-13 (Irr.)
Denov 1	310	Uz	2008	3-9 (Irr.)
Drujba	62, 434	RF, Uz	2020	2,7,8,10,11,12 (Irr.)
Dustlik	5	Uz	2005	4,5,10,11,12 (Irr.)
Durdona	434, 62	Uz	2009	1-13 (Irr.)
Esaul	62	RF	2011	1-13 (Irr.)
Yog'du	434	Uz	2019	1-13 (Irr.)
Jaykhun (zamin1)	315	Uz	2007	3,5,7-12 (Irr.)
Jasmina	12	Uz	2016	3,4,5,6,8,9
Zvezda	62, 434	RF, Uz	2016	1-13 (Irr.)
Zimnitsa	62	RF	2015	1-13 (Irr.)
Intensivnaya	287	KG	1981	5,8,9,11 (Irr.)
Ilgor	9	Uz	2021	11 (Irr.)
Istiklol 6	5	Uz	2017	4,5,8(Rainf.)
Istiklol 20	5	Uz	2019	4,5,5 (Irr.)
Khalim	62	RF	2019	1-13 (Irr.)
Krasnovodopadnaya 210	245	KZ	1980	4-6,8,9,11 (Rainf)
Krasnodarskaya 99	62	RF	2008	1-13 (Irr.)
Kukbulak	5	Uz	2001	4,5,8 (Rainf.)
Kroshka	62	RF	2000	1-13 (Irr.)

Lebed	62	RF	2019	1-13 (Irr.)
Mars 1	434	Uz	2006	2,5,9,11 (Irr.)
Ok-bugday	5	Uz	1993	4,8 (Rainf.)
Pakhlovon	9	Uz	2021	10,12 (Irr.)
Pervitsa	62	RF	2018	1-13 (Irr.)
Rapsodiya	318	SR	2013	2,3,4,7,10-12 (Irr.)
Sanzar 4	5	Uz	1990	1-13 (Irr.)
Sanzar 6	5	Uz	1991	4,5,10,11 (Rainf.)
Sanzar 40	5	Uz	2021	8 (Irr.)
Starshina	62	RF	2004	3,5,9 (Irr.)
Sugdiyona	5	Uz	2020	4,5,8,9,11 (Rainf.)
Tabor	62	RF	2019	1-13 (Irr.)
Tanya	62	RF	2010	1-13 (Irr.)
Tezpishar	5	Uz	1980	4,5-10 (Rainf.)
Termiz 5	22	Uz	2019	5,9 (Irr.)
Turkistan	315	Uz	2011	3,5,8-11,13 (Irr.)
Fergana	434	Uz	2021	12 (Irr.)
Farboma	12	Uz	2019	8 (Irr.)
Khosildor	5	Uz	1996	1-13 (Irr.)
Khisorak	315	Uz	2022	5,9 (Irr.)
Chillaki	434	Uz	2002	1-13 (Irr.)
Chimbay	15	Uz	2021	1 (Irr.)
Shortanbay 1	492	Uz	2021	1 (Irr.)
Shukrona	315	Uz	2021	5 (Irr.)
Yuka	62	RF	2019	1-13 (Irr.)
Yaksart	315	Uz	2014	1,2,4-13
Yanbash	5	Uz	1995	1,4,5,9,11,13 (Irr.)
Utkir	492	Uz	2020	1 (Irr.)
Uzbekistan 25	434	Uz	2021	5,12,13 (Irr.)
Kayraktash	9	Uz	2021	4,8 (rainf.)
Gallakor	315	Uz	2020	4,5,8,9,11 (Rainf.)
Garazsizlik	492	Uz	2019	1 (Irr.)

Gozgon	315	Uz	2018	2-12 (Irr.)
2.Winter hard wheat (Triticum durum Dest.)				
Yoqut-2014	5	Uz	2020	4,5,8,9,11 (Rainf.)
Javohir	5	Uz	2011	4,5,8,11 (Rainf.)
Istiklol	12	Uz	2019	8 (Irr.)
Istiklol-25	12	Uz	2020	5,8 (Irr.)
Karlik 85	6	Uz	2000	4,5,8,11 (Irr.)
Kakhrabo	434, 62	Uz	2007	2,3,5,6,8,9,13 (Irr.)
Krupinka	62	RF	2012	5,9,11 (Irr.)
Langar	315	Uz	2020	4,5,8,9,11 (Rainf.)
Leukurum 3	5	Uz	1976	4,8,11 (Rainf.)
Leukurum 21	62	RF	2000	1-13 (Irr.)
Marvarid	5	Uz	1998	5 (Rainf.)
Makuz 3	5	Uz	2000	4,5,8,9 (Irr.)
Mingchinor	315	Uz	2017	4,5,8,9,11 (Rainf.)
Nasaf	315	Uz	2021	5,11 (Irr.)
Sadaf	5	Uz	2020	8 (Irr.)
3.Spring soft wheat (Triticum aestivum, Emend. Fiori et Paol.).				
Bakhor -1	5	Uz	2013	4 (Irr.)
Sads 1	405	EG	1997	1-13 (Irr.)
Surkhak 5688	290	TJ	1942	4,5,8,10,11 (Rainf.)
4.Spring hard wheat (Triticum durum Dest.).				
Yoqut-2014	5	Uz	2020	4,8 (Rainf.)
Istikbolly	5	Uz	2018	4,5 (Irr.)
Langar	315	Uz	2020	5 (Rainf.)

The list of recommended wheat varieties consists of **72 winter soft wheat** (45-local varieties (Uz); 22-from Russia (RF); 2- developed jointly with Russia (RF, Uz); 1-from Kyrgyzstan (KG); 1-from Kazakhstan (KZ) and 1-from Sirinam (SR), **15 winter hard wheat** (13-local varieties; 2-from Russia), **3 spring soft wheat** (1-local variety; 1-

from Egypt (EG) and 1-from Tajikstan (TJ) and **3 spring hard varieties** (all local varieties).

At this, regions of Uzbekistan have order numbers in the register to simplify in writing their names continuously. So, the numbers imply (appendix 4):

The total wheat area under irrigating conditions in the republic was 1 million 32 thousand hectares in 2022, and it was planned to produce 7.8 million tonnes of crop, which would be 1.1 million tonnes more than the previous year.

But, today, the development of hard wheat varieties like **Musaffo, Nafis, Nasaf, and Zilol** remains a great problem for our wheat breeders. Because the planting area under them is not more than 5% out of the total area under the wheat crop of 1 million 300 thousand hectares. The crop taken from 5% of the land isn't enough to meet the needs of our food industry, which requires 120–150 thousand tonnes of hard wheat grain annually. Thereby, to meet this problem, our government has to import this amount of wheat grain from abroad for 10–15% of the expensive prices or have to compensate for this lack on account of soft wheat grain, which worsens the quality of food products.

1.9. Characteristics of local wheat varieties According to the table on the varieties of wheat recommended to be planted in 2022 in the territory of Uzbekistan, we can get acquainted with the characteristics of some winter soft wheat (*Triticum aestivum* L.), winter hard wheat (*Triticum durum* Dest.), spring soft wheat (*Triticum aestivum*, Emend. Fioru et Paol.), and spring hard wheat (*Triticum durum* Dest.) varieties.

1. Winter soft wheats (*Triticum aestivum* L.): **Alekseyich**, which has been included in the state register since 2017 in the Russian Federation to plant in the northern Caucasus.

Originator: The national centre of grain is named after P.P. Lukyanenko, and the seed is reproduced by the “Kubanzerno” scientific and practical association.

Origin: Lutences, 293k51 x Fortuna.

Diversity: Lutences.

General characteristics: plant structure—straight growing. Middle height. Height of plant: 77–96 cm. Wax spots on the upper nodes and weakness on the ears the ear has a pyramidal shape, a middle length, and is longer and white in middle density. Awn residues on the end of the ear are short- and middle-length. The internal part of the lower glume has a weak pubescence. The shoulder is straight-risen, middle width.

Tooth straight, very short. Grain is colored. The weight of 1000 grains are equal to 37–46 g.

Farm-variable traits: productivity of 5.0 tonnes per hectare was in the central black soil region, 0.6 ton in the northern Caucasus. The maximal productivity of 10.5 tonnes was registered in 2016 in the Republic of Crimea. Middle ripening, vegetation period: 228–278 days. Ripens 2–6 days later than variety Ermak and similar to Grom and Almira. Cold resistance is above the middle. Resistant to lodging. In the years of testing, it was superior by 1.0–1.2 scores to varieties of Batko, Almira, and Ermak. Resistance to drought is at the level of standard variety Grom. The bread-baking quality is excellent. Strong wheat. Resistant to the diseases of brown rust, mealy dew, septoriosis, and yellow rust. Moderately resistant to ear fusariosis. Susceptible to hard smut.

Variety “Andijan-2”. It was released in conjunction with the Scientific Research Institute of Cereals and Bean Crops in the Irrigation Area named after P.P. Lukyanenko (SRICBCIA) and the Krasnodar Agricultural Scientific Research Institute (KASRI).

Origin: Through the repeated selection method from the Kupava-29 bred sample.

Authors: F.A. Kolesnikov, L.A. Besspalov, L.P. Filobok, T.I. Gritsay, I.N. Kudriyashov, V.V. Maymistov, R. Tulanov, K. Eshmirzaev, T. Jalalov, and O. Kosimov.

General characteristics: middle height, resistance to lodging, the grain does not fall, spike forming begins 2-3 days earlier than variety Kupava. It belongs to the diversity of Lutescens. The spike has a cylinder shape, and spike thickness and length also have a mean index with high productivity. My own is short. Grain legume shoulder straight, the wideness middle, and the tooth straight and short. The spike is white, and the grain has a red colour and is prolonged.

Productivity: It gives 8.0–9.0 tonnes of grain per hectare in the condition of a high agro-background. The productivities of it were in the region of Khorezm (6.0 tonnes), in the Bukhara region (6.0–7.0 6.0-7.0 ton/ha and the same in ana.

Bread baking properties: weight of 1000 grains: 42–43 g; grain nature: 780–515 g/l. gives “Expansive” grain.

Resistance to diseases: to brown and stem rust, septoriosis diseases, at a lower index with dew and either with yellow rust in the high precipitation years.

Term of planting: According to the recommendation on account of the optimal regional term

Rate of planting: It is defined as 4.5–5.0 million per hectare of vital seed to grow.

Wheat variety of “Andijan-4”. It was developed in cooperation with the Cereal and Bean Crops Scientific Research Institute for irrigated areas named after P.P. Lukyanenko.

Authors: R. Tulanov, T. Jalolov, S. Teshabaev, V.B. Timofeev, L.F. Dudka, V.Ya. Kaftunenkov, V.A. Filibok, L.A. Bessalova, and I.N. Kudrashov.

General characteristics: early ripening, middle height (90-100 cm), resistance to lodging. It belongs to the species diversity of *Erythrospermum*. Ear: white, cylinder shape, middle length. The squama of spikelet has an oval shape. Awns have a white color, are spread, the middle is uneven, and the grains don't fall. The grain is red, oval-shaped, middle-sized, and the trench of grain is not deep. The weight of 1000 grains are 38.4-42.4 g.

Productivity: Its productivity has the potential to yield 8.0–9.0 tonnes of grain per hectare. An average productivity makes 8.0 tonnes.

Bread baking properties: the quality of the grain is good; it gives a “valuable” grain.

Resistance to disease: Infection with yellow rust has lowered indexes, lower than the middle index in the infection with brown and stem rust, and in the middle infection with ear fusariosis. Resistant to cold is higher than the middle index; it is resistant to drought and salt.

Due to the short period of vegetation, these diseases cannot have a significant influence on variety productivity.

Planting terms: The optimal term for the region is acceptable.

Planting rate: 5.0 million vital seeds per hectare to grow is marked.

Variety “Asr”. It has been developed at the Cereal and Bean Crop Scientific Research Institute.

Variety authors: R. Siddikov and S. Teshabaev.

General characteristics: Middle ripening; the height of the plant is 95–105 cm; resistant to lodging. The ear is cylinder-shaped and enlarged. It belongs to the *lutescens* species diversity. Ear squama has egg-shaped teeth that are straight and short. Grain is enlarged, red-coloured, and prolonged. The grain trench has a middle depth.

Productivity: The potential productivity gets up to 11.0–12.0 tonnes of grain per hectare. It's an average yield for two years at the

planting after winter chickpeas of 8.0 tonnes per hectare. Resistant to cold.

Flour and bread quality the weight of 1000 grains is equal to 46–48 g. Nature -790-830 g/l. It gives strong and “valuable” grain, depending on the growing technologies.

Resistance to diseases: resistant to dust smut, yellow rust. Resistant to brown rust disease in the field. Middle resistance to stem rust and septoriosis.

Planting term: accepted as the optimal term for the region.

Planting rate: 4.5–5.0 million vital seeds.

Variety of “Bobur”. It was developed in cooperation with the Scientific Research Institute of Cereals and Bean Crops in the Irrigation Area named after P.P. Lukyanenko (SRICBCIA) and the Krasnodar Agricultural Scientific Research Institute (KASRI). Included in the state register since 2006 and recommended for production.

Origin: It was developed through double selection out of the sample Eyka (1326-3600).

Authors: Yu.M. Puchkov, G.D. Nabakov, I.N. Kudriyashov, T.F. Solyarek, L.A. Besspalov, N.F. Fomenko, T.G. Varlamov, R.I. Siddikov, R. Tulanov, T. Jalolov, and S. Teshabaev.

General characteristics: early ripening, middle height, resistance to lodging, belong to Erythrospermum species diversity. Ears of cylinder shape, middle thickness, and length turn white at the time of maturity. The grain is red, enlarged, oval in shape, glassy, and weight of 1000 grains – 41-44 g. The grain trench is shallow.

Productivity: Productivity is 9.0–10.0 tonnes per hectare under high agro-practices. An average productivity makes 8.0 tons.

Planting term: recommended according to the optimal term of regional plantings.

Planting rate: 5.0 million vital seeds per hectare.

Variety “Durdona”. It was developed in cooperation with the Scientific Research Institute of Cereals and Bean Crops in the Irrigation Area named after P.P. Lukyanenko (SRICBCIA) and the Krasnodar Agricultural Scientific Research Institute (KASRI).

Authors: R. Tulanov, S. Teshabaev, I. Egamov, T. Jalolov, A. Mansurov, V.B. Timofeev, L.F. Dudka, V.Ya. Kovtunenkov, V.A. Filobok, L.A. Besspalov, and I.N. Kudrashova.

General characteristics: It belongs to the Lutescens species diversity; middle ripening; good tillering; stem straight growing; height

90–95 cm; the stem is resistant to lodging. Grain productivity is high. The ear has a cylinder shape, spikelet length and thickness are middle indexes, and every spike has 19–22 spikeletes.

Productivity: Its high productivity was equal to 7.0 tonnes on the competitive variety testing fields in the conditions of the Andijan region.

Bread baking properties: This variety gives “valuable” grain. Fitness for bread baking is good.

Planting terms: It is recommended to plant in the optimal winter planting terms of the Andijan, Namangan, Samarkand, Surkhandarya, Tashkent, and Fergana regions of the republic.

Planting rate: 4.5–5.0 million vital seeds per hectare.

2. Winter hard wheat (*Triticum durum* Dest.) varieties

Yoqut-2014. This variety was released in the laboratory of hard wheat breeding and seed production in the rain-fed lands of the Fallaoral Scientific-Experiment Station of Grain and Bean Crops SRI. Hybridization: [Marvarid x Waha (Siriya)] x Leukurum-3 and directed individual selection on adaptability to rain-fed areas, resistance to drought, heat, grain quality, and high productivity were used during the breeding process.

General characteristics: The height of plants is 78.6–109.2 cm. The stems of plants are resistant to lodging at the 7th score and resistant to drought, cold, yellow, and brown rust. Productivity consists of 13.0–12.1 tonnes per hectare. The seeds can be planted in the second and third decades of October, in the third decade of February, and in the first decade of March. Planting rates in the autumn at the level of 3.5 million vital seeds and in the spring at the level of 3.0 million seeds are considered optimal.

Javokhir. Gallaaral branch of SRI for grain and bean plants in the irrigation areas is this variety’s originator. It was developed through individual selection from progenies of hybrids after complicated hybridization of (Leukurum-3 x Karlik-85) x Yubelaynaya.

Authors: J. Umarov, Kh. Adilov, A. Amanov, and T. Urinbaev.

General characteristics: biologically, two-season wheat belongs to leukurm. It has a silindric ear, middle length and size, and a yellow color. The weight of 1000 grain is equal to 36.9–39.6 g. It is resistant to lodging and cold (correspondingly, by 5.0 scores). Productivity in rain-fed areas ranges from 1.0 to 1.2 tons. Vegetation periods: 192-198 days. Maceron-making property meets the level of 4.5, gluten content is 28%, and protein is 15.1%.

Karlik 85. This variety was developed by continuing selections out of progenies of complicated hybridization at the plant-growing SRI.

Authors: I.Sh. Shakhmedov, G.K. Kurbanov, and B.M. Djumakhanov.

General characteristics: autumn hard wheat belongs to Meliyanopus species diversity. Ear with awn and has white colour, silindric, middle length, and depth. Grains have a middle size, a dark yellow colour, and a circled shape. The grain ditch is not deep. The weight of 1000 grains are 38.4–45.8 g. Plants have an 181-200-day vegetation period. Resistance to cold is at the level of 5. The mean productivity in the irrigation area is 4.5 tonnes, and in the condition of rainfed, it is 2.6 ton\ha. Macorony and technological qualities of this variety are good.

A variety of **Leukurum 21** was released at the Krasnodar SRI of Agriculture named after P.P. Lukyanenko through hybridization of Kharkovskaya 1 x Leukurum 283 varieties.

Authors: V.V. Kostin, A.A. Mudrova, Yu.M. Puchkov, N.G. Fomenko, M.I. Domchenko, and V.A. Alfimov. It belongs to the Lekurim species group of biologic spring wheat.

General characteristics: white ear, has an awn, and is of average length and depth. Awn is white, saw-shaped; the grain is also white, oval, and a little longer. Ditch is deep and closer; the weight of 1000 grains is 39.0–45.0 g. It interbreeds with wheats of low height. Resistant to lodging and grain falling -5 score It has good over-wintering features. Middle ripening and has 210–220 vegetation periods. An average productivity in the irrigation areas is 3.8–4.8 tons/ha. Infection by the disease (yellow rust) registered at the level of 10.0-33.0%. The qualities of the making of macorony and flour are good.

Nasaf, this variety was registered in 2021 to be planted in the irrigating fields of the Kashkadaiya and Tashkent regions. Its origin is an individual selection from a hybrid combination of the Somat variety and the Silver 1 variety. It's potential productivity possible to give 6.0 tonnes, but in the conditions of production, around 4.0 ns. The colour of the grains is white. It also remarks that it is resistant to drought, heat, pests, and diseases.

3. Spring soft wheat (*Triticum aestivum*, Emend. Fioru et Paol.) varieties:

Bakhor. The gallaarl branch of SRI for grain and bean plants in the irrigation areas is this variety's originator. It was released as the

result of multiple individual selections out of hybrids: Sanzar 4 x K-571830

Authors: R. Siddikov, A. Khayitbaev, N. Umirov, and M. Juraev.

General characteristics: It is a biologic spring wheat and belongs to the Grekum species. The ear has a silinder shape, white, middle length. The middle size of grain is egg-like and has a red colour. The weight of 1000 grains are 31.4 g. The height of plants is characterised as the middle height, which is from 75 to 100 cm. Its resistance to lodging and shadding meets a 4.0 score. Productivity is equal to the average of 0.3–0.5 tons. It has a 4.0 score in its resistance to lodging and grain shadding. An average productivity makes of an average 3.0-4.0 tons\ha and its vegetation period: from 96 to 100 days.

Surkhak 5688. This wheat variety was developed at the Tadjikstan SRI of agriculture by the individual selection of the wheat variety Surkhak.

Author: I.G. Sukhobrus

It had been registered in 1942 to plant in rain-fed areas during the term of autumn in the regions of Jizzakh, Samarkand, Syrdarya, and Tashkent.

General characteristics: It belongs to the species Eritrospermum, two-season Biologic autumn wheat Ear har awn, white, naked. Grain is enlarged, the weight of 1000 gain is 37.2-43.5 gs., vegetation period is 174–180 days in the autumn planting term and 80 days in the spring term. An average productivity at the autumn term in the rain-fed fields was 1.8–1.9 tons^ha. In the spring term, 1.0 tonnes. The variety is resistant to grain shadding (5.0 score). Drought resistance: an average of 4.3; lodging: a 4.0 score. The susceptibility to diseases and pests is weak. Infection by the phatogens of yellow rust can occur at a level of 26.0% in years of adverse temperature.

The technological and bread-baking qualities of the variety are middle-grade: protein content: 8.5–11.3%; gluten: up to 22.5%; and flour output: up to 69.8%. The total bread baking mark is sufficient, equal to 3.0-3.8 scores.

4. Spring hard wheat (*Triticum durum* Dest) varieties include Langar and Istiklol.

Langar was developed by the breeders A. Amanov, Zh. Zhiyadullaev, O. Amanov, Sh. Dilmurodov, and A. Meyliev.

Its biological characteristics are: two seasons, middle ripening, and a weight of 1000 seeds of 40.8 g.

Agrobiological characteristics: it has 208–210 days of vegetation period; height is not high (95–98 cm); it is resistant to lodging; and productivity in the rainfed areas is equal to 2.2–2.6 tonnes per hectare. Contains 32.2% gluten and 14.5% protein.

Recommended regions for planting: Jizzakh, Samarkand, Kashkadarya, and Tashkent.

Chapter 2. Biology of wheat

Origin of wheat. Archaeological excavations of wild emmer (or hulled wheat) have indicated that the Eastern Mediterranean region of Western Asia was the first cultivated place, dating back as far as 9600 BC. It is a type of awned wheat that is tetraploid, with $4n=4x=28 = 4x = 28$ chromosomes. Its domesticated forms are *Triticum turgidum*, subsp. *dicoccum*, and *T. t. conv. durum*. And its wild form is called *T. t. subsp. dicoccoides*. Ripened grains of this shatter and scatter onto the ground, while in the domesticated emmer, the spike remains intact, which makes it easier for humans to harvest its grain.

Emmer wheat was one of the first crops domesticated in the Near East (appendix 1). But now it is grown in mountainous regions of Europe and Asia (photo 6). Einkorn wheat is another wild wheat that is grown in the mountains of



Photo 6. Historical picture about the threshing of wheat in ancient Egypt.

southern Turkey. It also refers to a wild species of wheat (*Triticum*) or to its domesticated form. Its wild form is *T. boeoticum* (syn. *T. m. ssp. boeoticum*), and the domesticated is *T. monococcum* (syn. *T. m. ssp. boeoticum*). This form of wheat belongs to a diploid species ($2n = 14$ chromosomes). Phenotypically, it is hulled wheat, with tough glumes (husks) that tightly enclose the grains. The spikes of cultivated

forms are similar to the spikes of wild wheat, except that the spike (ear) stays intact when ripe and the seeds are larger. The name of the einkorn refers to the fact that each spikelet of the ear contains only one grain.

The historical data result concludes that the cultivation of emmer reached Greece, Cyprus, and the Indian subcontinent by 6500 BC, Egypt by 6000 BC (photo 6), and Spain by 5000 BC. There is global recognition that Egyptians were cultivators of wheat, producers of wheat flour, and users of ovens to bake and develop the primary large-scale food production industries. Later, in 4000 BC, wheat had reached the British neighbors. On the sides of China's yellow river regions, wheat appeared in the period of 2600 BC.

There is also evidence that hexaploid wheat (with a chromosome number of $2n = 6x = 42$) has been confirmed in the results of DNA analysis of wheat seeds, dating to around 6400–6200 BC. This first-identified bread wheat (Triticum aestivum) with an adequate gluten amount for yeasted breads has also been identified in the result of DNA analysis in samples from a granary dating to approximately 1350 BC in Macedonia.

From a genetic point of view, wheat species have developed as an example of classic polyploidization, which evolves a combination of genomes from related species. Scientifically, wheat had diploid sets of chromosomes in its ancient forms until they combined to form tetraploid and hexaploid forms. These chromosome genomes are designated as A, B, and D. Each of these sets contributes 7 chromosomes (figure 5).

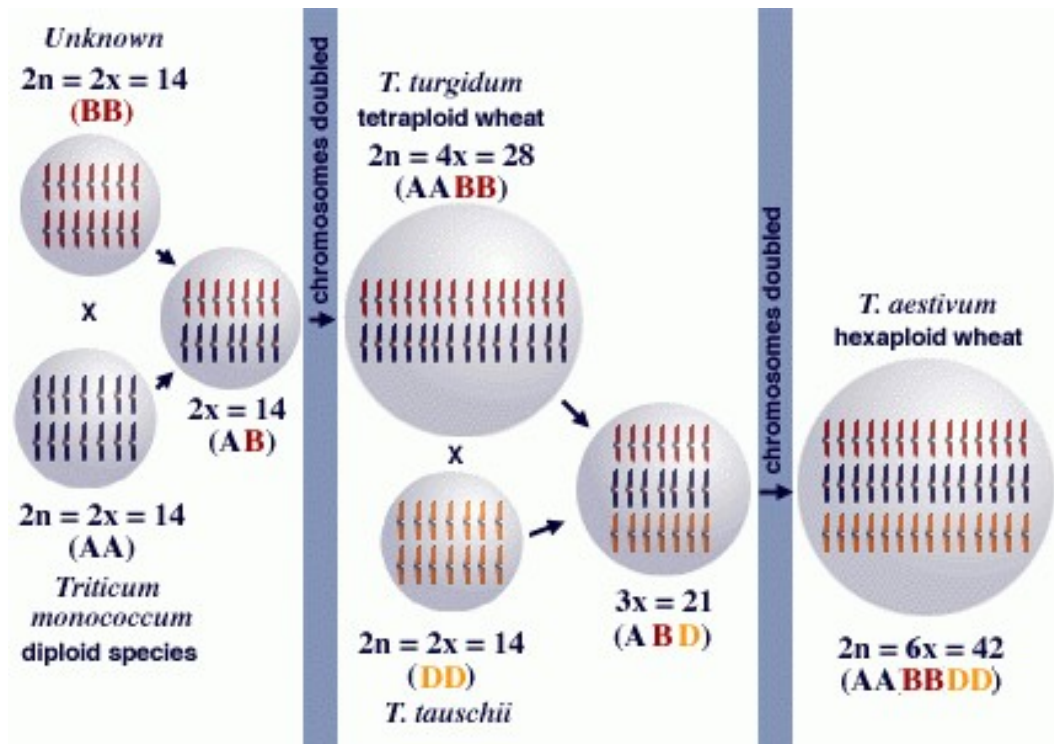


Figure 5. Genomic development of cultivating wheat species.

Advancing wheat-growing techniques Successively, wheat cultivation has moved from the Middle East to Europe and spread to the American continent. In the British Isles, wheat straw was used in the construction of houses to cover their roofs. This status of wheat was commonly kept until the 19th century. Since the 19th century, it has gradually become the main food item of mass consumption and has started to replace oats, barley, and rye from diets in the northern parts of Britain. In the second half of the 19th century, it demonstrated its enormous expansion of wheat production in the fields of the United States. The wheat grain has flooded the world market. In the comparison with potato, its price lowered by 40%. Together with potato production, it has made a great contribution to the nutritional welfare of the poor nations (photo 7).



Photo 7. **Traditional wheat harvesting.**

Historically, techniques in soil preparation, seed placement into the soil at the time of wheat seed planting, crop rotation, fertilizer application to support plant growth, modification in cultivation, and harvesting techniques have all been combined to promote the wheat plant as a viable crop. Since the replacement of broadcasting sowing with seed drills in the 19th century, another increase in wheat productivity has occurred.

Yields of pure wheat per unit area increased as methods such as cotton plant and wheat mixed plantings and the use of appropriate fertilizers became widespread. Improved agricultural husbandry in Uzbekistan has more recently included soil plowing and tilling machines, tractor-drawn planters, chemical sprayers and cultivators, combine harvesters, and better wheat varieties.

Great expansion of wheat grain production in the republic occurred as an enlarged area of cotton plant was planted to wheat just after Uzbekistan's state independence (in 1991) to ensure grain security.

Biologic properties. Wheat is an annual plant; there are different species, and perennial wheat varieties were created through hybridization. They are: winter wheat, spring wheat, semi-winter, and winter, as well as both, without difference. In terms of biology, winter wheat differs from spring wheat. Resistant to cold and drought, it germinates at 4–50 4-5⁰C of soil temperature. It has a high demand for moisture during the heading phase of development. 2 100⁰C of effective temperature is needed for a vegetation period for winter wheat and at least 1 300⁰C for spring wheat.

Drought has a great negative impact on the decrease in wheat productivity.

Scientists predict that winter wheat has 45–50 days of vegetation in the autumn and 75–100 days in the summer, while spring wheat has 90–100 days. Winter wheat in Uzbekistan withstands up to -35°C temperature under a thick layer of snow. The seedlings of spring wheat are able to tolerate up to $-8-10^{\circ}\text{C}$ of cold.

In general, the productivity of winter wheat in the condition of irrigation consists of 0.2-0.25 (in some cases, 0.7-0.8 tons) per hectare, and the productivity of wheat grown in the condition of rainfed area varies from 0.12-0.18 tons\ha.

Anatomy and physiology of wheat. The wheat plant has four basic parts: the head or spike (which contains spikelet, rachis, and kernels, or wheat seed), stem (two or three), leaves (two or three per stem), and root. Wheat plants grow to be about 80–120 cm tall, depending on the wheat cultivating varieties (figure 6).

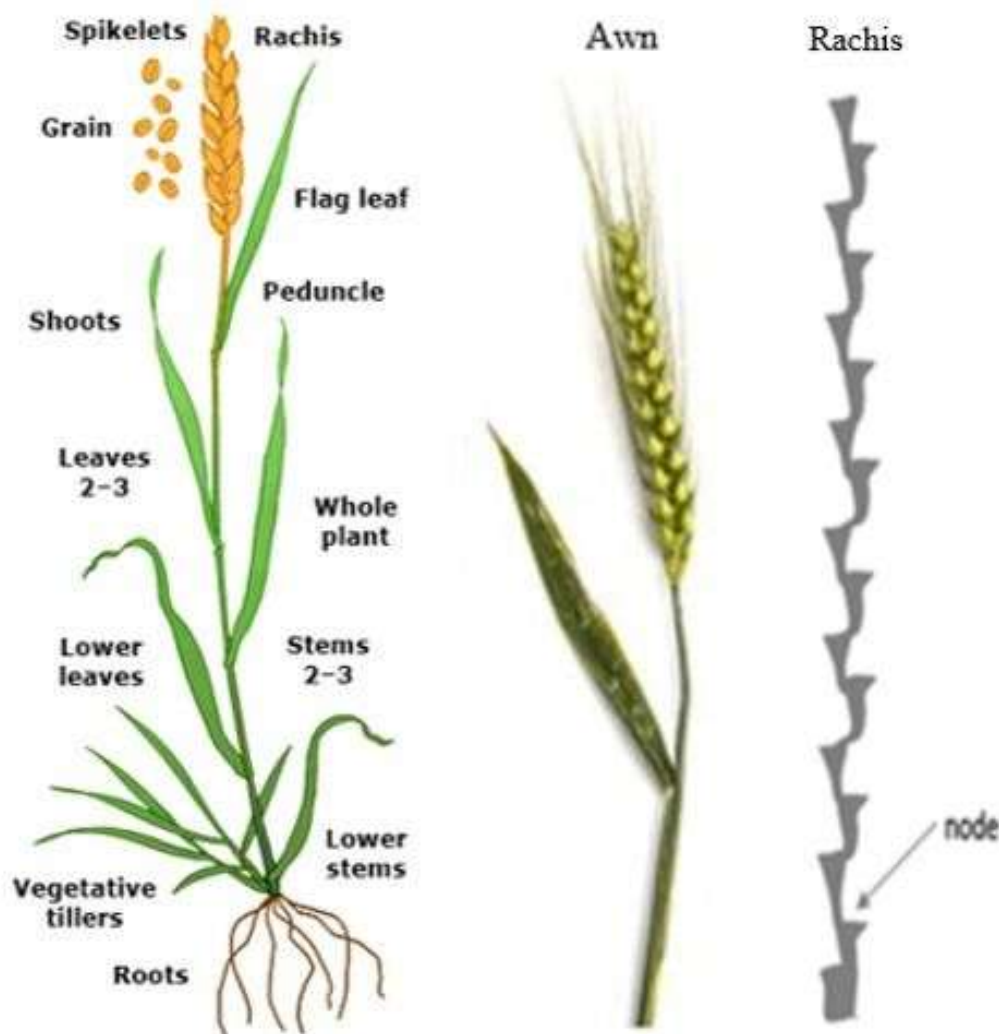


Figure 6. Some components of wheat plant.

The head (ear) contains the fruit cluster of the wheat plant, which is made of awns (often spikelets), grains, and rachis.

The stem holds the whole plant straight up and helps transport nutrients and water from root to root and throughout the plant parts.

The leaves are mainly responsible for the biological process (photosynthesis) taking place in the host plant, resulting in the turning of water, sunlight, and carbon dioxide into water, oxygen, and simple sugars.

The wheat roots penetrate the soil and absorb water and solvent nutrients from the soil, sending them up to the stems and other parts of the plant.

The awn of the wheat head is a slender, bristle-like attachment at the tips of spikelets.

Since the ear (spike) formation stage, it contains the main axis (rachis or rachilla), with each internode ovoid in section and curving around the spikelet. Each spikelet is attached at each node, and the rachis terminates in a spikelet set at right angles to the lateral spikelets.

Wheat leaves emerge from the shoot apical meristem of the stem until the transition to the reproduction phase, which is flowering. The last leaf produced by the wheat plant is called the flag leaf. The scientists identified that it has a higher photosynthesis rate than other older leaves to supply organic nutrients (carbohydrate) to the developing ear. In countries like Uzbekistan, the flag leaf of wheat, along with the second and third highest leaf on the plant, supply the majority of carbohydrate in the grain, and their condition is paramount to the accumulation of yield.

Scientists prove that wheat is unusual among other plants in having more stomata (or leaf pores) on the upper side of the leaf than on the underside. This was a reason to acknowledge that it might be an effect of it having been domesticated and cultivated earlier than any other plant. In general, winter wheat produces up to 15 leaves per stem and spring wheat up to 9. In terms of tiller formation, winter wheat, depending on cultivar, can have up to 35 tillers.

In the scientific survey, it was identified that the penetration speed of winter wheat roots into soil during plant ontogenesis differs and depends on the soil moisture. They grow the most intensively (2.4 cm/day) in the period of autumn vegetation, in the spring, and at the period of heading. From this phase until full maturity as well as for the

winter period, an average day of growth consists of 0.2–0.3 cm. It has also been stated that the use of water and nutrients by the wheat plant takes place better at the availability of the well-developed second- and third-order roots. The roots of the second order, which grow earlier than the roots of the third order in the condition of adequate moisture supply, may penetrate the soil up to 100–160 cm deeper and up to 260 cm at the time of wax grain ripeness.

Commonly, depending on wheat varieties, the wheat ear may be awned or not awned. They say that producing awns incurs a cost in grain number, but ear awns photosynthesis more efficiently than leaves with regards to water usage. So, wheat varieties with awns are much preferable in hot, drought-prone countries than in our temperate region. For this reason, awned wheat varieties could become more widely grown due to climate change.

Wheat yields from seeds planted to harvest are considerably dependent upon the development sequences described above. Some simple arithmetic makes clear the magnitude of some increase that can be obtained: one initially planted seed can typically give rise to a main stem and three tillers to form a total of four ears per wheat plant. Each ear can have twenty spikelets, each with three florets that develop a new seed. The result of the calculation shows (figure 7) that one seed can give rise in the next generation to something like 240 seeds ($4 \text{ ears} \times 20 \text{ spikelet/ear} \times 3 \text{ florets/spikelet} = 240 \text{ seeds}$). It is guessed that if one wheat plant produces even one or two more tillers, the seed yield per plant can be over 300 seeds. To be sure, inadequate growing conditions, in particular soil fertility, plant spacing, optimal temperature, soil moisture, pests, and disease problems, can diminish these yields. So, the total yield of grain in kilograms per unit area will also depend upon the size and weight of each grain.

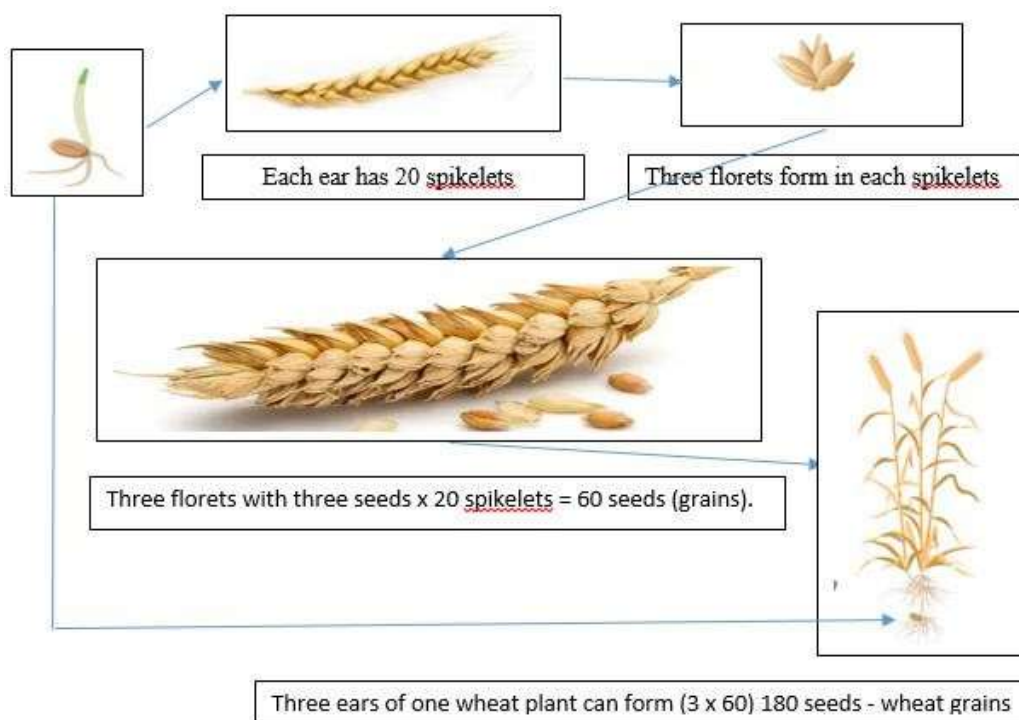


Figure 7. Seed (grain) are forming in the wheat plant.

Wheat development cycle. The biological feature of winter wheat is that in spring sowing, it gives good seedling; the plants tiller but do not establish stems and spikes. In order to have normal growth and development, the winter wheat needs to pass through vernalization at a definite temperature (0-3°C) for 35–60 days. In the process of development, wheat “goes through” stages (phases), which will define the amount and quality of the crop. They are: **seedlings, tillering, tubing, heading, flowering, and maturation (milk, wax, and full maturity).**

Internationally, literature concerning the growth and development of wheat describes that wheat’s growth cycle has the following divisions: germination, seedling establishment and leaf production, tillering and head differentiation, stem and head growth, head emergence and flowering, and grain filling and maturity (figure 8).

Seedlings. The most intensive germination of winter seed occurs at a temperature of 20-25°C. The seedlings in this area emerge after 7-8 days. The optimal temperature to get the maximum number of seedlings is considerably less than the process of growth and should be in the range of 12-17°C.

Getting the first leaf out of the soil is characterized by not only the seedling phase but also the transition of plants to a new quality state. If until this, the root growth and embryonic stem were supplied with

reserve substances of the embryo, now, with the appearance of the green leaf, the plastic substances take place in the growth, which establishes the result of photosynthesis. The duration of the seedling phase in normal conditions ranges from 15 to 25 days.



Figure 8. Developing the cycle of the wheat plant from seeds to the harvest of seeds.

At the later planting terms, the plants meet winter with one –three leaves. In such a case, the seedling phase is prolonged in spring at the renewal of the vegetation, and the whole period, together with the period of winter dormancy, may consist of 100–150 days.

Getting high field germination is one of the important goals of agro-practices because it depends on further care after plantation and the level of the future crop. The field germination at the cultivation of winter wheat using intensive technology should be 80–90%, but actually, in the farms, corresponding to statistical data, it is not higher than 50–70%, which means half of the seeds do not give seedlings.

Tillering. The tillering property is the characteristic biological feature of cereals. Tillering: this is the appearance of side sprouts and

crown roots on the plants. It initiates after the establishment of 3–4 leaves. The best optimal temperature for tillering in winter is because, at its death, the plant is killed. In the soil, it is placed at a depth of 1.5–3.0 cm and can withstand the frost up to minus 17–20°C. Depending on the terms of planting, there is autumn and spring tillering. The number of stems on the plant has been accepted as the tillering coefficient.

Overall tillering is defined by the number of stems per plant and the number of stems that give yield and productivity.

Usually, high productivity is formed at the productive tillering of 2–3 stems. The coefficient of tillering and the necessary plant density of productive stem standing (500–700 units/m²) can be adjusted with the help of agro-practices. Laying the seeds 4 cm deeper in the soil decreases the process of sprout establishment. The intensity of tillering is falling due to the high rate of sowing and the inadequate supply of plants with nutrient substances and moisture. Winter wheat tillering is also a variety peculiarity.

The possibility of the cereals is needed to be considered as a positive property. The majority of wheat varieties form 30–50% of their yield from side stems. The share of side-productive sprouts in the sparse plant stands consists of 60–70% of the grain crop.

Tube forming. Initiation of the phase is guessed at the moment when the first stem node emerges on the major sprout in the interval of 2–5 cm above the soil. This phase begins 25–35 days after renewing the spring vegetation. And it lasts 25–30 days. The cold and cloudy weather delays stem growth.

At the time of tubing, the vegetative mass growth intensively forms generative organs. Consequently, the maximum amount of water and nutrient substances is needed during this period of wheat growth. Their inadequacy in the soil causes a considerable decrease in yield.

It has been identified that the area of leaf surface per hectare should account for 50–60 thousand m² and more to get a highly productive plantation. The value of the leaf surface and duration of its photosynthesis activity depend on fertilizer, seed planting rate, variety, and other agro-practice measurements. It is especially important to ensure the high photosynthesis activity of the upper leaf, which gives up to 70% of assimilates.

Heading. Simultaneously with stem growth, the consequences of the sharp elongation of the prior internode take place, with the head emerging out of the upper leaf base, which means the initiation of the

phase of heading. The formation of reproductive organs is continued, as is the growth of vegetative mass and dry substances. The intensity of the growing process depends on the security of moisture and nutrient elements. This is the most effective period to treat the plantation with fungicides for the purpose of protecting winter wheat from diseases.

Flowering. In the normal condition, flowering is initiated 4-5 days after heading, which lasts 3-6 days. Flowering begins in the middle part of the ear and is gradually transferred to the lower and top parts. In the spikelet, first bloom the side (lower) flowers, then the middle ones. The grain is formed from the first term. The wheat plant is often a self-pollinating crop. Environmental conditions in the period from pollination until full maturity often influence the quality of grain.

The high temperature of the air strengthens the respiration of plants and facilitates excessive expenditure of carbohydrates, and the consequences of that accumulation of protein in the grain are increased. At a lower temperature, plant respiration weakens, and the accumulation of carbohydrates increases.

Maturity phase of the wheat plant. The grain capsule is established in the ovary membrane after flowering and fertilization. The growth of stems, leaves, and roots has ceased, and plastic substances come only in grains. The period of grain formation lasts 12–16 days, and the initiation of a milky mature is noted under the termination of this period. The size of the grain gets its normal value but is still green with a tiny view constitution. The moisture of grain in the milky phase of maturity accounts for 60–40%.

The constitution of grain in the wax phase of maturity reminds me of a moisture content of 40–20%. At the end of this phase, the grain acquires a normal color, and the intake of nutrient substances into the grain and its growth cease. Distinct harvests begin during this period.

Chapter 3. Phenology surveys and assessment of wheat samples

What are the phenology surveys? According to the answer given on the pages of internet information (2018), phenology is the science of the alterations in the development of plants and animals, in terms of their initiation and duration of the development stages, as well as the identification of interactions and dependence on the climatic conditions and place of survey.

So, plant development in wheat plants, considering developing periods and the formation of productive elements, was divided into six stages (Siddikov R.I., 2011), though the author noted that they have been accepted in the conventional order. They are:

1. Germination and booting (tillering).
2. Initiation of tubing.
3. Initiation of tubing.
4. Heading.
5. Flowering
6. Filling of grains and milk ripening.

In general, wheat breeders, like other plant breeders, have the intention of creating new varieties of wheat superior to commercial ones or improving productivity, precocity, adaptability, and resistance to biotic and abiotic stresses with a high quality of grain from bred plant materials. Breeder, keeping in mind forming economic valuable traits and properties and their dependence on climatic conditions, maps out exemplary phenology surveys like:

- *Field germination of seeds.
- *Plant stand density.
- *Plant height.
- *Number of leaves.
- *Coefficient of booting.
- *Resistance to colds and diseases.
- *Forming rachis internode number of the ear.
- *Number of spikelets on the ear.
- *Tolerance to drought.
- *Number of flowers in the spikelets.
- *Thickness of ear.
- *Tolerance to heat and pests.
- *Resistance to lodging.
- *Number of grains on the ear.

Of course, fulfillment of the above-listed phenology survey kinds is important in the research of breeding programs, where the value of the six developing stages is studied. Kinds and numbers of phenology surveys may be distinguished in the more detailed research on wheat development (figure 9).

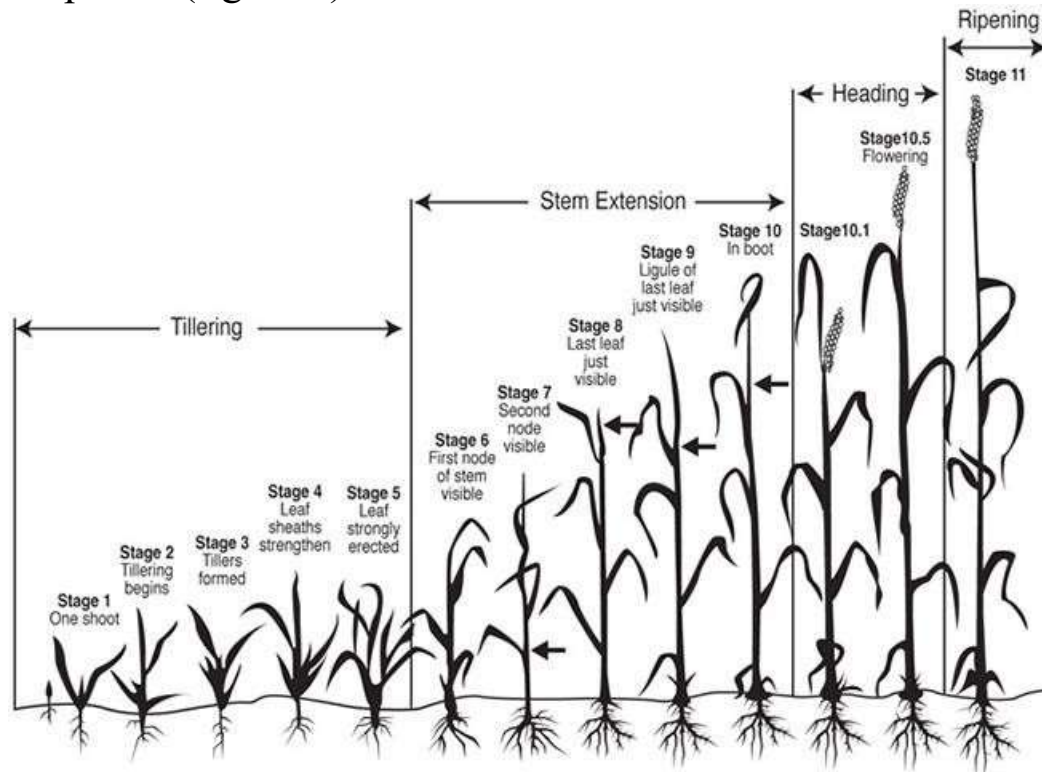


Figure 9. Phenotype alteration and development stages of wheat plant (internet source).

Phenology surveys in plant breeding and seed production began with the appearance of seedlings in the experimental field. As an example of a simple phenology survey, we can consider the field experiment with the study of 50 wheat varieties (photo 8) executed by the scientists of the department of plant growth at the TSAU. Of course, the planting of seed stocks and the disposal of the varieties along the replications and lots must correspond with a special manual on the conducting of field experiments (photo 1 in the manual of selection and seed production of grain and bean crops. 2018.).

With the growing number of variety numbers to study, it becomes hard to find plants of a certain variety in the next replications or in their lots. This problem deals with the scheme of field experiment placed on the page of the field journal (take a look at the scheme of experimental area, chart 1 in the above-mentioned manual).

To make it easier for students to understand, we will only present data from 5 varieties (as 5 variants). So, the experiment consisted of 5 variants with a rate of seed sowing of 4.5 million. The area of each lot is 3.6 m², and the area of every lot account for 50 m². A phenology survey of these experimental variants has been mapped out in three replications. To place variants on one layer, it requires below-accounted area.

There are 5 variants in the experiment and 3 replications: $5 \times 3 = 15$, so it requires selecting 15 lots. The total width of the area under plots consists of: $15 \times 3.6 = 54.0$ m. Together with two side defense paths (2.5 m + 2.5 m) makes 59.0 m. Defending paths of 10 m should be left from above and below sides of the recording area for the mechanic cultivator. And a gap of 2 meters is also left for irrigation and drainage ditches. And a path of 1 m for the observing path. So, the total length of the experimental area consists of: $13.9 + 10 + 2 + 1 = 26.9$ m.



Photo 8. Experimental area of the chair of Plant Growing, 2017.

In general, a targeted experiment for a chosen topic (for example, “study of the productivity of wheat varieties registered in the state register”) requires selecting 0.86 ($59.0 + 26.9$) hectares of land. At this point, the plants of the experimental variants occupy 0.70 hectares ($54.0 + 13.9$).

After planting, layers, replication, and plot arrays are marked by the numbered pegs. Pegs with their numbers and orders are copied to the appropriate columns of the chart in the field notebook for phenology surveys in time. The data containing charts from the field notebook are performed in the order of six developing phases of the wheat plants.

Initiation and completion of registration: the records of phenology surveys (observations) start at 5–10% **and 50–70%** of plants' readiness.

Agro-practice measures for the cultivation of plants in the experiment are carried out similarly to accepted methods in the experimental area of the university. Phenology surveys are implemented on the plants bearing 100 numbered labels selected from the registered area of every variant.

On the columns containing implementation dates of phenology survey charts are recorded the following dates:

the 1st of March, for recording the plant height and number of leaves;

the 1st of April, for height of plants, number, and length of stalk nodes;

the 1st of May, for height of plants, number of nodes, length of nodes, and spikes.

the 1st of June, for spike length, number of spikelets in the spike, and number of grains in the spike.

The height of the main stalks of plants, the number of nodes on the stalks of the plants, the number of leaves, the number of grains in the spikes, and the tilling stage on the experiment variants are determined based on data gathered from records of phenology surveys.

To correctly define the grain productivity in the experimental variants, the plots of variants are thoroughly inspected several days prior to the start of the harvest. The state of plants is inspected by separating the borders of lots. Recording of the crop is filled in the plants of the lots with the state of meeting the requirements on the damage and plant stand density.

Various proportions and equations are used to establish productivity depending upon spring or winter wheat varieties, simple or complicated, with the purpose of attaining maximum precision.

As pointed out in that manual, the most suitable proportion to define the productivity in the experiment on the selected topic must be taken. At this point, the productivity is defined comparatively to the grain productivity taken from each of the three places in the lots with an

area of 1m². That is, on the sample of grain yield taken from lots, the first sample was 650 g, the second sample was 640 g, and the third sample was 660 g. The average yield on the sample consists of 650 g.

The result is 1 m² – 650 g. 10 000 m² minus 6 500 000 g = 6 500 kg, or 6.5 tons per hectare. The productivity of all variants on the varieties in the field experiment and on the comparison of their productivity with the control variety is shown by using the below-presented table (table 6).

Because of the data in the table taken from the experiment, a definite summary account about the productivity of five wheat varieties introduced into the state register can be derived. That is, the varieties studied in the field experiment have differed in their various significances for each other in terms of productivity. The highest productivity on the comparison with control (+0.6 ton\ha) attributes variant 3. The very lower one (-0.5 ton\ha) on the productivity variant 5. The same as the control on its potentiality in productivity was variant 4.

Table 6. Productivity of the variants on the replications and on the comparison with control.

Variants	Productivity on the replications, centner\ha.			Average productivity, ton\ha	Difference from control, ton\ha.
	I	II	III		
1 (control)	60,3	58,5	57,5	5.8	-
2	56,5	58,6	55,4	5.6	-2,0
3	65,0	67,2	63,4	6.5	+6,4
4	58,2	59,3	57,6	5.8	-0,4
5	55,2	54,3	53,5	5.4	-4,5

When organizing an industrial experiment, methods are simpler compared to the conductivity of scientific research experiments. Only one variety had shown the highest results in the field experiments compared to the control in the industrial experiments associated with the breeding and seed production of crops. The variety grown on the farm fulfills the task of control. At the choice of the area for experiment, attention is paid to the peculiarities of the soil's state and melioration on the farm, district, and regional level. Because the introduction of the results of the experiment is proposed based on the conditions of the

above-listed territories. The size of the experimental area depends on the availability of seed sufficiency and economic questions and is 2 to 4 hectares.

Mostly, suitability of the variety to technical means, precocity, productivity, and quality of products are monitored in the industrial experiment, and the result compares with the indexes of growing variety on that farm.

Assessment of breeding materials. The new wheat variety with disease, pests, drought, salinity, and heat resistance that is productive with grain quality is needed to stabilize wheat grain production in Uzbekistan.

1. Assessment of wheat breeding samples for diseases. R.I. Siddikov (2011), who published the book "Winter wheat varieties and their growing technology in the irrigated lands," listed the main diseases and pests that caused significant crop losses in the wheat plantations of Uzbekistan.

Within the most destructive fungus diseases are (appendix 2): wheat hard smut (*Tilletia caries*), dust smut (*Ustilago tritici* Jens), septorios (Septoria tritici), brown rust (*Puccinia recondita* Rab. et Desm.), yellow rust (*Puccinia striiformis* Vest), powdery mildew (*Erysiphe graminis* DS), root rot (*Pseudoceicosporella hertotrichoi*) and fusarium.

The scales and assessment computer systems for the assessment of the damaging rate of cereal crop diseases and the resistance of plants to them were worked out based on mathematical modules (Strijekozin Yu.A., 2022).

There are two commonly accepted methods of yield loss assessment: experimental and calculation.

The experimental method consists of conducting special experiments and summing up the comparison grain yield taken from experimental and control (standard) variants.

The calculation method is based on the application of mathematical modules or composed scales on their bases for yield loss caused by the disease. This method does not require conducting complex experiments. The data of field observation collected during phenotypic inspections on the phytosanitary records are used for calculation.

Wheat hard smut damages the seedlings of winter wheat in the earlier development stage, transferring through seeds and soil. The main source of infection is teliospores, which land on the healthy surface of

seeds. The disease is detected visually during the grain harvest. The infected ears have less dimension, and instead of grain in the spikelets, they formed smut sacks with fungus telospores in them. The symptoms of infection are brightly seen at the end of milk and at the start of the wax ripening of grain.

That is why **assessments of wheat varieties' resistance to hard smut disease** are conducted at that stage of plant development. The major criterion of assessment is the recording of the disease spreading and its harmfulness. The bind of plants' groups taken in succession presents a probe for field analysis. The plant binds are taken from 10–15 points of the 100-hectare field, with 50–100 plants in each. If the field is larger than 100 ha, it is divided into two or several plots, and the probes are taken individually from each one. At this point, their spreading is an important index in the assessment. Calculation is done on the equation of $P = n/N \times 100$, where: P – prevalence of the disease, in%; n – number of infected plants in the bind of plants; N – total number of plants in the plants' bind. $P_{cb} = \sum SP / S$, where P_{cb} – mean index of infection, in %; $\sum SP$ – total result of infected area (S) on corresponding them indexes of prevalence of disease in the bind (P); S – surveyed area.

The above-mentioned methods for assessing the resistance of wheat varieties to hard smut can be used to evaluate the resistance of wheat varieties to dust smut, septoriosus, brown rust, and yellow rust.

Assessment of powdery mildew is fulfilled using four Manners scales on the infection grade, plant outlook, and plant state. 0 – absence of infection, plants healthy; 1 – very weak (infection up to 10%); 2 – weak (infection up to 10–25%); 3 – mean (infection up to 25–50%); 4 – strong (infection more than 50%).

They say that based on the assessment of science and practice, the loss of grain crops without protection measurement against harmful organisms consists of 25%, including an additional 8% in the result of pests.

2. Assessment of pest resistance. The often-occurring pests in the wheat plantations of Uzbekistan are listed in the manual about control of pests and diseases of agricultural crops (Sulaymanov B.A. and others 2013). They are (appendix 3): wheat thrips (haplothrips tritici), cereal aphid (sitodion avenae), bug pest cereal (eurygaster integriceps), cereal leaf beetle (oulema melanopus).

Wheat thrips. The active thrips have appeared since the beginning of the heading stage. The larvae get into the glumes and lemma of the

spikelet to suck their juices and later the grain. Their activity mainly results in not filling up grains at the time of harvest.

Cereal aphid. The larvae begin to feed in the spring with the warm weather. After the fourth stage of their own development, they form wingless females to give birth to alive individuals. In the next generation, they will be separated into wing-having and wingless individuals. They always feed by sucking the green and soft parts of plants, which causes plants to turn yellow and wither. The strongly damaged plants do not form spikes.

Bug pest cereal. Its harm takes place at the germination, booting, tubing, heading, and maturing stages. It will spend the winter outside the field, within things like mountains, forests, gardens, at the edges of water ditches, and under stones and leaves. It will spread by flying to the fields from the third decade of March to the first half of April. It has only one generation per year.

The damage to the non-matured spike causes the formation of a partly or fully white spike (puny ear), and the amount of protein in the grain has decreased. Damage at the level of 10–15% results in the unfitness of the grain to produce the flour. The seeds harvested from the field damaged by the bug pest cereal have 50% decreased sprouting.

Cereal leaf beetles. Their beetles spend the winter in the soil. It comes out of the soil in spring, and after feeding, the female one lays 3–7 eggs in the chain shape and continues up to 200. The larvae feed for two weeks, then leave an adhesive (sticky) cover that gets into the soil and turns into cocoons. It also has only one generation per year. So, the damage is mainly caused by the larvae.

The problem related to the harmfulness of wheat pests has not been fully solved by chemical control methods. The increasing use of pesticides catalyzes a biologic imbalance: the extermination of natural beneficial insects (entomofags) and the general development of pest insects.

Selecting resistant varieties to pests and introducing them into production is the best ecologically sound and efficient way of controlling wheat pests. Unfortunately, many of the currently commercialized wheat varieties are not resistant to pests and don't meet up-to-date requirements.

According to the wheat researchers at the Kashkadarya branch of the Scientific Research Institute of Grain and Bean Crops (the

SRIGBC), the **assessment of the resistance of wheat variety samples to pests** is fulfilled by using field and laboratory experimental methods. At this stage, seed stocks of 22 local and introduced wheat varieties and samples are sown in 1 m² areas (lots) with three replications in 2011–2012. The phenology surveys after seed sprouting and damage by aphides have the basics of this assessment method. Eventually, the damage results were evaluated by the six-mark indexes. The difference between marks depends on the significance of damage grades like the Mannersa scale (take a look at the assessment method for powdery mildew).

During the vegetation period, all phenology surveys and records on the damages caused by the above-listed pests are implemented. The data collected from the field experiment in correspondence with mark criteria (from 1 to 6) are reported in the annual accounts.

All ears, after maturity, of the plants in the lots are picked up and put into individual sample sacks. Ears were grinded alone by the special machine and then delivered to the laboratory for assessment of grain quality.

Lab analysis on the assessment of grain quality has revealed that less damaged varieties of Krasnodar-99, Jayhun, Turkiston, Kroshka, Khazraty Bashir, Istiklol, Selyanka, Yaksart, Khisorak, Krupinka, and Elomon had: gluten content: 31-33%; protein content: 15.7–16.6% (table 7).

Mean damaged varieties: Taniya, Polovchanka, Vita, Nota, Gozgon, Esaul, and Saidaziz contain gluten from 30 to 31% and protein from 15.4 to 15.8%.

Non-resistant varieties: Moskvich, Vostorg, Egizo, General content: gluten from 29 to 30%, protein from 14.1 to 15.4%.

Table 7. The results of laboratory grain quality analysis

№	Varieties	Gluten content of grain, %.			On average, %.	Protein content of grain, %.			On average, %.
		1	2	3		1	2	3	
1	Tanya	30.7	30.4	31.7	30.9	15.4	15.6	15.8	15.6
2	<u>Polovchanka</u>	31.9	31.5	32	31.8	15.6	15.2	16.1	15.6
3	<u>Moskvich</u>	30.4	30.8	30.7	30.6	15.1	15.4	15.6	15.4
4	<u>Istiklol</u>	32.6	32.4	31.9	32.3	15.8	15.6	16.4	15.9
5	Vita	30.8	31	31.4	31.1	15.4	15.7	15.7	15.6
6	Nota	31.4	31.7	32.2	31.8	15.6	15.8	15.8	15.7
7	<u>Vostorg</u>	30	30.7	30	30.2	14.9	15.2	15.4	15.2
8	<u>Khisorak</u>	32.7	31.8	32.5	32.3	16.2	16	16.4	16.2
9	Kroznodarskaya-99	33.2	33.4	33.5	33.4	16.4	16.7	16.7	16.6
10	<u>G'ozg'on</u>	30.8	31	31.2	31.0	15.4	15.7	15.2	15.4
11	<u>Jayhun</u>	33.4	33.5	33.6	33.5	16.7	15.9	16.8	16.5
12	Turkistan	31.6	31.7	32.5	31.9	15.3	15.5	16.2	15.7
13	<u>Krupinka</u>	32.2	32.7	33.5	32.8	16	16.2	16.6	16.3
14	<u>Khasrati Bashir</u>	31.4	31.7	32.4	31.8	15.6	16.2	16.5	16.1
15	<u>Esaul</u>	30.7	31.4	31.6	31.2	15.1	15.8	16.4	15.8
16	<u>Kroshka</u>	32	32.6	32.8	32.5	15.5	16	16.4	16.0
17	<u>Saiaziz</u>	30	30.6	31.2	30.6	15	15.4	15.8	15.4
18	<u>Egizo</u>	28.7	30.5	30.2	29.8	13.9	14.4	14	14.1
19	<u>Gneral</u>	29.5	31	30.6	30.4	14.5	15.2	14.8	14.8
20	<u>Selvanka</u>	31.8	32.5	32.8	32.4	15.2	15.8	16.4	15.8
21	<u>Elomon</u>	32	32.6	33.4	32.7	15.4	16	16.7	16.0
22	<u>Yaksart</u>	31.4	32	33.7	32.4	15.7	16.2	16.6	16.2

Visual phenotypic assessment of the wheat development stages (seed sprouting, booting, heading, milk, wax, full ripening, and duration of vegetation period) in the salt-exposed soil condition is a commonly accepted field method to evaluate the resistance of wheat variety samples, wherein the plant development intensity is the criteria of assessment (table 8).

The list of 14 variety samples in the table subjected to evaluation for their resistance to soil salinization were the left (didn't discarded) variety samples for their salt resistance and other traits and properties out of 183 studied variety samples. There was shown one standard, commercialized variety, Polovchanka, which was considered comparatively resistant to regional soil salinization in Uzbekistan. Other variety samples present themselves as introduced collection wheat samples. They had a unique importance for the wheat breeding process to select resistant samples to soil salinization. Selection was conducted through assessment of their salt resistance in conditions of soil salinization and comparison with the standard variety Polovchanka.

Table 8. Periods of phenology stages of winter wheat samples in different salted soil conditions (data of B. Abdullaev and others, 2017).

№	Variety samples	Growth stages							Duration of vegetation.
		Sprouting	Booting		Heading	Milk ripening	Wax ripening	Full ripening	
			Initiation	Completing					
Non-salted (agro-background) condition \ Salted (agro-background) condition.									
1	Polovchanka (st)	20 \ 25	26 \ 31	129 \ 128	52 \ 51	15 \ 15	20 \ 15	12 \ 9	208 \ 218
2	960-246-Droja	19 \ 22	25 \ 30	127 \ 124	48 \ 46	16 \ 16	17 \ 14	12 \ 8	220 \ 208
3	991533-46 Boema	18 \ 20	26 \ 30	131 \ 128	46 \ 45	10 \ 11	20 \ 17	12 \ 9	220 \ 210
4	030614-17-5140	18 \ 24	27 \ 31	130 \ 130	46 \ 46	10 \ 11	16 \ 15	13 \ 10	215 \ 212
5	Gobiston	16 \ 20	28 \ 32	134 \ 128	47 \ 46	9 \ 11	20 \ 16	13 \ 9	222 \ 210
6	№28 Anza	18 \ 22	28 \ 33	130 \ 128	47 \ 48	11 \ 10	22 \ 18	9 \ 8	219 \ 212
7	№29 Cham-1	18 \ 23	29 \ 32	132 \ 127	47 \ 46	12 \ 13	20 \ 17	8 \ 9	219 \ 212
8	№34 Aucet	17 \ 24	27 \ 32	132 \ 129	46 \ 45	10 \ 12	19 \ 16	11 \ 8	218 \ 210
9	Utiqui-96	16 \ 23	26 \ 29	135 \ 129	48 \ 51	14 \ 15	16 \ 14	11 \ 10	224 \ 219
10	№21 Yemiza-9	19 \ 29	28 \ 32	130 \ 126	50 \ 51	12 \ 12	15 \ 13	10 \ 9	217 \ 211
11	№24 Arrehane	17 \ 22	26 \ 33	130 \ 124	54 \ 51	13 \ 13	14 \ 13	14 \ 12	225 \ 213
12	№27 Cook	18 \ 24	28 \ 31	132 \ 129	54 \ 52	11 \ 11	15 \ 14	14 \ 9	226 \ 215
13	№30 Pavon-76	19 \ 22	28 \ 31	131 \ 129	58 \ 54	16 \ 14	17 \ 16	13 \ 11	232 \ 229
14	№35 Thatcher	18 \ 23	27 \ 32	131 \ 128	53 \ 50	12 \ 12	18 \ 15	12 \ 9	226 \ 214

The standard variety itself demonstrated some vulnerability to the salt effects. For example, in comparison to its developing behaviors in non-salted and salted backgrounds, it is obvious that this variety is susceptible to the salt effect at the developing stage of seed sprouting and booting initiation periods. Because its development at these stages was slower (5 days correspondingly) than its index in the non-salted background, But, in the successive development stages, its resistance was recovered. All the same, we can see in the result of those two negative data that this variety was left 10 days later its duration of vegetation period. Otherwise, this means that, despite its high productivity, it was comparatively vulnerable to soil salinization.

The data of other variety samples compared with standard, commercialized varieties are considerably different. For example, the most distinguished variety samples based on their intensity in the duration of vegetation periods in the salted soil condition were 960-246 Droja, 991533-46 Boema, Gobiston, №24 Arrehana, №27 Cook, №35 Thatcher. Their withstand in salted condition is pronounced by their earliness compared to non-salted condition, correspondingly 12, 10, 12, 11 and 12 days. Some of their resistance is mainly noted in the developing stages of booting, wax ripening, and full ripening (960-246 Droja, 991533-46 Boema Goniston, and so on).

A comparison analysis of these collection samples with the standard variety revealed that, with the exclusion of their late maturity

compared to the standard, some of them showed considerable resistance to salinity. For example, 960-246-Droja (-10 days); 991533-46 Boema; Gobiston; and №34 Aucet (-8 days). Considering other economic traits and properties, these variety samples were selected by the breeders for future breeding processes. This method of assessment in the selection of initial wheat materials based on their resistance to soil salinization is guessed to be the more simple, natural, and effective one.

3. Resistance to heat. One of the most recently used methods of assessment of wheat variety diversities' resistance to heat can be considered in the experiments conducted by the researchers of the Kashkadarya branch of the SRI of Grain and Bean Crops in 2020.

To define the protein coagulation temperature of the plant leaves in the lab was the basic core of that assessment method (Genkel, 1950). Currently, 2 grams of leaves are ground in the special dish. Then it was mixed with 25 ml of distilled water. The formed solution is filtered and heated with the help of an electrical heater until it reaches protein coagulation grade (table 9). The historical indexes on the coagulation of protoplasm proteins in wheat ranging from 55.0 (in some ecotypes) to 61°C and more (in the Central Asian heat-resistant wheat varieties) are used here as the main assessment criteria.

Table 9. Heat resistance of studied wheat varieties and samples (data of Sh. Khazratkulova and Kh.R. Togaeva, 2020).

№	Varieties and samples	Height of plant, cm.	Lebghth of the last node, cm.	Coagulation temperature of protein, °C.
1	UZ15PC-58	101.7	34.7	57.3
2	KR18-IWY-9826	109.0	34.3	58.7
3	KR17-FWWPYT-1547	107.3	34.3	60.3
4	KR18-IWY-9834	93.0	29.3	64.7
5	KR18-IWY-9835	97.3	35.7	65.3
6	KR17-FWWPYT-1605	106.0	40.3	66.7
7	KRBW17-6	113.7	36.7	67.7
8	KRBW18-5	108.3	38.7	67.7
9	KRBW18-7	107.0	32.3	67.7

As a result of this evaluation, some varieties and the samples at the stage of heading into a competitive variety testing nursery are selected depending on their heat resistance through this laboratory assessment

method and recommended to the wheat variety improvement programs. Locally commercialized varieties: Grom, Bunyodkor, Gozgon, and Shams have deserved the quality of standard varieties, and they correspondingly showed high coagulation temperatures of 60.7; 63.7; 67.7 and 66.7 °C.

31 variety samples were evaluated comparatively with the above-standard varieties. Most of them have lower coagulation temperature indexes than 60.7 (as Grom). At this point, the lower one was the sample UZ15PC-58 with 57.3 °C and so on. This means that its resistance to heat is very low. Indexes of heat resistance are growing in some others, like KR17-FWWPYT-1547, from 60.3 to 67.7 (as in KRBW17-6, KRB18-5 and KRBW18-7). These three samples have indexes at the level of the commercialized local variety Gozgon on their resistance to heat and were recommended to be used as heat-resistant donor genotypes.

4. Resistance to lodging. The conclusion of P.P. Lukyanenko (1973) has prompted that only the varieties resistance to lodging (photo 9) with high grain quality, valuable traits, and properties meet wheat production requirements. The soil conditions of Uzbekistan in the irrigated lands also require new soft spring wheat varieties with resistance to lodging.



Photo 9. Outlook of wheat lodging in the wheat plantation.

The 5-mark assessment method is used to evaluate the lodging of plantations: Mark 1. Very considerable lodging of plants does not permit machine harvest.

Mark 2. Considerable lodging of plants, which is hardening the harvest.

Mark 3. Mean means the stems have a sloped state, approximately at 45°.

Mark 4. Weak Weak: the stems are slightly sloped.

Mark 5. The lodging is absent, and the stems are standing straight.

In some cases, the following formula, $B=1+(4C/b)$ is used to make a more objective and obvious assessment of the resistance to lodging. Where B is the mark, b is the mean height of the plants in cm, and C is the lay of the sloped stems in cm. The dimension of grain product loss as a result of lodging depends on at what stage of plant development it happens. The plants may lodge even at the stage of tube initiation if the prolonged rainy weather occurred prior to this time. At the sloping of this time, the plants can gradually form a high crop. If the plants lodged at the stage of heading, this would negatively affect productivity. But the most probable lodging occurs at the time of grain ripening. This lodging has the least degree of influence on the crop structure.

The weight of 1000 grains at the heading stage of plants are decreased by 20–25% on average, at the milk ripening stage by 11–16%, and at the wax ripening stage by 5–10%. The number of grains on the ear and the productive stables forming are decreased at early lodging. The dimension of the crop loss at late lodging is mainly defined only by the decrease in grain weight. It must be noted that the planting and productive qualities of seeds are worsened at the lodging. Lower the weight of 1000 grains, uniformity, energy of sprouting, germination, and power of growth. As stated in the research, the productivity of winter wheat, cultivated from seed with lodging plants, is going down on average by 10% on account of some weakening of general generation development with less length of ear, productive stables, and overall productivity. So, if there are lodged parts of the plantation, they must be harvested alone, and the grains must be used for consumption purposes.

5. Assessment of productivity. In general, the productivity of the variety is determined by learning several traits, like productive tubing, the number of spikelets on the ear, the number of grains in the spikelet, the weight of 1000 grains, the productivity of the major ear, and plants. Each trait has made a definite contribution to the formation of plant

productivity. So, one of the assessments of wheat variety productivity can be considered in the results of field experiments (O.A. Omanov and others., 2014.), where hard wheat varieties and their productivity indexes were studied. This is not an exclusion of experiments where the productivity of wheat varieties is usually studied or evaluated together with other closely related characteristics such as resistance to diseases, lodging, drought, and flour quality. 112 varieties and samples were planted and evaluated. The planting scheme was 2 m² with one replication, and the planting norm of seeds was equal to 4 million plant units per hectare. The wheat variety Krupinka was a standard variety.

All phenology surveys and recordings on the height of plants, lengths of the last nodes, lengths of ears, number of spikelets on the ear, and resistance of plants to biotic and abiotic stresses have to be conducted. Because of the genetic probability that these traits and properties have a desired correlation to secure the level of wheat plant productivity, Herein, the positive correlation between plant height and productivity was $r=0.33$. The correlation between length of ear and productivity was also positive $r=0.17$ and the correlation between number of spikelets and productivity was the next remarkable one $r=0.30$. And eventually, 13 out of those studied variety samples showed the highest productivity compared to standard Krupinka. In the table 10, we can see 10 of them that were recommended by the researchers for further use as donors in improving the productivity of local wheat varieties.

Because their productivity potential in the region of Kashkadarya has even reached up to 2.6 tons (CBC 509 OMAT 3.1\3RASCON37\Tarro) over our local check variety Krupinka. So, the evaluation (assessment) or testing of the productivity of wheat initial breeding materials, selection, and using of such samples by the breeders in the next wheat breeding processes has a great importance in the additional improvement of the productivity of the new varieties.

6. Evaluation of grain for its bread-baking quality. Extremely high demands are placed on the quality of wheat grain. It is necessary that the wheat grain be enlarged with a glassy internal structure, a high loaf volume, and a high content of protein and gluten, which lead to good flour production and excellent bread baking qualities. Consequently, assessment of grain quality of breeding materials is accompanied without fail in all wheat breeding works and does not depend on their directions.

Table 10. Field experiment where wheat productivity was evaluated
(data of O.A. Omanov and others, 2010).

№	Variety samples	Plant height, cm.	Length of the last node, cm.	Length of ear, cm.	Number of spikelets, units.	Productivity, ton/ha.
1	Local check (st) Krupanka	78	42	7	19	5.3
2	CBC 509 OMAT 3.1\3RASCON37\Taro	84	37	7	17	7.9
3	LHNKE\HCN\PATA- 2\3\SOMAT-4\INTER-8	95	35	6	17	6.9
4	TARRO-1\2*YUAN- 1\AJALA-13\YAZI*2\4	100	41	5	15	6.7
5	SOMAT 4\SILVER 1	81	36	7	15	6.6
6	CBC 509\SOOTY 9\RASCON 37\9\USDA5	93	37	7	15	6.5
7	CMH85.797\CADO\BOOMER 33\4\ARMEN	86	36	7	20	6.5
8	MINIMUS\COMB 2\CHAM 3\3FICHE 6\	88	44	8	17	6.3
9	DCRIS\BECUM\LLARETA INIA\3\DUKEM	86	43	7	15	6.2
10	SOMAT-3GREEN- 22*RASCON-37\2*TAR	90	46	8	18	6.1
11	MEXICALI 75	72	40	6	17	6.0

The content of protein and gluten was and stays the restricting traits of high-quality grain production, and their level mainly depends on the genetic make-up of varieties and feeding security at the period of their growth and development.

The protein is denaturalized at the time of bread baking, and its structure is fastened in the form of porous bread crumb.

It was mentioned above that wheat grain should contain not less than 13.5% protein because its amount in the flour defines the fitness of a certain grain to use in what kind of product to produce. For example, baking bread requires 14-15% protein content, while preparing noodles requires 17-18%.

Assessment of protein content can be executed by using the device “Protein-1M” (photo 10).

The method of assessment involves measuring light-ray penetration into grain mass. At this point, the obtained photoelectric signal is converted into digital values of protein content and even the mass share of raw gluten in the whole wheat grains.

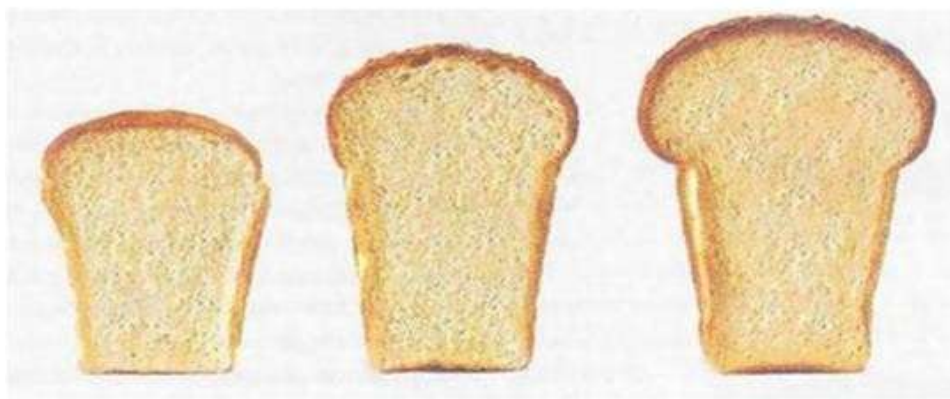
Procedure: The probe (50–60 g) of grain is poured into the glass cup and then into a cuvette. This cuvette is put on the analyzer of device “Protein-1M” and chosen the working regime. The device measures and demonstrates the result of the analysis. The producer of this device proposes to conduct the measuring three times with new probes and calculate the mean index in order to get better precision.

A deeper assessment of the wheat grain quality in the lab can be considered in our manual, “General Plant Breeding and Seed Production” (2020), recommended for practical training. Gluten amount determination in the grains of wheat varieties is described in the laboratory training of 15 and the classification of gluten quality in the 32nd training. A mechanical flour mixer and the device IDK are used to determine the content of gluten.



Photo 10. Device “Protein-1M” to analyze the grain.

The consuming demand for bread and its other food products mainly depends not only on the content of protein but also on the content of gluten (photo 11).



Gluten content -20%. Gluten content -30%. Gluten content -40%.

Photo 11. Dependence of the baked bread quality on the gluten amount.

The grains' consistency is divided into three groups: glassy, partly glassy, and mealy. Here, the glassy grains are usually distinguished for their high content of protein and gluten, which ensure the highest bread baking quality.

GOST 10987-76 is used to calculate the glassy index of grain. In the frame of this method, the grain glassy is defined by one of two ways: visual inspection or using a diaphanoscope.

Chapter 4. Wheat breeding

History of wheat breeding in Uzbekistan Historically, the cultivation of local wheat plant diversities out of cereal crops was the basic part of households by local peasants in Central Asia. The wheat plant was cultivated in the artificially irrigated areas and hillside of mountains under rain-fed conditions. Later, since the half of the 19th century, a great migration of the varieties of grain crops from Russia took place. The active effect on this was made by representatives of the Turkistan Agriculture Association (1885–1921) and “voluntary peasants.” The most constitutional part of representatives is made up of Russian migrants, foreign plant breeders, and Russian agronomists. By them were brought wheat varieties like “Poltava”, “Kuban (kubanka)”, “Donbas”, “Kharkov wheat”, “Arnautka,” and “Turkish red wheat” from the southern and western districts of Russia and widely dispersed throughout Turkistan. Some of these varieties were adopted, tested for their dignity, and reproduced everywhere.

It is very important to note that in spite of agricultural progress in our republic in the 1925–1940s, the efficiency of the grain production field is still at its lowered historic peasant household level. For example, the productivity of winter wheat in 1938 was 0.6 tons per hectare, and in spring wheat, it was around 0.5 ton\ha. Consequently, the state had planned to achieve the productivity out of cereals up to 0.26–0.3 tons\ha. Herein, the new productive wheat varieties were needed to be introduced into production. Wheat productivity in the years 1940–1942 had still been legged behind (0.8–0.10 tons\ha) despite taking those widespread measurements in the cereal production field. Every innovation in the cereal production field was highly valued in the 1930s and 1940s.

In 1934, Muslima Begimova, who lived on the common farm “Qahramon” in Mochay village of Boysun district, found the wheat plants in the field with enlarged ears, too many grains per ear, enlarged size, and hard grains. Then she brought the three of them into her home yard to grow. Since 1935 and 1937, she has seeded their seeds in her household, cultivated them, and, of course, led selection work on the growing plants. The information about her plant breeding could be achieved by the Tashkent and representatives of the government. Then a special commission was set up to verify its variety dignity, and as a result of this study, its high variety characteristics have been approved. Then, collective farm worker Muslima Begimova was awarded the

nomination of “grain master” by the government of Uzbekistan and the Central Executive Committee in 1937. And, a special decision was accepted on calling this new variety “Muslimka,” taken from its founder and creature, Muslima Begimova. This variety has passed successfully through experimental tests in the fields of rain-fed mountain and hill sides. Reproduction seeds were started to be planted in the areas of 300 hectares of irrigation and 1511 hectares of rain-fed conditions in Sariosiyo district. Further extension of planted areas was a great progress in our grain production because cotton plant growing was a state-prevailing policy in the 1950-1980s.

Grain production since the adoption of independence in Uzbekistan has become one of the most important problems for the government, and the main attention has been focused on growing cereal crops. At this point, the first attention is characterized by choosing wheat varieties that have a suitable response to local soil and climatic conditions. Herein, “Intensive,” “Sanzar-3” and “Sanzar-4” varieties were found to be the best-suited varieties for the condition of the Bukhara region in the results of experimental tests in 1994–1995, and their seeds were planted in this region.

Another good example in the development of wheat farming is the exchange of foreign practices. So, the wheat variety of Ulugbek-600 was the sparkling outcome of cooperation between agronomists and plant breeder scientists in the Samarkand region and agronomists in Ireland. This variety could reduce the vegetation period by 5-7 days and withstand diseases. The large number of grains per ear and superior grain quality have made it spread widely in the fields of local farms. Its seed reproduction has involved selection to save irrigation water.

Scientific Research Institutes (SRI), scientific centers, and experimental-testing plots were initiators in the achievements of creating high-productive wheat varieties resistant to ecological threats. At this point, the wheat varieties “Kadr”, “Nodir”, “Uzbekistan-25” developed by scientists of the Andijan SRI have remarkable importance in achieving expected yields in grain production. Furthermore, forecasts of planting areas across the region and agro-practices were also worked out by the scientists and breeders over time.

It should be noted that there are laboratories for developing the new wheat varieties and an experimental-testing field area in the Andijan district and region. 97 wheat varieties passed through this laboratory testing only in 2017–2021, and new and hybrid varieties have

been created. Mainly, wheat varieties were introduced from the Russian Federation and Kazakhstan. They have been used to hybridization with local variety diversities and have developed such varieties as “Kadr”, “Aziz”, “Uzbekistan-25”, “Navbakhor” and “Nodir” with unequal features. These wheat varieties have made it possible for the farmers to get 10–12 tons per hectare. At this point, average productivity is 0.8–10 tons/ha.

It is not exclusion that today, creating wheat varieties to withstand diseases is becoming the most important problem because of the loss of 20–30% and more accumulated yield in the consequences of infection.

Furthermore, the development of new wheat varieties resistant to extreme temperatures, hot wave impacts, rust diseases, soil salinization with high yields, and high grain quality is implemented in the experimental fields of the Kashkadarya branch of the SRI of Grain and Bean Crops (the KSRIGBC). In particular, wheat breeders at this center could manage to develop the “Bunyodkor” variety with the cooperation of scientists from the International Scientific Center for Dried Areas (ICARDA). It was developed as the result of individual selection out of hybrid plants driven by the crossing combination “Dorab-5” x “KS82117\MIT”. This variety has 100 grains per ear with a weight of 41–43 g. Its productivity per hectare consists of 0.76 tons with a high content of protein. resistant to lodging. Plant height is 90–100 cm. Ripens for 208–215 days. It was recommended to plant in the month of October in the central region of the republic and the Fergana valley (table 11).

Kashkadarya branch of the SRIGBC has selected 30 soft wheat varieties in the last ten years (2009–2019) and has passed through experimental tests. One of them was “Khisorak”. It stands out for its immunity to rust disease. The famous plant breeder N.I. Vavilov made his conclusion in 1964 about the absence of resistant local soft wheat varieties resistant to rust based on his own studies on the local soft wheat varieties conducted in Central Asia in the years 1911–1939. “Khisorak” wheat variety has fulfilled this gap in our wheat breeding programs, and it showed a high immunity to rust pathogens.

**Table 11. Economic performance of the winter soft variety
“Bunyodkor” in the 2009–2015 period**

Years	Plant height, cm.	Yellow rust infection, in %.	Productivity, Ton/ha.	Protein, in %.	Gluten, in %.	Weight of 1000 grains, g.	Grain nature, g/l.
2009	89.0	10MR	0.73	14.2	29.0	43.2	790.0
2010	93.0	TR	0.76	14.2	28.6	43.7	805.0
2011	92.0	5MR	0.77	14.2	28.4	42.8	808.0
2012	87.0	TR	0.72	14.2	28.1	42.9	785.0
2013	94.0	10MR	0.77	15.8	28.4	44.8	810.0
2014	102.0	TR	0.84	13.6	28.8	45.4	821.0
2015	93.0	R	0.73	14.2	28.6	42.5	805.0
An average	92.9	X	0.76	14.5	28.6	43.6	803.4

Notes: TR-no infection, no signs; R-chloroz or nictoz is notable, without spore; MR-less spore, less chlorez and nicroz.

This variety was released as the result of crossing the varieties Marjon and Sauz and was included in the state register in 2013. It is resistant to the diseases of yellow and brown rust and to drought. Its ear can form 100 grains, and the weight of 1000 grains is 39–42 g. The productivity reaches up to 0.75–0.8 tons per hectare. The height of plants of this variety is growing year by year. For example, in 2012, its height was noted at 78.8 cm, and in 2014, it was 88.0 cm.

Variety “Khisorak”, according to the recommendations of the collective of Republican Plant Growing, is being grown in the artificially irrigated fields of Andijan, Tashkent, Samarkand, Surkhandarya, and Kashkadarya regions. Now, its productivity has increased to 0.8 tons per hectare.

In the last few years, varieties of “Kukbulak”, “Ravon”, “Gallakor-2016” soft wheat were selected for rain-fed lands in the republic. These varieties need 118–125 days of vegetation to mature. These varieties are distinguished for their high height and grain quality in the dried areas compared to dwarf varieties.

Now, **50 soft wheat varieties** to plant in the irrigating areas have passed through variety trial experiments at the region branch of Kashkadarya Grain and Bean Crops SRI, and their economic and biologic properties have been studied. In correspondence with the experimental tests, 28 varieties were selected, accumulated, and introduced, and precision recommendations were worked out on the distribution of these varieties along the regions of the Uzbek Republic, taking into account their cultivation efficiency. At this point, “Yuka”, “Krosnadarskaya-99”, “Andijan-25”, “Alekseyich”, “Asr”, “Uzbekistan-25” and “Zimnitsa” are planted in the fields of northern regions like

Karakalpakstan and Khorezm. Middle late maturing varieties: “Tanya”, “Antonina”, “Bezostaya-100”, “Navbakhor” and early maturing: “Yaksart”, “Zvezda”, “Gozgon”, “Bunyodkor”, “Bobur”, “Turkistan”, and “Yogdu” were identified as the most productive varieties in the conditions of the southern regions of Kashkadarya and Surkhandarya. Other middle-ripening varieties like “Esaul”, “Yaksart”, “Semurug” except high-efficiency varieties in the regions of Tashkent, Jizzakh, and Syrdarya, are also being cultivated.

It was emphasized that the realization of scientific basis in cultivar selection into practice is shown by the introduction of 24 late and middle-ripening wheat varieties in the Fergana valley. There were created the obtaining of 0.8–0.10 tons of crops per hectare in the observation of appropriate agro practices.

Not only soft wheat varieties, but scores of **hard wheat varieties** **have** also been developed in our country in the years of independence. In general, the price of hard wheat grain is higher than 20–25 percent in comparison to soft wheat grain, and their varieties were grown on rain-fed areas of 120–150 thousand hectares. According to the other information, the area planted to hard wheat varieties in the condition of rainfed reaches up to 250–300 thousand hectares. These varieties are resistant to water deficiency and drought. That is why they are planted mainly in the southern Kashkadarya and Surkhandarya regions.

The history of hard wheat variety breeding in our republic goes also far back to the beginning of the 1940s. In the years of 1940–1951, plant breeder N. Pokrovskiy at the L. Lyutin State Experimental Station developed the hard wheat varieties “Leukurum-837” and “Melyanopus-40100.” The creation of the second progeny of these highly productive hard wheat varieties has been underway since 1960–1961. Herein, the varieties of “Leukrum-2F”, “Gordioforme-95” and “Provensial-88F” were released and planted in the area of 20–30 thousand hectares of the districts of Gallaarol, Qamashi, Chirokchi, and Nurata in the republic, as expected crops. Varieties of hard wheat: “Makuz-3”, “Makurum-129”, “Istiklol-5”, “Istikbolly” to plant in the irrigating fields, and “Leukurum-3”, “Marbarid”, “Javokhir”, “Charos”, “Yokut-2014”, “Billur non” to plant in rain-fed conditions were developed at the experimental stations in the years of republican independence.

The variety “Yokut-2014” has been registered as the perspective one since 2018 for fields of rain-fed conditions in terms of winter planting in Tashkent, Jizzakh, Samarkand, and Kashkadarya regions.

Flour produced from grains of these varieties is a valuable raw source for both bread baking and macaroni, confectionary, and pastries.

Attention to the selection of the best varieties and their location in the wheat breeding has intensified in the last few years. Herein, new winter wheat varieties introduced from abroad are being exposed to direct experimental testing on the farmlands. For example, the varieties of “Gratsiya” and “Grom” developed at the Krasnodar Agriculture SRI named after P.P. Lukyanenko (Russian Federation) were passed through state variety testing in 2009. This experimental testing was conducted in the fields of the farm Yongichdali in the Urta-Chirchik district of the Tashkent region. The results of this test showed that the potential productivity of the first variety, “Gratsiya” was 0.11 tons. The second variety, “Grom” was remarkable for its cold resistance in the year 2015.

The above-mentioned tendency in wheat variety breeding and its seed production is kept as the priority approach of breeders and government to ensure the sustainability of wheat grain production in the republic. Later, this approach is deepened by the inclusion of ecological testing of wheat varieties. In 2019, the information service of the Agriculture and Food Provision Scientific Production Center announced the leading ecological testing of winter wheat varieties. There were ecological tests of newly developed varieties at the Institute of Grain and Bean Crops SRI (IGBCSRI) and varieties introduced from abroad. This test in the sphere of wheat scientific research was implemented on the basis of an agreement between the IGBCSRI and the Russian Federation National Grain Center of Krasnodar, named after P.P. Lukyanenko.

According to the information service of the IGBCSRI, the winter wheat varieties “Alekseich”, Bezostaya-100”, Vekha”, Valena (photo 12), “Antonina” (photo 13) and “Gurt” introduced from the National Grain Center of Krasnodar were superior in their resistance to natural stresses like cold, drought, fungi infections (yellow and brown rust), and bread baking properties. The gluten content of grain is 28-30%, and the protein content is 14-16%. And the productivity ranges around 0.10-0.11 tons. It was also identified that these varieties could maintain their genetic adaptation potentials to the climate and phenotypic-biological properties for several years in the branches and scientific experiment stations of the institute located in the different regions.

Further, high and quality grain yields have been possible through the implementation of foundation seed production on these varieties at

the IGBCSRI and the provision of specialized seed-producing farms with pure planting seeds.

Currently, our republic has comprehensively developed a network of wheat breeding institutes, field experimental stations, and seed production farms across the regions of the country.



Photo 12, 13. **Wheat varieties of Valena and Antonia at the time of variety trial.**

As mentioned in the above-composed chapters, beside the IGBCSRI of Kashkadarya: SRI of Andijan for Cereal and Bean Crops in the Irrigated Areas (the SRICBCIA) and its branches in the regions, the Plant Growing Scientific Research Institute of Uzbekistan (Uz.PGSRI), the Uzbek Scientific Research Institute of Genetics and Experimental Biology (Uz.SRIGEB), Tashkent State Agrarian University (TSAU), and the Samarkand Agriculture Institute (the SAI) are engaging with wheat breeding in Uzbekistan. In particular, almost 14 000 world wheat seed samples are being kept at the depositors of the Uz.PGSRI (Amanov A.A. and others, 2013).

Wheat breeding aspects. Wheat breeding programs in Uzbekistan have unique aspects in the development of new wheat varieties. These aspects of wheat breeding were listed on the pages of previously published textbooks on wheat breeding. Correspondingly, the leading of them are:

- *Increasing of productivity.
- *Improving of cold resistance.
- *Tolerance to drought.
- *Tolerance to hot.
- *Resistance to diseases (appendix 2).
- *Resistance to pests (appendix 3).
- *Enhancing of grain quality.

Data on the average productivity of commercialized wheat varieties across the regions of the republic summed up for three years show 4.8 tons per hectare in the condition of irrigated land and 1.0 tons per hectare in the condition of rain-fed areas. These grain yields in the irrigated (table 12) and rain-fed lands (table 13) do not satisfy the demand of the wheat-growing farmers and the government by considering the soil and climatic conditions of the republic.

Because the lands of the Karakalpak Republic and Jizzakh region show lower grain yields, there is a need to improve the productivity of the commercialized wheat varieties there. It is obvious that the land of the Karakalpakistan Republic has the potential to yield 6.0 tons per hectare in some years, like 2009. regions, as Jizzakh has an average 3.6 tons. The last one is the problem, which clearly reminds the wheat breeders about the necessity of creating new variety genotypes that are adaptable to the conditions of the Jizzakh region. And other regions—Navoiy, Namangan, Syrdarya, and Khorezm—have the same challenges in the introduction of the new productive wheat varieties.

Table 12. Grain productivity of wheat in the irrigated lands, ton\ha (Amanov A.A. and others, 2013).

O\№	Regions	2008	2009	2010	An average (ton\ha)
1	Republic of Karakalpakistan	24.9	60.5	27.8	37.7 (3.8)
2	Andijan	58.6	61.8	62.1	60.8 (6.1)
3	Bukhara	55.9	56.9	57.1	56.6 (5.7)
4	Jizzakh	37.7	35.1	36.3	36.4 (3.6)
5	Kashkadarya	50.3	51.6	51.8	51.2 (5.1)
6	Navoiy	48.1	49.4	48.9	48.8 (4.9)
7	Namangan	48.8	47.5	49.2	48.5 (4.8)
8	Samarkand	52.5	51.0	51.8	51.8 (5.2)
9	Surkhandarya	50.1	55.6	50.7	52.1 (5.2)
10	Syrdarya	38.4	40.9	42.7	40.7 (4.1)
11	Tashkent	37.8	50.8	48.3	45.6 (4.6)
12	Fergana	54.5	51.8	54.8	53.7 (5.4)
13	Khorezm	45.0	45.9	46.3	45.7 (4.6)
	Per republic	4.7	5.0	4.9	48.5 (4.8)

We can see that the average grain yield in the rain-fed areas of the republic for three years consisted of 0.9 tons per hectare. But there were potentials of 1.4, 1.6, and 1.9 tons\ha. Even, according to examples of farms in the “Oktash”, “Tolkinshoh” and “Yonbosh” Jizzakh regions, 1.5–2.0 tons of grain yield of winter wheat varieties per hectare were taken. They are the outcomes of not only observing the required agro-practices but also selected varieties and their resilience to the conditions of these rein-fed areas.

In general, the productivity of agricultural crops is the result of the complex characteristics of the varieties. Usually, genetic scientists pronounce the term “complicated trait” depending on the combination of many qualitative economic traits and properties. So, breeders have to create early-maturing, resistant to stresses, diseases, and pests varieties to solve wheat productivity problems in rain-fed areas of the regions of Navoiy and Syrdarya.

The amount of raw gluten in the flour powder shows the texture and quality of bread baked from this flour as the examples presented below (photo 11, № from Ch.3).

Table 13. Grain productivity of wheat in rain-fed lands, ton\ha (Amanov A.A. and others, 2013).

O\№	Regions	2008	2009	2010	An average (ton\ha)
1	Jizzakh	5.5	10.2	10.9	8.9 (0.9)
2	Kashkadarya	3.1	9.3	11.6	8.0 (0.8)
3	Navoi	-	1.3	0.4	3.9 (0.4)
4	Samarkand	5.9	9.3	18.8	11.3 (1.1)
5	Surkhandarya	-	1.9	2.8	1.6 (0.2)
6	Tashkent	9.0	15.7	13.6	12.8 (1.3)
	Per republic	5.0	10.0	12.7	9.2 (0.9)

Gluten of wheat flour is referred to the chemical compound in the structure of flour including into a group of proteins, non-dissolving in the water, it is a family of proteins (mainly it consists of glutenin and gliadin proteins, and there are 15 irreplaceable amino-acids in its texture, essential for the man health) possible to form a sticky network that has a glue-like consistency when flour is mixed with water (table 14).

Table 14. Quality indexes of wheat varieties grown in the Khorezm region.

Region:

№	Varieties	Gluten			№	Varieties	Gluten		
		%	IDK (index)*				%	IDK (index)*	
1	<u>Moskvich</u>	30	93	II <u>s.w.</u>	8	<u>Bolg'ala</u>	35	33,6	II <u>s.h.</u>
2	Andijan-2	33	91	II <u>s.w.</u>	9	Tanya	24	74	I g.
3	<u>Kuma</u>	28	45	I g.	10	Nota	25	12	II <u>s.w.</u>
4	<u>Dokha</u>	30	93	II <u>s.w.</u>	11	<u>Kroshka</u>	25	35,2	<u>S.h.</u>
5	<u>Esaul</u>	28	39	II <u>s.h.</u>	12	Krasnodar-99	35	62	I g.
6	<u>Polovchanka</u>	35	26,4	II <u>s.h.</u>	13	Valentin (triticale)	30	45,9	I g.
7	<u>Pamyat</u>	20	67	I g.					

*I-good; II-sufficiently weak; II-sufficiently hard.

*I-good; II-sufficiently weak; II-sufficiently hard.

Wheat breeding methods. All plant breeding methods worked out by world botanic and genetic scientists, particularly on the pages of a manual called “General Plant Breeding and Seed Production” (Ashurov M.E., 2020), are used by wheat breeders depending on their breeding programs to determine certain wheat growing problems.

Selection of the best plant biotypes remains the best method of Uzbek breeders in releasing the new wheat varieties. This method embraces the most accountable part of their whole breeding process. That is why breeders usually use individual or mass selection.

Individual selection. About 2 000 - 3 000 wheat samples (accessions) are studied as the initial materials and the best ones (not less 300) are isolated in the individual selection are analyzed separately (chart 1). Ears thrashed, grains cleared, and planted alone. Every seedling and plant are later observed and evaluated. This method has its modifications as a single individual and continues individual selections. The plants with the characteristics which don't meet the requirements of the breeder are excluded. The number of best formed families consisted of 300.

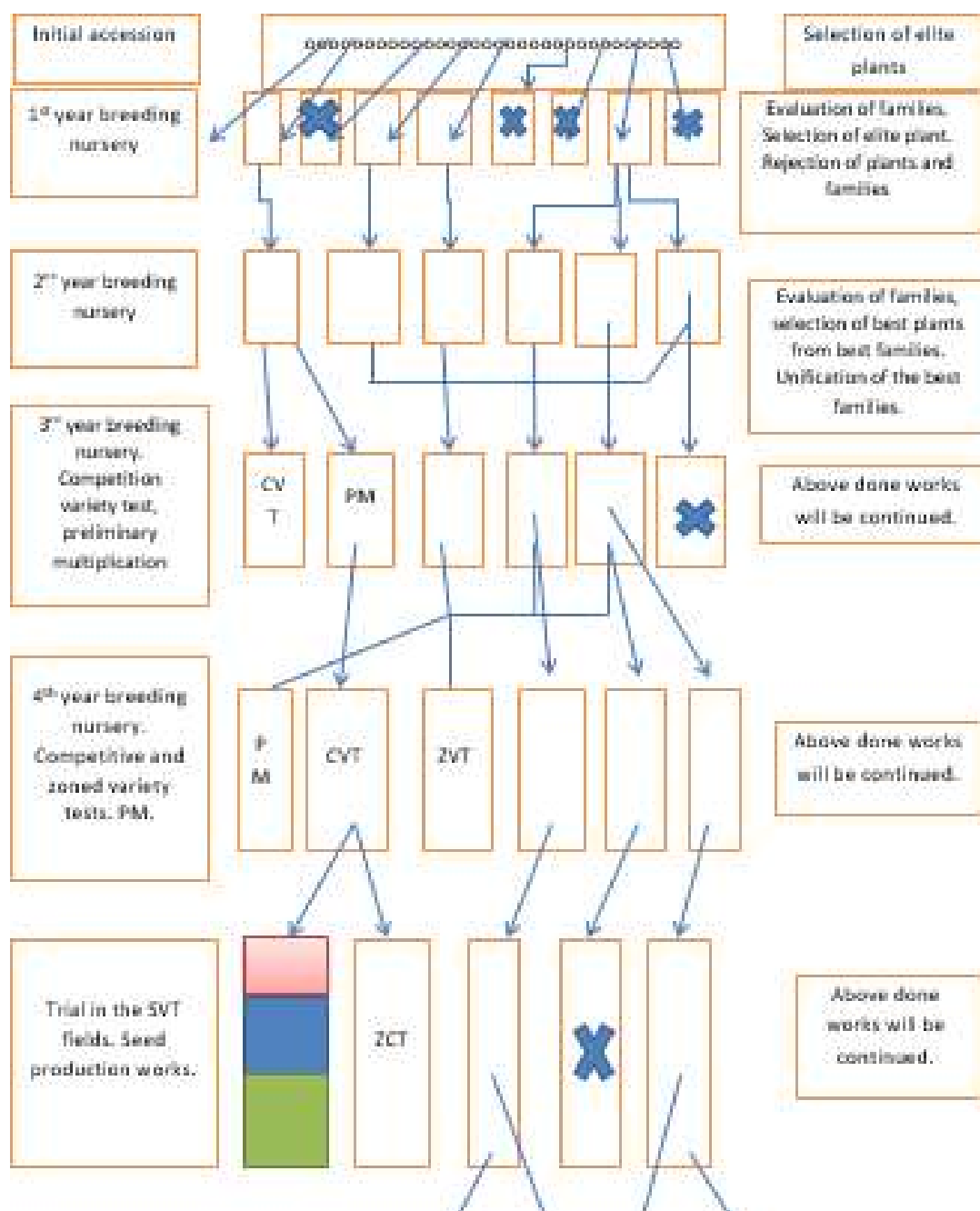


Chart 1. Scheme of individual and continues individual selection works.

Take a look at the chapter where the origins of the registered varieties are described, and you'll see what varieties have been developed as the result of individual selections. They are: Yoqut-2014 out of winter hard wheat (*Triticum durum* Dest.) Directed individual selection was used during the study of the hybrid plant population [Marvarid x Waha (Siriya)] x Leukurum-3 on adaptability to rain-fed areas, resistance to drought, heat, grain quality, and productivity. Javokhir: individual selection from progenies of hybrids after

complicated hybridization of (Leukurm-3 x Karlik-85) x Yubelaynaya; Variety Hasaf, registered in 2021, was also the result of individual selection from the hybrid wheat population. Surkhak 5688 is an individual selection from the wheat variety population of Surkhak.

“Bakhor”, spring soft wheat (*Triticum aestivum*, Emend. Fioru et Paol.), was released after multiple individual selections out of hybrids: Sanzar 4 x K-571830.

The last studies have shown that our ancient wheat variety diversities like Kizil bugdoy, Nomsiz, Bukhorbobo, Oq bugdoy, Tuya tish, Kal bugdoy, Kizil boshok, Kora kiltik, Ok boshok, Kayroktosh, Pandaki and others are the most potential initial materials (Babaev S.K. and others, 2024) in terms of adoptability to local soil climatic stresses and retaining of superior farm properties and grain quality traits. They are being used in the field breeding experiments of the laboratory for Grain crops genetics at the Institute of Genetics and Plant Experimental Biology (appendix 7).

Mass selection. In this method, the breeder selects several plants (elite plants), preferably from the initial variety population, and in the result of the analysis (testing), they may be rejected or selected. Seeds of selected elite plants were joined together and will be planted for further observation and improvement. This method also has its own multiple selection approaches, which are widely used by wheat breeders (chart 2).

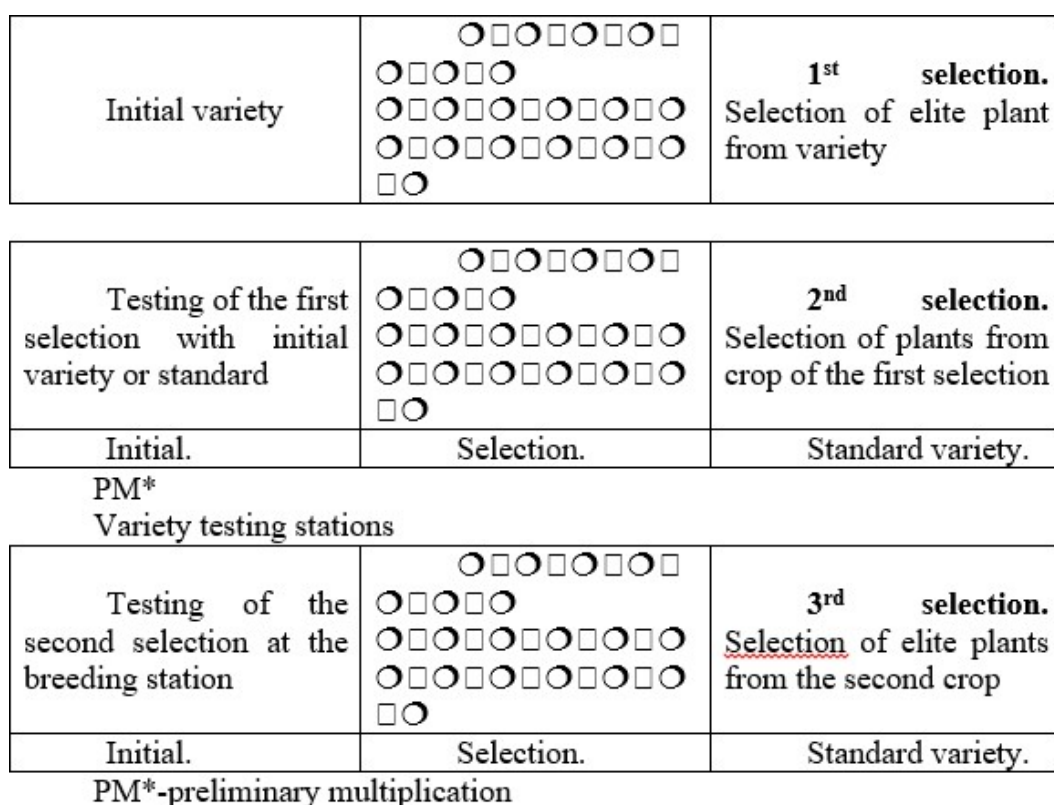


Chart 2. **Multiple massive selections work in the wheat breeding program.**

This method is also effective in wheat breeding and improving works. Many of our wheat varieties are the results of this method. For example, winter soft wheat varieties: The variety “Andijan-2”- has been developed through continued mass selection from the Kupava-29 bred sample. **The variety** of “Bobur” was the result of double mass selection out of the Eyka population sample (1326-3600).

Hybridization. Hybridization in wheat breeding is one of the main methods to form new initial hybrid materials for the breeding process. Then the breeder studies the dignity of the initial hybrid materials and remarks on the need for elite plants using individual or mass selection methods and testing. Ultimately, a new variety created through this complete method will be the result of transferring the valuable properties of parental varieties to hybrid progeny. So, hybridization helps to strengthen the stress resistance of hybrid plants, which makes it possible to select the resilient ones to certain soil-climate conditions.

The majority of cultivating wheat varieties were developed using the hybridization method. In the process of hybridization, one of its kinds can be applied. They are: inter-variety, inter-species, and inter-genus crossings (pollinations).

The orders of crossing: a pair (A x B), three sides (A x B) x C), continues (A x B) x B), and complicated (A x B) x (B x C) are used.

The wheat breeding process. The breeding processes at the scientific institutions are implemented in a similar way:

- *Nursery of initial materials.

- *Plant breeding nursery.

- *Control nursery.

- *Preliminary variety testing.

- *Competitive variety testing.

- *Production variety testing.

As described by A.A. Amanov and other wheat breeders (2013), **the initial material nursery** involves collection and hybrid nurseries.

Collection nursery deserves study, selection, and embracing into crossing (pollinating) of local and introduced from abroad varieties and samples. 300–1500 variety and variety samples are studied in this nursery. The area of the lot is 0.6–1 m², and the length of the row may be 1–2 m.

Seeds of F₁–F₅₋₆ hybrids are sown in the hybrid nurseries. The feeding area is 10 x 30 cm. The areas of lots are 1.5–6.0 m². The best lines are transferred to the plant breeding nursery.

Plant breeding nursery is established by hand or drill seeding. The feeding area is 10 x 15 cm, and the row length ranges from 6 to 8 meters. The number of planted families and lines will reach up to 3000 – 10 000.

Productivity, grain quality, resistance to cold, heat, diseases, and pests of families and lines are evaluated in the **control nursery**. Planting is fulfilled by the seeding drills. An area of 10–25 m² is allocated for every sample. The grain harvest has been mechanized.

The selected lines for their best properties are studied at the **preliminary variety testing nursery**. 80–120 lines are planted in similar conditions to production. Cultivated in two replications with an area of 25–30 m². The complete agro-biological and economic properties of these lines are evaluated.

competitive variety testing. Here, 40–50 lines selected from the nursery for preliminary variety testing for their superior indexes and properties are studied. The seeds of every line are sown in an area of 25–50 m². These wheat lines are studied for 2–3 years in the four replications. Some of them, which had better characteristics and properties during this study and had a productivity of 15–20% higher

than the standard variety, are prepared to transfer the state variety trial as the newly created wheat varieties.

Production variety testing. The best lines of competitive variety testing are studied in the nurseries of production variety testing. This experimental research is implemented in the fields of scientific institutes. The planting involves the study of 1-2 new line-varieties in 1-2 hectares of area, similarly to production conditions.

And this newly developed wheat variety or varieties are delivered to the state variety trial on the basis of 3 years of competitive variety testing and 1-2 years of production variety testing results.

Ecologic variety testing. This is the testing of the newly developed wheat varieties in different soil and climate conditions. The experimental-research work to be done in this testing is the same as in the competitive variety testing. Usually, 2–4 new varieties from every scientific research institute are selected and studied. The results of these ecological tests are used at the time of delivering the new variety lines to the state variety trial and originators to analyze the plant breeding works.

State variety trial and variety recommendation to the production. The state variety trial determines the new productive wheat varieties and their planting regions. Comprehensive evaluation of biologic, economic characteristics, properties, and selection of the best ones to recommend for planting are its major objectives. Testing of the new varieties (10–20 units) is conducted in the state variety trial plots of the state commission. A variety of testing plots, taking into account the different soil-climatic regions of the republic, have been located. The lot area is equal to 50–100 m² with four replications (each has 10–25 m² of area). The state variety trial lasts for a period of not less than three and not more than five years. The similar agro-practices accepted in the region are used for the cultivation of testing varieties.

Superior new varieties based on their characteristics and properties than standard in the first year of competitive variety testing in the state variety trial have completed production variety testing. This work is executed on the neighboring farms in the district, where a variety testing plot has been located. Perspective and commercialized varieties are planted side by side in the 2-hectare area.

New varieties with superiority over commercialized varieties for 2–3 years are recommended for planting. The varieties do not have perspectives to withdraw from testing. Of course, the recommended new varieties have to be more productive and resistant to cold, drought,

diseases, pests, and grain quality than the grown varieties. The conclusions about the recommendation are presented to the Ministry of Agriculture, and after consideration by the specialists, they are recommended for planting.

The recommended varieties are included in the state register. The list of varieties included in the register is announced annually. Including or exclusion is implemented by the decision of the State Commission of the Republican agricultural crop varieties testing.

The functioning process of wheat variety breeding in our country and commercialization of the newly developed varieties into production is able to secure the maximum grain crop (photo 14) in the harvesting years with an increasing year (2020, almost 6.0 tons per hectare) by year (2022, 7.0 tons per hectare).



Photo 14. Wheat grain crop.

Chapter 5. Wheat hybridization

Hybridization is the second option for our wheat breeders after studying the potential of the best foreign wheat variety diversities in the local regions with the intention of successively introducing the selected ones into production.

Hybridization in wheat breeding is one of the most essential methods for developing new wheat varieties. But to achieve hybridization outcomes, it often requires complicated hybridization procedures. One of the restrictions can be the genetic dissimilarities of the chosen wheat source species to crossing, which are considerably contrasted by their chromosome numbers.

The difference in the chromosome numbers of some initial wheat samples suspends fertile zygote, which is explained by the historic evolution of the wheat plant (figure 10).

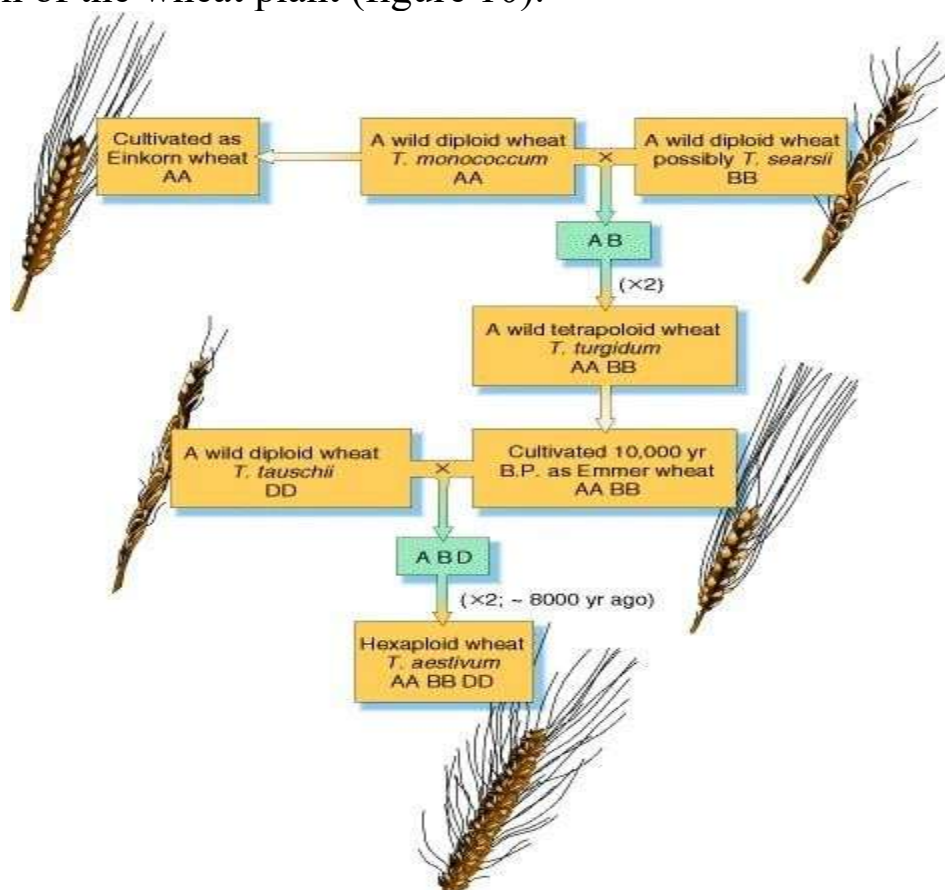


Figure 10. **Phylogeny of wheat diversities.**

The figure shows cultivated and wild diploid wheat forms having (AA and BB) two sets of seven chromosomes $2n=14$ and their further outcomes in natural hybridization. Then, their polyploid form, the

tetraploid (four sets of chromosomes; $2n=28$) driven by natural hybridizations between *T. monococcum* and *T. soarsii* (diploids). Our common wheat, durum or macaroni wheat, has a similar origin, resulting $2n=28$. Within the forms, which originated later (800 years ago), was our bread (soft) wheat with six sets of chromosomes (hexaploidy) $2n=42$.

In particular, hybrids between plants of diploid, tetraploid, and hexaploid wheat species are multi-promising breeding sources to improve commercialized wheat varieties. For example, crosses between *Triticum aestivum* (hexaploid) and *Triticum turgidum* (tetraploid) allowed enhancement of disease resistance, natural stress tolerance, and grain quality in the pentaploid ($2n=35$) hybrids. But unfortunately, it is not possible to get hybrids between them in field pollinations because of an imbalanced chromosome number. Some crossings under the activities of natural pollinators or man-made pollinations will not let fertile zygotes form into successive, normal somatic cell divisions. In the case of taking hybrids, they would be poorly fertile in the F_1 individuals, which would affect pollen development and subsequent fertilization.

As scholars explain, this is due to the order of the meiotic process, where chromosomes search for their homologies and remain univalent or, on the contrary, multivalent between normal homologies, generating unbalanced gametes. Of course, fertilization with such abnormal gametes results in frequent aneuploidy descents, leading to even full sterility.

This problem has also existed in the breeding of most agricultural crops and has been solved historically by the creative and research activities of geneticists and breeders. And now this is not a barrier preventing interspecific hybridization owing to the use of colchicine treatment after either anther culture, microspore culture (androgenesis), or cytogenetic irradiation approaches (in vitro culture, embryo culture).

Generally, successful fertilization in the wheat flower is achieved by the landing (or adhering) of the pollen on the pestil, which germinates and forms a pollen tube. Then, after getting moisture, it forms a pollen tube, which penetrates into the pest's transmitting tract. Further, this tract provides the pollen tube with the needed physiological juice to grow towards the ovary. According to double fertilization, upon arrival at the ovary, the two haploid sperm cells are released from the pollen tube to fuse with the egg and central cell for fertilization.

The easier cross-pollination in wheat takes place at inter-variety crossings where both parental varieties belong to the same wheat

species. The proposed procedure of the BBSRC, John Innes Centre, Designing Future Wheat, and University of Birmingham to hand cross-pollinate wheat plants to obtain hybrid seeds is one of the comparatively simple practices in wheat hybridization.

Herein, to perform the hand cross, it is necessary to have the necessary toolkit, which contains of (photo 15): toolkit (crossing book, forceps, scissors, a test tube with ethanol, crossing bags, crossing tags, and a stapler). Each of them has its own special function:

- *A crossing book is needed for the wheat breeder or wheat researchers who planned to conduct cross-pollination. It comprises the schemes of plant breeding nurseries, the numbers of rows from which female and male plants will be selected to do hand crossings, the probable dates of crossings, and the necessary notes.

The forceps are used to remove the florets (spikelets) and anthers. They must be inspected before use to determine their clean and sharp states.

- *Scissors are needed for cutting the florets at the time of emasculation.

- *Ethanol is used to sterilize the forceps and scissors after completing the first plant in order to prevent cross-pollination between crossed plants or to avoid cross-pollination.

- *A crossing bag is needed to beg the spike after emasculation and after pollination to avoid additional cross-pollinations.

- * The crossing tag is used to label the pollinated spike with the help of crossing tag. On the tag is recorded information about maternal and paternal plants and the date of pollination according to the records made in the crossing book.

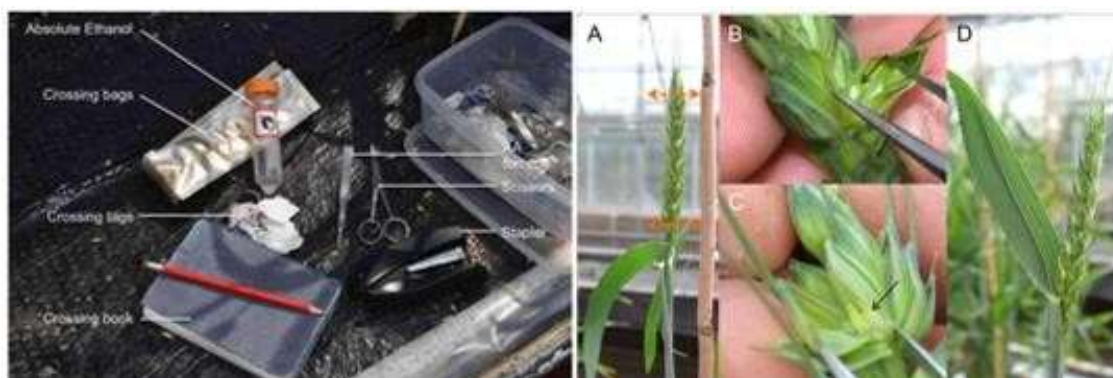


Photo 15. Wheat crossing kit and time of emasculation.

To identify the optimal time to begin the hand cross-pollination, it depends on the knowledge level of the heading stages of the female and male plants. This is essential to synchronize the work of emasculation and pollination. If the varieties considerably differ at their developing stages, their seeds must be sown, taking into account the coinciding heading stages of both varieties.

The state of fully spike emerging from the spike flag indicates the readiness of the spikelets to emasculation (photo 16). Naturally, not all spikelets along the spike come together to mature, so in the photo, the part to be removed before emasculation is pointed out by the red arrows (A). Also in this photo there is a green anther with a black arrow and not-developed stigma (C), slightly yellow anthers, and a feathered, tight stigma, ready for emasculation (2B,C).

Other varieties may be excluded (D) in regard to their state of emerging spike from spike flag. In some varieties, wheat flowers mature rather before the spike gets out of the spike. That is why adequate knowledge of the heading stage of plants in a certain wheat variety is essential to obtaining enough hybrid seeds. Pollination at the time of advanced pollen maturation is leading to hybrid seeds, probably with self-pollination.

First, remove spikelets developed at the tip and base of the spike by using scissors or forceps; these spikelets are not able to produce normally developed hybrid seeds. The florets stand in the center of each spikelet. Then cut across each spikelet, leaving approximately two-thirds of it, allowing you to easily remove the anthers (photo 17) and pollinate (photo 18).

The central floret developed in the center of each spikelet is removed in this order: place the forceps (A) at the base of the floret and (B) pull it out in one jerk twist. Verify to be sure that no one has anthers left in place of the floret. You know, there must be three anthers per floret (D), so count them every time in the removal of the florets in order not to miss any of them, as it could cause self-pollination. Not always all anthers develop properly; some may lean behind and have a small, white anther-like structure at the base of the ovary.

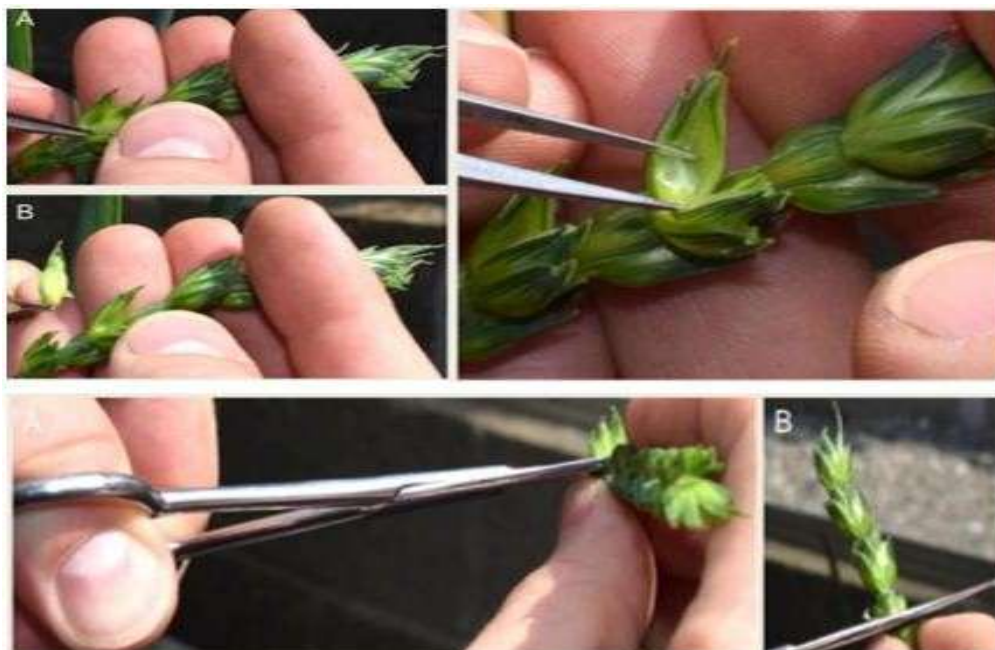


Photo 16, 17. **Order of floret removing and emasculation.**

When removing anthers, need to be careful because some of them may still be green, while others may be green or yellow, so make sure no pollens are still coming out (photo 18).



Photo 18. **Anther removal.**

Herein, it is recommended to pull out the anthers by holding them by their tip (A) and to try to pull out the three at once without damaging or extracting the stigma. Even so, do not let anthers slip off your forceps and fall back onto the spike again.

After this, it is time to use a crossing tag to label the female plant (scientifically, receptor), writing on it the date, maternal sample name, and paternal plant, and check it, comparing the information from the crossing book. And now cover the emasculated spike with a crossing

bag to prevent natural cross-pollination and secure it with a tie. It is required to be careful not to damage the emasculated spike.

To differentiate between non-pollinated and pollinated spikes, the crossing tag is to be left hanging for the unpollinated and put into the bag for the pollinated spike.

Pollination. Efficient pollination will be done when pollen and stigma have reached the proper developmental stage. Usually, stigma matures after two or three days of emasculation. Fluffy or feathered state of stigma shows its maturity to pollination (photo 19). Pollen matures when the anthers start to turn from green to yellow and be slightly rounded (photo 20). Pollen viability lasts for a few minutes.



Photo 19, 20. **Immature and mature stigmas and anthers.**

Gently remove the anthers with the help of forceps from the floret and place them on the skin of your hand (photo 20). The maturity of the anthers gets speedy with the effect of your skin's warmth. The photo shows two stages of anther development: the first has already released pollens. The second is greenish-yellow, just ready to split and release pollen (B). Your warm hand helps them reach maturity. Such anthers may be used for pollination as pollen donors in regard to the receptive stigmas of the receptor plant.

Attentively hold by the tip and tap it above the floret that the pollens fall inside. One mature anther ensures that it pollinates two to three florets. In the case of many donor plants with enough pollen, it might be useful to pollinate additionally.

After completing pollination of the whole spike, record the date of the pollination and the name of the donor plant on the crossing tag, and bag the spike (ear) with the tag inside this time. And use its tie to seal the bag (photo 21).



Photo 21. Bagging the pollinated spike of the receptor plant with crossing tag inside.

Questions on the studied texts:

1. What kind of scientific research institutes are functioning in Uzbekistan for creating varieties and hybrids of grain crops?
2. Please, can you remember special phenotype particularities of the wheat plant and the structural makeup of its spike?
3. Can you describe the parts of wheat grain and their designation?
4. What types of cultivating wheat do you know and their distinctness?
5. Do you know growing wheat varieties in the republic?
6. How can you characterize the biology of wheat?
7. Remember the wheat breeding history in Uzbekistan and has our nation its local variety diversities?
8. What wheat breeding aspects have priority in our republic, and why?
9. What properties of wheat breeding materials are assessed to use them in the breeding process?
10. How is assessed the initial material of wheat accessions?
11. List the names of wheat breeding methods and the results.
12. Why is phylogeny of wheat diversities necessary to learn wheat hybridization?
13. What is a crossing kit, and what tools are needed to fulfill the wheat hand crossing?
14. What do you choose needed wheat flower to pollinate?
15. Name the steps of crossing order.

Chapter 6. Seed production of wheat and control seed quality.

Annual reproduction of seeds of new and promising wheat varieties by maintaining their variety purity and typical properties is the main object of wheat seed production.

The system of seed production for cereal crops in our republic has begun to function based on a single system formed by the law "About seed production" of the republic of Uzbekistan on August 29, 1996, and the decision "About the policy of the republican government of Uzbekistan in the field of seed production" on September 19, 1996.

According to this system, scientific research institutions provide experimental farms with seeds of initial seed stock materials (reproduction) of recommended plant varieties and promising varieties.

In turn, the experimental farms provide farms specialized in elite seed production with enough super-elite seeds.

Farms specialized in elite seed production. produce seeds of elite and I-reproduction and provide farms specialized in public seed production with superior reproduction seeds.

And public seed production farms provide technical (goods) grain-producing farms with II-III reproduction seeds.

So, scientific institutions, experimental farms, and elite farms reproduce (propagate) elite seed and I-reproduction of recommended plant and promising varieties in their service rendering regions.

Insurance fund provision in order of 100 percent out of reproduction and super elite seeds, 50 percent of elite seeds, and 15 percent of I-reproduction seeds is adopted.

Two processes are implemented in seed production, depending on its main object: variety-renewing and variety-exchanging.

Variety renewing: this is the concept of renewing the seeds of a certain variety with its superior seeds. The seeds lost their valuable traits and properties as a result of long-term sowing and mechanical contamination with seeds of other varieties and crops, biologic worsening on account of cross-pollination, and the loss of valuable traits and properties after disease infections.

The term of variety renewal is determined by the agriculture-managing organs on the basis of proposals made by scientific institutions.

Variety exchanging: the variety being planted in a certain region is changed to the one that has superior productivity, product quality, and

valuable traits and properties. The speed of variety exchanging has crucial importance. This process relates to the creation of new varieties, their introduction into production, and the organization of their seed production.

Requirements posing to seed stock. Requirements on variety purity, germination, infection with diseases, contamination with weeds, and humidity are presented to the seeds of elite, the first category, and successive reproductions.

The variety's purity is determined by the results of the appraisal. The following categories of variety purity have been established:

*Elite – 99.8%.

*1st category – 99.5%.

*2nd category – 98.0%.

*3rd category – 95%.

Germination of seeds and other indexes involving in seed stock's sowing quality of wheat and other grain crops and their study and analysis are given in detail in our manuals: "Selection and seed breeding of grain and grain-bean crops" published in 2018 (<http://library.ziyonet.uz/uz/book/126706>) and "General plant breeding and seed production" published in 2020 (<http://library.ziyonet.uz/uz/book/126727>).

Indexes of the sowing qualities of seed stocks are presented in the state seed standards. Seeds that do not meet state standards on their quality indexes lead to a decrease in the productivity of varieties. That is why they do not let it be used for sowing purposes.

Influence of reproduction on productivity and seed quality. The influences of various reproduction seed stocks on productivity features have been studied in numerous studies. The reduction in productivity in one of the studies was noted since the III–IV reproduction seeds in another one; the reduction is noted since the VI–VII and successive reproductions. Some researchers guess that the higher the reproduction, the greater their productivity; others exclude the effect of seed reproduction on production. They come to the conclusion that high yields may even be taken from VIII–X reproduction seed stocks.

The historically available data on seed production and seed science stated that the productivity of seed stocks depends mostly on the plant's growing condition but not its reproduction.

Preliminary seed production (figure 11):. The main object of the preliminary seed production is to produce high-quality seeds for the

production of elite seeds. The initial seeds are the seeds produced based on seed production and agro-practice methods, meeting the state seed standard requirements for variety purity and sowing quality. The best plants of a certain variety are selected and cleared up from other species and varieties in the process of elite seed production. Weak-growing, less productive, disease-infected plants, lines, and families are excluded.

The initial division of seed production is made of the following.

Individual family selection establishes the base of winter wheat elite seed production.

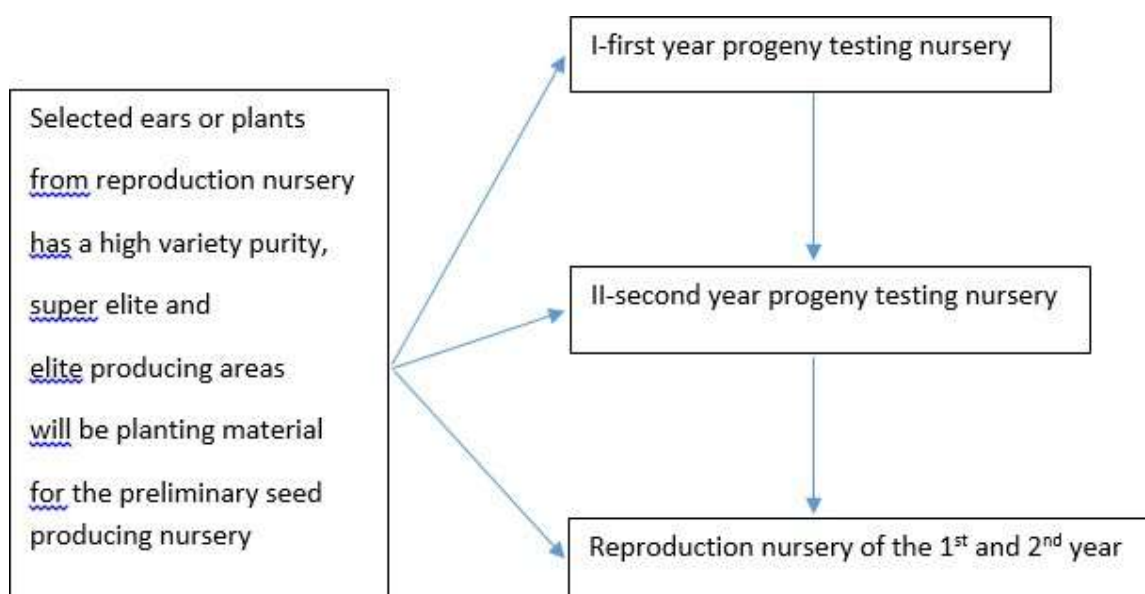


Figure 11. Structure of the preliminary wheat seed production process.

As stated above, selected ears, plants from reproduction, and super-elite planted areas are used to sow in the nursery of the **I-year progeny testing**. The number of progenies is determined by the coefficients of seed selection efficiency and requirements for elite seeds. Planting is executed in the 30 cm-apart rows (photo 22) with the help of a special drill (appendix 11). The best families are harvested alone and thrashed. The superior ones, after laboratory analysis, passed on to the II-year progeny testing nursery.



Photo 22. **Dispose of the experimental wheat plants in the wheat families.**

The best selected families from the nursery of 1-year progeny testing are planted in the **II-year progeny testing nursery**. The families are evaluated again. Not less than 100 families are planted. Planting is conducted by the special drill. Less productive, disease-infected, and week-gone-on families are registered. The best ones are combined and used to plant in the 1-year reproduction nursery.

I-year reproduction nursery. Planting is executed in wide rows (30 cm apart) in order to speed up seed propagation. The families of off-types and varieties of diseases infected are removed. The crop is harvested by the mechanical harvester. The output of conditioned seed consists of 70–78 percent.

II-year reproduction nursery. The seeds taken from the 1st year reproduction nursery is sown here. Planting and other crop harvesting works are similar to the measurements implemented in the first year of production nursery. Grain is cleared in the grain cleaning machines and, in the sacks, piled up, isolated, and stored. These seeds are sown for the production of super-elite seeds.

Retaining the variety purity of the crop in super-elite and elite seed production is important; don't let biologic and mechanical contamination occur. A proper agro-practice is applied. Plantations are registered in the special report. Other plant species and variety plants are exterminated (photo 23), and bordering lines of grown plants are cut prior to harvesting. Thrashed grain is cleaned and put in sacks. Tags are put in the sacks. The tags bearing records on the crop type, variety, reproduction, and year of harvest are adhered to the sacks.



Photo 23. Removing off-type plants from the seed stock field.

Insurance funds are formed at 100 percent of every variety of super-elite and at 50 percent of elite seeds.

Approbation of cereal areas planted to seed stock. Approbation is conducted every year with the aim of determining the variety grade and seed quality in the plantation disbursed to seed stock provision of recommended and promised varieties.

The contamination degree with hardly separating cultural and wild grasses as well as weeds, prohibited (quarantine), and the most harmful and poisoning grasses is marked and evaluated, along with the infection of plants with diseases and pests and the evaluation of variety grade quality. The observation of seed production instructions for high-quality seed production is controlled. The cleared state of the plantation from other species' plants and varieties (appendix 5), the preparedness of the area to harvest, the state of warehouses, and the correctness of the documents are considered.

Work organization. Approbation is conducted in the farms having a seed stock provision plan under the ministry of agriculture, governments of regional agriculture, departments of district agriculture, scientific institutions, experimental farms, and farms specialized to produce seed stock for their own needs.

The field approval at all kinds of scientific institutions and farms having reproduction nursery, super elite, and elite planted areas is conducted by the commission disbursed from the ministry of agriculture of the Republic of Uzbekistan and the government of regional agriculture. Specialists of the Republican Seed Control Center, breeders of scientific research institutions, or staffs of preliminary seed production departments have included their names in the member list.

The specialists of the district agriculture department passed through the special courses, and having admittance for conducting approbation can fulfill approbation in the farms, which have an obligation to sell the quality seeds to state funds (I, II, and III reproductions). Specialists of grain products enterprises have a right to participate in the approval.

The appraiser takes a bundle (a wheat sample) across the wheat field (photo 24), analyzes the content of the bundle, and composes an appraisal statement.

According to the related manual, the approbator, prior to harvest, completes the approbation and registration and then has to hand the approbation documents revised by the senior approbator to the farm.

Registration of top variety areas is implemented based on the field state of crops and documents given to the planted seed stock.

The following documents are filled in on the basis of the approval results of grain bean crop plantations: to reproducing plantations (F1, F2, and F3) seed crop that is intended to be used for own demands, approval statement on the form of 193; to reproducing plantations, a seed crop that is intended to be used for sale, and an approval statement on the form of 195; to the plantation of original and elite seeds in the form of 199; to plantations, have been recognized as unfit for planting purposes—a culling statement on the form of 200.

Certificates of seed stock (for reproduction nursery, super elite, and elite), certificates of seed stock, certificates of variety grade, and approval statements for the last year are needed to prove the truth about the precisely planted variety.

Agronomist-approbatory fixes the availability of the documents on the seed stock planted in the field; if something is absent, he must restore it. Must be confident that the variety had not been exchanged with another variety at the time of planting. The nature state of the field is inspected by the approbatory, and if there is the necessity to remove plants from this field, he or she organizes it. Identifies the boarder of the

field to be approved, drafts the ways to take the approval bundle, considers the observation of the production of seed stock, and gives instructions if it needs to find additional seed stock fields.



Photo 24. Wheat approbation process in Sharof Rashidov district of Juzzakh region.

The procedure for the detailed analysis of wheat bundles is given in our previous manual, “Selection and seed production of grain and bean crops,” published in 2018 (look through the 30th practical training, <http://library.ziyonet.uz/uz/book/126706>).

Generally, the purity of the variety is determined by the appraisal. The variety purity for super elite and elite seeds must be not less than 99.7 percent, and 100 percent for reproduction nursery. For I, II, and III reproduction fields, it presents three categories:

*variety purity in the 1st category – 99.5%.

*variety purity in the 2nd category -98.0%.

*variety purity in the 3rd category – 95.0%.

The reproduction of the plantation is marked on the base of variety-grade documents presented by the farm.

The crop taken from elite fields is guessed as the I-reproduction, the crop from the I-reproduction will be the II-reproduction, and so on.

According to the results of the approval, fields of the super elite and their seeds do not meet the requirements on variety purity and other quality indexes and do not have a permit from the Ministry of

Agriculture of the Republic to use these seeds; these fields and seeds are documented as the first reproduction.

Also, in the result of approbation analysis, the seed stock fields are discarded if contamination is more than 3 percent with hardly picking out weeds (wild oats), more than 5 percent with cultural plants stems, infected by hard and black smut more than 0.5 percent.

The compiled approbation statements after signed by the responsible agronomist are approved by the controller and presented to relevant organizations.

Seed control. State control above seeds' sowing quality is implemented by the state service center (photo 213) or state service rendering center on the certification of agricultural crop seeds in the controlling inspection over the agro-industry complex, as set out in Decision № 712 of the Cabinet of Ministers of the Republic of Uzbekistan dated September 16, 2022.

The specialists of the "O'zagroinspeksiya" inspect all available seed stock materials in the farms corresponding to the state standards. The seeds, which have a certificate, are admitted to sowing.

At this point, an average sample is taken to determine the seeds' sowing quality. A working sample is isolated from it to define seed purity, germination vigor, germination vitality, and the weight of 1000 seeds. The rest of the average sample is used to define moisture and damage caused by warehouse pests. The first sample is put into a seed probe sack. It has a tag in it for analyzing data. The second sample is put into a glass bottle with a 0.5-liter capacity, and it is closed tightly with cork and special drying gum. The taking of average samples is documented with a reference. The certificate about the fitness of seed stock for planting is given by the "O'zagroinspeksiya" on the basis of analysis. The results of the analysis are given if the quality of the seeds does not meet state standard requirements (table 15).

Table 15. The requirements of the State standard for seed stocks of wheat.

Indexes of planting quality	1 st class	2 nd class	3 rd class
Seed purity, in %.	99.9	98.0	97.0
Seed of other crops, unit.	10	40	200
Weeds in it	5	20	70
Germination, in %.	95.0	92.0	90.0

Moisture, in %.	14.0	14.0	14.0
Disease spores, in %.	0.01	0.03	0.05

Part III. Breeding and seed production of barley.

Chapter 1. Barley botany and world importance.

According to the published scientific and practical information, barley (order of *Hordeum vulgare*) belongs to the annual (photo 25) and perennial grasses (open <http://library.ziyonet.uz/uz/book/126706> and look at lab training of 10th for barley diversities) cereal plant of the grass family *Poaceae*. Barley, according to the number of grain rows and their order on the ear, is divided into multiple rows, two rows, and intermediate.

There are nearly 30 species of barley that establish polyploidy ranges ($2n = 14, 28, \text{ and } 42$), and one of them is *H. H.Sativum* which is planted. This species has three subspecies: *H.vulgare* L – common barley, *H.disticum* L – two-row barley; and *H.intermedium* Vav.et Orl., intermediate barley.

Asia is its native land, and it is commonly used for breads, soups, stews, and other food products. In spite of its growth as animal fodder, it was an irreplaceable source of malt for alcoholic beverages, especially beer.

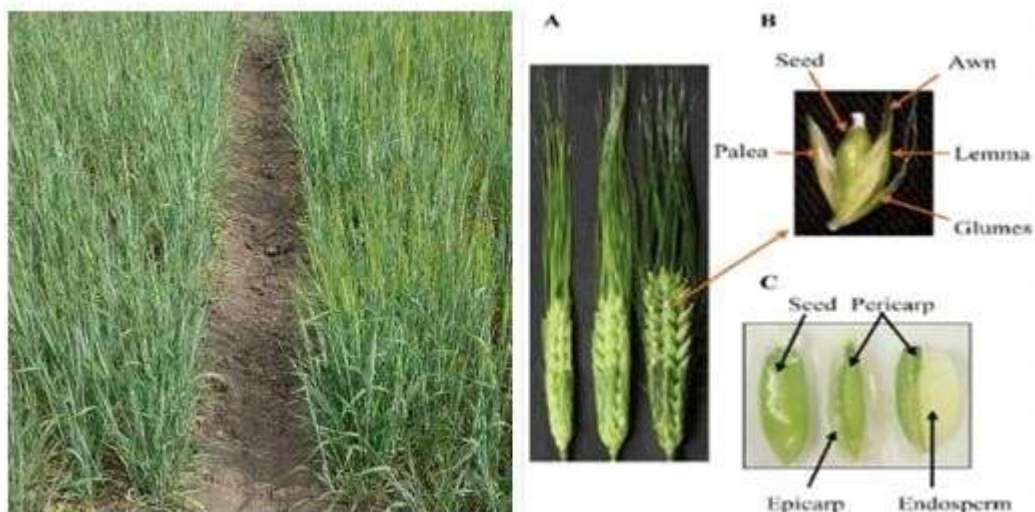


Photo 25. Growing barley plants, their spikes (A), and components of a spikelet (B, C).

Its biology has caused it to divide into winter and spring kinds. The stem is characterized by its empty tube consistence, which has 4–6 nodes. The plant's height ranges from 30-35 to 130-134 cms.

The barley plant forms a group of self-pollinating flowers along the spike and is covered with glumes (photo 25). Seed sprouting happens

at a temperature of 4-5 °C. Plants need 22 °C to grow and develop. It is resistant to heat and withstands dry weather. Grain may be covered, or nude grains have yellowish, light orange, and light grey colors. The weight of 1000 grains vary from 30 to 60 g. Grain has 64.6% carbohydrate, 13% water, 2% protein, 5.5% starch, 2.1% oil, and 2.8% ash.

The vegetation period of barley varies from 55–110 days in spring barley varieties up to 180–210 days in winter barley varieties, depending on variety properties and regions of planting. It gives up to 5.0 tons per hectare on the irrigated lands.

Barley is considered one of the world's four most important types of grain, along with corn, wheat, and rice. Data from the United States Department of Agriculture (the USDA) informs us that the world barley production in October 2023-2024 will be 141.77 million metric tons. But this data, unfortunately, was lowered from last production year by 6.55%, or 9.93 million, around the globe.

Barley is mainly grown to feed animals, produce food products, and brew beer. Its production by country, according to the last update on November 20, 2023, is given in the table 16.

Table 16. Worldwide barley production (values in metric tons).

№	Country	Production	№	Country	Production
1	European Union	48,650,000	31	Switzerland	185,000
2	Russia	19,500,000	32	Moldova	185,000
3	Australia	9,700,000	33	Tunisia	170,000
4	Turkey	8,200,000	34	Chile	155,000
5	Canada	8,000,000	35	Tajikistan	140,000
6	United Kingdom	7,150,000	36	Uzbekistan	140,000
7	Ukraine	5,800,000	37	North Macedonia	140,000
8	Argentina	5,300,000	38	Afghanistan	110,000
9	United States	4,029,000	39	Egypt	108,000
10	Iran	3,000,000	40	Libya	100,000
11	Kazakhstan	2,700,000	41	Armenia	90,000
12	Ethiopia	2,400,000	42	Kenya	80,000
13	China	2,000,000	43	Korea, South	69,000

14	India	1,690,000	44	Bosnia\Herzegovina	66,000
15	Morocco	1,350,000	45	Eritrea	65,000
16	Syria	1,100,000	46	Zimbabwe	55.000
17	Azerbaijan	1,100,000	47	Pakistan	55.000
18	Belarus	1,100,000	48	Georgia	50.000
19	Algeria	1,025,000	49	Bolivia	48.000
20	Mexico	950,000	50	Lebanon	30.000
21	Iraq	800,000	51	Jordan	25.000
22	Uruguay	750,000	52	Yemen	25.000
23	Serbia	620,000	53	Turkmenistan	20.000
24	Norway	600,000	54	Ecuador	13.000
25	Brazil	495,000	55	Albania	12.000
26	Kyrgyzstan	450,000	56	Israel	10.000
27	South Africa	390,000	57	Saudi Arabia	10.000
28	New Zealand	310,000	58	Colombia	8.000
29	Japan	237,000	59	Oman	2.000
30	Peru	210,000	60	Bhutan	1.000

Chapter 2. Growing varieties of barley in Uzbekistan and their characteristics

As it was mentioned above, barley (*Hordeum* L.) belongs to the cereals and its annual and perennial plants out of the grass family *Poaceae*. There are about 30 species, and one of them *H.sativum* which is grown. In Uzbekistan, mainly varieties of two-row barley (*Hordeum vulgare* subsp. *Vulgare*) and six-row barley (*Vulgare* subsp. *Herastichon*) are grown.

The drought-resistant barley plant is an invaluable asset to our agriculture, and traditionally, it is grown in the northern regions for grain production, in the western regions for beer production, and in the southern regions for forage production. The chemical ingredients of barley grain comprise, on average, 13% of water, 12% of protein, 64.6% of nitrogen-free substances, 2.1% of oil, 45–67% of starch, 7–11% of pentoses, 1.7–2.0% of sugar, 2-3% of fat, 3-5% of ash, 3.5–7% of cellulose, and others. Barley grain is not suitable for bread baking because of its low gluten content and lowered protein quality. But the amount of protein drastically changes (8.2–19.9%) under different growing conditions and variety diversity.

We can, in particular, analyze and paraphrase the private history of barley variety breeding in our republic by tracing the activities of one of the barley breeding and its seed production laboratories, which are functioning at the Gallaaral Scientific Experiment Station of the Scientific Research Institute for Grain and Bean Crops located in the Djizzakh region.

This laboratory had begun its scientific activities in 1913. The barley variety Nutance-27 was the first outcome, not only for the pioneer breeders and scientists who worked at that laboratory but also in the Republic of Uzbekistan. The variety was created by using the individual selection method under the scientific guidance of F.A. Kvyatkovckiy from Baysun local barley diversities (samples).

In 1939, the second result was the spring form of the local Pallidum variety, which successively expanded into production in rain-fed areas of the Samarkand and Tashkent regions. And, since 1956, a variety of Unimly arpa has been developed to bear the boiling industry. This unequal barley variety was developed by breeders V.Ya. Smirnova and others. Further, by cultivating on the rain-fed lands of Central Asia, its area has reached up to 1.0 million hectares since the 1970s.

Well-known barley variety breeders like F.Q. Qurbanov, N.V. Pokrovskiy, and others have achieved splendid scientific research results with the creation of series of new varieties like Nutance-161, Nutance-6, and Nutance-24.

Since the 1970s, varieties adopted to rain-fed conditions, intensive type, protein-rich, tend to forage production, and bear boiling purposes, resistant to drought conditions, have passed through wide testing. In 1980–1984, the variety Nutance-799 was developed, and promising hybrids for the coming breeding process had been taken from hybridizations between local barley varieties that were resistant to heat, drought, and early ripening, and Jupon, China, Sweden, and the Netherlands' comparatively resistant to diseases and lodging varieties.

Zafar and Tazim barley varieties have been the result of the scientific research activities of the laboratory staff in the years 1980–1985. The variety of Lalmikor was developed in 1985 and has half-intensiveness, high protein content, resistance to heat, cold, lodging, shading in rain-fed areas, and forage production purposes. It is preferred to be planted by the farmers in their rain-fed fields across the regions of Djizzakh, Kashkadarya, Surkhandarya, Samarkand, and Tashkent.

In 1983–1991, the breeders of this laboratory conducted ecological variety tests in cooperation with scientists from the Ukrainian plant breeding and genetics institute and could develop a new barley variety of Yugadar. This variety revealed the highest productivity (9.4 ton\ha) at the Issikkol variety trial plot in Kyrgyz Republic in 1993 and was included in the state register.

The barley variety Savruk, designated for the purposes of beer boiling, was also developed in 1993 and registered in 2002. The patent was taken for the variety of Bolg'ali in 1997. In the years 2003-2005, the varieties Noziktam and Nurota were developed to be rain fed and resistant to biotic and abiotic stresses of nature. Their beer-boiling pair, the Pibobar variety, was created in the years 2006–2008. The next developed varieties are:

Khotira-59 and Dunyo-M in 2012-2014;

Mushtarak and Sharof-100 in 2015–2017;

Bakhorikor and Abu Gofur 20 were registered in 2019.

In total, 105 barley varieties have been developed by the breeders of this laboratory during its historical period and delivered to plots of state variety trials. And 25 out of them were successfully registered and

recommended to plant throughout the republic. One of them registered to plant in the fields of the Kyrgyz Republic.

According to the State Register on the recommended crops to plant in the regions (appendix 4) of Uzbekistan, we can see the list of barley diversities and varieties planted in 2022 (table 17).

It's preferable to learn barley varieties regarding their preference by the farmers and reprocessing industry. From registered barley varieties, it can be seen that there are varieties that were registered a long time ago, such as "Unumly Arpa" (registered in 1956), "Lalmikor" (registered in 1995), "Mavlona," and "Temur" (registered in 1997).

The first one, "Unumli arpa," undoubtedly has a unique and vast array of genotype potential. Look at the table; in spite of its usage for a long period (since 1956), it is cultivated almost exclusively in the rain-fed areas of the regions (1–12). Actually, it has the best adaptability to various soil and climatic conditions and even to the differences in the multi-year weather ranges. Of course, this is the merit of its breeders at the time when this variety was created, a combination of initial breeding materials and used breeding methods.

Table 17. Barley diversities and varieties are recommended for planting in the territory of the Republic of Uzbekistan.

Name of varieties.	Order № of originator..	Code of the country	Registered year	Recommended regions to plant.
1. Winter barley (Hordeum vulgare L. sensu Lato).				
Abu Gofur	5	Uz	2015	4, 5, 8 (Rainf)
Abu Gofur 20	5	Uz	2019	4, 5, 6, 8, 9, 11 (Rainf)
Adir	5	Uz	2015	4, 5, 8 (Rainf)
Bakhorikor	5	Uz	2019	4, 5, 6, 8, 9, 11 (Rainf)
Vokha	315	Uz	2019	1-13 (Irr)
Dobriya 3	62	RF	2011	1-13 (Irr)
Ikhtiyor	5	Uz	2015	4, 5, 8, 9, 11(Irr)
Kondrat	62	RF	2012	1-13 (Irr)
Lalmikor	5	Uz	1995	4, 5, 8, 9 (Rainf)

Mavlon	5	Uz	1997	5, 8, 12 (Irr)
Mezon	5	Uz	2021	1-13 (Irr)
Mushtarak	5	Uz	2021	4, 8 (Rainf)
Novosadski 625	318	SR	2015	5, 8, 10 (Irr)
Novosadski 565	318	SR	2015	5, 8, 10 (Irr)
Nonius	318	SR	2015	3, 5, 9 (Irr)
Obikor	5	UZ	2021	3, 5, 9 (Irr)
Savruk	5	UZ	2002	4, 8 (Rainf)
Temur	12, 17	Uz	1997	5, 8, 12(Rainf)
Unumli arpa	5	Uz	1956	1-12 (Rainf)
Sharof-100	5	Uz	2021	4, 8 (Rainf)
Kizilqurgan	5	Uz	2002	1-13 (Irr)
2.Spring barley (<i>Hordeum vulgare</i> L., sense Lato				
Vodka	381	RF	2000	7, 8, 10, 11, 13 (Irr)

“Unumli arpa”, it is the bred variety of Uzbekistan grain production SRI (“Don” scientific production association). Originated from the Maroko sample, using individual selection by the breeders U.T. Rahmatulin, V.Ya. Smirnova, I.S. Kostinko, and V.I. Filipov. The variety was included in the state register in 1956 for planting in all rain-fed areas of the regions except Khorezm. The winter or spring terms of planting do not affect its productivity. Botanically, it belongs to the species Nutance. The ear has two lines of spikelets, dark yellow; the awn has a tooth; the grain has a cover that is enlarged; and 1000 seeds have a weight of 48.6–60.0 g. The grain productivity in the rain-fed area in the test years (1995–1999) was equal to 1.9–2.0 tons per hectare (photo 26). The vegetation period lasts for 198–200 days. The resistance to drought has reached 5.0. The variety includes a group of valuable barleys. It has excellent boiling quality.

“Lalmikor”. It is also the bred variety of the Uzbekistan grain production SRI (“Don” scientific production association). Developed by the individual selection method out of hybrids, it was taken from crossing combinations of varieties: Yujnokazakhstanskaya 43 and Nutanc 799. Authors: Yu.A. Aripov, B.N. Pitoya, and T. Mamatkulov. This variety is grown in the regions of Jizzakh, Kashkadarya, and Samarkand. It is a seasonal wheat and belongs to the Hutanc species.

Two-row ear with a light-yellow color, middle length, and long awn; the grains are enlarged; the weight of 1000 seeds consists of 59.5–61.8 g.

The grain productivity per hectare is 2.3 tons per hectare. During middle ripening, the vegetation period lasts 180–200 days. Resistant to drought and good to cold. Tolerant to lodging and grain shading: 5.0 mark. Feeding quality is good. Resistant to diseases and pests.



Photo 26. **Barley trial plot in the rain-fed condition.**

“**Mavlona**” is the third barley variety developed by that SRI. The same individual selection method was used in developing this variety too. The source wheat population was hybrid wheat plants taken from crossings of V-27 (K-25376, Bulgaria) and Variety Tazim. T. Mamatkulov, M.V. Lukyanova, and others were its authors.

It was registered in 1997 to be planted as a winter crop in the irrigation conditions of the regions of Kashkadarya, Samarkand, and Fergana. Botanic winter barley belongs to the *Parallelum* species. The ear has six rows with an equal corner shape and is dark yellow and short. The awn is yellow and 2.0–2.5 times longer than the ear. The grains are light yellow, and the weight of 1000 seeds is 40.4–48.8 g.

Grain productivity consisted of 4.0–5.1 tons per hectare in the test years of 1995–2000. Variety characterizes middle ripening: 205–224 days. It has tolerances to grain shading and lodging, and its resistance to cold is estimated at 4.7–5.0 marks. It has good properties based on its

food quality, which is determined by the content of 10.2% protein. It is resistant to diseases and pests.

“Temur”. Samarkand Agriculture Institute and “Don” Scientific Production Firm are the originators of this barley variety. T.Kh. Khodjakulov and others are its authors.

A two-time individual selection method was used in the breeding process. A complicated hybrid plant population (Pallidum 90 x HVS 63180\73; Pallidum 90 (Ager x Omar) x HVS 63180\73) was the initial material. The created variety had the needed results in the testing fields of Kashkadarya, Samarkand, and Farghana, and since 1997, it has been introduced into the production of these regions to plant in the winter term on the irrigating lands.

It has double-term planting properties (biologic spring) and belongs to the Pallidum species. Ear is yellow, four-corner view, middle dense. Ear awn is not sufficiently developed but longer, light yellow, coarse, and fragile. The grain is enlarged, yellow, and long. The weight of 1000 seeds are 43.9 g. An average productivity of this variety was (1999–2000) at the level of 4.9 tons per hectare in the Samarkand State variety trial station.

The middle ripening vegetation period lasts up to 193 days. Its positive indexes are: tolerant to lodging and shading; resistant to cold: 4.0–5.0 marks. It has a good feeding property and has 13.3% protein.

Resistant to diseases and pests. Weakly infects (9.0–10%) with yellow rust.

"Mezon," this variety, was developed at the barely breeding and seed production laboratory of the Gallaaral experimental station of the SRIGBC. It is the result of individual selection from a hybrid population taken between variety radical (Russia) and Ricotenze (Egypt). The variety designated to plant in the irrigation conditions of the soil characterizes its resistance to heat, drought, and diseases.

The variety belongs to the species Parallelum, straight, two three-angle, six-row ear, grain-yellow, and densely placed. With awn, the awn is longer (1–1.5) relatively to the ear and toothy, a light-yellow color.

Dormancy passed at a temperature of 0-12°C. It is resistant to -14°C at its booting stage. The seeds germinate at a temperature of 1-2°C, seedlings tolerate -8 -8°C. The variety is also salinization resistant. But it is not resistant to excess moisture and acidic soil. The technology of grain and taste indexes in the production of barley groats is good.

Grains have an enlarged size and are yellow; the grain ditch is sallow, even. The porridge cooks rapidly and uniformly, which gives it a large volume, an attractive smell, and a pleasant taste. The grains have a mean size and ellipse shape; 68–74 grains form on the ear; the plant's height is 70.5–75.0 cm; it's resistant to lodging and grain shading; the cold resistance is equal to 7 (resistant). Grain nature is 630–655 g/l, protein content in the grain is 14.3–14.9, 1000 grains weigh 36.8–40.5 g, and vegetation period is 195–209 days.

This variety has been registered as a plant to produce forage since 2021. Its productivity has averaged 5.9–7.8 tons per hectare at the state variety trial plot in 2015–2018. The vegetation period in the Denov State Variety Trial plot consisted of 206–209 days. The variety has been recognized as the perspective for irrigating areas since 2019 across the Republic.

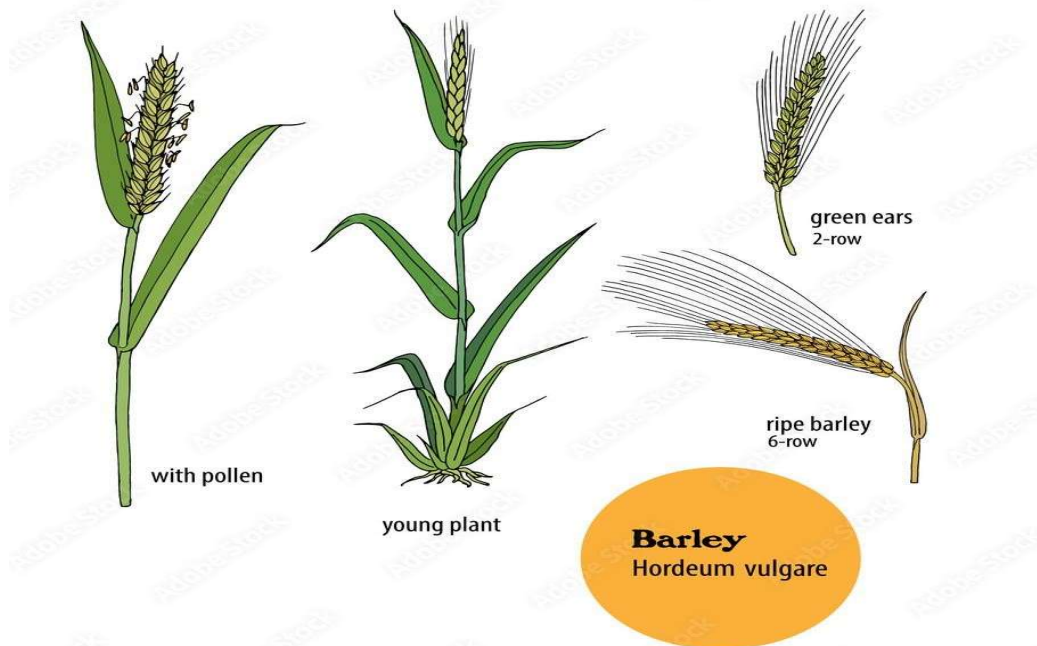
The seed planting rate was identified at 4.0–4.5 million units in the Karakalpakstan Republic, Khorezm region. 3.5–4.0 million for the Samarkand, Jizzakh, and Tashkent regions and 4.0 million for the Ferghana region.

Seed sowing method: narrow row (7–8 cm), row sowing with row crossing. Row crossing planting is giving a good result in the open fields. The depth of seed sowing is 4–6 cm. The seeds are required to be in 1 and 2 classes of germination and disinfected by fungicides. The seeds are sown in the second decade of October in the Samarkand, Jizzakh, and Tashkent regions; in the first decade of October in the Karakalpakstan republic and Khorezm region; and in the last decade of October in the southern regions. Ignoring these planting terms causes the loss of young plants and leads to fewer plant stands.

Fertilized application by phosphorus at the rate of 90 kg and nitrogen at 30 kg before plowing of soil. 70 kg of nitrogen is applied in spring (March) as the first feeding; the second 80 kg of nitrogen is spent in the tubing stage. Feeding with nitrogen is combined with rainwater precipitation.

Chapter 3. Biology of barley

Barley (*Hordeum vulgare*) is an annual plant (a member of the grass family) with a height of 30–60 cm and which reaches up to 90 cm on the cultivating varieties (figure 12, below). The stem stands straight with 30 cm long leaves, which have a 2-3 cm width and are flat and smooth. The root system has a fibrous form. At the end of vegetation, barley plants produce an ear with an awn 10 cm long.



Each spikelet has a one-flower structure with four or six edges of up to 1.5 cm in width (figure 13, 14). The spike rachis is flexible without breaking down into sections.

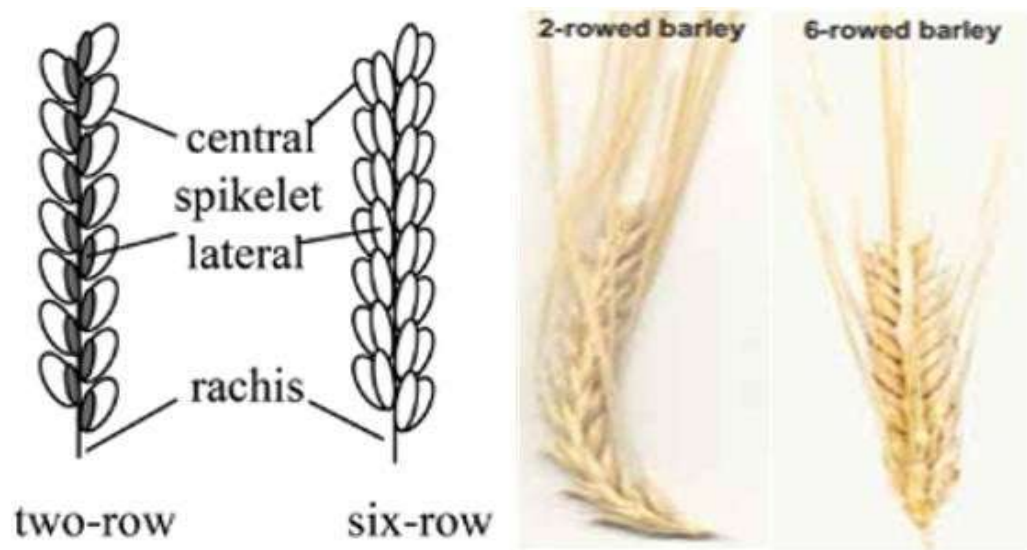


Figure 13, 14. Barley spikelet structure and farmed ear kinds.

All spikelets unite into groups of three each. All of them are fruit-forming and present idle views.

Spikelet lemma is a line awl shape dragged out to the thin awn, usually longer than their length. The bottom flower lemma (palea) is an egg-lancet shape (photo 27, 28).

Common barley (two rows) is a self-pollinating plant, but crossbreeding does not exclude it. Barley plants flower in the months of June and July. The grain is its fruit, and it forms in the months of July and August.

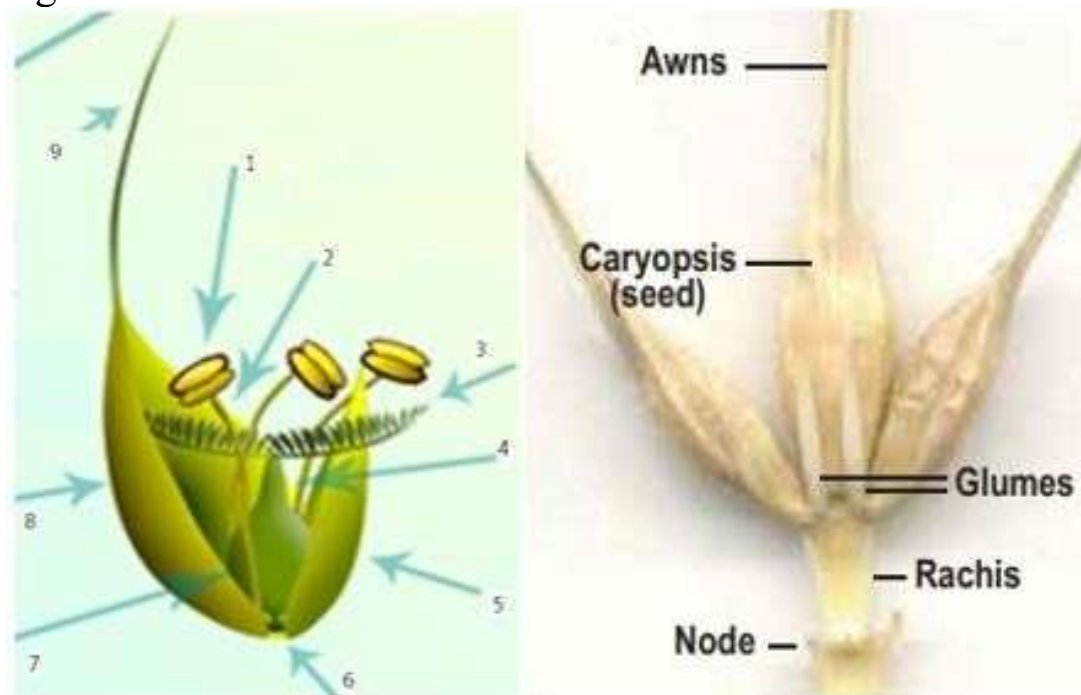


Photo 27, 28. **Schematic representation of barley flower and spikelet architecture:** 1-anther; 2-filament; 3-stigma; 4-style; 5-palea; 6-lodicles, 7-ovary; 8-lemma; 9-awn.

The following subspecies exist:

*Wild barley. *Hordeum vulgare* subsp. *Spontaneum*.

[syn. *Hordeum ithaburense* Boiss.]

[syn. *Hordeum spontaneum* K.Koch]

*Two-row barley. *Hordeum vulgare* subsp. *Vulgare*.

[syn. *Hordeum distichon* L. = *Hordeum vulgare* subsp. *distichon*]

[syn. *Hordeum hexastichon* L. = *Hordeum*]

*Six row barley. *Vulgare* subsp. *Herastichon*.

As mentioned above, the barley diversity of common barley—two-row barley is a widely distributed crop from the native land of pre-Asia—and six-row barley originated in South Asia. The spikelets of

both diversities are sat in three by two side spikelet rachi, forming six longitudinal rows on the lengthwise spikelet.

But, in the two-row barley, as in the wild barley, only two out of six sat near spikelets are fruit bearing. The grains are formed from them; the other four are fruitless and transformed into spikelet lemma. That is why two rows of grains ripen and a notable four rows of lemma in two by the two sides of the ear.

On the six-row barley, there are six sat spikelet fruits side by side, and therefore the ripened ear has six row grains.

Genetics. Frank R. Blatner informs us (2018) that about 33 annual and perennial species have been recognized in *Hordeum*. Some of them are divided into several subspecies, and about 45 different taxa belong to this genus. Interestingly, they grow in temperate and arid parts of all continents but Australia. It originated approximately 14–10 million years ago in the territories of Southwest Asia and around the Mediterranean Sea.

The *Hordeum* genus has three genome representatives: diploid ($2n = 2x = 14$), tetraploid ($2n = 4x = 28$), and hexaploid ($2n = 6x = 42$). By the way, except for two autopolyploid cytotypes (*H. bulbosum* and *H. brevisubulatum*), all polyploids of barley are allopolyploids. It is a genetic rule that allopolyploids are formed through interspecific hybridization. Here, usually genome duplication takes place just before cell division at the process of chromosome conjugation and stabilizing the karyotype by allowing chromosome pairing and an orderly distribution of chromosomes during meiosis.

Predominantly possible pathways in the formation of plant allopolyploid formations as well as in barley genetics were explained and used successfully by the genetic scientists. It turns out that it can particularly be achieved, or most often, by way of unreduced gamete formation and subsequent fertilization that takes place in the sexual cell.

In the first chance, an infusion occurs between two unreduced gametes, resulting in a polyploidy species (figure 15). This approach is scientifically termed a **one-step pathway**. Actually, more steps are needed in nature, where the reduced gamete merges with an unreduced gamete, establishing a **triple bridge** that subsequently requires reduced gamete in future generations. The next way of forming polyploidy is the **two-step pathway**. Herein, the doubling of chromosomes is achieved through (1) a homoploid hybrid and (2) somatic doubling to form the cell karyotype (nuclei) in a polyploidy state.

Developing stages of the barley plant.

Barley is an early-ripening crop. The vegetation period of barley (from germination to maturity) depends on the planted varieties and conditions of growth. The vegetation period of early-ripening varieties lasts 50–60 days, while late-ripening ones last 100–120 days (Belarus, 2019).

The barley plant also has various unique developing stages, and knowledge (or proficiency) about them allows agronomists and barley variety breeders to visually identify vegetative and reproductive stages in a crop's life cycle or in the initial breeding samples, like introduced variety diversities and even in obtained hybrid progeny plants. An adequate level of proficiency is always necessary for barley breeders in the breeding process to select superior plants based on their developing performances and ultimate productive potential.

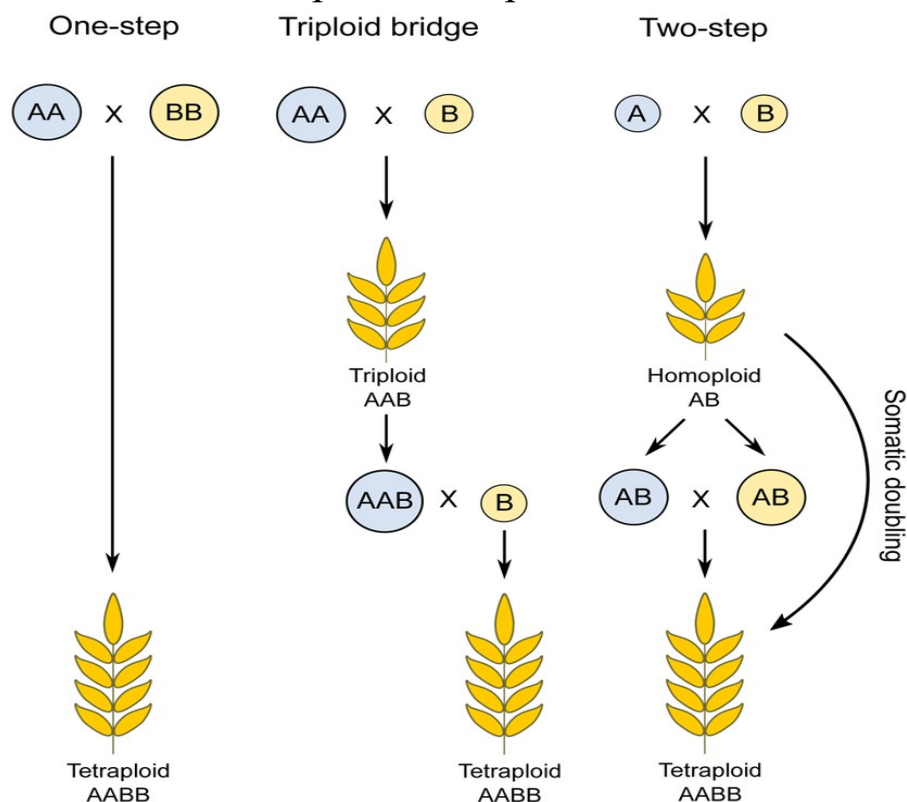


Figure 15. Pathways to form barley polyploidy species.

As stated by Meghan Gleason (2019), two common scales are used at the staging of barley plants. They are the Zadoks scale and the Feekes scale. Both measure plant maturity via vegetative and reproductive stages, but in metric quantification, they differ slightly from each other. According to his five stages:

Feekes 1. **Emergence:** seedlings of seed are germinated, begin to break the soil crust, and come out of the soil (figure 16). During this time, it's important to examine the healthy and uniform plants along the seed beds. Some of the best plants or the whole sample plants from the point of view of selection can be noted by the breeder in his field notebook. They will present their first shoot and early leaves comparatively earlier than other plants and samples.

Feekes 2–3. **Tillering:** At this stage, the stages of two and three characterize a plant that has begun to tiller. This means that the plant is forming auxiliary side shoots. At the end of these two stages, the plants have completed tillering. These two stages are a very good time to monitor the infection by disease pathogens and the damage after the distribution of pests. The breeder can note the vulnerability of the studied samples to local diseases and pests.

Feekes 4-5. **Green up:** The plants begin to grow upright by forming plant vegetative and generative elements during this “green up” stage.

Feekes 6–7. **Jointing:** The first node appears in the sixth stage. The swollen bump becomes visible at the base of the shoot. Active cell division takes place in the nodes, and leaves and tillers arise. In the seventh phase, the second or third node appears on the plants.

Feekes 8. **Flag leaf:** In five to ten days, depending on the environmental conditions, the flag leaf will emerge. This is the last leaf, which signals the change between vegetative and reproductive growth.

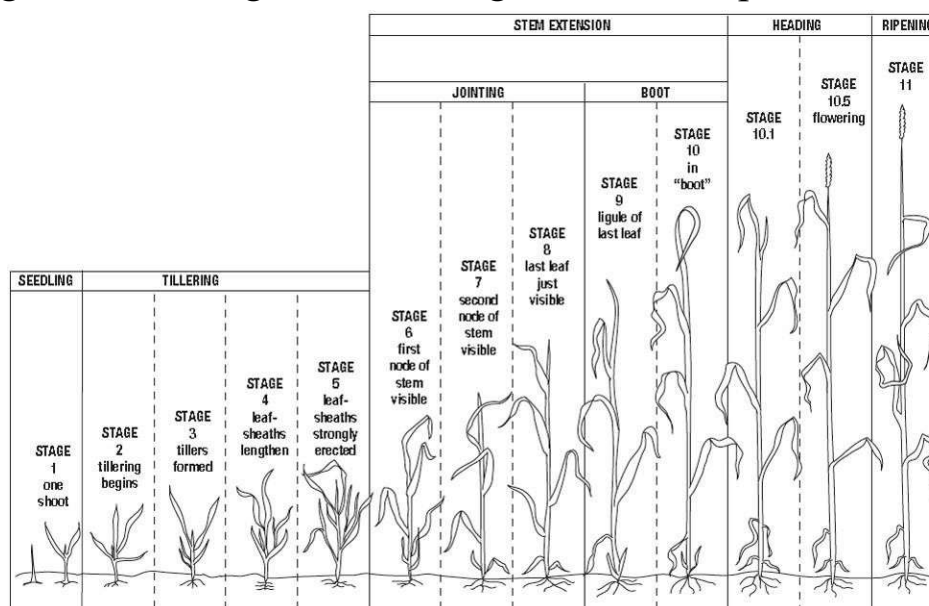


Figure 16. Barley crop staging, growth and development.

Feekes 9–10. **Boot:** The ligule of the flag leaf will be visible at Feekes Stage 9. It is a membrane on the inside of the flag leaf that connects the leaf to the sheath. The flag leaf fully develops at this stage.

The head is not yet formed during this time; it is still encased in the sheath and has only begun its swelling. Once the head appears out of the sheath below the flag leaf, the whole plant enters stage 10. A decimal scale is used in this stage to describe milestone developments during the boot stage. They are subdivisions that should be recorded when approximately 50% of the plants in the field have reached the decimal index:

*10.1. Awns visible, heads emerging.

*10.3. Heading half complete.

*10.5. Heading complete, flowering has begun.

Feekes 11. Ripening: After flowering starts, the pollination will be completed in four or five days. Ripening begins after pollination is complete. The decimal system is used in this stage again to distinguish the milestone developments of the barley plant:

*11. Formation of kernels, early milk ripening.

*11.1. Kernels full size, medium milk ripening.

*11.2. Kernel content starchy and readily crushed, leaves drying, glumes yellowing.

11.3. Kernels semi-hard, leaves dry, nodes yellow.

11.4. Kernels hard, plant dried.

Chapter 4. Barley breeding programs in Uzbekistan

Annually, nearly 40 000 hectares of land area are planted to barley varieties in Uzbekistan (2014), with a productivity of 0.4 tons per hectare, which provides 162 000 tons of grain.

Barley breeding works are implemented mainly in the Scientific Research Institute on Cereal and Bean Plants in the Irrigating Lands (the SRICBPIL), located in the district of Djizzakh region; the Kashkadarya Scientific Research Institute on the Plant Breeding and Seed Production of Cereal Crops (the Kashkadarya SRIPBSPCC), located in the Karshi city of Kashkadarya region; the Scientific Research Institute of Grain and Bean Crops (the SRIGBC), located in the district of Andijan, and their regional field experimental stations. Plant breeding departments of some agricultural institutes also lead plant breeding work with barley.

Today, the crucial challenges standing before our barley breeders are to develop and introduce into production the barley varieties with properties of early ripening, high productivity, resistance to soil salinity, lodging, diseases, double cropping in a year, and to work out innovative elite seed production methods. These breeding and seed production prospects have to focus on irrigation and rain-fed lands in the republic. Here, breeders have to take into account the differences between genotypes of forage barley, food (porridge and gruel) barley, and beer-producing barley diversities.

The grains of the forage barley variety should comprise more protein and its irreplaceable amino acids (lisin, tryptophan, and phenilalanin).

Grains of barley varieties to food product producing should be possess not only high nutritious but indexes of technologic and excellent taste with enlarged grains, yellow color, shallow trench on the grain and soft surface.

The stricter requirements that new barley varieties pose to beer brewing. These kinds of barley varieties must contain heavy grains (40 and more grams of 1000 grains), not less than 80% of the output from the sieve (2.2 x 20 mm), and malt output.

The decision to undertake these tasks mostly depends on the selection of initial materials for the breeding process.

Initial materials to use in barley breeding directions. Usually, the breeders use the best local and introduced varieties to develop **highly productive barley** varieties. Because, annually, our local barley

varieties are very vulnerable to heat weather at the grain-accumulating stage and produce a lower 20–30% yield than anticipated.

According to D.T. Abdugarimov (2007), the barley collection of the Plant Growing Scientific Research Institute has in its depository nearly 18, 000 barley samples with their rich and valuable source qualities for plant breeding. Barley varieties developed in the neighboring countries have high productivity and have adapted to their environmental stress conditions. Often, their environmental stresses are like our regional conditions, which is why they are frequently used by our breeders in their own breeding processes.

Barley varieties created in foreign countries like Germany, Sweden, Denmark, the Netherlands, Belgium, France, Great Britain, and six-row barley from the USA and Canada are more attractive but less adaptable to our local climatic soil conditions, and they are used in the process of hybridization to create **hybrid populations with vast genetic variation** for further selection intentions.

Barley breeders in Germany, France, and some other countries are known for their naked-grain **barley varieties**. In the last advertisements, we can read about one of such varieties, Pirona, released by the English barley breeders (photo 29). It was developed to produce barley flour for baking bread, pasta, cakes, and biscuits; grain (for breakfast cereals); malt; soft drinks; and thickening agents for cooking.



Photo 29. Field view of naked barley variety Pirona.

These kinds of barley varieties, with their useful characteristics, attract the continuous attention of our barley breeders, but they are not yet commercialized in our country. Usually, they have more protein than coated grain varieties and can be attracted to the breeding process to develop varieties in the direction of the forage and food production industries. In contrast with our varieties, naked barley varieties are not exempt from such lacks as grain shattering, easy penetration of moisture by the grain on the spike and growing there, and faster apical point (growing point) damage of grain at the grain trashing, which results in the seed germination lowering. To improve these shortages, it would require more time and additional efforts by our breeders to develop local naked grain barley varieties.

Russian barley breeders have made great progress in creating naked grain varieties designated for forage production (2018). The varieties of such barley, Nudum 95 and Granal 32, have increased nutritional substances: raw protein, up to 20.6% in contrast to 13.0% in the standard; irreplaceable amino acids, -4.83 to 5.05% in contrast to 3.96% in the standard; raw fat, -2.30% in contrast to 2.10 in the standard; and so on.

The best barley varieties of Russia would be greatly help to our breeders in the creating the good **forage** varieties. Its breeders used barley forms of Ethiopia to develop varieties which comprise much protein (13-18%) and lysin in the protein (4-6%). In common varieties these indexes range from 2.2 to 2.5%. The varieties of Rizo 1508 (Denmark), Lys3a (Hayprole) are non-allele gene donors. Much more lysin content doesn't related with its much protein content. In contrast of these, Bankuti and Koran varieties from Hungary have distinguished considerably for their high protein contents.

Generally, two row barley varieties are used to **beer brewing** but in America and in Canada there are multi-row barley varieties: Genesis, Endeavor, Brewski, and Buzz (from the United States); and Bow, Synergy, Connect, Lowe, Copper, and Churchill (from Canada, 2021) for this purpose. Later, this kind of barley varieties were developed in the European countries (Beka, Holker, HB120, Bahate, Bokoji, and Sabini, 2020) too. The main requirements posing to them are: seed germination not less 95% and simultaneous seed germination. Difference in the forming of seedlings will cause worsening the quality of producing malt. Preference will be given to yellow color of grains and thin cover membrane on the grain.

The barley variety diversities of Czechoslovakia, Austria, and Germany have superior beer-brewing qualities. Grains of some Russian varieties: Moscovskiy 121, Combiner, Nosovskiy 9, Azimut (2022), Vlagodar (2022), Deva (2022), and Evgeniya (2022) were also highly valued by the beer brewing companies.

In particular, Russian scientists engaged in the inheritance and genetic control of beer brewing variety hybrids. At this stage, spring barley varieties Omskiy 87, Signal, Odesskiy 100, Maresi, Viba and their f1 hybrids were studied. The volume of research was made up of 400 perspective lines, and every combination had 20 lines. The varieties Omskiy 87, Omskiy 88, Omskiy 89, and Omskiy 90 were sown as the group standards. About 200 of the best variety lines meeting beer brewing requirements were selected and delivered to the laboratory for malt index analysis.

The best varieties for beer brewing have a membrane index of 92. And protein content must be at a level of 9–10%, and since it is increasing to 13%, it leads to a loss of taste and unfitness of the variety to the beer brewing. The more starch (78–84%) in the grains, the higher the beer output. It must be noted that there is no considerable distinction between barley to create forage variety (Ratnik, Golozerniy 1) and beer variety, which is why there are pairs using varieties (Nutans 187, Kazanskiy 6/4, Combayner, Moscovskiy 121 and others).

It is known in agriculture that **early ripening** has a negative correlation with high productivity. But barley breeders could develop early-ripening varieties with high productivity; they are: Tomsk, Krasnodarskiy 35, Mamluyk, Biom, Abalak and Nevan.

The historical Diamant variety of Czech was one of the varieties possible to generate an uncountable number of new **high-product-quality** varieties. Such kinds of barley varieties are highly evaluated and applied in different breeding works. Only this variety was the initial material to create 12 new varieties in Czechoslovakia and 5 in Germany. Russian variety Ujniy can also be an example. On the base of this barley variety were developed such varieties as Hutance 244, Odesskaya 100, Meridian, Moscovskiy 2, Kharkovskiy 74 and others.

Improving the **resistance of barley varieties to soil salinization** in irrigating **conditions** is a priority direction in barley breeding. Because the soil of many regions is subjected to different salinization degrees, getting the needed grain crop from barley has mostly challenged its resistance. Thereby, breeders of experimental field

stations located in regions with soil salinization also conduct selection works on the salt resistance or tolerance to adaptation of new varieties in the conditions of soil exposed to salinization.

In 2017, scientific research by the TSAU (Umarova Zh.T. and others, 2017) studied the seedling germination energy of perspective barley varieties: Makhsuldor, Saykhun, Syrdaryo, Navosadski-565, Navosadski-525, and the standard, commercialized variety Bolgali (table 18). The seeds (500 units) of these varieties were sown alone on an area of 1m² in the four replications. These varieties could show their growing potential in the middle-salted soil-climatic condition of the Syrdarya region. They have considerable values for the standard variety of Bolgali. In the first date of records, all local varieties were superior to standard (20%) but only one, Syrdarya, which was a little bit low (2%). Both of the foreign varieties differed from each other. Navosadski-565 (photo) has shown 5% more growing potential than standard in the condition of middle-degree salted soil. Navosadski-525 (photo 30) has been affected, and its index was lower by 4% than the standard (20%). Further growing activities between the studied varieties were specific, depending on their origin and genotype.

Table 18. Seedling formation potentials of winter barley, in%.

№	Varieties.	Origin	Periods of sprouting				
			18.10.	20.10.	22.10.	24.10.	26.10.
1	<u>Bolgali (st)</u>	Uzbekistan	20	38	56	75	84
2	<u>Makhsuldor</u>	-\\-	23	45	60	77	89
3	<u>Saykhun</u>	-\\-	29	47	62	78	92
4	<u>Sirdaryo</u>	-\\-	18	35	54	73	82
5	Navosadski-565	Serbia	25	46	58	79	90
6	Navosadski-525	Serbia	16	30	49	70	80

At the last date of the survey, or in eight days (October 26.), the index of the standard variety Bolgali has achieved up to 84%. While some of them, Makhsulot, Saykhun, and Navosadski-565, could demonstrate their superiority on the salt resistance in comparison with the standard correspondingly: 89, 92, and 90. Of course, these three varieties could display valuable high potential in this soil condition and can be recommended as salt-tolerant initial materials for future barley breeding programs.

This progress would predict that the ultimate productivity of varieties will often be provided by the energies of these remarked varieties.



Photo 30. Varieties of Novosadski 565 and Novosadski 525.

We know that the productivity of any agricultural crop is directly correlated with such traits as early plant maturity, the number of plants per a certain area, the number of grains per plant, the weight of 1000 grains, and so on.

The numbers of plants in the studied varieties per m² of area were also recorded by the scientists of the above-mentioned experiment (table 19). The more active plants were grown in variant 3 (a variety of Saykhun). These plants had the highest potential for germination, and now the number of grown plants out of the 500 planted seeds (500) is the top one (460) for the fifth record. Even so, we can see its power since the first record time, which was the highest one (145) in comparison to others.

This manner of the highest growth on the faster plant number forming in the saline soil belongs to the other: Novosadski-565 (125) and Makhsuldor (145) also. Eventually, these three barley varieties will prove themselves as the donors to improving the salt resistance of future developed barley varieties.

Table 19. The number of barley seedlings on the recorded dates.

№	Varieties	Origin	Periods of sprouting				
			18.10.	20.10.	22.10.	24.10.	26.10.
1	<u>Bolgaly (st)</u>	Uzbekistan	100	190	280	375	420
2	<u>Makhsuldor</u>	-\\-	115	225	300	385	445
3	<u>Saykhun</u>	-\\-	145	235	310	310	460
4	<u>Sidarvo</u>	-\\-	90	175	270	365	410
5	Novosadski-565	Serbia	125	230	290	395	450
6	Novosadski-525	Serbia	80	150	245	350	400

Another barley variety, Temp (Russia), has strong resistance to NaCl salinity in the soil in the field experiment conducted by the scientists of Dagestan State University in 2016. There were studied three well-known varieties (table 20).

This variety is saved in the catalog of the Russian Institute of Plant Growing and available to all neighboring countries to use as a recognized donor for its soil salt resistance.

Table 20. Barley varieties subjected to the study.

№	№ of VIR catalogue.	Species diversity	Name	Origin
1	K-21905	<u>Pallidum</u>	<u>Zavet 3</u>	<u>Krosnovarskiy region</u>
2	K-15240	<u>Pallidum</u>	<u>Dagistanskiy 239</u>	<u>Dagistan</u>
3	K-22055	<u>Nutans</u>	Temp	<u>Krosnovarskiy region</u>

Some European barley varieties are distinguished by their **resistance to lodging**, and they are invaluable initial materials in hybridization. The most famous varieties are Narimchanin, Zazerskiy 85, Propino, Avalon, Laureate, and Ellinor. Resistance to lodging is frequently related to the lower height of plants, but there are also high-height plant varieties that are resistant to lodging.

Powdery mildew, black smut, dwarf rust, root rot, dark-brown spotting, net spot, fuzarious and bacterious are distractive **diseases** to barley varieties and developing new resistant varieties to them has great importance in barley breeding.

Powdery mildew has a considerable effect on the productivity of barley varieties in Western European countries. Monte Cristo was a donor variety for a long time. So, their barley varieties have remarkable resistance to this disease, and our breeders prefer to select those varieties as foreign donors to improve our local barley varieties. Moreover, Canada and the USA barley breeders also have a lot of powdery mildew-resistant varieties that are used in the breeding programs. For example,

Canadian breeders applied the Rabot and Modia African barley varieties in their breeding processes.

Smut infection of barley ears (2018) causes the crop to lose 0.2–0.3 tons per hectare, or 10–15%.

Black smut doesn't mean nothing for European barley breeders, but in the USA and Canada, tolerable varieties were developed for it. At this point, the use of the special genes of Run 3, Run 6, and Run 8 has been efficient in this direction. The genes of Run 3 and Run 6 were found in the variety Djet from Ethiopia and have been transferred to the varieties Convist, Bonanza and Ogalitsi from Canada. Run 8 was found in the Milton variety of Canada. All these genes can be entered into new varieties through incremental crossings. In contrast to other genes, these genes are not related to genes negatively affecting valuable farm traits and properties. In neighboring countries, Russia also has barley varieties such as Pervenets, Moscovskaya 2, Vityaz, Atlant and Kazak that are resistant to smut, and they might be used by our breeders.

The genes Pa 7 and Pa 3 that are efficient against dwarf rust were maintained in the varieties of Czechoslovakia (Karat) and other European countries.

Odesskaya 82 and Lotos varieties from Russia are famous for their resistance to root rot.

There are other donors who are resistant to diseases and pests. Their number grows gradually because, during the period of working with them, the breeding organization inserts their resistance to their own valuable varieties. Other traits, like resistance, do not have any interest. For example, the above-mentioned variety Djet has tiny seeds, is not resistant to drought, and has less productivity. Primitive Northern America and Arab continent varieties have many negative traits. Intensive research on the combining of different disease-resistant donor genes has resulted in the creation of complex resistant varieties Elim, PAN 3408, Ratel, and SSTo127 which are available to all breeders to use in barley breeding programs. For example, there were varieties Western Fort and Ottawa 3092 A, SY Buzzard and SY Nephin resistant to powdery mildew, smut, dwarf rust and some pests.

Krosnoyarsk SRI was known for its variety of samples picked out of the world collection resistant to fungus diseases of barley. Along with this, the growing method of isolated tissues continues to work out the production of technologies for producing resistant spring barley regenerators to abiotic factors. Herein, 116 regenerators were produced

from 11 parental barley variety samples, and 80% of them were taken from selective medium. Later, it was announced that 20 regenerator lines were reproduced from their seeds. Two lines out of them were superior to the standard in terms of productivity. Other regenerator lines have a range of traits distinguishing them from parental forms.

Cereal aphids, wheat bulb fly, leatherjackets, grey field slug, Swedish fly are barley **pests**.

Beatris (κ-31175), Khadjibey (κ30844), Amilet (κ-30943), Sasha (κ-31110) and Arat (κ-31200) were the best resistant barley varieties to pests in the field studies of the Russian scientists in 2017.

Rainy and cold spring days in Uzbekistan rapidly change into drought and hot days. As a result of this barley being at its crop-accumulating stage, it is exposed to strong heat and loses 20–30% of its potential crop.

Our breeders, in spite of the adequate **drought** resistance of local barley varieties, continue to use the varieties from drought-affected regions as an important source of hybridization. They are barley varieties from the deserts of southern Russia, Ukraine, and Middle Asia. Prekosius 143 is one of the most resistant varieties to drought. Other drought-resistant donor barley varieties are Solum and Solar (from the USA, 2019), Chiffa (2016), Assiya (2016), and Khanata (from Morocco, 2017).

The cold resistance of the initial material has great importance for the winter barley varieties and their breeding. The properties related to cold resistance belong to southern Ukraine and northern Caucasus varieties such as Rosava, Vista, Snejnaya Koroleva, Ivan, Luda, Surpriz, Istochnik, and Aleksandriya.

It was especially emphasized that the Don Plant Breeding Center could breed barley diversities that have deep-located booting nodes and double nodes. One of them is able to provide the needed number of boots in any condition of cold. Developed barley breeding directed to cold resistance formed in the countries of Germany, Sweden, and Latin America. Their barley varieties (Amidala, Lexy, Avalon; SW Judith, Anneli, Kannas, Arild and Q. Palomar (1994), Q. Painé (1997), and Q. Ayelén (1998)) can be successfully joined in our barley breeding programs.

Double cropping in a year by using early-ripening plant varieties is the crucial direction in adapting agriculture to modern climate change, which already has become a world challenge. A double cropping system with the use of different crop varieties has been worked out by scientists

in various countries since the 1990s (Russell Moomaw and others, 1991). In particular, scientists in the US found a positive effect of the barley-sweet corn system on farm productivity (18.5 and 5.6 tons per hectare for the double system and single cropping, respectively) and return on investment (1.8 and 1.4 as the benefit cost ratio for the double cropping and single cropping systems, respectively).

The development of early-ripening barley varieties by our breeders has the same object as the extension of double-cropping areas in the republic. The productivity of successive crops like grain and bean crops in Uzbekistan depends on the vegetation periods of winter crops. That is why the study of barley variety diversities from different parts of the world is essential for our breeders to involve them in crossings and create early-ripening varieties to meet double cropping requirements. The barley variety “Mezon” released at the Gallaaral scientific experiment station of Grain and Bean Crop SRI has fully coincided with the farmers interest in a double cropping system. Hybrid lines from the crossing of Radical (Russia) and Pikotense 483 (Egypt) and individual selection have enabled the breeders to evolve this variety. It belongs to the species diversity of *Parallelum*. Performance of the variety “Mezon” shows its early ripening in comparison with the standard variety “Qizilkorgon” (table 21).

Table 21. **Valuable farm traits and properties of variety “Mezon”** (Data published by T. Mamatkulov and others, 2020).

№	Indexes.	Measuring values.	Vegetation period of “Mezon” an average for years of 2015-2018.	Vegetation period of “Qizilqo’rg’on” an average for years of 2015-2018.
1	Productivity	Ton\ha	66.9	63.6
2	Grain natura	G\L	643.8	631.7
3	1000 grain weight	Gr	39.2	37.9
4	Amount of protein	%	14.6	12.3
5	Height of plant	Cm	71.2	86.8
6	Vegetation period	Days	200.8	205.7
7	Resistance to lodging	Mark	5.0	4.5
8	Resistance to disease	%	0	5
9	Resistance to shading	Mark	5.0	4.2
10	Number of grains per ear	Unit	71.0	65.7

There was also another barley breeding direction, which was called **a lot of stem barley breeding**. This breeding direction of barley based on the creation of barley varieties tolerant to a high plant density has arisen due to a lower level of competition, like in the wheat population. There are available plant samples with 700–800 ear stems per 1-meter square area. Some scholars believe that their number can be increased to 1000.

Direction to much lysin containing variety and diversities. There was a special direction for the lysin-containing varieties on the base of the lys gene. Grains of these barley varieties are usually designated for food product production. But many lysin-content varieties, like Odesskiy 84 L, have negative genetic correlations with productivity by 10–15%. Of course, this situation affects the slowing down of breeding activities directed toward the development of high-lysin-content varieties.

Chapter 5. Barley breeding methods

There are well-known plant breeding methods such as selection, hybridization, heterosis, mutation, inbreeding, polyploidy, haploidy, and genetic modification. To know which one or some of them was or were preferable and successful to use by our barley breeders, it needs to read the methodic origins of registered and planted barley varieties in our republic. So, according to the state register of 2022, there were 21 winter and 1 spring barley variety (table ..). Six of them were introduced as foreign varieties, and the remaining 16 varieties were created by our breeders in Uzbekistan.

Analysis of the originating ways of some of those 16 local varieties showed that most of them (Abu Gofur, Abu Gofur 20, Adir, Bakhorikor, Vokha, Ikhtiyor, Lalmikor, Mavlano, Mezon, Mushtarak, Obokor, Savruk, Temur, Unumli arpa, Sharof-100, and Qizilqorgon) were the result of inter-varieties of individual selections. Of course, intra-species hybridization is the most frequently used method to create plant population diversities for individual selection of desirable plants out of them. And, because of using geographic remote genotypes:

Lalmikor from the crossing of Ujnokazakhstanskaya 43 and Nutance 799 belongs to the Nutance variety species;

Mavlona originated from crossings of Bulgarian V-27 and Uzbek Tazim, which belong to the Parallelum variety species.

Mezon, from Russian Radical x Egyptian Pikotenze 483, belongs to the Parallelum variety species;

Savruk through individual selection from a hybrid of Unimly arpa X Kharkovskiy 84;

Temur through double individual selection from complicate hybrid (Pallidum 90 x HVS 63180\73; Pallidum 90 (Anjer x Omar) x HVS 63180\73 (mutant variety Elite);

Unimly arpa originated from the Maracco variety sample, which belongs to the variety species Nutance, and in the crossings, these developed varieties have pretty complicated genetic contrasts.

Saturating backcross and multiple individual selections were also applied (Temur evolved from Pallidum 90 x HVS 63180\73; Pallidum 90 (Ager x Omar) x HVS 63180\73 and two individual selections) in the breeding processes. Usually, this saturating cross is used in the breeding process for the congestion of the genes of disease resistance and the high lysin content of the newly developed genotype.

D.T. Abdukarimov (2007), in his textbook on "private selection," underlines that "**hybridization of remote forms** in barley breeding has no practical importance. But in this, attention should be focused on the ease of crossings between cultural barley species: *H.spontanlum* and *H. agriocrithon* Aoberg. Crosses between other species will not yield any positive results. Let it be seeds at this, but their germs won't be alive."

The growth of the germ in the nutritious medium has enabled the formation of 15 hybrids between cultural barley and wild species. Except for this, hybrids have been formed between barley and rye, wheat (in particular, *T. timopheev*), wild wheat, and different species of *elemis*.

Using cultural barley as a paternal grain helps to make crossing easier. Crossing with wild species is considered purposeful because of the existence within them of the most resistant forms to drought, cold, salinization, and diseases. Unfortunately, often the hybrids formed are sterile (infertile) and useless in barley breeding. Amphidiploid between barley and wheat: *Tritodeum* (*Triticum* + *Hordeum*), but it's difficult to say its performance.

In the internet source, we can see the question: What are the methods of barley breeding? And its answer is: pedigree selection, single seed descent, and double haploid (DH) production.

The pedigree method means the selection of certain plants belongs to self-pollinating species and progenies taken from them; often they are lines without mixing seeds of other lines. In the west, it is called "ear-to-row." This is a basic method utilized by our barley breeders as an individual selection out of hybrid progenies.

Single-seed descent is explained as an easy inbreeding process aimed at deferring selection in successive generations of a pollination between two homozygous lines. And what is a double haploid? According to the internet source, a double haploid is a genotype formed when haploid cells undergo chromosome doubling. Hand-made double haploids are important in barley breeding programs.

Haploids in barley breeding. In general, haploids are organisms with gametic chromosome numbers in their somatic tissues. They may arise spontaneously or be induced in many artificial ways. According to the information provided by Gail M. Littlejohn and R. de V. Pienaar (2013), there are four methods of haploid production. They are: the use of the *hap* gene, ovule culture, pollen and another culture, and the interspecific cross between *Hordeum vulgare* and *Hordeum bulbosum*.

And they especially note that the last has been used most extensively, as it consistently produces relatively large numbers of haploids. These haploids originate from the elimination of the *H. bulbosum* chromosomes from the developing embryo. Due to the degeneration of the endosperm, the embryos are grown on sterile culture medium to enable them to continue their growth and development. In this way, scientists obtain large numbers of haploid barley plants. By using this method of plant breeding, South African barley breeders hope to improve their barley varieties.

In 2021, it was reported that 75 percent of west Australian barley areas had been planted by the Spartacus and Neo barley varieties, which were developed through mutation methods. It was also underlined that Neo has the potential to further enhance Australia's reputation as a global leader in the provision of malting-quality barley. Furthermore, the variety is well suited to medium- to high-rainfall environments, boasting strong pest and disease resistance and superior grain quality indexes.

Recently, L. Cistue and others (2023) studied differences in creating linkage maps from DH populations derived from female and male gametes and increased population size better for QTL (quantitative trait locus) mapping (figure 17).

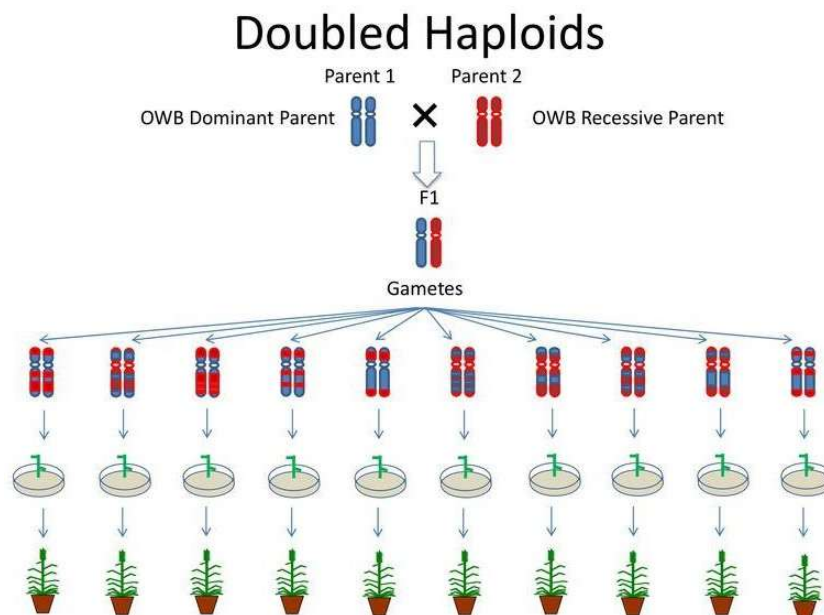


Figure 17. Comparative mapping of the Oregon Wolf Barley using DH lines derived from female and male gametes (L. Cistue, A. Cuesta-Marcos, S. Chao, B., 2023).

82 unique individuals of doubled haploids from female gametes and 93 individuals from male gametes were combined into a new population of

175 through the use of different types of molecular data on linkage for this population: RFLP, AFLP, SSR, DArTs, SNPS, and RADs. Scientists waited for some differences because two different parental populations had derived from different meiotic events. In particular, we identified positions on the chromosome where QTL-controlling traits have been found. They are genes known as VRS1 and ZEO1.

Induced mutation. This method is widely used in barley breeding. The first barley mutant variety was developed in Sweden: a radio mutant of the varieties Pallas and Mary Banus. There are many such varieties now. In 2021, Boryana Dyulgerova and N. Dyulgerov from Bulgaria assessed the variation of quality traits among mutant lines of winter barley. At this point, nine mutant lines were driven from the advanced breeding line Kt3029 and ten mutant lines derived from the variety GA-Luttrell. In the experiment, the content of protein, starch, lysine, fat, ash, and fiber was determined. Considerable differences among the mutant lines and the parent forms for the analyzed traits were observed. Considerably higher protein content compared to the parent was found in the grain of mutant lines 22/1-5, 22/2-10, and 22/1-12 from line Kt3029 and 26/1-1, 26/1-3, and 26/2-11 taken from variety GA-Luttrell. The grain of mutant line 26/2-12 had the best combination of protein and starch. Mutant lines 22/1-11 and 22/1-12 from Kt3029 and 26/1-1, 26/2-1, and 26/2-12 from variety GA-Luttrell showed a good combination between protein content and 1000 grain weight. These mutant lines can be included in the breeding processes for the creation of varieties with improved feed indexes.

Russian scientists: A.Nikolai, N.Shchennikova and others (2021) conducted a comprehensive assessment of the spring barley variety “In memory of Dudin” by using the method of individual selection from the treatment of the spring variety “Bios 1” with laser red light (wave length 632.8 nm) for 60 minutes. The most remarkable contrast of this mutant variety to its standard was its 4–7 days earlier ripening. And then, based on this comprehensive assessment, the authors have recommended this variety for the state variety test.

B. Prasad, and others (2022) recognized that induced mutation has become an established tool in agricultural plant breeding. Otherwise, it provides supplement germplasm to improve crop varieties in certain specific traits and properties. According to their statement, induced mutation is successfully used in various aspects of barley breeding too. For example, lax panicle, reduced plant height, earliness, biochemical

modification, and physiological mutants were isolated. So, In recent years, interest has doubled in mutation research since induced mutagenesis is also gaining importance in plant molecular biology as a tool to identify and isolate barley genes and study their structure and functions.

The scheme of commonly functioning breeding processes, stages of plant breeding, and using orders of nurseries worked out for cereal self-pollinating crops coincides also with the biological features of barley and is used usually by our barley breeders either. The aim of barley breeding in this scheme, as in other self-pollinating crops, is to select homozygous, highly productive plants, assess their offspring, and release a new variety on their base. Accordingly, this scheme reflects the plant breeding research order with a number of bred samples in the successive nurseries.

Nursery of initial material:

- a) collection;
- b) hybrid;
- c) special.

They deserve to be the main source of genetic diversity from which to select the necessary plant forms for further work. Collection material, mutants, polyploidy, and other accessions are studied in these nurseries, and plant pollinations are carried out.

1. **Collection nursery.** The primary study of the initial material—the best local varieties, foreign breeds, and valuable accessions to plant breeding—aims to select the most perspective forms for further study and comparison in the next stage (in the plant breeding nursery) of plant breeding works. Beside this, replanting (ones for 2–5 years) of collection accessions to maintain the germination of seed stock material is conducted in the collection nursery.

The number of accessions in this nursery may sum up to 300 to 2000 and more. 100–200 barley grains of every accession are sown on the lot with a length of 1-2 m. The feeding area varies from 5x20 to 10x30 cm. The standard is laid in 20–30 studied numbers (sometimes in 10–20). Replication is absent (photo 31).



Photo 31. **Mechanical seeding in experimental lots and nurseries built by Kazakh scholars in 2018.**

The best accessions are harvested from the whole lot, as the bundles view or hand harvest on the 50–100 superior ears per lot, as well as in the view of individual elite plants.

1. **Hybrid nursery.** All hybrid generations from F1 to F6, and even the more late generations, are planted in this nursery. Mechanic planters (photo ..) are used to ensure a plant feeding area of 5x20, sometimes 10x20 or 10x30 cm, for reproduction of earlier offspring, or at the selection of elite plants and seed drill SSFK-7 with a row width of 15 cm, at the lot of splitting generations of the hybrid population, designated to select elite ears.

The standard is laid out in 10–30 numbers. The size of the lot is defined by the seed number and hybrid generation (usually not more than 10 m²). The number of rows is defined depending on the grain amount of F1 and selected elite plants F2, and F3, the number of lots, the scale of hybridization, and the number of selections. 2 m is convenient for F1 hybrids, 6 m for F2 and F3.

In the hybrid nursery are harvested: a) individual elite plants, selected based on certain traits; b) the best ears; and c) the best families of older generations.

On both above-mentioned nurseries, the number of lots, number of selections, origin (combination of hybridization), height of plants, number of productive stems, botanic diversity, and ear shape are indicated. Rejection on grain (color, plumpness, weight of 1000 grains, and so on) is conducted after the trashing of individually selected plants or selected families.

c)Special nurseries. The necessity of special nurseries arose from the use of methods such as polyploidy, tissue culture, and cell culture in plant breeding to culture mutant forms, or polyploidies, aneuploids,

haploids, and others. The nursery of hybridization and the nursery of parents also belong to the group of special nurseries.

3.1. A plant breeding nursery is laid without replication. The material was evaluated over two years: the first year saw the formation of a plant breeding nursery (PBN-1), and the second year saw the formation of a plant breeding nursery (PBN-2). Plant breeding material of all selections of elite plants, ears, and accessions; lines of repeated selections from splitting lots; plant breeding nurseries of previous year plantings; and other materials come in PBN-1. Their general number in the enlarged plant breeding centers reaches 5–10 thousand.

The size of a lot in the PBN-1 individual line can be different, that is, with various numbers of rows, but the length of these rows must be the same. Planting is conducted by hand drills (for example, SPR-2 by the construction of SibSRIA), with a rate of sowing of 10 to 40 seeds per strip meter. Lines are compared with each other and with the standard, which is disposed of in 10-20-40 lots.

Phenology surveys and assessments of resistance to lodging and infection by diseases and pests are carried out in the vegetation period. Thorough inspection and rejection of bad lines on the root in the field before the full maturity stage begins are implemented, and after thrashing, on the grains. Not more than 4–5% are selected for further work.

The lines are sown in PBN-2, selected from the first-year plant breeding nursery (PBN-1). The planting is conducted with the help of seed drills SSFK-7 or SKS-6-10 in the lots with an area of 2-5m².

The surveys and assessments were similar to those from the previous year in PBN-1. Individual selections for repeated sowing in the plant breeding nursery are fulfilled in the most valuable but not yet uniformed phenotypes. The best isolated lines are harvested in combinations, with a few specialized combines. Rejection on productivity is conducted in the laboratory; the grains are weighed, the weight of 1000 grains is defined, and protein content and quality indexes for beer production are identified. The best offspring (25–30%) are submitted to the control nursery.

Control nursery. Here, the seed material is enough, and it allows us to begin assessment and compare testing material per area. With this, the size of lots rises up to 2-10m² and more. Beside this, the replication of the experiment is included. The planting is executed with the seed drills

of SSFK-7 or SN-16P, with the seed rate accepted in the production with the two, four replications.

Testing numbers are assessed based on the individual trait and so on their totality; within them, productivity is the major one. Additionally, taking into account the productivity of the stem stands per meter area of two neighboring rows on the lot and the plant height in the three places.

In parallel with the positioning of the control nursery, the seeds are sown on the infected background to assess their resistance to different kinds of rust, smut, and mildew. The valuable lines are harvested by special combiners. The grains are weighed after drying, with a defined weight of 1000 grains, uniformity, plumpness, and beer brewing quality. The numbers significantly superior to the standard are defined through statistical treatment. Desirable numbers (20–25%) are selected for the next steps of the breeding process on the basis of the main final data.

Preliminary (small) variety trial. Here, as in the control nursery, the assessment of numbers under testing by their crop per area is continued. The best lines out of the control nursery are assessed in the preliminary variety trial. Recording area of a lot to cereals makes of 10–25m², four replications, randomized positioning of varieties, or systematic. The standard is laid out in 5–10 testing lines, which are now named varieties. Planting is done by seed drills of SN-16P or SSFK-7, with a seed planting rate accepted in the production. The number of testing varieties is 25–30, but at great work scales, it may reach 100.

Phenology surveys, assessment, isolation of gaps, harvest, and inspection of probe bundles are carried out using the method of state variety trials. As a rule, all sets of varieties are planted in parallel in the provocation background to evaluate their resistance to fungus diseases and cold. Harvest is conducted by special combines. 1–3 kg grain average probes are taken from every variety for full technological and biochemical analysis. The data from crop recording and other corresponding inspections undergo statistical treatments. The best ones are isolated based on the result of the comparison of the summed data to study in the competitive variety trial.

Competitive (basic) variety trial. Here will be given the basic assessment of the superior varieties, which came from preliminary variety trials and were taken to ecological variety trials by other SRIs, isolating some from them that were superior to commercialized local varieties.

The total number of varieties tested in the competitive variety trial usually ranges from 10 to 20 and may reach 40 to 60. The planting is similar to a preliminary variety trial. Replication is four or six fold folding with random or systematic variety positioning. The area of the recording lot for cereal crop is 25–50 25-50m². The varieties are studied for 2-4 years according to the method of the State Variety Trial.

Ecological (within stations) Variety Trial. This is an important link for finalizing the assessment of the new varieties and filling competitive variety testing. Its aim is to study the simultaneous reaction of new varieties in the different soil-climatic zones, to obtain first-hand information about their resilience, and to check the productivity data taken in the experiments of the originator.

Ecological variety trials are organized at all plant breeding establishments of any plant breeding station. A competitive variety trial has been accepted. Two-four better varieties are created in plant breeding establishments and plant breeding centers, and two-three standards are included in them.

Special Variety Trial. The necessity of conducting new variety assessments arises often in plant breeding practices on traits that were not fully revealed at the testing in the common conditions. The special variety trial is organized in such situations.

Variety trials in different agro-backgrounds, production variety trials, and others belong to it.

Preliminary seed reproduction. The originator of the new variety must provide the necessary amount of seeds at the moment of delivering the new variety in the state variety trial to send in several state variety plots and in the plot of the production variety trial. So, 0.5–2.0 tons of grain and grain-bean crops are demanded. And in the case of including the new variety in the state register, a great deal is needed to organize variety replacement. That is why, beginning with preliminary variety testing (in some cases, from the control nursery), preliminary seed reproduction of the best varieties has also begun.

Chapter 6. Phenology surveys and assessment of barley samples

According to the state register for 2022, 21 winter and 1 spring barley varieties are cultivated in our republic. 16 of them have been developed locally as a result of our scientists and plant breeders at the cereal crop scientific research institutes and their field experimental stations. These scientists and plant breeders who are leading barley breeding and its seed production are annually dealing with phenology surveys and assessments of barley diversities and their hybrid progenies.

A phenology survey on the annual development stages of breeding materials and barley's individual organs, which characterize in contrast the expression of phenotypic alterations (figure 18) along the vegetation period, is essential for creating the new barley varieties.

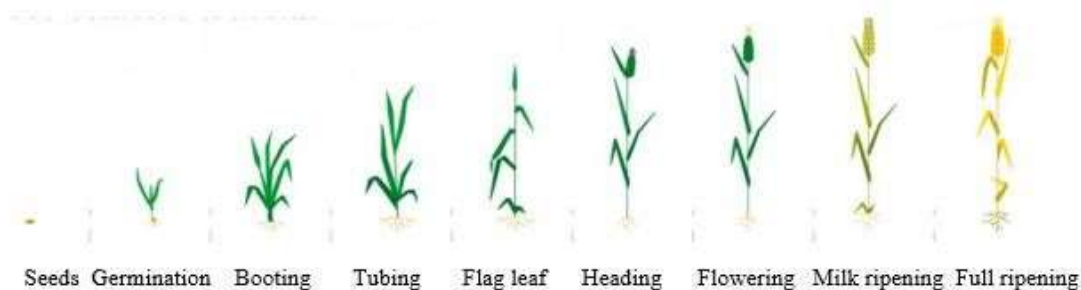


Figure 18. Developing stages of barley plant.

As a rule, phenology surveys in the developing stages are accompanied by one or several environmental stresses that affect the growth and development of barley initial materials, variety diversities, and hybrids. The terms of beginning and completing phenology surveys in plant development stages are determined by whether 10–15% of plants are in the definite stage and up to 75% of plants end this stage of development (take a look at <http://library.ziyonet.uz/uz/book/126703>).

October 15 and a few days earlier or later, depending on the regional climate and soil conditions, are the best dates to plant winter varieties of barley in our republic. The spring planting term is until the end of March.

One of the best and latest examples of conducting phenology surveys is the one conducted by barley breeders (N.D. Kuyliev and D.T. Juraev) from the Kashkadarya branch of Grain and Bean Crop SRI. These scholars have conducted a phenology survey on the selection of early-ripening and productive winter barley varieties and lines. Varieties of Vokha, Sulton, Kamashi, and Chimkurgan were standard, and 16

barley lines were taken as objectives of the experiment. Analysis has been implemented on the phenologic and biometric indexes gathered from three replicated areas of 30 m² in the agro-ecologic and test nurseries.

The phonologic surveys on the varieties and lines have revealed that their germination stages were noted on October 15-16th of October. There were no differences in the germination between them. According to the phonologic surveys, the booting stage took place on November in 34–37 days after germination (table 22).

The tubing stage prolonged from December 30th to March 17th within variety and line diversities. Lines with speed tubing stage have double-season planting biology, and lines that had tubing stage in the month of March were winter ones.

Table 22. The results of phonologic survey of winter barley in the competitive variety test nursery (N.D. Kuyliev and D.T. Juraev, 2019-2020).

<u>Nurseries.</u>	<u>Origin.</u>	<u>Germination date.</u>	<u>Booting date.</u>	<u>Tubing date.</u>	<u>Heading date.</u>	<u>Days up to heading.</u>	<u>Full mature date.</u>
1	Vokha (st)	15.10.	28.11.	1.03.	30.03.	167	26.05.
2	KR18 BYT Naz-17	15.10.	25.11.	9.12.	20.03.	157	26.05.
3	KR18 IBYT-2	15.10.	26.11.	29.01.	18.03.	155	25.05.
4	KR19 SEL50-26	16.10.	25.11.	19.02.	28.03.	165	27.05.
5	Sultan (st)	15.10.	24.11.	30.12.	19.03.	156	27.05.
6	KR18 BYT Naz-19	16.10.	24.11.	30.12.	19.03.	156	26.05.
7	KR18 IBYT-3	15.10.	25.11.	21.02.	27.03.	164	29.05.
8	KR19 SEL50-27	16.10.	27.11.	24.02.	1.04.	168	29.05.
9	Kamashi (st)	15.10.	28.11.	18.02.	20.03.	158	26.05.
10	KR18 BYT Naz-7	16.10.	25.11.	2.03.	30.03.	167	29.05.

11	KR19 SEL50-13	15.10.	27.11.	17.02.	27.03.	165	26.05.
12	KR19 SEL50-40	16.10.	26.11.	25.02.	4.04.	171	26.05.
13	<u>Chimkurgan</u> (st)	15.10.	24.11.	17.02.	27.03.	164	26.05.
14	KR18 BYT-14	16.10.	24.11.	17.02.	19.03.	155	27.05.
15	KR19 SEL50-22	15.10.	25.11.	20.02.	26.03.	163	24.05.
16	KR19 SEL50-41	15.10.	23.11.	20.02.	1.04.	169	27.05.
17	KR17BRagYT-P-29	15.10.	28.11.	25.02.	5.04.	173	25.05.
18	KR18 IVYT-1	16.10.	28.11.	23.02.	8.04.	176	30.05.
19	KR19 SEL50-23	15.10.	21.11.	8.01.	28.03.	165	27.05.
20	KR19 SEL50-42	16.10.	25.11.	7.01.	26.03.	162	25.05.
Mean index		15.10.	26.11.	17.03.	27.03.	164	27.05.
The upper index		16.10.	28.11.	30.12.	8.03.	176	30.05.
The lower index		15.10.	21.11.	7.01.	18.03.	155	24.05.

The heading stage dates of the variety and lines have shown that the heading stage has fully passed from March 18 to April 8th. The heading stages of standard varieties Sultan and Kamashi corresponded to the 19-20th of March. The heading stages of the standard varieties Chimkurgan and Vikha have passed respectfully: the 27th and 30th of March. Heading stage dates of KR18 IBYT-2 and KR18 BYT-14 lines passed on March 18-19th which totaled 155 days from germination to heading. And in these phonologic surveys, it was discovered that the above-mentioned lines passed through this stage earlier, and it can be predicted that these lines are more resistant to environmental stresses.

Data analysis of phonologic surveys on the durations of ripening stages of the standard varieties has led to the definition that the Chimkurgan variety needs 224 days from germination to full ripening; Vokha and Kamashi: 225 days; and Sultan: 226 days. The six lines: KR18_BYT_Naz-7, KR17BRagYT-P-29, KR19_SEL50-42, KR19_SEL50-22, KR18_IBYT-2, and KR18_BYT_Naz-19 have shorter vegetation periods (222-223 days) than standard varieties (figure 19).

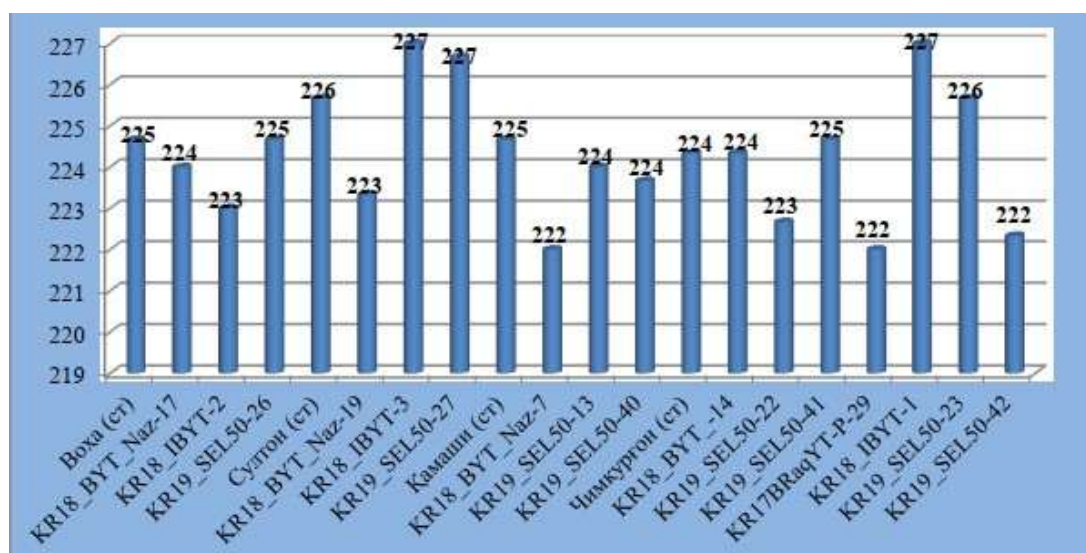


Figure 19. Vegetation periods of winter barley varieties and lines.

Assessment of barley diversities in the phonologic surveys is fulfilled by one of the different (**direct and indirect**) ways.

The first analyzed example of a phenology survey on the selection of early-ripening winter barley varieties and lines fulfilled by scholars at the Kashkadarya branch of Grain and Bean Crop SRI belongs to the direct way of assessment. Because the breeders studied the earliness of barley variety diversities visually on the field, all research has been done by them manually, without any laboratory tools.

In general, the **resistance of plants to cold (or frost)** is understood as the ability of plants to retain a high level of vitality under the adverse conditions of winter. The barley varieties are distinguished by their cold resistance. But the probability of plants losing under cold is increasing with the planting of spring varieties in autumn.

The resistance of barley variety samples to cold (or frost) is assessed by using the International Classificatory SEV Genus Hordeum L. (1983) recommendation. Its assessment scales are involved in:

- *Very low (resistance less than 30%).
- * Low (31-50.0%).
- *Middle (51-70.0%).
- *High (71-90%).
- *Very high (resistance more than 90%).

There were many experiments to assess the introduction of foreign variety samples with local variety diversities. Their resistance is determined by the phenology surveys. Planting their seeds on a 1

m² area with one replication is fulfilled by using 300 viable seeds from every sample.

Assessments of the resistance of barley varieties to early-spring **drought** are conducted through indirect laboratory methods (Russia, 2020). Here, the seed sample of a certain barley variety is germinated in the sucrose solution. It is based on the indicator of RSR (root-to-shoot ratio) in the seedlings, which shows the relative redistribution of flows of plastic substance between the root and above-ground organs. This method and its indicator allowed us to divide the analyzed varieties into three groups of drought resistance. The high-resistant varieties presented the first group: Sunshine (RSR = 67.5%), Odesski 22 (64.0%), Persey (70.4%), and Sebastian (69.0%). Malz has a relative RSR of 55.4% and enters the weak-resistant group, and TB Flavour and Patricia enter the sensitive third group (47.7% and 48.6%).

Studied the efficiency of using the express-laboratory method (2016) to verify the effect of **chloride salinization**. In this aim, the activity of different concentrations of NaCl (from 100 up to 300 mM) and polyethilenglicol (from 5 to 15 mM) on the germination and initiation stages of barley seedling formation. This method enables indirect assessment of the state of seedlings in view of phenomenon variability in plant ontogenesis (table 23).

Resistance of barley variety diversities to **smut** (photo 32) can also be assessed through a direct approach. Identification and placing of sample plants in the definite classes based on their resistance and using corresponding scales to record the infection are implemented manually. Scientists use the following scales proposed by All Union Plant Growing and All Union Plant Protection Institute to assess the variety's resistance to smut infection:

Table 23. Effect of NaCl solution on the germinal roots and above-ground sphere of barley variety seedlings. Control H₂O, 0 atm.
(Omarova Zh., Absaludinova M.P., 2016.).

NaCl mol/l.	Germinal roots.			Above ground sphere.	
	Amount, units.	Length, cm.	Biomass, mg.	Length, cm.	Biomass, mg.
K-21905 Zabet 3					
0	4.9+-0.11	6.2+-0.18	79+-4.2	7.8+-0.21	96+-3.6
0.1	2.8+-0.35	3.1+-0.17	41+-2.8	3.6+-0.13	39+-1.3
0.15	2.5+-0.39	2.4+-0.83	33+-2.8	2.9+-0.33	31+-2.1
0.2	2.4+-0.58	2.2+-0.33	23+-2.1	2.1+-0.32	20+-2.6
0.25	0	0	0	0	0
K-15240 Dagistanskiy 239					
0	5.3+-0.32	6.8+-0.31	77+-3.2	7.8+-0.33	86+-3.2
0.1	3.4+-0.28	4.2+-0.21	35+-2.1	4.7+-0.23	44+-1.9
0.15	3.5+-0.33	3.3+-0.33	32+-3.1	3.4+-0.33	28+-1.1
0.2	2.8+-0.31	2.6+-0.31	25+-3.4	2.9+-0.47	23+-4.2
0.25	0	0	0	0	0
K-22055 Temp					
0	4.6+-0.12	5.3+-0.23	52+-4.3	7.5+-0.47	79+-3.2
0.1	3.4+-0.25	3.2+-0.12	34+-1.3	3.6+-0.33	36+-2.1
0.15	2.8+-0.23	3.1+-0.22	26+-3.3	3.2+-0.28	28+-3.3
0.2	2.6+-0.63	2.5+-0.33	24+-2.5	2.3+-0.33	20+-1.3
0.25	2.2+-0.41	2.2+-0.21	21+-4.2	1.9+-0.33	19+-3.7

9-extreme high resistance (infection grade 0-10%);

7-higher (11-25%);

5-mean (26-50%);

3-lower (51-75%);

1-very low resistance, infection grade (76-100%).



Photo 32. Heavily infected ears and cross section of healthy (left) and infected seed (right, Stephen Neak and Marcia McMullen. NDSU, 2005).

The complex of pathogen organisms in the years of broad infection of grain crops cause essential losses of 20–40% of crop on account of

decreasing productive stems and biomass of plants, lowering the number of grains on the ear and their weight, as well as plant lodging, which leads to grain germination in the ear. The most distractive diseases of barley are: powdery mildew, black smut, dwarf rust, root rot, dark-brown spotting, net spot, dark-brown spotting, rinhosporious, net spot, fuzarious, and bacterious.

A direct mark assessment of the development intensity of diseases in the field is usually conducted on the following scales:

0 mark – the plants are healthy;

1 mark – moderate damage of organs or plants;

2 mark – moderate damage, strong damaged organs or no plants;

3 mark – mean damage, strongly in some organs or strong in plants;

4 mark – strong damage of organs and plant death.

At the uniform distribution of diseases, the recording of the diseases may be conducted by a-ny side of the field, letting off 25–50 m from the edge of the field, then going deep 100–200 m into the field, analyzing a certain amount of plants or selected probes of stems or leaves by the triangle or randomly from 7–10 sites at the uneven along the diagonal of the field.

There is an increase in the harmfulness of stem-hidden pests (Swedish fly larvae), which can damage up to 70% or more of plants in the crop in their favorable years (V.K. Andreeva, 2002). The degree of damage is studied through picking up plant probes, anatomy analysis (stem splitting), species composition of pests (by larvae), and the level of their colonization in the plants at the end of the booting stage and tubing initiation. Recording of plant damages is fulfilled on the drying of the central sheet.

Assessment of resistance barley varieties to cereal flies is conducted according to the scales of All Union Institute of Plant Protection (2003):

1 mark – resistant, major stems were damaged less 10%;

2 mark – mean resistant, 10-25% of stems have been damaged;

3 mark – weak resistant, 25-50% of stems have been damaged;

4 mark – not resistant, more than 50% have been damaged.

Some of the years were favorable to provide a good provocation background to the colonization of pests. The seedling stage coincided with the flying of Sweden fly.

Dominated by the species composition in the population: Sweden fly (-40–60%), spring fly (-10–15%), and stem flea – up to 10%).

Mainly, grain of barley varieties is the raw source used to produce food grains, malt for beer brewing, and forage for livestock feeding.

The commodity attractiveness of barley grains is expressed by the grain size, color, and deepness of the grain ditch, which are determined in the earlier stages of barley breeding.

That is why the color of barley grain, shape, enlarged size of grains, and uniformity are also important in the results of phonologic surveys. All these indexes **can be assessed by a visual, direct method.**

Indirect assessment with other indexes like peel of grain, germination energy, sprouting ability, uniformity through sieve, and protein amount is conducted in the latest stages of barley breeding. At this point, to relieve the grain peeling, they have to sink into 3% caustic sodium. Sprouting ability is defined by sinking the seeds into water for a certain time and then leaving them under air, satisfied with the water steam. Germination energy (% of grown seeds) is determined in three days, and sprouting ability in five days. Seeds germinating together are considered the seeds of the best beer-brewing variety.

Groats output amount in the groats direction of barley is **assessed** according to its technologic and nutritional (edibility) features. Volume of porridge formed after cooking, cooking coefficient relative to the amount of consumed grains, smell, and taste are taken into account.

The **beer boiling qualities are pretty fully assessed** during the beer boiling process and testing of prepared beer quality. First, the malt is prepared. In it, the grain is revived and dried. At this point, the endosperm turns into a soft structural shape. Compositions like starch, protein, and other spare substances split and gathered together the enzymes that had made this splitting possible. The malt grinded and was mixed with water (rubbed). The produced wort – solution of endosperm substance—malt is filtered from residues (small parts) and cooked with himel. Then it was filtered again, cooled down, and added to the beer yeast. Leave it to ferment. It results in the production of beer.

Malt extract, which is the percentage of dry substance entered into solution, and wort density (with a picnometer or reflectometer) are determined. The color is determined by the iodine solution suited to the wort color. The color is characterized by a millimeter value of 100 ml of iodine in a 0.1 n water solution.

Malt's diastic power (D.P.) is expressed via maltoza in the gram value formed from starch under the influence of 100 g of malt. The best D.P. of malt is more than 250. 200–250 is good; if it is less than 150, it shows that the quality of this malt is bad.

Indirect indexes related to barley's beer boiling properties are utilized in the earlier stages of barley breeding. For example, the percentage of grain in flour, like endosperm, has a positive correlation with malt extraction. This index of the best beer boiling barley varieties is equal to 96–100%.

Mexican scholars Juan-Pablo Ramirez and others (2020) worked out a visual quality **assessment method for malting barley** using color, shape, and texture descriptors (photo 33).

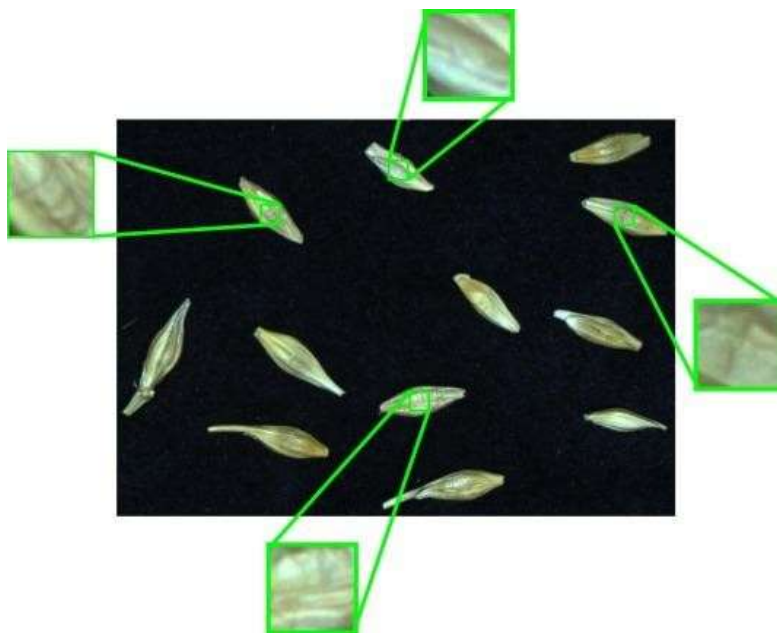


Photo 33. Close-up views of some grains of malting barley, motivating the inclusion of texture features for classification purposes (Juan-Pablo Ramirez-Paredes and others, 2020).

According to their description, this method consists of a complete pipeline of vision and machine learning algorithms aimed at assessing the quality of malting barley grain. They declare that previous solutions based on computer vision have solved this problem to varying degrees and often require the grains under inspection to be clearly separated. The results of this method show that the local phase quantization descriptor, combined with color and shape features, provides the best results even against improved local descriptors like industrialized methods. They say

that their approach is fast, tolerates touching grains, and provides an assessment that complies with local industry regulations.

This method of assessment has essentially made it easier for many other barley grain producers, whose assessment is based on hand evaluation for color, odor, damage, and kernel quality; laboratory analysis on site to test for germination capacity (95%), moisture content (12–13%), kernel plumpness, and acceptable levels of protein (12.5% or less).

The nutritious (forage) value of barley-bred samples is usually assessed through feeding laboratory animals (mouse, rat, pig) with appropriate additives and watching the increase in their alive weights.

Chapter 7. Crossing methods of barley

Hybridization is the most frequently used method in barley breeding. That is why scholars have thoroughly worked out different efficient techniques of barley hybridization. But the pollination of barley doesn't vary from that of other self-pollinating grain crops. It is the same as the pollination technique applied to wheat varieties, where it is implemented compulsorily.

Often, the flowering times of geographically remote parental plants don't coincide with each other. In such cases, cut off spikes are stored in the refrigerator, and spike stalks are immersed in water. At this temperature of 2.2°C, it is possible to store the spikes for 26 days. 10°C secures storing them for up to 14 days.

Pollination of barley plants can easily be done in the field and in greenhouse conditions. Of course, indoor-grown parental plants are usually easier to work with, and pollinating success is often better. The most newly advertised crossing method in barley varieties may be the technique of barley pollination, which was developed by Jerry Franckowiak and others in Austria and William Thomas and others in the UK.

According to their description, pots with barley plants are arranged on the benches. The pots are labeled. The label for each pot contains information about the greenhouse chamber, plant identification number, and sample name or collection code (photo 34). Plants in the pots are convenient to move and place to any place you want. You can sit nearby while crossing.



Photo 34, **Hybridization of barley in the working condition.**

The needed tools are shown in the photo 34. Special magnifying glasses help you see spikelets and their anthers clearly. Choose the

female plant, a spike that has several days of growth before pollen leaves the shade. Note! If the anthers near the center of the spike appear pale yellow, the spike is too old to emasculate.

Clip off the spike near the tip of the last spikelet; remove the flag leaf and the upper part of the awns (photo 35, 36). Expose the female spike by unrolling the flag leaf sheath (photo 37) and then clip every spikelet just above the anthers (photo 38). The anthers become visible inside the clipped spikelets (photo 39).

Use a fine-pointed tweezers to remove the anthers from each spikelet (photo 40). Clipping of the spike is complete when the awn and the upper half of each spikelet are removed.

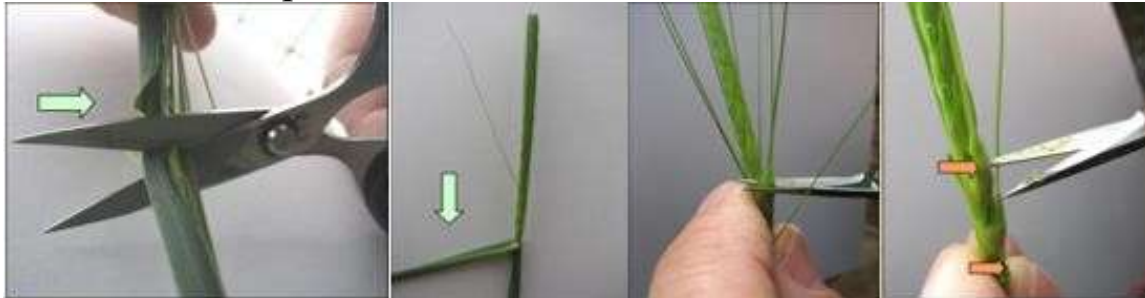


Photo 35. **Emasculation of spikelet.**

The female spike is emasculated by removing the three anthers from each spikelet (photo 41). Re-check the spikelets after emasculating to make sure no anthers have been missed.



Photo 36, 37, 38, 39. **Removing the anthers.**

After the emasculating of the female spike has been completed, place it in a numbered (14) glassing bag. The number on the glassing bag indicates the number of crossing combinations. The female spike will be ready to pollinate when the spikelets open—or show a gap between lemma and palea. A closed spikelet may indicate seed development. Before pollination, check to determine if any of the spikelets have already set seed; this should be removed.

The next step is the selection of a male parent plant. Choose the plant to be used as a male or paternal plant. Find a green spike that has not shed pollen. Its anthers are still pale yellow and are still at the base of each spikelet. Clip the spikelets above the anthers (photo 42). One to five minutes after cutting the spikelets of the male, the anthers start to enlarge and puff up (photo 43). In a short period of time, the filaments start elongating and induce the anthers upward. Begin to shed pollen, which can be used for pollination, may be done by one of the two submethods: twirl or another transfer method.

(Another transfer method). Remove one anther from the male spikelet (photo 44). At this point, the anther can be easily broken to shed pollens. Place the anther above the open female spikelet and break the anther. Each anther pollen can be used to pollinate 2, 3, or more female flowers (spikelets).

(Twirl method). A tube is placed over the emasculated female parent and a male spike with dehiscing anthers is inserted through the top of the tube and twirled to shed pollen over the female spike (photo 45).



Photo 40, 41, 42, 43. Using of Twirl method in the hybridization.

When hand pollination is complete, the glassine bag over the female spike is to be replaced.

Write a label for the pollination with the female plant listed first, followed by the name of the male parent plant. Write the date when the pollination was made (photo 46). Place the tag near the bottom of the glassine bag and make a fold to hold the tag.



Photo 44, 45, 46. **Laballing of the pollinated spikes.**

Then attach the tag to the spike with the string and the glassine bag with a paper clip. If the pollination is successful, the enlarging of the seeds will be visible in 7 to 10 days.

Let the authors of this textbook, on behalf of yourselves and the readers, gratify cordially the colleagues Jerry Franckowiak and William Thomas for their picturesque photo, which enabled them to clearly show and describe the hand pollination method of barley.

Chapter 8. Seed production of barley

It is known that barley in our republic is being sown annually in an area of 216 000 hectares (2018). At this point, the annual stability of barley grain production in this area depends mainly on the scientific and practical activities of barley breeders and their seed producers. They are working together to improve seed-producing methods in order to secure the production of high-quality planting seeds (seed stocks) in order to provide this area annually with high-variety seed progenies.

The commonly accepted scheme of winter barley seed production involves successive preliminary seed production procedures, which include:

- *Selection nursery.
- *Nursery of first year progeny testing.
- *Nursery of second year progeny testing.
- *Nursery of reproduction 1-4 year (original seed, OS).

At this stage, the nursery services select elite plants, which are the originators of the elite. And selection nursery gets its initiation from plant plantations of nursery of original seed reproduction, elite and special plantations of selection nursery.

A selection of typical, healthy, straight-standing, not-shaded plants is needed to lay the nursery in the seed production plot.

The nursery of the first year of progeny testing is laid by the seeds of selected elite plants. The number of progenies in this nursery depends on the seed multiplication coefficient of this crop and the plan of requirement for elite seed production; in all cases, the number must not be less than 300.

The nursery for second-year progeny testing is designated for further selection of the best and rejection of inferior progenies. It is laid in the area after a desirable predecessor crop and sowing in a wide row. Seeds of every progeny are sown on the seed bed alone. To control, the standard (the elite seeds of the last year) is planted in 20–30 rows. Phenology surveys and assessments are the same as in the nursery during the first year of progeny testing.

The goal of the nursery for the first 1-4 years is expressed by the maximum rapid reproduction (multiplication) of the seeds of a certain variety and maintaining high variety purity and productivity qualities.

A locally modified and improved method for barley seed production is presented in the scientific paper written by barley breeders

T. Mamatkulov and Zh. S. Usarov (2023). They have comprehensively described the original seeds' reproduction of the barley variety "Adir" with using modern innovation methods.

This variety has been included in the register since 2015 to be planted in the rein feed areas of the regions of Jizzakh, Samarkand and Kashkadarya.

The method of barley seed production begins with the composition of a preliminary seed production scheme (figure 20), getting ready for the experiment area, planting, and soil feeding agro-practice. These practical works were fulfilled according to the methodic manual (2004) in the SRI of Rain Fed Farming.

Scientific research during seed production consisted of field surveys, accounting and analysis, and selection in the progeny nurseries. Practicum on the Plant Breeding and Seed Production of Field Crops (1987), International Classificatory (1983), and Mathematical Statistics by B.A. Dospekhov (1987) were used in the isolation of typical plants with reproducing varieties.

The resistance of plants to cold in the field was the most important property for the variety "Adir". That is why it was assessed just after winter by counting the number of surviving plants during overwintering.

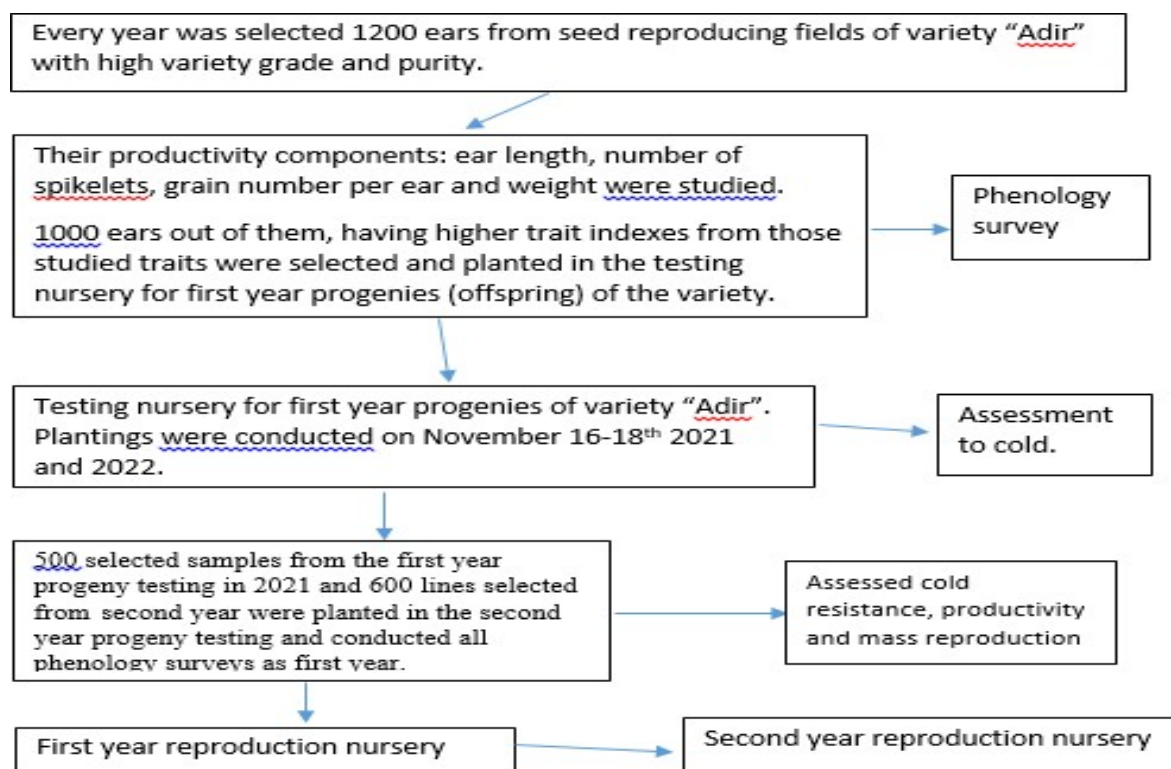


Figure 20. Preliminary seed reproduction scheme of barley.

The climate conditions of the autumn and winter months in the crop years 2020–2021 were unfavorable and negatively affected the germination of barley seeds. In the consequences of the conditions, the majority of sown seeds were killed. The seedlings of survived seeds have begun to emerge since the second decade of January, when the maximum temperature reached 16.3 16.3°C. The germination was registered on February 19-25th.

Less atmospheric precipitation and cold and even frost in the winters of 2020–2021 and 2021–2022 have facilitated the assessment of the cold resistance of “Adir” variety lines. Assessment was conducted according to International Classificatory (1983). The analysis shows that the resistance of plants varied from 3 to 9 marks. In 2021, five lower groups had 31-50%, or 0.57%. Middle group: 232 (26.5%). Upper group: 623 (71.28%). Very high 14 (1.6%).

In 2022, the middle group consisted of 160 lines (16.9%), the higher group 600 (60.0%), and the superior group 321 (23.1%). These selections, of course, made it possible to create cold-resistant plants in the laboratory (table 24).

Table 24. Distribution of plant progenies in the first-year progeny testing nursery of the variety “Adir” on their cold resistant features into groups.

№	Variety	Years	Number of offspring	Groups on their cold resistance, units.				
				Very low, less 30%.	Low, 31-50%.	Middle, 51-70%.	High, 71-90%.	Superior, more 90%.
1	<u>Adir</u>	2021	674		5	232	623	14
2	<u>Adir</u>	2022	1000			169	600	231

The differences in the field surveys of the variety “Adir” and the variety “Lalmikor” (standard) similar to themselves on the criteria of similarity and stability of the traits and properties according to the test conducted manual are given in the table 25.

Table 25. Assessment of progenies of variety “Adir” in the nursery of first- year progeny testing on their progeny differing (d) and stability (s) criteria.

Name of inspections	Phenotype traits															
	Plant stipuls		Spot on the stipuls		Antosion spot on the stipuls		Aers' shape		Ear density		Bending of first ear node		Node of two row ear		Grain shape	
	d	s	d	s	d	s	d	s	d	s	d	s	d	s	d	s
2021																
1 st field inspection	65	809	62	747	78	699										
2 nd field inspection							30	669	26	643	25	618				
Laboratory inspection													1	617	2	615
2022																
1 st field inspection	11	989	8	981	7	974										
2 nd field inspection							18	956	17	939	16	923				
Laboratory inspection													3	920	2	918

As a result of the 1st field inspection in 2021, 175 lines were discarded and 699 were selected as typical phenotypic traits under the numbers 3, 4, and 5. In 2022, correspondingly 26 and 974 at the 2nd field inspection on the traits with numbers of 14, 15, and 19.

As a result of laboratory inspections, 3 were rejected and 615 were selected in 2021, and 81 were rejected and 918 were selected.

Totally, 615 lines typical of phenotypic traits for the variety “Adir” in 2021 and 918 in 2022 were selected and recommended for study in the nursery of second-year progeny.

Phenology surveys on the vegetation period of the lines sown on November 16–18, 2021–2022, in the nursery of first-year progeny tests have revealed that the period of days from seed planting up to seed sprouting lasted for 63–64 days in 2021 (photo 47, 48). In 2022, this period was considerably prolonged, depending on the winter conditions, and consisted of 99–100 days.



Photo 47, 48. Assessment of samples with high germination in the nursery of first year progeny testing.

The period from seed germination to heading lasted for 171–172 days in 2021 and 170–171 days in 2022, and the period from seed germination to maturity consisted of 212-213 days in 2022 and 213-214 days in 2022 (table 26).

Rejection of lines in the nursery of first-year progeny testing is conducted on the basis of attention, focusing on the traits of the main productive ear, the number of spikelets per ear, and the weight of one ear. As usual, great attention at the time of individual selection in the preliminary seed production of barley varieties is focused on the productivity of lines.

615 typical lines selected in 2021 and 831 in 2022 for a two-year period of seed production were grouped based on their productivity compared with standard elite (“Adir”) plants. They are: 293 lines higher by 105.0%; 228 –higher than 115.1%; and 28—very high (more than 125%) in 2021. In 2022, correspondingly to them: 372, 245 and 85. Additionally, other lines were selected based on their productive stems (grams/m²), weight of 1000 grains, grain number per ear, and weight of grain per ear (table 26).

Meanwhile, 1200 ears have been selected from reproduction fields based on their variety grade and plants’ typicality, enlarged ear, grain, and stem height uniform, not subjected to black smut and spotting in the nursery of first-year progeny.

Table 26. Vegetation period of the variety “Adir” in the nursery of first year progeny test.

Years	Number of progenies, units.	Seeds.			Up to tubing, days.	Up to heading, days.	Days up to heading.	Wax ripening	Days up to ripening.	Maturing, days.	Days up to Maturity.
		Date of planting	Germination	Days until germination, days.							
2021	1000	16-17.11	18-19.01	63-64	8-9.02	6-7.05	171-172	1-2.06	197-198	16-17.06	212-213
2022	1000	17-18.11	24-25.02	99-100	14-15.03	6-7.05	170-171	4-6.06	199-200	19-20.06	213-214

Biometric analysis of the selected ears: plant height, ear length, number of grains, and weight of grains per ear were recorded in the register. According to the analysis, ears with high indexes, evenness, and fullness of grain have been assessed visually. Then the seeds of every selected ear were put in special small packages and composed into garlands.

The method of field surveys in the nursery for second-year progeny testing focused on the population of 500, selected from the first-year progeny testing in 2021 (table 27), and 600 lines selected from the second-year. The planting area is 5m², seed planting rate is 2.5 million seeds. The standard (elite progeny of the “Adir” variety) is laid out in 19 lines (photo 49, 50).

21 out of 500 lines studied for their cold resistance in 2021 showed low (3 marks) or 4.20%; 128 lines, or 25.6%, were middle (5 marks); 399 lines, or 67.8%, were high (7 marks); and 12 lines, or 2.4%, were very high (9 marks), belonging to the groups on the resistance to cold. Most of the lines assessed had high marks: 399, or 67%, were high, and 12 lines were very high.



Photo 49, 50. **Nursery of the first year progeny test of variety “Adir”.**

In 2020, the consequences of very favorable weather were mainly high (71–90%): 125 lines, or 20.8%, and a very high mark (more than 90.0%): 474 lines, or 79.2%.

According to the manual on barley difference, typicality, and stability, the differences between the variety “Adir” and the similar variety “Lalmikor” (standard) were the following: value of leaf bending, sensitiveness of antatsion color of stipules in the first field inspection, calendric shape of the ear, softness of ear density, awn of the ear, strengthening of the first node in the second field inspection, and third, laboratory assessments on the availability of mean hills on the nodes of awn of two-row barley, and elliptic shape of grain, which made it possible to assess all these differences.

Table 27. Indexes of the productivity of progenies of the variety “Adir” in the nursery of the first-year progeny test.

Groups on the productivity indexes (comparative to standard, in %.)	Years	Selection results in the testing nursery		Test results					
		Number of selected lines, units.	Productive lines than standard, %.	Yield, g/m ²	Comparison to standard, %.	Number of productive stems, g/m ²	Weight of 1000 grains, g.	Weight of grains per ear, g.	Number of grains per ear, unit.
Very low (less 75%).	2021								
	2022	11	1.32	114	73.8	186	58.2	1.22	22
Low (75.1-105%)	2021	16	2.60	46	95.0	77	53.1	1.1	21
	2022	68	8.18	139	92	264	62.2	1.35	24
Middle (105.1-115%)	2021	293	47.6	55.0	110.0	85	55.1	1.25	23
	2022	372	47.8	169.9	110.0	291	64.2	1.51	25
Higher (115.1-125%)	2021	228	37.1	60.0	120.0	93	56.0	1.45	25
	2022	245	29.5	185.3	120.0	303	65.7	1.62	28
Very high (more than 125%)	2021	28	4.55	62.9	125.8	97	57.5	1.55	26
	2022	85	10.2	206	133.4	323	66.3	1.73	30
An average index of standard variety	2021	50	8.13	50.0	100	82	54.2	1.21	23
	2022	50	6.02	154.4	100	253	62.4	1.43	24

Assessment of productivity in the nursery of second-year progeny testing is fulfilled by using the international classificatory SEV genus *Hordeum* L. (1983) worked out in the All Union Plant Growing SRI. The following groups were isolated with regard to the standard variety: 1-very low (less than 75%); 3-low (75.1-105%); 5-middle (105.1-115%); 7-high (115.1-125%); and 9-very high (more than 125%).

Provisioned 102 kg in 2021 and 283 kg in 2022 seed stocks from these nurseries (photo 51, 52, 53) and planted in the area of reproduction of first-year progenies.

These seeds were enough to plant 12.5 hectares. Planting is done by a special experiment seed planter. All agro-practices elaborated for rain-fed areas possible in the experimental plots.



Photo 51, 52, 53. First year reproduction area, seed sowing in the nursery of second year progeny testing and harvest.

By mechanic combine, 1050 kilograms of high-quality seeds of the variety "Adir" were harvested in 2021 in the first reproduction nursery (photo 53) and 550 kilograms in 2022. 3 710 kilograms in 2022 from the reproduction nursery of the second year. This high-quality seed stock has made it possible for breeders and seed producers in 2023 to plant superior progeny of the barley variety "Adir" in the area of 20 hectares.

Questions on the studied themes:

1. On the basis of what government laws is a functioning seed production system for grain crops?
2. What is the difference between the law of "About seed production" and "about achievements of plant breeding"?
3. Where are the sowing grain seeds produced?
4. Do you remember about seed reproductions and insurance funds?
5. What is the importance of strain (variety) changing and variety renewing?
6. Report about the seed production system, scheme, and approval of seed-producing fields.
7. What is the crop of barley and its economic values?
8. Name some cultivating varieties and their properties?
9. Describe the phenotype and spike types of barley.
10. Characterize the initial materials for barley breeding and breeding programs of barley breeders.
11. How and what traits and properties of barley breeding materials are assessed?
12. What tools are used to hand pollinate barley plants in the plant breeding?
13. Please list the nurseries that are used in the preliminary barley seed production.

14. On what kind of traits (indexes) is conducted the selection of the elite plants in the seed production?

15. What does the term "rejection" mean in plant breeding and seed production?

Chapter 9. Approbation of barley seed fields

Approbation, as mentioned in the information on agriculture, is the field observation of a seed-producing plantation with the aim of defining the variety purity or typicality of plants belonging to one of the varieties, the weedy level of the plantations, infection with diseases, and pest damage.

450 hectares is the maximum area for barley to be approved (appendix 5). If the area to be appraised is larger than 450 hectares, it is divided into plots and the appraiser will take the appraisal bundle alone from each one (photo 55). The bundle should have no less than 1,500 plant stems.



Photo 55. Forming up the approbation bundle by one of the approbatory persons.

Picking them up, not less than 150 points (about 10 from each) are going to pass through the diagonal of the field. One bundle is taken from the fields of seed-producing farms and two from the fields of scientific-research establishments. The taking of approval bundles in the scientific-research institutes begins in the reproduction nursery.

At the time of bundle picking up, the approbatory defines the total weedy level of plantations on the scale (in the marks):

- *0-fully absence of weeds;
- *1-inconsiderable level of weed availability;
- *2-middle level of weed availability;
- *3-considerable.

The picked bundle is tied, a label is placed inside it, and the other is tied outside. The bundle analysis must be done during the next two days after picking up.

All stems at the time of analysis are separated into the following fractions:

- *Stems of the main variety: this is the most enlarged fraction; its stems are tied to hundreds;
- *Stems of other varieties, diversities, and species of the same crop;
- *Underdevelopment stems of the testing crop with non-fruit bearing inflorescences or with puny underdevelopment grain, having inadequately clear expressed testing variety traits;
- *Stems of difficult-to-separate cultivated plants by species; taking into account only well-developed plants; non-fruit-bearing plants will not take into account; seeds of oat and wheat in the barley belong to the difficult-to-separate seeds;
 - *Weed stems of difficult to separate: Tatar buckwheat;
 - *Stems of noxious weeds;
 - *Stems of quarantine weeds – dodder and others.;
 - *Stems of testing crop, infected by smut and hard smut.

The stems of each fraction were recounted, tied alone, and again united in a total bundle, on which hung the former label. This bundle is retained in the field for three months and at the scientific-research institutes for 12 months in case of inspection.

Taken number of stems of all fractions but underdevelopment of main crop and quarantine weeds expressed in percentage. On the quarantine list, weeds registered their number and name.

Example of the defining variety purity at the analyze testing bundle of barley stems of the variety Abu Gofur.

The variety purity (%) is determined by the ratio of the number of stems of the main variety (1464) to the number of testing crops (1464 + 28). Stems underdevelopment and infected by smut, as not having adequate expression of variety traits doesn't include them in the

calculation. In our example, the variety purity is equal to 98.1% (1464–100).

The percentage of contamination with difficult-separating species is determined by the ratio of the number of stems of this species (16) to the number of main crops, including the stems of difficult-separating crops (1464+28+16).

The percentage of contamination by difficult-separating crops is equal to 1.1; similarly, the rest of the fractions are calculated: contamination by difficult-separating weeds consists of 0.9%, and infection by dusty and hard smut is correspondingly 1.2 and 1.1%.

The categories of the plantation are defined by the variety's purity. If the variety purity of the barley plantation is less than 99.5%, this plantation is classified in the I category, not less than 98% in the II category, and not less than 95% in the III category.

Plantations, in our example, are classified in the II category. Elite barley should have a variety purity of not less than 99.7%.

It was accepted that the variety purity of the seeds planted in the farm fields must be in the I category, and the seeds planted in the common fields should not be in the II category. If the variety purity of plantations is less than 95%, they are rejected out of the variety plantations.

Notes: Not suitable for use on seed-purposed and plantations that have contamination with difficult-separating crops (more than 5%), with difficult-separating weeds (more than 3%), and total infection with various kinds of smut (more than 5%).

Seeds contaminated with quarantine, poisonous, and noxious weeds (not difficult to separate) are not excluded from seeds suitable for planting but stored and cleaned along with other seeds.

Elite seeds of barley are not used to reproduction when their infection by dusty smut is more than 0.3% (on the stems) or hard smut is more than 0.1%.

Approbatory completes the approval with the drawing up of a “statement of approval” on the variety and quality of seeds (Form № 195). On variety plantations recognized as unsuitable for seeding purposes, draw up the “Rejection Act” in two copies (Form № 200) given below (appendixes 9, 12).

Every given statement must be signed by the agronomist-approbatory and representatives of the farm that participated in the approval.

The senior agronomist-approbatory is responsible for examining the correctness of the approval, legalizing all approval documents, and confirming them.

Approbation statements unsigned by the senior specialist are invalid.

Part IV. Breeding and seed production of rice.

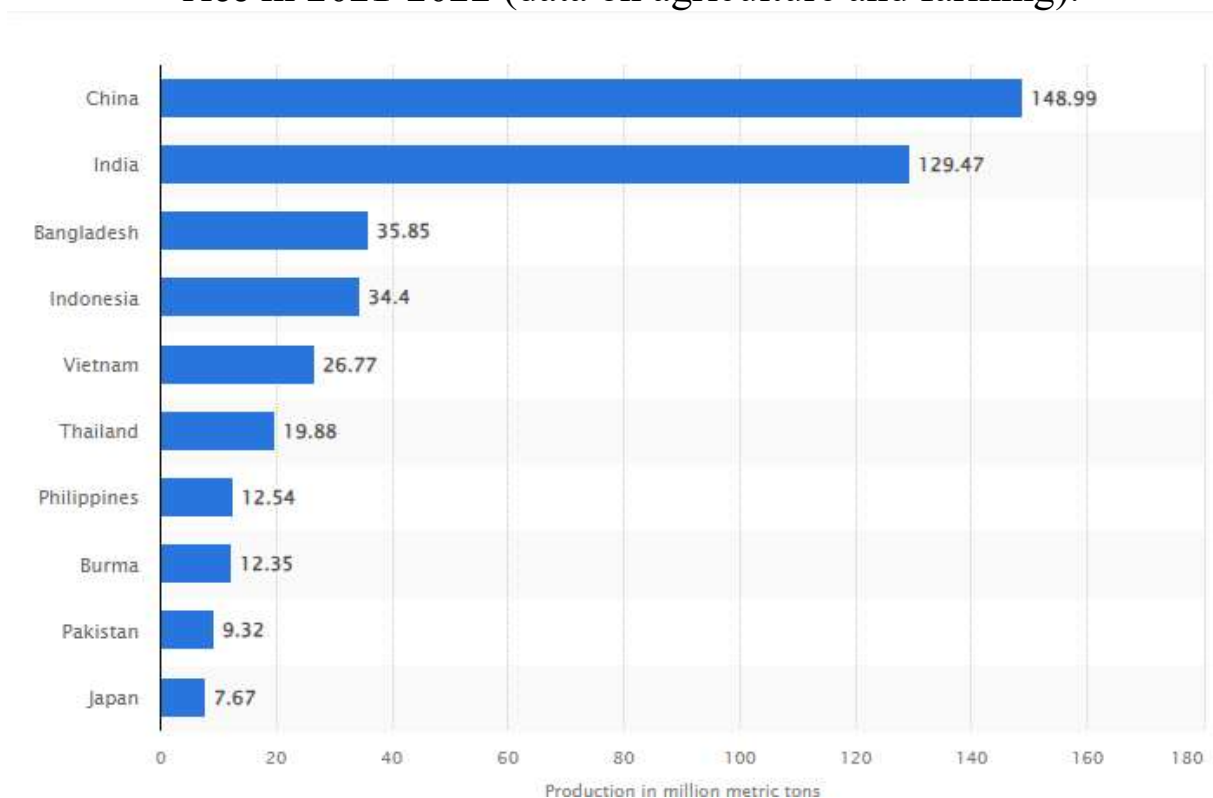
Chapter 1. Importance of rice in the world

Rice is explained as a complex carb that provides a prime source of energy for over half of the world's population. Because it contains a decent amount of fiber, protein, vitamin V, iron, and manganese. This means it can play a vital role in fighting malnutrition.

Looking through an internet source, we can watch more than 100 countries list growing rice. The total production by these countries in 2021 was 787.293.867 metric tons. The record production has been in China: 212.843.000 tons of paddy rice. The smallest producer was the Federate State of Micronesia (175 tons).

The last data on the 10 top rice producing countries in 2021-2022 (in million metric tons) shows again that China is the leading country in the world for rice production (table 28).

Table 28. World-leading countries based on the production of milled rice in 2021-2022 (data on agriculture and farming).



The names of the countries show that the continent of Asia is the overwhelming part of the world in rice production. Within Asia, China has the most share—148.99 milled rice—and India, which is close to

China—129.47. Production in other countries with regard to these two countries rapidly falls (beginning in Bangladesh: 35.85).

Chapter 2. Rice botany and its economic value.

Scientists K. Pravat and Binod Bihari Sahu describe (2021) that cultivated rice, *Oryza sativa* L., is a semi-aquatic annual grass (photo 56) belonging to the family Poaceae of the monocotyledonae class of angiosperm plants.

Genus *Oryza* has another cultivated species, namely, *Oryza glaberrima* Steud, and about 20 wild species. The *Oryza sativa* complex has seven species, including two cultivated rices, and they belong to the AA diploid genome with 24 chromosomes. In Asia, *O. sativa* is differentiated into three sub-species based on geographical distribution, namely *indica*, *japonica* and *javanica*.

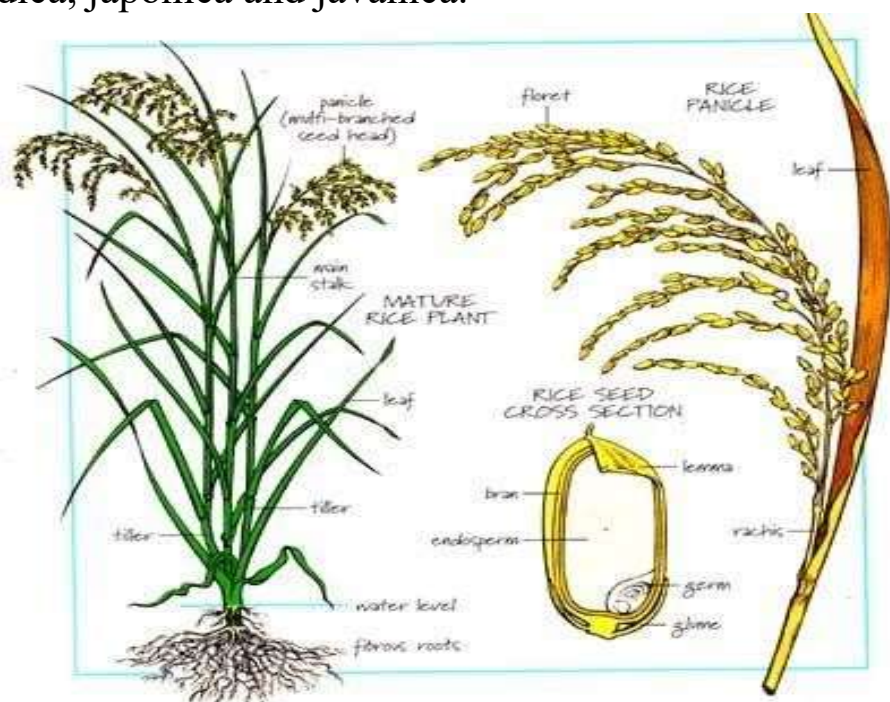


Photo 56. **Rice plant and its structural parts of organs** (internet source).

As they characterize rice plants, they are native to semi-aquatic conditions, where the presence of inter-organ aerenchyma facilitates the exchange of respiratory gases in submerged plant parts. Its flower is bisexual and self-pollinated. As a crop, it has a varying growth period of 3–6 months. Plant height also changes from 0.4 to more than 5 meters in the case of floating rice diversities.

According to these scholars, rice has three distinct growth stages: vegetative, reproductive, and ripening. The first covers a period from germination to panicle initiation (photo 57). This stage of development

lasts up to the production of tillers from stem nodes in acropetal sequence during this period.

The reproductive stage of plant development involves the period from panicle formation to heading.

The last development stage, the ripening stage, extends from heading to grain maturity. They especially note that each reproductive tiller bears a terminal panicle-type inflorescence (photo). Spikelets are borne on pedicels on the primary and secondary branches of the panicle. They have individually flowering orders that produce one seed each at the time of maturity. The spikelet at the top of the pedicle bears two undeveloped glumes, two sterile lemmas, and one fertile floret borne on a short stem axis named rachilla (rachis).

The fertile florets have six stamens and one pistil (carpel) with a feathery stigma enclosed between the lemma and palea. The seeds consist of a caryopsis (brown rice) and a hull. Caryopsis has two parts: the embryo (germ) and the endosperm (photo 58). The hull of the rice panicle comprises lemma, palea, and rachilla.

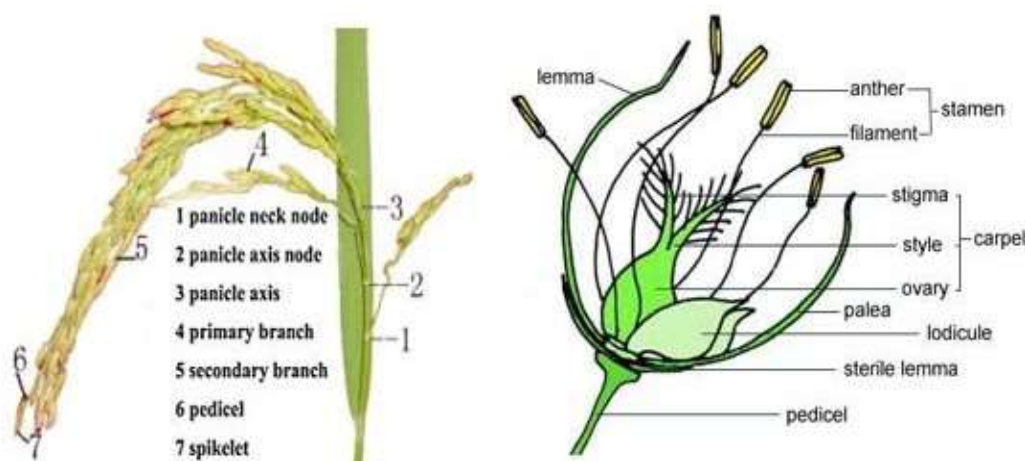


Photo 57, 58. **Parts of rice panicle and floret** (internet sources).

Rice is one of the cereal crops. Rice grain has three outlooks: long grain (6–8 mm), middle (5–6 mm), and small or round (4–5mm). The weight of 1000 grains ranges from 25 to 43 grams. The share of lemma and palea (flower shells) out of grain dry weight consists of 14–35%; the share of seed nuclei is 65–86%; the share of germ is 1.5–4.5%; and the increase in grain size in rice leads to a decrease in shell shares.

The economic importance of rice and its grain, such as brown and milled rice, is enormous.

Brown rice is needed in medicine to improve blood supply by cleaning blood vessels, maintaining blood glucose levels, stabilizing the digestive system and metabolism, and promoting the elimination of toxins (photo 59).



Photo 59. Rice grains, before reprocessing and after reprocessing.

It is well known that one-half of the world population—all of East and Southeast—is wholly dependent upon staple foods produced from milled rice. It is estimated that 95% of the rice crop in the world is eaten by humans. Milled rice is cooked by boiling or can be ground into flour. Flour is used alone to bake bread, cereals, noodles, or a variety of food items in people's cuisines.

Chemical content of rice grain (milled) makes of protein: 5.4-12.6 (6.9-10.0) %; starch: 75-85 (77-87) %; fiber: 8.5-12.5 (0.1-0.2) %; fats: 1.5-3.3 (0.2-0.4) % and ash: 4.7-7.0 (0.5-0.7) %. Also has vitamins: B1, B6, PP, manganese, phosphorus, magnesium, selenium, copper and amino acids for the health of a man.

Even so, it is needed to produce such alcoholic beverages as Japanese sake.

The people of Uzbekistan cannot imagine its cuisine without daily rice within food products because of "Plov", a national dish that is cooked only with rice. Furthermore, rice is used in the preparation of many foods and for all other purposes (medicine and perfumery) mentioned above. The hay of rice is also used in the textile industry to produce shoes, thread, sacks, paper, and compass preparation. 1 kilogram of rice hay has 22 grams of protein and 0.24 nutritious units, which makes it suitable for use as forage to feed farm animals. Beside this, rice hay is a good fertilizer for soil because of its content of 8 kilograms of nitrogen, 1 kilogram of phosphorus, and 12 kilograms of potassium per ton.

In 2021, the rice-growing areas in our republic will have been expanded to 37 thousand hectares, or 40%, and will total up to 129.3 thousand hectares. 66.7 thousand hectares out of this were planted in main crop areas and 62.6 thousand in areas after the main crop. In 2022, rice will be grown on an area of 110 thousand hectares and the crop will consist of 516 thousand tons, which is the result of a yield equal to 4.7 tons on average.

The majority of national demand for rice is provided by the crop harvested from local rice varieties (occupying almost 90–95% of the planted area) released at the Scientific Research Institute of Rice Growing (photo 59). Unfortunately, all these measurements directed at satisfying national demand for rice products have not yet justified themselves. On the pages of the journal “Agro ilm” in 2019, it was noted that with a need of 40 kg per person, only 8–9 kg are produced.

Chapter 3. Rice varieties grown in Uzbekistan

The state register for 2022 embraces 19 rice varieties belong to *Oryza sativa* L. recommended to plant in the rice growing regions (appendix 4) of Uzbekistan (table 29).

Table 29. **Rice varieties grown in the regions of Uzbekistan.**

№	Varieties	Originator country	Year of introduction into production.	Recommended regions to plant.
1	<u>Avangard</u>	<u>Uz</u>	1982	1, 2, 7, 10-13.
2	<u>Alanga</u>	<u>Uz</u>	1993	1-13.
3	<u>Gulzar</u>	<u>Uz</u>	1995	1.
4	<u>Gulistan</u>	<u>Uz</u>	2019	1.
5	<u>Gujakhon</u>	<u>Uz</u>	2012	1, 9-11, 13.
6	<u>Jaykhun</u>	<u>Uz</u>	1998	1, 13.
7	<u>Ilg'or</u>	<u>Uz</u>	2012	1, 9-11, 13.
8	<u>Istiqbol</u>	<u>Uz</u>	2002	10, 11.
9	<u>Istiqlol</u>	<u>Uz</u>	2002	13.
10	<u>Iskandar</u>	<u>Uz</u>	2009	1-13.
11	<u>Lazurniy</u>	<u>Uz</u>	1986	1-13.
12	<u>Mustaqillik</u>	<u>Uz</u>	2009	1-13.
13	<u>Nukus 2</u>	<u>Uz</u>	1986	1-13.
14	<u>Nukus 70</u>	<u>Uz</u>	2011	1, 13.
15	<u>Sanam</u>	<u>Uz</u>	2003	1-13.
16	<u>Sitora</u>	<u>Uz</u>	2020	11.
17	<u>Tantana</u>	<u>Uz</u>	2019	11.
18	<u>Tarona</u>	<u>Uz</u>	2019	11.
19	<u>Uz-Ros 7-13</u>	<u>Uz</u>	1948	2, 7, 9, 10-12.

The years of introduction of the varieties into production show that variety Uz-Ros 7–13 had been commercialized in 1948. Its adoptability and productivity potential have not yet been exhausted. This kind of variety phenomenon is a rare case in agricultural crops. You see, at this time, it is being recommended to plant in regions 2, 7, 9, and 10–12 (appendix 4). From the point of view of plant breeding, this variety serves as the best example of the combination of selected parental forms to develop the new variety and its method of breeding.

Varieties of Avangard, Lazurniy, and Nukus 2 were also developed correspondingly in 1982, 1986, and 1986, which are some of the representatives of the oldest generations as the splendid achievements of rice breeding and its seed production.

Uz-Ros 7-13. This variety was released at the Rice growing Scientific Research Institute of Uzbekistan. It was developed by N.I. Kosarev and E.I. Sverjanov through multi individual selection from the hybrid population of the hybridization UzPos x Kharazabu. Belong to the sub-species Bulgaris. Weight of 1000 seeds: 30.5 g, resistant to lodging. The average grain productivity was 5.1 tons at the testing plots in 1999–2000. The variety is late-ripening and needs 120 days to mature.

It is recommended to plant at the earlier stages of planting in the southern regions of the republic. Technological and groats output quality are superior: groats output consists of 66% and output of not damaged, whole milled rice amount makes of 80%. It has 5 marks on its eating taste within the recommended varieties to plant.

In all testing years, this variety has demonstrated the best resistance to *pyricularia oryzae*.

Avangard. This variety was also released at the Rice growing Scientific Research Institute of Uzbekistan via hybridization of the varieties VIR 4879 and Uzbekskiy 5.

The authors of this variety were P.A. Pulina, S. Riskhieva and A. Agidiev. Since 1982, it has been commercialized in the regions of Andijan, Namangan, Fargana, Syrdarya, Tashkent, Khorezm, and Karakalpak Republic. The variety belongs to the sub-species of *Sub-vulgaris*.

It is characterized as a middle tubing panicle, half awn, awn weakly pressed, light yellow. The grain has an egg-like shape and a smooth surface. Peel makes 17.0–18.0%. weight of 1000 seeds: 31.5–33.5 g. The average productivity in the testing years (1992–1996) was 4.2 tons per hectare in the Tashkent region. The surprising productivity (8.2 ton/ha) was recorded in the Khorezm test plots.

Middle ripening variety, its vegetation period is 86–110 days. The variety has a short stem, which is why it does not lodge. Technologic and quality of groats are high: 65.0–76.4%. The color of milled rice is white, but sometimes it changes to a light yellow. Food estimation is good.

This variety isn't infected by the *pyricularia oryzae* in nature. It belongs to a strong rice group.

Variety Lazurniy. Bred variety of Rice growing Scientific Research Institute of Uzbekistan. Hybridization of VIR 4977 and UzRos 59. Authors: T. Isakhanov and P.A. Pulina. It has been in production

since 1986 in the regions of Surkhandarya, Syrdarya, Tashkent and Khorezm.

This is the first Uzbek long grain variety and belongs to the indica sub-species. Panicle has spread and is strongly bent. The grain is transparent and in a long shape. The average grain productivity was equal to 5.0–6.6 tons per hectare in the test years of 1996–2000.

Late ripening varieties have a vegetation period lasting 98–120 days. The technologic quality and grain output are good: 98.0–99.0%. The share of whole milled rice makes up 85.0%. Its palov (the name of the famous Uzbek national food) making quality is also superior. On the grain, it enters the list of valuable rice varieties. And it wasn't infected by the *pyricularia oryzae* during the years of testing.

Nukus 2. is a bred variety of rice grown at the Scientific Research Institute of Uzbekistan. It was developed through hybridization of the introduced Vir-4959 (Corbetta from Italy) and Dwarf Shiovskiy. Authors: P. A. Pulina, T. Boboniyazov and S. Rikhsieva.

Nukus 2 belongs to Dikhroa diversity. The panicle is slightly bended, has awn, awn rough-uneven, and is yellow.

The grain is transparent, round, egg like, and weighs 1000 seeds (28.2–28.8 g). An average productivity of 7.3–4.6 tons per hectare in 1996–2000.

Variety has a middle vegetation period, which is equal to 81–95 days. And the stems are dwarf (70–77 cm) and rapidly growing. Highly demanding on the water at the time of germination.

Resistant to lodging and shading, groats output and cooking quality are standing at high grades: transparent level is 91.0%, whole grain amount is 86.0%. Porridge taste has a 4.0 mark. It also enters the valuable varieties' list. Not infected by the *pyricularia oryzae* in the years of testing.

Chapter 4. Growth stages of rice.

Seed germination and seedling sprouts. Even and adequately full seedlings are the most responsible in the cultivation technology of rice.

Seeds do not need to breathe oxygen; endosperm develops on account of unairobic breathing. Anaerobic breathing is increased when the seeds are laid deeper (4-5 cm) and cause the death of the seeds.

The seeds germinate at a temperature of 10-46 °C, at the lower temperatures root germ, 34 °C is the optimal temperature to germinate. Some rice forms do not give seedlings at the start of flooding with water. The good germination of enlarged seeds has been identified by the scientists in anaerobic conditions. From seed germination up to seedling sprouting, which takes 7–15 days, this depends on air temperature, soil moisture, and the energy of seed growth (photo 60).

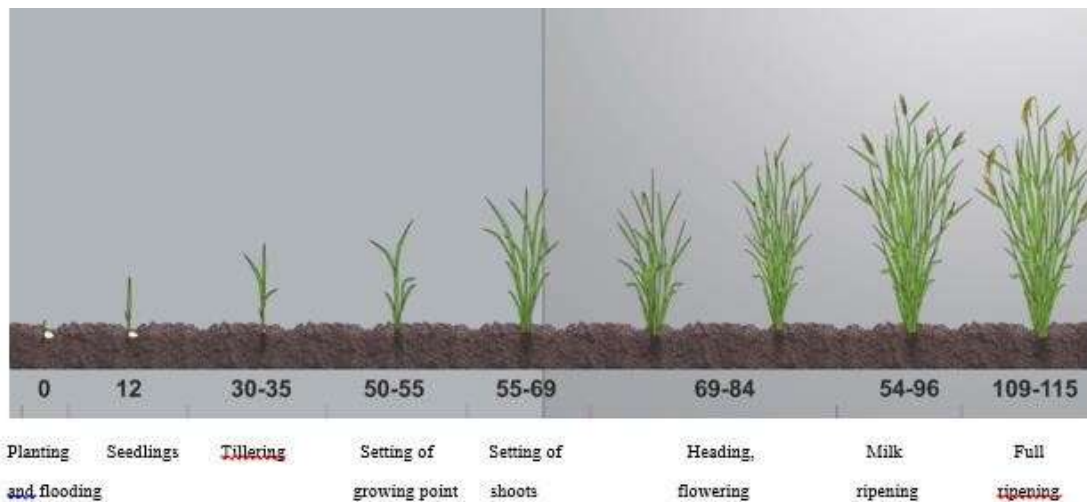


Photo 60. **Rice plant development stages** (Agro Consulting).

3–4 leaves will establish themselves in the developing stage of seedling, which coincides with the start of tillering. Usually, tillering passes on in aerobic conditions.

The rapid growth of root systems takes place during the period of seedlings. Air cells appear in the roots, which provide plants with oxygen. The seedlings flooded with water up to 15 cm come out easily.

Tillering and shooting. The seedlings rapidly grow at a temperature of 20-30°C which stimulates fertilizer application during this period. Axillary buds are initiated in this condition, which leads to the development of tillering. Tillering begins with the formation of 3–4 leaves and lasts until the setting of 8–9 leaves, when the shooting is

initiated. The tillering is the responsible moment of the development stage, and it defines the duration of the vegetation period. The shooting begins when the plant has 8–9 leaves. The panicle and its parts develop in this stage. The beginning of this stage depends on variety earliness because on the early-ripening varieties, it begins when the plants have 5–6 leaves, and on the late-ripening varieties, it begins at the 8–9 leaves (table 30).

Flowering. Flowering on the rice plant coincides with heading. If heading takes place in the first half of the day, flowering takes place in the second half of this day. And flowering occurs in the afternoon; the heading begins in the morning of the second day. The flowering depends on the daytime temperature. 30°C is the optimal temperature for flowering; the minimal is 15-20°C, maximum is 50°C. The flowering begins with the top part of the panicle, the first spikelet. Often, the flowering does not follow the accepted order. The flowering of panicle lasts for 5-8 days. The highest number of flowered spikelets is observed in the next 2–3 days. 70–80% of the air humidity should be kept to the optimal level for flowering. Rice doesn't flower in the extremely low (40%) humidity of the air. The flowering of one spikelet lasts, on average, 1 hour. On a cloudy day, this process was delayed.

Table 30. Group of rice varieties depending on vegetation period.

Groups	Number of days, from seedling sprout to heading	Vegetation period, from seed flooding up to full maturity, days.	Total mean temperature for vegetation period, °C.
Extra early ripening	45-50	90-100	2000-2200
Early ripening	51-55	101-110	2200-2300
Middle ripening	56-65	111-120	2300-2500
Late ripening	76-100	125-140	2600-2700

Fruit setting. The performance process and maturity of grain are passed through several stages: the forming of grain, germ development, endosperm formation, the filling of the grain with nutrient substances, and a decrease in the amount of structural water. This period is divided into three periods of maturity: milk, wax, and full maturity.

At milk maturity, the grain expands in length and width, and the content recalls milk. 11–12 days passed since the day of pollination, and the content of water during this period was 70%.

At wax maturity, the seed has a powdery content and is cut by nails. The water content at this stage is 35%, and this stage lasts for 20 days. 5-7 days passed from wax ripening to full ripening, and all periods of maturity lasted for 3–40 days, depending on the condition of the environment. The development of the lower spikelets is delayed by adverse climatic conditions.

Rice varieties based on their vegetation period are divided into the following groups:

Ontogenesis. 11 stages are distinguished in the rice plants:

1st stage - the tip of growth is not yet differentiated; the first three leaves have been laid in the germ, the surface leaf-coleoptile, the next leaf without a blade, and the third as germ-like with a blade. This stage coincides with germination and the beginning of seedling initiation.

2nd stage - the embryonic stem is differentiating and is laid on the boot of the leaf; the leaf formation is completed, and the side roots are formed. This stage occupies the space between seedling sprouting and tillering.

3rd stage - the tip of growth is differentiated. Panicle segments appear; the first axis order is laid; the longer this period, the more productive the panicle. This stage is part of the developing stage of tillering.

4th stage - growth of the first, second, and next twigs takes place, the spikelet tubercles are laid, and the individual spikelets are isolated. At the end of the stage, the panicle reaches 1 cm. This stage coincides with the end of tillering.

5th stage- spikelets are differentiated with the formation of spikelet and flower glumes (lemma and palea), lodicule, and generative organs: anthers and pistils evolved. This stage is completed near the end of the shooting stage.

6th stage - the setting of generative tissues in the anthers and pistil, embryo sack, ovule, and pollen grain are formed. The stage is continued in the stage of shooting.

7th stage - floret axis growth takes place along the entire floret, glume, axis, and hey. All organs of the flower enlarge over time. This stage initiates at the end of the shooting stage.

8th stage - flowering, pollination, and fertilization.

9th stage - re-embryo is formed, embryo develops, and endosperm. The embryonic development of seeds takes place.

10th stage - endosperm is formed, the starch grain is formed in it, and aleuron also lay.

11th stage - full development of grains and milk, wax, and full maturity. Endosperm and germs lose water.

The environmental condition can affect the speed up or delay the passing of all developing stages.

Chapter 5. Rice breeding directions

The dominant activity in the world of rice breeding is visible in the countries of Asia, Latin America, and Africa. The International Rice Research Institute (IRRI) has developed drought-tolerant varieties that are being planted by farmers in several countries, such as Sahbhagi dhan in India, Sahod ulan in the Philippines, and Sookha in Nepal.

The IRRI is world-known and biggest, headquartered in Los Banos, Philippines, has offices in 18 rice-growing countries in Asia and Africa, and more than 1,000 scientific research staff. Established in 1960, it has contributed rice varieties that contributed to the Green Revolution in the 1960s, which preempted the famine in Asia. Only in India has it developed over 400 improved rice varieties and better farm practices and technologies for enhanced rice productivity. Accelerated climate change research, environmental sustainability, and soil and water management.

The results of field trials suggest that new drought-tolerant varieties have an average yield advantage over drought-susceptible ones of 0.8–1.2 tons per hectare under drought conditions. New varieties in the Philippines exhibited a yield advantage of at least 2 tons per hectare over non-tolerant varieties. A gene for salinity tolerance, called Saltol, has been incorporated into local rice varieties in countries across Asia.

In the countries of Latin America, newly developed rice varieties are resistant to rice blast and have remarkable after-harvest reprocessing qualities. Such released varieties after 2010 have begun to become the dominant rice varieties in Columbia (Fedorroz 67 and 68), Peru (La Esperanza), Ecuador (SFL09; SFLO 11), Bolivia (MAC 18), and Panama (IDIAP FL137). In African countries, commercializing drought-tolerant varieties is a potential aspect of mitigating the negative impacts of climate change associated with the often-occurring drought and longer heat waves.

Herein, drought-tolerant varieties were expected to produce about 30% of their potential yield after six weeks of vegetation under water scarcity before and during the flowering stage and grain filling stage. New drought-tolerant varieties have been released and disseminated in sub-Saharan Africa. For example, ARICA 16 and NERICA 4 were released correspondingly in Benin and Madagascar in 2013 and 2015; FARO 58, 59, 63, 64, and 65 were also developed in Nigeria from 2011 to 2015.

Many other biotic and abiotic stress-resistant rice varieties have been developed throughout the member centers of the IRRI and they are being used by other scientists in rice-growing countries as invaluable germplasm sources to improve rice breeding efficiency.

It is known that the directions of plant breeding in a certain crop are involved in the research program of the Scientific Research Institute in Uzbekistan. The Scientific Research Institute of Rice Growing of Uzbekistan (Uz.SRIRG) tackles almost all problems associated with rice growing in our republic. And according to its challenges to meet the requirements of farmers, consumers, and industry for rice and its products, Uz.SRIRG and its regional branches: Karakalpak, Khorezm, and Andijan, are constantly carrying out scientific research on the directions of:

- *Creation of high-yielding, early, middle, and late-ripening, resistant to biotic and abiotic stresses, high-tech rice varieties designated to grow in different agro-climates of Uzbekistan with intensive and resource-saving technologies;

- *Renewing varieties of rice cultivating in the Republic, implementing strain changing, and carrying out preliminary seed production;

- *Working out and extending the production of leading intensive production agro-techniques to lower investment expenditure and enhance the productivity of rice areas;

- *Working out new technological methods to save mineral fertilizers and other agro-chemical means in the aim of maximal use of the rice varieties' potential and recommending them for production;

- *Mechanization of rice cultivation and its perfection.

- *Working out the new approaches to improve high-rice progeny seed production methods and so on.

Our rice breeders and its seed producers have a solid opportunity to tackle the challenges listed above. In this regard, world rice collections are one of the essential initial materials that later became more available due to international relations set up with plant breeding-oriented world organizations like CGIAR. And old partner-breeders from neighboring rice-growing countries have strengthened their close cooperation in exchanging rice germplasms and conducting research together in joint plant breeding programs to deal with similarly associated issues.

Productivity and early ripening. Our rice breeders, rice seed producers, and agriculture specialists have begun a new innovative approach to deal with this challenge. To get two crops in a year was their innovative idea, and for this, they had chosen three early-ripening rice varieties: Sanam, Nukus 2, and Nukus 70. According to their idea, the seeds of these varieties were planted on a 20-hectare area in the eight districts of the Khorezm region.

Transplanting rice seedlings based on that idea results in obtaining the first crop in the first decade of July. The second seedling planting is planned to be done this month, and getting the crop is anticipated in the month of October. Herein, rice transplanting experiments from Japan, China, Coria, the Philippines and India are being conducted by our scientists and farmers to ensure a desirable outcome in the double increase of former local rice crops.

To date, early-ripening rice varieties in the Izbaskan district of the Andijan region have allowed to harvest the first crop at the end of July (news of the Ministry of Agriculture, 02.08.24). And planting of grown seedlings in the greenhouse has been started on their places (photos 61, 62). All these scientific-practical works are carried out by the scientists of rice-growing SRI included in the system of the national Center of Science and Innovations at the Ministry of Agriculture.

In 2021, our scientists introduced 15 rice varieties from Vietnam, 15 from China, 6 from Coria, 4 from Russia, and 2 from Turkey to hybridization with local rice varieties with the aim of incorporating needed genes into our newly developed rice varieties.

A rice breeder from Vietnam has been invited to help our breeders and seed producers adapt some of their foreign rice varieties to local conditions.



Photo 61, 62. Rice paddy before harvest and planting rice seedlings.

Preliminary outcomes of the above-mentioned works show that the annual production of rice to sustain the people's demand for rice

products consisted of 611 000 tons, which increased by 287.5 thousand tons over the past few years.

Rice seed production practices have also been improved. In regard to these practices, the selected rice seedlings have been sown since May 15th with the help of imported special mechanical seedling planters on an area of 1,200 hectares under the main area.

With the participation of scholars from the China National Rice Institute, the Thailand International Cooperation Agency organized working networks and capacity-building online courses to further enhance rice seed production processes and reprocessing technologies of produced products.

In particular, the above-mentioned rice breeding and its seed production procedures have made it possible to increase productivity by 43%, resulting in a yield of 5.0 tons per hectare.

Water-saving direction. Economical calculations about water consumption per hectare to produce rice revealed that water consumption per hectare consists of 20 000 to 30 000 m³. Today, some of the rice-growing farmers, considering the water shortage in the republic, have faced rice production problems. That is why rice breeders, in order to decrease water consumption by the side of farmers, have to develop for them early-ripening rice varieties, which have made farmers able to plant after harvest of winter cereal crops. By doing so, farmers will save on water consumption and increase their crops.

To create rice varieties resistant to **biotic and abiotic stresses**. It was identified that the rice plant in Uzbekistan is infected by over 20 kinds of diseases. Picalirios (*Piricularia orizae cavi*) is one of the most harmful of them. It damages the leaf, stem, and panicle, which delay photosynthesis, cause stems to broke down, and considerably decrease the crop. In 2017, the results of a field experiment conducted in the field of the scientific research station of the Tashkent rice and grain-bean crops determined that the share of infected plants in the standard variety and in other experimental varieties ranged from 10.7% to 16.0%. This disease decreases the productivity of rice varieties by 20–25%.

Seedlings of rice varieties are affected by furious disease pathogens at their first developing stage, which considerably restricts productivity. Studies by scholars from the Tashkent State Agrarian University (2019) show that the seedlings infected by the pathogens of Fuzarious are dried and fully lost (photo 63, 64).

The pathogenic effects of this disease continue in all subsequent development stages of rice plants. It was either identified that if one healthy plant produces 10 to 20 panicles, in the consequences of this disease, these indexes decreased by 15-20%.

The next rice plant disease is Gelminthosporious (*Helminthosporium oryzae* B. de Haan). Pathogens of this disease cause the withering of seedlings and fully developed plants and the rot of root nodes. This disease decreases the crop by 5–10% and often by 30–40%.

Rice mosquito, rice miner, costal fly, corn moth, and bread sawfly are the injurious pests on rice plants. The favorable condition for pests' development comes since the start of vegetation development stages of rice—germination, seedlings, and the beginning of tillering.



Photo 63, 64. **Rice seedlings infected by Fuzarious pathogens.**

Damage to rice plants from corn moths (*Ostrinia nubilalis* Hb.) and bread sawflies (*Cephus pygmaeus*) was increasing in the last few years, and the state was forced to announce a two-year project to reduce the harmfulness of these pests. The corn moth gives three to four generations during the vegetative season, and its damage has become high. Mainly, the hatched worms (photo 65, 66) from eggs first live in a swarm and feed on leaf tissues.

The bread sawfly has one generation per season, and its female forms 80 to 150 eggs.

Soil salinization, lowered temperature, and a deeper layer of water are the **abiotic factors that are** declining the anticipated crop from rice varieties.

According to the official information, 60–70% of arable land in our republic has been subjected to different levels of **soil salinization**; in

detail, 15% of this is a strongly salted area. So, our rice breeders have to work in the direction of developing rice varieties resistant to salinization. This would be the decision on maintaining the stability of annual rice production in the regions where the soil is subjected to salinization.



Photo 65, 66. Worm of Corn moth and adult Bread sawfly.

Chapter 6. Rice breeding methods

Today, only the Uzbek Scientific Research Institute of Rice Growing has over 2,000 collection materials representing foreign and local samples at its disposal and purposefully utilizes them in the rice breeding processes. During the 2017–2022 years, the rice varieties Tarano, Tantana, and Sadaf were released as resistant to diseases and pests, shedding, and lodging.

At the end of our analysis of the growing rice varieties, we isolated 4 rice varieties (Uz-ros 7–13, Avangard, Lazurniy, and Nukus 2) out of 19 varieties included in the state register and substantiated them as the best achievements of rice breeders. All of them were bred as the result of intra-species hybridization and the selection of the best plants from the hybrid population. Thereby, we can consider selection and intra-species hybridization to be efficient rice breeding methods in Uzbekistan.

Selection of initial materials and hybridization. They are used jointly by our rice breeders. Their orders are copied down from the All Russian Rice Growing SRI (figure 21).

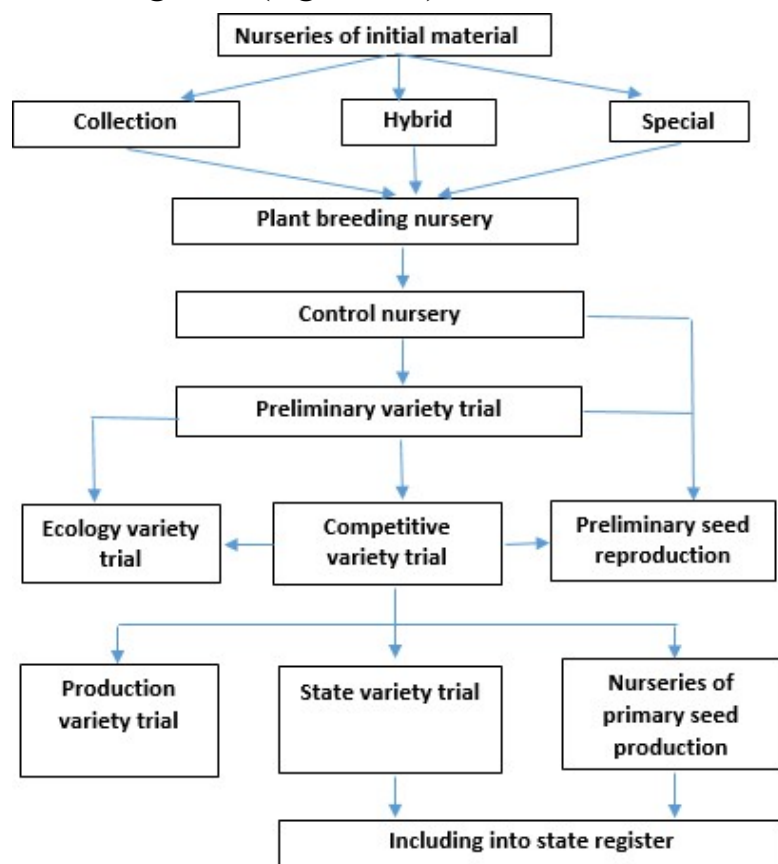


Figure 21. A scheme of plant breeding processes with self-pollinating plants.

According to this, the plant breeding process gradually leads to the scheme being accepted by the self-pollinating plants (nursery of initial materials, plant breeding nursery, control nursery, preliminary testing, competitive testing, ecology testing, production testing, and state variety testing). The nursery of initial materials involves the collection nursery, the nursery of mutants, the nursery of parents (the nursery of hybridization), and the nursery of hybrids. The selection of initial material or parental plants is implemented in the first breeding nurseries. Often, the parental plants are grown in the containers for convenience of crossing and adjustment of flowering times through shading or lighting. Cultivation of the first generation in the greenhouse is being recommended to accelerate the plant breeding process. Growing and study of the breeding materials in the following nurseries are carried out as the commonly accepted method for self-pollinating plants. Practical use of this method by our scholars can be seen in the rice breeding experiment implemented at Fergana State University (2022).

Following that method, they have isolated 1m^2 ($1\text{m} \times 1\text{m}$) of area for every experimental land lot in the collection nursery and 2m^2 ($1\text{m} \times 2\text{m}$) for lots in the breeding nursery. And the seeds of all experimental plant samples were planted in their lots consequently without replication. The seeds of the standard varieties, Guljakhon, Ilgor, UzRos 7–13, and Lazurniy, were planted by hand in every 10th and 20th land lots. The norm for seed planting was 500 seed units per m^2 . These procedures fully coincide with the rice breeding methods of the Russian All Union Rice Breeding Scientific Research Institute and the Uzbek Scientific Research Institute of Rice Growing. And the quantitative data taken from the experiment during the phenology surveys is treated statistically with the help of B.A. Dospekhov.

The below-listed field works, phenology surveys, and measuring works were conducted in the experimental plot:

1. Humus content across ploughed soil and total nitrogen, phosphorus and potassium elements were determined.
2. The seeds of the experimental samples were planted strictly in their land lots, and the seedling plants were cultivated in an adequate agro-practice condition.
3. Phenology surveys were conducted according to the methodical manual “State variety test control of agricultural crops.”.

Totally, 327 rice samples and standard varieties (Uz-Ros 7–13, Avangard, Lazurniy, and Nukus 2) were planted and studied. Out of the

phenology surveys, seedling germination, tillering, heading, flowering, and maturation periods were recorded. Survey outcomes revealed that seeds vigorously germinated in the 306 lots with sparse germination in the 21. Plants of rice samples, depending on their growing periods, were selected into 3 groups: early ripening (with a growing period up to 110 days); middle ripening (from 115 to 125 days); and late ripening (130 and more).

At the time of maturation, the best representative plants from every group were selected, biometric analyses (plant vegetation period, height of plant, number of grains, weight of 1000 grains) were carried out, and the final selection was based on the biologic and economic traits.

Productive tillering is one of the most valuable farm traits. That is why the scholars paid great attention to the formation of this trait in the conduct of the study. The results of the survey have exhibited that Guljakhon, Ilgor, and Uz-Ros 7-13 have respectfully 2,4; 2.6 and 2.8 indexes, while selected samples of Tahngkn, D-195, F2-D-3, VIR 141 2006, 389 x UzROS 7/13, IR-3 could show top indexes at the level of these standard varieties.

It was discovered that there are interesting ones in selected samples with a weight of 1000 grains. For example, VIR 7690 (37.6 g.), WAB 880-56-43 (39.0 g.) and 329-01 x 267-01 (40.0 g.). And these samples were recommended for use in the coming crossings as one of the parental initial materials.

The soil-climatic condition of the Amudariya basin is very distinguished from other regions of Uzbekistan where the soils have been affected at different levels by salinization.

Interspecies hybridization and individual selection have become traditional rice breeding methods in Karakalpakstan. At this point, the initial material is created purposefully. High-productive samples, after evaluation of their resistance to chloride salinity, lowered temperature, deeper layer of water, and *Pyricularia* are incorporated into hybridization. Often, one of the parental forms has to be a local variety; another is a high-productive variety from a foreign origin that is closer to our region for its phenotype and biological traits.

Taking into account the complete nature of quantitative traits, the pairs for hybridization are selected within one or various ecotypes of complex economic-valuable traits in order to fill each other with yield structure, the period of a certain developing stage of plants, resistance to lodging, and other adverse factors mentioned above.

Research in hybrid populations is continued with the method of reseedling. A comprehensive assessment of hybrids with the second and successive generations on their productivity, vegetation period, plant architecture, and resistance to lodging and shading is implemented prior to elite plant selection. In regard to plant breeding, hybrid populations exhibiting high productivity in the first generation and maintaining it in the next generation are the most valuable. Further, recombinant selection based on the prior planned selection methodic parameters, mainly based on the isolation of transgression forms in productivity recombinants, is conducted.

The selected forms are handled in successive nurseries, studied, and evaluated in correspondence with the commonly accepted scheme of plant breeding (Smetanin A. P. and et al, 1972).

The special attention of breeders is focused on the positive complex of traits at the time of elite plant selections out of the hybrid population. Selected elite plants were compared with standard, commercialized rice varieties in the breeding nursery. Vegetation period, plant architecture, number and weight of panicles, weight of 1000 grains, and plant productivity are the major criteria of the assessment. The selected plant forms based on their superiority on the complex of traits studied in the control nursery. These forms are studied in much more detail, starting with the control nursery, given the privilege of forming extra-earliness, earliness, and middle maturity variety samples with good productivity and grain technologic quality, possessing good resistance to lodging, shedding, infection by *Pyricularia*, soil salinization, cold temperature, and deep water layer in the period of seedling germination. Then, the more distinguished variety samples of the control nursery are studied in the competitive variety testing nursery for three years to get complete and objective marks.

Variety samples distinguished for their complex of economic-biological traits and properties, high productivity, and resistance to extreme conditions are studied in production and ecologic variety testing (figure 21). And the preliminary seed reproduction on the formed varieties having a sustainable high yield with a positive complex of traits and properties is started and transferred to the State Commission on the variety testing of agricultural crops.

The original eco-types of rice were created as the result of this multiyear plant breeding with good adaptation to the local soil-climatic conditions of Karakalpakistan. Furthermore, the rice varieties Nukus-2,

Gulzar, Sanam, Nukus 70, and Gulistan were developed similarly with their characteristics of good plasticity, positively responding to improved growing conditions, and occupying all areas planted to rice in Karakalpakistan.

Their distinguishing features are their early maturity, plasticity, and ability to produce stable grain yields of 4.0-4.5 tons per hectare even in heavily salted soil following the development of plump salt marshes. The potential productivity of these rice varieties is achieved at 6.0–6.5 and 9.0–10.0 tons/ha.

All other plant breeding methods are also suitable for use in rice breeding. And we can analyze their efficiencies in rice breeding from foreign breeders.

The method associated with **DNA markers** directed to get genotypes resistant to diseases of rice has a wide scale use by the Russian rice breeders because of its opportunity to choose necessary genes along the way of plant breeding. First of all, the importance of the resistance to *Pyricularia* is explained by the great losses to rice-producing farms from the consequences of this disease. In addition to reducing yield losses, disease resistance also means reducing the dose of chemical treatment for rice.

Scientists of Kazakh SRI of Rice Growing (2017) used **molecular screening** of chromosomal DNA regions of rice plants to deal with problems related to salt resistance of growing varieties. According to the official information, the yield decrease in the last year was from 5.0 to 3.5–4.8 tons per hectare and the quality of producing products (outcome of cereals from 65 to 45–50%). At this stage, molecular screening of chromosomal DNA linked with QTL (quantitative trait locals) to salt resistance is carried out with the help of PZR-analyze. The microsatellite RM 493 and AP 3206 markers, closely linked with targeted chromosomal regions, are applied. It was defined that the marker of RM 493 was very informative to ranging genetic tissues of rice on the trait of salt resistance.

The research has revealed polymorphism between genotypes, in contrast to the studied trait. The object of study were varieties and variety diversities (including offspring of different generations of hybrid combinations) of rice (*Oryza sativa* L.) from Russia, Kazakhstan, and the Philippines (totaling 34 genotypes). This method used in plant breeding could successfully assess and select the initial material for rice breeding based on the resistance to various types (chloride, sulfate, and

carbonate) of salinization. The hybrid F2 of the variety Khankayskiy 429 x Collection sample 4-09 and the varieties Marjan and Madina accumulated the most (in percentage) biomass at the three types of salinization. Consequently, the scientists concluded that these genotypes present the breeding dignity and worth as initial material in the breeding scheme for salt resistance.

The method of mutagenesis in rice breeding is considered by Russian scientists (2002) as a relatively new method to create initial material. In some cases, using this method makes it possible to decrease the duration of the plant breeding process and facilitate obtaining desirable initial forms. They also noted that creating genetic diversity (or variation) with the help of mutagenesis doesn't reduce the value of hybridization, which is the most widely used method to get initial material.

Hybridization and induced mutagenesis are the two genetic contrast principles and complementary methods of creating new forms.

As they informed us, dimethyl sulfate and diethyl sulfate at concentrations of 0.1 and 0.3% were used for the first time to treat grains of the rice varieties Kurchanka, Lider, Violetta, Sprint, Talisman, and Pavlovskiy. The mutants obtained as a result of this research may be used in rice breeding to improve the shortening of stem height and plant earliness.

Rice breeding **at the level of cells** also reduces rice breeding time in comparison with traditional methods. Callus, suspension cultures, isolated protoplasts, organogenic explants, and cultures of somatic or androgenic embryoids in vitro may be used as the experiment objects to conduct research on cell plant breeding. The choice of one of those objects depends on the availability of elaborated technology for a certain crop as well as the ultimate aim of the research. The forming callus tissue is tested under a concentration of selective factors (any of abiotic factors), at which differentiation takes place within callus tissue colonies. It was reported that the first positive results (resistance to NaCl and Na₂SO₄) were taken.

Chapter 7. Rice surveys and evaluation of initial breeding materials

Multiyear rice planting practices show that the best terms for seed sowing in spring are 25.IV, 5.IV, and 15.IV in the Tashkent region and 30.IV, 10.IV, and 20.IV in the Khorezm region, taking into account the planting varieties' vegetation period.

Two ways of planting are available in Uzbekistan:

1. Rice seeds are sown in the soil and flooded with water.
2. Using rice seedlings to plant.

The first method of seed planting begins when the stable day temperature of the water reaches 14°C. The seeds are sown at a depth of 3–4 cm in the soil by the mechanical seed drills. Seed planting norms are 20x15 for late-ripening varieties and 15x15 for middle-ripening, with 1–2 seeds into the seed nest. The optimal condition for getting a high yield is secured when the total number of plants standing per m² is 250–300. The seed drills must sow 5–6 million vital seeds per hectare to keep this plant standing. After planting, the plot is flooded with water.

In the second method, the seedlings are prepared in the special nurseries for seedling growth. The surface of the soil must be higher than neighboring land plots in order to drain water from the nursery at the right time. The seedlings are ready to plant in the main areas: on the early-ripening varieties in 25–30 days, and in 30–35 days for the middle and late-ripening varieties. The plant is standing the same as in the first method. This work is being done in the watered soil, which is why it is difficult and time-consuming.

A group of scholars carried out a field experiment with the rice variety Iskandar to determine the optimal term for rice seedling planting after main crop harvesting in the Andijan region (table 31).

Table 31. Development of rice variety Iskandar depending on the planting terms.

Varieties and terms of planting	Number of productive stems, unit.	Total number of stems, unit.	Plant height, cm.	Weight of 1000 grains, g.	Crop, ton/ha.
25.VI					
Iskandar	193,7-	213,1-	120,5-	31,5	7.0

	221,1	243,1	122,2		
Guljakhan (st)	198,5- 223,0	218,3- 245,3	118,2- 121,1		
5.VII					
Iskandar	231,8- 260,6	210,8- 236,9	122,3- 124,4	31,7	7.7
Guljakhan (st)					
15.VII					
Iskandar	227,6- 203,2	250,4- 223,5	121,8- 122,1	31,4	7.1
Guljakhan (st)					

They studied three terms: 25.VI, 5.VII, and 15.VII in order to determine the optimal term out of them. The seedlings were prepared in time (after 30 days of growing in the special nursery) by the recommendation of the Rice growing SRI. Another variety of Guljakhon was taken as the standard to compare the taken data. It is obvious from the results included in the table that July 5th is the most optimal term in the Andijan region to plant seedlings, which facilitates the highest grain yield.

Field surveys (phenology observations) are conducted **to assess the breeding materials of rice plants**. All plants in all nurseries are involved in inspections at every stage, beginning with the time when 10% of plants entered a certain stage and being completed when 50% of plants entered. Milk, wax, and full maturity are identified on the spikelet in the middle part of the panicle.

The productivity at the first stages of plant breeding is determined by the productivity of plants. Beginning with the breeding nursery, the calculation of productivity is fulfilled by the method of random thrashing.

A biometrical analysis of the probe bundle is conducted to determine the productivity of plants and the structure of productivity. The following traits are analyzed: height of plants, general and productive bushiness, panicle size and its density, number of spikelets on the panicle, weight of grain with panicle, weight of 1000 grains, filminess, sterility, grain to straw ratio.

The filminess of rice grain is defined through the isolating of 5 grams of grain in an average out-of-seed sample. The peels of all grains in the 5-gram grain probe are peeled gently with the help of tweezers. Then, weighing peels and cleaned grains alone, their weight is identified as the total probe weight ratio in percentage.

The plant standing density in the plot is taken into account in the competitive and production variety trials at the time of full seedling appearance and before harvesting. The assessment of shedding and lodging is conducted 10 days after full maturity. Shedding is determined by pressing the panicle by hand, lodging visually on the scale of five marks.

Assessment of the shedding is also conducted by leaving plants on a definite area for 5, 10, and 15 days and then picking up a definite number of spikelets and accounting for the percentage of fallen grains.

Resistance to fungus diseases is assessed during the artificial infection. Taking into account the percentage of infected plants and the harmfulness of the disease to a certain sample.

As mentioned above, *Pyricularia* (photo 67) is the first disease for its harmfulness to the rice plant and its crop. Its missel is overwintered in the seeds, straw, and hay. Distinguish its three forms: leaf, node, and panicle. The losses of rice crop in the consequences of infection are usually up to 25%, and in the years of mass spreading, up to 60% and more.

Harmfulness of disease is manifested in:

- *-decreasing of seed germination;
- *-death of seedlings;
- *-loss of individual plants in the period of vegetation;
- *-setting a few number of grain in the spikelets;
- *-forming undeveloped or puny seeds.

Rice breeding to create varieties resistant to *Pyricularia* has been undergone for a long time by the rice breeders of All Union SRI of Rice Breeding in Russia. As a result, they have such varieties as Liman, Rapan, Garant, and Lider, which were recommended to be used in the breeding processes as initial materials. But still, there is not any variety not infected with this disease.



Photo 67. Rice plant infected with *Pycalirios*.

Assessment of rice samples on their resistance to insect-pests.

N.G. Otamirzaev (2024) has studied the occurrence of insect pests feed on rice paddy and determined that their population density on 1m² of area makes up: Bokovlav crabs (*Leptestheria dahalacensis* sars) – 50 pieces, 0.3 pieces of Barley minions' larvae (*Hydrellia griseola* Fall) on two stems, 32.0 pieces of Coastal fly larvae (*Ephydra macellaria* Egger) and 1 piece of Rice long nose bug (*Hydronomus sinuaticollis* Faust) on 1m². 5 pieces of Corn propeller worm (*Ostrinia nubilalis* Hb.) on 1 stem of plant.

They cause a considerable loss of rice productivity and the damage by these insect-pests is assessed by the using of the ten-point scale of the International Rice Research Institute:

- resistant plants: 0–1 point–no damage, small brown spots, covering less than 25% of the total leaf surface on the studied plants;
- medium resistant plants: 2–5 points–typical elliptical blast spots, 1–2 cm long, covering 26–50% of the total leaf surface on the studied plants;
- susceptible plants: 6–10 points–typical blast spots of elliptical shape, 1–2 cm long, covering 51% or more of the total leaf surface on the studied plants.

At the assessment of grain quality, glassiness is defined as the presence of a white spot on the grains in the cereal, the output of the cereal, and the taste of porridge. Taking also into account the length and

width of grains. Grain quality is assessed at all stages of the plant breeding process and at the selection time of elite plants.

The index of grain glassiness is very important to the rice. The glassy grains give more cereal output than whole grains at the time of reprocessing. At the time of boiling, such grains maintain their integrity.

100 grains are isolated from the grain sample to define the glassiness of rice grain. Then 50 polished grains are cut across the section with the help of a knife. The brilliance (glassiness) of the endosperm and nuclei is identified by the powdery ratio in percent. The glassiness of the left 50 grains are also defined similarly. The total glassiness (Tg) is accounted for by the formula: $Tg = Fg + Pg: 2$. Where: Fg-number of fully glassy grains; Pg-number of partially glassy grains. The result is rounded to a whole number (photo 68).

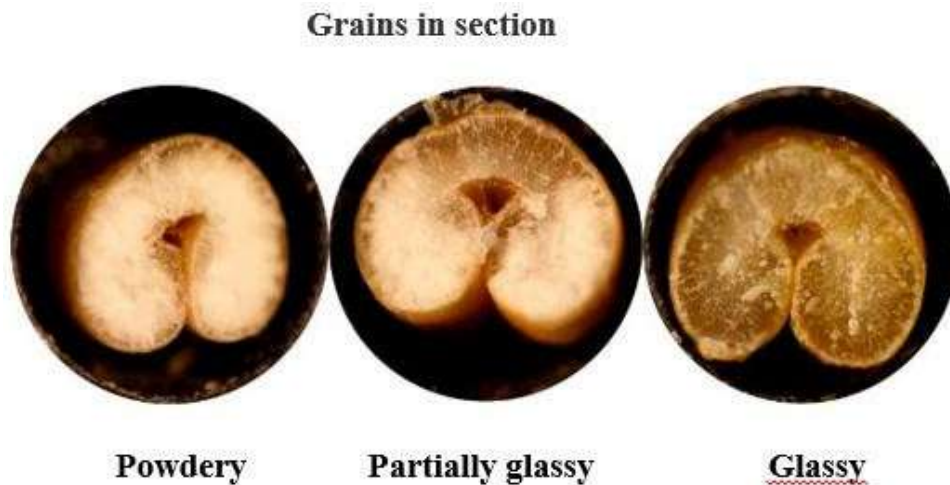


Photo 68. **Degrees of glassiness of rice grains.**

On account of phenotypic traits, the breeders pay attention to the following schemes: the plants must be straight standing, with strong and short straw, with a deeper placed node of bushing, resistant to shedding, and have 2-3 stems with an enlarged, fully matured panicle. The panicle must be dense, with a great number of fertile spikelets.

Chapter 8. Hybridization technique of rice

Pollination of rice by hand is a comparatively difficult process.

The generative organs of rice flowers are very sensitive to damage and fluctuations in temperature and humidity. The rice breeders of the world elaborated several methods of pollination to facilitate the pollination process: the clipping method, the hot water method, the Dr. Ramiah method, the vacuum emasculation method, the cuttack method, the brown paper method, and Rhind's method. They are easily available on the internet and can be chosen to use in a personal rice breeding process.

The quality of the fulfilled pollination and fully hybrid seed setting depends on the knowledge of the pollinating person about the floral biology (photo 69, 70) of the rice plant. The floral biology of rice involves: terminal panicles have perfect florets; they are bisexual and self-pollinating; each floret (flower) has six stamens; their long filament, lemma, and palea protect the flower; and a well-developed carpel with two feathery stigmas, styles, and ovary. Florets bloom usually between 2-4 days; blooming starts from the top (tip) part of the panicle and proceeds downward; pollen shed takes place at the time of flower opening (starting at 8–10 am); each spikelet (floret) opens for 30 minutes then closes; receptivity of the stigma continues for 1–4 days; pollen vitality is possible for 24 hours; fertilization completes during 3 hours after pollination. There is genetic behavior such that another dehiscence takes place immediately after the opening of the spikelets.

Needed kit to conduct hand pollination of rice: scissor, forceps, polyethene bags, gentle brush, tags, and threads.

Emasculation is the responsible moment for all controlled pollinations. It involves the removal of anthers and protecting the stigma from cross-pollination. The female plant chosen for emasculation must be insect- and disease-free and healthy. Its flowers are going to open by next morning. Removal of immature and opened flowers by the help of a scissor (photo 69).



Photo 69, 70. **Emasculation and bagging of emasculated rice flower.**

Lemma and palea are cut (clipped) off at the place 20% below their tip with the help of a scissor. Stamens are removed one by one with forceps. The afternoon is the best time for emasculation.

Bagging

emasculated rice florets with polythene bags is one way to protect against pollination by non-desirable pollen. Panicles of the male plant are also to be chosen. **They are** also expected to open in the morning. They must have spikelets whose anther length is about 60%. Then pollens collected from the anthers of chosen male plants and put on the stigma at the emasculated flower of the desired female paren are fulfilled. This work is done the next morning, when the stigma becomes receptive. It would be better if the panicle of the male plant with yellow and turgid anthers was put in bright sunlight for 15 minutes.

The last work involves the temporary removal of the isolation bag from the female plant and pollination by dusting pollen from the opened anthers over the stigma of the emasculated flower. At another time, whole anthers are inserted inside the floret with the help of brush or forceps.

Tagging. Tagging is done after bagging the pollinated floret again. A tag is tied to the panicle with thread. The tag bears the following information: number of rows in the nursery, combination of pollination (Iskandar x Guljakhan), date of emasculation, and date of pollination.

Chapter 9. Seed production of rice

The announcement and decision of the government about the choosing of rice seed producing farms in Uzbekistan was published in 2021. According to this document, to provide the rice producing farms with variety, regenerated and certified seed stocks is essential for high and sustainable rice crop production in the republic.

The real absence of rice seed production system across the republic and impossibility to guaranty in delivering of cleaned, graded and provision of certified seed stocks to rice producing farms were the main reasons to accept above mentioned state decision. In fact, in 2020 the rice fields of our republic needed 21.4 thousand reproduced seed stocks but was provisioned totally 615.4 ton certified rice seed stock: 351.4 ton from Karakalpakstan and Khorezm branches of Rice growing SRI and: 264 ton from Karakalpakstan experimental station of Grain and Bean Crop SRI. In 2021 this need to rice seed stock has increased even more, up to 22 thousand ton to plant under main area of 66.7 thousand hectare and 62.2 thousand hectare of area after the spring crops.

It is obvious that the amount of these provisioned seed stocks was not able to provide all rice producing areas of the republic. That is why, the most of the rice producing farms have had for a long period to prepare their seed stocks in their own fields. Such order of seed stock production often lead to the reduction of productivity of the rice varieties.

The aim of the state to choose the potential farms across the rice producing regions of the republic is the first, to produce guaranty regenerated seed stocks; the second, rice seed production system is organized and produced certified generation of seed stocks; and the third, the productivity is increased on the account of the planting of certified seed stocks by the rice producing farms.

The preliminary requirements of the scientists to the selected rice producing farmers are:

- *-not arrange seed stock producing field more than one year in one place;

- *- 2-3 time of removal, with root off type plants (red grain forms and others which visible pre heading stage of plant development) in the aim of retaining of variety purity;

*-to have privilege for rice producing farms in the purchasing of mineral fertilizers, in the providing of needed water, weeding and completing harvest in time.

Rice seed production at the Scientific Research Institute of Uzbekistan, its regional branches and in the farm level is corresponded to the following order (system):

1. Super elite and elite seeds are produced in the first and second year seed nurseries from the original seeds selected in preliminary seed production nursery at the Uzbek Rice growing SRI and its regional branches.

2. I and II reproduction seeds are produced in the special rice seed production farms in the regions of Tashkent, Surkhandarya, Khorezm and Karakalpakstan Republic.

3. III reproduction seeds are produced in the seed production farms at the specialized rice growing farms and are sown in the production areas to produce commercial grain.

Not specialized to rice growing and small landowner rice growers and farmers getting II or III reproduction seed stocks from State fund to produce commodity rice.

According to the resolution of the Cabinet of Ministers of the republic of Uzbekistan (2020) the following scheme of rice seed production organization was approved for our republic (figure 22).

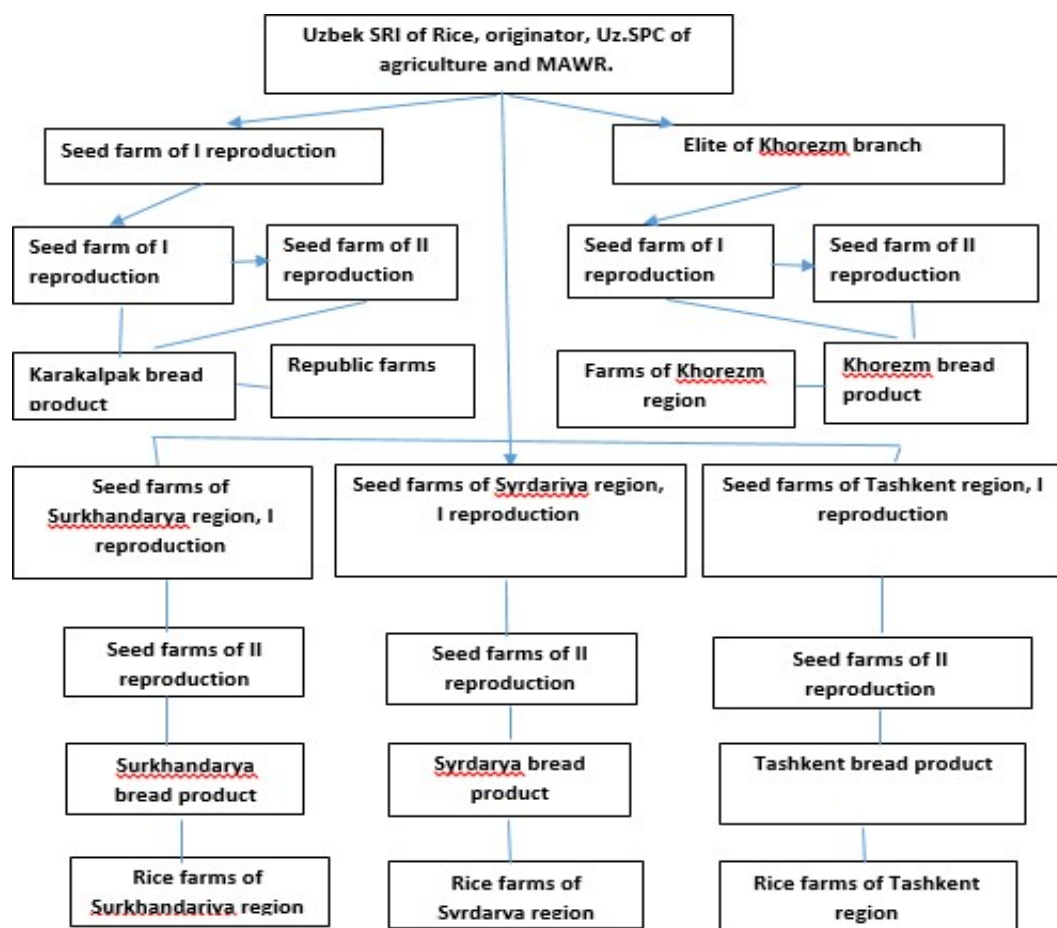


Figure 22. Scheme of rice production organization in the republic of Uzbekistan.

Here, the bread product in the scheme is the State corporation (Uzhlebobproduct). This organization is responsible on its account to build required number of workshops on the provision, grading, sorting, disinfection and packaging rice seed stocks and as well as their delivering to the farms after preliminary part-time work in the specialized workshops with issuance of a quality certificate. Moreover, organization of rice producing clusters has become one of the priority aspect in the improving rice production in the republic.

They say that organization of rice seed production on the base of industry is meeting the modern requirement and has an important significance in the improving of seed production. At this, provision of high yield and quality seed stock takes place due to specialization of seed production and organization it taking into account of biologic properties of varieties (early ripening, middle ripening and late ripening) and regions' natural-climatic conditions.

Analysis of multiyear scientific research works' results, indexes of rice seed stock farms, State variety trial networks' data and foreign rice production experiments (photo 71) have revealed that organization of seed production on the base of industry for late ripening varieties in Surkhandarya region, on the middle ripening varieties in Tashkent and Khorezm regions and on the early ripening rice varieties mainly in Karakalpakistan will be more purposeful. Its economic efficiency was scientifically proved and practically demonstrated in the results of special scientific works and annual production reports.



Photo 71. **Spatial view of International Rice Research Institute.**

Scientific Research Institute of Uzbekistan is closely cooperated with International Rice Research Institute with headquarters in Philippines which has international reputation in the world rice variety development, rice management, and its seed production. In its presentation is written that “IRRI develops new rice varieties and rice crop management techniques that help rice farmers improve the yield and quality of their rice in an environmentally sustainable way. IRRI works with its public and private sector partners in national agricultural research and extension systems in major rice-growing countries to do research, training, and knowledge transfer.”

Questions on the studied themes:

1. What is the importance of approval in the seed-producing fields of barley, and who is responsible for its quality?
2. On the basis of what is analyzed is the state of the seed field, and what is the analysis itself?
3. Do you remember about the approval statements and their kinds?
4. Tell me about the economic value of rice plants in the world and in Uzbekistan.
5. Can you imagine phenotypic distinctness between plants of wheat, barley, and rice?
6. Remember the botany of the rice plant and its diversities?
7. Describe the plant-developing features of the rice plant and its generative parts.
8. Name commercialized rice varieties and their demand by our nation.
9. Characterize the growing stages of a rice plant.
10. What rice breeding directions are priorities for our rice breeders?
11. List the most efficient methods being used in the improvement of rice varieties.
12. How are rice breeding materials assessed in the rice breeding process?
13. What is the peculiarity of rice crossing technique?
14. What is the rice seed production state in Uzbekistan?
15. Are you able to remember the rice seed production scheme in the regions of the republic?
16. Do international rice institutions cause the improvement of local rice production methods?

Chapter 10. Rice approbation

Approbation in rice seed producing fields is conducted when the grain peel color has formed at the beginning of its full maturity. The conducting order of rice approbation is similar to wheat approbation.

In the case, when the field designated to conduct approbation was used to plant and cultivated different rice varieties in the previous year it is divided into parts according the number of planted varieties and is picked up probe bundles individually. 100 hectare is accepted as the limit area to inspect plants and to pick up one probe plants (appendix 5). The spatial isolation of the field must be 150 meter. If the area is larger than 100 hectare, then it is divided into two parts and two samples (bundles) will be taken alone from each one, moving through their diagonal directions. At this, from 100 points of inspection in each one will be taken at least 1000 plants.

Plants of approbation bundle to inspection are grouped into following plant types:

1. Main variety stems.
2. Stems belong to other variety and species.
3. Stems of main crop infected by black smut and nematode.
4. Stems of very dangerous weeds.
5. Stems of poisonous weeds.
6. Stems of hard isolating off weeds.
7. Undeveloped stems of main crop.

Infection grade of field with nematode and smut in % is determined individually for every disease. The presence of this diseases in the field is recorded in the approbation statement. Nematode is a prohibited disease that is why the stems and panicles infected by it will be send to quarantine inspection to verify (photo 72).



Photo 72. Symptoms of nematode disease: field (a) and nursery (b) presented by Matiyar Rakhaman Khan, 2015.

Agronomist approbatory instructs farm managers to harvest infected field and storage its grain alone in the specially isolated warehouse. The fitness of the grains harvested from such kind of fields to sowing is solved by the decision of the quarantine inspection. Rice millet and enlarged fruit millet are hard isolating weeds. The rice fields is cleaned from these and other (photo 73) rice plants (with red, darker, yellow, light brown colored rice grains) prior to approbation. These field also is marked in the approbation statement and underlined the necessity of special grain cleaning after harvest.

In the case, when the plants' infection by the disease of smut and rice afelenchoma is found at the time of approbation the seeds of this field are marked as unfit to sowing.

According to the requirement of the state standard, seed stock variety purity belong to I category must be 99.05%; II category-98% and III category not less 95%. Seed stock rice must be free of quarantine weed seeds and grains infected by diseases.

Elite seeds of rice must be free of red grain and other wild rice grains (photo 74) and to be elite variety purity not less 99.08%; The purity out of sowing quality of the 1st class seed stock rice must be not less 99%; seed germination -95%; seed moisture, not more -14%. These indexes in the 2nd class of seed stock rice must be respectively: 98%, 90% and 14%. Mixtures of red grain and other wild grains are required not more: in the I category of rice seed stock -0.1%; II category -0.3% and III category -1.0%.



Photo 73, 74. **Impurity of rice field and rice grain** (internet sources, 2023.).

Part V. Breeding and seed production of corn

Chapter 1. Corn and its economic importance

Corn, *Zea mays* (Maiz) is its scientific name. It's a monoecious, predominantly cross-pollinating cereal plant of the grass family – Poaceae. Chromosome number of corn is stable, $2n = 20$. It was originated from northern America and has become one of the most widely distributed food crop over the world. It is used as human food, in livestock feeding, as biofuel and as the raw source in national industries.

Historically it is explained that it was first domesticated by native people of Mexico about 10 000 years ago Teosinte (photo 75), a wild grass was ancient form of modern corn. Modern corn was the result of prolonged deliberated selections of



Photo 75. Teosinte is the grand parent of modern corn.

the people. Its indigenous diversities later had spread by the time of native Americans. They taught European settlement which let introduction into Europe and other continents of the world. And sooner it has become one of the most important crop in the world.

Phenotype characteristics of corn are tall, reaches 2 to 3 meters in height and occasionally grows as tall as 7 m, annual grass with tassel on the top of erect, robust stem. The large narrow leaves are spaced alternately on opposite sides of its stem. Male flowers are formed on the tassel located at the top of the plant and consists of a central spike and variable number of lateral branches. Anthers can be yellow, purple, or red.

The female inflorescences placed on the base of middle leaves of the stem and after fertilization are transformed into the edible ears (cobs)

as the spikes with a thickened axis, bearing many rows (4-30) of florets. Each floret contains a single ovule. From each floret, a style will elongate towards the tip of the cob, forming long strands of tissue called as silks. Silks have short hairs to capture pollens. After pollination of its ovule arises matured grains (figure). Each corn cob is enclosed by modified leaves called husks. There are corn varieties with colored grains such as white, yellow, red, blue, pink and even black.

The diversities of grown corn include dent corn, flint corn, flour corn, sweet corn and popcorn. The kernel structure is the basic characteristic to distinguish them each other.

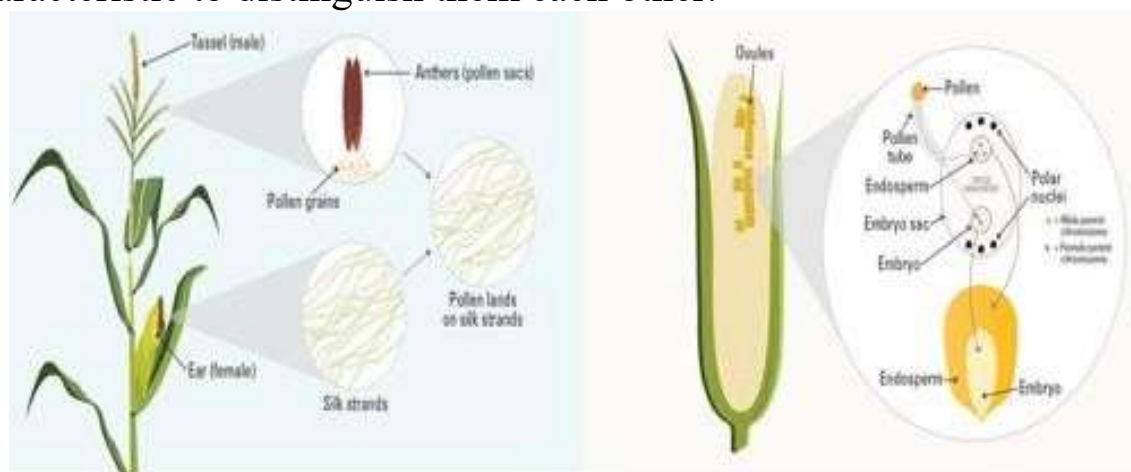


Figure 23. **Corn pollination** (Tom J. Bechman, 2018).

Dent corn is grown primarily to feed animal and for reprocessing industry, is characterized by a depression in the crown of the kernel. Flint corn, mostly is used for decoration. Flour corn, is an important source of corn flour. Sweet corn and popcorn, commonly used as food, their sugar is not converted to starch as in other corn types. Beside this, corn has demands from consumers to use as the biofuel, and as a crude material in industry.

According to world social information, the overall quantity of corn produced worldwide is predicted to hit 1.17 billion metric tons in 2023 (figure 24).

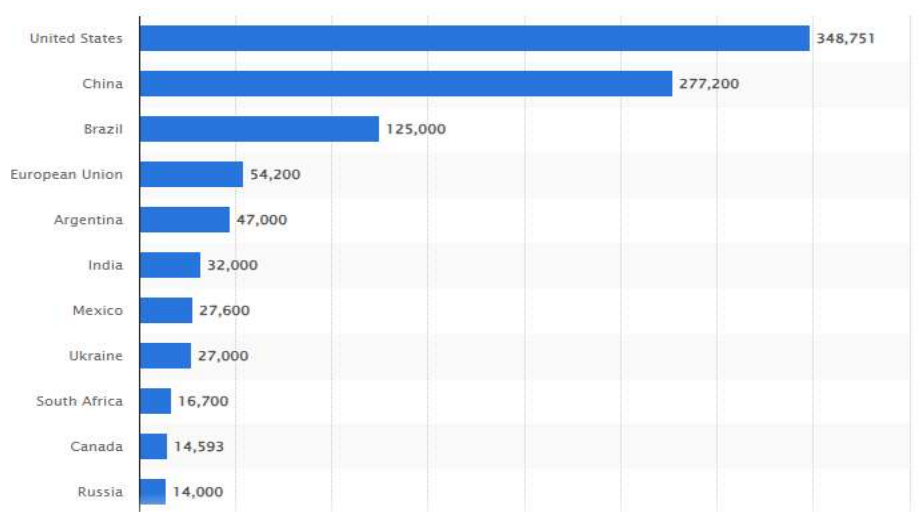


Figure 24. Global corn production in 2022\2023, by country (in 1.000 metric tons).

Corn has a great importance in our republic either, in terms of food for human consumption, livestock feeding and as a raw material for industry. 16 corn varieties (table 32) and 63 hybrids have been registered to plant in the regions of the republic for the crop year of 2022.

Such varieties as Uzbek Zubovidniy (1962), Kremnistaya UzROS (1969), Moldavskiy 425 MV (1991) are being cultivated for more than 30 years and are cherished by the farmers and corn breeders as the most potential in the local growing conditions. At this, Uzbek Zubovidniy is valued to produce silos for livestock feeding, Kremnistaya UzROS and Moldavskiy 425 MV are replaceable varieties in the both purposes as grain and so silos production.

Table 32. Recommended corn varieties to plant in the regions of Uzbekistan.

№	Varieties	Number of originator	Code of the country	Year of registration	Recommended regions to plant.
1	<u>Карасув</u> 350 АМВ	18	UZ	1998	1-13(G*)
2	<u>Келажак</u> 100	18	UZ	2021	3, 11(G)
3	Кремнистая Уз РОС	4	UZ	1969	4,6,8,10,11,13(G,S*)
4	Максима	412	HU	2017	11(G)
5	Молдавский 215 АМВ	272	MD	2007	1-13(G,S)
6	Молдавский 257 СВ	272	MD	2000	1-13 (G,S)
7	Молдавский 425 МВ	272	MD	1991	1-13(G,S)
8	ПЛ 71	473	TR	2019	11, 13(G)
9	<u>Термо</u>	474	CH	2017	1-13(G)
10	<u>Uzbek Zubovidniy</u>	6	UZ	1962	1-13(S)
11	<u>Эсдалик</u> - 80	18	UZ	2021	2, 7, 8, 11, 12(G,S)
12	Uzbekistan 300MV	18	UZ	2012	1-13(G)
13	Uzbekistan 400 DP	18	UZ	2009	1-13(G)
14	Uzbekistan 420 VL	18	UZ	2001	11(G)
15	Uzbekistan 601 ESV	18	UZ	1996	1-13(G)
16	Uzbekistan 2018	13	UZ	2020	3, 8, 11, 13(G)
*Note: G-for grain production; S-for silos production.					

Analysis of the growing corn hybrids (F1) have shown that such hybrids of Spain: Borja, Donana, Matora are being grown throughout the republic since 2011 to produce corn grain. So, they were the superior ones within introduced hybrids from all neighboring and foreign countries in regard of genetic adoptability, resilience and potential to our climatic and soil conditions.

As before underlined that Corn Scientific Experimental Station (photo ..) of Uzbekistan (Uz.CSES) is the coordinating center on the research to create local corn varieties and hybrids in Uzbekistan and has close scientific-research ties with USA, Serbia, Hungary, Ukraine, Russia, Kazakhstan, China and Korea in exchanging of bred seeds and working out of associated corn breeding projects.

The study of characteristics and origin of the best corn varieties: Uzbek Zubovidniy, Kremnistaya UzROS, Moldavskiy 425 MV in remaining methodic actual in spite of the new varieties (Uzbekistan 400

DR, Uzbekistan 300 MV, Kelajak 100, Esdalik 80) developed by the breeders of this center in the last years of 2007-2020. Because, more probably the production time has tested and shown the best combination of initial materials and breeding methods in the result of which those three corn varieties had been developed.

Uzbek Zubovidniy. This was a variety of Experimental station of Middle Asia and All Union Plant growing Institute and originated from sample of K-12081. Authors: V.P.Gorbuniv, S.G.Tarakanov. It belong to teeth like species. The grains have white color, extraordinarily enlarged. The height of plants reach up to 320-360 cms, many leaves. It is one of the late ripening corn varieties and vegetation period lasts from full germination till milk, wax maturity 123 day. Green mass productivity consists of 70.0-98.0 tons. Good fits to mechanical harvest. Damage from diseases and pests is unconsiderable.

Kremnistaya UzROS. According to the available information this variety was created from selection out of local corn populations. Grain is white, grain productivity makes of 6.8-7.0 tons per hectare. The weight of 1000 grain -259.4-273.5 gs. Late ripening, vegetation period -135-137 days. Protein -8.8-9.8%, starch -76.3-74.7%. It has middle infection with disease of smut.

Moldavskiy 425 MV. It was developed by the group of scientists at the Moldavian Corn and Sorghum SRI. The seeds like yellow and teeth form. The height of plants -260-270 cms, and they have about 18 leaves. The cob has silindric shape, the length -20 cm. The weight of matured cob -230 g. Weight of 1000 grains -270.0-302.0 gs. Output of grain -78.0-85.0%. An average grain productivity were 7.0-10.0 tons\ha in 1995-1997 at the republican variety trial networks. The record productivity was registered in Surkhandarya region -11.5 ton. Middle ripening -120-131 days. Damage by the diseases and pest consists of inconsiderable level.

Chapter 2. Growth stages of corn

The latest and a simple description of corn growth stages was written by Michael Plumblee and others (2023). They have noted that identifying corn growth stages is essential for successful crop management of pests and diseases, watering and fertilizer application. And of course, in terms of knowledge it is also essential for corn breeders and its seed producers to work out efficient plant breeding program and to produce high quality planting seeds.

Corn seeds (kernels) begin to grow when they absorb about 30% of their weight in water (figure 25), less than this level of absorb of water or rapidly soil drying in the seed zone may slow down or stop further seed germination

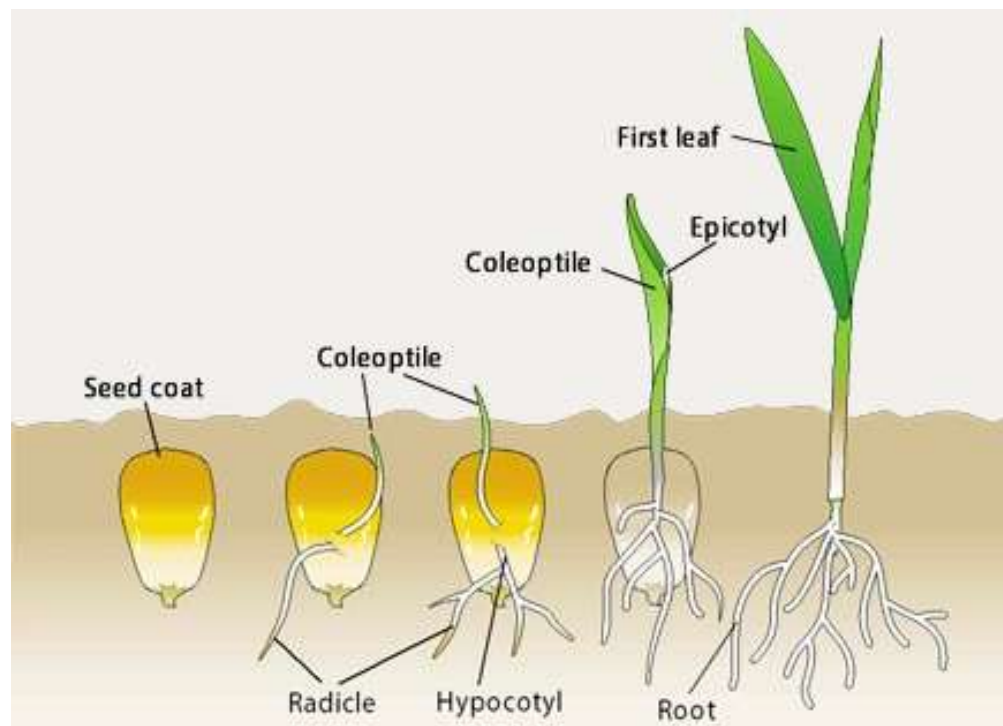


Figure 25. **Corn seed germination and emergence stage of development** (I.Ciampitti, 2013).

On their description, corn seed germination and its growth development is divided into 1) vegetative (V) and 2) reproductive (R) growth stages. Starting time of each development stage has been accepted when at least 50% of plants in the inspecting area are at that stage of development.

The vegetative growth stage begins with corn emergence and is completed by tassel forming. And the reproductive growth stages begin

with silking and end a black layer forms, showing physiological maturity.

1. Seedling emergence (VE) is the first vegetative (V) growth stages of corn. The seeded corn seed prior to germination absorbs water equal to 50% of its weight.

At this time, the mesocotyl which is the center of developing root and younger developing shoot, pushes the shoot to the soil surface. The developing root is called primary root which begins to grow downward and either lateral roots making up the seminal root system (figure 26). They absorb water and nutrients during the vegetation stages.

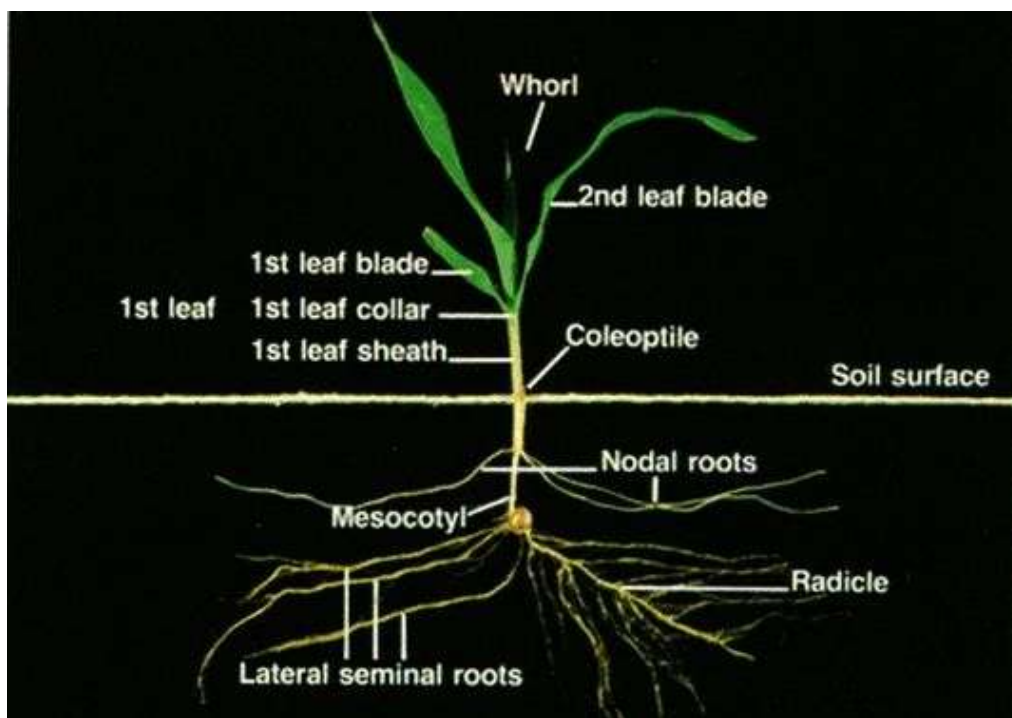


Figure 26. **Description of corn seedling development.**

The coleoptile and mesocotyl elongation stops after emergence. Further growing of seedlings continues from the stem apex (growing point), formed just above the mesocotyl and below the soil surface until the growing stages of V5-V6.

Scientists facilitated understanding the stages between VE and VT by designating them numerically as V1, V2 and through V(n). The (n) explains (photo

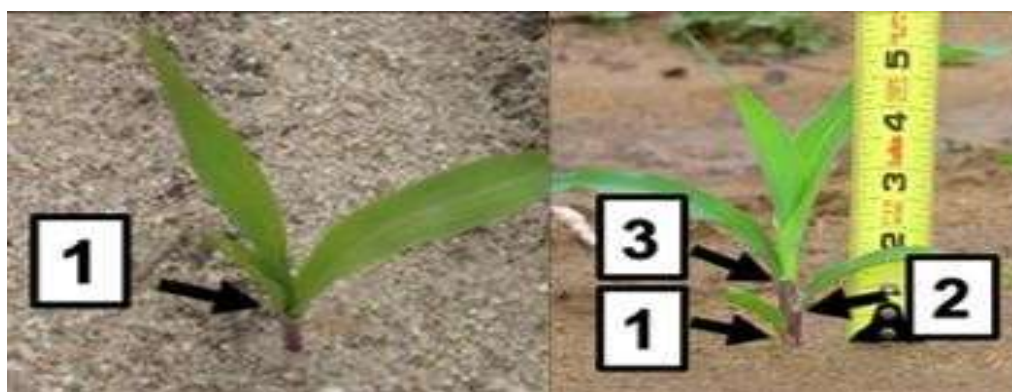


Photo 76, 77. **V1 and the V3 growth stages of corn plants.**

76, 77) the stage with the top leaf fully expanded before the stage of VT. A leaf is considered fully expanded if a leaf collar (the discolored line by Michael Plumblee, between the leaf blade and leaf sheath) is visible.

VT developing stage of corn. As the scientists identified that vegetative growth stage in corn cease with the forming of a tassel, VT. As in the photo 78, 79. VT stage occurs when a tassel of plants is fully expanded prior to the forming of silks (photo 80). It is noted that, tassels will be visible for approximately two to three days before the formation of silks. With this growth stage it indicates that the total vegetative growth will occur on the corn plant with all formed leaves.



Photo 78, 79, 80. **VT stage, expanding of tassel and formation of silk** (images credit: scientists of Iowa State University).

Reproductive growth stage (R). The scientists remark that reproductive growth stage of corn continues in six growth stages before reaching physiological maturity. They have presented naturally clear pictures about each stage and a definite descriptions below.

R1 and R2 stages belong to silking (photo 81), as noted the silks are first visible outside the husks. Emerging of silks continues towards the tip of the developing ear in two to five days and remain receptive to pollen for up two weeks. Falling pollen grains down from tassel are caught by the silks and occurs pollination.

R2 as they named blister stage (photo 82). This stage occurs when the kernels begin to expand, white blistering outside. This growth stage usually passes during ten to fourteen days after R1. And the silks beginning to dry down and turn into brown.

R3 and R4 developing stages. R3 stage or milk growth in which the kernels is pale yellow outside and filled with a milk-colored fluid which is mainly starch. As they say, the kernels at this time have 80% moisture. Surveys revealed that this growth stage occurs eighteen to twenty-two days after R1 (photo 83).

Dough stage occurs in the R4 growth stage (figure 84). Starch continues to accumulate and thickens to a pasty consistency. The kernels turn darker yellow. This growth stage occurs twenty-four to twenty-eight days after R1.

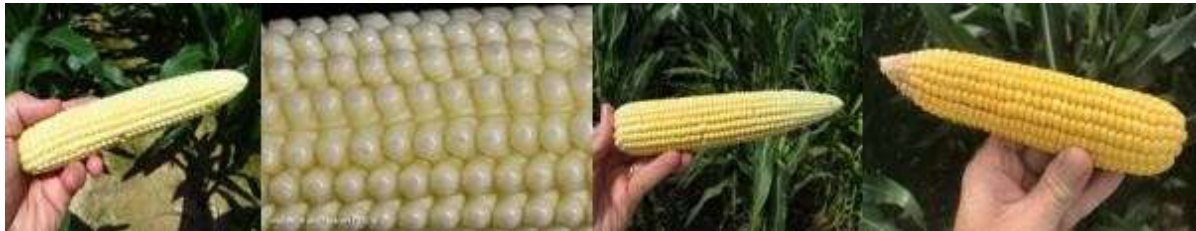


Photo 81, 82, 83, 84. **Development stages of corn kernels** (image credit: Eric Larson).

And now coming R5 and R6 stages where the most kernels are formed into dent shape. Since R5 stage, the kernels are drying down, beginning at the top. This growth stage occurs approximately thirty-five to forty-two days after R1. Kernels at their R6 stage have 30% to 35% moisture content. So, R6 growth stage occurs fifty-five to sixty-five days after R1.

Chapter 3. Corn breeding directions

The Corn Scientific Experimental Station of Uzbekistan (photo 5) is coordinating all corn breeding research in our republic and providing priority breeding directions as well. According to its functioning corn breeding activities, the main corn breeding directions are:

- *Creating early and middle-ripening varieties.
- *Develop hybrids with high grain and silo mass.
- *Selection of hybrids with a high content of lysin.
- *Development of hybrids with drought resistance.
- *Early-ripening hybrids are suitable to plant after the main crop harvest.
- *To adapt world-introduced hybrids to local conditions.
- *Highly productive hybrids suitable to grow under intensive technology.

Often, the above-mentioned directions of corn breeding deal with the use of the plant heterosis phenomenon. Here, the expected result is based on the heterosis effect of hybrids derived from the crossing of self-pollinated (inzucht) corn lines. Furthermore, improving the productivity of different hybrids with various heterosis levels can be implemented through maximal enhancement of such traits, defining the productivity of hybrid plants as the number of cobs per plant, the size of cobs, the number of kernels per cob, and the weight of 1000 kernels.

On a global scale, France is regarded as the laboratory for the creation of new corn varieties and hybrids. According to internet resources, **early-ripening corn hybrids** are developed through the crossing of corn plants accumulated in local conditions for a long period with American corn lines to strengthen their cold resistance.

A great deal of attention in the creation of **highly productive hybrids** is paid to hybrid lines with two cobs because of the almost fully exhausted potential of hybrid lines with one cob. The stability of cob number and grain yield index per plant have also been closely related in years of adverse climatic conditions. As it is often noted, plants without yield in plants with two cobs are met less frequently than plants with one cob. Selection in creating two cob corn lines is focused on the approach of blooming terms between panicles and cob silks. Either way, selection must be directed to select plants with uniform components of the productivity trait in order to increase productivity through multi-cob lines. With a positive result in this direction of corn breeding, which

means obtaining a multi-corn line, the vegetation period of plants is also prolonged.

There are two, three, and multi-cob corn forms, and from this point of view, the term “multi-cob” is used in scientific research to develop multi-cob corn varieties. This kind of corn breeding research is being continued in neighboring countries and the USA.

Developing **hybrids with high grain and green mass (silos)** is achieved in particular through improving the disease and pest resistance of the hybrids or varieties. Actually, this direction of corn breeding is very difficult because of over 40 disease pathogens that attack corn plants during vegetation. Most of them have fungus origins with their different physiologic races. Black smut, for example, covers the whole soil body of the plant; flour dew transforms all corn cobs into spore mass. Bacterial pathogens cause the decay of corn stems and roots. Nematode, rust, and gray leaf spot viruses also lead to considerable damage (photo 86).



Photo 86. **Some of corn plant diseases.**

In one literature, 25 insect pests and in others, about 70 species diversities have harmful effects on corn plants in their growing stages. Within them, corn or stem moth is considered the most destructive one and causes enormous loss of corn crop (photo 87). Its caterpillar damages leaves, kernels, stems, cob pith, and pedicel, which initiates the development of infection by different disease pathogen organisms.



Photo 87. Some of corn plant pests.

Other corn plant pests are: corn worm, ear worm, fall armyworm, wireworm, corn leaf aphids, and so on. All of them together have an unrestrained effect on the corn plant population, which is not in a proper state to harvest at the end of the crop year.

Corn breeders also rely on the genetic potential of their corn collections to improve host resistance to disease and pests. They lead research at the examples of achievements reached by the scientists of advanced world corn.

The high resistance of six tetraploid populations, including wild teosinte (*Euchlaena perennis*), to drought, cold, lodging, corn stem moth, and cotton moth, has been identified by Russian scientists E.B. Khatefev and others (2014). They were isolated individual populations that have selective resistance to certain biotic or abiotic stresses.

Another historic example of increasing the genetic resistance of corn hybrids to diseases and pests is the use of high-resistant existing hybrids. Here, the “Ht” mutant gene is introduced into new hybrids from American corn lines bearing this gene. Such corn lines as ON 7, Stx St., 62, Su 325 and Cu 325 were also resistant to many known corn diseases. Some of them with the mutant gene “ag” (1st chromosome) were able to provide resistance to harmful grasshoppers. In these kinds of corn breeding directions, varieties have increased productivity by 15-20%, as a result of pure line hybridizations by even 100% and more.

To create heterosis corn hybrids is still one of the priority directions in corn breeding. Breeders, in this direction, hope to overcome the complex challenges standing before corn breeding. Hybrids with heterosis potential will have dominance over all other corn hybrids and varieties. Self-pollinated hybrids are the initial material in this corn breeding process. Different methods are used to develop self-pollinated corn hybrids, but the standard method is the most widely used one.

Considerable progress in the creation of **drought-resistant corn hybrid** materials has been made by Russian scientists such as O.N. Panfilova and others (2020). They could select drought-resistant hybrids in the study from two groups of inbred hybrids based on their vegetation periods: early ripening and middle ripening. These two groups of hybrids amount to 223. The standards for these two groups of hybrids were, respectively, Ma 21, F 7, P 346, and IKP 153. In the research plot, they were disposed of in every 20 numbers. The size of every lot to plant seeds of samples is 9.8 m².

Methodic recommendations on conducting field experiments with corn (1980) and methodic instructions on corn breeding (1982) were used to conduct records and surveys. Mathematical treatment of the taken data has been conducted with the help of dispersion analysis by B.A. Dospekhov (1985). A complex assessment of the drought resistance of corn lines and hybrids was fulfilled by the methodic instructions of the VIR.

The main traits to study in this direction of corn self-pollinated collection lines were: days from germination to flowering of ears (cobs), vegetation period, height of plants, grain yield per plant, harvest moisture of grain, cobs setting ability per plant of inbred lines, average weight of cob, and grain output per cob.

Seasonal precipitations and temperatures in 2016–2019 were major criteria for selecting drought-resistant corn lines. The seasons with less wet soil differentiated collection corn lines based on their productivity level per plant. Most of the lines were vulnerable to relatively dry conditions and lost their yield. The decreasing grain per plant consisted of 21.3 g in standard Ma 21, in the lines RP 33 (39.5 g), RP 325 (20.0 g), and so on. Contrary to this, all corn lines without loss of grain productivity per plant were considered drought-resistant and were recommended to use further corn breeding programs.

Chapter 4. Corn breeding methods.

It was noted in the corn breeding literature that **mass selection** was the main method until the end of the 19th century. It means the selection of the best plants based on the traits of the cob, bringing together their seeds, seeding together, and forming new offspring. Of course, in the result of using this method has made possible to develop many historically famous corn varieties. Later, some of these varieties were invaluable initial materials to create updated varieties.

Gradually, mass selection converted into **individual selection**, which involved the selection of the best single cob, planting the seeds of this cob in a seed bed alone, assessing the progeny plants, and forming historical varieties like Uzbekskaia Skorospelka. And another variety, Uzbek Zubovidniy, is a bright example of the advantages of this method. It had been developed by our corn breeders using this method, which was registered in 1962 and is still growing in the fields of our republic. Time by time, this method got older and has paved the way for other new corn breeding methods.

Considerable progress in corn breeding in Uzbekistan occurred with the introduction of the **inter-variety hybridization** method and the creation of inter-variety hybrids. The effect of this method on increasing productivity consisted of 15-20%. The first result of this method was the development of Uzbekistan 601 ESV, the simple hybrid between V-73 and the UzNIIJ 1 line, by S.Patkhullaev and others (1992).

The use of **heterosis** in corn breeding has started international progress in the use of self-pollinated hybrids in hybridization. In a short time, this method has become the major plant breeding method for corn. Because it has made it possible to increase corn productivity by over 100 percent. To generate self-pollinated lines, the quality of the initial material is essential in the production of corn heterosis hybrids. The standard method (figure 28) is one of several existing methods for getting heterosis hybrids.

Conducting self-pollination of plants during six–seven generations is the basic core in the production of heterosis hybrids and selection according to the complex of valuable traits. S₆-S₇ (self-pollinated lines) have become phenotypic uniforms at a high level.

Self-pollination in the initial materials in the first year is conducted according to their genetic feature variability. 20–50 plants out of lines in the inter-line hybrids; 100–200 plants are self-pollinated using inter-

variety and artificial varieties in order to fully embrace all biotypes in the populations.

In the S_0 , the plants do not meet the imposed requirements on the phenotype structure, and cobs are rejected. In the second year, 25–30 grains are sown in one row, and 5-8 of the best plants in this row are self-pollinated.

3-5 cobs remain to continue the work after the rejection of all inappropriate plants. In the third year, seeds from 3-5 cobs from every family are sown in the rows individually. Rejection of plants is continued; plants in the best rows are self-pollinated, and 3-5 cobs are selected from these areas.

In the next years (4, 5, 6, and 7th year), self-pollination of the best plants and selection according to plant and cob traits are continued until the plant uniformities are achieved.

The plants are evaluated on their combination ability (CA) along the creation of the lines in this method of standard or testing, which is pollination with testor-analyzer. The silks of female plants are defended (covered) before appearing on the panicle threads of male plants.

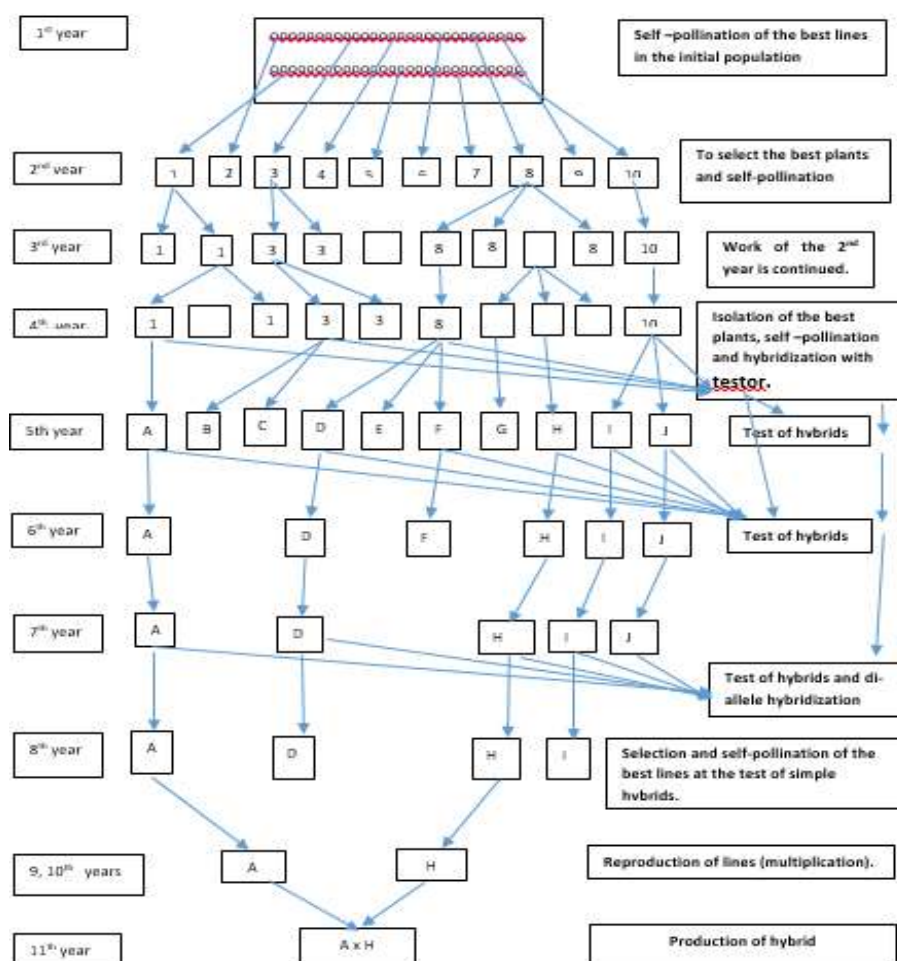


Figure 28. **Standard method in the producing of corn heterosis hybrids.**

Male plant panicles are also covered with paper package isolators (see photo 88). Picking up the pollen grains is done better after morning dew by bending down the top part of the plant with an isolator and shaking it a few times. Then the isolator with fallen pollen grains is untied and is ready to bear above the silks of cobs and pollinate them. The pollination is done by shaking the open isolator above the tip of cob silks and dumping the pollen grain on the silks (photo 89). The tassel bag is put on the cob of the pollinated silks (photo 90) and staples the folded corners together on the other side of the stalk, leaving a little free. This will allow room for growing hybrid corn cobs. All results that hybrids took from such hybridizations were historically named as the first cycle lines.

The standard method for producing heterosis corn hybrids is still the major method in many corn-growing countries. Gradually, corn breeding progressed from simple inter-line material to inter-pair

heterosis lines. The hybrids created from these kinds of hybridizations were named the second cycle lines.



Photo 88, 89, 90. **Order of hand corn hybridization process.**

Cumulative plant breeding. This method was used in corn breeding to produce improved lines. The combination ability of self-pollinated lines after their S_3 - S_5 in the method of standard is tested, and the best ones are selected. Selected lines are subjected to interline pollinations. The hybrid plants taken as a result of these pollinations are exposed to self-pollination for 3-5 generations by using the standard method and pollinated with tester to identify the combination ability. Self-pollination occurs several times in the lines with good combination ability, which has made it possible to increase genes, providing control over higher productivity. This idea led to the conclusion that the best corn lines can be produced from parental forms of higher heterosis hybrids.

Continuous (backcross) hybridization method. This method is used to improve the serious traits of existing lines. For example, according to the former textbook (Abdukarimov D.T., 2007), they are: protein gain, liysin, oil amount, resistance to some diseases, and others. They say that this method is efficient if the trait needed to be improved in the line is controlled by the monogene. This line is continuously pollinated with lines that are the source of this trait. In this process, the first and following plant generations are repeatedly pollinated with paternal to produce an improved line. Pollination to saturate is continuous for 5–6 years. The plants with the traits to be improved are selected after every backcross.

Controlled self-pollination is conducted along the backcross if the targeted trait is characterized as the recessively inherited trait. At this, lines saving of any genes in their genotypes are selected to proceed the breeding work. Self-pollination is implemented after 5-6 backcrosses to reinforce the new traits in the lines.

Haploid method. This method facilitates to produce homozygous lines in the rapid method. This process makes of two stages: 1) producing of haploids and isolating the best ones: 2) duplication of haploids.

Haploids are produced through the pollination of specially selected initial lines. Lines with a strong liability to haploid pathogenesis are used as the mother plants. Checkers ensuring the dominant color trait of the plant or rootlet are being taken. Brown color (a BPICR-gLg3) and dark red testers are used as the quality of marking. These testers provide a dark red or blue color of aleuron layer in the marker plants and a dark red color of rootlets (figure 29)

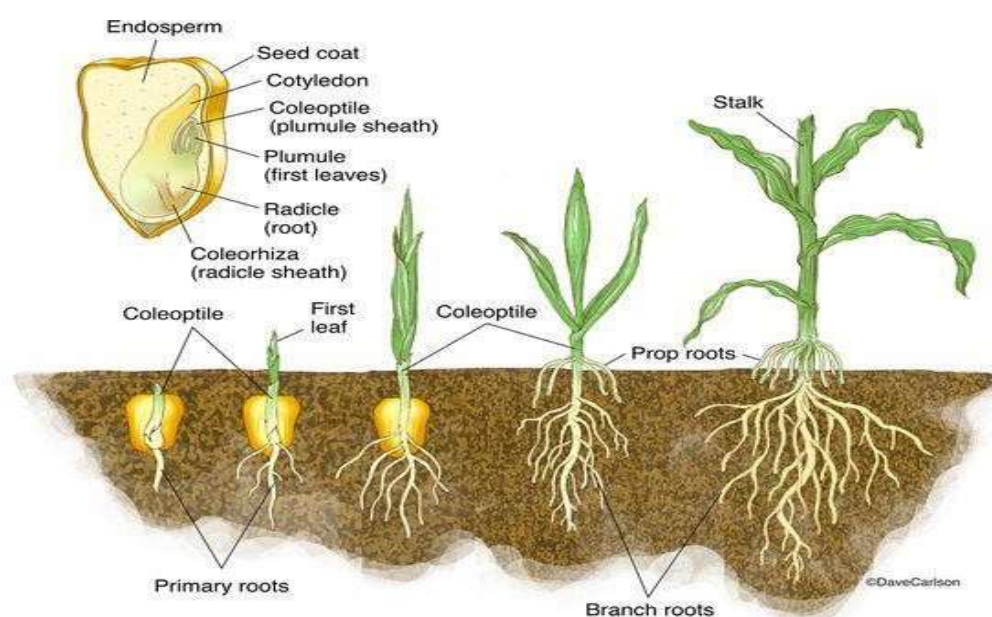


Figure 29. Using of specific markers in the corn breeding.

The marker (APuIPu 2) of a dark red plumule (in germ or embryo) has one signal trait: the dark red color of the coleoptile. And this dark red marker of germ (ACR-njr) will remain the marking trait on the stem of the youth plant.

Colored kernels are formed as a result of line hybridization with these marker pollens, and the haploids are distinguished according to their colorless germs and colored aleuron layers. In other cases, haploids may be isolated, depending on the colorless germinating seeds. In later

terms, the haploids are determined through the cytologic method by the number of chromosomes out of the rootlet tip.

Recurrent (from time to time) selection. This is the increase in the needed gene concentration in the plant population, which focuses on the use of recombinations taken from the hybridization of the best genotypes. Corn lines produced by this method are the main sources of self-pollinated lines, and in some cases, they are directly introduced into industrial production (figure 30).

Figure 30. Recurrent selection scheme in corn breeding.

Corn variety, hybrid (simple, pair line), and other materials can be used to conduct recurrent selection. In the first year, some plants of the initial population (S_0) isolated according to their economic valuable traits are self-pollinated and, at the same time, pollinated with testers. A plant subjected to testing can be used as the mother plant if it has two cobs; one of them is self-pollinated, and the other is used to pollinate with a tester.

1) equally mixed the seeds of the best lines to freely pollinate; 2) the best lines are planted individually in the rows and pollinated by hand in different directions on the diallel scheme.

The continuation of this plant breeding process in general is the same as the breeding process in the standard method.

Reseproc recurrent selection. This method is used to produce lines and increase the genetic diversity of the breeding materials. Genetically, two kinds of populations (two varieties, artificial or simple hybrid) are selected to begin the breeding process. Every population has self-pollinated lines, and they pollinate with testor. B-population serves as a testor to the A-group plants and contrary. The pollens of self-pollinated plants are dusted on the 4-5 silks of randomly selected testor plants. In the second year, two groups of testors are tested: the testor population of $A \times S_0B$ and the testor population of $B \times S_0A$. In the coming year, the seeds of the best self-pollinated lines isolated after testing will be sown using the cobe raw method and pollinated in various combinations. It results in the formation of A_1 and B_1 populations to use in the next breeding cycle. The lines isolated after the next selection cycle gradually improved.

The theoretical basis of this breeding method means that it increased the concentration of desirable alleles in the populations, which provided a higher dominance of the selected lines in the hybridization.

The high efficiency of the method of resiproc recurrent selection is noted in the relevant literature. It was also successfully used in the corn breeding program to create pair-line hybrids on the basis of multi-heterosis and inter-variety hybrids.

The induced mutagenesis method is often used in corn breeding programs by foreign scientists as a unique approach to improving some of the economic traits and properties of the initial materials.

Hybridization of a remote corn sample. This method facilitates the introgression of rare but variable traits of remote corn accessions into hybrids ready to use in the industry. present superior resistance to diseases and pests and considerable tolerance to environmental stresses.

Today, taking into account the local soil and climatic conditions of the republic, corn is mainly growing as the second crop. Consequently, early-ripening corn varieties and hybrids have a high demand from local farmers. There are 16 varieties (table) and over 60 F1 hybrids from Spain, Turkey, and other countries. Overwhelmingly, the majority of them have vegetation periods of 85–90 days.

Chapter 5. Types of corn hybrids.

Various hybrids are produced as a result of the reintroggression of self-pollinated corn lines. Corn varieties are also included in hybridization. It was marked that if the lines are marked by the letters A, B, C, and so on, and varieties with S, the formulas of the hybrids are written in the following order (figure 31, 32):

A x B - simple, inter lines hybrid;

(A x B) x C – triple lines;

Two pair lines – (A x B) x (C x D);

Variety and inter line – S x A or S x (A x B);

With lines and variety – (A x B) x S;

Complicated with four lines – [(A x B) x C] x D;

Complicated with five lines – [(A x B) x C] x (D x E);

Complicated with six lines - [(A x B) x C] x [(D x E) x F];

Complicated with seven lines – [(A x B) x C] x DC] x [(D x I) x F];

Complicated with lines and variety – [(A x B) x S] x (D x E) x F];

Modified lines are formed when the sister lines (A₁, B₁ and so on) were used in the hybridization:

Simple modified – (A x A₁) x B or (A x A₁) x (B x B₁);

Modified with three lines – (A x B) x (C x C₁).

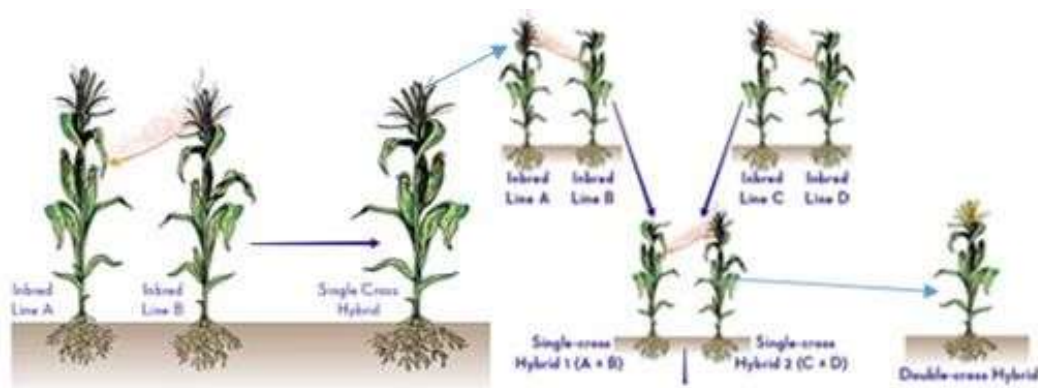


Figure 31, 32. **Scheme of simple and double hybrid production.**

Stabilized productivity of all hybrids can be achieved when the parental forms have been chosen correctly. Producing the interline simple hybrids is a very easy way. Their plants are uniform, ripen

simultaneously, and distinct in product quality. The latest simple hybrids are: BP 263\326 – 1 x BP263\326 – 4) x KV399. Backcross hybrid (KV263 x KV326) x KV 263 was the best initial material for creating sister lines. The line KV 263 with higher combination ability was used to backcrossing.

Three-line and pair-line (double-line) hybrids are more suitable to be cultivated in regions with adverse soil-climatic conditions. On the data of A.P. Potapov, we can see the productivity indexes of three lines and simple corn hybrids (table 33).

To create complicated corn hybrids and provide adequate seed stock becomes gradually difficult and turns into a kind of problem. The method, to overcome this problem was worked out by Yu. K. Kobolev at the Genetic Institute. This method has made it possible to create complicated hybrids and efficient hybrid seed production.

It means that not a simple hybrid but a three-line hybrid is used as the mother form in the breeding process. In some cases, there may be four-line hybrids or even line and variety hybrids to create early-ripening new hybrids. Here, mother-form hybrids make it possible to increase productivity and adaptability in the progeny. Within productivity, increases the hybrid seed production (coefficient of seed multiplication) in both paternal and maternal initial hybrids.

Table 33. Productivity indexes of three lines and simple corn hybrids (Potapov A.P., 2016-2017).

No.	Name.	Type of hybrids.	Productivity, t/ha.	Harvest moisture, %.	Raw grain output, %.	Grain row number on the cob, un.	Number of grain in the row, un.	Weight of 1000 grain, g.	Breeding index.	Output of dried grain, %.
1.	Doc.1	3-line	6.29	29.5	75.3	17.8	37.4	271	2.56	83.3
2.	Doc.190	- -	6.58	33.0	75.6	15.2	35.3	288	2.83	86.1
3.	Doc.2	- -	6.59	27.6	76.2	15.8	36.7	291	2.80	86.1
4.	Doc.17	- -	6.66	29.1	74.7	15.2	38.3	273	2.73	88.2
5.	Doc.14	- -	6.90	29.2	76.7	16.8	38.2	267	2.82	87.2
6.	Doc.7	- -	6.96	33.3	77.7	15.2	34.5	256	2.63	87.5
Mean on the group			6.66	30.3	76.0	16.0	36.7	274	2.26	86.4
7.	Doc.148	2-lines	6.28	31.1	77.1	15.2	29.5	282	2.38	85.7
8.	Doc.149	- -	6.59	33.2	85.5	14.8	33.4	306	2.45	87.9
9.	Doc.27	- -	6.66	30.3	77.4	14.8	38.6	288	2.66	86.5

Historically well known Russian complicated corn hybrids were: Colectivniy 210 TV; Odesskiy 20 MVL (four lines hybrids); Jerebevskiy 86 MV, Rostovskiy 220 MV (five lines hybrids); Odesskiy 80 MV,

VGI-9-MV (six lines hybrid); Odesskiy silosniy 190 MV (lines and inter variety).

All the above-listed methods for obtaining corn hybrids are implemented comparatively easily on the basis of using mechanical wide-scale hybridization in the production (photo 91) which has made it possible to harvest a bumper crop of hybrid seeds.

Hybrids are produced at the base of Cytoplasmatic Male Sterility (CMS). The discovery of the CMS in the corn has played a great role in spreading corn hybrids. This is a maternally inherited trait that is the result of the suppression of viable pollen grain production.



Photo 91. **Scheme of disposal of female and male plants in the field to get hybrids.**

CMS of maize (cms-7) was first described in Texas in 1952. It helps to decrease handwork in the hybrid production process and improves corn seed production efficiency (photo 92). The following types of CMS (Abdukarimov, D.T., 2007) are widely used today in corn breeding: Texas type T; Moldav type: M (S); and type: C.

It was recommended that the T-Texas type of CMS not be used in the hot and high-moisture regions (USA, Middle Eastern, and South European countries) where *H. maydis* southern yellow mosaic disease is widely spread.

M(S) and C are recommended for use in Ukraine, Georgia, and the Northern Caucasus regions where nematodes may be spread.

CMS acts if there is sterile factor (S) in the cytoplasm and recessive alleles of restoring genes in the nucleus.



Photo 92. **Outlook of male fertile (A) and male sterile (B) tassels of corn plant** (Firoz Hossain, 2019).

The fertility of the pollen is restored by the availability of Rf-dominant genes. At this, Rf1 and Rf2 for T type of CMS; Rf3 for M type and Rf4, Rf5, Rf6 for C type.

Transferring corn hybrids into sterility bases demands a source of sterility-fortifying and fertility-restoring complexes. That is why the response of new perspective lines to be taken as parental forms to cytoplasmic male sterility is to be evaluated. The assessment is conducted through pollination of the experiment line and tester which is the source of sterility.

Tester cob silks are pollinated by the pollen mixture taken from 5–10 experimental line plants. Next year, the fertility level of offspring will be monitored via cultivation in the field. At this stage, full sterility, sterility fortifying and progeny fertility—fertility restoring—and half restoring of fertility or sterility are also analyzed.

The first and second groups of lines are selected for further plant breeding processes. Sterile and fertile-restoring analogies of mother forms are prepared by the method of saturating pollinations. Their vegetation period, other traits, and origin are held under attention to prevent the genetic approach of these lines with other forms at the selection of sterile and fertile sources.

The scheme of producing sterile analogy of line A:

1st year – CMS (MS) source x A

2nd year – (MS) x A) x A

3rd year – (MS x A²) x A

4th year – (MS x A³) x A

5th year – (MS x A⁴) x A

6th year – (MS x A⁵) x A

The sterile analogy of line A is reproduced in the field where it has been isolated together with fertile line A successively in the rows. The overwhelming majority of corn lines have recessive alleles of restoring genes. Therefore, producing sterile analogies does not pose considerable difficulties.

But the production of fertility-restoring lines is quite a complicated process. The reason here is the lack of potential (5–10%) to restore fertility in the lines under the hand of breeders. Beside this, different fertility rates can be observed in the hybrid progenies formed from the hybridization of several sterile forms with equal fertility-restoring CMS. Valuable and definite lines are widely used in the production of restoring analogies, and searching works on the new ones within lines produced with the help of different methods are conducted.

There are several schemes to form fertility-restoring analogies. A certain one out of them is used depending on the hybrid type, sterility, and fertility types—the sterility trait. The scheme of creating an A-restoring line on the basis of fertility:

1st year – fertility source, B x A;

2nd year – (B x A) x A;

3rd year – (B x A²) x A.

Fertility-restoring ability is determined in the third year when the (B x A²) x A hybrid plants are pollinated with a sterile analyzer. Plants are able to form more fertility as they are used to continue the saturation. The lines formed in their 7–8 years are self-pollinated and exposed to selection. You see, this scheme needs a long time because of the inspection of its restoring ability.

Chapter 6. Corn hybridization

Hand hybridization using in the corn breeding process was described in the previous chapter, in the text of corn breeding methods or more detail from 6th practical training materials of teaching manual <http://library.ziyonet.uz/uz/book/126727>.

Various, highly effective hybridization technologies (photo 93) have been integrated into the production of corn hybrid seeds due to the phenotype of the corn plant as a monoecious plant with perfect flowers: separate male and female flowers on the same plant.

The order of mechanical hybridization in corn breeding can be studied using the example of the cultivation of the first hybrid generation, published by Kh. Sh. Tarchakov (2020). The scheme of seed planting is the most responsible moment in the proper disposition of maternal and paternal plants in the field and getting adequate quality of hybrid seeds. The disposition of parental samples in the rows or the numbers of their rows will be specially accepted depending on the vegetation periods of the hybrids to be produced.

Early-ripening hybrid Nart-150 SV. It was developed through pollination of the simple maternal hybrid NT-1S and the paternal self-pollinated hybrid NMU-1250SV. Seed reproduction was based on the sterile base with the scheme of full restoration of fertility.

The most purposeful planting scheme for this kind of hybrid is 12:4. That is, 12 rows are going under the planting of the maternal hybrid sample, and 4 are going under the paternal plants. 8:2 and 6:2 schemes can be used depending on the availability of other technical means on the farm to plant and care for plant cultivation, ultimately cutting off paternal plants after pollination.

Middle-early hybrid Ross 209 MV. This middle-early (FAO 280) has been developed as the result of hybridization between simple hybrid Roza M and Rido MV. Its seeds are reproduced on the sterile base and on the scheme of full fertility restoration. 12:4 is the accepted scheme of planting. So, 12 rows are planted under the maternal sample of Roza M and 4 rows under the paternal sample of Rido MV. It is possible to use other schemes, such as 8:4 and 6:2, depending on the modifications of the available technique on the farm to cut off paternal plants after they have fully flowered (to pollinate). The optimal plant standing per hectare

is 70–75 thousand in the irrigating area and 50–55 thousand in the rain fed area.

Features of hybridization in the **middle-ripening hybrid** Kavkaz 412 SV. This hybrid was developed as the result of the hybridization of the simple hybrid Beryoza “S” maternal sample and the self-pollinated line Vukovarskaya 158 BS. The scheme of planting with 12:4, which means 12 rows for the maternal sample and 4 rows for the paternal sample, has been accepted purposefully. Other options like 8:4, 6:2 and 10:2 are possible. The availability of a special technique to harvest paternal plants after fully completing flowering is taken into consideration when choosing the scheme of planting for parental samples. In particular, observing these rules has made it possible to conduct qualitative mechanical pollination and get inherent-quality hybrid seeds.



Photo 93. Corn hybrid production field and mechanical top cutting.

In the photo 91, we can see the next option (scheme of disposition of maternal and paternal plant rows), in which the tassels of plants in the first row are left as the paternal to pollinate the maternal plants of the four rows without tassels. This is one of the practical methods used by the farmers. They have a modern tractor, which helps annually produce hybrid corn seeds.

According to the scientists of F. John and others (2014), the efficiency of industrial corn hybrid seed production and the qualities of the produced seeds depend on the following factors:

*Maternal and paternal plants' identity and purity presentation.

*Ratio of maternal rows and paternal rows (12:4, 8:2, 6:2, 10.2, 4:1) in the seed field.

*Timing of planting of the maternal and paternal plants.

*Timely removal of the tassels from the maternal plants before they shed pollen and before silk sticking out.

*Timing of maternal silk emergence relative to paternal pollens shed.

*Avoidance of contamination of maternal silks with foreign pollens.

*Avoidance of seed mixtures between and within the maternal and paternal plants.

Chapter 7. Seed production of corn

The latest description of corn seed production methods in Uzbekistan is possible from the article by Kh.K. Nazarov (2021) under the topic “Efficient methods of quality corn seed production.” As he noted that individual-family selection was used in the primary seed production of corn varieties, and this kind of work was not used for self-pollinated lines (parental forms) of the best commercialized corn hybrids in Uzbekistan. And now, the planting of corn hybrids has become dominant in the territory of the republic.

The first work on the primary seed production of parental forms of middle-early ripening and middle-late corn hybrids in Uzbek corn breeding made use of scientific and practically specific procedures.

The breeders from the selection nursery to the preliminary reproduction nursery get a lined-up initial material with high grade typicality (uniformity), defining the main parameters of released varieties or hybrids in the process of primary seed production. The works in primary seed production allow to save high productive properties in the sowing seeds laid by breeders at the creation of varieties or hybrids and other indexes like product quality, uniformity of plants, and so on.

The demand for corn elite seed in industrial seed production is determined by its biological features. On the basis of this, the number of selected plants—the future progenitors of the families—is counted based on the typicality, taking into account the reproduction coefficient.

Knowing the main ways of common fertile seed growing, lines of sterile analogues, lines of sterile fixation, lines of fertility restoration, and common fertile varieties in corn seed production is important.

The process of seed production of sterile analogy lines and analogy-fixation lines is similar to the seed production process of common fertile lines.

The following nurseries are laid to cultivate seeds of common fertile lines: selection nursery, seed nursery, and elite nursery.

Selection nursery is laid one time for three to four years without distance isolation, with the seeds taken by self-pollination of the best typical plants of seed nursery, and elite seed of this variety is planted in one row in every 10–20th line as the standard. Self-pollinated seeds also contain the seeds of fixer with simultaneous pollination, typical plants of sterile analogy. The seeds out of every pair of cobs are planted in rows

with 30–50 grains alone. Here, the standard is disposed in every 10th family as a two-row planting of elites of this line (one of them is the sterile analogy, the other is the fixer of sterility). Phenology surveys are conducted in every family from germination up to harvest. At this stage, uniformity of plants, color of seedlings, bushiness, availability of wax spots on the plants, corrugated shape of leaves and disposition, their width, availability of the blade on the cobs, color of cobs, stigma and anthers, and type and size of tassel are assessed and recorded. The size and length of the cob pedicle, the height of the stem, the length of the set of the first cob, and resistance to diseases are determined. The traits of cob and grain—size, shape, number of grain lines, consistency, grade of tooth form, color of grain, and core of cob—are studied.

Off-type pairs of families, in which even one plant with a flowering tassel is rejected.

The seed nursery is laid in a distance-isolated plot (not less than 200 m), and the residue seeds of self-pollinated lines taken from typical cob pairs and checked in the selection nursery (for the first year) and seed nursery (for the next two–three years) are planted in it. Planting is conducted in two terms: the families of sterile analogy are planted at the beginning, and before emerging, their seedlings, the families of analogy fixer of sterility. The seeds of every family are sown in individual rows without isolation, one by one. Off-type families and plants are rejected until they flower in the vegetation period. At the time of harvesting, additionally, off-type families were rejected according to cob traits. The crop of fixer is harvested first and then sterilized. The crop of typical families is united into one batch—the super elite of self-pollinated lines.

Elite nursery is laid by the seeds of super-elites, followed by rows of self-pollinated sterile lines cultivated in the seed nursery. The works of the elite nursery involved the removal of off-type plants as a result of biological contamination and, after harvest, cob impurities. To avoid contamination of rows, analogy fixer is harvested first until full maturity.

The growing of seeds of common fertile varieties is based on mass and individual selections. The best selected cobs in the field are united into one batch (super-elite) and used to plant in the elite nursery. The number of selected cobs must be at least 400–500, or 2–3 times more than required to plant. The cobs are taken at the period with yellowish husks of cobs, but the leaves and stems are still green. **Hybrid seed production.** As a hybridization method in the condition of the field

described in the previous chapter, seeds of female (maternal) and male (paternal) plants are sown in a ratio of 3:1 to produce hybrid corn seeds. Naturally, hybridization only by male plants takes place after mechanically cutting off the tassels from female plants. It results in the formation of the first (F1) hybrid seeds in the cobs of female plants. This is the resulting corn hybrid seed material that, after the required reprocessing, can be bought to plant in the fields.

Scientifically, the process of hybrid seed production is divided into four parts:

Creating and reproduction (multiplication) of self-pollinated lines.

1. Improving and reproduction of parental form seeds.

2. Producing of the F1 seeds out of parental forms.

3. The finishing of gathered seeds at the seed producing enterprises.

Today, modern technologies embrace the fulfillment of this process in the industry of agriculture. Their production capacity is closely related to the availability of adequately equipped facilities for the provision of corn hybrid seeds. For example, the seed-producing company MAIZE fulfills this process in one technological cycle under fixed control above the implementation of all the stages of hybrid seed production.

The company fully responds to the quality of the seeds produced. At this stage, the organism (seed) has properties that are not encountered in the parents. Self-pollinated corn lines are used to produce hybrids, and the grade of heterosis is regulated by the choice of targeted line combinations.

The scientists and peer staff of this company are guided by the concepts of heterosis, a phenomenon often encountered in corn plantations. Corn, as the cross-pollinating plant, easily lets in hybrids as the result of compulsory or controlling pollinations of two genetically distinct homozygous parents (inbred lines). The first generation (F1) is quite more productive than their parents. The effect of heterosis is that the stronger the inbreeding-generation of parental lines, the better their combination abilities are relative to the heredity of heterosis.

Often, the productivity of hybrids is superior by 20% or more than that of parental samples. Beside this, hybrids in the growing have higher survival potentials in regard to environmental stresses. As the initial material, European corn hybrid producers commonly use Flint and Dent variety diversities (table 34). The main reason to choose these two ones

was their contrast in historical climatic conditions, which led to the formation of considerably distinguishing biologic properties and traits.

Table 34. Properties and traits of initial forms to corn breeding in Europe.

Properties and traits	Flint diversities	Dent diversities
Flowering	Earlier	Later
Relation to photo period	More longer day	More short day
Seedling development	Fast	Slow
Cold resistance	Better	Bad
<u>Tillering</u>	Often	Rare
Size of grain	From small to big	Enlarged
Shape of grain	Round like	Prolonged
Color of grain	Yellow, light red	Light white
Grain texture	Hard, glassy starch	Soft, powdery starch
Moisture return	Earlier, slowly	Later, fast
Potential productivity	low	High

Different forms of hybrids are used as the planting seed, distinguishing on the type of the method to get planting material (hybrid seeds) out of inbred lines:

$A \times B$ = single cross (pollination).

$(A \times B) \times (C \times D)$ = double cross (figure 33).

$(A \times B) \times C$ = three way cross and

$(A \times B) \times \text{variety}$ = variety line hybrid (top cross).

The simple hybrids (the first year) after the effect of inbred depression on maternal plants will not produce enough high-yielding planting seeds. That is why the seeds of double (the seeds of the second year) or three-way crossings are produced in the production.

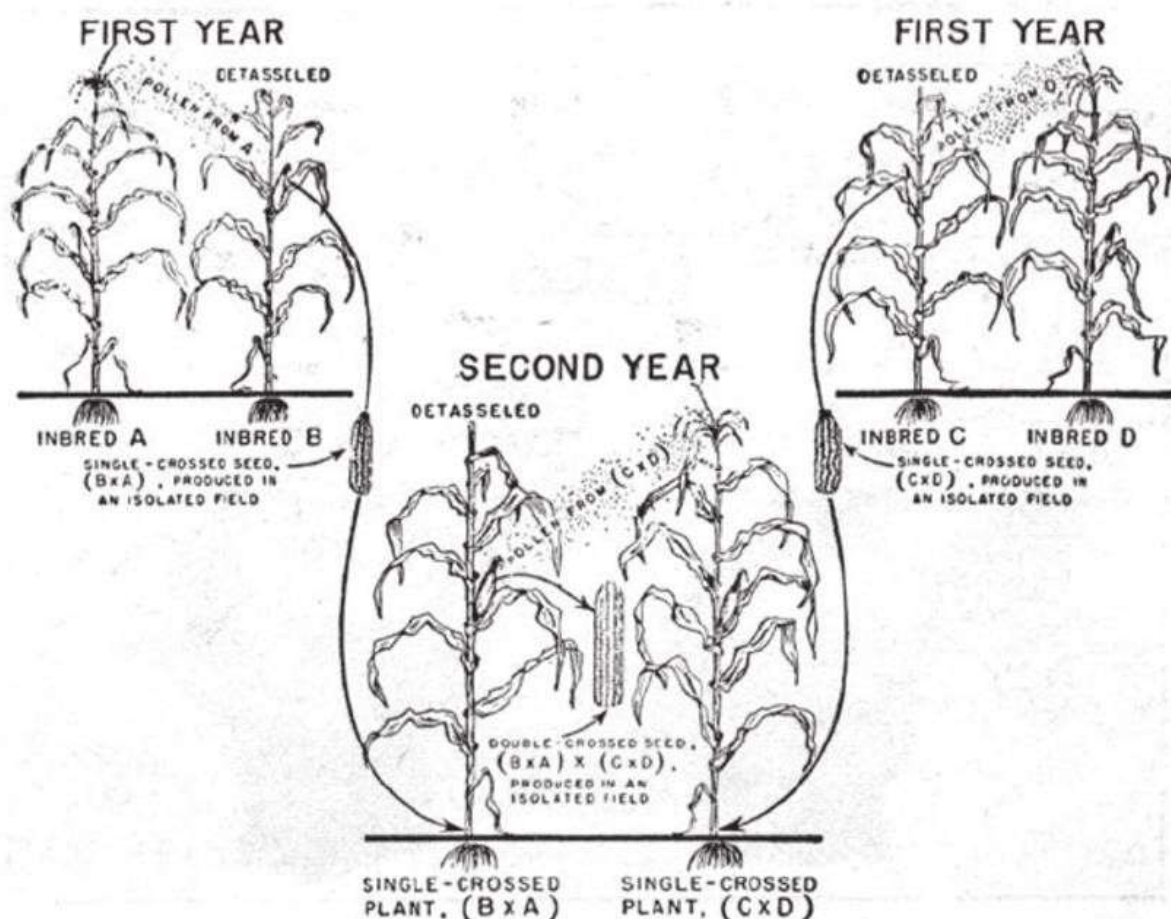


Figure 33. **Corn hybrid seed producing methods** (Linkin A. Powell, 2015).

Maternal form F1 of a one-pair hybrid is needed to get the yield out of a double hybrid. The other pair, hybrid F1, is used as the paternal form. In the practice, they present: the plot with 6 or 8 rows planted to maternal plants and 2-4 rows - paternal. Cultivation of plants is implemented with rows of 65–70 cm a part, and the distance between maternal and paternal rows may be wider than 95 cm. This allows the possibility of visual division between them and the possibility of easy harvest of paternal plants by silos cutting combines for green fodder.

Emasculation of female corn plants through the removal of tassels is very easy due to the separated positioning of male and female flowers on the plants. So, only pollen from paternal plants falls on the cobs of female forms (lines or F1 pair hybrid).

Removing the tassels of maternal forms can be done by hand and is compulsory until flowering. It requires much and thorough work. The delaying of tassel removal effects the quality of planting seeds. As a

rule, passing through four times is required to complete this operation properly.

Today, in spite of the labor-consuming property of hand tassel removal, biological systems of creating male sterility on the maternal lines at the base of cytoplasmic male sterility are not applied in practice. Furthermore, to create fertile hybrids, the male partner must restore genes, which prolongs the process of creating and testing inbred lines. Beside this, the other reason is that in the 1970s, appeared Texas-cytoplasmic male sterility, prone to the T-race of the pathogen of southern gelmintospore (*Cochiobolus heterostrophus*, anamorph *Bipolaris maydis* southern blight) in the vast areas of corn in the USA. It caused tremendous losses and was a reason to refuse the use of this mechanism.

But this method in the seed production of Russia is still used. And many of the corn hybrids imported from Russia to our republic are the result of this method.

Questions on the studied themes:

1. What is the methodic rule for picking up rice plant approval bundles?
2. Into what groups is separated the content of the rice plant bundle?
3. Retell the botanic, genetic peculiarity, and origin of the corn plant.
4. Can you explain the distinctness of corn plants from previously studied grain crops?
5. Do you remember about the developing stages of the corn plant?
6. List corn breeding directions in Uzbekistan and their importance.
7. Do you know about corn diseases and pests?
8. What does the term "inzucht in the corn breeding and its seed production?
9. Is it important to standardize the improvement of corn hybrids?
10. What is cumulative plant breeding?
11. Do farmers cultivate hybrid corn? If yes, what kind of hybrids are used widely?
12. How is used mechanical means to cross corn plants?
13. Why is corn hybridization thought comparatively easy?

14. List the kinds of corn seed production nurseries and their designations.
15. How many parts are divided in hybrid seed production?
16. Do our breeders use foreign corn variety diversities (hybrids) in their own corn breeding?

Chapter 8. Corn approbation and ground control.

Field approval is conducted in the seed production processes of agricultural crops and has a specific importance in the corn planting seed provision.

The agronomist-approbatory, with the participation of the farm seed producer, conducts field approbation with the aim of identifying the fitness of corn plantations for the provision of seed. At the appraisal, the variety quality of corn plantations (uniformity-typicality) and grade of their infection by diseases and pest damage.

Field approbation is carried out at the full maturity of corn plants (photo 94) in the plantations of original, elite, reproduced seed lines, hybrid populations, and parental forms—simple hybrids. Plots of simple hybridization, three-line, first-corn progeny of double-interline hybrids, and hybrid populations will not be exposed to field approval. They are registered in order to take into account the variety of plantations of this crop.



Photo 94. Time of corn plant maturity.

At the approbation of a plantation with **parental form-simple hybrids**, an average simple out of 250 cobs (10 cobs from 25 points) is taken from every 50 hectare. If the area of a certain hybrid line under the appraisal plot is larger than 50 hectares, additionally, 25 cobs will be taken from every 5 hectares over 50 hectares. The participation of

agronomists in the seed reprocessing enterprise is compulsory in the approval process.

Two probes are taken from all plantations of original and elite seeds, one by one, from every diagonal of the field, using the method of simple hybrids. They are analyzed, and the results are included in the approval statement. Typicality and other indexes are accounted for with the mean arithmetic value of the results of two probes.

At the time of approval, the cobs are divided into cobs of main type and impurity. The line to be analyzed, the hybrid population, belongs to the first type. The healthy cobs and infected cobs of the main type independently, at what rate of progress and availability of xenia grain up to 1% belong also to this group.

The main type of cobs of the analyzing line, hybrid or hybrid population, is determined by the consistence (density), color of the upper and middle parts of the grain (photo 95), shape of the cob, number of grain rows, and color of the pith according to the method of UPOV.

The persistence of grain (photo 96) is defined on the middle part of the cob. The consistence of grain may be changed in the dent forms to the side of flint forms in the secondary and not fully developed cobs. Such kinds of cobs with the characteristics of such grain shapes, colors, and pith are included in the main type.

The presence of cobs with contrast colors of pith at the time of field approval considers the impurity if their availability was not foreseen in the description of the originator. As healthy and so infected cobs contrast to cobs of the main type, they belong to the impurities. Cobs containing more than 1% of xenia grains also belong to the non-typical (photo 97).



Photo 95, 96, 97. Study of corn cob samples.

The xenia grains are calculated only on the cobs of the main type. The number taken is divided by the number of cobs of the main type and multiplied by 100. The xenia grains are grains that contrast in color with

the main sample. In sugar corn, xenia is considered the grain having a non-sugar consistency. At the calculation of xenia grains and defining the xenia, partly infected grains by smut as well as cobs damaged by 25% of the surface by rodents are excluded (photo 97).

The percentage of grain infected by disease is defined as the total number of analyzed cobs. At this stage, infected cobs are affected by bubbles and loose smut, fusarial, red and grey rot, diplodiosis, and nigrosporis. One cob may be infected simultaneously with several cobs. That is why total percentages of all diseases can exceed the total percent of infected grains.

The content of corn grains infected by nigrosporos, grey and red rot, and fusarial in the account of 100 cobs does not exceed 300 grains in the original and elite seeds and 500 grains in reproduced seeds. After treatment in original and elite seeds, the availability of infected grains by these diseases is admittedly not more than 0.5% in the reproduced seeds—1.0% out of the seed weight of the main crops.

The statement of field approval is compiled in three copies based on the results of field surveys, one of which is original, the second is elite, and the third is reproduced seeds—parental forms of hybrids. Reproduction is defined on the basis of variety documents for planted seeds.

Control over carrying out field surveys is implemented by the representatives:

- state inspection.
 - organs of regional agriculture.
 - plant breeding establishments (originators).
- Needed documents for every plot of hybridization:
- statement of plot isolation (not less 200 m.).
 - statement of field survey on the accepted form.
 - results of **ground control** of sterile maternal forms.
 - card of attendance on adhered form.

Storehouse (or barn) approval also has incredible importance in corn growing and quality planting seed production (table 35). This measurement is the incremental procedure for the field approval. At the time of its conduct, the corn cob batch is sorted to remove all impurities. Totally 200 cobs of a probe—40 cobs from five places and from three lays—and different depths of the batch with a weight of up to 10 tons (beginning with 2.3 tons) are picking up. If the weight of the batch exceeds 10 tons, each 3 tons additionally takes 10 cobs.

The analysis of the cobs is done similarly to the field appraisal. The probe is divided into cobs of the main type and impurities of other types. The persistence of the grain is defined by the middle part of the cobs. Xenia grains are calculated only on the cobs of the main type. At this point, cobs infected partly by smut and damaged more than $\frac{1}{4}$ by rodents are excluded from analysis.

Ground control. Its integration into the practice of variety control for Russia was a compulsory term of entry for Russia into the Organization of Economic Cooperation and Development (OECD).

If the approval is a worked-out measurement in Russia, ground control is one of the important elements at the seed certification, which requires a certain effort in its integration into the system of variety control.

As a rule, all grown seeds of parental forms of corn hybrids in compulsory order should be studied by the ground control method in the specially selected institutions. The middle sample is taken by observing the functioning standards. 600 seeds are sown from every sample in the soil in two replications, each with 300 seeds.

The number of plants is counted after the germination of seedlings to define field germination. Typicality (uniformity), sterility, plant fertility, and uniformity of cobs in the period of vegetation are identified visually. Rogueing (variety cleaning) in this experiment is not conducted. Off-type plants are marked by the labels, which are tied up on the cobs. Non-typicality is calculated out of all harvested cobs based on the analysis of cobs based on their typicality.

Sterility of parental forms is defined in the period of full flowering of tassels and cobs. Partly, the fertile plants are grouped into fertile.

To get high-quality hybrid seeds of the first generation, the seeds of parental forms that were not passed through ground control should not be admitted to sowing. If the freshly harvested seeds are planned to be used for sowing, they need to be checked through ground control in the winter in countries like Argentina, Chile, and so on.

Fertility of sterile self-pollinated lines should not exceed that of original seeds (OS) at 0.1%, elite seeds (ES), and reproduced seeds (RS) at 0.5%. The fertility of sterile parental hybrid forms (ES 1) should not exceed 1%.

Generally, the provisioned corn planting seeds (seed stocks) should meet the accepted variety and planting seed quality indexes presented below (table 35).

Table 35. Verity and planting qualities of corn seeds (Gost R. 52325-2005).

Seed category	Seed purity, %, not less.	Variety uniformity %, not less.		Content of xenia grain, unit/100 cobs, not more.		Germination %, not less.	Moisture %, not more.
		On the approbation data					
		Field	Storehouse	Field	Storehouse		
OS*	99	99.5	100	20	0	92	14
ES*	99	99.5	100	20	10	92	14
PS*	98	99.0	100	100	30	92	14
PS+*	98	98.0	99	300	100	90	14

*-varieties and hybrid population

What is the difference between field approval and ground control? They say that the disadvantage of the method of field appraisal is that it registers the state of plants only once at the time of harvesting (or flowering), leaving them beyond the growth and development of plants during the vegetation. In this point of view, ground control is becoming more precise, which surveys the state of variety plantations along all stages of plant development.

Part VI. Breeding and seed production of rye.

Chapter 1. Economic importance of rye.

We know from the information involved in the textbook of private plant breeding published in 2007 by D.T. Abdukarimov that there is no variety developed in Uzbekistan. A single variety, Vakhshskaya 116, registered to be planted in the republic, was released from the Vakhsh division of the Tajikistan Agriculture Scientific Research Institute.

Later, due to the intensification of grain crop cultivation in our republic, we can see a broadening of rye variety and variety planting in Uzbekistan. Now, we can see two winter rye varieties: NS SAVO from Zaire (Congo), and our Shalola included the State Register of Agriculture crop varieties to plant in 2022. They are introduced into production in the regions with irrigation: 2, 5, 11, and 11, respectively. Both are considerably new varieties, created in 2020. The variety of Vakhshskay 116 developed in 1983 also remained in the state register for irrigation lands across the republican regions (1–13) in the spring term of planting.

Rye, a cereal grass (botanic Secale), is grown extensively as a grain, a cover crop, and a forage crop. It is a tribe (Triticeae) of wheat and closely related to both wheat and barley (genera Triticum and Hordeum).

Grain of rye as wheat and barley is used for flour producing, bread baking, beer boiling, to produce whiskeys, vodka and animal fodder (photo 98, 99).



Photo 98, 99. Rye and some of its products.

The distribution and habitat of wild rye have been placed in the central and eastern parts of Turkey and in adjacent (neighboring) areas. In particular, there is evidence that rye was among the first cereal crops systematically grown around 13,000 years ago in the valley of Syria. Historically, its planting areas extended up to Ireland and Britain in the north hemisphere.

Winter rye is known for its cover plant property, allowing it to be planted as cover ground for the winter season in the region. It has remarkable features to grow during the warmer days of the winter when sunlight temporarily warms the plant above freezing, even while there is general snow cover. Due to these features, it can be used to prevent the growth of winter-hardy weeds and can either be harvested as a bonus crop or tilled directly into the soil in the spring to provide more organic matter for the next summer's crop.

Its superiority over other cereal crops is that it grows better in heavy clay and light sandy soil and in infertile or drought-effected areas of soil. This crop tolerates a pH between 4.5 and 8.0. The soil with a pH of 5.0–7.0 is the optimal condition to grow rye. It prefers fertile, well-drained loam or clay-loam soils.

The most cultivating areas under rye are located widely in Central and Eastern Europe (table 36). It is the main bread cereal in the areas of eastern Germany, Poland, Russia, Belarus, and Denmark.

Table 36. Internet source of top rye producers (in metric tons).

Producer	2021 ^[34]	2019 ^[35]	2017 ^[35]	2015 ^[35]	2013 ^[35]
 European Union	7,958,440	8,367,410	7,357,245	7,851,644	10,210,326
 Germany	3,325,600	3,237,600	2,737,400	3,487,800	4,689,100
 Poland	2,472,860	2,415,640	2,673,642	2,013,148	3,359,271
 Russia	1,721,912	1,428,421	2,548,719	2,086,675	3,359,873
 Belarus	845,000	755,547	669,841	752,600	648,432
 Denmark	672,490	883,510	723,200	771,700	526,800
 Ukraine	593,150	334,680	507,850	391,070	637,730
 China	512,248	525,944	526,728	496,971	620,000
 Canada	472,790	333,400	341,300	225,500	222,900
 Spain	315,750	261,550	139,178	331,930	384,300
 United States	249,130	269,810	260,410	292,010	193,710
 Turkey	200,000	310,000	320,000	330,000	365,000
World total	13,223,426	12,816,515	13,011,548	12,937,204	16,649,965

The overwhelming majority of farmers grow winter ryes, which are planted and begin to grow in autumn. In spring, the plants develop and produce their crop. There, autumn-planted rye shows fast growth and reaches its maximum height of about 120 centimeters (4 feet), while spring-planted wheat has only recently germinated. Vigorous growth of rye suppresses even the most noxious weed, can be grown without the application of herbicides, and gives an average of 2.0 tons of crop per hectare.

Scientists and rye breeders identified that depending on the seed size, seed surface, and porosity, the physical properties of plants affect their attributes. So, seeds' surface area is directly correlated to the drying time. The smaller sizes of rye seeds than other cereal crop seeds have increased heat transfer. And these seeds with lower porosity also have a lower tendency to lose water during the drying process (photo 100).

Leading rye breeders suggest that the optimal characteristics of *Secale* cereals, for example, wheat, can be combined with another perennial rye, *Secale montanum* Guss, in order to form *Secale cereanum*, which has the beneficial traits of each. The hybrid rye *Secale cereanum* can be grown in all environments, even in unfertile soil, and it protects the soil from erosion.



Photo 100. **Seeds of various kinds of field and grain crops.**

Moreover, the above-mentioned mixture of *Secale* diversities leads to improved forage quality by containing digestible fiber and protein. And the information about the new genome of *S. cereanum* and its ability to cross fertilize with other species also gives hope to our rye breeders in creating local spring rye varieties suitable for cultivation in the soil-climatic conditions of Uzbekistan.

The increasing trend of rye growing in Uzbekistan has to do with its food value. The grain of rye contains useful for human organisms and rapidly digests proteins, fats, carbohydrates, organic acids, amino acids, mineral salts, micronutrients, and vitamins (A and PP). It is also famous for its name, “black bread.” Its medicinal properties in regard to our organisms are endless. And the hay of rye is invaluable forage for feeding agricultural animals. Today, the total planting area of the republic under rye varieties is 8 000 hectares (M.Sh. Makhramova and S.Kh. Oroqov, 2021).

Rye has high resilience to our condition of natural stresses, which can be studied by analyzing the available characteristics of planting varieties: NS SAVO, Shalola, and Vakhshskaya 116.

Rye-NS SAVO (photo 101) is a winter rye. Middle ripening, height of around 145 cm, good over-winter property, high resistance to diseases, 75 hectoliters, weight of 1000 seeds, 28 g. Contains 10% of protein; genetic productivity is high. Due to the longest period of its dormancy, the planting is recommended to begin earlier, from September 20th to October 5th. Optimal plant density: 500–550 units of seeds per meter square.

In particular, M.Sh. Makhramova and S.Kh. Oroqov (2021), scientists of the Samarkand State University, studied the technologies for growing the rye varieties as the second crop. The varieties of Shalola and Vakhsh (Vakhshkiy) -116 (photo 102) were the experimental rye varieties. Studied photothyntetic and water exchange properties showed that the surface area of the leaves of the variety Shalola was equal to 13.11 cm², while the surface area of the leaves of the variety Vakhsh-116 was smaller: 11.12 cm². Particularly, this difference proves the dominance of the newly developed variety Shalola in its preferable resilience to local growing conditions. But the variety of Vakhsh-116 maintains higher levels of water amount and transpiration activity than the variety of Shalola.



Photo 101, 102. **Rye varieties of NS SAVO and Vakhshskay -116.**

The vigor of growth and germination of the seeds of these varieties in the laboratory showed that the growing vigor of Vakhsh-116 was 80.3% and the germination was 98%. These two indexes on the variety Shalola were, respectively, 75% and 98%. It is clear that the seeds of Vakhsh-116 are undoubtedly vigorous. On the number of grains per ear, Vakhsh-116 has 75, but the variety Shalola has a bit more: 78. On the contrary, the weight of 1000 grains is 45 g and 39 g, respectively. The general grain productivities of these two varieties of rye were 3.1 and 2.9 tons per hectare in the field conditions of the Samarkand region.

The growth of winter rye varieties and their productivity in the conditions of the Kashkadarya region was studied by the scientists N.F. Yodgorov and B.R. Khasanov (2021). NS SAVO and Vakhsh-116 were experiment objects. These scientists substantiated that growing and getting grain is the most efficient within grain crops in our republic.

Because of its resilience, grain crop sustainability, practical significance in the crop rotation, and lowered competence in regard to soil fertility, fertilizer norms, herbicides, and pesticides, which lead to an environmentally pure and cheap product.

At this, seed planting norms of those two varieties were 4.0, 5.0, and 6.0 million ha in the early (15th of October) and middle (1st of November) with accepted fertilized application. The productivity in the first term of planting consisted of an average of 1.9–6.3 tons per hectare, depending on the seed planting norms, and in the second term of planting, it was 1.8–5.6 tons per hectare, or 0.1–1.0 tons lower than the first term of planting. The planting density of 5.0 million plants per hectare was the optimal plant standing, which ensured the highest productivity of the studied rye varieties of Vakhsh-116 and NS SAVO (table 37).

Table 37. Effect of different factors on winter rye productivity.

№	Planting term	Norm of fertilizer, kg/ha.	Varieties	Earlier term (15.10.).			Middle term (01.11.).		
				Grain yield, ton/ha.	Difference from control		Grain yield, ton/ha.	Difference from control	
					Ton/ha.	%		Ton/ha.	%
1	4 mln/ha	Control (no fertilizer)	NS SAVO	1.9			1.8		
			Vakhsh-116	2.0			1.8		
2		N200 P120 K90	NS SAVO	4.7	2.8	149.2	3.8	2.1	118.9
			Vakhsh-116	4.9	2.8	137.7	4.0	2.1	115.8
3	5 mln/ha	N240 P120 K90	NS SAVO	5.5	3.6	192.0	4.5	2.8	158.9
			Vakhsh-116	5.6	3.5	173.5	4.7	2.8	154.1
4		Control (no fertilizer)	NS SAVO	2.1			2.0		
			Vakhsh-116	2.2			2.1		
5	6 mln/ha	N200 P120 K90	NS SAVO	5.6	3.5	168.8	4.6	2.6	133.8
			Vakhsh-116	5.7	3.4	154.3	4.6	2.5	120.5
6		N240 P120 K90	NS SAVO	6.3	4.2	201.4	5.5	3.5	179.5
			Vakhsh-116	6.3	4.1	183.9	5.6	3.5	168.1
7	6 mln/ha	Control (no fertilizer)	NS SAVO	1.9			1.8		
			Vakhsh-116	2.1			1.9		
8		N200 P120 K90	NS SAVO	5.3	3.4	177.1	4.3	2.5	138.9
			Vakhsh-116	5.4	3.3	160.9	4.4	2.5	127.6
9	6 mln/ha	N240 P120 K90	NS SAVO	5.7	3.8	198.4	4.9	3.1	171.1
			Vakhsh-116	5.9	3.8	185.5	5.2	3.3	169.3

Chapter 2. Genetics and biology of rye.

The latest literature data about rye genetics was analyzed and presented by Mono Schreiber and others in their scientific view on genetic diversity and the relationship between domesticated rye and its wild relatives revealed through genotyping sequencing (2019). The more detailed cytological features of rye genotypes can be observed by looking through the scientific paper of Rolf Schlegel and others (2022).

According to this literature, rye (*Secale cereal* L.) is the second most commonly used cereal crop after wheat in European countries for bread baking. Genetically, it is a diploid ($2n = 14$) grass of the Triticeae tribe, which also embraces wheat (*Triticum* spp.) and barley (*Hordeum vulgare* L.) in its list.

The high tolerance of rye to frost was formed as a result of naturally selected biotypes in the colder climate of Central and Eastern Europe and even its ability to thrive on their poor soils. In spite of such adverse growing conditions, rye plants could maintain their higher productivity than wheat. Rye retained many characteristics of its closely related cereal crops, wheat and barley. They are the same center of diversity as the wild progenitors and have seven chromosomes in a haploid number.

Its domestication has a wide explanation related to its spread as a “hitchhiking” weed in wheat and barley plantations after adaptation to an agricultural habitat. On the basis of this hypothesis, N.I. Vavilov suggested that rye domestication may have proceeded in two stages: the first is that primarily rye became a weed that already had acquired traits such as a tough rachis and enlarged grains to facilitate simultaneous harvest with wheat and barley. The second: for its superior performance across the northern climate, farmers started to plant and harvest alone, speeding up its turning into a fully domesticated crop.

According to Frederiksen and Petersen (1998), “rye belongs to the small genus *Secale* with only three taxa, which contains the putative wild progenitor *S. cereal* subsp. *Vavilovii* together described subspecies (possibly weedy) and two other wild species, *S. strictum* and *S. sylvestre*.”

Among these, only *Secale cereal* is a crop at the current time, and *S. strictum* may have been used as a forage crop.

The species of the genus *Secale* differ in biology and in terms of breeding. *Secale cereal* (rye) is an annual outcrosser despite its sel-

compatibility in its wild progenitor *S. creale* subsp. *Vavilovii* and in breeding lines of cultivated *Secale* cereal. *S. strictum* is a perennial outcrosser, but *S. sylvestre* is an annual selfer.

Interspecific hybridization between all rye relatives is possible, although some cases are lower, as in the example of *S. sylvestre* with other species. Here, some chromosomal translocations cause lowered fertility in hybrids. Spontaneous pollinations between cultivated and neighboring wild species occur often.

Establishing the chromosome number of rye historically required a long period of development in genetic science analysis. The number of 7 was set after evidential meiotic and somatic cell pairing and divisions (figure 34).

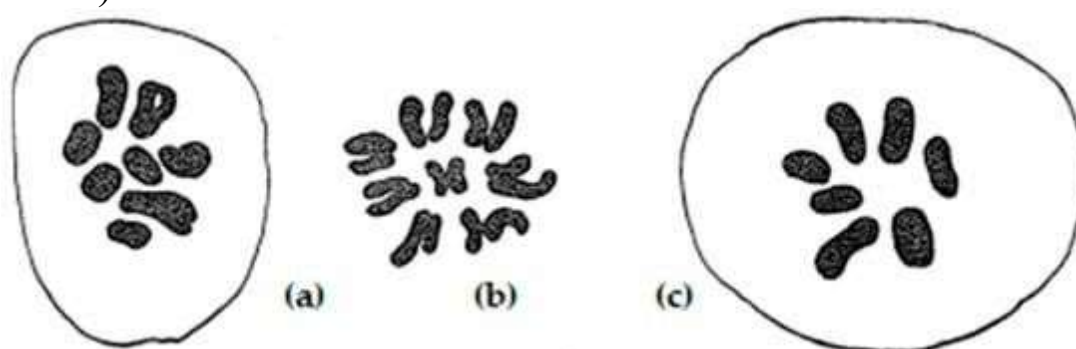


Figure 34. **Drawing of meiotic chromosomes of rye.**

Where, (a) eight bivalents during diakinesis; (b) eight separating bivalents during early anaphase I; and (c) eight bivalents during metaphase I. Sometimes V-shaped configurations were observed (Rolf Schlegel and others, 2022).

The biological response of rye to growing conditions contrasts significantly with that of most cereal crops. As mentioned above, rye can grow well in much poorer soils. That is why this crop is especially valuable in regions where the soil has sand or peat. Rye withstands cold better than other cereals and has gained the preference of farmers to plant it for its survival ability with snow cover that would otherwise result in winter kill for winter wheat. Consequently, the farmers grow winter rye varieties, which are planted and begin to grow in autumn. In spring, the plants develop and produce their crop.

Rye has the following developing stage in its life cycle:

- Germination.
- Leaf development.
- Tillering.

- Stem elongation.
- Inflorescence emergence.
- Flowering.
- Development of fruit.
- Ripening.

Germination. Rye seeds are able to germinate in the autumn soil at a temperature of 1–5 oC. And it needs a temperature of 90 oC for field emergence under sufficient soil moisture. In science, this stage marks the coleoptile emergence from caryopsis, penetrating the soil surface (figure 35). Note: Rye has been found to be more tolerant to salt-exposed soil conditions during germination than varieties of wheat and triticale. The planting depth of rye seeds varies with soil moisture, soil type, seasonal conditions, regional conditions, and the rate at which the seedbed dries.

The general rule accepted by experienced farmers is to plant seeds as shallow as possible. Place the seeds in the moisture zone to be provided with it, taking into account that the drying front will not reach the seedling roots before leaf emergence. The period of germination lasts at a constant low temperature (5 oC, for example) and, in some cases, can germinate on a cycle of 16 hours at -30 oC and 8 hours at 200 oC over seven days. The results of field experiences show that the sowing depth of rye seeds influences the rate and percentage of emergence. Deeper seed placement slows down the emergence. If the seedlings emerge from greater depth, they will be weaker and more prone to biotic and abiotic stresses, which cause them to get tiller poorly.

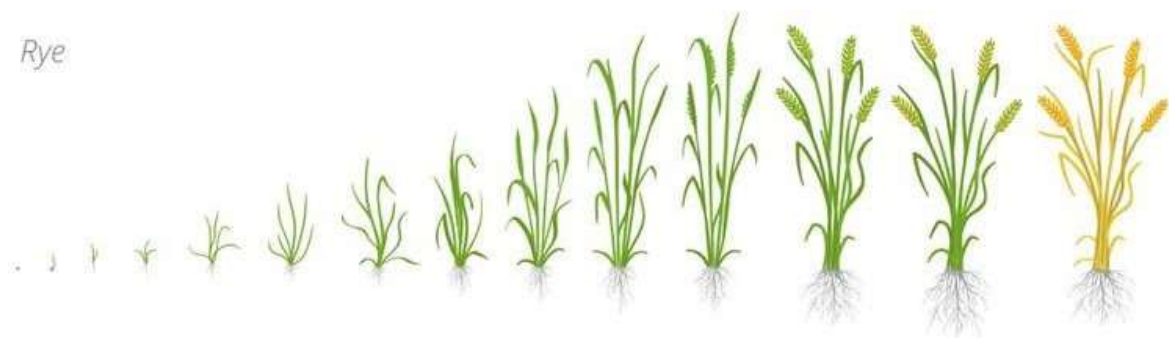


Figure 35. **Growth stages of rye plant.**

Leaf development. The first leaf is unfolded in this stage of rye plant development. And rapidly produces the ground cover, which protects the soil against the forces of wind and water erosion. Often,

cold weather stimulates the vegetative growth phases (**tillering, stem elongation, and inflorescence emergence**) to the generative phase.

During this period of growth development, cereal rye has a more extensive root system in the top 30 cm in comparison to wheat and oats. Of course, a powerful root increases soil stabilization and improves the plant's tolerance to soil drying.

It has also been found that rye achieves more rapid rates of pre-anthesis dry matter accumulation, irrespective of whether it was grown at high temperatures of 20–15 °C or low (10–7 °C) day-night temperatures. Compared to triticale and wheat, it has a greater tiller number and leaf area per plant at low temperatures.

Flowering. In nature, rye plants require increasing day length to induce flowering. According to this, flowering is induced by 14 hours of daylight with daytime temperatures of 5–10 °C. Here, rye plants have a shorter growth period than other winter and spring cereal crops that also differ considerably in their vernalization period. So, winter types of rye plants require 40–60 days, whereas spring rye types require only 10–12 days of cold temperatures to shift into the reproductive stage of development.

Plants are characterized by: inflorescence, a dense cylindrical spike not enclosed in the leaf sheath; spikelets subtended by two glumes, solitary at each node of the rachis; not digitate; sessile; erect with two (rarely three) bisexual florets (figure 36); breaks above the more or less robust two flower glumes; lemma; three anthers; anther filaments; stigma; ovary; palea (figure 37).

Development of fruit. In some literature, the development cycle of rye is divided into 12 stages (figure 38). According to this literature, since the third stage begins formation of spikes, spikelets, flowers and grains.

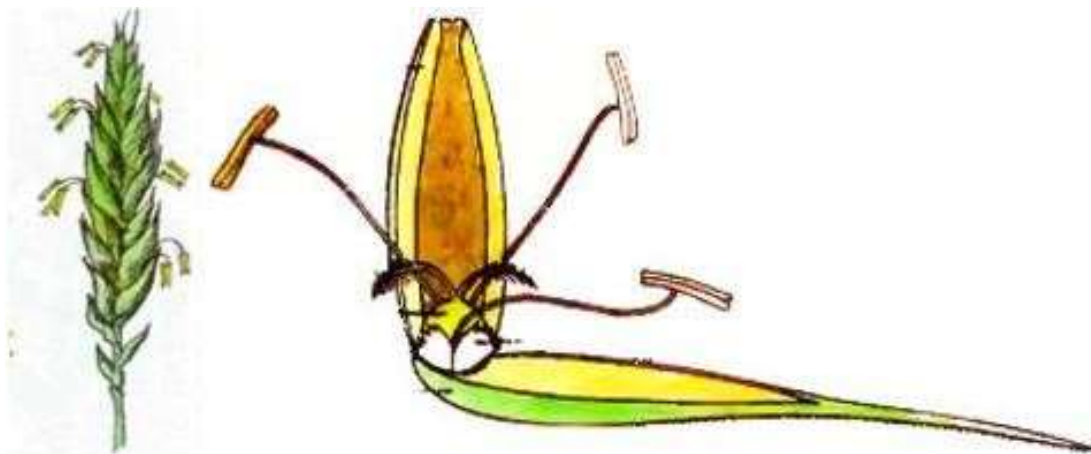


Figure 36, 37. **Flowering rye spike and structure of Spiklets (florets).**

The process of developing these parts takes place in the early spring. Then, the plant enters stage five—organogenesis (seed development). This process passes rapidly. Meiosis of pollen mother cells and the formation of tetrads, the embryo sac, and the egg take place during stages six and seven of this process. The elongation of shoot internodes is observed in the seventh stage. And the plants' ear development and elongation occur in stage eight.

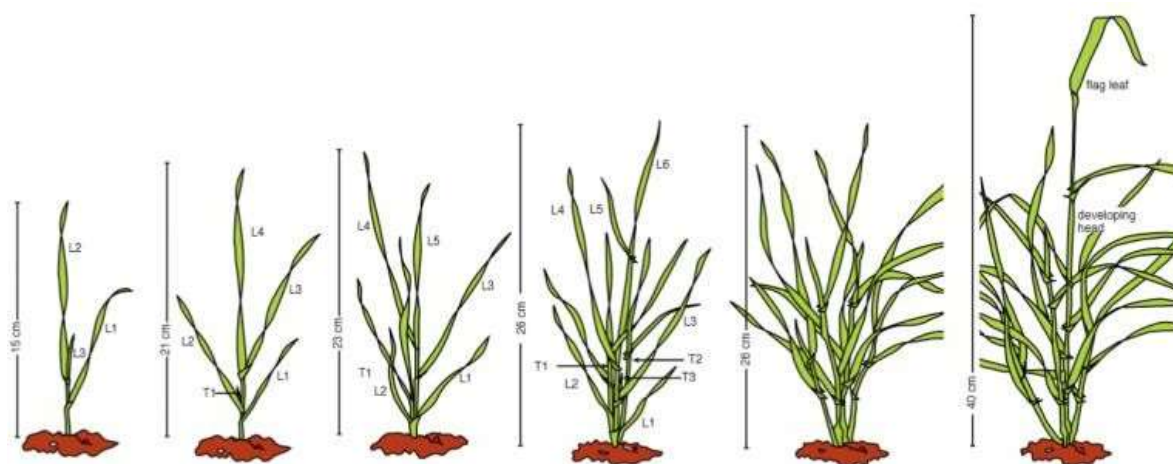


Figure 38. **Formation of leaves and tillers of rye in 12 developing stages** (Agriculture of Victoria, 2013).

Ripening. Fertilization and maturation of the plant ear are begun and follow in the remaining four stages of development. The flag leaf of rye is smaller and less important in plant photosynthesis. Usually, rye has the longest stems within all small grains, and these form an enlarged photosynthetic area. This area makes up 60–80% of the total plant area at the time of grain formation. Leaf and blades provide 15-20% of such area for grain set, which is much lower than other grain crops. Flowering and grain fill are the most important periods of yield formation.

Usually, rye ripens earlier than oats. The vegetative period lasts for 120 to 150 days. And the total growth period, from sowing to harvest, lasts for about 290 days. More detailed information on the rye developing stages is available from Agriculture Victoria for growing cereal rye (2013).

Chapter 3. Breeding directions of rye

Rye has not been a popular crop in our agriculture, and that is why it has not been worked out with its extensive plant breeding process and proper seed production. Mostly, our rye breeding works conducted by our breeders are being continued on the basis of the creative results of Ukrainian and Russian scholars. They are used by our scientists as the most valuable manuals in breeding local varieties like Shalola and their seed reproduction. Furthermore, there is functioning cooperation in the sphere of plant genebank exchange and research collaboration on plant breeding. And even because of their closeness in terms of geography, soil, and the high rank of Ukraine and Russia in the list of rye grain production (table 36), their achievements in rye breeding and its seed production are easily available to our grain crop breeders and seed producers.

According to our scientists, A. Khamzaev and V. Ismailov, who are engaging with rye variety research (2019), the productivity of rye varieties grown in irrigated lands of the republic has no challenge. But resistance to lodging, diseases, and grain quality are remaining at their lowered indexes.

Our breeders and breeders in the in the above-mentioned countries are jointly focusing on the research and development of new rye varieties, taking into account industry and farmers' demands. Depending on these demands, rye variety development and its seed reproduction research embrace various essential directions of breeding research.

The creation of rye hybrids is one of the latest directions in grain crop breeding research. The value of this rye breeding direction is explained by the fitness of the rye plant to produce not only products for the food and forage industries but also ethanol and biogas. Now, there are a series rye hybrids at the disposal of farmers to choose the most suitable one. This direction of rye breeding involves such main aims as:

- *high productivity potential and stability: good grain crop, resistance to drought and lodging, increased weight of 1000 grains.

- *resistance to diseases such as spores, orange rust, powdery mildew, pinchospores, and snow mold.

- *quality: grain nature, flour output, falling number, content of starch and raw protein, height of amilogram.

The cultivation of rye hybrids in European countries has been going on for over 20 years. Russia intends to plant hybrid rye in 100%

of its area. The rye hybrids that enjoy great popularity in enlarged agricultural enterprises are: ACT, Agr-Eco, Riat, Syukden, and Cherkizovo.

Advantages of hybrid rye begin with superiority in productivity: its crop is higher than that of traditional rye by 20–25%. Its highest technological resilience is its distinct advantage in terms of:

- *resistance to lodging and germination “on root”;
- *uniformity of stem height and robust stem stand;
- *even development and plant ripening;
- *high coefficient of tillering.

All these advantages let decrease the rate of seed planting up to 2 million vital seeds per hectare (80–90 kg/ha), which is twice as much as common rye varieties.

As our scientists mentioned above, the resistance of rye varieties planted in our republic to lodging, diseases, and grain quality remain challenges to be solved. That is why they are the most important directions in the rye breeding research and scientific programs of our SRIs on grain crop breeding.

Additionally, two rye breeding directions: 1. to create annual diploid and tetra-ploid rye varieties; and 2. to create perennial ray varieties with ear and grain traits similar to cultivating rye, many leaf types, resistance to cold, diseases, and pests, were underlined by Kh. Egamov in his teaching manual on “Plant breeding and seed production of some agricultural crops”.

In particular, the research conducted by E.P. Urban and others (2022) in Belorussia has made it possible to achieve a considerable outcome on the use of heterosis effects on the base of cytoplasmic male sterility (CMS). The outcome contains the creation of a system for the competitive, highly productive rye varieties: population-based tetraploid and diploid, as well as hybrids of F1: Lobel-103, Galinka, Plisa, and Belgi.

Rye breeding researches in the direction of resistance to lodging. V.D. Kobilyanskiy and others (2017) studied the agro-biologic and technologic quality of commercialized rye varieties Eniseyka, Sinilga, Mininskaya, and Krasnoyarskaya universalnaya, remarking on their higher cold resistance and lodging. The best one was Krasnayarskaya Universalnaya in comparison with Standard. And then it is recommended to use it as the initial genotype in the improvement of these two variety traits.

The effect of lodging of rye plants until flowering and at the beginning of milk maturity on the bread-baking quality of winter rye was studied by V.V. Chaykin and others (2019). The considerable worsening of bread baking qualities of grain was identified in both terms of plant development. It was supposed that the major reason for this was the increase in alfa-amalaza enzyme, and the quality of flour was essentially worsening.

Presented the results of a 10-year study (2008–2017) on the comparative research of winter rye varieties with recessive-poly genes (the first group) and dominant-mono genes (the second group) of short stem type.

Five varieties were tested in every group and evaluated on six traits: productivity, winter overcoming, plant height, weight of 1000 grains, number of fallings, and viscosity of water extracted from grain content. On every trait defined: stability of phenotype (SP), ecologic variation (EV), ecologic plasticity (EP), general (GAA) and specific (SAA) adaptive ability, breeding value of genotype (BVG).

Already in 2018 (Utkin E.I. and others), it had been shown that the trait of resistance to lodging depends on many factors: plant height, firmness of straw, root system power, and grain weight per spike. A definitive challenge appears at work with these data because of the genetic stipulation of traits being in strong dependence on the annual condition. So, the genetic character of resistance to lodging remains unsolved. The highest winter-resistant variety, Viyatka 2, with a recessive polygene type of short stem, has a tall straw (up to 185 cm) and weak resistance to lodging (an average 4.5 mark along a 9 mark scale). The varieties of the new generations: Falenskaya 4, Rushnik, Flora, and Grafiniya with dominant monogene types of stem have a shorter and stronger straw and are characterized by great resistance to lodging. A comparative assessment of varieties on the resistance to lodging is presented in the figure 39.

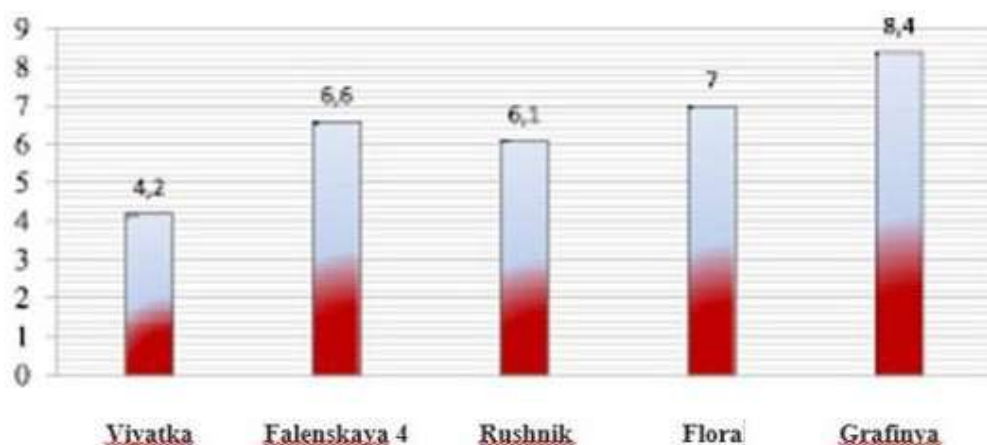


Figure 39. Assessment of rye varieties' resistance to lodging, in marks (2003-2017).

Direction of the model variety. The Russian breeders of rye, based on their collected experience, have tried to create an ideal rye variety with certain parameters. Of course, it is difficult because of the greatness of the effects of environmental factors. But, relying on the multiyear experiment data, some Russian scientists worked out the parameters of the model winter rye variety (table 39).

Rye breeding researches in the direction of resistance to diseases.

The more informative criteria for the assessment and selection of resistant initial material to fusarial wilt were brought to light by T.K. Sheshegova (2005). The source possessing field resistance and tolerance to fusarial wilt was created and introduced into the breeding process. The possibility of enhancing the ecological adaptivity and resistance of winter rye to fusarial wilt disease through recurrent individual-family and bio-typical selections in the variety and hybrid populations in the natural and artificial epiphytes 17 perspective populations studied at the competitive variety trial were created in the sphere of this scientific research. Two winter rye varieties, Falenskaya 4 and Snejena, were extended into production, and one, Rushnic, has been in state variety testing since 2002.

The results of the work were successfully used to work out a number of practical recommendations for agricultural production on the control of grain crop plantations from complex diseases (1996). They have significance for targeted search of resistant initial material and creation of effective sources and high-productive, resistant to fusarial

wilt disease varieties: to conduct diagnosis of fusarial wilt in the winter rye using models of artificial phyto-pathosenosis.

Ergot, a disease of grain crops caused by the fungus *Claviceps purpurea* (Fr.) Tul, is a progressing disease in the rye plant. Developing rye varieties resistant to this disease was also continued by T.K. Sheshegova and others (2021). In particular, these scientists could identify the composition and content of ergocalciferol (EA) in the sclerotia of the local population, *C. purpurea*. There has been a weak positive connection between the total content of EA in sclerotia (toxicity) and the infection of 100 new rye varieties.

Table 39. Parameters of a model winter rye variety.

Economically valuable traits	Indexes of standard, Falenskaya 4.	Indexes of a model variety.
Productivity, t/ha.	3.9-7.9	7.0-8.0
Number of spikelets per spike, units.	30-36	32-35
Density of spike, spikelets per 10 cm of rachis length	32-34	32-35
Number of grain per spike, units.	45-60	55-70
Weight of grain per spike, g.	1.1-1.8	1.8-2.2
Weight of 1000 grains, g.	24-34	34-38
Productive stems per 1m ² at harvesting	240-360	350-400
Vegetation period, days.	340-350	330-340
Cold resistance, %.	80-90	90-100
Ecological resilience	higher	higher
Resistance to lodging*, marking.	5.4-9.0	8.0-9.0
Regeneration capacity after infection by snow mold, %.	89-100	90-100
Resistance to leaf-stem disease infection*, mark	6.3-8.0	8.0-8.5

Note* - assessment on the 9 mark scale.

Effective genetic sources have been revealed for rye breeding, combining resistance to infection by fungus *C. purpurea* and lowering the accumulation of EA in the forming fungus sclerotia in the plants. The goal of this study was to determine the total content and composition of ergocalciferol in the sclerotia *C. purpurea* isolated

from winter rye. The genotypes with resistance to sporines and no accumulation of EA fungus in the sklerotsiys have been brought to light. At this point, information about the content of EA was important to search for immunity and valuable bred genotypes combining resistance to infection by sporines with the capacity to suppress the accumulation of EA. It was discovered that the new rye populations of Rumba, Garmoniya, and Simphoniya were distinguished by these properties.

Rye breeding research is in the direction of improving grain quality. On the suggestion of A.A. Bisharev (2015), the traits of the highest grain of winter rye are guessed to be the grain's larger size, high nature, and resistance to grain germination “on root.” Grain germination in the ear is a well-known genetically negative trait that has considerable consequences for the quality of baked bread. So, the creation of new, high-quality varieties with resistance to grain germination in the ear (photo 104) is the important goal of rye breeding.

According to contemporary understanding, the baking quality of rye grain presents the state of the carbon-amylase complex. That is why the major task at the rye breeding to improve bread baking properties consists in optimizing the main parameters of this complex to secure the highest resistance to grain germination in the ear.



Photo 104. Views of rye grain grown in the ears.

Creating the varieties with a lowered activity of ferment alpha-amylase and a higher number of falls is the first step in achieving this. The difference in inter-variety resistance to grain germination in the ear shows the possibility of improving this trait by the methods of hybridization and selection.

27 winter rye samples of collection distinguished for their cold resistance, resistance to lodging, productivity, and grain quality, and also six hybrid combinations taken previously by breeders at the

hybridizations of the best variety samples on their productivity and grain quality, were the materials of the research. Varieties: Bezunchujskaya 87 and Saratovskaya 6 served as the maternal forms of hybridization. And Bezunchujskaya 88, Alpha, and Otello 3 were paternal forms.

Phenological surveys and records have been conducted in the lab by choosing 45 plants in 3 replications. Plant height and crop structural elements (productive stem stand, grain number per ear, weight of grain per ear, weight of grain per plant, and weight of 1000 grains) were determined. The amilolytic assessment of grain was conducted according to a commonly accepted method. The experimental data treated by the dispersion and correlation analysis defined ecological resilience, stability, gomeo-statistics, and dominancy.

The results of this experiment have shown that varieties of Bezunchujskaya 88, Alpha, and Otello 3 were donors of low activity of α -amylase. The absence of close interaction between α -amylase activity and productivity elements gives the possibility to combine the higher indexes of productivity with a higher bread baking quality of grain in one genotype. The optimal parameters of plant height, weight of 1000 grains, and “number of falling” of selecting populations for the growing zone were determined. The new rye variety Bezenchujskaya 110, combining high productivity and grain quality, has been submitted to the state variety trial.

As stated by academician A.A. Goncharov (2016), the bread baking quality of bred materials has improved after 10 cycles of divergent form selections (photo 105) on the tenacity of water extract (TWE) in the population of varieties Alfa and Moscovskaya 12.

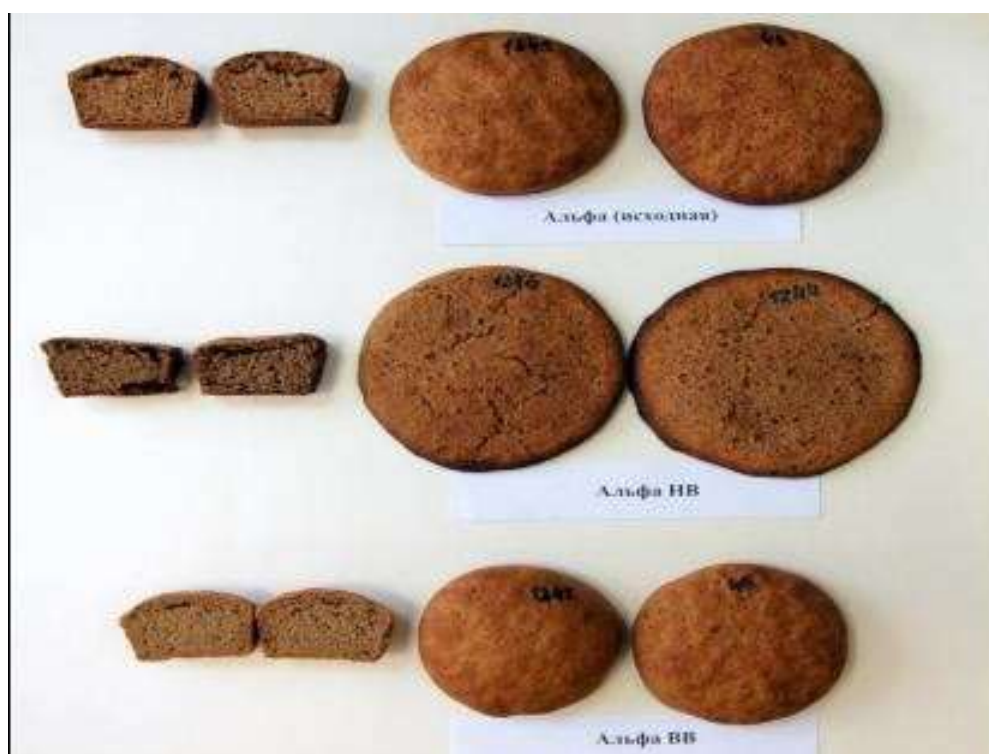


Photo 105. Laboratory baking of bread from the grain of low-tenacious (HB) and high-tenacious (BB) plants of the variety Alfa after 10 cycles of divergent selection.

The efficiency of selections has depended on the variety, genotypes, and selection direction. As noted, selection in the plus direction was more efficient than in the minus direction. The potential trait of the TWE has increased in the high-tenacious population by 3.3–6.0 fold, while in the low-tenacious population it has decreased by 2.6–3.5 fold. Of course, the flour of high-tenacious plants has pretty good bread-baking qualities.

Grain baking quality was also partly an important matter in the studies of V.D. Kobilyanskiy and others (2017). Herein, study of amilotic activity has shown that varieties of Krasnoyarsk breeding have optimal baking quality (350–645 e am.) in the contrast meteo-condition years. By the way, hydro-termic conditions have a considerable effect on the level of amilogram. Excess moisture in the period of grain formation and harvest in 2014 had led to the lowering of this trait down to the optimal boundary (350–365 e. am.). In the favorable year of 2015 to form high-quality grain, the top level of amilogram ranged along the varieties at 385–455 e. am. The drought in 2016, at the time of grain formation, has led to an increase in amilogram levels in all varieties. The variety of Krasnoyarskaya universalnaya is characterized by the most

stable high index of amilogram (350–505 e. am). This variety has a standard level on the general bread baking assessment and superiority over it on bread output capacity.

The development of plant breeding science for new varieties with the use of contemporary, including molecular, methods is one of the main links in the intensification of the agricultural field (Urban E.P. and others, 2022). Rye, in this regard, is not excluded. This crop in Belarus is the traditional strategic crop, mostly defining the country's food security. The main achievements in the use of different directions of rye variety breeding have been described in a historic context. The main approaches involving screening the world diversity of winter rye in the condition of Belorussia, using experimental polyploidy, hybridization, stabilizing selection, and molecule-genetic methods have been described.

Working out and using contemporary methods let us discover a series genetic mechanisms and principles that, in turn, considerably enhanced the efficiency of different rye breeding directions (population and heterosis). Today, the scientific-practical center of NAN Belorussia for agriculture, the Institute of Genetics and cytology NAN Belorussia elaborated a new breeding method, including molecule-genetics, which is especially important to increase efficiency to get competitive varieties.

For a long time, it was guessed that the grains of rye do not have **gluten**, but later it was identified that as rye protein, so as wheat protein, it is possible to form gluten, and it has turned a new direction in rye variety breeding. Research in this direction is being conducted in many Russian scientific research institutes. Ranges of raw gluten content by 6 to 26% in the grain of rye were discovered in the laboratory of technology. The amount of gluten varies with protein content ($r = +0.90 \pm 0.12$).

Create annual diploid and tetraploid rye varieties. This direction of rye breeding has been successfully implemented by Russian rye variety breeders. The results of the assessment such varieties on their productivity defined that many of them are not inferior to standard cultivating varieties. More important is their stable productivity during continued years of cultivation (table 40).

Create perennial rye varieties with ear and grain traits similar to cultivating rye, resistant to cold, disease, and pests. Of course, perennial rye is the result of remote hybridization between annual winter rye and perennial wild-growing species. It has a lifespan of 3–4 years, a

powerful root system, high drought and cold resistance, and accelerated development compared to perennial grass. The height of the perennial rye is up to 150 cm, and its weight is 1000 grains (17–20 g). Grain contains 13.7% protein, with 2.5% lizin. It occupies second place in terms of green conveyer after early-ripening varieties of annual rye. Northern Caucasus is guessed as the traditional region to grow this kind of rye.

Table 40. Productivity of diploid and tetraploid varieties of winter rye in the conditions of the north-western region (Safonov I.V., Aniskov N.I., 2022).

VIR catalog number	Name of the variety	Yield, t/ha						± to standard	% to standard
		2018	2019	2020	2021	Σ	Average		
Diploid varieties (<i>Secale cereale</i> v. <i>vulgare</i> Koern)									
11000	Il'men'	3.39	2.91	8.0	5.5	19.8	4.94	–	–
11868	Ofeliya	3.27	2.97	10.3	9.4	25.9	6.48	+0.65	113.2
11569	Yasel'da	3.65	3.03	9.0	7.6	23.2	5.8	+1.55	131.4
11863	Vostok	3.29	2.78	7.1	6.8	19.9	5.15	+0.88	117.9
11867	Evrika	4.6	1.5	6.8	6.9	19.8	4.96	+0.85	117.2
11755	Irina	3.68	3.04	7.8	7.5	22.0	5.5	+0.57	111.5
11880	Sigma	3.4	1.05	0.9	6.9	7.25	1.8	–3.1	36.5
Tetraploid varieties (<i>Secale cereale</i> v. <i>nudipaleatum</i> Kobyl.)									
11089	Verasen'	2.65	1.75	6.7	6.9	18.0	4.5	–0.44	91.1
11869	Plamya	3.72	1.98	7.3	7.2	20.2	5.05	+0.11	102.2
11754	Sibir'	3.11	2.6	6.2	5.8	17.7	4.43	–0.51	89.7
11805	Sibir'4	3.62	2.9	8.5	6.4	21.4	5.36	+0.42	108.5
11879	Verosim	3.61	1.08	3.2	2.1	10.0	2.5	–2.44	50.6

Derjavenskaya 29 is the common variety (photo 106). This perennial rye variety has been designated to form a field of fodder pasture for agricultural animals. As well as to grow for green mass and the production of nutrients from its reprocessing (silos, cakes, and grass flour). Derjavenskaya 29 is noted for its thin stem, high life cover, and elongated period of ear formation, and it outperforms all varieties of annual fodder rye. Its powerful root system makes it possible to grow plants of the variety in heavy and light sandy soil conditions. Its drought resistance is as good as that of any forage crop.

Such kinds of rye varieties would be preferable for our agriculture, where livestock farming is especially important and promotes the decision of **rye breeding directed to develop varieties with forage-produce properties.**

The forage value of winter rye varieties depends on their intensive growth of vegetative mass in the early developing stages and their ability to grow after cutting what defines business, growing up, and plant foliage.

The variety of Viyatka is the most rapid-growing, combining a pretty decent crop of vegetative mass with a high grain yield. Usually, world collections from Australia, Poland, Czechoslovakia, the USA, and Canada have considerable forage dignity. Beside the variety of Derjavinskaya 29, there are Derjavinskaya 181, Derjavinskaya 60+60, and Pervinets, which give comparatively higher green mass or grain for 2-3 years.



Photo 106. Rye variety of Derjavinskaya 29 in the experimental field.

Perennial rye Kupriyanova, out of wild species, has a special interest in breeding forage. It is distinguished by its plentiful bushiness, forming up to 300 stems, good foliage, and comparatively thin stems that are resistant to lodging. Forms an abundant green mass with a pretty content of protein.

Tetraploid varieties are also regarded as good initial materials to develop varieties designated to produce forage from diploid rye varieties.

Chapter 4. Rye breeding methods and initial material

In the context of the rye breeding presented in public view, it was especially noted that the following plant breeding methods, such as polyploidy, the use of winter rye heterosis, remote hybridization, interspecies hybridization, and selection out of local varieties and natural populations, were the most useful ones.

The method of reforming the diploid varieties into **polyploidy** (tetraploid $-2n = 28$) has been extensively studied and applied in rye breeding. It was identified in the last few years that the method of doubling chromosome number by colchicine solution treatment of seeds, seedlings, and spikes is the most available and adequately efficient one.

Getting of rye tetraploids by the way of crossing $2n \times 4n$ under the name of valence crossing method is widespread in Germany. The world's rye breeding has resulted in the development of about 40 rye tetraploid varieties. Germany, Sweden, the Netherlands, Poland, Hungary, and others, like the USA, are the leading countries where tetraploid rye varieties have been developed and studied. In Russia, it has also begun using this breeding method on the base VIR collection, plus about 30 varieties and forms of this crop.

By the way, polyploidy forms of the foreign rye-bred accessions reveal inadequate resilience to the harsh Russian climate conditions. This was the primary reason why many plant breeding institutes were so interested in developing original tetraploid forms from locally commercialized diploid varieties with high cold resistance. In some scientific research institutes, preference is given to getting tetraploid forms on the base of diploid hybrids of the first generation. They studied the possibility of holding firm the heterosis effect in the transition into polyploidy.

High-productive tetraploid forms are created by the method of hybridization of tetraploids out of various geographic origins and successive selections. Polyploidy in rye breeding increases the enlarging of the cell by 1.5–3 times. Which, in turn, has altered a number of economic traits and biologic properties. For example, increasing leaf size facilitates a rise in green mass output, surpassing the nutritious value of green mass in diploid rye, which favors using tetraploid rye for green feed. Increasing the power of straw, especially the thickness its wall, and increasing the share of tissue sclerenchi in the structure of lower nodes have enhanced the resistance of tetraploid rye to lodging. It

also surpasses diploid rye in grain size and, often, protein content. Decreased grain shading in tetraploid rye varieties is owing to increased flower legumes and a more robust fruit stem. Also has a more prolonged period of after-harvest maturation, which has made possible higher resistance to grain growth at the time of storage.

But tetraploid rye has some weaknesses. For example, the increasing leaf size in the early developing phase accompanies the growing amount of water in the leaves, which leads to weakening the cold resistance of plants, especially in winter with the snow layer. Lower productive bushiness of tetraploid rye varieties in comparison with their diploid analogies. Moreover, the high percent of lax ear decreasing grain crop is another major challenge preventing the widespread introduction of tetraploid rye varieties into production.

The increased laxity of tetraploids over diploids has been attributed to inadequate pollination as a result of less flying of enlarged pollen grains. Such enlarged pollens often occur in the plants of aneuploidy populations, which form gametes with a broken number of chromosomes and are not able to fertilize. These shortages can be removed with the increasing tetraploid genetic diversity of rye, the hybridization of better forms, and successive selections. The sources of such genetic diversities are the tetraploid varieties Verasen, Sebrouka, Spadchina, Zaveya-2, Igumenskaya, Dubinskaya Kameya 16, and Polnovesnaya released by Belorussian rye breeders. They can also be directly planted in production areas to produce forage for livestock. For example, Kameya 16 is a winter tetraploid with a cold resistance of 87.5–95.5%, a height of 1.35–1.45 m, a weight of 1000 grains of 49.7–51.45 g, and a maximal yield of 7.5 tons per hectare.

Multiple mass selection is usually used in rye breeding. As rye is an outcrossing crop, the selection of elite plants is not only important in the year of selection; it is also important in the regulation of outcrossing with other plants. Herein, the conduct of negative selection is one of the ways in which such regulation is exercised—removing the worst plants and plants with undesirable traits from plantations until they flower.

Later, the method of multiple individual selection became widely used in the breeding of rye. This method involves such methods as individual-family and family-group selection, so existing varieties usually possess some negative traits and cannot be improved with the help of mass selection.

The method of “**Halve**” used in the breeding of many outcrossing plants is also used in the rye breeding, which maintains part of the seed as a reserve for planting in the next year after assessment in the breeding nursery. Generally, the breeder applies not only one of those methods but their combination at different stages of plant breeding processes.

Use of winter rye heterosis. Many researchers remark that heterosis in the winter rye displays boosting growing energy and field germination of seed, increasing cold and drought resistance, productive bushiness, ear enlargement, increasing the number of grains per ear, and enhancing grain quality. These indexes represent different combinations in every certain case; in some cases, the hybrids exceed parental forms on productivity by up to 57%; in other cases, such exceeding is not noted or even depression is noted.

The main problem of using heterosis is related to the selection of pairs, the crossing and experimental creation of the initial material, and also mastering the methods of mass hybridization (photo 107) of components in the production of heterosis hybrid seeds. The use of heterosis variety mixes at the natural outcross has not found extensive application in the consequences of the considerable lowered heterosis effect. The main reason for this is the absence of heterosis at the crossing of closely related varieties and insufficient mutual outcrossing.

At the selection of components, it is necessary to use varieties of various ecological types, most differentiated in the genetic relation, to get hybrid heterosis seeds. Varieties and lines possessing high combination ability are selected using polycross methods, topcross, diallele crossing, and others.

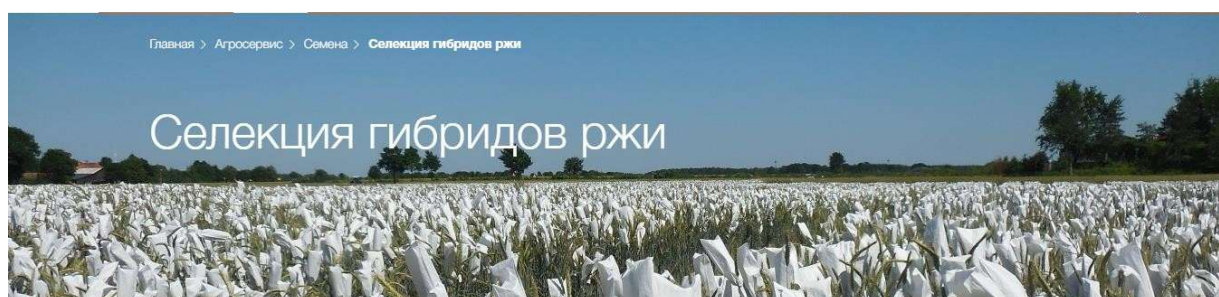


Photo 107. Experimentation on mass hybridization with rye in Russia.

The absence of a mass hybridization method is the major reason for getting hybrid rye seeds. The use of cytoplasmic male sterility (CMS) in corn, sorghum, and other crops is considered one of the most

effective methods for creating hybrid heterosis rye. The existence of CMS sources in many winter and spring diploid and tetraploid rye varieties has been discovered by former Soviet plant breeders. On V.D. Kobilyanskiy, mature stigma and anthers of the rye flower are formed at the top of the sterile plant and at the foot of the fertile plant.

Creating hybrid rye varieties. The main objects of hybrid rye breeding are:

- *the highest potential for productivity and stability: a decent grain crop, resistance to drought and lodging, and a and a high weight of 1000 grains;

- *resistance to diseases such as ergot, brown rust, powdery mildew, rinhosporios, and snow mold;

- *quality: grain natur, flour output, number of fallings, starch and raw protein content, height of amilogram.

The main criteria for the breeding of hybrid rye for silos and biogas production are: biomass productivity, methane output, vegetation period, and the starting of the grain milk ripening phase.

The formula for getting rye hybrids is very simple but requires many years of breeders's hard work. It pronouncing: Hybrid rye = (ACMS x B) x R-SYN. Where: (ACMS x B), maternal form (seed source): the result of inbred line crossing with sterile and normal cytoplasm. The sterile plasma, or cytoplasmatic male sterility (CMS), fully excludes the establishing pollens on the maternal plant form. This condition is necessary to control pollination on outcrossing rye.

R-SYN – paternal form (pollen source): artificial population, which particularly contains two parental components and gene-bearing genes. Such genes are responsible for the fertility restoration of hybrids, which involves the crossing of maternal and paternal forms. The given condition is necessary because the hybrid rye can perform grain after restoring fertility.

The results of hybrid rye breeding clearly show that the trend of the hybrid population on productivity is too much ahead of the population trend. This achievement is especially important as the result of an annual analysis of productivity conducted in Germany. This is scientific evidence about the breeding potential of hybrid rye (figure 40).

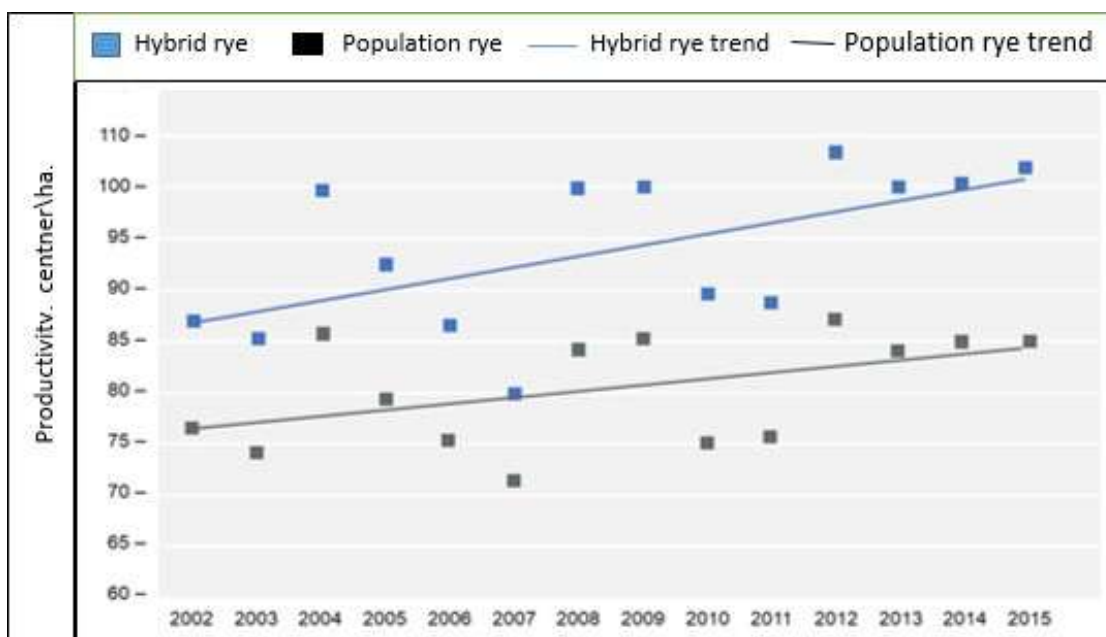


Figure 40. **Comparison of productivity progress between hybrid and population rye** (Data of the KWS LOCHOW, 2016).

Remote hybridization. Remote hybridization is also used in rye breeding. Wild rye species of *S. Kuprianovii* and *S. Montanum* were used by A.I. Derjavin in crossings with the cultivated rye varieties to create perennial cultural rye. He obtained many perennial forms in different directions: grain, green forage, and silos. In spite of the various valuable properties of these forms and varieties (multi-year cycle, resistance to cold and drought, and others.), they have a considerable shortage of small grain sizes (the weight of 1000 grains is 18–20 grams). The crossing with enlarged grain forms of diploid rye is used to overcome this and transform perennial forms at the tetraploid level, which, according to the data of N.V. Sitsina, enlarges the size of the grain, the content of protein in the grain, and the green mass and firmness of the straw.

Under the guidance of academician N.V. Sitsin, experiments were carried out on the hybridization of rye with wheat grass with the purpose of taking hybrid rye, which possessed higher cold resistance, resistance to fungus diseases, and grain of more high quality.

Polyploidization is used to overcome the sterility of F1 hybrids and created rye-wheat grass amphidiploids ($2n=56$), which are valuable breeding material. Such kind of hybridizations between wild and cultivated ryes (*Aegilops* and *Haynaldia*) were conducted at the institute of genetics and plant breeding in Azerbaijan.

The latest study by O.G. Silkova and others (2021) on this account involves the karyotype analysis of hybrids between wheat and rye genotypes (figure 41). Here, karyotype reorganizations was observed in three groups of F5 wheat rye hybrids 1R(1A) x R. Aberrations, including aneuploidy, telocentric and Robertsonian translocations.

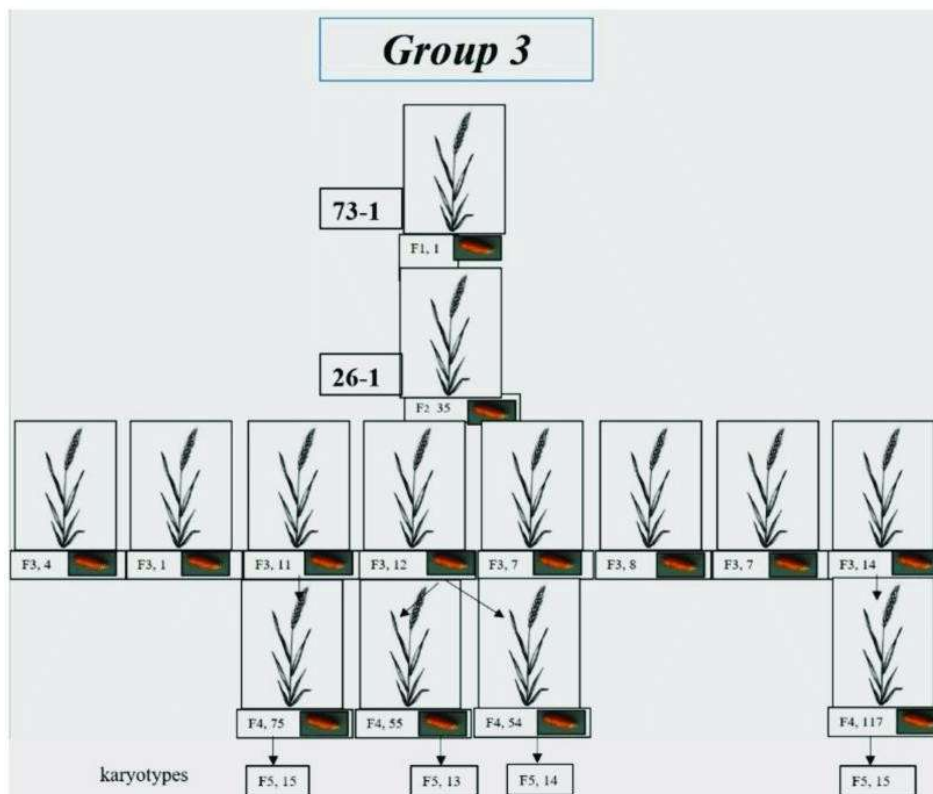


Figure 41. The scheme of individual plants of F1 and F4 generations and the taken seed numbers in the hybrid plants.

The method of compulsory self-pollination. This method of compulsory self-pollination (inzucht or inbreeding) is extensively used in the breeding of European countries. Taken self-pollinated lines become powerful means to enlighten internal diversity of varieties. Within self-pollinated lines were obtained auto-fertile forms as well as a series of constant lines possessing individual economic-valuable traits: dwarf, with strong, not lodging straw, many leafy, resistant to powdery mildew and other diseases, and so on.

Simultaneously, sterile forms with various phenotype chances of ear and vegetative parts are segregated in the progenies of self-pollinated lines of rye. Most of them are characterizes with lowered vitality, vigor and productivity. Straightly using of isolated lines, possessing individual valuable traits is usually not leading to success. Inzucht can be used in

the first stages of plant breeding to fasten individual desirable traits. But, this method has a special value in the using it to get heterosis effect.

One of the reasons for not using the inbred line is that along the depression of plants, it increases their self-fertility, which is why the grade of outcross fertilization and hybrid seed output are decreased. The creation of forms with male sterility has made it possible to widely use interline hybrids as corn in rye breeding.

Inter-varietal hybridization. This method is one of the most commonly used in rye hybridization because it involves freely inter-variety crossing; it is called the method of complete populations when several varieties take part in the cross-pollination and creation of initial material. Cross-pollination is achieved through alternation rows included in hybridization (varieties and samples, and not only one but several years of freely pollination). The complicated hybrid populations, decently adopted at the successful option of components to local conditions and more productive than initial forms, are developed as the result of freely pollination of initial samples and multiple selections on every form.

The method of freely inter-variety pollination with one-time severe selection of components is successfully applied in the Scientific Research Institute of Agriculture in the southeast of Russia. Historically known varieties of Voljanka, Saratovskaya krupnosernistaya, and Saratovskaya 4. Winter rye varieties of Chishminskaya 2 and Chishminskaya 3 of Bashkiria were also developed by this method at the Chashminskoy experimental farm. Lack of control in the pollination and charge of the breeding process with material from non-control pollination are the main shortcomings of this method.

The method of pair crossing with emasculation of maternal plants, which are planted within paternal plants to freely pollinate, or artificial isolation (often with unbleached calico isolators) is widely applied.

One of the main methods of rye emasculation involves cutting the lower part of the flower with its anthers at the moment of spike formation or 2-3 days prior to flowering with scissors. Damaged anthers usually wither and do not set pollen. Some of the breeders use the method of flower cutting with the removal of pollen.

The following variants of hybridization with full exclusion of maternal pollens are used in the Belorussian Scientific-Research Institute of Agriculture: 1) artificially laying pollen on emasculated spikes placed under a paper isolator; 2) limited-free pollination of

emasculated spikes of maternal varieties when pollinator plants are placed under a group isolator (bottle method); 3) planting of maternal varieties on the lot of variety-pollinator with successive emasculation of all spikes of maternal varieties and free pollination of them with pollens of variety-pollinator.

The third mode is considered to be the most productive, providing the best setting for hybrid seeds. Forms possessing a greater quantity of positive, non-equal value traits are selected in the quality of their components. But it is not always possible to get desirable combinations of traits as the result of simple, inter-variety hybrids. With this aim, complicated crossing—saturated and stepped—has become widely used in rye breeding. These methods acquire special significance in the breeding process for grain quality, resistance to lodging, and others. They are broadly used in the breeding work of SRIs in Russia and Ukraine.

Cloning. The method of cloning is used at the breeding institute of V.Ya. Yurev and other breeding centers. In some of them, rye breeding with the use of cloning has become a major mode, with crossings within the most valuable clones. Breeding acquires more broad opportunities at the rye cloning stage to study the biotype composition of populations as well as conduct crossings and selections.

The propagation coefficient increases up to 300 thousand and results in the possibility of testing the seeds, harvested from clones, just in the preliminary reproduction, propagating them on the isolated plot, carrying out assessments in the provocation background, assessing bread baking, and miller quality, which is a comprehensive assessment of the selected clone on all economically valuable traits in a year. Historically known as Hybrid 173, it has been commercialized widely since 1971 as the result of crossing the two clones of the variety Suyda and successive individual family selections.

Inter-population breeding. All rye varieties: as local so-breds, they are complicated populations possessing a great diversity of various traits and properties that can be improved by selecting the existing varieties and creating new ones. Mainly, the methods of strait selection of the most valuable forms in regard to economy from old variety populations as well as rebirthed populations, which are populations formed as the result of natural out-crossings of foreign varieties with local varieties and adopting local conditions, were applied at the beginning of rye breeding. For example, more than 40 varieties

developed in 12 countries took their origins from the variety Getkusskaya Lakhova, including a series of varieties in Ukraine: Kharkovskaya 194, Kharkovskaya 55, Yireva 1, Veselopodolskaya, and others.

The overwhelming majority of European bred varieties (including some from Skandavian countries) are related in their origin to varieties of Probesteyskaya, Zelanskaya, Shlanatedskaya, and Shampanskaya. Many varieties in Russia (Viatka 2, Viatka moskovskaya, Falenskaya) driven by Viatka and Eleseyivskaya gave birth to many new varieties (Bezunchujskaya joltazernaya, Saratovskaya 1, Vojanka). And even though a great number of old local varieties are broadly used in rye breeding nowadays, let it be not as material for direct selection but for hybridization and in creating the needed initial material. These materials play an invaluable role in the breeding of drought, cold, and disease resistance.

Initial material. Methods of continuously straight selection from limited initial material are one of the reasons rye breeding lags behind. Most newly grown varieties of rye have a narrow rate of relationship with a few initial varieties. Intraspecific and interspecific hybridization with attracting of the best forms and varieties of cultivated, wild accessions, including sources of dwarfish stem from the world rye collection, donors with high content of irreplaceable amino acids, heterosis on the base of diallel crossing and poly-cross, and more widely using polyploidy and mutagenesis are more efficient breeding methods that have made it possible to create productive, intensive types of winter rye varieties with high technological quality of grain.

Initial material of different origins gathered together in world collections is necessary for the release of new varieties. The world collection has distinguished itself along its many important biological and economic properties: competitive cold and drought resistance, less response to growing conditions, and comparatively high resistance to pests and diseases. That is why they are basic at creating new ray varieties. But they also have many shortages: comparatively small grain, less productive, considerably lodged, and so on. Consequently, broadly using a rich European variety set representing exceptional interest is necessary for hybridization.

European rye varieties are desirable initial materials for Russian rye breeders because of their adaptability to local soil and climate conditions, pretty productivity, large grain size, adequate resistance to

seedling formation, as well as to lodging. They could help considerably improve Russian varieties in the trend of rye breeding. But they are less cold-resistant in regard to Russian conditions. This does not exclude the value of these European (Germany, Poland) varieties for Ukraine, Belorussia, Baltic region countries, and Uzbekistan. For our rye breeders, Russian grain crop varieties and the results of their breeders are most familiar. Thereby, Russian varieties are often attracted to cultivating initial materials in their own breeding processes. In particular, such tetraploid Russian rye varieties as Sibir 3, Praleska, Krijachok, Zernafrajnaya tetra, and Sibirskaya universalna were recognized by I.V. Safonova and N.I. Aneskov (2023) as initial materials for improving the productivity of grown varieties.

Usually, rye varieties of **Poland** distinguish for their high moisture response, pretty decent crop, they have enlarged grains, grain strongly covered in its glumes, comparatively cold resistant, some of them have high protein content in the grain, relatively resist to brown, stem rust and powdery mildew. They are: Dankovskie Złote, Dankovskie Diamant, Amilo, Ambar and others.

Dańkowskie Złote, Dańkowskie
Diamant, Amilo and Amber,
Dańkowskie Złote, Dańkowskie
Diamant, Amilo and Amber,
Dańkowskie Złote, Dańkowskie
Diamant, Amilo and Amber,

Sweden bred rye varieties (as Boyko Spring Rye) famous for their cold resistance, high productivity, grain quality, resistance to lodging, dwarf stem and vigorous seedling formation. Finland varieties have high cold resistance and grain quality which makes of 15% and more protein content in the grain.

Czechoslovak varieties (as Ceske, Valticke and Tesovske) often remark for their enlarged grain sizes by 50 gram and over (photo 108) on the weight of 1000 grains and resistant to lodging.



Photo 108. Rye grain size of some Czechoslovak varieties (second) in comparison with wheat (first) and triticale (third) grains.

Chapter 5. Assessment methods of rye breeding materials

Available and newly created bred materials for the development of rye varieties are evaluated on the following characteristics: productivity, cold resistance, drought resistance, resistance to diseases and lodging, grain quality, response to fertilizers, and agro-practices. Assessment is conducted by the direct and indirect traits in the usual and provocation backgrounds.

Comparative assessment of rye varieties conducted by T.Ya.Ermolaeva and others (2019) is the virtual example of the common method to evaluate A comparativeivity of rye-bred materials. 21 contemporary winter rye varieties were taken for field experimentation. The field experiment for crop years 2016–2018 covered 13.2 m² area under every variety with three replications. At this point, we used seed drills (SN 16). It makes 2 lots of 1 m each. Lots or raw 30 cm apart. Seed sowing rate: 4 million per hectare. The density of the stem stand was defined through bundle selection out of 1 m², ear indexes, and plant height by 25 plants from every replicate (photo 109).



Photo 109. One of the experimental plots of rye breeding materials.

Determined following indexes, taking into account the basic principles of breeding indexes to improve the improve the genetic, economic, and other important properties of plants: Index productivity: ratio of grain weight (g) to total dried biomass of plants (g). Mexican index: ratio of ear mass (mg) to ear length (cm). Fino-Skandavian index: ratio of grain number per ear (unit) to ear length (cm). Index perspective: ratio of 1000 grain weight (g) to length of ear (cm). Index

attraction is the ratio of ear weight (g) to straw weight (g). Index of ear potential productivity: ratio of ear grain weight (g) to weight of ear with grains and multiplying by the number of grains on the ear. Density of the ear at 1 cm rachis: ratio of the number spikelets in the ear to its length (cm). Content of grain in the ear: ratio of the number of flowers with grain setting to the total number of flowers, multiplied by 100%. The results of these indexes are necessary to substantiate the virtual productivity of each variety studied in comparison with others.

The productivity can be defined comparatively to the grain productivity taken from each of the three places in the lots with an area of 1m². That is, on the sample of grain yield of ears taken from lots, on the first sample, it may be 650 g., on the second sample, 640 g., on the third sample, 660 g. The average yield on the sample consists of 650 g. (Look at 1 -practical training of the manual in this text book: Selection and seed production of grain and bean crops.

Teaching manual. <http://library.ziyonet.uz/uz/book/126706>).

The result is: 1 m² – 650 g.

10 000 m² – 6 500 000 g. = 6 500 kg or 6.5 ton per hectare.

So, in this field, the method of productivity assessment showed that the most productive winter rye varieties for the years 2016–2018 were Valday -4.74 ton\ha; Moskovskaya 12 -4.61 ton\ha; Marusenka - 4.60 ton\ha; Tolovskaya 41 -4.23 ton\ha and Flora -4.15 ton\ha. And the less productive one was Estafeta tataristana -3.35%.

Assessment of cold resistance. The assessment of bred material in the field is very objective. And it is conducted systematically for several years, but not every year comes with the with the natural conditions needed for the assessment of bred materials. That is why the breeders worked out and applied indirect and provocation methods such as early sowing, nitrogen application, and snow accumulation in the less snowy year. Planting in the plot with lowered relief and temporary flooding during the period of snow melting.

The hills and highlands are also used under plantations to assess the cold resistance of plants in regions with more harsh climatic conditions, as well as to apply ice-keeping equipment and refrigerator chambers.

Hibernation of plantations is assessed by different methods: visual, by accounting of vital and dead plants, sowing in boxes (method of V.Ya.Yurev), with the help of tetrazol, and indirect modes. It is known that the leaf shape of varieties varies depending on their cold resistance.

So, the structure indexes of leaves can be successfully used to reject weak, cold-resistant plants in the process of plant breeding.

The method to determine cell juice concentration in the tissues of plants can also be applied to the preliminary assessment of selected materials for cold resistance. It was identified that there is a positive correlation between cell juice concentration in the leaves and the number of overwintered plants and a negative correlation between cell juice concentration in the autumn and damaged plants.

Drought resistance. To define the germination of seeds in the solution with increased osmotic pressure, responding to water lack (for instance, saccharose solution) is an indirect method of assessing the relative drought resistance.

Rye varieties able to germinate in conditions of osmotic stress and form powerful primary root systems can further be more drought-resistant in natural field conditions. This method lets isolate promising material with resistance to drought at the earlier stages of organogenesis, which is important at the selection of winter crop varieties resistant to autumn drought. The concentration of solution-osmotic must be different, taking into account the diversity of plants under experiment. 10% saccharose concentration to evaluate the germination was assigned for winter rye seeds by researchers A.A. Belozarovoy and N.A. Bome (Parfenova E.S. and others, 2018).

E.S. Parfenova and others conducted an experiment under the guidance of the above-described method to indirectly assess the drought resistance of 23 winter rye samples within them, 9 commercialized varieties, and 14 promising populations in three districts of the Kirov region (table 41).

Table 41. Varieties and promising populations of winter rye to evaluate their relative drought resistance.

Commercialized varieties	Promising populations
Viyatka 2, Krona, Falenskaya 4, Kirovskaya 89, Dimka, Snejana, Rushnik, Flora, Grafinya.	Kiprez, Rumba, Rosa, Nioba, Leda, Sadko, Perepel, Snejana S30/07, Falenskaya universalnaya, Grafinya OP-15, Grafinya OP-14, Kiprez Ku-16, Kiprez KU-15, Falenskayaya universalnaya OP-14

The procedure of assessment involved the germination of seeds in the saccharose solution at a concentration of 10.5% (12 atm). Percentage of seed germination (P%) and lowering grade (depression) of accumulation dried biomass (Z%) were used as the assessment criteria. The index of Z characterizes the level of growing processes with increasing osmotic pressure. The samples have been distributed to five groups (table 42. based on the percent of seed germination).

Table 42. Distribution of winter rye samples to relative drought resistance.

Number of group on the grade of drought resistance	Interval of trait value «seed germination», %	Number of varieties in the group	
		Piece.	%
1 – unstable	0 – 13,9	1	4,3
2 – weak	14,0 – 27,8	3	13,0
3 – mean	27,9 – 41,7	8	34,8
4 – over mean	41,8 – 55,6	3	13,0
5 – highest	55,7 and more	8	34,8

The analysis of varieties conducted in accordance with the worked-out method allowed for the distribution of winter rye varieties into groups. The varieties Crona, Kirovskaya 89, Falenskaya 4, Grafiya OP-15, Kiprez, Sadko, Snejana S30\70, Perepel, Nioba, Grafiniya, and Rushnik were the most drought-resistant. Kiprez, Perepel, Crona, Grafiniya OP-15, and Sadko were isolated for their lowered indexes of depression (5.2, 15.6, 24.4, and 29.6%, respectively) in the group of highly resistant to osmotic stress. The isolated samples can be considered promising for further study of drought resistance in natural field conditions.

Assessment of resistance to diseases. Ergot (*Claviceps*) fungal disease is one of the biotic stresses in regard to rye varieties, their productivity, and grain quality (photo 110). One of the methods of assessment of rye resistance to ergot is the use of T. Miedaner's scales. The procedure of the method involves the inoculation of experiment plants with a water solution of local conidium of *Claviceps purpurea*

picked up from fresh collected rye sclerotium (a synonym of the fungus Mycelium). At this inoculation, there are 10–15 plants with 3 replications. T.K. Shashegova and others (2021) took 26 diploid rye varieties.



Photo 110. **Symptoms of infected ears of grain crops with pathogens of ergot.**

(*Secale cereale* L.). Two indexes—damage (share of plants with sclerotium in the probe,%) and contamination of grain by sclerotium (content of sclerotium in a grain probe, % per weight)—were used to characterize varieties. The content of EA (ergoalkaloids) and their composition in plant extractions are indirect evidence about the resistance of plants to the disease.

The analysis of extractions is conducted at the special biochemistry and physiology laboratories. It was identified that the tested genotypes were mainly vulnerable to ergot. Immune forms in winter rye varieties were absent. Variation between 10 varieties made of 5.8 to 33.0% contamination of grain with sclerotium consisted of 0.3 to 1.4% (in the indicator variety correspondingly: 100 and 37.0%). The amount of EA in the sclerotium collected from rye plants ranges from 0 to 0.36% per their weight. The scientists predict that the content of the EA is important in the search for immune and valuable genotypes, combining resistance to ergot infection with suppressing the accumulation of the EA. The German variety populations of Rumba, Garmony, and Simphoniya are distinguished by this property.

Resistance to lodging. The resistance of varieties and hybrids to lodging is evaluated on the five-mark scale at the visual assessment. At this: 5-lodged but erected; 4-lodged at weakly grade; 3-varieties with mean grade lodging; 2-strongly lodged before harvest (photo 111); and 1-unfit to machine harvest.

Later, analysis of the mechanic properties of the stem of the initial material and hybrids of rye is conducted in many plant breeding institutes for the assessment of resistance to lodging. The stem height, length, diameter, and weight of the lower internodes and their opposition to breaking by the device of AFI are studied.

It was identified that in some instances, the anatomic structure of the stem (thickness of the mechanic ring, quantity, and diameter of the vessel-fiber bunch) was studied because of the availability of more conducting bunches with an enlarged diameter of the mechanical ring in the no lodging plants. Also, it is known that the powerful root system is correlated with its resistance to lodging, and assessment is carried out with the selection of plants based on the grade of root system development. Herein, the study of 20-day-developed plants has been recommended at the beginning of the bushing stage of development. Varieties of Eskulap, Gran, and Crona are recommended as the most resistant to lodging rye varieties.

Assessment of grain quality. The quality of rye grain, as with other cereal crops, in breeding practices is accepted to determine the output of graded flour at milling and bread baking. In contemporary terms, the bread-baking quality of rye depends mainly on the state of the hydrocarbon amylase grain complex. Strengthening of amilitic enzyme activity and especially α -amylase in the condition of increased humidity causes starch to decrease and lose its hydrolyte property, making the grains unfit for bread baking.



Photo 111. One of the rye varieties has poor resistance to lodging.

The stickiness index of water-floury suspension at the claysterization services is an indirect index of amilic activity. Rye with good quality should have maximal stickiness on the amilograph—not less than 400 index, “falling number” on the device Harberga-Pertena—not less than 200 s. Later, the laboratory technology of the Falenskoy breeding station worked out micro-modifications of this method. It lets rapidly and with adequate precision assess breeding material using 3.5–5 g of grain.

The working principle involves: water-flour suspension is prepared in the test tube of 20 ml capacity (2 g) out of fresh milled oil-seed meal and 10 ml distilled water at a temperature of 20°C and clayistered for 45 seconds in the water bath at continuous stirring. The time of immersion (in seconds) is determined by the stopwatch. Indicator “falling number” represents the total time (in seconds) from placing the test tube in boiling water until the end of the falling rod in the clayistered suspension. The higher the value of this index, the lower the amilic and autolytic activity.

Grain quality testing methods. So far, an adequate development of breeding work with the target of improving food and the technological quality of rye grain has not been formed. Inadequately studied biochemical features of rye grain and weakly developed assessment methods for rye grain quality.

Grain quality depends on a series of environmental factors and the biological features of varieties. Grain on the ear often germinates in regions with much precipitation at the time of harvest, which considerably lowers the bread-baking quality of the harvested grain. Therefore, creating rye varieties resistant to grain germination of the ear is the major goal in rye breeding to improve grain quality with lowered activity of α -amylase.

Long-term experiments were continued in the northern-west counties of Europe, where grain loss has historically been higher, and they have gathered a number of scientific evidences to improve grain quality.

Comparative tests of varieties and world collection samples on the amilic activity of rye grain have demonstrated that the varieties Viyatka, Viyatka 2, Hybrid 2, Bambo, and K-9722 have a good state of carbohydrate-amylase complexes.

Increasing protein content and improving its amino acid compound on account of the high content of lysin has great importance, along with

enhancing rye resistance to germination in the breeding process. The level of protein content is different in the conditions of various zones. For example, in the Baltic region: 10%; non-black zones: 10.6%; central non-black zone: 11.0%; Siberian zone: 12.5%; and West Kazakhstan: 14.6%.

Variety features in regard to protein content pretend weakly; growing conditions render a stronger influence. A great deal of attention is paid to the creation of rye varieties with a high content of protein in the grain. The use of world collections is irreplaceable in this regard. A variety of Saratovskaya krupnozernaya developed on its base and was remarkably isolated in good batches of rye with increased protein content. Weed-field rye with 20% or more protein content is attracted to hybridization with cultivating varieties in some plant breeding institutes. Polyploidy has a considerable role in enhancing grain quality because the protein content in the grains (photo 112) of tetraploid forms and varieties is higher by 2–4% in comparison with diploid varieties.

It was identified that there is a positive correlation between glassiness and protein content of grain, which has made it possible to select winter rye based on glassiness in the development of varieties with high grain quality. Noted relation between grain color and its quality: for example, green grain is marked with increased protein than yellow, contains less amount of ash, and gives flour with superior quality.

The efficiency of using hybrid rye in the production depends on the quality of obtained inbred lines with the CMS systems. **Assessment of the level of sterility/fertility parental inbred lines and F1** is the main requirement at the creating the hybrids (Gordey I.A. and others, 2008).

Fertility level is assessed visually, using the Geiger points (from 0 to 9) on the scattering degree of pollens out of flowers at the time of blooming: 0-3 points – sterile, 4-5 – semi fertile, 6-9 fertile.

Fixation of 8-10 flowers per spike on the 3-4 plants in every line with 70% ethyl alcohol is also used to evaluate the fertility. Studied fertility under the microscope on the atsetocarbone preparations. Analyzing up to 500 pollen grains.

Beside the Geiger points, 4 point assesement of pollen reduction proposed by Belorussian scientists (Gordey I.A. and others, 2008): 4 point – normal pollens, 3 – weakly reduced, 2 – mean reduced and 1 – strongly reduced (at least 1\3 long, normally developed pollens).

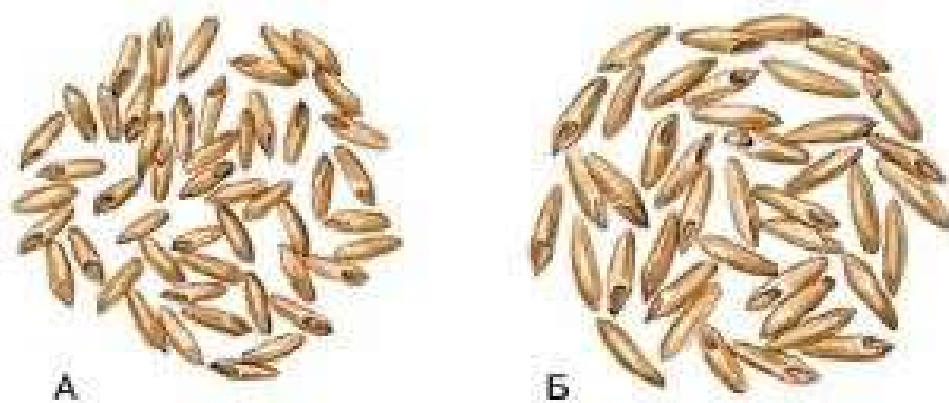


Photo 112. The seeds of diploid A ($2n=14$) and tetraploid B ($2n=28$) rye varieties.

Chapter 6. Hybridization technique of rye plants

The structure of spike, spikelets and flowers of rye and studied wheat and barley is similar. Hybridization technique of wheat and barley can be applicable to the plants of rye also, taking in account of some specific developing distinct features of rye flowers.

Rye has become a cross pollinator plant in the result of difference on the maturing of pollen and stigma of flowers unlike the self pollinators: wheat and barley.

Artificial hybridization in the rye plants is also actual for improving rye breeding materials in the breeding processes. But, any beginner prior to start hybridization procedure must to have knowledge about special structure of spike, spikelets and flowers including, generative parts of them (figure 42). Overall makeup includes: two outer glumes, Inner floral glume, spikelet glumes, pistil, lemma, stigma and anthers.

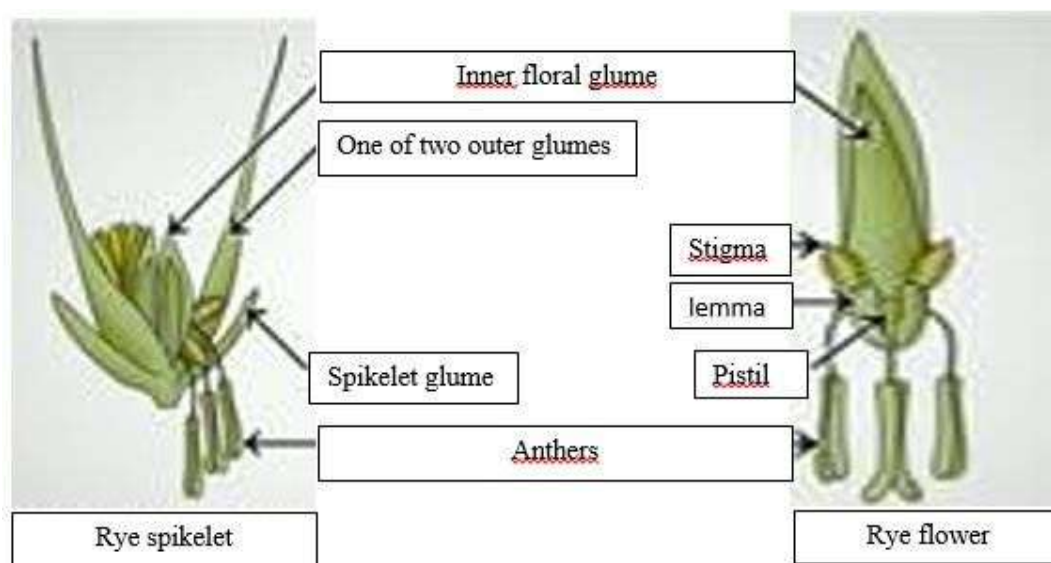


Figure 42. **Structural and generative parts of rye spikelet and flower.**

To have toolkit to hand pollination: crossing book, scissors, forceps, a tube with ethanol, crossing bags, crossing tags and a paper stapler.

Steps of hand pollination: 1.Preparation of inflorescences to pollination. 2.Emasculation and flower isolation. 3.Pollen collection from paternal flowers. 4.Pollination of emasculated maternal flower.

Preparation inflorescences begins with selection of flower (inflorescence) which imposed by following requirements:

1. Flower should not be pollinated at the time of emasculation.
2. Flower must be entirely full developed.

The following works are to be fulfilled at the preparing of whole selected spike: less developed spikelets formed on the two ends of spike by the help of forceps, leaving usually about 5 out of them on both side of spike. Top part of these spikelets is cut off with scissor to be seen its inside and to do easy removing the anthers (photo 113). This is the emasculation of the left flowers.

Bagging the emasculated spike is done by the help of crossing bags, now using them as the isolators and is fastened lower open part of bag with paper stapler (photo 114). Of course, prior to emasculation and isolation of emasculated spikes the identification data about the maternal plant is written on the isolating bag and in the cells of blanked table in the crossing book with the order numbers.



Photo 113, 114. **Emasculation and bagging of the rye spikes.**

Pollination of maternal plants with pollens of paternal plants is implemented in a certain of time, after emasculation and the isolation of flowers of inflorescences. Pollination is done via putting off the isolators with the help of gentle brush (or forceps) in the early morning times (from 6 to 10 hours) when the pollens are most sticky on stigmas. And again, is put crossing bags on the pollinated spikes and secure lower part.

In the production scale, the preference is being given to the creation of mass hybrid rye with using of rye's field outcross (photo 115). Here, the breeders are interested to use the phenomenon of heterosis. Because, the hybrid rye planting has made it possible to increase the productivity by 20-25%. At this, the hybrid rye fully

maintains such important properties of parental forms as resistance to drought and cold.

In the cross-pollination is used plants (maternal) of inbred line selected on the SMS and sterility firming and inbred lines with fertility restorer (paternal). The technique of artificial pollination of rye is extremely simple. During the rye pollination, two workers walk through the nursery of paternal plants with taut ropes in their hands. At first, the plants gradually bend over, then, freeing themselves from under the rope, they hit each other with force. As a result, rye pollen scatters in all directions and, being picked up by even a small breath of wind, is carried over an even greater distance, gets on the stigmas of the plants.

Of course, the best results are obtained by additional pollination when it is carried out throughout the entire flowering period. The need for this is obvious. Rye usually blooms from the middle of the spike; the next day the next pairs of spikelets bloom up and down, etc. There are spikes and whole plants that behind in development and bloom several days later. Therefore, one cannot limit oneself to one-time additional pollination. In the repeated case, the rope is pulled in the opposite direction 1-2 hours after the first pollination.

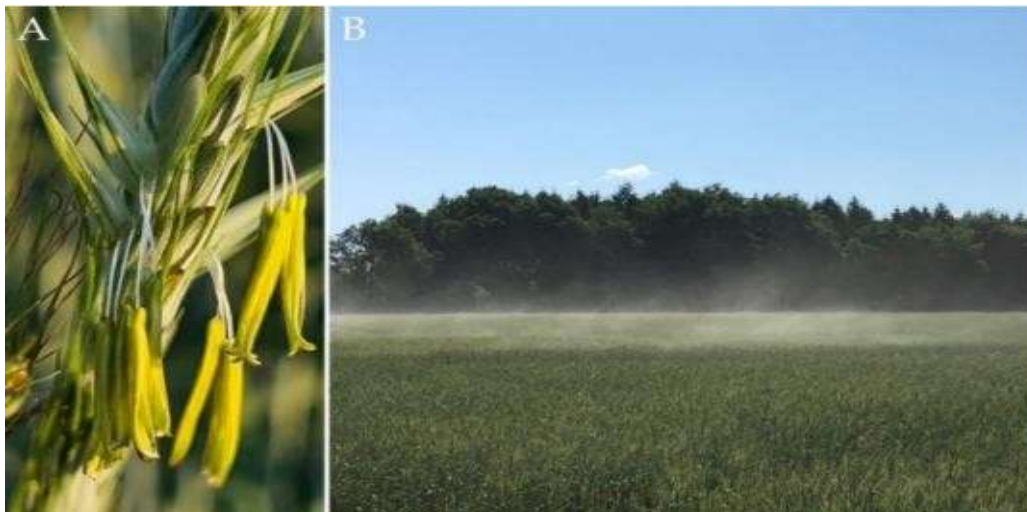


Photo 115. (A) Dehiscent anthers of the rye spikelets and (B) rye pollen dispersed by wind throughout the field above the plant population (Bernd Hackauf and others, 2022).

Chapter 7. Seed production of rye

The plantation under rye varieties is not considerable in comparison with other cereal crops in our republic, and the number of registered varieties is also low (NS SAVO, Shalola in 2022). Their local seed production work is mainly being guided by European neighboring countries like Russia and Belarus, where rye breeding and seed production systems and schemes have adequately advanced. The planting qualities of rye seeds are to meet the requirements of GOST R 52325-2005 (table 43).

Table 43. Planting qualities of rye seeds.

Seed category.	Seed purity, % at least.	Content of other crop seed, piece/kg, not more.		Mixes, not more in %.		Germination, at least in %.
		Totally	Including of weedy seeds	Smut like forms	Ergot sclerotium	
OS	99.0	8	3	0	0	92
ES	99.0	10	5	0	0.03	92
RS	98.0	60	30	0.002	0.05	92
RcS	97.0	200	70	0.002	0.07	87

The scheme of taking elite seeds insuring rapid reproduction (propagation) of low-pentosan containing rye cultivars (photo 116) is proposed by the researchers of Krasnoyarsk SRI of agriculture and the Center of Federal Research of the All Union Institute of Genetic Resources.



Photo 116. Seeds of low pentosans containing rye variety Yantarniy (AgroNovost newspaper, 2021).

They say that the seeds of rye varieties have an increased quantity of anti-nutritious substances that negatively affect digestion in home animals when they are used for forage purposes. Rye grains contain 5-7 times more water-soluble pentosans than wheat grains. V.D.Kobilyanskiy, a doctor of biological science, has worked out an unequal method to get rye varieties with a low content of pentosans that has made it possible to increase the demand for rye grains.

The variety of Yantarnay without analogy in the world on the lowered content of pentosans (0.53%) is a particular result of that researcher.

The reason for outcrossing the biology of rye is to include a great number of variants (mass and individual selection, method of halve, method of genetic reserve, pair crossing) in the methodology of rye breeding and **winter rye seed production**.

Mass selection. Selected seeds of the best plants are united with the isolation of small seeds by sieving on the sieve and planted in the nursery for reproduction. The scheme of elite seed production includes the following links: first- and second-year reproduction nurseries, super elite, and elite. Mass selection is applied to the rapid reproduction of new, promising, and deficient varieties. Its technical simplicity and economy are the main advantages of this method. Mass selection lets you get elite seeds with high productive properties, but it does not ensure full variety purity. The main disadvantage is that there is no possibility to inspect genotypes on their progenies.

Individual-family selection. This method is grounded in individual selections of the best plants, each of which is separately tested along with the offspring for two years. Seeds of elite plants are sown along the families (nursery of first-year testing). The better families harvested, threshed individually and used to plant in the nursery of the second year of testing.

The seeds of the best progenies are united and replanted in the nurseries of first- and second-year reproduction, then in the super-elite and elite.

The main disadvantage of the method is that the seeds of the best families are established from outcrossing with all nursery numbers, including inferiors. So, conducting the discarding until flowering of inferior forms along with some traits (for example, productivity) is impossible.

Method of halve. This method allows full control over pollination. The core of this method involves the planting of the seeds of every elite plant. The remaining part is in reserve to test offspring. The getting of the elite seeds at the use of the method of halve is led by the scheme: selection nursery, nurseries of the testing of the first year and second year, nursery of reproduction, super-elite, and elite.

100 seeds are selected out of the crop of every elite plant and planted in the nursery for the first year of testing; the rest of the seeds are left in the reserve. The seeds were stored as spares from those plants, which were isolated as the best ones in the nursery for first-year testing. Families with undesirable characteristics in the field are rejected until they flower. The remaining best families are harvested together, cleaned, and graded, with heavier ones selected. The United Crop goes to the nursery for reproduction.

Method of pair crossing with using of indicator ears. It has been worked out at the Federal Research Center of the All Union Institute of Genetic Resources, named after N.I. Vavilov, to take elite seeds of lower pentosan winter rye varieties. Lower pentosan-containing grains have definite phenotypic features. Their shells are more thin, smooth, transparent, and glassy. Grain analysis of a plant crop, selected visually based on the traits of thin shell grain, shows the higher correlation of anatomy-phenotype parameters with the assessment of up-to-date biochemical methods. This has made it possible to conduct a visual selection of low-pentosan grain plants.

500 ears are selected for the elite or super-elite plantations. The grains of the best ears are assessed with the help of special devices on their indexes of thickness and transparency of grain peel. The remaining seeds after rejection are poured and used to plant in the pair pollination. Rejection of plants with undesirable characteristics is carried out in the rye pair pollination nursery in the next year of spring at the time of growing. Plants are marked for pairs after heading. Individual plants with ears are isolated out of both plant pairs; others are left under the whole isolator. If both freely pollinated (indicator) ears have thin, covered grains, it means that pair fits the plant.

The seeds of every pair are studied in the nursery of the elite pair progeny test. Lots of inferior plants in the nursery that do not meet the seed production requirement are removed. And the seeds with the best lots are brought together to lay out the nurseries of reproduction. This

method is pretty time-consuming, but it makes it possible to select offspring without segregating on the sign of low pentosan grain.

The method of genetic reserve provides for retaining positive characteristics of population varieties through the restriction of generation numbers. The seed fund for high reproduction is created in the year of recognition of the variety as a perspective (promising) one. The seeds of the reserve fund are stored in an inert medium and used for a period of 3–4 years.

If there is no strain change, the reserve fund is renewed after its expending by way of selection and document as the reserve fund of the second generation. The method available lets support the initial quality state of the variety and ensures industrial plantations of genetically pure seeds.

Simultaneously applying the methods of genetic reserve and pair crossing with the use of indicator ears (table 44) is presented as the most purposeful in the primary seed production of low-pentosan rye varieties to decrease the chances of getting elite and maintain new valuable characteristics.

The considerable renovation in the rye varieties of Belarus and their seed production took place in the later years, which has resulted in the creation of a number of highly productive varieties with short stems, cold resistance, enhanced resistance to lodging, and seed germination on the ear. The method of production of original winter rye seeds described by E.P. Urban, a doctor of agricultural science, has promoted much to achieve this progress.

The productivity of diploid varieties Ofeliya, Alkora, Loto, Paulinka and Golubka is 0.6–0.7 tons per hectare, while the productivity of tetraploid varieties Plamya, Polnovesnaya, Praleska, Zazerskaya 3, and Belaya Veja also has the same and more tons per hectare. Hybrid Belarus varieties Lobel-103, Galinka, Plisa, and foreign breeds Askary, Fugato, and Amato belong to the highest productive (0.8–0.9 tons/ha) rye varieties.

Reproduction of outcrossing varieties, such as rye, is pretty complicated and represents a basic mixed hybrid population. It is known that population and structure of its genotypes gradually change with each generation, subjected to constant changes. For example, dominant-short stem rye varieties, as a result of genetic segregation and the emergence of high-stem genotypes in the population, may lose their existing short-stem varieties for a period of 5-7 years. Herein, it

concludes that the seeds having a restricted number of generations, counting from time to release the variety, which is the bred reserve fund (genetic reserve), are the most valuable initial material for the production of elite.

Table 44. Scheme of primary seed production of low pentosan varieties of rye (Vestnik KrasGAU, 2020, №5.).

Year	State Variety Trial	Fund of genetic reserve of the first generation	Renewed fund of genetic reserve
1	Recognition of the variety as promising	Planting in the nursery of “Breeding reproduction of not commercialized variety”	-
2	Results of the first year testing	Reproduction crop “Breeding reproduction of a not commercialized variety”	Selections in the nursery of pair crossing
3	Results of the second year testing	Super elite plantation	Pair crossing, planting of elite pair offspring
4	Including into State register	Super elite crop	Crop from the nursery of the elite pair, planting in the nursery of first year reproduction
5	-	Super elite crop	Crop from first year of reproduction, planting in nursery of second year reproduction
6	-	Super elite crop	Crop from nursery of the second year

			reproduction, planting of super elite.
7	-	-	Crop of elite seeds

Continuous individual (individual-family) selection of high productive, short stemmed, resistant to lodging and plant diseases with two-time verification of them in the progeny is the core of the getting of original winter rye variety seeds. The worked-out scheme of original winter rye seed production consists of 4 links and nurseries (figure 43).

At **this stage**, the nursery **of selection** is laid on the families with the elite seeds, selected from the population of the highest reproductions. Planting is done with the plant standing 30x20 cm (photo 117). The group of families is surrounded by the planting of the same seeds of one variety of different origins to improve pollination conditions and enrich heritable structures.

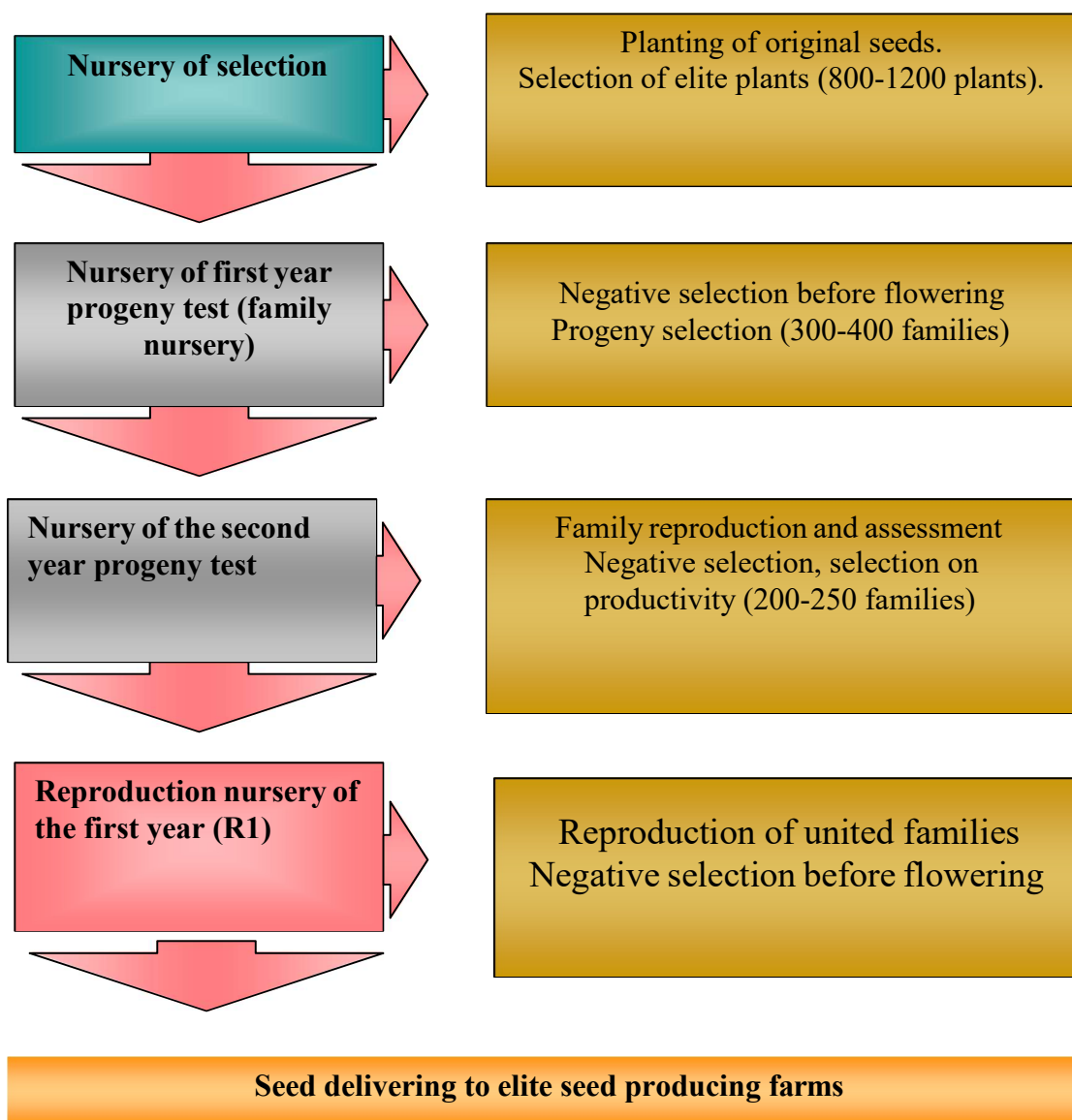


Figure 43. **Scheme of winter rye original seed production.**

Phenology surveys are carried out in the nursery of selection, and the cold resistance of families, resistance to lodging, and diseases are determined. Weak cold-resistant, infected by diseases, and progenies uneven in height are rejected up to flowering. The selection of elite plants (800–1300 pairs) is conducted before harvesting. Final assessment and selection of elite plants for planting in the nursery of first-year progeny testing is done after biometric analysis, threshing of every elite plant, and defining grain quality (color, plumpness, shape, uniformity, and size).

Belarusian rye breeders and seed producers optimized the selection of initial plants, normed the quantity of selecting elites, and bulked their discards within the threshold limit of variation in quantitative characteristics. In particular, 800 to 1300 initial elite plants are selected

in the nursery of selection of winter rye elite, taking into account discarding in the range of 20–40% to lay the nursery of first-year progeny testing on the traits of variety purity, immunity, productivity, and so on, and to establish a seed insurance fund of 100%.

Nursery of the first year progeny testing. Selected elite plants are planted in the lots with an area of 2m². The seed sowing is done with the help of the seed seeder (SKS 6–10) and other modifications. Planting norm is taking into account 200 vital seeds per 1 m² (80–100 kg\ha in the case of mass row planting). Standard: in every 10th row. In this nursery, the same records and surveys are conducted as in the nursery of selection.



Photo 117. **Seed population of bred rye families.**

After separated threshing, the productivity and quality grain of the best families are used to lay the nursery for second-year progeny testing. The total bulk of rejects in the nursery of the first-year test is 25–35%. The amount of progeny in the nursery is identified by the account of phenotype and biologic uniformity of varieties, demand for elite seeds, establishing of transferring, and insurance funds at the size of 100%.

This nursery is based on the type of plant breeding nursery. The method of transferring half of the insurance seed fund is widely used in its formation. The remaining seeds of those families, which in the past year had shown better results at the field evaluation on productivity, cold resistance, resistance to lodging, and diseases, are sown. Not only the families that got the highest mark for the period of vegetation, but also those (mainly) from which the most progenies were selected to plant in the next year, belong to the valuable families.

Nursery of the second year progeny testing gives the possibility of conducting a more authentic assessment of families on the main trait of productivity. Planting of families is carried out on the lots with an area of 10 m² in two replications (photo 118). The elite standard lot is disposed of in every tenth family. The norm of seed sowing is 250–300 vital seeds on 1 m² (130–150 kg\ha in the account of per mass row planting).

In this nursery, every family is studied on cold resistance, resistance to lodging, infection by diseases, and uniformity of plant architecture. Weak, cold-resistant, infected by diseases, and not uniform plants are discarded until flowering.

The harvest is done along the lots. Rejection on productivity and grain quality is done after threshing. Usually, 2\3 families are united and used to plant in the nursery of the first-year reproduction. The rest of the best families deserve the quality of the insurance fund and will be planted in the nursery next year. This is the most valuable breeding material.



Photo 118. One of the exemplary seed producing nursery of rye varieties.

The total bulk of rejection in the nursery of the second-year progeny testing consists of 15–25%. The experiment has shown that the outcome of the works in the original seed production can be considerably increased on account of selection optimization, the use of nurseries with optimal feeding areas, the application of an etalon sample of an elite plant, the use of the the use of the model of $x+3b$ to assess progeny productivity, and so on. By keeping into mind that variation of

quantitative traits bears modification character, the “better” and “inferior” progeny at the replanting produce a mean level of productivity, discarding on productivity is recommended to be conducted with the help of the criteria of $\bar{x} \pm 3b$, that is, the mean free and standard difference. Standard is used only as the etalon of variety typicality in the assessment of progeny on the phenotypic architecture.

The reproduction nursery of the first year (R1) is laid by combining seeds from the nurseries of the second year of progeny testing. Planting is done in row mode with a seeding norm of 3.5–4.0 vital seeds (180–220 kg/ha correspondingly).

Species and variety cleaning, as well as the removal of disease-infected, weak-developed, and off-type plants, are conducted until flowering.

The grade of genetic variety heterogeneity and the character of deviated form (especially in dominant-short stalk rye varieties) in the original seed production considerably affect the bulk and severity of selection, thereby the bulk of elite seed production and, naturally, the rate of adoption of new varieties in industry.

So, application of specially laid nurseries of selection gives an opportunity to increase (5–6 fold) the area to study every generation in the nurseries of first and second year generation testing, significantly decrease the number of generations to be laid, accelerate the cultivation of high-quality original seeds, and get the necessary amount with less labor expenditure and means.

The nursery of the first-year reproduction in this scheme of seed production has made it possible to get conditional seed of not less than 0.3 tons per hectare, which will be transferred to elite-producing farms.

Over 50% of winter rye plantations in Belorussia are tetraploid varieties. There is genetic incompatibility between tetraploid and diploid rye. So, biologic contamination at the outcrossing between these two rye forms does not take place but increases the lax ear on the tetraploid rye, which decreases productivity.

The mechanic mixing of diploid and tetraploid seeds is the most dangerous in the seed production of rye varieties, which takes place during planting, grading, harvesting, and grain storage. For example, the productivity decreases by 0.6–0.8 tons/ha if 10% of diploid seeds are mixed with tetraploid seeds.

Rye variety seed producers have to pay great attention to the new short stalk varieties developed through hybridization with tall stalk, and

that is why in the plantations there appear to be a to be a significant number of tall stalk plants, which are to be removed in order to keep the short stalk trait in the variety population. It is necessary to remove them until they flower. The number of such plants in the seed stock plantations must not be over 4%. And the limiting border between diploid and tetraploid varieties has been set up at least 200 m.

Rye hybrid seed production is the profitable sector of grain crops which has become dominating priority in the top rye cultivating countries of the world. The level of competitive heterosis (superiority over standard variety) of the up to date hybrid varieties in the condition of production makes up 15-20%.

The main objects at the seed breeding of winter rye hybrids of F1 are:

- *Creation of collection bred-valuable inzucht-lines (photo 119) with high combination ability and weak expressing of inbreed depression in the generations.



Photo 119. Production of elite rye inbred lines by bagging (Bernd Hachauf and others., 2022).

- * Identification of sterility fixers and fertility restorers.

- *Creation of CMS (sterility fixer +male sterile analogy of sterility fixer / ♀/, fertility restorer / ♂/).

- *Elaborating efficient method of seed reproduction maternal male sterile (MS) components of hybrid varieties.

- *Working out economic purposeful scheme (figure 44) of obtaining the hybrid seeds and system of hybrid rye variety seed production.

It is seen, this proposed scheme of hybrid variety production is characterized by its long lasting period which has 11 years. So, it was

not yet a proper way in the solving the problem of working out economically profitable scheme of hybrid rye variety seeds.

General breeding scheme for hybrid rye

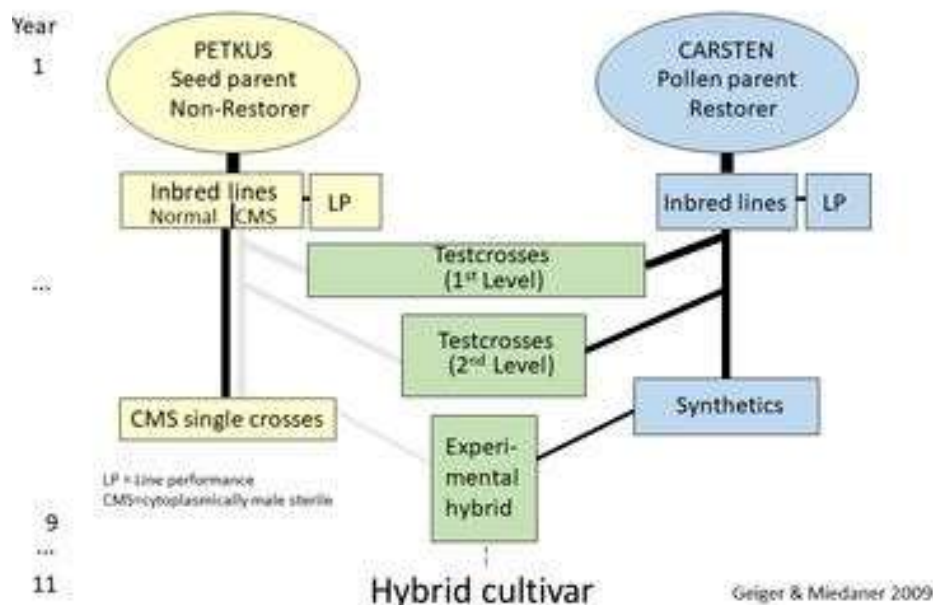


Figure 44. One of the proposed scheme for hybrid cultivar seed production.

Questions on the studied themes:

1. What is the major tasks of agronomist-approbatory at the procurement of corn sowing seeds?
2. Do you remember the required, Gost indexes on corn variety grade and seed planting quality?
3. What crop is rye and its economic value in agriculture and food industry?
4. Retall about world countries where rye has economic and social important?
5. What is genetic, botanic makeup and biology of rye?
6. Do you remember structure of rye spike and spikelet?
7. What is the farm advantages of rye hybrids?
8. How are assessed the rye varieties and its initial hybrid diversities?
9. Do our breeders take on with rye breeding and its seeds production?
10. Are there any crossing differences between rye and other crops?
11. Can you draw the scheme of winter rye seed production?
12. Describe the supposed scheme for hybrid cultivar creating?

Chapter 8. Approbation of rye seed stock plantations

The order of approval for rye seed stock-producing institutes and seed-producing farms is described in more detail in the instruction on approval of variety plantations published in 1995 in Moscow.

Depending on the biology of pollination in rye, its order of approval varies out of other grain crops.

The category of variety purity in rye plantations is identified by the number of years of reproduced variety seeds on the basis of documents; on the basis of these documents can be defined the generation after the release of elite seed out of plant breeding—an experimental establishment (photo 120).



Photo 120. Agronomist A.G. Biyakov with his specialists at the moment of approbation.

Belonging to what variety of the rye plantation is identified by the variety documents given to the planting seeds. The percentage of plantation typicality is not identified on the ear or on the grain because of the strong variation in phenotypic characteristics of rye varieties.

Disease infection, contamination with hardly separating weeds, quarantine, and harmful weeds are determined by the picked approbation bundles (appendix 5).

The selected bundle is analyzed entirely, isolating stalks of the following groups: main crops; rye, infected by ergot; rye, infected by smut; hardly separating cultural plants (cultural oats, appendix 6); hardly

separating weeds (wild oats); quarantine weeds (prickly nightshade, dodder, sweet sultan); harmful weeds (silky aple, foxtail, Japanese barnyard millet, bristleglass); poison weeds (creeping thistle, blue bottle, cornbind, and others); non-developed stalks of main crops.

The seed stock plantations subjected to rejection in the case of discovering quarantine weeds are used on the agreement of local state inspections on the quarantine plants. As well as approbatory, at the inspection of grain plantations, the visually defined probable productivity of the plot and either availability of quarantine weeds or grade contamination with weeds (on the scale): 0: complete absence of contamination; 1: not considerable; 2: mean; 3: strong contamination.

The percentage of infection of plantations with diseases (singly on every species) and contamination with hardly picking out cultural plants and weeds is calculated in the order, set up to grain crops.

Wheat and barley also belong to the hard-to-pick-out cultural plants in the rye plantations. The rye plantations are recognized as unfit for planting purposes if their contamination with wheat and barley consists of over 3%, with sophora thick fruit also over 3%, and infected by hard and stem smut over 0.5%. Infection with the hard and stem smut of original and elite plantations is not admitted.

Infected rye seed stock plantations with ergot are not excluded from the list of variety plantations, and the availability of infection is noted in the approval statement.

Contemporary short-stem rye varieties developed on the basis of short-stem dominant donors are not distinguished by 100% uniformity in plant height. The population of such varieties in the consequences of genetic segregation contains a definite number of tall plants, superior to low-stemmed varieties in height by 20–30% and more. The appearance of low-stemmed plants is accepted as mechanical and biological contamination.

Criteria for tall stalk plants are calculated for single groups of tall, grown stalks. That is why the height of 25 stems of the main variety is measured. The calculated mean arithmetic belongs to low stems, multiplied by 0.2, and multiplying to 0.2 and taken data is summed with the mean height of a group of low-grown stalks. Criteria by dividing the stalks into two contrast groups are taken into account in the result.

For example, the average length on the result of measuring 25 low-grown stalks is 120 cm. Criteria with low stems will equal:

$$C - (120 \times 0.2) + 120 = 144.$$

The stalks with a height of 144 cm or more belong to the group of tall grown, but less to the group of low grown.

The number of low stems is calculated on every bundle (probe), and the result is included in the approval statement. The percentage of tall-grown stalks is defined by the ratio of the number of such stalks to the total number of main crops. The result is written in the column. The stalks deviated from the main variety type as well. Calculation is finished at tenth of share.

The following amount of tall, grown stalks is admitted to the plantations of the rye varieties, depending on their reproductions:

For diploid varieties:

1. Nursery of the first year of reproduction – not more 1.0%;
2. Nursery of the second year of reproduction – not more 1.8%;
3. Super elite – not more 2.5%;
4. Elite – not more 3.0%;
5. First reproduction (R1) – not more 3.6%;
6. Second reproduction – not more 4.0%;
7. Third reproduction – not more 4.5%;
8. Fourth reproduction – not more 5.0%;

a) For tetraploid varieties:

1. Nursery of the first year of reproduction – not more 1.0%;
2. Nursery of the second year of reproduction – not more 2.0%;
3. Super elite – not more 3.0%;
4. Elite – not more 5.0%;
5. First reproduction (R1) – not more 7.0%;
6. Second reproduction – not more 10.0%;
7. Third reproduction – not more 16.0%;
8. Fourth reproduction – not more 30.0%.

If plantation under approval does not correspond to the to the required restriction, reproduction is set on it in the corresponding of the taken results (super elite is transferred to elite, elite to the first reproduction, and so on.).

If the share of tall grown stalks in the diploid varieties exceeds 5% and in the plantations of the tetraploid varieties is 30%, such plantations are transferred to the non-variety.

Variety plantation under approval is considered fit for seed stock purposes if observed in a spatial isolation; mechanic mixing with other varieties was not noted; damage to the plantation with smut; and

contamination with hard picking out of cultural plants and weeds did not exceed the fixed norms.

The approval statement is compiled for plantations after successful approval on the form 199 for registration and the form 200 for plantations under rejection (appendix 12). The Approbation Statement of 199 has to be printed in three copies: one is left in the seed-producing farm, the second to the district agriculture organ, and the third to the marketable grain in the provisional organization. And 200 in two copies: one is left on the farm, the second to hand over the regional senior approval.

Part VII. Breeding and seed production of sorghum.

Chapter 1. Sorghum, its social and economic importance

According to the last internet sources, sorghum is the annual and perennial grass in the plant family Gramen or Mint (Poaceae). It has about 30 species, which grow in Asia, Africa, South and North America, Europe, and Australia. Varieties of domesticated sorghum have become the fifth most important cereal crop in terms of production and planting area (figure 45). Today, they have gained wide attention as a promising “one of the leading” crop to tackle the challenges of global food security. Indeed, they are cultivated to get food, feed, forage, fuel, beverages, technical goods, fodder, and brooms.

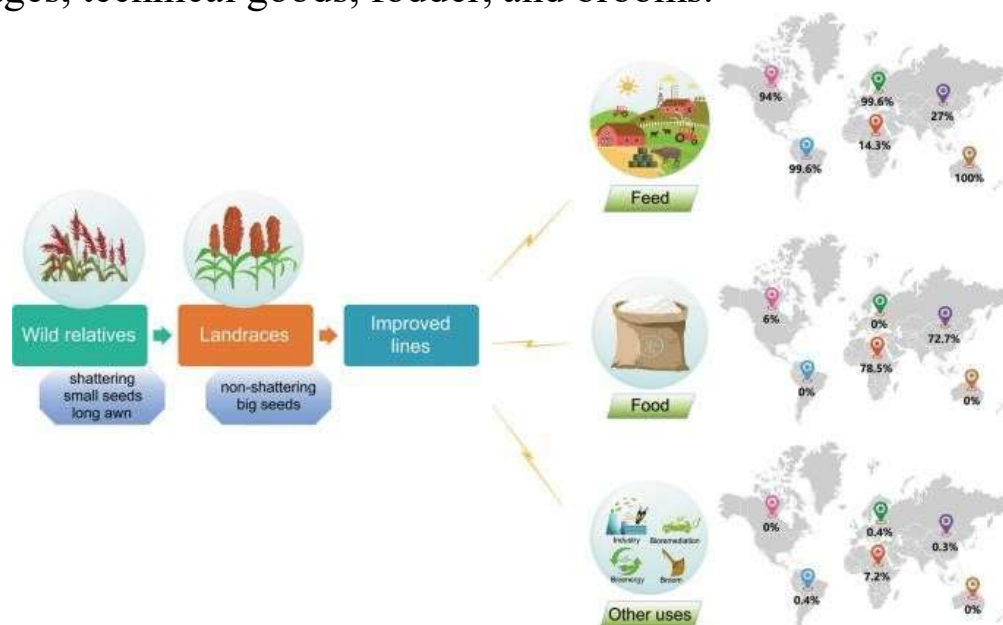


Figure 45. **Utilization of sorghum in different regions of the world** (Huaigeng Hao and others, 2021).

Now, cultivating sorghum diversities is characterized as one of the oldest crops in world agriculture, and Africa is underlining its native country.

The data of the FAO (the Food and Agriculture Organization, which is a specialized agency of the United Nations that leads international efforts to defeat hunger around the world) show that Nigeria (6806 tons), Sudan (5248 tons), the USA (4770 tons), Mexico (4754 tons), and Ethiopia (4200 tons) are the first five top-ranking countries within the 12 leading countries of the world (table 45).

The table has data for more than 35 years of world progress on sorghum grain production, from 1985 up to 2022. It is a very good chance to find out in what country the sorghum production was constantly growing in the course of this past period of history. To our great regret, one side of the growth of production bulk is noted only in one country, Burkina Faso: from 798 thousand tons in 1985 to 144,000 tons in 2022.

Even in such countries as the USA, Mexico, India, and Argentina, production levels have drastically fallen in the last 8–10 years, which in particular consisted of 6 000 tons in the USA, 4 000 tons in Mexico, and 2 000 tons in India and Argentina.

In general, the area planted to sorghum is progressively decreasing with growing yield per hectare. Still, the bulk of sorghum in the world for the last 40 years was noted in 1985, which was made of 77.6 million tons.

According to the data from the FAO, 55.6 million tons of sorghum were harvested in 2010 across the world and 63.9 million tons in 2016. An average productivity of 1.37 tons per hectare. It was noted that Jordanian farmers achieved the highest productivity (12.7 tons per hectare), while the average productivity of the giant sorghum producers in the USA was 4.5 tons per hectare.

Table 45. Production of sorghum over the world (000 of tons)

Countries	Production on the crop years						
	1985	1995	2005	2012	2014	2016	2022
Nigeria	4911	6997	8028	6900	6741	6939	6806
Sudan	3597	2450	2600	1883	6281	6466	5248
USA	28456	11650	9848	6272	10987	12199	4770
Mexico	6597	4170	6300	6969	8394	5006	4754
Ethiopia	-	1141	1800	3604	4339	4752	4200
India	10197	9327	8000	6010	5390	4410	4151
China	5696	4854	2593	2003	2885	2401	3180
Brazil	268	277	1530	2016	2279	1154	2923
Argentina	6200	1649	2900	4252	3466	3029	2883
Australia	1369	1273	1748	2238	1282	1791	2648
Niger	329	266	944	1376	1426	1808	2101
Burkina-Faso	798	1266	1553	1923	1707	1742	2014

In the previous textbooks on the breeding and seed production of grain crops, it was written that the world area under sorghum ranks after such crops as wheat, rice, corn, and barley (photo 121). Its plantations are mainly located in Asia (49–50%) and in Africa (32–33%). In the American continent, 15%; in Australia and Europe, only 2–3%. On the data for 2020: India plants: 6.2–18.2 mln. hectares; Nigeria: 2.1–6.9 mln. hectares; Sudan: 1.5–7.1 mln. hectares; USA: 1.9–6.5 mln. hectares.

The nutritional value of sorghum grain consists of: every 100 g of it contains a total of 339 kcal of energy; 74.3 g of carbohydrates; 6.3 g of dietary fiber; 11.3 g of protein; 3.3 g of total fat of which saturated fat is 0.5 g., monounsaturated fat is 1.0 g; polyunsaturated fat is 1.4 g; vitamins: B1, B2, B3, B5, B6, B9, E; and mirco substances: calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper, and selenium.

F.Toryev and Zh.Sobirova (2017) mention that sorghum grain is being used in India, China, Syria, and others for bread baking. Johar Roti, a kind of common Indian flatbread, is made from sorghum flour and is known widely to tourists visiting Indian cities. It is a major ingredient to incorporate into a gluten-free diet (photo 122).



Photo 121, 122. Plants and seeds of one of the growing sorghum species.

It is known that white sorghum has been cultivated in the territory for 2.5–3.0 thousand years and now belongs to the region of Uzbekistan. Its area in Uzbekistan was 140 thousand hectares at the beginning of the 20th century. The historic top on the planting area of sorghum in Uzbekistan was in the years of 1930 (250–300 thousand hectares) and

has been declining since 1956 (76 thousand hectares). Letting its area be used for corn growing. Which has resulted in around 5 thousand hectares (2007). The productivity is 1.0 tons.

Directions of use involve sorghum grain, forage or sugar fodder, broom type, and others. Here, grain sorghum is widely distributed, and it is grown in Asian and African countries as a food crop. As the above-mentioned scientists also underlined, people in our Khorezm and Karkalpakistan are still baking bread from the flour of sorghum grain and wheat. At this point, the share of sorghum grain consists of 30–50%. The baked bread at this place is so good in terms of nutrition and taste (photo 123, 124).

Now it has become an attractive crop since increasing the number of private landowners in Uzbekistan and neighboring countries. The same progress is observed in Moldova, Ukraine and the Northern Caucasus.

Sorghum has various uses, and it makes up the main part of fodder as grain, silos, green mass, hay, mono-fodder, flour to reprocess for the production of different nutritious granules, and concentration feeding cakes for agricultural animals. They have 12–13% of protein, 70–80% of starch, and 3.5% of oil. 1 kilogram of grain has 1.3 nutritious values; 1 kilogram of silos is 0.24 feeding units.



Photo 123, 124. **Bread types baked from sorghum flour in India and Uzbekistan.**

9 sorghum variety diversities were registered to plant in the regions of Uzbekistan (table 46).

Variety of NS Djin from Serbia Republic Sabantuy and Sajen are from the Russian Federation. The rest of the six varieties are developed by our sorghum breeders. They occupy mainly our regions. In this point

of view, Korabosh, Uzbekiston pakanasi, and Uzbekistan 5 are the leading and longest-grown varieties.

The Manual (2020) on the cultivating agro-techniques of sorghum varieties published by K. Azizov and other researchers of the Corn Breeding and Seed Production Scientific Experiment Station (the CBSPSES) informs us that Khorezm region was the second native land of sorghum, and it has been known here for 2.5 thousand years. And nowadays, its main areas (over 20 thousand hectares) are spread in the Karakalpak Republic, Khorezm, Bukhara, Navoiy and Fargana regions.

Table 46. Sorghum variety diversities included into state register in 2022.

Varieties	No of originators	Code of the country	Year of registration	Regions recommended to plant
Dualet	317	UZ	2010	1, 13 (I)
Korabosh	18	UZ	2012	1,4,10,13(I)
NS Djin	318	SR	2017	11(D,I)
Sabantuy	502	RU	2020	7(I)
Sajen	502	RU	2020	7(I)
Tashkentskoye Belozernoye	13	UZ	1983	1(D,I)
Uzbekistan pakanasi	13	UZ	1974	2-4,6-8,10-12 (D,I)
Uzbekistan 5	13	UZ	1981	3,5,6,11(D,I)
Uzbekistan 18	13	UZ	1981	

Korabosh. This variety was developed through multiple selections of the variety Krasniy Yantar by the breeders of the CBSPSES and registered to be planted in 2012 in all drought-affected regions of our republic to provide green fodder for livestock production farms. It belongs to the group of sugar sorghum. That is why it is also used as a raw source to produce sugar.

Plant height gets up to 220–250 cm. Early-ripening variety, and the vegetation period lasts 105–110 days. It is resistant to salt and drought. The sugar content in the main stalk is equal to 16.0%. Two cuts of harvest give the green plant when it is planted for the main crop. The

grains have a black color. Panicle is like a broom (photo) with a length of 24.5-28.0 cm. Weight of 1000 seeds: 24.3-25.0 g The grain productivity is 2.2–2.4 tons per hectare, and the green mass reaches up to 3.5–3.9 tons per hectare.

Infection by black smut of cereals is surveyed at around 1.0–3.0%.

Uzbekistan pakanasi. This variety was created using individual selection out of a local late-ripening dwarf sample at the Uzbek Livestock Production Scientific Research Institute (the UzLPSRI) and registered in 1974 to plant in the regions of Andijan, Bukhara, Jizzakh, Namangan, Navoiy, Samarkand, Syrdarya, Tashkent and Fargana.

The variety belongs to the group of grain sorghum.

The height of plants ranges from 90 to 120 cm, and the growth and development duration lasts for 135–138 days. The number of leaves is 16.3. The panicle (photo) is developed in a hanging state with a white egg shape. Its length is 20.9 cm. The weight of 1000 seeds is 23.1 g. Grain productivity consists of 7.5 to 8.5 tons per hectare.

The variety is late-ripening; the vegetation period lasts up to 130–140 days. Resistant to drought, lodging. The bulk of the stalk juice reaches up to 72.0–74.0%. The amount of protein in the grain is equal to 9.2%, and starch is 80.7%. Infects with black smut up to 0.01–0.02%.

Grain productivity is 8.0 ton\ha.

Uzbekistan 5. This variety was also released at the UzLPSRI in 1981. It is the result of selection from a hybrid between the Hegeri dwarf and the six-month local variety. It was recommended to plant it as the second crop in the regions of Tashkent, Bukhara, and Kashkadarya for grain and silos.

It belongs to the group of grain sorghums. Seedlings are light green; the main stalk has 10 internodes and develops 10 to 12 leaves up to grain harvest. The leaves grow up to 54.0 cm with a width of 6.8 cm and have light white lines within the green blade.

The height of the plant reaches up to 170-190 cm. Growth and development duration lasts for 105–110 days. Panicle (photo 125) is straight, resistant to shading, longed egg shape, white, and naked. Its length is 25.0–27.0 cm with a width of 6.6 cm. The length between the panicle and the last internode is 51.2 cm, and between the last leaf and the panicle and the panicle is 17.4 cm. The weight of 1000 seeds is 40–42 g. Grain productivity ranges from 4.0 to 4.5 tons per hectare.

The variety is resistant to drought, lodging and shading. The juice in the stalk consists of 72.0–74.0%. The amount of protein is 9.2%, starch - 80.7%. It infects black smut up to 0.01–0.02%.



Photo 125. **Panicles of the varieties of Korabash, Uzbekistan pakanasi and Uzbekistan 5.**

Furthermore, the content of carbohydrates (starch) in this plants of sorghum makes up 70-80% which is another valuable source of successfully using these plants to produce of alcohol.

Depending on farmers' desire can be grown the variety “Khashaki 1” representative of **African millet** or Negro's millet (photo 126). African millet is annual grass of family Poaceae.



Photo 126. **African millet growing in the fields of Burkina Faso (2021).**

Its native land is tropical Africa, where it was cultivated 4900 years ago. A single plant has growth up to 3 to 4 m, and a panicle has a

cylinder shape with a diameter of 10 to 20 mm. Every panicle forms 1000 to 3000 grains with a size of 5 mm. Grains have white, yellow, red, or black colors. The plant is relatively resistant to pests.

Variety of “Khashaki 1”. It is a sorghum variety that was created at the Uzbek Corn Scientific Research Station through selection out of the introduced foreign sample HHVBC tall and successive multiple selections (photo 127).

Botanic characteristics. The variety belongs to the African millet, *Pennisetum africanum* (L), and includes *K. shaum* species. Plants are small and light green. The height of the stalks gets up to 225.0–235.0 cm with green leaves; the length of the leaves is 45.0–48.0 cm; the width is 5.0–6.0 cm. Panicle is straight, tightly held, longer 25.0–30.0 cm, wider 3.0–4.0 cm, without awn, white-grey, and weighs 35.0–40.0 g. Grains are half-covered, easy to thrash, white-grey, egg-like, prolonged, smaller, and weigh 1000 seeds 10.0–11.0 g.



Photo 127. Outlook of variety “Khashaki 1 in one of its plantations.

Agro-biologic characteristics: It is an early-ripening variety. It takes 70–75 days from seed planting to reaching maturity. Resistant to soil salinization and drought, and tolerant of lodging. It distinguishes itself by its rapid growth after cutting off.

Economic characteristics: First and second cut-off productivity made up 60.0–62 tons per hectare of green mass. At the first cutting, it gives 45.0–46.0 tons of silos mass and 3.0–3.5 tons of grain. This variety

proved in 2012 to be the best quality of green silos to feed agricultural animals.

The result of the last tests (I.V. Massino and others, 2016) to identify the variety's dignity figures out of its many advantages over its initial breeding materials on the economic valuable characteristics is presented in the table 47. The amount of green mass cut during vegetation, height of plants, productivity of green mass in tons per hectare, and harvest of dried substances are highly valued by the sorghum breeders in terms of farm interest, and thereby the first attention is paid, namely, to these characteristics in the creation of the new varieties.

It is clearly obvious that none of the initial sorghum forms are able to produce the second cut, but variety Khashaki 1. This has made it possible that, at first, it prolongs the period of providing agricultural animals with green food, and at second, it enables an additional crop of 31.9 to 54.1 tons per hectare annually.

Table 47. The results of tests where studied the economic characteristics of the variety Khashaki 1 and its initial introduced forms (2012-2013).

Variety and collection samples	Days up to cutting		Plant heights on the cuttings, cm.		Green mass yield, t/ha			Crop of dry substances, t/ha		
	1	2	1	2	1	2	Total	1	2	Total
2012										
Khashaki I	54	31	147,9	181,2	46.08	54.14	100.22	11.76	11.92	23.68
HHVBC tall (1)	70	—	168,5	—	48.00	—	48.00	12.48	—	12.48
HHVBC tall (2)	90	—	237,0	—	45.32	—	45.32	10.88	—	10.88
HHVBC tall (3)	90	—	234,0	—	74.00	—	74.00	19.98	—	19.98
HHVBC tall (4)	90	—	258,7	—	88.00	—	88.00	19.36	—	19.36
2013										
Khashaki	51	36	205.1	186.4	53.16	31.90	85.06	11.69	70.2	18.71

I										
HHVBC tall (1)	70	–	263.0	–	39.54	–	39.54	9.17	–	9.17
HHVBC tall (2)	72	–	239.7	–	46.52	–	46.52	10.28	–	10.28

Chapter 2. Biology of sorghum

Classification. Sorghum belongs to class of the Sorghum Moench family the Poaceae and has many forms. On its taxonomy exists several opinions between scientist botanists. The widespread one is the classification of VIR which had been compiled on the base of anatomy, phenotype, bio-chemic and physiological characteristics of crop.

On the basis of this classification, sorghum is differentiated into the following species: *S. guineense* (Stapf) Jakushev; *S. banturum* Jakushev; *S. durra* (Forsk) Jakushev. The last one in its turn is divided into three subspecies: *S.durra* ssp. *aethiopikum* jakushev; *S.durra* ssp. *nubicum* Jakushev and *S.durra arabicum*, Jakushev (photo 128).

S. chinense Jakushev; *S. saccharatum* Jakushev; *S. technicus* (Koern) Roshev which divides into two ecological groups: Eastern Euro Asia and Western Euro Asia.



Photo 128. Outlook of one of sorghum collection exhibition plot.

S. sudanense (Piper.) Stapf. Sudan grass has been planting since 1909.

S. aluum P. perennial root stalk and height growing plant for use to get green mass, silos and pasture purposes.

Now, 4 greatly spread sorghum species out of the Sorghum class are: *S. vulgare* – common white sorghum (photo 129). *S. chinense* – gaolyan, *S. cernuum* – sorghum and *S. sudanense* – sudan grass.

These are species are annual and they are grown for producing food, technical and fodder products. Johnson grass is one of the wild

representatives of sorghum and its well known as a noxious weed in the crop plantations of the Caucasus and Central Asia (photo 130).

Phenotype peculiarities. Root system – fibrous, strongly developed, penetrates up to 2.5 meters deep in the soil and spreads to 60-90 cm. around. Air or stalk roots will form from the surface nodes of the main stalk.

The height of the plant has reached from 0.5 m to 2.5 m or in some countries up to 7 m. Thickness – 1-2.5 cm., hollow pith, half dry and plenty watered. Plants with 1-2 to 5-8 stalks with panicles will form during the vegetation. Some forms, mainly of Sudan grass tend to strong tillering.

Leaves are simple – leaf blades wide, covered with a wax layer. Every plant has 8- 25 leaves depending on the diversities and length of up to 1 meter.

Inflorescences – various forms and length panicle, mainly 10-40 cm long, broom sorghum is 50-60 cm. long.



Photo 129, 130. Sorghum (a-developed panicles, b-spikelet, c-grain; 1,2-broom sorghum; 3,4-grain sorghums), Jonson grass.

Two spikelet are located on the top of every branch – bisexual and male flower, the last one falls off later (figure 46). Bisexual (flower) spikelet usually has two flowers, one of them is an ovary, which is why grain will develop from top flower.

Mail spikelet has one flower. Lemma of the spikelet covered with pubescence or naked. At the time of maturation, the pubescence has yellow, light yellow, rose, red and black colors.

Fruits – round or egg-shaped grain are naked or have a peel tightly covered with residual pubescence of lemma. Grain has colors of white, yellow, brown and even black. The dormancy period of grains is very short. Therefore, seeds falling into good soil conditions after harvest will give seedlings. If the endosperm of the seeds is red or brown they have fermenting substance of tannin. This is desirable for producing of maltose and alcohol but decreases the nutritional quality.

Biologic properties. Sorghum extremely responsible for high temperatures and resistant, on this index it is superior to millet and corn. At the -2-3 °C it is killed. It is known in the world of agriculture for its soil drought but air drought resistance.

The seeds begin to grow at 12-13 °C, some of them at the 15-16 °C. Seedlings are killed in short period of -2 °C. 10-25 °C is the optimal temperature for seedlings. The minimum temperature at the flowering period is 14-15 °C, at the maturation – 20-35 °C. Total active temperature 50-consists of 2250 – 2500 °C. It likes light. The vegetation period prolonged in the longest day condition despite of its short day nature. Vegetation period of early ripening varieties is 90-105 days, middle ripening once -106-120 and more.

Sorghum, in the condition of Uzbekistan, has the greatest opportunities. It is resistant to drought, heat, and salt. It withstands a salt concentration of 0.6-0.8%. It can be easily grown in mountains and slopes. It has a 150–200 transpiration coefficient.

Leaving green the whole plant of many varieties, even at the full maturation of grains, is its specific peculiarity.

Sorghum is a self-pollinator, can be cross pollinated, depending on the species its amount gets up to 3.3 to 16.5%.

Flowering begins after 1-5 days following the formation of panicles. The first, top spikelet begin to bloom and gradually they spread on lowered woods. Stigma and stamen arise simultaneously in the opened spikelet. Mature anthers split open and pollen grains poured down, which caused pollination.

The first opens yield giving spikelet (figure 47) and then will open male spikelet without yield but producing plenty of pollen grains. The period of blooming lasts for 1-2 hours and one whole panicle lasts up to 10-13 days.

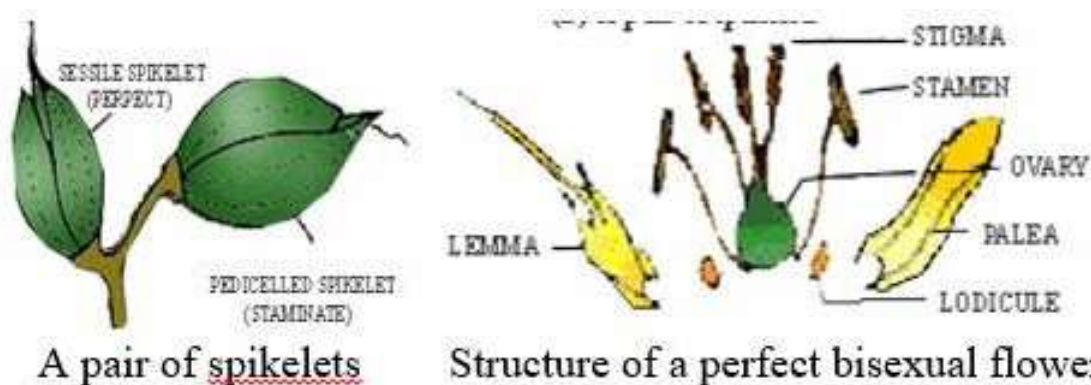


Figure 46, 47. **Inflorescence of sorghum vulgare.**

Blooming takes place mainly in the morning. The optimal blooming occurs at an air temperature of 16-18°C and 60-80% of moisture. Lowered tend is watched when the temperature rises, does not depend on the normal relative moisture and even will suspend. Lowering of the air temperature, precipitation, dew and cloudy air medium have also caused delaying. Pollen grains start rapidly growing just after landing on the stigma. Its vitality prolongs up to 5 hours. Stigma is ready for fertilization 1-2 days prior to opening the spikelet and vital for 10-14 days.

Sorghum genetics. All cultivating species of sorghum, including Sudan grass have 20 chromosomes in their somatic cells. The general number of sorghum species makes up 5 polyploid range: *S. versicolor* ($2n=10$), *S. alnum* P. ($2n=40$) and *S. hatepense* (L) Pers. ($2n=40$) – Jonson grass – perennial weed grass.

Three genes: Ma 1, Ma 2, Ma 3 influence the duration of the vegetation period. Their different combinations forms eight genotypes and four phenotypes: Ma 1 Ma 2 Ma3, Ma 1 Ma 2 ma 3 – extremely late ripening; Ma 1 ma 2 Ma 3 – late ripening; Ma 1 ma 2 ma 3 – mediate; ma 1 Ma 2 Ma 3, ma 1 Ma 2 ma 3, ma 1 ma 2 Ma 3 and ma 1 ma 2 ma 3 – early ripening.

This phenomenon is noted in the long-day light condition (more than 14 hours), and in the short-day light (10 hours) condition, all plants of the same the same genotype ripen earlier. The experiments state that nearly 90% of sorghum plants are short-day plants, 10% of plants have weak or neutral photoperiodic reactions, and this situation has made it possible to create early-ripening varieties to plant in the northern regions.

The dwarf stalk characteristics of sorghum are controlled by four dwarf recessive genes: dw 1, dw 2, dw 3, and dw 4. The genes cause a shortening of length within nodes; homogeneity with only one recessive gene decreases plant height by about 30 cm.

Cytoplasmic male sterility (CMS) of plants existing in the plant species as a maternally inherited trait (figure 48) is widely used in sorghum breeding. It has been scientifically identified that CMS is caused by the interaction between the nuclear and mitochondrial genomes.

CMS in the sorghum breeding is explained as the result of interaction between sterile cytoplasm of one species and recessive fertility restoring genes of the another species:

$SM_s M_s \times N ms m s$

$F_1 S M s m s$

$F_2 S M_s M_s; 2 SM sms : S ms ms$

So, the ratio between fertile and sterile plants of sorghum species makes up 3:1.

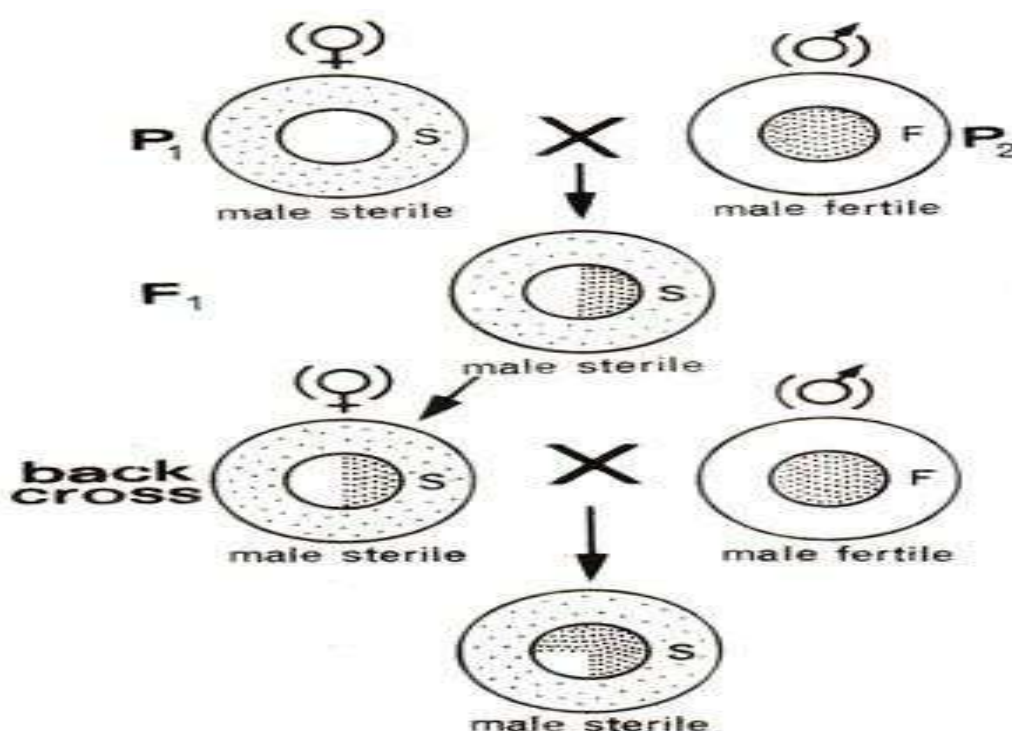


Figure 48. Process of cytoplasmic male sterility regulation.

Chapter 3. Goals and directions of sorghum breeding

Reaching 5–6 tons of **grain yield** and up to 25–50 tons of silos—green mass yield, annual yield stability, as well as creating variety and hybrids with complex economic traits. At this stage, dwarf sorghum plants with 150 cm stalk height and panicles are fit for the mechanical harvest of the crop. Moreover, less branching, which has one or two stalks, makes it easier to use mechanical means to harvest a crop.

Contrary to this, the plants selected to develop varieties and hybrids in the direction of **silos provision must** be high-grown (2–2.5 m), have many leaves with three–five stalks, not less than 25–30% dried substance of green mass at the time of wax maturation stage, as well as a lot of carotene in the green mass and less storing of sianogen glikozidin (photo 131).



Photo 131. Sorghum variety diversities to study for grain and silos production purposes.

Vigorous re-growing after grazing by farm animals or mechanical cutting is the most important property of **Sudan grass** varieties and hybrids.

The panicles of **broom or technical sorghum** should be bright green, red without spots, 35–50 cm long, thin, and elastic.

The resistance of **sorghum to cold** is closely related to tannin in its structure; it prevents the development of pathogenic fungi in the growing seeds. But the availability of such substances decreases **the nutritional value of forages** because complexes of substances produced prevent enzyme hydrolysis in the stomachs of agricultural animals.

An increase in the nutritional value of grain and leaf-stalk weight is the urgent challenge of grain and fodder sorghum breeding. This property is related to the availability of proteins and irreplaceable amino acids, primarily lisin.

The content of sianogen glikozidin must be reduced in the sorghum breeding directed to the quality of **forage sorghum** varieties and hybrids because it produces sinil acid at the time of hydrolysis under the specific enzyme. This leads to the poisoning of agricultural animals. Concentration of sinil acid related to sorghum variety, developing stage, time of night and day, and applied agro-practices.

Sweet sorghum varieties and hybrids contain 20% and more sugar which can improve sugar concentration in the forage and fodder's sugar-protein ratio and, at the same time, make it possible to use this sugar in the confectionary industry to produce a wide range of dinks and foods.

The factor of the sugar from syrup of sorghum, which has almost twofold less production cost, is the economic factor of its introduction into the production of syrups, and thereby the price of this product is lower than sugar made from beetroot or sugar cane.

The sugar content in the structure of **Sudan grass** is less than that of sorghum. Improving the quality of variety and hybrids in the silos and forage sorghum breeding depends on the reduction of grain peels and the provision of easy thrashing because the spikelet peels have decreased by 15 to 20% of the silos weight and nutritional value.

The creation of varieties and hybrids resistant to diseases (photo 132) and pests is the priority direction of sorghum crop breeding.



Photo 132. **Fungal diseases observed and studied in sorghum plantations in eastern Kenya.**

Virus mosaic, dust black smut and various blight (rot) make up the most destructive diseases of sorghum. These diseases spoil seeds, seedlings and plant stalks. Instead of these we have to learn the informations of world scientists like Irene Njeri Koima and others (2022). Naturally, the diversities of the diseases and pests in our region vary and tends to diversity increasing because of integration of sorghum germplasm exchange. Symptoms of eight sorghum diversities is given in the photo 132. They are: (a) Anthracnose disease symptoms on the leaf sheath and panicle parts; (b) leaf blight symptoms: long, elliptical, yellowish lesions on the leaf blade; (c,d) Alternaria leaf spot disease symptoms: oval, brown spots with whitish to yellowish center on the leaf blade; (e) sorghum rust: rust pustules with red mass of spores on the leaf blade; (f) sorghum mildew (*Peronosclerospora* spp.): yellow stripes running along the leaf blade; and (g,h) covered kernel smut (*Sporisorium sorghi*).

Pests: mainly, aphids, bug of grains and stalk or corn butterfly.

Above mentioned goals and their decision greatly depends of the availability of **initial material** for sorghum breeding.

Major center in Uzbekistan dealing with goals of sorghum breeding and its seed production is remaining the Uz.CSES which was reset up in 2007 (photo 5). And in 2014, this station has entered the structure of the SRIGGBCIL (photo 3).

Today, the new and main initial materials as Daulet, Korabosh, Azamat, Massino, Ozodlik varieties are used by our sorghum breeders for improving growing varieties of sorghum with attracting world collections located in our republic and abroad. This station has set up international relations with the Agriculture Scientific Research Institute of Krasnodar, a Russian SRI of plants, and has built up close cooperation with its Kuban (at present, a branch of the SRI of Plant Genetic Resources named after N.I. Vavilov) and Ukraine SRIs to cooperate and, in particular to exchange of genetic resources.

A series of samples were taken from the rich collection of all Russian SRI of plant Growing, ICARDA, IKBA, ICRISAT and studied as the quality of initial material. Work on the organisation of seed production for forage crops in different regions of the country was initiated with the assistance of ICBA and ICARDA.

According to the latest textbooks on grain crop breeding, only in the depository of the All Union Institute of Genetic Resources of Plants

(located in St. Petersburg—former Leningrad) are stored more than 11 thousand sorghum samples as initial materials. Some of them are distinguished by their early ripening, consisting of 80–90 days. These samples had been found in the introduced forms from China. Instead of these, there are samples characterized for their resistance to drought, salinization, cold, rapidly growing onset of vegetation, and dwarf plant samples.

There are high productive potential grain and sweet (sugar) sorghum samples; at this level, grain productivity makes up 10 tons per hectare, and its green mass is 60–70 tons.

The initial material can be isolated into forms resistant to sorghum and black smut. In nature, Negrityan sorghum is very resistant to this disease. A variety of Sarvashi from Hungary was resistant to sorghum plant bugs, and successively, many new sorghum varieties have been developed using this variety as the initial material. And Cafr sorghum was resistant to the damage caused by the life activities of the stem moth.

All sorghum samples consisting of 22-29% sugar are considered to be potential initial materials to develop sweet sorghum varieties (photo 133).



Photo 133. Panicles of Ukraine sorghum varieties (2017) containing in the range of 8-24% of sugar.

The protein of sorghum was not balanced on the irreplaceable amino acid structure; lisin and metionin out of them have a great

biologic value. The amount of lisen in the structure of sorghum protein makes up 1.81 to 2.49%, and metionin makes up 1.22 to 1.97 %.

There are some variety samples containing more than 3% of lisen, for example, Korichnevozernoe 481. Another variety, Geneticheskoye 129, was known for its balanced protein content, which reaches up to 19.3%. These and other new variety diversities with enormous potential from the breeding point of view exist in our SRI of plant genetic resources.

Chapter 4. Sorghum breeding methods.

Up to now, nine sorghum varieties have been registered to be planted in the regions of Uzbekistan. They are: Dualet, Korabosh, NS Djin, Sabantuy, Sajen, Tashkentskoye Belozernoye, Uzbekistan Pakanasi, Uzbekistan 5, and Uzbekistan 18. Out of them, Korabosh, Uzbekistan Pakanasi, and Uzbekistan 5 have the potential to spread to more areas in Uzbekistan as a result of their dignity and attraction to farmers' attention. In terms of plant breeding, we can predict that the breeding method used to develop these three varieties is the most effective method for creating sorghum varieties and more resilient (suitable) in the condition of Uzbekistan to grow sorghum.

According to the data on these varieties, Korabosh was developed as the result of multiple selections out of the variety population of Krasniy Yantar. Uzbekistan pakanasi was developed by individual selection out of a local late-ripening dwarf sample. And Uzbekistan 5 was also developed as the result of selection from a hybrid population between the Hegeri dwarf and the six-month local variety. So, the method **of selection** out of a variety of hybrid growing populations in the local conditions can be one of the most desirable methods to evolve the superior sorghum varieties in the condition of Uzbekistan.

Teshale Mato and others (2023) also highlighted that **recurrent (multiple) selection** is the most efficient method in sorghum breeding programs to evolve two kinds of cultivars: open-pollinated or pure-line cultivars (mainly for developing countries) and hybrid cultivars (for developed countries where the seed production system is well developed).



Photo 134. Photo by Teshale Mato, where shown genetic diversity of sorghum population in grain color.

Indeed, the first steps of sorghum breeding, as with other crops, began with selection out of collection and from local samples. For example, using individual, individual-family, and family selections, varieties were developed: Kubanskoye Krasnoye 1677 (for grain), Krasniy Yantar, Kubanskiy Yantar, Oranjivoye 160, and Ranniy Yantar Dnepropetrovskiy (for silos), as well as Venichnoye Rannee and Venichnoye 149 (for broom), which are being used as the initial materials by our sorghum breeders.

Afterwards, hybridization was taken on the basis of self-pollination in combination with fertility. As a result of using this method, the following varieties were developed: Genicheskoye 11 and Hasine 4, to silos – Zernogradskoye 3 and Kamishinskoye 7, as well as Sudan grass varieties: Mironovskaya 10, Kbytlskaya 100, and others.

The method of heterosexual hybrid production. Self-pollinated lines deserve to create such hybrids with hybrid vigor; they will prevail parental variety diversities on productivity and other economic characteristics. In this, breeders are hybridizing between desirable parental lines (see photo 135) followed by selecting desirable plants from segregating populations until homozygosity is achieved.



Photo 135. A crossing block using by sorghum breeders of Iowa State University.

Usually, the following **self-pollination** is implemented in sorghum plants: the panicles of the main stalks (photo 135) are isolated prior to flowering by the special isolators. Early-flowered panicles are cut off with the help of a pruner. The isolators are taking off after the blooming and forming of grains. The homozygosity (uniformity) of self-pollinated lines on the phenotype characteristics is surveyed in the 3–4th years. It was identified that the depression of sorghum after its self-pollination does not happen. It has made it possible to use simple hybrids in the industry.

The method mentioned above is widely used by foreign sorghum breeders because of its easy applicability for improving specific traits such as disease and insect pest resistance, plant height, early maturity, etc. on the basis of pre-heterozygosity. As mentioned, this method and its modifications will lead to the development of pureline cultivars.

Moreover, it should be taken into consideration that self-pollinated lines of sorghum are not only focused on heterozygosity plant breeding but also serve as the primary sources for the new varieties to be created. The sorghum varieties such as Skorospelka 89 and Kiz-590 (Omarova A.Sh. and others, 2021) were developed as a result of this method. The last one is middle ripening, with a vegetation period of 122-123 days. An average grain productivity of three years makes up 4.3 tons per hectare. Tanin content consists of 7.6% and resistance to lodging. Designed to be used for sorghum crop breeding.

The creation of highly productive hybrids is highlighted by our neighboring sorghum breeders in Kazakhstan. They stated that the

selection of parental forms (lines) with high combination ability is the key to securing a good outcome. At this stage, locally bred varieties, artificial, specially valued, and promising hybrids are suggested as the source of initial materials. The list of constant lines (from our own and worldwide collections) has been compiled. **Visual selection, topcrossing, and diallele crossings** are recommended in the selection, creation, and enhancement of initial materials. In particular, the sugar sorghum variety Asel (2017) has been developed as a result of these researches. It belongs to *Sorghum saccharata* Korn. diversity. Middle ripening with a vegetation period of 116–118 days. Resistant to lodging and grain shading. Protein content is 9.2% and sugar content is 22.2%, while the standard variety, Kazakhstanskoye-16, has 19.9% in its stalk juice. An average grain yield for three years has been 5.3 ton/ha. Resistant to lodging and diseases.

The use of the CMS in sorghum breeding and its seed production. So, it is clear that creating hybrids on the basis of crossing two genetically different parental lines is the leading strategy of sorghum breeding. Their offspring (hybrids) enlighten heterosis, which is characterized by higher vitality and productivity than parental lines (hybrid vigor). But this effect is maintained only for the period of one generation, remaining the challenge in hybrid vigor.

Seed production of hybrids of many crops, including sorghum, requires controlled pollination of maternal lines (A) possessing cytoplasmic male sterility (CMS). This is one of the commonly used scientific modes (figure 49, 50) for solving the above-mentioned problem owing to males, which is caused by single recessive genes.

At this point, ms is commonly used because its expression of the MS is stable and constant in many environments. Sterile line plants do not produce pollen, and their reproduction occurs through crossing with fertile line-analogy (B), which has an identical set of nuclei but a fertile type of cytoplasm.

Hybridization with paternal lines (R) is executed at the freely flowering point because of line A, which does not produce pollen.

In order to set seeds by the hybrid plants, the paternal line must deliver genes to restore fertility to the genotype of the hybrid (F1), suppressing CMS effect.

The scientists, Nataliya Alpatova and others (2023) at the VIR named after N.I. Vavilov, have discovered and patented the DNA (genetic) marker (figure 51), by its help, they quite quickly selected the

plants with the required characteristics, namely, to identify RF2 desired gene bearers and restore fertility to the CMS, type A1.

Identification of genes is accelerated multiple times with the help of identification markers and may be implemented in a two-week term. Then as the common regime it is necessary two year season (2 year) to fulfilment of crossings and assessment of trait availability in the first hybrid generation. In the result of these researches was created homozygous lines of sorghum, distinguishing on capability

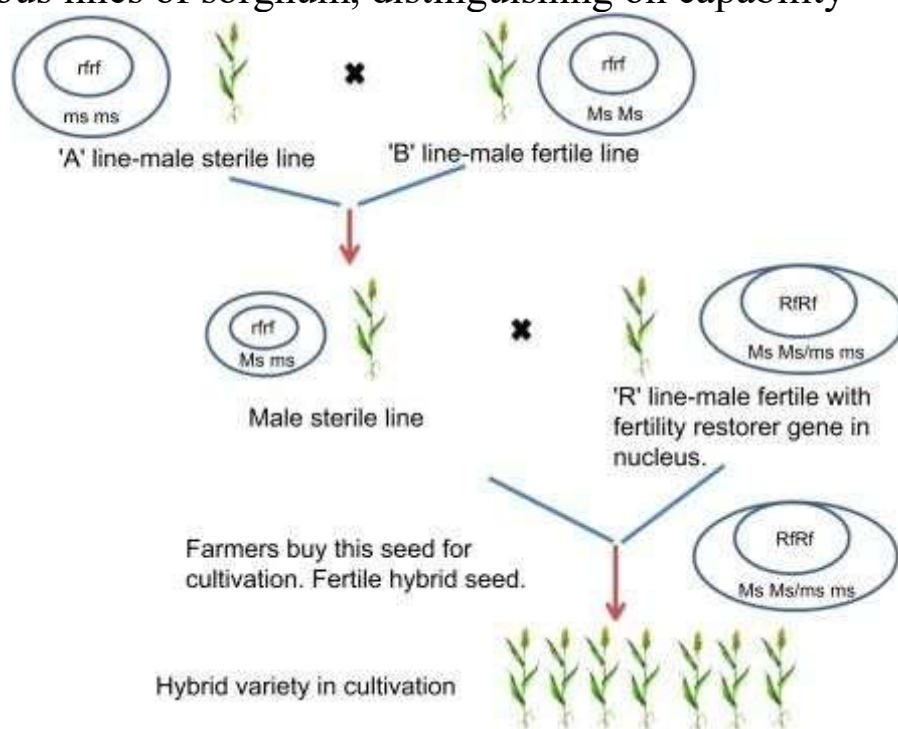


Figure 49. **Conventional hybridization order in sorghum** (S. Rakshit and A. Bellundagi, 2019).

to restoring of fertile pollens. The proposed gene candidate in the locus of RF2 was identified and enlightened by polymorphisms in successive nucleotid fragments in the bearers of dominant and recessive alleles, characterized by variant successiveness associated with the dominant allele RF2, and elaborated on the mode of its identification.

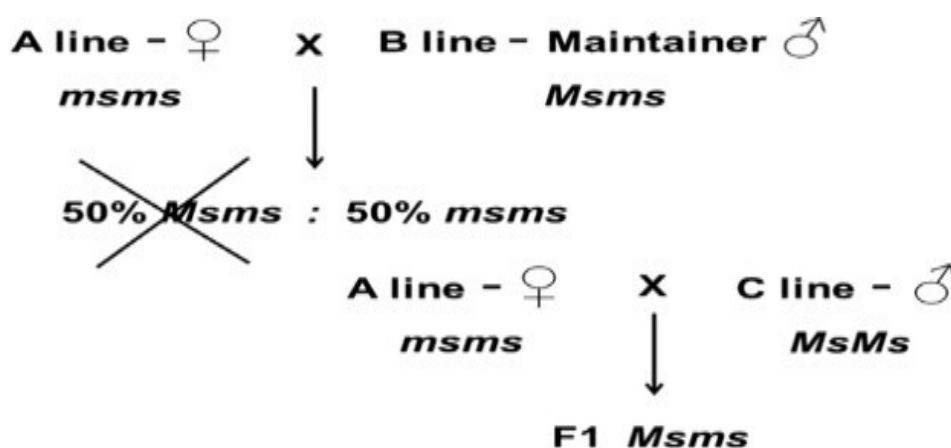


Figure 50. Hybrid seed production using recessive genetic male sterility (Temesgen Begna, 2022).

The marker worked out by those scientists was named after CAPS-572 and was secured on the sorghum samples from the VIR collection. They studied 20 lines selected for resistance to cereal aphid (*Schizaphis graminum* Rondani) out of samples of bread sorghum and pointed out that marker fragments characterize lines with restoring fertility pollens but are not discovered in sterile lines or lines of sterility fasteners. Moreover, they pointed out that, with the help of markers, F1 hybrids can be identified as bearing gene *Rf2*, which had been taken by them from paternal parent.

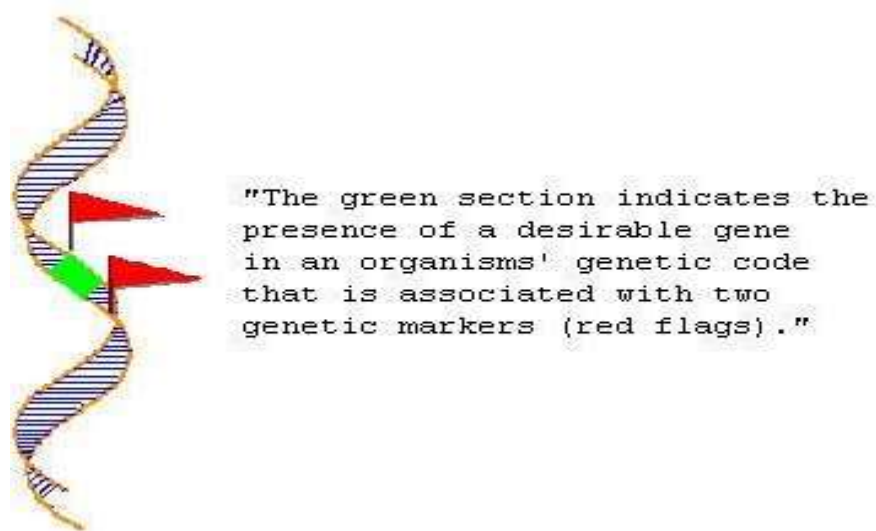


Figure 51. Simple example of explanation for genetic markers (ISAAA, 2024).

The method of field assessment of collection samples belongs to cultivating species of the genus *Sorghum bicolor* (L.) Moench based on their phenotype characteristics, biomass, and seed productivity, and the

successive selection is also acknowledged by Russian sorghum breeders (Kubalnik O.P. and others, 2022) as the most efficient one. The study of the gene fund by them has made them able to isolate 18 samples as the donors of valuable farm characteristics to develop new forms. Some of them were donors of several economic traits: on the 6 traits (Volonter), 5 traits (Shaherezada), k-302, and L-39\12. 4 traits: Izolda; Sahara; k-256; k-257; L-66\13; L-67\13. 3 traits – Moment; Chayka; k-327; L-44\13.

According to the elaborated variety model and the result of variety testing studies, the new sugar sorghum variety Izolda was singled out. Its advantages over the standard variety Vojiskoye 51 on biomass crops are over 21.0% and on seed crops, over 11.1% in the conditions of 2020–2021.

Chapter 5. Hybridization technique in sorghum plants

Phenotypic architecture and development of sorghum panicles considerably differ in sorghum diversities (photo 136) and from other cereal crops, and that is why their pollination order and technique have specific peculiarities. Two kinds of spikelets are developed in the panicles of cultivated sorghum diversities (see photo 137, 138). The first one is named sessile, and the second is pedicellate. The sessile spikelets have male and female parts—bisexual (feathered purple stigmas—Se and yellow anthers—Pe in the floret), whereas the pedicellate spikelets may be male or sterile (photo 139, 140).



Photo 136, 137, 138. **Closed (compact), Semi Open and Broom type of sorghum panicles** (Arun Chacko, 2020).

We can analyze one of the quite simple orders of pollination described by A.A. Shatikin and N.S. Sharko (2016), which is considered by the authors as the least labor expense and time-requiring one, **using watered emasculation at the hybridization** of grain sorghum. It is guessed that this method has good reliability, reaching, in some years, up to 100% of seed setting. Emasculation with water is its main peculiarity.



Photo 139, 140. **Spikelets of cultivated sorghum (*Sorghum bicolor* or *Moench*)** by Elizabeth J. Hermesen (2022-2023).

To begin the work of pollination (hybridization) earlier in the day, the better is before splitting open flowers. It was noted that flower blooming occurs at the delay of the beginning of the work and even at the soil shaking from the setting of needed wooden pegs.

At the rejection of flower buds, it considerably affects the date of successive pollination of panicles. So, if you leave only buds that bloom today, pollination may be conducted in 2-3 days; if you leave buds that bloom later, they will be ready for pollination in 4-5 days.

But precise forecasting in this situation is difficult because of the considerable effect of weather on flowering rates. A cold atmospheric medium with rainy weather may take a week or even more to delay the pollination of panicle because the stigmas stay fertile for a long time.

Sorghum plants flowers in quite a long time, which is why the problem with selection usually does not arise. Practically, several panicles for pollination could be found all the time in the parental nursery. But, in some time, when parental plants considerably differ in their terms of flowering, what forces the breeders to cut off panicles of the early-ripening parental to synchronize at the beginning of panicle setting? Sooner or later, the plants will begin to set new panicles.

Often, the initial materials of grain sorghum may be of tropical origin, and they have relatively short-hour light biology and will not set generative organs in our long-hour light days. This also should be taken into consideration if it is necessary to shorten the light time in innovative ways. Of course, it needs some expenditures and manpower. If the scientists have green house facilities, no problem. It would be a great possibility to regulate daylight durability. But with the month of August,

the days start to become naturally shorter, and such kinds of sorghum diversities begin to set panicles.

It is important to register that progenies in F1 from photo periodicals and local parents do not have any photo periodic reactions. In successive generations, some plants have characterized their photoperiodic behavior to set generative organs. But the percentage of such hybrid plants is not greater.

Several well-developed panicles of maternal plants in the nursery are isolated and registered in the hybridization workbook. As a rule, there are two replications, but the number of replications, depending on the study, can be increased up to three or four. The chance of getting nearly 100% of hybrid seed is guaranteed at 2 replications, the availability of professional assistants, and favorable weather conditions.

The recommended method by scientists have been conducted in 86 crossing combinations during the the years 2011, 2013, and 2015, and all of them have been successful. The result of the first year with a hot summer was at 74%. The average day temperature at the time of hybridization was +26.5 to +30.0 °C with the maximum at +43.0 °C. During this period (19–27 July), the average daily air moisture was 27%.

Hand pollination begins with cutting off open anthers in the florets (spikelets) and late-developing florets with the help of small scissors. Only florets—the blooming of those that takes place today or tomorrow—are left. Usually, their number on the normally developed panicle makes up 70–200 pieces. After this operation, a wooden peg with its number corresponding to the numbers in the hybridization workbook is installed with the help of a work hammer in the soil near this plant. In the event that some of the florets splitting open as a result of the soil's micro-shaking, these florets are immediately removed and the next operation starts. This is the putting of the polyethylene package on the panicle (photo 141). The bottom of the bag is opened before being put on.

At the option of polyethylene packages, special attention should be paid to its durability to withstand environmental effects and capacity. It was put on a panicle and fastened to the stem under the panicle with string. After that, let's get down along the stem to the part called the "skirt." It holds firmly. The place of tying up is where the gap between plastic and stem becomes top. The 100 grams of water are poured into this "skirt," and the upper part of the package is fastened up with string

to the peg. The stem of the plant also fastens up to the peg to prevent the damaging effects of the winds.



Photo 141. View of the hybridization nursery in the sorghum breeding plot.

Prior to beginning the pollination, it is necessary to hold the panicle under a polyethylene package for 3-5 days. This depends on the option of flower bud age at the time of preparation of the of the florets for isolation as well as the weather conditions.

The readiness of panicles can be easily controlled visually through polyethylene; let it not be clear, but it is seen when the anthers of flowers soaked with water start to get dark and become less able to produce pollen. After that, polyethylene packages take off and are put on packages made of pergament paper.

Usually, this operation coincides with pollination and passes at the time of another splitting along the greater part of sorghum plants. This time, as a rule, is 8–10 hours in the morning and easily defined by the shaking of panicles—the start of "dusting."

To prevent outcrossing from neighboring plants, the replacement of packages is conducted quickly and without delay. In the case of discovering an inconsiderable number of dark pollens, they are immediately removed. If the pollens are too many, the panicle is left under the polyethylene package for 1-3 days.

Pollination is conducted through the lower part of the paper package. The panicle of the paternal plant enters through this place up to the top part of the isolator package and will shake several times actively in order for the pollen to land on the stigmas of the maternal component.

Then the paternal panicle is removed, and the maternal panicle with an isolator is fastened to the peg.

The needed tag is set on the plant stem under the panicle with records of the date of hybridization and the names of maternal and paternal plants. This information is written on the pages of the hybridization workbook, along with other necessary commentaries.

There is another kind of hand pollination method that involves thermic treatment. Thermic treatment is done by means of the field thermostat PTU-1. At this stage, emasculation of maternal plant panicles is achieved through a hot hit at 48–50 °C. As a result of this thermic hit, all pollen grains lose their vitality, while 70–80% of stigmas are left alive.

These two ways and other innovative methods greatly help to increase the efficiency of current sorghum hybridization, which is still difficult depending on the specific flower structures.

The new developing varieties of sorghum are also characterized by the fact that flowering and maturation occur unevenly. The timely rupture in maturity of grain, even in the sphere of one panicle, ranges from 8 to 15 days. 8–15 days delay, relatively on the main stalk, flowering, and maturation on the tillering woods. So, finding a more efficient method for pollinating sorghum samples is the remaining challenge for young plant breeders.

Chapter 6. Assessment of initial material in sorghum breeding and seed production

Assessment of breeding material in the sorghum breeding process is conducted according to many indexes. At this stage, phenotypic surveys related to assessment are implemented mainly in the field with plant vegetation period and along plant developing stages.

The growth rate of sorghum seedlings in the first 30 days (photo 142) is an important index for sorghum plants. Because the growing rate at this moment is considered an indirect index of the cold resistance of sorghum samples, (Salem M., 2019).

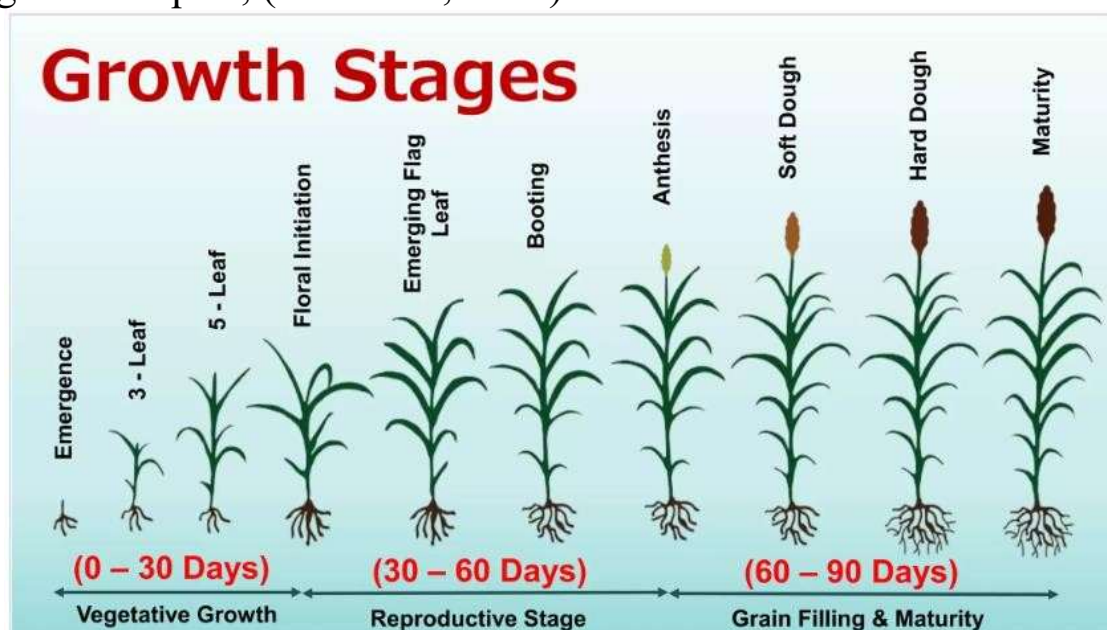


Photo 142. **Growth stages of sorghum** (Salem M., 2019).

The amount of poisonous compounds I_2 in the structure of green plants is determined in the KI solution. For this, the plant part at 10–12 cm above the soil is cut off, and solution is poured on the cross section of the plant stem. If the section has been colored dark blue, the poison (HCN) amount is up to 0.1%. It shows that the plants of sorghum are dangerous for agricultural animals. If the conducting tissues of the stem are colored in some way by spots or are not colored at all if the amount of HCN is at an insignificant level.

Resistance to dusty black smut is assessed by the provocation method. At this stage, artificially infected medium is used to evaluate susceptible plants by counting their number and percentage ratio to all plant numbers in the plot.

The resistance of sorghum samples to cold is assessed in the laboratory. The lowered temperature is created in the artificial chamber medium up to -6–8 °C and plants of samples are grown in this chamber.

Resistance or tolerance of sorghum to soil salinization is evaluated through seed germination in a solution of 2% NaCl in the water. At this point, seed germination percentage is a criterion to show their resistance. If the germination is not over 20%, the sample's resistance will be very low. 21–40% is low. 41-60% middle, 61-80% strong, and more than 80% middle strong.

Muhammad Ahmad Yahay and others (2023) partly assessed the drought tolerance (photo 143) of 225 sorghum genotypes under non-stressed (NS), pre-anthesis drought stress (PreADS), and post-anthesis drought stress (PoADS) conditions in field and green house conditions. Grain yield parameters were the main data collected in this assessment to point out their drought tolerance. The mean grain yield in the conditions of NS, PreADS, and PoADS consisted of 3.7, 1.8 and 2.6 tons\ha, in that order. The best genotypes selected in these conditions for initial materials in future breeding programs were genotypes G119 and G127, with grain yields of 5.6 and 6.3 tons\ha, respectively, selected as being suitable in the conditions of non-stress. Genotypes G8 and G71 with their yields of 2.5 and 2.6 tons\ha were best-suited for pre-anthesis drought stress conditions, whereas genotypes G115 and G120 with yields of 4.2 and 4.3 tons\ha were recommended for post-anthesis drought stress conditions, respectively.



Photo 143. Impacts of drought condition in sorghum plantation.

F.V.Alabushev and others (2019) suggest a multi-criterial assessment of variety samples of sorghum on their series economic traits

to select varieties meeting the requirements of the variety model and to use them as initial materials in the sorghum breeding programs. At this stage, experiments of the assessment are conducted corresponding to the methodic instruction on the study of collection samples of corn, sorghum, and groat crops, the method of the State Commission on Variety Trial of Agricultural Crops.

The results of the study of 13 variety samples show that 5 varieties: D3868, KD388, Sahornoye 105\3, Feniks, and Listvenit have green mass productivity at the level of the model variety (over 45 ton\ha).

At this stage, programs of Excel and Stata 10.0 with the calculation of standard deviation, weight coefficient, and integral evaluations were used to assess major farm traits in the breeding work: green mass productivity, durability of vegetation period, height of plants, size and number of leaves, sugar content in the juice of the stems of variety diversities.

The criteria of assessment (main economic traits) and their contribution to the formation of promising samples, as well as the values of these indexes, which have to be characteristics of the variety model, were identified in the result of the multi-criterial analysis. Variety samples: Feniks (2.67), Ujnoye (3.80), and variety Denyut (4.29), obtained the highest integral assessment. Then, samples of Ujnoye and Feniks based on the results of many years were submitted to the State Variety Trial in 2019, with a variety of Debuits included in the State Register since 2003. So, multi-criterial assessment can be used in the sorghum breeding process to single out samples that meet the requirements of breeding programs.

Such indexes as content of raw protein, carbohydrate, and fats were taken into account as the first importance at the assessment of sorghum green mass on the data of 2018. The green masses of L-5, L-109, and L-1327 have more 11.4–11.9% of raw protein, respectively, than the standard variety Voljskoye 51 (9.7%). At this stage, protein is determined in the laboratory by the method of Keldalyu (GOST, 10846–81), carbohydrates by the method of Bertrana (field total compound with the help of the portative reflectometer RL-2), fats by the method of Sokleta (GOST -Government Standard, 13496.15–97), and tanini by the method of T.A. Suslova (E.A. Vertikova and A.N. Kurnetsova, 2018).

Tanin, as a polyphenol, is a hereditary compound in the sorghum plant (figure 52) which plays a protective function in the plant against animals and pests.

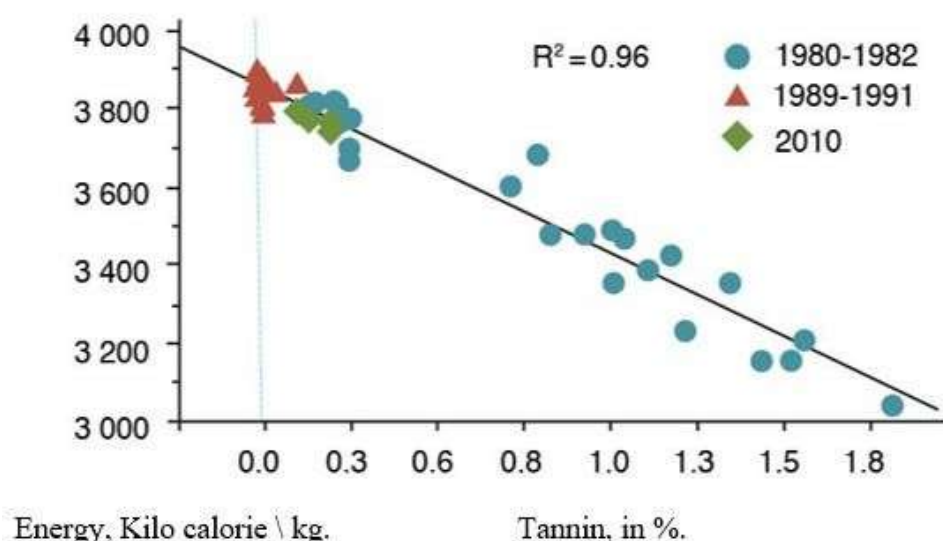


Figure 52. Enhancing of nutritious value of sorghum fodder and decreasing tannin content in the sorghum breeding.

For this reason its increased level in plants decreases the nutritional value of fodder and negatively affects the health of animals. Its content is restricted to 0.3%. Of course, breeders could decrease it in the past 30 years. Assessment of its content in the sorghum grains is carried out through the determination of polyphenols in two replications on the basis of their reaction with vanillin in the presence of hydrochloric acid.

Centrifugation and shaking of extraction out of plant parts with the addition of ammonium and determination of the density of the solution taken are also used to evaluate the tannin content in the initial materials.

Sugar content in the stems of sweet sorghum is one of the most important economic traits and is what sorghum breeders are interested in when estimating its content in the initial breeding samples. The general assessment method was the pressing of stalks with a roller press (photo 144) to extract the stem juice. The stem juice is used to calculate the total juice yield.

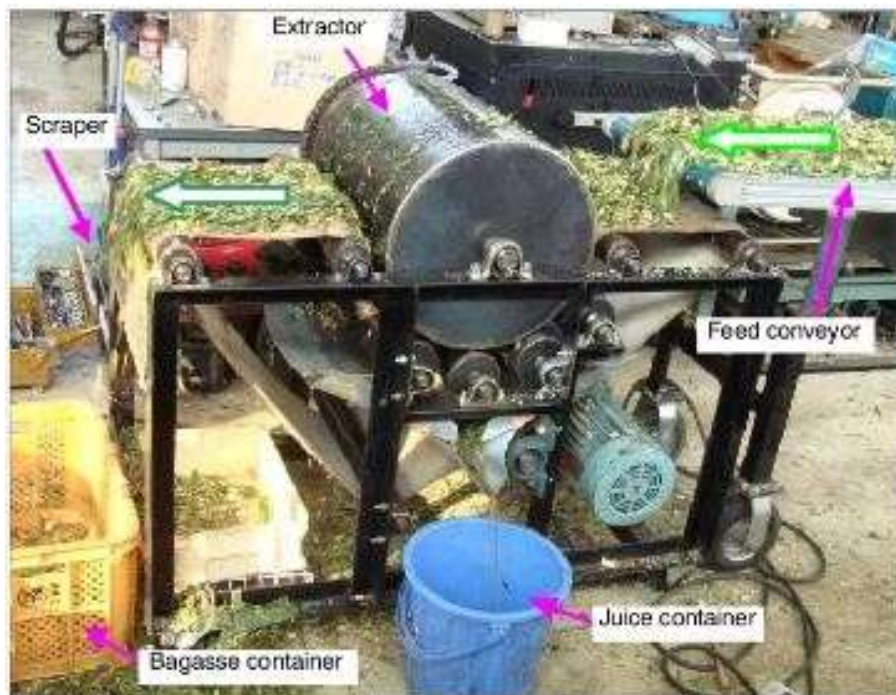


Photo 144. **Equipment for juice extraction test** (Hiaozheng Sun, 2010).

Then determine the amount of total sugar in the extracted juice. The total sugar is estimated in the juice after hydrolyzing the non-reducing sugars by 1N HCl. The reducing sugar is estimated by Nelson's modified Socony's method.

The use of the Portative Reflectometer RL-2 is the latest and most mobile method of assessing the total water-soluble sugar content in the sorghum plant.

Chapter 7. Seed production of sorghum

The Russian Federation is the closest neighboring country to Uzbekistan, where sorghum has enlarged areas, and its sorghum seed production has already become a leading example of improving local sorghum seed production. Russian scientists consider sorghum seed production quite simple for experienced agronomists, with some specific acceptance.

Seed production of commercialized sorghum varieties or hybrids is carried out on the basis of four key links:

1. Nursing of selection.
2. Seed stock nursery.
3. Super-elite plots and
4. Elite plot.

The state standard requirements pertaining to sorghum seed quality are presented in the table 48.

Table 48. State standard requirements posing to planting seed quality of sorghum (GOST, 11229-75).

Sorghum	Seeds of basic crop, at least %	Withdrawal out of basic crop, not more, in %.	Seed structure			Moisture, not more, %.	Class on planting standard.
			Seeds of other plants, piece per 1 kg	Weedy from that, piece per kg, not more.	Germination, at least, %.		
Grain.	99.0	1.0	12	7	90	13.0	I
Sugar.	97.0	3.0	35	20	85	13.0	II
Broom.	95.0	5.0	150	100	80	13.0	III
Sudan.	98.0	2.0	0.2%	20	80	15.0	I
Hybrid	95.0	5.0	0.5%	20	70	15.0	II

Nowadays, scientific seed-producing organizations and cluster farms tended by scientific research are engaged to produce super-elite and elite seeds of all commercialized sorghum varieties, as well as fertility-restoring and sterile lines. Beside these, line seeds and variety

restorers, which present themselves as paternal forms of hybrids, are also cultivated.

First reproduction seeds (R1) in the seed production go to planned variety renovation and strain (variety) changing, activating first of all in the specialized cluster farms. The most recommended variety change in agrarian enterprises consisting of agricultural sectors of the economy is after third reproduction.

Grain materials produced by seed-producing enterprises accepted in specialized provision points were additionally treated and improved to meet planting conditions. Such a treatment is fulfilled on the same seed-producing farm with the availability of its own seed-improvement facilities.

The following works are indispensable to getting a plump crop with high-quality hybrids and varieties:

Place seed-producing nurseries exclusively on the fertile soil plots and apply the full-needed fertilizer components under pre-planting soil tillage.

To fulfill seed sowing work in the early stages, which is optimal, to increase plant stand density approximately 10–15%, which prevents undesirable infertile tillering, as well as to create a favorable condition to mature panicle evenly, to clean the seed plant population out of off-type plants (photo 145).



Photo 145. Sorghum plantation with different variety diversities (CABI Compedium).

To conduct pre-harvest desiccation of the plantation by using chlorate magnum according to all recommended instructions.

Observing all the above-listed rules has made it possible to get a plump crop with anticipated quality indexes.

According to the scientific conclusions of the doctor of agricultural science, A.V. Alabushev (2012), the technology of growing seed sorghum has a special difference from grain crops. The main requirement for the plot option under sorghum is that the soil be free of weeds (mainly from annual cereals) because slowly growing sorghum seedlings may be suppressed by actively grown weeds in the first 20–25 days.

Sorghum does not prefer the soil structure and grows in all soils. The preparation of the soil to plant sorghum is commonly accepted for all grain crops.

Isolation distance to prevent biologic spoilage is essential at the time of seed propagation for any crop. Isolation distance is also needed between sorghum varieties, sudan grass varieties, and broom varieties. Between dwarf grain varieties, it must be 200–250 meters; between sugar varieties with tall plants and spread panicles, it is needed to be 300–350 meters.

In the instructions for approval, it was noted that the spatial isolation of sorghum plantations should be at least 500 m in dwarf hybrids and varieties (up to 150 cm) and up to 1000 m in height varieties and hybrids (150 cm and higher).

Seed sowing is as practiced as a solid drill and wide row-sowing with 45–70 cm apart. The sowing rate is 800 000 vital seeds per hectare; at the wide row sowing, it is 300–400 000 per hectare. The field with plants in their 3-5 leaf stage of growth can be treated with new herbicides to protect them from weeds.

In time, seed sowing in the regions has important technological significance. It was identified that 2500 °C of sum effective temperature is needed to form full-valued seeds for middle-ripening sorghum varieties, at this point to early ripening (2300 °C).

As above mentioned, the optimal sowing seed sowing rate of 400 000 vital seeds per hectare coincides with the seed rate of middle and early-ripening sorghum varieties in the seed production fields. This norm ensures the most optimal conditions for growth, development, and the formation of high yields with the proper biologic properties of planting seeds. Increasing the plant stand density leads to lowering these indexes.

A number of experiments have shown that seed quality, for example, the weight of 1000 seeds, varied at different norms of seed planting. For example, 21.6–25.8 g were formed at the seed norm of 300–400 000 per hectare, while 21.–23.7 g were formed at the seed norm of 500 000 seeds per hectare.

Wide-row seed planting (45–70 cm) with conditioned seeds is often preferable with 400 vital seeds to get a high yield (3.5–4.5 ton\ha).

There is no need to plant sorghum for seed in the plots where last year there were sown seeds of sudan grass, broom sorghum, and grain sorghum. Because the remained seeds in the soil from the last crop can grow in this year and pollinate with new variety diversities and cause biologic contamination.

There is an instruction to not let mechanical contamination occur when transporting the seeds of sudan grass and other sorghum crops. In the case of their mixing, removing their plants will be possible in the seed plantation. This is possible when plants begin to form panicles; the off-type panicles are visible, and they are removed from the field. But this measurement is to be repeated two and three times, depending on prolonged panicle formation along the different developing plants. Not only in the plantation, but all off-type plants growing around the plantation will be cut down and utilized to feed animals.

The use of selection in the sorghum seed production process enables the maintenance of provisioned seed purity, quality, and high productivity. Massive selection is conducted in monoecious phenotypic varieties, taking into account clarity and keeping marked conditions. The main purpose here should be the selection of seeds from re-crossed and fully mature panicles of elite plants. At this stage, fully mature panicles with a short part of scape to hold are cut off. These panicles are remarked on plants that are not damaged by insects, not infected by leaf bacteria, and do not spot diseases.

Panicles are graded according to their outlook and maturity, and depending on the needed amount of seeds to plant, their number is to be 1000 to 2000. They are tied in a group, dried, and thrashed; the seeds are cleaned and registered as super-elite seeds.

Individual-family selection is conducted in non-phenotypic monoecious or new varieties. At this point, the major aim is to improve variety purity or some of the economic traits and properties (earliness, productivity, type of panic, and so on.).

Family selection works similar to mass selection, where panicles are selected together. Their productivity and grain quality account for each other for each other individually. 300–500 panicles out of productive ones are dried, then thrashed individually, and seeds put in individual seed bags with numbers. Seeds are sown in the spring in the selection nursery using the half method for assessment and study with 1-2 replications. Every lot will have at least 50 registered plants. In the vegetation period are carried out all planned, plant phenotypic measures and data calculations.

The next year, the left seeds are properly mixed and seeded in the protecting, seed-producing nurseries. The taken seeds will also be registered as super-elite seeds.

Seed production of varieties belonging to African millet is conducted similarly to that of sorghum varieties. The requirements for planting seed qualities of African millet varieties are given in the table 49.

Table 49. State standard requirements posing to seed planting qualities of African millet varieties.

Crop type	Grade	Seed purity, at least, %.	Seed structure			Germination, at least, %.	Moisture, at least, %.
			Seeds of other plants, not more, %.	Weed seeds, not more, %.	In this, harmful, piece \ kg.		
African millet	Planting seeds	90	0.4	1.0	200	65	15

Briefly about agro-practices for sorghum and African millet. To wash out salt before seed sowing if the soil of the field subjected to salinization. Seed sowing of African millet is carried out after 7–10 days of sorghum seeds' planting. Sowing is conducted with the help of precise drills. The planting norms of sorghum varieties and African millet are, respectively, 10–12 and 4 kilograms.

Seed seedlings grow slowly in the first month of vegetation, and 2-3 times of weeding are needed to control freely growing weeds. 90–110 thousand seedlings are left for plant stands per hectare.

Fertilizers are applied in autumn at rates of 90 kilograms of phosphorus and 60 kilograms of potash. Nitrogen fertilizers: after 1st watering, when plants have 8–10 leaves, at a rate of 120–130 kilograms (net weight).

The second watering is at the time of flowering, and the third is at the time of milk maturity.

Chapter 8. Approbation of sorghum seed plantations

Sorghum field approbation embraces all variety plantations designated for seed harvest and plantations for maternal sterile lines in the reproduction nursery, as well as pollinator varieties or paternal forms from the nursery for hybridization in the case of repeated use of their seeds.

Approbation in sorghum is conducted at the beginning of seed ripening in most plants and only after field surveys in the nurseries of reproduction and hybridization.

Before approval of plantations and prior field surveys of hybrid populations, approbatory verifies the availability documents on the farm for planted seeds, whether or not the isolation from plantations and sorghum hybrids, from broom sorghum, sorghum-sudan hybrids, and sudan grass fulfilled or not the main requirements of seed production agro-practices.

Variety purity is determined through a process of plant bush inspection within the plant bundle gathered from 500 plants. These plants are picking up 10 plants in a diagonal direction, from 50 points out of 50 hectares.

These 500 plants contain other varieties of plants that were also grown in this field. In general, a bundle presents a mixture of plants that will be grouped into groups of broom, grain, and sugar, as well as hybrids: sudan grass, sorghum-sudan, and gumay, depending on the outlook, phenotype of the panicle, shape of the spikelet, peel of the seed and grain, main stem, and leaf line shapes (photo 146).



Photo 146. Southern African sorghum breeders inspect variety population like our approbation.

Mainly, these groups are formed:

- 1) main variety;
- 2) other varieties of these groups;
- 3) poisonous plants;
- 4) quarantine plants (Approbation of grain crops, 1995).

The result of approbatory is registered in his the field journal.

The purity of the major variety is determined by the total number of plants in the bundle and the presence of other varieties and group plants (broom and sugar sorghum plants) in it.

Infection of plants with diseases of cereal crops and other crops is also identified compared with typical and healthy plants of the major variety.

At this point, 95% of variety purity is attributed to the super and elite variety plants (SS and ES) of sorghum, and 95% is attributed to the plants of reproducing seed (RSs).

Infection of plants by smut (photo 147) is identified on the same plants, which is used to determine the variety purity and accounts for the percentages out of all the numbers of analyzed plants.



Photo 147. Sorghum panicle stricken by head smut (NAADS).

If the plants of Super Elite are infected by black smut of cereals at any grade at the developing stage of flowering and panicles of elite plants infected 0.1% (0.5% in that instruction) by this disease at the stage of flowering are considered unfit for seed provision and exterminated.

The existence of smut is not admitted in the nurseries of reproduction, super elite, and elite. Variety purity is the approbation attributes to two categories: first, at least 98%, and second, at least 95%. Plantations of super-elite have to be not less than 100% elite—at least 99%. Not more than 0.5% of sudan grass, sorghum-sudan hybrids, gumay, and other species of sorghum plant mixes are admitted for the first category at the appraisal, and not more than 1% for the second category.

Increasing mixtures within crops over the admission level lowers grades of variety purity. As a result of this, the grade of the crop is transferred from I to II or from II to III. II and III grades are guessed unfit and are not used. These unfit plants for seed provision are registered in the documents of approbation.

The existence of sudan grass mixes and sorghum of other groups or groups, variety sudan, and between-group hybrids is not admitted.

Analyzed 500 plants alone as in the sterile plant rows, and so in the rows of fertile analogy at the approbation of plots with reproduction of lines and hybridization. At the first passing across diagonal, surveyed plants and panicles of one parental form (sterile or fertile) and coming back, plants and panicles of another parental form. If the variety purity

of one of the parental forms (sterile or fertile) shows a lower than admissible level established for hybrid seeds, all plantation are rejected.

The variety and purity of hybrid seed plantations are determined through plant inspections without picking up bundles. At this point, approbatory passing across (in step way) a plot of hybridization or reproduction of sterile lines in two directions (perpendicular to each other). Along the way, he inspects 500 plants of maternal forms from a plot up to 50 hectares (20–25 plants from each of the 25 points). And at the second, the same quantity of plants from the fertile analogy or variety restorer.

Statements in 2-4 copies are composed on the basis of approval, depending on the designation of the plantation or category of farms. A field survey is conducted in the plots of hybridization and reproduction of sterile lines (maternal forms of hybrids). A statement of survey on the form of 194 is composed of its results. The results of the approbation conducted in the variety plantations reflect in the registered approbation statements composed in the statement forms of 193 and 197 (appendixes 8, 10).

Questions on the studied themes:

1. On guidance of what instruction is fulfilled the approval in the seed producing fields of rye?
2. When the seed-producing field is rejected for its unfitness to sow seed procurement?
3. What are the designations of the approval statement forms of 199 and 200?
4. Tell about sorghum and its social and economic importance.
5. In what countries of the world is sorghum planted as a food crop?
6. Do you know local sorghum species is grown historically in Uzbekistan?
7. Name the varieties of sorghum included in the state register to plant?
8. Describe the sorghum classification and phenotypic distinctness of sorghum diversities.
9. Can you characterize the genetics and natural properties of the sorghum plant?

10. List the goals and directions of sorghum breeding that are implemented and researched by our sorghum breeders and its seed producers.

11. What do you say about Sudan grass?

12. Has CMS had a considerable effect on improving the productivity of sorghum variety diversities?

13. How are sorghum breeding materials assessed to select for the breeding process?

14. Tell about sorghum panicles, their structure, and crossing peculiarities.

15. What are four links in the sorghum seed production?

16. List standard requirements for sorghum seed planting quality.

Part VIII. Oat breeding and its seed production.

Chapter 1. Oat, its social economic importance

Oat, avena in Latin, is an annual grass-like plant involving family cereals (Poaceae). It enters the widely known species of sowing oat, which is extensively cultivated on an industrial scale as a food and fodder crop (photo 148).



Photo 148. View of one typical oat plantations

Its social importance can be explained by its solubility, like the beta-glucan in oatmeal, which lowers the blood cholesterol of the organism. It was especially noted that a meal containing oat bran enables a 23% drop in total cholesterol. All know and scientists confirm the multi-mechanism responsibility characteristics of the diseases, like an increase in blood cholesterol levels. Additionally, only oats have antioxidants, which improve human heart health.

Oat grain has numerous uses in food production: reprocessed grain as an ingredient in soup, boiled, rolled, or crushed into oatmeal, and even ground into fine oat flour for other kinds of national meals. Reprocessed oat grain is chiefly eaten as oat porridge. There are other kinds of baked oatcakes and bread made from oat flour.

Naked grain and hulled oat grain are commonly in demand to feed mainly horses where high-calorie fodder is needed. Oat hull is also involved in different reprocessing processes to prepare attractive, rich, easily digestible food pellets. There are many kinds of technical

facilities for producing new varieties of products to feed cattle and all kinds of ruminants.

26.4 million tons of oat grain were produced in the world in 2022. In terms of countries' production, seven countries in the world lead the list of top oat grain-producing countries: Canada: 5.2; Russia: 4.5; Australia: 1.7; Poland: 1.5; Brazil: 1.3; Finland: 1.2; United Kingdom: 1.1; Spanish: 0.87; USA: 0.84; Germany: 0.75; Sweden: 0.73; Argentina: 0.72; China: 0.60. At this point, the main exporter was Canada, followed by European countries like Sweden and Finland. The USA was the main importer.

In Uzbekistan, according to the manual of this textbook (<http://library.ziyonet.uz/uz/book/126706>) oat is valued as a food source for nation and agricultural animals. It is noted that oat grain contains of 10-15% of protein, 40-60% of starch, fats -4.6% and cellulose – 8-10%.

Productivity, resistance to lodging, earliness, grain shading, characteristic of covered grain, paired grain manner, many fruit bearing stems on one plant, amount of protein and fat, uniformity of grain, resistance to drought and to diseases of smut and rust are the most farm attractive priorities of oats within grain crops.

In 2022 four oat varieties were planted (table 50) in our republic (in the state register) involved in two groups: winter oat (*Avena sativa* L.), and spring oat (*Avena sativa* L.).

Table 50. Recommended oat varieties to plant in the regions of Uzbekistan, 2022.

Number of requisition	Variety	Number of variety originator	Code of country	Year of registration	Regions to plant.
Winter oat varieties					
2017011	NS Yadar	318	SR	2020	5,11(irr.)
7200277	Tashkent 1	13	UZ	1980	1-13(irr.)
7503911	Uspekh	13	UZ	1981	8,9,11(irr.)
Spring oat varieties					
7302029	Uzbekskiy shirokolistniy	13	UZ	1981	1-13(irr)

We can see four oat varieties planted in the fields of farmers in Uzbekistan, which are NS Yadar, an introduced oat variety from Serbia, and three locally created varieties: Tashkent 1, Uzphech, and Uzbekskiy shirokolistniy. All three local oat varieties have been exceptionally adopted because of their long periods of cultivation (since the 1980s).

Variety Tashkent 1 was developed at the Uzbekistan Animal Breeding Scientific Production Association, "Zotdor elita." Individual and multiple selections of overwintering forms out of variety "Bezantina-11" were used. The vegetation period for accumulating grain consists of 198–205 days, while green mass can be cut in the days of 171–174 to feed animals. Variety is very resistant to overwintering and tolerant of lodging and grain shading. The richness of the leaf formation is equal to 43.0-45.0%.

The productivity of the grain potential of this variety reaches 2.4 tons per hectare, and the whole dry substance crop gets 9.3 tons (data from the Samarkand State Variety Trial, 1993–1997).

It has been registered in the state register since 1980 and planted in all irrigated fields of the republic in the winter term.

Uspekhs. It is the bred variety of the former Union Plant Growing and Animal Breeding Scientific Production Association, "Zotdor elita." A plant bush is like a half-brush with a strong stem. Hulls of flowers and spikelets have similar structures. The grains have a middle size and a weight of 1000 grains, made up of 19.0–22.0 g. Average grain productivity is 2.6–2.9 tons per hectare, while green forage productivity is 66.5 tons.

The vegetative period of this variety makes up 190 days. It is tolerant of lodging and was recommended to be planted in the regions of Samarkand, Surkhandarya, and Tashkent.

Uzbekistan shirokolistnaya. It is also the variety of the former Union Plant Growing and Animal Breeding Scientific Production Association, "Zotdor elita." The authors of this variety were A.S. Holikov and others. The late-ripening biotype selection method out of the Australian wide leaf sample (K-11302) was used in the development of this variety.

Biologically, this oat variety belongs to the spring Purnaks species. The vegetation period in the intermediate condition lasts up to 185 days, and in the spring, it lasts 102-107 days.

The bush is standing straight up, extended, tooth simple, panicle enlarged, one basic, yellowish-brown, and has a long awn (1.5 cm). Seeds are enlarged and brown; 1000 seeds' weight makes up 29.8–31.2 g. An average grain yield makes up 2.7 tons, while dried mass yield is 10.8 tons. This variety has been registered since 1981 to be planted in the following regions: Samarkand, Surkhandarya, and Tashkent.

NS Yadar. This variety is one of the introduced varieties from Serbia. It was registered recently, in 2020 (photo 149). This variety is characterized as middle-ripening, resistant to cold, high-resistant to diseases, with a weight of 1000 grains (29 g). It comprises 13–15% protein and oil, 6–7%. The genetic potential of productivity is said to be high. Adaptable to various cultivating conditions. The uniqueness of this variety is that it can be planted in combination with bean crops.

It has been included in the state register since 2020 with the recommendation to plant in the regions of Kashkadarya and Tashkent in the republic.



Photo 149. Plantation of oat variety NS Yadar prior to harvest.

Chapter 2. Biology of oats

Classification. In the world, the classification of oats is given in the following order: Kingdom: plantae; Clade: tracheophytes; Clade: monocots; Clade: commelinids; Order: poales; Family: poaceae; Subfamily: pooideae; Genus: avena; Species: *A. sativa*. Binomial name: *Avena sativa* L. According to the information provided by R.R. Ismagilov (Ufa, 2019), there are about 25 species.

Sowing oats are divided into hulled and naked grain oats (figure 53). Hulled forms are the most productive ones, and they occupy broadened planting areas while naked grain oats spread.

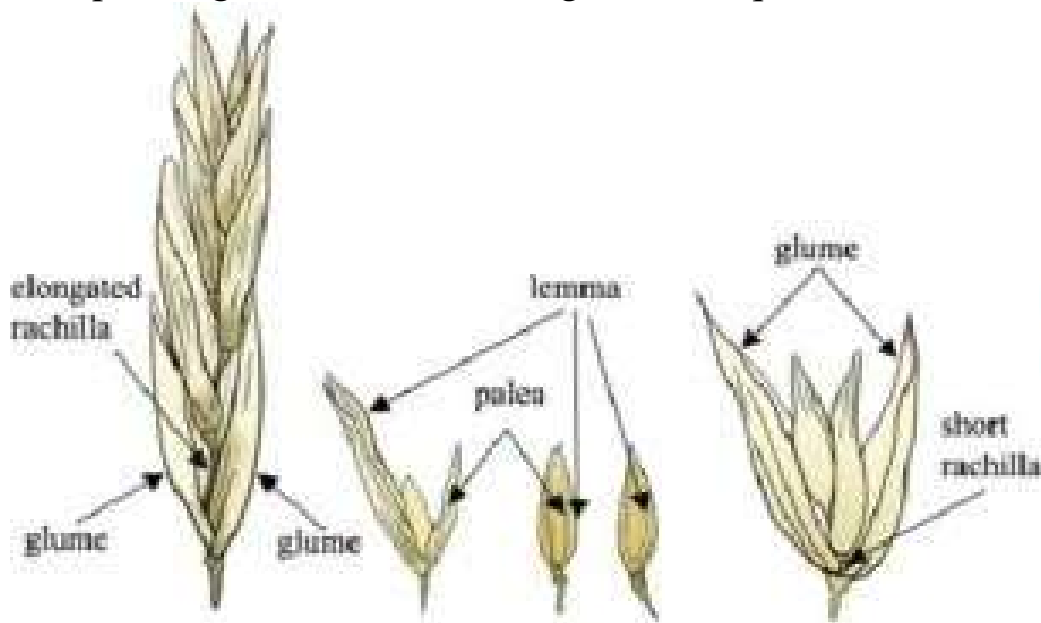


Figure 53. Differences between hulled (left) and naked oat (right) spikelets.

Naked oats have enlarged multispikelets with soft glume. That is why, at the time of thrashing, the grain separates easily. The glumes of hulls are harder. The naked oats are responsible for moisture.

Oat diversities differentiated each other by the structure of the panicle (spread or compressed), spikelet lemma (white, yellow, brown), and availability of grain awn. Without awn, forms of oats have not more than 25% awns in the spikelets of the panicle. The number of awns decreases in years of heavy precipitation, while dry (and lowered agro-practices) conditions favor increasing the number of awns of the same variety.

In the nature exist many diversities of sowing oat. They are: aurea, aristata, mutica, krausei, montana, obtusata, and jnermis. Mutica, aristata, and aurea within this group of oat diversities are the most widespread diversities of sowing oats (*A. sativa*). There are some keys (component traits) to identify the oat diversities (table 51). But sometimes there are difficulties in recognizing the white and yellow color of the grain. Two methods were created to find one of them precisely when their colors were closer to each other.

The first method is to treat the seeds with a hydrochloric acid solution. At this point, hydrochloric acid in its 10% solution is poured on oat grains, and in 10 minutes, the seeds are taken out and dried. In 5 hours, the yellow grains become intense yellow. In 18 hours, the white grains will turn a light brown color.

The second method involves lighting the seeds with ultra-violet rays. Under lighting, the white grains of oats give a light lightening—light gray or blue. The yellow grains of oats will give dark lightening—dark-brown, grey-brown, or violet-brown.

Table 51. Diversities of sowing oat – *A. sativa*.

Diversities	Shape of panicle	Grain hull	Grain color	Awn availability	Weight of 1000 grains, g.
Aurea	Spread hanging	hulled	yellow	is	26-33
Aristata	Spread hanging	hulled	white	is	35-40
Mutica	Spread hanging	hulled	white	no	36-42
Krausei	Spread hanging	hulled	yellow	is	41-46
Montana	Spread hanging	hulled	brown	is	-\\-
Obtusata	Compressed	hulled	white	no	-\\-

Jnermis	Spread hanging	naked	white	no	-\\-

Phenotypic peculiarities. Annual, grass-like plant with a height of 50–170 cm, always with naked nodes. The root is a fibrous root. Stalk: straw with 3-6 mm in diameter and 2-4 nodes (figure 54).

Botanists specifically describe the architecture of the oat panicle as an inflorescence that comprises a main branch axis (or rachilla) with primary, secondary, and tertiary branches that terminate on a spikelet. Also, every spikelet, depending on the variety peculiarity, contains one, two, three, or more grains (Yungs, Shands, 1974).

Leaves are regular, green, linear with boot, rough, length 20, 45 cm, and 8–30 mm in width. Flowers are small, gathered in 2-3 spikelets, forming a rare compressed panicle with a length of up to 25 cm. Spikelets are middle-sized, with two or three spikelets. Spikelets in the lower part of the panicle have awns or are all without awns. Glumes of spikelet have a length of 25 mm, a little longer than spikelet (figure 54). Rachilla of the spikelet is naked. The lower lemma of the spikelet is lancet-shaped and about 20 mm with an upper tooth-shaped tip. The enlarged part is naked only, with a little pubescence on the base or only naked. A little bent, straight, or absent. The blooming of spikelets took place in August. Fruit is a grain.

Biologic properties. Oats are remarkable for their soil moisture response, resistance to cold, and less reaction to soil than other grain crops (but rye). These characteristics of this crop have made it possible to occupy the seventh rank in the production of grain within grain crops, following wheat, corn, rice, barley, sorghum, and millet.

The seeds of oats begin to grow at a temperature of 2–3 °C, and the seedlings withstand frosts up to -4–5 °C. The vegetation period lasts 80 to 110 days, depending on the growing condition and variety. The three embryonic radicles of seeds are developed during the germination of oats' seeds.

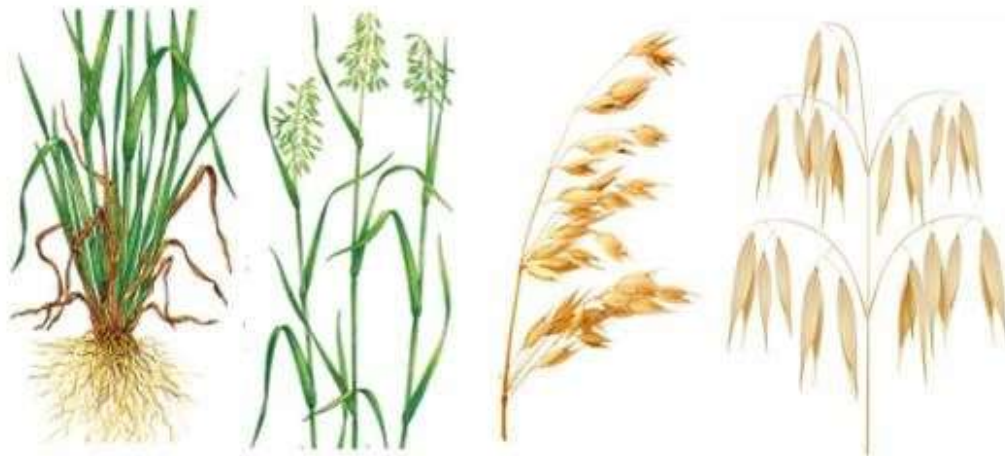


Figure 54. **Vegetative and generative organs of oat plant.**

The main stem grows slowly in the first days (1-2 mm per day), but roots swiftly (figure 54). The seedlings emerge on the soil surface on the seventh and tenth days in the field. The tillering stage of plant development starts with the establishment of the third and fourth leaves (on the seventh–ninth day after germination). Beside this, there are additional roots, lateral shoots (tiller shoots), and two-three fruit-bearing stems. Bud panicles set on the main and lateral shoots at this stage of plant development. The energetic growth of the stalk and panicle is observed after the stage of tube release, and the accumulation of much dried substance takes place from tube release to shading.

The flowering of oat panicles is going from the top of the panicle to the middle part and from the ends of branches in the first order until the main rachilla of the panicles. It continues for six, eight, and, in some cases, nine and even ten days.

The maturation of panicle prolongs until one month. The grains on the top part panicle and on the end of the woods lowered order are developing harder, which are shading first at the lagging of harvest, which lowers not only the crop but also its quality.

Additional information about biological properties of oats the reader can find in our manual on plant breeding and seed production of grain crop, published in 2019 (<http://library.ziyonet.uz/uz/book/126706>).

More detailed explanations about the development of winter oats are given by Australian scientists (Ben Trevaskis and others, 2022). The schematic view of the oat life cycle in the Australian context describes the sowing and establishment of crops that take place according to water security in autumn and then plants (figure 55). Their resistance to cold

temperatures during the late autumn and winter vernalization (take a look at the glossary).

Flowering and grain production stages occur during the optimal period of spring, after the last cold risks of frost and before the onset of summer heat and decreasing irrigation water.

The figure shows early shoot apex development and the first view of the transition from vegetative phase (V) to reproductive development phase (R), or the double ridge stage (DR). The relationship between developing phases of growth, fruit set (vegetative and reproductive), and ripening reflects the dependence on seasonal climate. Of course, the impact of phase durations on physiological properties and yield-related components of plants is formed together with the relevance of growth stages to the formation of products such as forage, hay, and milling.

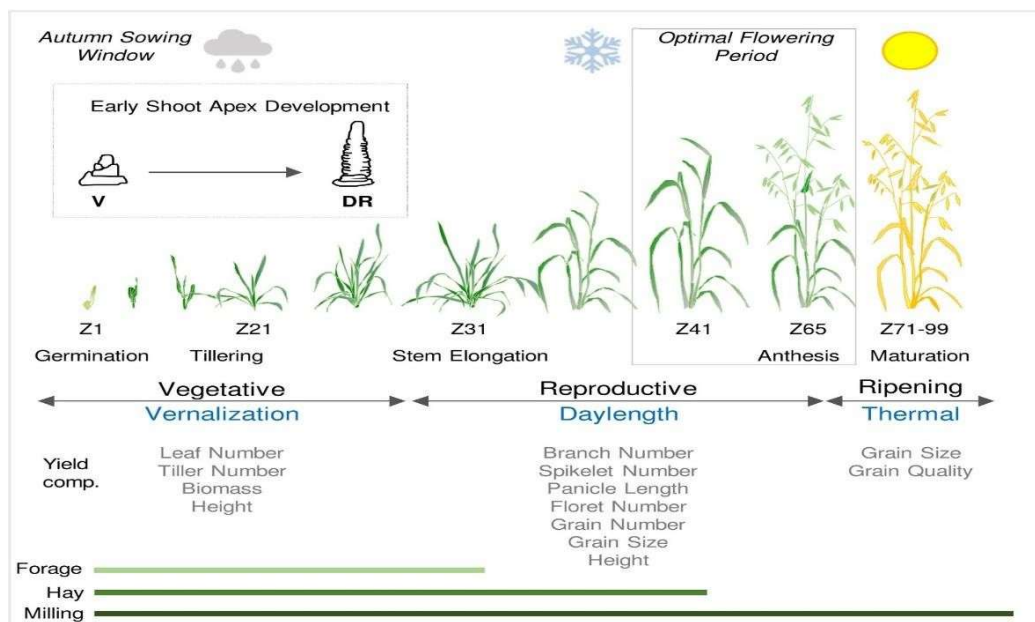


Figure 55. Growing and development stages of winter oats.

Oat genetics. Oats, *Avena sativa* on its genomic set, *Avena sativa* is an allohexaploid $2n=6x=42$. Contemporary analysis devoted to oat phylogeny, where molecular DNA was combined with phenotypic evidence, has placed the oat genus *Avena* in the Pooideae subfamily, which comprises some cereals like wheat, barley, and rye. You know, they are in the Triticeae tribe, while *Avena* is in the Poeae, together with grasses such as *Briza* and *Agrostis*. By the way, the wild ancestor of *Avena sativa* and its relative *A. byzantine* is *A. sterilis*, which is naturally hexaploid—wild oat. One of the minor crops has six sets of chromosomes.

According to our textbooks on grain crops, we know that 14 chromosomal oats (*Avena* L.) belong to the Poaceae family, and there are about 70 perennial and annual cultivated and wild species that have polyploidy lines: $2n = 14, 28$ and 42 species diversities and geographic distribution (Vavilov, N.I., 1987).

The genomic researches of Yong-Bi Fu (2018) with the 25 *Avena* species have demonstrated that *A. sativa*'s hexaploid AACCCDD genome derives from 3 diploid oat species (of course each of those has 2 sets of chromosomes). They are: the CC -*A. ventricosa*, the AA - *A. canariensis* and the AA - *A. longiglumis*. And additionally to these two tetraploids oats (each has 4 sets of chromosomes): manely the AACCC - *A. insularis* and the AABBB - *A. agadiriana* (figure 56). Of course, at first formed tetraploid and then hexaploids. According to the suggestion of genetic scientist Jinsheng Nan (2023), hexaploid hulled oat *A. sativa* and the naked oat *A. sativa* var. *nuda* diverged some 51.200 years ago, long before their domestication. This implies that as shown in the figure of ... they had been domesticated independently.

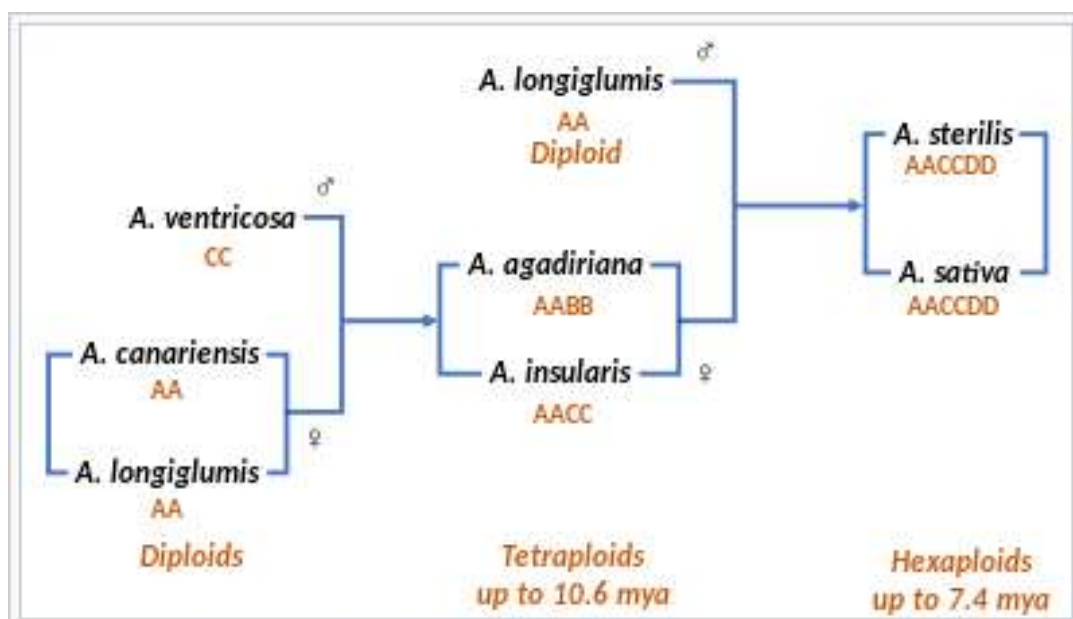


Figure 56. The phylogenetic map of oats, how hexaploidy species derived from diploid and tetraploid species.

As an agricultural crop, *Avena sativa* L. requires continued genetic improvement to meet the necessities of agriculture and industry. At this stage, genotyping is considered the best approach to solving challenges like this. But in this, some problems arise. The genotyping is

complicated by the presence of sub-genomes, which appear as the result of polyploidy in the cell cycle.

As a rule, organisms with polyploidy may have more than one pair of homologous sets of chromosomes. Thereby, the task of searching for needed markers of oat is put before scientists. The markers need to be filtered to exclude those variants that confuse several locuses. The genome studies of oats are also difficult because of the size and complexity of the hexaploidy genome and different chromosome reconstructions. All these reasons affect the rate of oat genome study in comparison with other grain crops.

In general, **genotyping** is the methodic process of determining the allele content of locuses in a certain genome, as called genotype, which helps shed light on the difference between two biotypes or allele frequency within population biotypes. Mostly, genotyping has established the comparative analysis of the sequences of the DNA of certain biotypes with the application of available technologies for molecular markers. It is an important step along the way to genome analysis—to analyze the molecular breeding of agricultural crops like oats.

Genome analysis and mapping in the example of oat breeding have promoted the identification of the most valuable traits and properties of related species of oats (Varsha G., 2016): 1) *A. Sterilis* (wild red oat); 2) *A. Fatuva* (common wild oat); 3) *A. Byzantina* (red oat); and 4) *A. sativa orientalis* (common side oat).

Chapter 3. Oat breeding directions

In much literature, like “private plant breeding” of field crops (Abdukadirov D.T., 2007), it is underlined that there are four major directions: fodder-forage grain production, food grain production, green plant cutting, and pasture establishing to grass grazing. They force oat breeders to make decisions in many aspects of developing new oat varieties and hybrids.

The general requirements standing before oat varieties designated **to produce grain are**: high grain productivity; response to growing conditions; stability of annual crops; grain hull availability and paired as well as lowered puny seed percentage; precocity; resistance to lodging; grain shading; diseases; pests; and ecological plasticity. These indexes belong to intensive-type varieties (photo 150). Other requirements, like the amount of protein and fat and amino acid compounds, exist. Nutritious is needed for grains, as is grain size, plumpness, uniformity, high level of protein, and less fat (accelerate fat worsening at the time of storage causes an acidic taste).

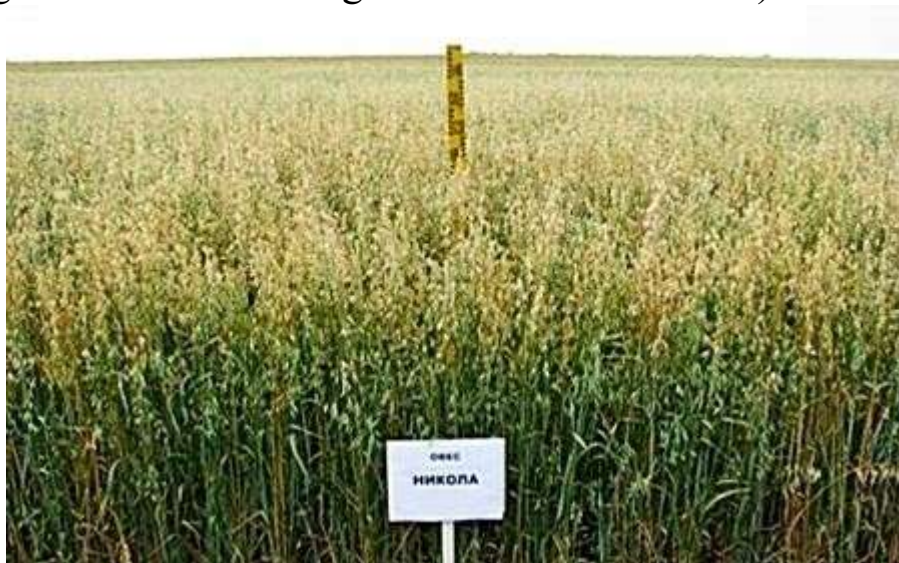


Photo 150. **Variety Nikola developed to get grain.**

The main requirements for oat varieties to be developed **for green plant cutting** are: high protein content, good leaf formation, green mass productivity, and reproduction coefficient. The small seeds are proposed to be more suitable in this state. And more importantly, not only varieties with small seeds, but the grass on the soil should be tolerant to harming under the foot pressure of animals at the time of grazing and rapid growth again.

A successful result depends on identifying the main traits of the breeding process, taking into account the soil, climate, and technological conditions in the organization of breeding works, and often changing the requirements posed to varieties.

Oat breeding is directed toward high productivity. The major requirement for the new oat variety is high productivity. This trait is related to a complex of traits, properties, and growing conditions. Increased productivity on account of increased tillering is not correct because it prolongs the vegetation period, not even maturity, not grain uniformity, and leads to other negative consequences.

As usual, additional stem setting (tillering) does not get over 1.3, while in a lower plant stand, tillering can make up to 5-7 product-bearing stems. Productivity of panicle is one of the yield levels providing indexes. It drives the grain number and weight of 1000 grains on the panicle (photo 151).



Photo 151. **Panicles, spikelets, and grains of oats (1-hulled; 2-naked).**

The number of grains on the panicle is a constant trait of variety. The grain weight may be differentiated within spikelets. To create varieties with two grains per spikelet is considered by the breeders to be the optimal one. According to this, the productivity of the oat varieties is primarily dependent on the spikelet number, seed number, and weight of 1000 grains.

Half and compressed panicle forms are preferred because such panicles allow to plant 6 million seeds and harvest 2–2.5 tons of yield, in which panicles of plants set 35–45 spikelets per panicle. These numbers

will increase by over 100–120 spikelets per panicle if there are high agro-practices.

It is important to remember that the selection is targeted at panicle productivity, which leads to rising plant height and prolonging the vegetation period. To prevent this, the crop index will be increased, which is the increase in grain output based on biologic yield weight.

Properties of plant vitality, intensive photosynthesis, period of certain developing stages, and resistance to negative environmental stresses (ecological plasticity) have a great importance in the breeding directed to productivity increasing.

Oat breeding is directed to increase the resistance of varieties to lodging. Selection of resistance to lodging is conducted together with productivity increasing. Selection is targeted at this trait, which leads to a decrease in stem height and an increase in the yield index.

On the other side, oat hay is a good nutrient for agricultural animals, which is why decreasing the plant height to 75–80 is not purposeful. At the same time, the firmness of the stem and elasticity, thickness of lowered nodes and length, development grade of the secondary root system, and panicle shape (half-compressed or branched are preferable) influence the rate of resistance to lodging. Donor varieties: Universal, Rovestnik, Fix, Nemchinovka, Yakov, Sayan, Konkur, Skakun (photo 152), Alaman, Zhorga (Razakhstan), and others.



Photo 152. **Productive performances of the variety Skakun** (Russia, 2024).

At this point, the advertising data of the oat variety Skakun shows: maximal productivity at the state trial: 7.9 ton\ha while in the production conditions: 6.2 ton\ha. It is middle-ripening, middle-stem height and depth, and resistant to lodging and grain shading.

Breeding is directed toward disease resistance. Selection for immunity was developed. Mainly, individual selection is experienced in the provocation backgrounds of hybrid and mutant populations. This problem can be solved by cell breeding. The first, not typical (horizontal), then by race, not typical (vertical) resistance will be taken into attention. The most harmful diseases are: loose smut, rust, liner rust, powdery mildew, virus diseases, and others. Loose smut occurs across all oat-growing regions.

17 races have been isolated out of the leaf strip (loose smut) in the soils of neighboring countries. 4th and 6th races are the most spread ones. 3rd in west Siberia, 3,4,14,19th in northern Kazakhstan. Resistant varieties: Arman, Nikola, Antey, and Ishimskiy 13.

All oat varieties are being planted in the neighboring republics, susceptible to rust diversities. Comparatively resistant ones are Duman and Bayzat (Kazakhstan, 2019).

Scientists in the USA, Canada, and Australia use successive hybridization between vizantiya and common oat and mutagenesis to create resistant varieties to many kinds of rust diseases. 48 races of crone rust have been found in Commonwealth countries, more than 100 in the USA, and 14 stem rust diseases. Weakly infected races of crone rust (228, 231, 239, and 240) are widely spread. 316, 335, and 456 races are highly virulent ones. It was discovered by some scientists that the productivity of resistant varieties and variety diversities is lower than that of susceptible ones.

Many line varieties are developed in the USA to control rust diseases. They have to be uniform in their phenotypic traits and have resistance to different races of rust. The breeders of these varieties are usually guided by the principle that the genotypes of these varieties are capable of withstanding the widespread spread of any rust races and, thereby, providing productivity to the variety for many years to come.

D.U.Erimin and others (2022) stated that the resistance of oats to diseases controlled by definite dominant species For example, resistance to corona rust is controlled by the dominant gene Pc, discovered in the various varieties and samples of oats and described over 60. On the basis of these, we used the varieties Bond, Victoria, Red Rustproof,

Landhafer, Trispermia, Ukraine, Santa Fe, Clinton, and Garry as quality resistant gene sources. Bond type resistance is determined by two complementary genes, Pc-3 and Pc-4; in the types of Red Rustproof, Landhafer, Clinton, and Trispermia, the dominant genes are detected. Resistant types of Santa Fe and Ukraine have been stipulated by coupled two genes: Pc-6 and Pc-9 (Santa Fe), Pc- 9 and Pc-6c (Ukraine). These varieties are potential donors to improving the corona rust disease resistance of planting oat varieties.

Oats breeding is directed toward the nutrition of oat grain. The grains of oats have a thick,, smooth, enlarged, thin peel, which will have a lot of protein and irreplaceable amino acids. The quality of grain is considerably worsening under the effects of increased peel content and pair grain status. Unfortunately, high peel status, non-even grain setting tendency, and lowered protein content are the characteristics of many of the new oat varieties.

According to the information, the protein content in oats ranges from 12.5 to 18.5%, and the lisin in them is -3.2 to 5%. On the protein quality scale, oats have a leading rank among grain crops because they contain 80% of albumin and globulin. They provide a higher solubility of oat protein in water and contain a lot of lisin. There is no negative correlation between amounts of oat protein and lisin. But varieties with a high protein content have less productivity. In spite of this, genetic research and practical breeding work demonstrate the possibility of combining high productivity and high protein content into one variety genotype.

Also, there is information about the USA scientists, who use a lot of protein-containing Mediterranean oat varieties (photo 153) to increase the protein content of the new oat varieties.

Much higher protein content in the hybrids is observed when wild oats are taken as the maternal form. They say the American oats can also serve as a protein source to increase protein content. Here, we can add that some of the oat varieties developed in the commonwealth countries are Tubinskiy (12.46%), Vyatskiy (16.88% in the fodder direction), Mestniy Tunis 1 (15.10%), Medved (13.11%), and Taydon (16.48% in the food direction), which are distinguished for their high protein content (Krasnodar, Russia, 2019).



Photo 153. **Mediterranean oats, *Avena fetua* L.** (Internet source.).

Chapter 4. Oat breeding methods

The oat crop in our republic does not have the same priority as wheat, corn, and barley, so we have not found its annual definite planting area or the amount of seeds provisioned to plant. In our textbooks devoted to grain crops' breeding and seed production, we were also informed that not all worked-out plant breeding methods are used in the development of new oat varieties. From internet sources, we could also see that the main methods of oat breeding are:

- choosing of parental pairs
- selection
- hybridization
- artificial mutagenesis

From the point of view of world-leading countries on oat growing and production like Canada, Russia, Australia, Poland, Brazil, Finland, the United Kingdom, Spain, the USA, Germany, Argentina, and China, we planned to analyze the last oat breeding method used by scientists in these countries to develop their latest oat varieties.

Canadian oat breeders (Dr. Kiby Nilsen and others, 2023) particularly tend to develop the milling quality of oat varieties suitable for organic production. In this purpose, they are evaluating and identifying initial materials (photo 154) with a high level of resistance to oat rusts, acceptable milling quality, suitable environmental conditions across Canada, and ever-increasing organic markets.



Photo 154. Canadian plant breeders have such areas – “Innovation Fields” are designated “Agricultural Research” (Laura-Lee and Jim Dyck, 2008).

Dr. Weikai Yan and others (2023) are working out optimal agronomic practices to retain the high and stable grain yield and quality of newly developed cultivars (varieties). **Genomic selection** methods are one of the basic methods in their plant breeding process. They improve the genomic technique to deploy rust resistance genes through a survey of Pc gene (gene responsible for controlling resistance) potential in the growing cultivars throughout Canadian oat plantations. Jointly with North American breeders to enhance the genetic diversity of neighboring oat varieties, and then through joint testing and genotyping that helps germplasm exchange.

At this time, Canadian oat breeders and seed producers advertise their newly developed varieties: Ore6251M, Ore3541M \$ Ore3542M – SeCan, Ore Level148, Ore Level150, and others as sources of high quality, high yielding, increased kernel density, uniformity, improved nutrition and safety, continued adaptation and integration with the soil, and an ever-changing climate for breeders and seeds for oat farmers.

Here, the letters and numbers in the names of varieties mean: in the example of the variety Ore3541M. Ore – oat advantage program (oat research), 3 – very good lodging resistance: on a scale of 1 best to 9 worst; 5 – medium maturity: on a scale of 1 earliest to 9 latest; 4 – above average yield: on a scale 1 highest to 9 lowest; 1 – in the series of agronomic practices; M – for milling.

Plant breeding companies like “Lifeasible” render a wide array of plant breeding services, from traditional breeding to modern marker discovery, positional cloning, marker-assisted breeding, haploidization, embryo rescue, polyploidization, genome-wide association, QTL and association mapping, space breeding and others.

The Russian Federal Research Center “Nemchinovka” has a laboratory on oat breeding and preliminary seed production. This laboratory carried out oat breeding to create hulled and naked grain oat varieties with higher potential productivity and resistant to biotic and abiotic stresses. **Intraspecific hybridization with using of geographic remote parental forms** is the main plant breeding method. Hybrid populations and perspective lines developed by the scientists (photo 155) of this laboratory underwent ecological testing in Ulyanovskom, Kurskom, Verkhnevoljskom, Tulskom, Kalujskom, Ijevskom, Kotlasskoy, Chehcenskoy, Kabardino-Bolkarskom, Aktubinskom (Kazakhstan) regions.

During the period of functioning of this laboratory, it released 27 oat-hulled grain varieties and 3 naked grain varieties through its collaborations and co-authorship with other scientific-experimental institutions. Varieties of Arkhan, Azil, Borets, Bulaniy, Vsadnik, Griva, Grum, Dragun, Derbi, Zalp, Kenter, Lev, Nemchinovskiy 61, Opolniy, Risak, and Yakov. These varieties occupy all regions of the Russian Federation.



Photo 155. Oat breeders of the laboratory of oat breeding and its preliminary seed production (2023).

Commercialized breeding companies like InterGrain (2024) are engaged in the breeding of oats under the guidance of the national oat breeding program. They create new varieties for milling and hay oats, side by side, with a broad genetic base equipped to meet the ever-growing needs of Australian farmers and exporters. The oat breeding works are carried out by the scientists of the South Australian Research and Development Institute (SARDI, photo 156).



Photo 156. **Breeding plots of the research department of the SARDI.**

Scientists working out short, medium and long term breeding processes:

***Short term:** increasing population sizes and selection intensity. Reduced time for variety development cycles (using speed breeding and summer nurseries). Improved seed propagation (reproduction).

***Medium term:** Develop and apply **genomic selection methods through genome sequencing**. High throughput phenotyping of hay yield and quality.

***Long term:** Widen the oat gene pool.

Over the past 20 years, the oat breeders of this institute have released 17 varieties, including eight hay varieties.

Oat breeders in Australia rely heavily on North American germplasm (collections) introduced with oat improvement programs. They guess oat germplasm from Canada and the USA is well suited for fodder-direction breeding too. And they could release local varieties: Wintaroo, Brusher, Kangaroo, Mulgara, Tungoo, Tammar, Forester, Koorabup, and two recently released ones: Wallaby and Kultarrin (2022), 13008-18, and Koala (2023). In 2020, eight of their new hay varieties made up more than 80% of export hay produced in Australia, while nine milling oat varieties made up more than 90% of Australian milling (grain) oat varieties.

They are the best initial materials for our oat breeders. For example, their short characteristics are: 13008-18 is the variety of InterGrain company. It is a dual-purpose oat variety and is intended to be used in all growing regions of Australia. And Koala, which is a mid-to-long-season oat variety and suits growing rainfall soil conditions. Both of these varieties have improved disease resistance and have

world-superior yield potentials, making them good options for growers and grain consumers.

According to the Polish oat breeding history (by Anneta Koroluk and others, 2022), for a long period there were used **selection, intraspecific and interspecific crosses**. These methods focused mostly on improving yield and resistance to environmental stresses did not narrow the existing oat gene pool, as many scientists say, but enabled the release of cultivars (varieties) that are competitive in the European market.

Now functioning, many plant breeding and seed production companies (see photo 157) like Danko offer their new oat varieties developed on the basis of the latest implemented tools and breeding methods for **evaluation of oat germplasm using cytogenetic and molecular analysis**, which also promote the annual registration of improved varieties.



Photo 157. One of the experimental fields of oat varieties diversities in Poland.

Reflex spring oats are one of the high-yielding varieties advertised in the recommending channels. It is distinguished by a low percentage of husks and the highest fat content, which provides superior feeding quality with a high energy value.

It was also noted that this variety has low soil requirements and is recommended for cultivation throughout the country of Poland. Its seed production is carried out in several seed centers in Poland: Kopaszewo, Szelejewo (Wielkopolska), Laski (Mazowsze), Dębina (Pomorze), Sobiejuchy, Łagiewniki (Kujawy), and Modzurów (Śląsk).

In Brazil (by Marcelo T.P. and Luiz C.F., 2020), especially in the southern regions, oat cultivation has progressed in the last two decades, having reached 375 000 hectares of oat planted area in 2018, with grain production of 800 000 tons. Corresponding to about 300,000 tons more

than the previous record, reached in 2005 (data by CONAB, 2019). This success is not only due to specific cultivation technologies but also to the joint efforts of various SRIs under the coordination of the Brazilian Oat Research Commission (CBPA), who work cooperatively to assay (test) grain yield and other agronomic traits of the collection samples and new white oat lines that are being developed by breeding programs.

The pedigree modified method (Itamar C. Nava et al, 2016) was used in the oat breeding program. For example, this method involved in the segregating population developed from the pollination UFGS 995090-2 x URS 21 was developed and selected from F2 to F6 with the help of a modified pedigree method, conducted at the experimental station. At this point, the main traits and procedures of the breeding method consisted of:

1. Plant density varied from 25 to 30 seeds per linear meter in the F2 generation.

2. Selection of the best plants started in F2, and only one panicle from each selected plant was harvested.

3. Selection of the best families started in F2-F3.

4. Each panicle harvested in the previous generation composed a two meter long double –row in the next generation.

5. Plant density was determined by the number of seeds present in the previously selected panicle.

6. All generation was conducted in a no-tillage system, with soybeans as the preceding crop. At this, the main criteria used in the breeding nurseries included: vigor and biomass, when plants develop up to 6 to 7 leaves (40th days after emergence); plant height, number of days to flowering and to full maturation; disease resistance; lodging resistance and panicle fertility at the maturity stage. In the condition of lab traits related to visual (or screened) grain quality were selected: on their size, shape, uniformity, grain filling and health (absence of diseases: blach spots, fusarium).

In the breeding program (Marcelo T.P., Luiz C.F., 2020), Urs Monarca is a hulled F6 derived from the line created from the simple pollination UFRGS 06 6083-3 x UFRGS 006183-2. This cross was conducted in 2008. Seeds of the first generation (F1) were sown in 2009. Panicles from all F1 plants were harvested and threshed to plant their seeds in the next year as F2.

Selection was begun since F2 out of the segregating population and continued up to F6, corresponding to the pedigree-modified method

described above. As a result of a result of that method, all segregating populations were grown in the nurseries in a non-till system (planted in June and harvested in October).

The breeding process with selection continued until 2014, when three F5-6 lines were marked with numbers of 146155-1 to 146155-3 and UFRGS 146155-3'. In 2015–2018, they passed through cooperative trials in eight to ten locations across the country. And the end of this breeding process was accompanied by the release of the line UFRGS 146155-3 as a cultivar with the name URS MONARCA. It represents a new option for farmers across the sub-tropical regions of Brazil.

It is a variety with high and stable grain yield, best grain quality, short vegetation with short plant height, good resistance to lodging, very good dehulling (73.6%), low grain breakage (less than 1%), and a high milling yield (>65%).

The development of oat breeding methods in China (Zongwen Zhang et al., 2023) can be an example for us from neighboring Asian countries. Crossbreeding (inter-variety and inter-specific) was popular in oat breeding after the 1960s.

Later, irradiation treatment with gamma rays was mainly used as an irradiation method. Usually, the proper radiation dose of gamma rays should be 15,000–25,000 roentgen units, and the dose rate should be 100–150 roentgen units per minute. The well-known Chinese oat varieties Yanhong 3, Fuza 2, and naked variety 1809 were developed after irradiation treatments. Now, the different approaches to biotechnology are widely used in oat breeding (figure 57, 58).

Germplasm evaluation

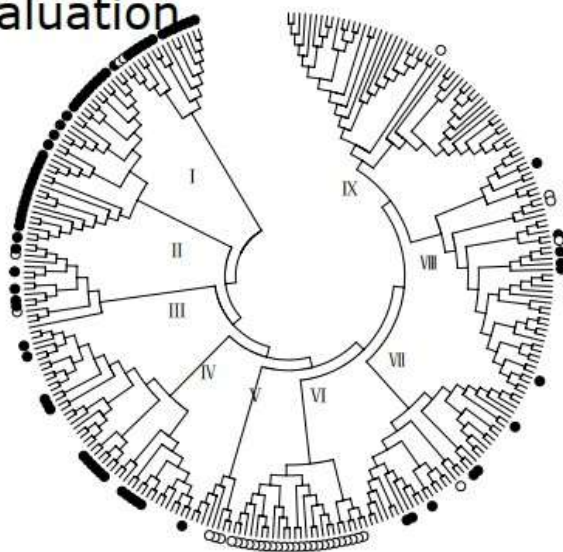


Figure 57. Clustering of 281 naked collection samples by neighboring analysis.

Where, ●Domestic cultivars; ○Exotic accessions; Domestic landraces are unsigned.

Oat growing condition and main directions of oat breeding in China:

- *Different agro-ecological zones.

- *To use both: grain and fodder.

- *Biotic and abiotic stresses.

- *Growing in cool and high altitude mountain.

- *Regions with a mixed system of cropping and animal husbandry.

High yield:

- *10% higher.

- *A good combination of yield components.

- *Spikes per unit.

- *Kernels per spike.

- *1000-grain weights.

High quality:

- *High protein content (more than 17%).

- *B-glucan content*, became a priority in order to meet the requirements of processing.

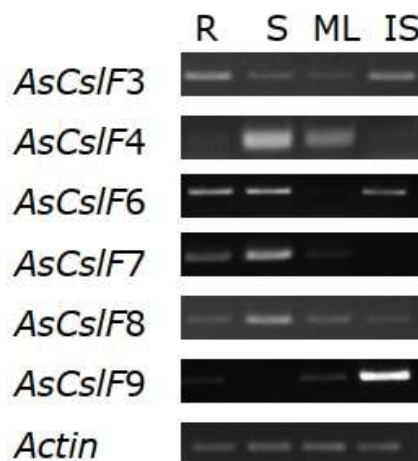
- *green stems with a high protein contents at maturity, and higher plant stature (over 120 cm).

Resistance to biotic stresses (smut, rust, BYDV, aphids) and drought (annual rainfall <300 mm).

Major growing oat varieties In China: Bayou series, No.1-13; Jizhangyou series; Baiyan series, No. 1-11; Mengyan series and Dingyou series.

Identifying genes of useful traits

- *β*-glucan synthase gene, designated *AsCSLH*, and its genomic DNA sequence were cloned from the oat landrace *Xiayoumai*



R: Root; S: Stem;

ML: Mature Leaf;

IS: Immature Seed

Figure 58. **Identifying a SNP** closely linked with B-glucan content, which can be used as a marker for selecting high B-glucan content for establishing the MAS.**

*B-glucan is a soluble fiber occurring in the brain of oats in the amount of 5%. It is hydrates and contributes to dough stickiness.

**SNP – single nucleotide polymorphism.

Chapter 5. Hybridization technique of oat plants

The necessity of isolating the oat plants to prevent their natural pollination with off-pollens considerably hardens the oat breeding work.

Oat crops are to be disposed of at least 1000 meters apart to ensure the insecurity of variety oat crops from outcrossing. To have oat areas of about 20 hectares each at the oat breeding institutes is purposeful to propagate bred families and lines in their good isolation (at least 200 meters from each other) for further hybridization.

“Screened” isolations are used to build small isolated (individually) areas with 1-2 m², and even the oat areas are located between top-height crops at a distance of at least 50 m from each other. Beside that, meter-sized metal frames (photo 158, 159) are also constructed to isolate different oat plant samples before their crossing to control hybridization, and at the time of pollination, they help to cover plants with gauze material.



Photo 158, 159. **Handmade frames for isolation of oat plants**
(Marzena W., at al., 2018).

Breeders can install pegs beside the plant bush with attached transparent caps—isolators—to put on the plant panicle in the case of a rare oat sample with a little bit of panicle in the nursery row.

Hybridization of oat plants with rice involves the selection of plant panicles, emasculation, and pollination. It is better to follow the example of oat crossing described by the breeder, G. Varsha (2016).

As we know, blooming begins in the upper floret. We also should know well about the existence of incomplete flowers because of a lack of sepals and petals. To know the diversities of florets and their components (photo 160) also. At this stage, each normally developed

floret of oat spikelet has two lemma, two palea, three stamens (anthers), a stigma, two large glumes, and an awn.

The necessary tools to be required for successful emasculation and pollination are dissecting forceps, dissecting scissors, needles to do lace, paper tags, paper clips, and cover paper bags (isolators).

Also, we should be reminded of the oat flowering biology, which reminds us that oat is predominantly a self-pollinated crop, and in order to ensure complete isolation, the spike is enclosed in a bag. The bagging thing must be cotton cloth or, as usual, a paper bag.

And now emasculation, which is done by removing the anther with forceps. Depending on the biology of oat panicle development, it may be made at any time of day, but it would be better in the morning because mornings are generally a good time for scientists to pollinate. We must focus on ensuring its quality. In particular, successful emasculation is the result of selecting the right spike for the emasculation, which must still be enclosed by the flag leaf sheath (photo 161).

The next step is opening the flag leaf sheath using the forceps and forcing the leaf edges with the help of the of the forceps, as shown in the photo 162. After that, the sheath and flag leaf are cut with the help of a dissecting scissor at the level of the first node of the rachis (photo 163).

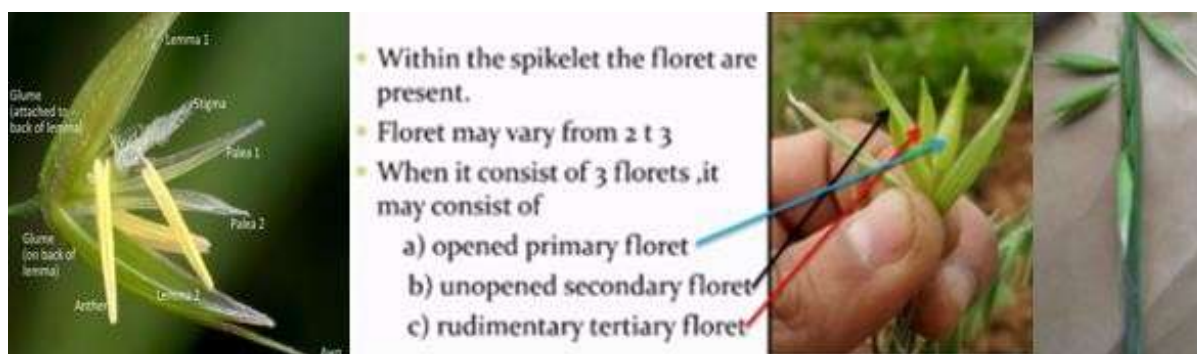


Photo 160, 161, 162. **The parts of oat spikelet, their development order and selected spike** (Varsha G., 2016).

Removing or cutting off the lateral florets and tips of the selected spikes is the next steps of hybridization (photo 164). The anthers are seen after cutting off the edge of spikelet and they will be removed with the help of forceps. And continue to remove of anthers in this order from all florets (photo 165). This is the emasculation of the oat flowers to prevent self-pollination.



Photo 163, 164, 165. Opening the selected spikelets, cutting off the sheath, flag leaf and removing anthers.

Then, after removing all anthers from spike florets in order to prevent outcrossing (or contamination from foreign pollens), the emasculated spikes will be bagged (photo 166). At this moment, the emasculated flowers of the panicle are ready for pollination. The scientists knew that the oat pollen's viability would last from early morning until midmorning. While stigma is receptive all day if mature pollen is available,.

And now to pollinate maternal flowers with anthers of paternal flowers. This begins with selecting the right spikelet (or spike) of the paternal plant in which the male pollens (anthers) have begun to dehisce (photo 167). Pollination delayed for 3-5 days in the condition of Uzbekistan, depending on the development of oat plants and especially the flowering biology of paternal plants.

At the availability of paternal panicle, the sharp scissor is used to cut off the top one-third of the selected paternal spikelet to expose the pollens (photo 167). This act helps to make all anthers visible, and the spike is used to dust on the emasculated maternal spike (photo 168). The spike is shaken above the maternal spike with the tip of the forceps to fall the pollen on stigma. The falling of pollen will be visible because of their yellow color and when they land on the surface of stigma. And now is the time to end the process of pollination. At this point, make the necessary records on the paper tag and lace for the tag with needles and by its thread. Records have the names of maternal and paternal plants, the date of emasculation, the date of pollination, and the name of the assistant (or breeder).



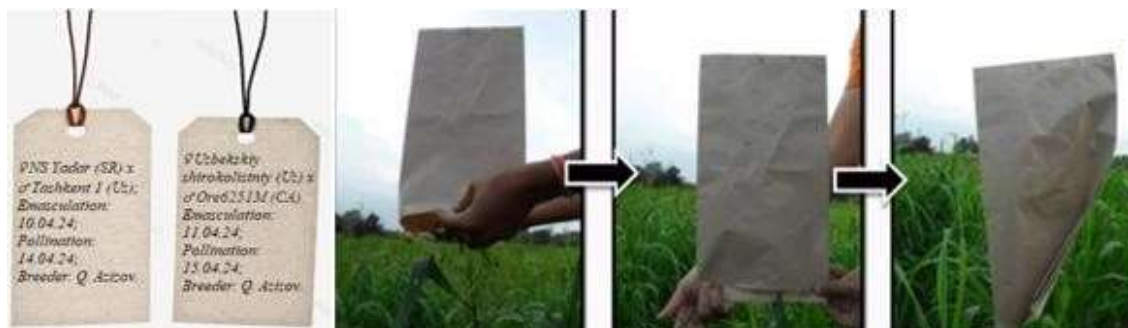
Photo 166, 167, 168. **Begging a emasculated panicle, spikelet with dehised pollen bag, cutting top part of this spike and dusting (pollination).**

Attach the paper tag with its lace or with a paper clip on the node under the panicle. And bag the panicle with pollinated spikes. The bag also bears the same information as a paper tag, which is why this information is written similarly at the time of preparing them (bunch of photo 169).

Pollination of oat flowers is considerably tedious to perform, and often the seed set is low. Artificial cross taken against natural, interval between emasculation and pollination, letting pollination by man-selected pollens, harming the stigma, temperature, and light changing in the bag are the factors affecting and resulting in low seed set.

Pollinated plants firmed on the wooden sticks are left until harvest time with their tags and bags. Information about the tags and bags registered on the pages of the hybridization book helps accurately pick up individual hybrid seeds in autumn.

There are some other methods of oat crossings used by oat breeders, depending on their choice:



Bunch of photo 169. **Paper tags and bags to use at the time of oat hybridization.**

*Artificial pollination of a maternal panicle put under a pergament isolator with picked-up pollens.

*Constrained free pollination: at this stage, paternal plants are disposed of under a group isolator (glass-bottle method or placing pollinators by side), and maternal plants are planted near the paternal plants, allowing emasculated spikes to pollinate freely.

The last method is being considered the most efficient one.

Chapter 6. Assessment of oat breeding materials

Oat breeding materials are assessed in the process of studying initial materials and the creation of new forms and varieties, their productivity, cold, drought, diseases, pests, lodging resistance, food, and technologic properties of grain, and according to their reaction to the growing in intensive technologies, including response to fertilizer application, together with different chemicals and local agro-practices.

Assessment of breeding material is carried out on the direct and indirect indexes in the common and provocation backgrounds with the help of field (photo 170) and laboratory methods (photo 171). The method of state variety trials for agricultural crops (Moscow, 1989) is often used as a guiding instruction to assess initial plant samples, hybrids, and varieties.

The productivity (grain or hay) of oat varieties, hybrids, and collection samples is the first priority economic trait in oat scientific breeding research. According to the requirements of that guidance, samples of the varieties with more than 15% lowered productivity are not delivered for quality assessment in the laboratories of the state variety trial.

The new example of oat productivity assessment in the correspondence of that guidance we can see in the context of the master's dissertation of A. Makhmudov (2023) on the theme of “Isolation of initial oat samples with valuable economic traits for plant breeding from oat collection.” Ecologically remote variety samples consisting of 15 numbers have been presented for oat collection in this research.

Productivity is a complicated trait, and it is determined by the result of the calculation of some plant productive components that enter the biometric surveys and measurements of plant breeding works. 50 plants of every plant sample in the I and III replications were tagged for detail measurement and data collection.

The following phenology surveys are carried out according to the state variety trial with those tagged oat plants:

- seed germination in the field condition;
- plants' number, m²/piece (at the beginning of vegetation and its end);
- plant stem height, cm (10.05 and 01.06 days);
- variation of leaf surface (along vegetation period);

- accumulation of dried substance by plant (along vegetation period);
- number of panicles per plant, length, piece\cm;
- grain and hay productivity per plant in the experiment and summing up productivity per hectare.

The last one is the assessment method of every oat sample and their standard varieties to identify productivity potentials.

So, two mature stem probes from two points in 1m² area each in all replications of samples from the experiment are marked. Then plants are taken by cutting off stems at the height from which the harvester is cutting. They are put in specially prepared sample bags or made into hay bundles. Then they threshed in the special machines, and grain was also separated by the grain sieves of this machine (photo 172).

Grain and hay brought together from every replication of samples are weighed on a special scale with an accuracy of 0.1 gram. An average weight of grain or hay from two samples will give the first data about the productivity of every studied oat sample and their standard varieties.



Photo 170, 171, 172. Researcher Georgie Troup evaluates a range of international oat gerplasm in the field (2019); assistant S.Tagetdinova, department of plant breeding and seed production of agricultural crops, is preparing an oat bundle to lab analyze (2024); and a new grain thresher.

Assessment of 70 hulled oat samples and 16 naked oat sample forms on their productivity and biochemical indexes was carried out earlier (2014) by O.A. Usova and others. The seeds of the samples were sown in 2010–2012 in the microfields (3 m²) of each laboratory. And determination of oat samples' productivity has been done according to the state variety trial method (table 52). The most productivity for hulled

grain oats and naked grain oats has to be considered in 2011 (advantages of productivity over 2010 and 2012 consisted of 200–230 g/m²).

On the basis of the data in the table, it is easy to deepen the assessment of the productivity of plants per individual plant in the nursery and per hectare. For example, take 419.1 g/m² for hulled grain forms and divide by the number of plants in the nursery. The taken gram of grain will demonstrate the productivity per plant. Or multiplying 419.1 g/m² by 10 000 m² you can get the productivity per hectare: 419.1 x 10 000 = 4 191 000 g = 4 191 kg = 4.19 c = 4.1 ton/ha. This order of calculation can be continued as an assessment of productivity for every studied sample (take a look at the manual of this text book, 2019: <http://library.ziyonet.uz/uz/book/126706>), and you will learn to identify the productivity of every studied oat sample and your standard variety.

Assessment of the cold resistance of oat variety samples was also implemented in the experiments of A.Makhmudov (2023). This is a good chance for us to analyze the method, taking into account the local climatic conditions of Uzbekistan. It was also noted that oat has to pass through 70–90 days of its compulsory dormant period. This period is characterized as the adverse environmental period harming plants as a result of frostbitten plants under lowered temperatures in the winter.

Table 52. Characteristics of the collection nursery on productivity and grain quality (2010-2012).

Parameters	Productivity, g/m ²			Protein, %			Starch, %			Fat, %		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Hulled grain forms												
Min	60.0	250.0	73.0	11.6	9.6	10.1	40.8	44.8	38.6	2.9	3.2	2.2
Max	363.0	765.0	350.0	16.9	15.2	48.8	48.8	48.8	42.5	5.8	6.5	5.8
Mean per nursery	253.6	419.1	199.2	14.4	11.9	12.2	45.0	46.5	39.9	4.7	4.6	4.1
Naked grain forms												
Min	72.0	150.0	80.0	17.6	14.7	15.4	58.9	46.8	45.5	5.9	4.7	4.7
Max	143	440.0	147.0	21.9	16.5	18.4	60.3	64.0	60.3	8.5	9.6	6.9
Mean per nursery	123.5	319.3	114.2	19.1	15.6	16.8	59.8	59.7	57.1	6.9	6.2	5.9

Scientists discovered that varieties planted before winter days are able to delay their growth considerably and, at this time, accumulate a definite amount of sugar, which ensures a decrease the loss of cold effects in the winter.

The cold resistance of plants is assessed visually in the spring by counting the number the number of plants left alive and their number in percent compared to the number of plants before winter (table 53). Additionally, through this visual method, plant thinning grade is assessed in different parts of the field.

According to the state variety trial, the average assessment of cold resistance is calculated up to a precision of 0.1 mark as the mean arithmetic of the index along the replications. Assessment of plantation state before winter and spring, after emerging foliage in every replication with corresponding marks: 5-excellent state with proper plant stand; 4-good state with plant stand of 71–80%; 3-mean state with plant stand of 61–70% 2-not good state with a plant stand of 51–60%; 1-state in autumn is bad, with a with a plant stand of 31–50% and 0 seedlings lost; saved plants are not more than 30%.

Drought resistance. Cultivation of drought-resistant varieties is one of the most important means of combating drought. The most productive use of water at a higher temperature, lowered humidity of soil and air, and higher yield in these conditions with good product quality means plants' capability under drought (photo 173).

Field methods to assess drought resistance. Assessment of breeding material may be conducted directly in the field with available traits; at this stage, no special experiments are laid. A thorough survey on drought resistance, comparing the crop and product quality of varieties in drought, and favorable effects on the precipitation of years are carried out in common field conditions with all studied varieties and breeding numbers.

It is necessary to know how drought affects plants' growth, size of ear and grain setting, colors of leaves, speed of their drying, and so on. Similar surveys and accountings of relative decreases in the crop of different varieties in the dried years let to identify the rate of their drought resistance.

Table 53. An average results on the resistance of oat variety samples to cold (A. Makhmudov, 2023)

№	Variety samples	Name of countries	Number of over wintered plants (%)		Mean, (%)
			2021	2022	
1.	Uspex (standard)	Uzbekistan	75	65	70
2.	<i>Umutica</i>	<i>The USA</i>	70	85	77
3.	<i>Av. Bujantuna</i>	<i>The USA</i>	70	75	75
4.	<i>Avsativv</i>	<i>The USA</i>	90	80	85
5.	<i>Annea</i>	<i>The USA</i>	85	75	80
6.	<i>Av bujantuna</i>	<i>South America</i>	85	85	85
7.	<i>Av bujantina</i>	<i>Argentina</i>	80	75	77
8.	<i>Bug'ant nidro</i>	<i>Algeria</i>	75	70	71
9.	<i>Av sotivo</i>	<i>The USA</i>	40	65	55
10	<i>B/naz</i>	<i>Kyrgyzstan</i>	50	40	44
11	<i>Av bujantina</i>	<i>Turkey</i>	65	70	70
12	<i>Anzea</i>	<i>Spain</i>	85	75	77
13	<i>Mest V amreo</i>	<i>Turkey</i>	85	90	90
14	<i>Satina</i>	<i>Spain</i>	75	70	71
15	<i>Abtusata</i>	<i>-SSR</i>	86	80	83
16	<i>Anren</i>	<i>F. RG</i>	50	40	44

For example, varieties have experienced a great oppressive action of drought and not resistant varieties gave less crop in those conditions in comparison with other good resistant varieties.

Accounting for dry matter growth is an important indirect trait in the assessment of varieties on drought resistance. The growth of dry matter in all crops is decreased at the beginning of dry weather, but in dry-resistant varieties, this process goes more slowly than in non-drought-resistant ones.

50 to 100 plants were picked up once for 2-3 days at the first appearance of drought on the plantation of every variety to determine the dry matter. Its growth for a long time in comparison with temperature, relative air humidity, and soil moisture can adequately characterize the relative drought resistance of comparing varieties.



Photo 173. Oat experimental field of Cornell Cooperative Extension (2016) to deal with drought challenges in New York state.

Assessment of drought resistance in the special installation. Plants of various varieties are planted in the vessels to assess their drought resistance to air drought, which can be transferred into a chamber with a dry air ventilation installation where the plants are exposed to strongly warmed air and wind. Prior to supplying air to the chamber, let it go through refrigerator installation or hygroscopic substances where it dried and then heated up. Usually, it has a temperature of 38-40°C and a relative humidity of 16–18%.

Assessment of varieties in this method gives comparable productivity of experimental and control (standard) plants.

Assessment of loose smut. Economic loss caused by loose smut at the level of 1-2% infection leads to a decrease profit of 5-20% (Wilcoxon and Saari, 1996).

Infected production fields and an artificially infected background are needed to assess the resistance of oat variety diversities. Accounting of oat plant damage by loose smut is conducted in the production condition on the appraisal bundle, picked up from a hundred places in the diagonal of the field (1 500 stems). Two approval bundles are picked up in the seed production plantations.

For example, you have passed through the diagonal of a certain field and have picked up a bundle with 1,500 stems. After its disassembly, you found five stems damaged by loose smut. This equates to 0.3% ($1\ 500 = 100\%; 5 - x\%$).

Artificial infection of plants is done during flowering and, in some cases, after flowering. A prolonged period of infection is an index of the strongest susceptibility of plants to infection.

The results of accounting pronounce general accepted indexes of disease spreading. The classification of resistance is implemented on an

international scale: resistance (R) – damage up to 10%; susceptible (S) – damage more than 10%.

Assessment of oats for diseases. Many diseases of agricultural crops cause huge damage, decreasing crop quality. The rust of oats is the first to belong to them. Resistant oat varieties to this disease are important as agro-practice and chemical control means. But creating new resistant varieties is not easy, and beside this overwhelming majority of rust pathogens have huge reproduction rates and physiologic races.

Assessment with the help of 5 marks (0–4) can be used to determine the visual grade of infection in oat plantations. For example, various types of leaves' infection by leaf rust are determined by this system of assessment (figure 59).

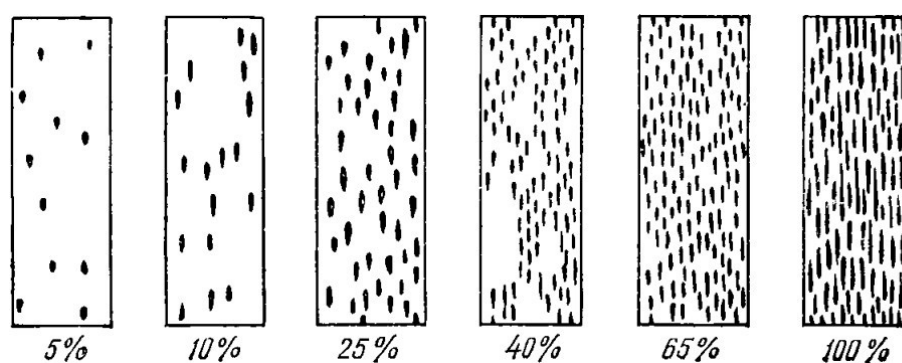


Figure 59. Immune types and grade of oat infection by leaf rust.

Thus, non-sensitized (resistant) plants when there is no sign of disease are marked by 0; 1, 2, 3, and 4—correspondingly, infection of very weak, weak, middle, and strong damage to plants.

The appearance of rust in the field depends on the zone of the plantation and the cropping year. In the absence of a natural background, artificial infection of plants was applied through the spraying of suspensions of spores brought together from affected varieties. The suspension is prepared by adding 10 liters of suspension to 100 m² of plot. The precise assessment of rust resistance of variety diversities takes place only in this method of artificial infection by clean races. At this point, the grade of resistance to rust is determined by the percentage of leaf area covered by pustulams. Commonly, the special scales are used for this purpose.

Accounting for damage caused by harmful insects is conducted in all nurseries and in variety reproduction plantations. The possibility of

the most complete assessment of the resistance of breeding material appears in the years of mass spreading of a definite pest. At this point, taking into account the effect of weather and agro-practice on the number of insects and their harm is obligatory in the years of study. The grade of resistance of the varieties to pests is determined by counting the average number of damaged plants (stems) or harmful insects per unit area (1m^2).

Resistance to lodging (bunch of photos 174) Productivity is the main index characterizing the level of agricultural production. Resistance to lodging is also an important index because the loss of grain as a result of lodging grain crops can range from 15 to 40% (Vargach Yu.I., 2019).

There are many worked-out methods to assess the lodging of grain crops recommended by scientists. The easiest one of them is the assessment by 5 mark system, where 1 mark is massive lodging, 2 mark is strong lodging, 3 mark is the mean grade of lodging, 4 mark is weak lodging, and 5 mark is lodging that is absent.

Assessment of oat variety suitability for intensive harvesting technology. As in other grain crops, oat varieties also assessed their suitability for mechanical harvesting, which depends on a range of traits (resistance to lodging, uniformity of maturation, height of stems' stands, grain shedding, and so on):

5-variety fully fitted to mechanical harvesting, harvested fully without losing;

4-mechanical harvesting is partly difficult;

3-mechanical harvesting is possible with the help of specially mounted equipment;

2-mechanical harvesting is possible only in one direction for the harvest of lodged plantations;

1. There is no possibility of mechanical harvest.



Bunch of photo 174. Experimental field of Yu.I. Vargach with 300 oat samples, 300 grain per 1m² on 0.15 ha to study lodging, yield and adaptability (2019).

Assessment of harvested grain quality.

In the processes of oat breeding and its seed production, it is needed to analyze some of the grain quality traits such as grain humidity, weight of 1000 grains, germination, availability of germinated and cold-effected grains, grain nature (weight of 1 liter of grain), grain damage by insects, and diseases.

Chapter 7. Seed production of oat

The seed production of oats has an important role in ensuring an excellent source of nutritious matter in comparison with other grain crops that don't contain gluten. Products made from oat grain decrease the amount of fat in the food ration and increase the daily consumption of carbohydrates and starch. Its starch and B-glycan render multi-side action on organisms, reduce cholesterol levels and normalize sugar levels in the blood, contact, bind, and remove radionuclides from the gastrointestinal tract, heavy metals, and other toxic matters.

Efficiency of seed production in the primary links, taking into account plant breeding methodology, is improved continuously for widely spread hulled oats and so for naked oat varieties (Batalova G.A. et al., 2015).

Plant breeding methodology for naked oats includes study and selection of genetic donors and sources, creating genetic diversity in breeding material by the method of direct selection (screening), and hybridization with successive selection. The appearance of naked oats is not full; almost all newly developed varieties have 1–6% hulled grains. Minimizing their amount in the new varieties requires conducting negative selection in the breeding nurseries and competitive variety testing in the varying agro-climatic conditions.

That is why individual selection was used in the naked oat breeding of Persheron out of a hybrid population of ♀OA 503/1 (naked grain) and ♂Ulov (hulled grain) and successive mass selection on the naked grain out of seed progenies of individual selection.

Original oat seed production is implemented on the scheme and accepted for self-pollinating crops (figure 60). As a rule, it is individual-family selection. It enables the saving of variety genotype, its productive and other economic useful properties through the selection of better productive and healthy plants (panicles), each of which is then studied along with the progenies in the course of two years in the nurseries of the progenies of the first year and second year.

The next nurseries, or reproduction nurseries, of the first year (RN I) and the second year (RN II), are formed as the result of combining two-year individual assessments of the progenies of individual plants (families).

Conducting such kind of seed production on a given scheme requires attracting a considerable number of specialists to select elite

plants (elite), establish the NIPT (nursery of the first year progeny testing) and NIIPT (nursery of the second year progeny testing), conduct variety and species cleaning and rejection (discarding) in the field and laboratory, individual seed sowing and harvesting, including hand (NIPT), drying, and improving elites and their seed progenies.

The scientists, taking into account the job-consuming and tedious character of that process, worked out approaches to organize the original seed production of naked grain oat at the stage of the NIPT and NIIPT.

At this stage, the selection of elites is carried out by isolating the panicles of the major stem of a plant (1,500–2,000 pieces out of each variety) annually.

Nursery of the second year progeny testing (NIIPT) is used as the quality of selection place. That enables us not to lay a special nursery for selection and isolation elites with higher reproduction and corresponding quality, which ensures a decrease in the number of rejections of their offspring in the NIPT and NIIPT. The elite panicles are bind into bundles of 100 pieces each, dried, and stored until threshing in the airing chamber in a hanged state by panicing down. At the threshing, the elites with a low number of grains and the availability of hull or mediatory grains are rejected. On the manual revision, off-type elites are puny, undeveloped, and with deformed grain.

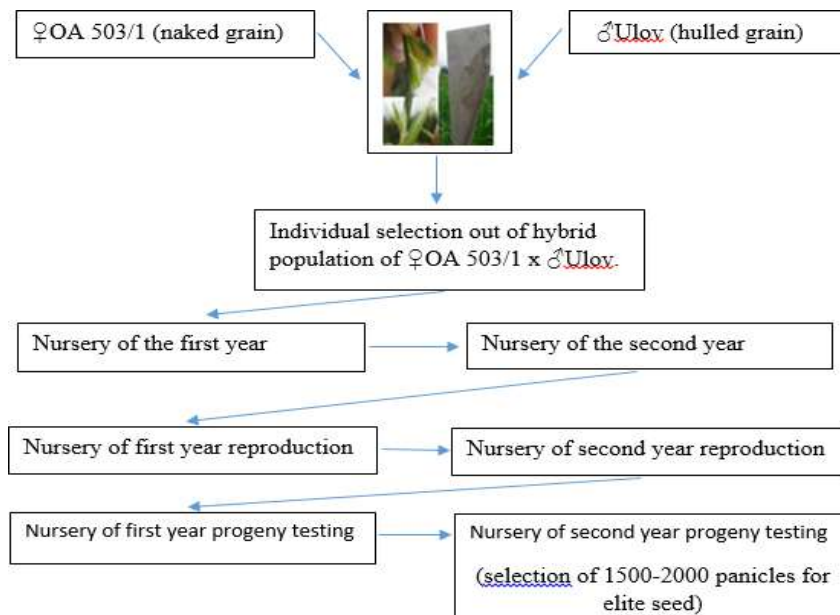


Figure 60. Scheme of primary oat seed production created on the described text.

Sowing in the nursery of first-year progeny testing is conducted by using cosset seed drilling (photo 175) with the elite seeds left after laboratory analysis (1 300–1 800 progenies) on one row with a length of 1 m or on two rows of 1 m each, depending on the amount of seeds. The control places 50 numbers (progenies)—seeds of RN I. A label with the lot number is installed after 5 numbers for control.

Surveys are carried out during the vegetation over the plantation and rejection, starting from the developing stage of the full seedling germination stage. At this time, it is possible to distinguish the oat seedlings from other grain crops. The first leaves of oats are turned to the left; in other grain crops, they are turned to the right. Availability of a ligula-thin transversal film between the leaf sheath and the leaf blade is the distinctive feature in the period of tillering and heading—removed-off type, not developed, disease-effected,

The main rejection is implemented at the stage of full heading: removed-off type, not developed, disease-infected plants prone to lodging out of elite progenies with the help of a sickle or hand. Then, after continued systematic surveys on the maturity rate and plant state in the nurseries, progenies at the additional appearance of defects, with lowered grain setting on the panicles (on the visual inspection), and deviations in the timing of maturation are rejected.

As a result, typical, productive, and healthy plants remain to be harvested in the NIPT. This ensured the taking of productive progeny and completed seeds, which allowed for continuous harvesting with a plant breeding combination like Winterstaiger (photo 176).



Photo 175, 176. Specially created seed driller and harvesters to grain crop breeders and seed producers.

For the convenience of subsequent works, 5–10 families are placed in one bag; indicate the culture on the label, variety, number of lots, and

year. Control variants are harvested separately. Seeds are inspected in the laboratory after drying and processing every individual bag and removing hulled and mediatory grains. Further, these seeds are combined and form the NIPT.

The sieve for processing is chosen so as to remove a small fraction because the weight of 1000 grains, together with the energy of growing and germination, is an important index of seed quality. Individual grains of the spike of the naked oat panicle differ in phenotypic structure, size, and quality. The weights of first, second, and third grains have a ratio of 3:2:1. The first grain has the highest weight and most demanding value. The most productive plant comes from it. The highest field germination in 2006–2012 was taken from the heavy and middle seed fractions (82–83%; $r=0.71$) of the variety Vyatskiy (Batalova G.A. et al., 2015). This biological principle applies to all grain crops.

Seed sowing in the NIPT is carried out by a batch seeder with a lowered sowing norm (4–4.5 mln vital grains/ha), the length of the lot is defined by the dimensions of the plot allocated under nursery, and depending on the availability, it can be 50–100 m.

Crop, variety, nursery, and year are shown on the poster. Surveys and accountings in the vegetation period are similar to those in the NIPT. The spacing of the path between lots is not less than 0.5 m, which ensures rejections during the vegetation period. The employers walk along the path from both sides of the lot and remove infected, damaged, off-type plants and plants with doubt—they may be of the of the mediatory type or with mediatory grains.

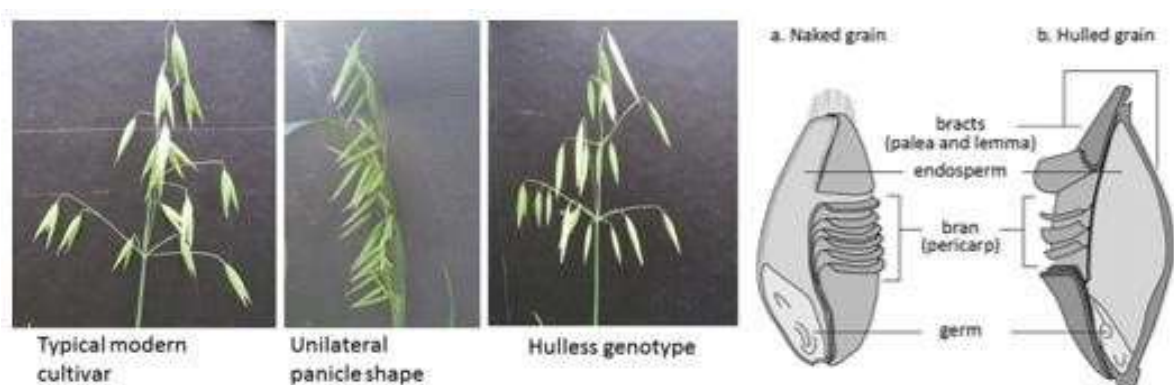
Prior to harvest, the elite panicles are selected, and, if it is needed, additional discarding is carried out on the off-type and infected plants, as well as plants that deviated during the maturing term.

Harvest is conducted with a breeding harvester in linen bags weighing up to 20 kg. The label indicates the crop, variety, nursery, and year. Laboratory inspection is done after drying and seed processing of every bag, manually removing hulled and mediatory grains. The seeds are brought together and used to sow the NR I (nursery of the first-year reproduction) and then the NR II.

Accuracy, timeliness, and organization of production technology in seed production are important. Nurseries are located according to the best predecessors in crop rotation. It enables the production of pure variety, free of hard-separated cultural mixes (barley and ray in oats) and

weeds, not damaged by pests and diseases, and biologic full-value seeds.

Planting qualities of seeds (growing energy, germination, weight of 1000 grains) in a considerable grade are determined by optimal terms of harvesting. The panicles of the naked grain varieties have a multi-flower construction (4-6 pieces). The earlier the grain sets (spikes the upper and central parts of the panicle), the more physiologically mature it would be at the time of threshing, and with a great probability, it cleans from the film (bunch of photo 177).



Bunch of photo 177. Different features of oat panicles and grains (Jugo Hautsalo, 2018; Natalio Alonso, 2019).

Grain of naked form, maintaining the film, often occurs in the late-maturing lower spikes. Germ of naked grain oats is easily prone to damage during harvest and processing. As early as and so late as the harvest of grain affect seed quality. A decrease of 8–12% in seed germination was observed in the naked seed planting harvested 15-20 days later than the optimal harvesting term.

Harvest should be conducted when the grain achieves a humidity level of 18–16%. The seeds from the reproduction nursery were stored in the new bags with internal and external labels in stacks on pallets, indicating variety, nursery, number, batch volume, and crop year.

Chapter 8. Oat approbation

The approval order for the oat seed plantations is available in the instruction on the approval of variety plantations (approved on May 5, 1994). 450 hectares have been noted in Table 3 of this instruction for the limitation the area to be one-time surveyed, in which the approbatory passing through diagonal directions stops at 150 points to pick up at least 1500 straws.

Further, according to this instruction, variety purity of oat is determined by analyzing plants by root or on the approbation bundle (photo 178). The straw (stems) bundle is disassembled into the following groups:



Photo 178. Approbation bundle taken from oat variety Verniy (2020).

- *main variety of approbating crop;
- *other species, diversities and varieties of approbating crop (variety mixes);
- *main crop, damaged by different species of smut, fuzarium and other diseases;
- *hardly separating cultural plants;
- *hardly separating weeds;
- *noxious weeds;
- *toxic weeds;
- *quarantine weeds;
- *underdeveloped stems of the main crop.

The availability of quarantine weeds (dodder, ragweed, and others) is not permitted in the seed plots; the seed plots have to be excluded if there are some plots with these weeds, and the crop from these plots will be used in accordance with the agreement with local state inspections on the quarantine plants.

The number of straws (stems) in all groups is counted after the analysis of plants on the root at all points, or bundle disassembly and analysis of all of them.

The percentage of variety purity is identified by the ratio of the number of fruit-bearing stems of the main variety to the total number of developed stems of approved crops.

Percent of infection of plantations with smut, fuzarious, and other diseases is defined for every species of smut and diseases individually and calculated as a ratio to the total number of developed stems of the main crops (including stems, infected diseases).

Percent of plantation contamination with hardly separating cultural plants and weeds is identified by the ratio of the number of fruit-bearing stems out of these groups to the total number of fruit-bearing stems of main crops, including stems of determining groups for exclusion of stems and infected diseases.

For example. In the result of the analysis of oat plants of the variety Verniy, it was identified that the stems of the main variety Verniv were 1,600, other varieties and diversities were 17, hard-separated cultural plants were 10, infected by smut -3, and so on.

To account the percentage of variety purity is used the following equation:

$$\frac{1600 \times 100}{1600 + 17} = 98,94\%$$

Making round the share of hundred on the rule making round, and in the statement of approval indicates variety purity (98.9%). To account for the percentage of contamination of plantations with barely separating cultural plants (barley), the following equation is used:

$$\frac{10 \times 100}{1600 + 17 + 10} = 0,6\%$$

Contamination of plantation with hard separating weeds is calculated similarly. The percentage by dust smut is calculated with the using the next equation:

$$\frac{3 \times 100}{1000 + 17 + 3} = 0,2\%$$

Infection of the plantation with other kinds of smut is calculated as the calculation of dust smut. The taken data is entered in the section of the approval statement, “Results of Analysis.” At this point, the quarantine weeds, numbers and names are written.

Barley and ray belong to the hardly separated cultural crops in the plantation of oats. If total contamination by hardly separating cultural plants does not exceed 3%, the authority gives instructions to farmers about thoroughly cleaning seeds; if it exceeds 3%, the plantation recognizes it as unfit to use for seed purposes.

Sophora, foxtail, cephalaria, wild oats, and others belong to hardly-separated weeds. If total contamination with all hardly separated weeds exceeds 3%, the plantation is recognized as unfit for seed purposes.

The variety certificate accompanying the seeds must indicate the availability or absence of quarantine for toxic and harmful weeds on the plantation. The plantations are excluded (but elite) if they have different species of smut that summarily exceed 0.5%.

Composed the following documents based on analysis of approbation:

- *statement of approbation on form 193 (appendix 8) - reproduction plantations, the seeds of those are intended to use for own needs;

- *statement of approbation on form 195 (appendix 9) - reproduction plantations, the seeds of those are intended to sale;

- *statement of approbation on form 197 (appendix 10) – plantations of original seeds and for elite;

- *statement of approbation on form 199 – for all registered variety plantations;

- *statement of rejection on form 200 (appendix 12) – for unfitted plantations to seed provision recognized in the result of approbation.

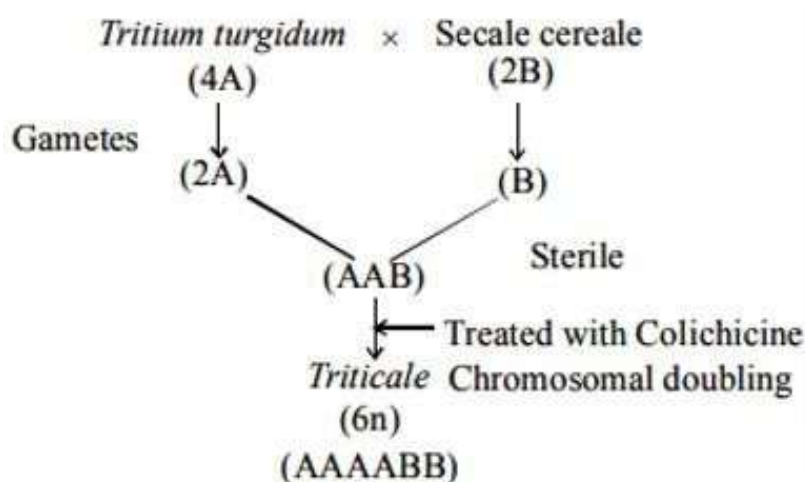
Part IX. Triticale breeding and its seed production.

Triticale – a new plant species of the world created by scientists' plant breeding activities (figure 61).

Chapter 1. Triticale, its social economic importance

Hybrid crop out of wheat and rye hybridization results in a grain crop. It has become one of the most important crops in ensuring food security for nations, fodder in animal husbandry, and poultry farming. It is cultivated in agriculture in one of the three directions: green mass, fodder, and bread flour. In terms of green mass and fodder, it is recommended to feed animals earlier with juicy food to increase cattle milk production. And the mix of fodder with the products of wheat, barley, and other crops enriches the nutritional value of concentrated fodder granules, which greatly increases production efficiency. In the condition of Uzbekistan, the green crop consists of 40.0–50.0 ton ha (cutting at the period of heading); grain productivity is 5.0–8.0 ton ha; and it is resistant to fungus and virus-related diseases.

Worldwide, the top three producing countries are: Poland, Germany, France, Belarus, Spain, and others. Overall, their grain production in 2022 was 14.16 million tons, and these five European countries have a share of 76.27% of total world production (figure 62).



Top triticale producers in 2022 ⁽¹⁾		
Numbers in million tonnes		
1.	Poland	5.44 (38.42%)
2.	Germany	1.93 (13.63%)
3.	France	1.61 (11.37%)
4.	Belarus	1.19 (8.4%)
5.	Spain	0.63 (4.45%)
6.	China	0.39 (2.75%)
7.	Turkey	0.32 (2.26%)
8.	Russia	0.31 (2.19%)
9.	Austria	0.29 (2.05%)
10.	Czech Republic	0.21 (1.48%)
World total		14.16
Source: UN Food and Agriculture Organization		

Figures 61, 62. **Origin of triticale and top triticale producing countries.**

Outlook of ear, construction, and grain shape remind wheat and ray. But triticale distinguishes from wheat on the following traits: its

stem is thicker than wheat stem, firm, resistant to lodging, leaf and ear larger, and grain.

Triticale grain contains 1.0–1.5% and 3.0–4.0% more protein than wheat and ray correspondingly. Moreover, triticale grain has 3.8% lisin and 2.0–4.0% fat. But the quality is a little low.

The grain of triticale is used in bread baking, the food industry, beer brewing, and animal feeding. Bread baking quality is lower than wheat, but mixing them in the ratio of 70–80% to 20–30% correspondingly gets very good quality bread. In the term animal feeding, its green mass, or silos, has a 0.1–1.0% digesting advantage over wheat and ray.

We can see six registered triticale varieties in the state register of the Republic of Uzbekistan for the allocation of variety diversities of agricultural crops in 2022 (table 54). All the varieties are local, developed by our breeders, but one Odisey is from Serbia. And almost all are recommended to plant in the condition of irrigation (I). Only one, Dustlik-4, has been recommended for planting in dry land.

Prag serebristiy is the most long-cultivated variety in the list, and it can be explained by its valuable genetic potential, characterized by its high adaptability, which occupies many regions (2, 7, 8, 11, 12). This variety and Norman and Farkhad have a definite bred and economic advantages to be desired by the side of our local farmers.

Table 54. Triticale variety diversities growing in our republic.

Numb er of order.	Varieties	Number of originat or	Code of the originat or, country.	Year of registrati on	Recommen ded regions to planting.
Triticale (Triticosecale Wittmack)					
20110	Dustlik-4	5	UZ	2021	5, 4, 8 (D)
38	Norman	6	UZ	2008	1-13 (I)
20040	Odisey	318	SR	2020	5 (I)
33	Prag	6	UZ	1998	2,7,8,11,12
20100	serebristiy	5	UZ	2016	(I)
36	Sardor	6	UZ	2008	4,5,6,8,9,1
92000	Farkhod				1
23					1-13 (I)

20060 34 20040 32					

Pirag serebristi (Seed Production, 2014). This variety was developed with the cooperation of scientists from Dagistan and Uzbekistan Plant Growing SRI. F1 was derived from crossings of wheat Mironovskaya yubeleyniy, a short stem ray mutant, and pollens of Triticale Jenkins (USA).

Since 1982, it has been introduced in the irrigated land of Uzbekistan as an intermediate crop. The height of the plant gets up to 140–150 cm; tillering makes up 2.5–5.0 cm. Leaves consist of 49.2 percent of the total weight. Length of leaf: 25–40 cm; width: 2–3 cm; ear is white; depth: 9–11 cm; and it has 35–37 spikelets. Awns are a white, weak spread with a weight of 1000 grains (49–50 g).

30.1–35.5 tons of green mass crop were taken in the testing years at the Samarkand and Fergana variety testing branches. And 6.1–6.5 tons per hectare of grain crop were taken at the Samarkand state variety testing station for the periods of vegetation: 177 days for the green mass and 212 days for the grain crop (178–183 days).

Tolerance to lodging is equal to 3.5 and resistant to cold in the condition of Uzbekistan.

Norman. This variety is released by the Scientific Research Institute of Plant Growing. It was developed through individual selection of a sample population from Mexico from a world collection. Authors of the variety: Djumaxanov B., Kurbonov G., Morgunov A., Alimov J., Ziyadullayev Z., and Jurayev M.

Variety belongs to the biologic winter triticale. Grain has a middle size. The weight of 1000 grains is 47.8 g. Variety belongs to top-height variety groups. Plant height is an average of 100 cm to 134 cm. Variety resistant to lodging and shedding with a 5.0 mark. Resistance to cold is also 4.0–5.0 marks. Average productivity: 54 ton\ha. Vegetation period: 201–212 days. Infection by agricultural diseases was not noted in the competitive variety testing. Since 2008 was recommended to plant irrigating conditions of regions.

Farkhod. This variety is also released by the Scientific Research Institute of Plant Growing. It was developed as the result of individual

selection from the population of Mexico (578193). Djumaxanov B., Kurbonov G., Morgunov A., Alimov J., Ziyadullayev Z., and Jurayev M. are the authors of this triticales variety.

The variety belongs to the biologic winter. Grain has a middle size. Weight of 1000 seeds: 46.8 g. It enters the top-height variety group, which shows a height of 100–135 cm. 5.0 mark of resistance to lodging and shedding. And cold resistance also has 4.0–5.0 marks. Productivity: an average of 5.4 tons. Vegetation period: 189 to 190 days. Infection by agricultural diseases was not recorded in the competitive variety testing.

Since 2008, it has been recommended to plant in the irrigating conditions of regions in the winter term (see photo 179, 180, 181).



Photo 179, 180, 181. Development of triticales plants (on 08.04; 22.04 and 19.06.23) in Okdarya district, Samarkand region.

Chapter 2. Biology of triticale

Triticale is a plant cereal crop comprising properties of wheat and ray. There are spring and winter forms. The root system developed well, getting into the soil at a depth of 1.5–2.0 m and having six sleeping roots. The bush of triticale distinguishes itself with higher tillering and is capable of establishing 5 to 10 shoots. The leaves are enlarged, lancet-shaped, or elongated, with a length of 20–35 cm and a width of up to 3 cm, dark green, and covered with wax-like spots.

Straw is comparatively high (grain varieties: 90–150 cm and fodder varieties: up to 180 cm.), the ear is long (10–15 cm), and the grain is enlarged. Awn grows from the upper tip of the external lemma in the spikelet (or inflorescence, ear, or spike). Spikelets of the ear (photo 182) attached to a cauline structure of the axis or rachilla (figure 62) which bears two glumes and several florets. Each floret has an external bract (as a lemma) and an internal bract (as a transparent palea).

The reproductive structures resulting in the forming of grain enclosed between lemma and palea. The last leaf connecting ear and straw is called flag leaf (or simply “flag”).

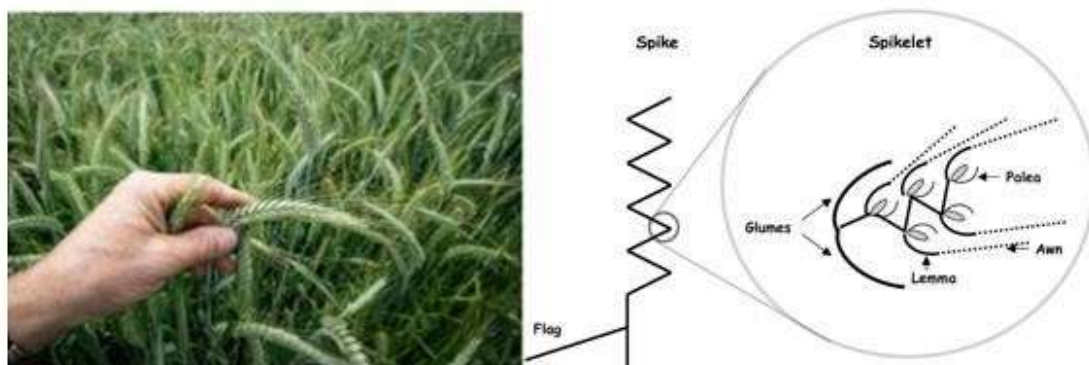


Photo 182. Figure 62 **Triticale spike and structural parts of spike.**

The grain of triticale has a yellow-brownish spot. Grains do not shed even at maturity, which is characterized by a wrinkled surface with grooves in the center. The weight of 1000 grains is equal to 40–60 g.

Triticale has two biologic forms: spring and winter. The seeds of triticale start to grow at 5 temperature of 5°C and 20°C is optimal. The seedlings appear 5-7 days after sowing. The tillering stage of growing begins in autumn and continues in spring. It can withstand to the cold of 18-20°C.

Cultivating triticale varieties in Uzbekistan have 165–200 and even 250 days of vegetation. They are self-pollinators and can also outcross.

They have low sunlight, a long day, and irrigation. Triticale requires much water in the developing stages of seedlings, tubing, heading, and maturing. But it does not react to soil fertility and does not grow well in saline and swampy lands.

The nutritional value of triticale grains is higher than that of wheat and rye grains. Protein content makes up 11–12% of the grain and 10–11% of the hay. But its bread-baking quality is lower than that of wheat. The resistance of triticale plants to fungus and virus diseases is remarkable.

Take into mind that triticale matures 5–10 days later than wheat. Triticale consumes 4–5 kilograms of nitrogen, 1.3–1.6 kilograms of phosphorus, and 3.6–4.0 kilograms of potassium out of the soil to produce 100 kilograms of grain and corresponding hay.

Chapter 3. Origin and genetics of tritcale

It was said that the idea of combining traits and properties of wheat (*Triticum*) and ray (*Secale*) into one plant (Triticale) came true after the publication of an article about the production of wheat and ray hybrids by Yelson, probably in 1875 in Edenbridge (Scotland).

A constant intermediate hybrid between wheat and ray was isolated by Rimpay in Germany in 1881, but its importance has not been given any attention and has not been used in practice at that time.

G.K. Meyster watched naturally arising wheat x-ray hybrids in 1918 at the Saratov agricultural experimental station. In 1925, V.N. Lebedov found natural ray wheat hybrids in the experimental breeding station of Beloserkov.

In terms of commercialization, Triticale is available as a second-generation hybrid. As a rule, it combines the yield potential and grain quality of wheat with the environmental stress tolerance of rays. Depending on the parental cultivars, tritcale can more or less resemble either of them. Wheat always plays as a female and ray as a male parent, which gives sterile hybrids that must be treated with colchicine to induce polyploidy and thereby give them the ability to reproduce themselves.

V.E. Pisarev (Abdukadirov D.T., 2007) in Russia led the breeding of 56 chromosome tritcale. At this point, soft wheat ($2n=42$) was crossed with ray ($2n=14$) and developed 56 chromosomal amphidiploid tritcale (chromosomal view):

$$\begin{array}{ccccccc}
 \text{Soft wheat} & \times & \text{ray} & = & \text{hybrid} & + & \text{colchicine} = \text{amphidiploid} \\
 2n=42 & & 2n=14 & & & & \\
 n=21 & & n=7 & & 2n=28 & \dots\dots\dots & 2n=56
 \end{array}$$

At this point, the main principal is a treatment of wheat and ray hybrid ($2n=28$) and double-increasing the chromosome number ($2n=56$) which becomes amphidiploid. This amphidiploid means the hybrid plant is diploid for two genomes derived from wheat and ray species. On the other hand, tritcale is an allotetraploid. Historically, different ploidy levels have been developed and evaluated over time:

*Tetraploidy tritcale -4x, $2n=28$ (AABBRR), AA – wild genome wheat with RR – ray.

*Hexaploid tritcale -6x, $2n=42$ (AABBRR), hard wheat with ray.

*Octoploid tritcale -8x, $2n=56$ (AABBDDRR), soft wheat with ray.

Keep in mind that tetraploids have some promises, but **hexaploids** are successful enough to attract farmers huge interest. A.I. Derjavin was one of the first scientists to study hexaploid triticales. In 1933, he crossed wheat and rays to get the first amphidiploid. After that, in many countries and in Uzbekistan, active works began in this direction (photo 183). The hexaploid forms of triticales have some prevalence in self-reproduction. They have high productivity and are less prone to meiosis breakage.

Easy crossings within hexaploid forms and with octoploids result in the getting out of D genome combinations, which lets us select more forms with constant meiosis (secondary triticales).



Photo 183. **Herbarium ears of wheat triticales and ray.**

Genome equations to produce triticales are given below:

$AABBDD$ (soft wheat) $\times$ RR (ray) = $ABDR$ + colchicine = $AABBDDRR$
(primary octoploid triticales);

$AABB$ (hard wheat) $\times$ RR (ray) = ABR + colchicine + $AABBRR$ (primary
hexaploid triticales);

$AABBDDRR$ $\times$ $AABBRR$ = $AABBDDRR$ = $AABBRR$ = $AABBRR$ (
secondar hexaploid triticales).

A.F. Shuldigin (1970) at the Ukraine Plant Growing, Breeding and Genetics Scientific Research institute has created 42 chromosomal amphidiploid triticales crossing hard wheat ($2n=28$) with ray ($2n=14$).

Chapter 4. Triticale breeding directions

Grain and fodder quality improvement directions are the most important objects in the reports of triticale breeding and its seed production. In particular, they underlined that more than a hundred years have passed since the first amphidiploids were created, which could involve a new genus of cereal plants with higher indexes of grain productivity, resistance to stresses, and grain quality. But a range of challenges (inadequate resistance to dangerous pathogens, abiotic factors) are still left unresolved, which makes it difficult to spread the triticale varieties with high grain quality.

Taking into account its great potential for green mass accumulation, triticale must have a considerable place in our regions. At this point, it must be introduced instead of winter wheat, which is inferior both in yield, feed quality, and nutrient yield per unit area. Moreover, to maximize the potential of new winter triticale varieties, the productivity of animals depends mostly on the variety features of the crops. Triticale attracts special attention for its peculiarity of being higher than parental forms in terms of green mass productivity and product quality.

The scientists of Kazakhstan (A.B. Abuova and others., 2022) at the Kazakh Scientific Research Institute of Agriculture and Plant Growing have implemented the works on triticale breeding since 1970. They emphasize that triticale flour, by uniting the biologically valuable matter of ray with the bread baking properties of wheat, is able to resolve the problem of ray flour deficiency in the food industry and, furthermore, may contribute to the expansion of the range of bakery and flour confectionary products because of its increased food value.

They continue to research the technological properties of various triticale varieties as a potential source for the bakery and confectionary industries. Varieties of Taza, Balausa, Asiada, Koja, and Baru are objects of investigation. These varieties for the last 3 years demonstrated a productivity of 45 in dry land and up to 11.6–12.0 ton/ha of grain in irrigation conditions.

Analysis of organoleptic and physic-chemical indexes of triticale grain quality as well as flour taken from different bred varieties of Kazakhstan has been carried out. As a result of this complex investigation, 5 Kazakh varieties: Asiada, Koja, Tasa, Balausa, Baru and

other varieties introduced in southern Kazakhstan do not exceed the fixed norm on the content of weeds and grain impurities, and no pest infestation of grain stocks was detected.

Studied triticale varieties on the content of raw gluten showed gut indexes in the range of 18–23%. Qualitative assessment of gluten indicates that all samples belong to the group II (sufficiently weak). Indexes of physico-chemical analysis of triticale flour probes indicated gut potential possibilities, allowing us to recommend their use in the production of bakery and flour confectionary products.

All samples taken of triticale flour exceeded the standard on the content of protein, and the most protein content was in the flour from the variety of Baru (13.3%). The others, Taza, Aziada, Koja, and Balausa, can also take precedence within breeding source materials to improve triticale grain qualities.

Remarkable achievements in triticale breeding directed to fodder production are notable at the Northern Kuban Agricultural Experimental Station (NKAES). The breeders of this station (photo, 184) engage to create winter and spring triticale varieties and to introduce into production such varieties as Jnets, Brat, Kinyaz, Valentin 90, Svat, and Khleborob. Varieties such as Tikhon, Sergiy, and Ullubiy are passing through the state trial. The variety of Tikhon has truly fodder designation.



Photo 184. A.Yu. Belyakoba-scientific staff of the NKAES, explains about the fodder dignity of Triticale (2018).

It attracts a great deal of attention owing to its short plant height and resistance to lodging, and it showed a green mass productivity of

14.3 tons per hectare at the variety testing. On the content of feeding unite, it is superior over the main fodder crops—barley and oats. In the calculation of one feeding unit in the grain, triticale contains 110–125 g of digestable protein, whereas in wheat it is only 93 g, and in barley it is 85 g at the zoo-technical norm of 105–110 g.

Drought resistance of triticale varieties is the next challenge because our southern regions are known for their water scarcity farming characteristics. This situation is worsening due to the climatic changes in the last decades, increasing the importance of swiftly introducing drought-resistant and tolerant varieties of agricultural crops. At this point, it is believed that triticale is the more economically efficient crop in our southern regions.

These problems are dealt with by searching for and creating genetic sources possessing complex positive traits and, on their basis, creating more perfected varieties of winter triticale and harvesting grain and fodder with the desired quality.

In 2022, scholars of the Andijan Institute for Agriculture and Agro-Technologies (Gaybullaeva M.Kh., 2022) studied the resistance to stress conditions of 11 triticale varieties, and two of them, the Sardor and Toyimli varieties, were the leading drought-resistant triticale varieties, and they were recommended by these scientists to use in the triticale breeding programs to improve cultivating varieties.

Complex research embracing the productivity and resistance of triticale variety diversities to heat and drought was implemented by breeders at the Dry Land Farming Scientific Research Institute in Jizzakh (Isakov K. and others, 2023).

The seeds of variety diversities: Farkhad (as standard), Sardor, Dustlik-4, Plot 22 VAR-35, Plot 31 VAR-49, Plot 61 VAR-49, Plot 28 VAR-12 and Plot 14 VAR-34 were sown in 25m² each with 4 replications by using breeder's seeder CKC-7-10 and harvesting with the harvester "SAMPO-130" (appendix 11). Results on the productivity showed that Plot 61 VAR-49, Plot 22 VAR-35, Sardor, and Dustlik-4 have rising advantages over standard Farkhad (22.6 c\ha) respectively: 1.0, 1.4, 2.6, and 2.8 c\ha.

Variety and variety diversities of Sardor, Dustlik-4, Plot 22 VAR-35, and Plot 61 VAR-49, according to the presented table 55, for a two-year average were 2-4 days early ripening, and the weight of 1000 grains had 0.6–3.4 g heavier grains. On the volume of grains, Sardor and Dustlik-4 have 15.9–18.4 g advantages.

Sardor, Dustlik-4, Plot 22 VAR-35, Plot 31 VAR-49, and Plot 61 VAR-49 were isolated as the initial material for upcoming triticales breeding to improve the economic traits and productivity of cultivating varieties (table 56).

Table 55. Valuable economic traits and productive indexes of triticales variety diversities in Gallaaral (2020-2022).

№	Variety and lines	Period of heading, days.	Weight of 1000 grains, g.	Grain volume weight, g/l.	Height of plant, cm.	Productivity, c/ha.	Difference from standard, +/-
1	Farkhad (st.)	26.04	39.5	766.3	108.6	22.6	0
2	Sardor	22.04	42.9	782.7	106.0	25.2	+2.6
3	Dustlik-4	22.04	42.7	764.7	103.6	25.4	+2.8
4	Plot 22 VAR-35	23.04	38.2	768.0	102.0	24.0	+1.4
5	Plot 31 VAR-49	23.04	40.2	763.0	98.5	23.0	+0.4
6	Plot 61 VAR-49	25.04	37.9	767.6	90.9	23.6	+1.0
7	Plot 28 VAR-12	25.04	40.1	759.0	103.5	22.7	+0.1
8	Plot 14 VAR-34	25.04	38.2	764.6	102.3	23.4	+0.8

Also, 10 varieties and lines of triticales planted in the control nursery have been analyzed in the laboratory to identify their resistance to heat and drought. The results presented in the table 57. So, coal flag sheet eversion reached from 9.6° to 14.2° in Plot 61 VAR-49. In variety Farkhad, 12 12°. The length between upper nodes consisted of 20.4–28.0 cm in Plot 1 VAR-15, while in the Farkhad variety, it was 20.3 cm.

On the basis of the experiments and data presented in these two tables, the breeders have come to the conclusion that Sardor, Dustlik-4, Plot 22 VAR-35, Plot 31 VAR-49, and Plot 61 VAR-49 in the nursery of samples and Plot 61 VAR-49 and Plot 1 VAR-15 in the control nursery for their early ripening, advantages in the weight of 1000 grains, productivity compared to standard Farkhad, and resistance to heat and drought were selected and recommended as the best triticales samples for future plant breeding processes.

Table 56. Resistance of triticale varieties and lines to heat and drought in dry land (Gallaaral, 2020-2022).

№	Varieties and lines	Coal deviation of the flag sheet, degree.	Plant height, cm.	Length between upper nodes, cm.	Water conservation in the leaf, %.
1	<u>Farkhad (st.)</u>	12.0	80.1	20.3	74.3
2	Plot 14 VAR-34	9.6	81.0	20.6	76.6
3	<u>Sardor</u>	13.2	77.6	23.7	73.4
4	Plot 4 VAR-20	12.8	78.4	23.7	75.2
5	Plot 22 VAR-35	10.7	80.0	20.7	74.0
6	Plot 91 VAR-15	14.2	79.9	21.6	76.3
7	Plot 31 VAR-49	10.7	81.5	28.0	75.0
8	Plot 61 VAR-49	9.6	80.5	23.3	71.5
9	Plot 15 VAR-34	10.8	80.4	22.5	74.8
10	Plot 1 VAR-15	11.2	81.8	20.4	74.5

To continue the study of the registered triticale varieties in the specific soil conditions of the republic is another, not less important, direction in the full use of every variety's genetic and economic potential. Influence of different seed planting terms and norms in grass alluvial soil conditions of Khorezm region on the growing and development of local varieties Farkhod and Norman was studied by scholars of Urganch State University (Abdullaev I. and Pirova M., 2024).

The research has been conducted in the years 2022–2023, with 18 options and 3 replications on one belt. Rows in the experimental plot have a 70-cm spacing with a length of 50 meters. The area of each lot make up 280 m², recorded area -140 m². The total area of the experiment consisted of 1.6 hectares. The whole farming field was operated under a 1:1 rotation system (cotton plant: cereal).

The seeds of selected varieties were sown in three terms (table 57): 15th of September, 1st of October, and 15th of October, with the three seed sowing rates, respectively: 4.0 mln\ha, 5.0 mln\ha and 6.0 mln\ha.

Fertilizers of nitrogen (46%), ammonia seltra (34%), phosphorus (P2O5-20%), and calcium salt (K2O-40%) have been used to feed winter triticale plants. Phosphorus and calcium were applied at 100% under autumn plowing. Nitrogen fertilizer was used twice: 1st feeding at the tillering stage of development and the second at the tubing stage.

The main field surveys and analyses focused on the determination of net photosynthetic productivity indexes (the NPPI) across studied plant materials. On the first variety, Farkhod, the NPPI was higher on the 15th of September than on the 1st of October and 15th of October. The highest index of the NPPI at rates of sown seed was marked at 6 mln^ha

on the 15th of September, followed by the 1st October and the 15th of October.

Table 57. The placing system of experiment elements.

№	Winter triticales varieties	Seed sowing terms	Seed rates, million\ha	Index of net photosynthetic productivity, g\day\m ²
1	<u>Farkhod</u>	15th of September	4.0	6,68
2			5.0	7,34
3			6.0	7,89
4		1 st of October	4.0	6.29
5			5.0	6.93
6			6.0	7.45
7		15 th of October	4.0	5.78
8			5.0	6,55
9			6.0	6.79
10	Norman	15th of September	4.0	6,79
11			5.0	7,58
12			6.0	8,09
13		1 st of October	4.0	6.36
14			5.0	7.07
15			6.0	7.61
16		15 th of October	4.0	5.85
17			5.0	6.50
18			6.0	7.96

The same character of progress was seen on the second variety of Norman.

Overall, the first term of planting (**15th of September**) in both varieties has a similar advantage over the second and third terms of seed sowing. Within the sowing rate, of course, 6 mln[^]ha has the highest NPPI in all terms of sowing. Between the two varieties, the superiority belongs to the variety of Norman in the Urganch soil and climatic conditions.

Chapter 5. Triticale breeding methods

Efficient breeding methods of triticale in the world have widely started to develop since the functioning of triticale breeding programs initiated in Mexico (CIMMYT, International Maize and Wheat Improvement Center), Poland, and France in the 1960s, followed in Brazil, Portugal, and Australia in the 1970s of the past century (Oettler, 2005; McGoverin et al., 2011).

As they reported, early triticale varieties were exceptionally nutritious; the grains of those varieties have far more proteins and lysine (irreplaceably amino acids) in comparison with wheat. But it was proven that they have many agronomic deficiencies: low grain yield, poor seed set, shriveled grain, tall plant height causing to lodge and lose yield, premature seed sprouting, and flour with lowered baking quality.

The most difficult part of observing scholars is that this complicated combination of difficulties is a barrier that could never be breached. Despite this reality, much scientific research has been implemented to disentangle these barriers and work out the suitably special agro-practices.

In 1967, scientists watched the triticale plants, which were accidentally fertilized by pollen blown in from neighboring dwarf bread wheat plants. After a few **purposeful selections, offspring resulted** in a new productive line called Armadillo.

This new triticale line had improved fertility: it was productive, neutral to day lengths, considerable short straw, resistant to lodging, and matured early with plump grains. Armadillo greatly helped to resolve some of Triticale's problems related to efficient agro-practices. Since the 1970s, **pollination (crossing)** with dwarf triticale forms, including Armadillo, and purposeful selections have continued in other world countries.

Russian triticale breeders accept Polish triticale samples to analyze their traits and properties (Medvedov A.M. and others, 2020). This is their traditional work to improve local varieties on account of foreign ones. They had learned 52 Polish winter triticale varieties in 2007–2009; in 2013–2016, 17 variety samples; and in 2018–2019, 20 new Polish variety samples were tested in the Moscow region. Otherwise, this is the scientific methodic process of embracing the introduction, selecting (and crossing, and again selecting).

The short straw The Polish varieties Grenado, Argento, and Korvetto have possessed complex economic-valuable traits and properties in Moscow and in other regions' conditions, which is why they were used in the breeding programs of Russian scientific centers.

Selected Polish varieties: Felo (k-4010), Hortence (k-4012), Preco\Kill\Rex\Aos\Rex at the investigation of gene fund in Moscow region in 2017-2019 for their constant short stem (95-110 cm), increased resistance to winter stresses (7-9 marks), snow mold (5-7 marks), and brown rust (9 marks), and enlarged, good grain set on the ear (56-59 grains) with grain weight per ear: 2.8-3.1 g, weight of 1000 grain: 50-52 g., grain per 1 m² makes up 860-890 g.

Overall, in 2007–2018, over 100 Polish variety samples were studied on complex indexes, and the most valuable ones were used in the release of new, more perfected lines and varieties of triticale. Kapella is one of them, driven from a Polish spring variety sample (k-2045) through the method of selection based **on ecological mutagenesis**. This variety has a complex of desirable traits.

Sibard-triticale variety (photo 185) has been created by scholars of the Ural Federal Agrar Scientific Research Center (2021). It developed through the selection method out of a hybrid population of Sirs 57 x Bard.



Photo 185. Performance of the triticale variety Sibard.

Plant height: 95–105 cm. The bush is prismatic with a length of 8–10 cm and short awns on the spike top. 45–50 pieces of grain will form on the ear, with a with a weight of 1000 grains of 40–42 g. Raw protein

content equal to 13.2-15.6%, what is higher by 1.5% over wheat, 3.4% is over ray.

Ecological adaptive potential is remarkable; it can be cultivated in more than 20 regions of Russia, from central to western Siberia. Winter resistance consists of about 90% and withstands snow mold, which is one of the most harmful diseases. The result of this disease may be the loss of 40–50% and even 100% of crops.

Moreover, this variety has higher biological potential and can get grain by 5 tons per hectare. In the competitive variety testing, Sibard showed productivity of 5.5 tons, which is superior to standard Bashkirdskaya korotkostebel'naya by 0.7 tons. While the vegetation period of the new variety is shorter (3–4 days),.

Two: Morman and Farkhod, out of three long-period cultivating varieties (Pirag serebristiy, Morman, and Farkhod) in Uzbekistan (registered in 2022), were also developed through individual selections from Mexican world collections.

Interspecific hybridization with subsequent individual selection from the TAZA x Prag-45 hybrid population was used in the development of the winter triticales variety AZIADA (photo 186). Variety has a middle-ripening character, with 275-278 days. Winter resistance is high: 90–100%. Plant height gets up to 120 cm, productivity is -3.3. Resistant to hard smut, weakly prone to yellow, stem, and brown rust occurring in Kazakh conditions.

The ear has a pyramidal shape with a length of 12–13 cm and a middle density. Grains are enlarged, prolonged, and red with shallow trenches. The weight of 1000 grains is 57.2 g, inversely to the standard: 52.4 g. An average productivity consisted of 7.5 tons. The content of lysine ranges from 3.8 to 3.9%.



Photo 186. **Performance of triticale variety AZIADA.**

The lesser-known Kasakh triticale variety Koja was also evolved by the method of **interspecific hybridization** [(AD 114 x Prag-26) x TAZA] x TAZA with **subsequent individual selection**.

More complicated **(inter-genus) hybridization** (2021) and **continuous individual selections** (AD-170 x Kavkaz) were used by scholars of the Kazakh Republic to create the triticale variety TAZA (photo 187). It is winter-resistant, has good tillering, and has a robust straw with a height of 105–110 cm. It does not lodge. Ear and grain are large; a weight of 1000 grains makes up 56 g. Multi-flowering and grain setting get up to 60–70 grains per ear, which results in a high crop.

The potential productivity of the variety TAZA consists of 8–11 tons. The average productivity in the rain-fed area is 3.0-3.5 tons. Belorussia has begun creating triticale varieties in the green mass cutting direction (2024). The specialists have taken new qualitative breeding material from this fodder crop, attracting genetic sources from local and foreign triticale breeding. The initial forms were created by the method of intraspecific and interspecific hybridization with successive individual selection at the established populations.



Photo 187. Performance of triticale variety TAZA.

The triticale variety Slavko is the outcome of the work of the Scientific Production Center (the SPC), which is suitable to use as grain fodder and green cut directions. The new variety samples for this variety have been delivered to the State Variety Trial (table 58).

Table .. New Belorussia winter triticale varieties included into State register of Belorussia Republic in 2021-2022.

Varieties	Zveno	Slavko	Atlet 17	Grodno	Berezino	Uste
Vegetation period, days	300-302	305-307	310-312	312-315	310-315	310-312
Maximal productivity, ton\ha	9.0	10.3	9.5	9.8	9.3	10.6
Weight of 1000 grains,g	46.4	45.1	44.8	43.8	45.6	42
Raw protein content, %	10 - 11.9	8.7-9.1	10-12	9.7-11	10-11	10-10,5
Starch content, %	73.3	76	67.7	69.3	71.3	74

The variety of Slavko has middle straw forming and a high leaf setting of 47–49%; 2.5-4.0% is superior to standard. Resistant to lodging, higher than the standard variety of Dinamo. Variety is designated to the direction of grain-fodder and green-cut use. The average grain productivity in the years of testing consisted of 6.4 ton\ha.

Conventional breeding methods, which embrace partly crossing and subsequent selections, are relatively time-consuming (10–12 years), continuing on the basis of several rounds of crossing and targeted selections in the hybrid populations. Therefore, conventional triticales breeding has gradually developed into a **DNA-based molecular breeding method**.

Beside this, breeders of triticales are also very interested in the use of modern breeding techniques, including **haploid and double haploid breeding, embryo rescue, and genomic assisted breeding methods**, as well as efficient and targeted triticales breeding.

The results of haploid and doubled haploids provide acceleration for breeding process durability. The genetic variability of parental forms is fixed in a short time due to the double haploid method, and adequate homozygous lines are obtained from them. Thereby, the use of this method in triticales breeding is valued as “an indispensable tool” (Slusarkiewicz, Jarzina, and others, 2017).

Nowadays, **the application of molecular DNA markers** has become a part of contemporary plant breeding methods, including triticales breeding. Searching for and identifying certain markers linked to or located in the genes of initial forms and determining desirable traits increases selection efficiency. For example, to promote the determination of markers for biologic, genetic traits, and genome characteristics of triticales, Turka and others (2015) composed the first umtrahigh-density linkage map to use in triticales genome analysis.

Of course, as in other grain crops, triticales breeding methods are evolving. Wurschum and others (2017) evaluated the potential of genomic prediction for triticales breeding. Genomic prediction is the use of genomic information about initial breeding materials to obtain estimated breeding values for these materials, which are then used subsequently to select desirable plant biotypes.

All these innovative breeding methods in triticales breeding conclude that selection at the base of the genome can be successfully utilized to increase selection outcomes in triticales breeding.

However, the successful utilization of these methods in practical breeding by our triticales breeders is not straightforward or important. Furthermore, it must be underlined here that the area of triticales is not enlarged in Uzbekistan and its enlargement and prioritizing of triticales breeding depend on the agricultural strategies of the republican government. So far, triticales breeders have limited themselves to

conventional breeding methods and are now adopting some modern breeding technologies.

In 2008, Francois (from Canada) and Archana Chugh (from India) reported progress made to develop doubled haploid methods with triticale plants. They highlighted well-established hybridization, anther culture, isolated microspore methods in triticale breeding, and germplasm development programs for diverse genotypes. It was especially noted that C17, N6, and NPB99 induction mediums for microspore culture are widely preferred. They carry maltose, sucrose, or in combination with them, and others. Also, it was underlined that spontaneous doubling has been reported at low frequency in microscope-derived triticale plants, making chromosome doubling by chemical colchicine necessary for hybrid-derived triticale plants. The procedure of isolated microscope culture has become a very efficient method that will open successful opportunities for gene control and transfer in triticale.

Research by Akina and Victoria Nikolaevna (2013) on cell technology for attracting the gene bullet D-genome of wheat and evaluating their economic-valuable traits in the created triticale lines is one of the good examples of teaching triticale breeding at the level of cells.

Her scientific aims were to get new hybrid combinations: triticale x wheat on the basis of modern varieties of these crops with the use of in vitro, assess the parameters of androgenesis in vitro in the interspecific hybrids, shed light on the shares of affect genotype, nutritious medium, and their relation to the main stages of haploid plant getting, and get DH-lines in the pollen culture of interspecific hybrids.

She could get new interspecific hybrids by using embryoculture in vitro on 36 reciprocal combinations of crossing -13 direct and 23 reverse. Created and included in the collection of DH-lines, distinguishing by a complex of economic and valuable traits. And even lines 8 and 9 were presented in the control nursery due to their high grain productivity and weight of 1000 grains.

The order of androgenesis plant development has been explained in detail in the research of T.I. Dyachuk and others (2017), where they evolved triticale lines to the condition of Povolje.

6 hybrids of elite winter triticale lines: № 1 – F2 AD-1//MAG/Ellada; № 2 – F2 Student/Patriot//Ellada; № 3 – F2 Valentin/DH-25//MAG/Kornet; № 4 – F2 MAG/AD1// Saratovskaya8, soft wheat; № 5 – F2 MAG/AD1//MAG/Ellada; № 6 – F2 Ustinya/DH-30 served to get haploid plants and DH-lines.

Selected the donor plants at their vacuolized microscope stages and cut shoots stored in the refrigerator at a temperature of +2...5°C for 7–10 days. All work on the disassembly and cultivation of pollen was conducted in the required conditions. The spikes were sterilized by the solution of “Belizna” for 8 minutes, followed by three washes with sterilized water. Almost 2 thousand pollens are cultivated per hybrid. C-17, with the addition of 2.4-D (2 mg/l) and kinetin (0.5 mg/l) as the growth regulator, served as a quality inducing medium.

In 6 weeks, the embryonal structure (ES) with a size of 1 mm was placed in the medium for plant regeneration, containing the quality growth regulator IUK (1.0 mg/l) and kinetin. Cytological control for sporophyte development was conducted by the terminal preparations with paint of atsetocarmin. Efficiency of the definite haploidization stages was assessed on the following parameters: embryonal structure output (the ES, as % to total number of pollens in vitro), plant regeneration (% to total number of the ES), yield of green and albino plants (% to number of regenerators).

These haploid plants were treated with colchicine (0.2%) with 8–10 drops of DMCO in the quality of the membranotropic agent at room temperature for 5 hours to get doubled haploids (DN lines).

Cytological analysis on the cell level demonstrated that in 7 days, the main part of the pollen was killed. The remaining parts continue as gametophytes with successive degeneration into vegetative and generative nuclei; only a small population of cells transfer to the sporophyte way of development with the next equal division (photo 188, a). Some microspores are divided into vegetative and generative cells with the following mitotic activity of vegetative cells (photo 188, b). The multicellular structure is formed as a result of the next division, which is left for some time in the shell of microspores (photo 188, c).



Photo 188. Cell development stages in getting triticales haploid plants.

Intensive growth of multi-cell formation promotes stretching and rupture of microspores (photo 189, d), followed by the establishment of

an embryo-like structure (photo 189, e). Subsequent cultivation of the ES in the medium for regeneration leads to the formation of haploid plants (photo 189, f, g, and h).

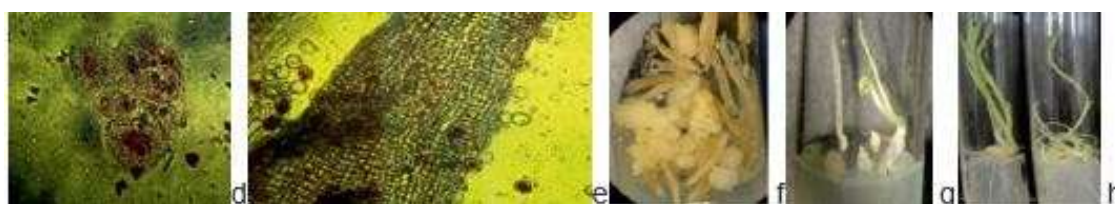


Photo 189. Cell development stages in getting triticales haploid plants.

So, the order of steps in the getting of haploid plants in pollen culture of triticales: a-equal division of microspores; b-vegetative cell division; c-multi-cell structure; d- rupture of shell; f-embryo like structure and g, h-successive regeneration stages.

Overall, 1129 haploid plants were taken in the experiment, including 309 green and 820 chlorophyll-defect ones (albinos). Their ratio depends on the experimental options, and the higher formation consisted of 31.3–95.2%. This is one of the deterrent factors in the production of haploid plants in the triticales pollen culture.

It was identified that the genotypic effect of the formation of triticales embryo gene structure makes up 75%, nutritious medium -3.2%, and relation of factors -20.1%. And the use of the pollen culture method has made it possible to create homozygous lines in a short time and to form initial material on their basis for triticales breeding for dry land conditions in Povolje.

The wide specter of variation in selecting traits reflects numerous types of combinations in the microscopes and gives the possibility of conducting selections for the rapid creation of varieties with desirable properties. DH-lines are studied in various periods of breeding and possess complex, selectively valuable traits. At this time, it is important to note that the genetic dependence of all periods of haploid plant development and the higher percentage of albinism still limit the possibility of widely using this haploid biotechnology in plant breeding.

A laboratory for marker- and genome-based plant breeding was set up in the Russian Federation (2019). Its main directions of research include such questions as:

*Creation of perspective lines of agricultural crops through the methods of marker-assisted and genome-assisted breeding.

*Search and development of molecule-genetic markers of genes, controlling the quality of triticales grains.

*development of new systems of DNA markers, plant genotyping, and others.

To date, scientists in laboratories, in close cooperation with practical plant breeders, have achieved many outcomes in the creation of crop lines and the improvement of growing varieties.

Unfortunately, as noted above, the high percentage of chlorophyll defect (albinos) in haploid plants (31.3–95.2%) remains one of the obstacles in developing biotechnological methods in triticales breeding. To overcome this problem, it has been partly solved by the discoveries of Renata Oriowska (2022).

This scientist proposed to effect plant regeneration with abiotic stresses, adding ingredients (copper and silver ions) to the induction medium. This medium influences biochemical pathways and haploid plant regeneration efficiency. As a result of DNA methylation, changes in DNA sequence variation occur, and here, under the influence of copper and silver ions, green plant regeneration efficiency changes. The copper ions have considerably promoted the production of more green regenerators in triticales breeding.

Also used genes out of parental forms of triticales and molecule markers to solve different challenges in triticales breeding (Emsova M.V., 2020). For example, in the comparison of triticales with initial wheat lines, it was identified that triticales is very cold-resistant on account of chromosomes from rays. By the using of molecule markers have been determined three locus of cold resistance in the ray chromosomes of 5A, 1V and 5R.

Replacing chromosome 1R of ray with the chromosome 1D of wheat is considered one way to improve the bread baking quality of triticales. Potential interest in the perfection of triticales bread baking quality is also present through replacing the 1R chromosome of Ray with the 1U chromosome of *Aegilops umbellulata*.

Activity of α -amylase defines another shortcoming of triticales: the tendency for grain to germinate on the root, which decreases quality and crop. It was shown that the resistance to germination of grain on the root is enhanced by the availability of chromosomes replacing 2R2D.

Plants with replacing 2R\2D have less height than other plants. There are informations that replacing the chromosome 2R of ray with

chromosome 2U of *Aegilops umbellulata* cause to decrease the height of triticale hybrids.

On the type of development, wheat, rye, and triticale may be spring, autumn, or spring-autumn. Transition of winter plants to generative development requires a prolonged (1-3 month) period of lowered positive temperature (vernalization); spring crops are able to start heading without it. Autumn and spring can develop as spring and as winter types. Time of starting generative development and heading are the important adaptive traits. The type of development as well as the duration of the vegetation period are controlled by the gene *Vrn* (response to vernalization).

Chapter 6. Hybridization of triticales plants

To know the cross ability of triticales with other varieties of the same crop and with parents—wheat and ray—is an extraordinarily interesting question because of its generative structure as the interspecific hybrid between wheat (facultative self-pollinator) and ray (obligate out-crosser). O.V. Dudaeva (2005) and A.V. Shirokolova and others (2014) appropriately studied the biological peculiarities of the triticales generative system and outcrossing liability.

According to their conclusion, a distinguishing system of regeneration has been established in Triticales. The knowledge about its generative peculiarities promotes the building of an efficient breeding process to improve the seed setting on the triticales ears and seed production, especially at the preliminary stage of seed production.

Triticales has become a formal self-pollinator and, at the same time, is actively able to pollinate with other triticales varieties and with parental species of wheat and ray. Such behavior makes breeding and seed production difficult in spite of spatial isolation norms equal to 150 meters. The value of spontaneous hybridization between triticales varieties varied from 0.31 to 4.4%, while with rays it was 0.23–1.46% and with wheat it was not considerable.

Hybridization—crossbreeding triticales plants to produce new triticales genotypes—encourages choosing appropriate plants, preparing the male and female parents for cross-pollination, and the whole procedure of pollination. At first, we need a triticales crossing kit (photo 190), which is a set of embroidery scissors, fine-point forceps, glassine crossing bags, paper clips, a permanent marker, and absolute ethanol.



Photo 190. Crossing kit to pollinate triticales plants.

In addition to these working tools, you also need two triticale plants that you are going to cross pollinate. It is more important to review the anatomy of a triticale plant. Each plant bush makes up a primary stem (tiller), a second stem, and a tertiary stem (photo 191). Their number depends on environmental conditions and variety properties. Along each stem form several leaves; the top one is called a flag leaf, and above it forms a spike, which takes place during flowering, pollination, and producing seeds (grains).

The spike (green ear) is made up of a number of spikelets, whose florets, embracing the reproductive organs, are covered by the glums (photo 192). Each floret has both male (anthers) and female parts (pistils). There are three anthers that contain pollen and pistils sitting between them. Pistil has an ovary at its base and fluffy white stigmas at the top (photo 193).

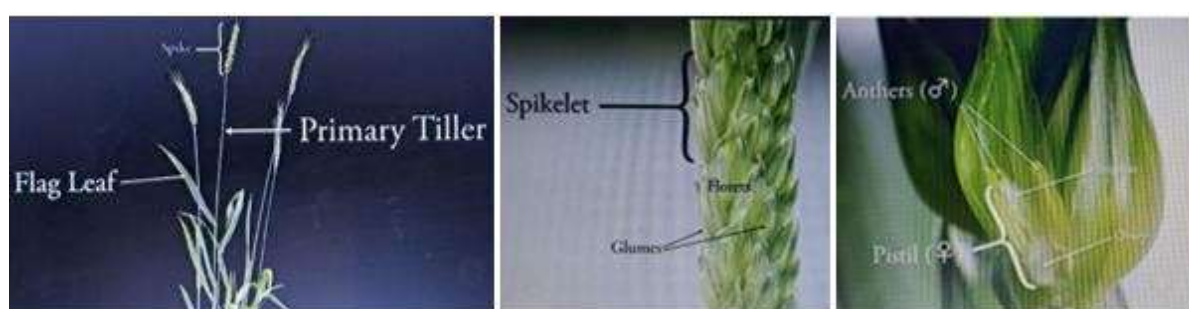


Photo 191, 192, 193. **Up soil anatomy of plant, spike parts and floret parts.**

As we learn above, triticale is preferably self-pollinating but can outcross at levels of 4% and more. So, to control outcrossing, you must use the emasculation of a spike by removing the anthers, leaving the pistil intact, if you want to breed between specially chosen parental plants.

It is important to concentrate attention on the spike with pollen from another chosen plant without risking self-pollination. This ensures your pollination is indeed the result of two parentally chosen, appropriate plants.

At the beginning of emasculation, you will be assured that there will be a male plant chosen to provide mature pollen. And choose its spike with anthers that are getting yellow to access. Use forceps (photo

194) to open a room between the external bract (as a lemma) and the internal bract (as a translucent palea).

We should know that the ear maturity in triticale begins with spikelets located in the center of the spike and goes outward. As a guide, the center of the spike should be at the base of the flag leaf (photo 195). This state of the spike and flag leaf is a sign that it is slightly more mature than the female spike and will soon start to give mature pollen. This spike is proper to identify it as the male parent's spike and to bag it (photo 196).

Afterwards, the female parent spike should be chosen, which is also ready to be emasculated. Most often, the spikes at the proper stage of their sexual maturity will stay partially encapsulated by the leaf sheath anther. Because maturation rates of ear vary depending on the cultivar and environmental conditions, it is important to check the spike before selecting.

Be attentive; the anthers near the center of the spike are green. This is again a sign that they are still immature. No doubt, this spike is at its appropriate stage to be emasculated.

Further, remove the underdeveloped spikelets of the female spike from the top and bottom. These florets are thought to be unlikely to produce good seeds. The spikelets of the triticale spikes have varying numbers of florets. It is better to do cross-pollination with the outermost florets since these florets are more likely to produce the best seeds.

With the help of your forceps separate the middle florets and hold them at the base of the on. Then gently bending pull down until the inner florets detached from their seats (photo 197).



Photo 194, 195, 196, 197. **Choosing male plant spike, spike maturing, bagging male parent spike and detaching of middle florets.**

Continue moving the middle florets from one side of the spike, and then continue on another side of the spike. If you are working with the plants in a pot, then rotate the pot to access the opposite side. Be careful; do not injure the plant stems by bending and twisting them around.

And bend the spike to separate the spikelets. With the help of your scissors, cut the top part off of every floret. The bottom part of the spikelet is left to expose the anthers. In order to not injure the needed parts of spikelets, cutting at the right height is important (see photo 198). It ensures you gain free access to the anthers without tampering with the pistol.

Next, it is time to remove the three anthers from each floret because you are trying to prevent self-pollination. It is important that all anthers be removed. Enter your forceps between the translucent internal and external bracts and open the floor; gently grasp the anthers and pull them out (photo 199).

To verify the florets were completely emasculated, you should deposit the extracted anthers on your hand for counting them. If you could find fewer anthers in regard to the number of florets, you would find the reminders and remove them completely. It is common to put your thumb on the emasculate spikelet. It helps to move ahead with easy progress.

It is useful to do the second check when you have finished emasculating all florets and cover the emasculated spike with a glycine crossing bag to keep the pistol from damage. Label the crossing bag with the order number from the crossing book, the plant's name (variety name), and the date of emasculation.

In the field, cross-pollination is most effective in the morning hours, from about 10 to 12 a.m. At these times, plants do not feel water and heat stresses, which reduce the viability of pollen.

Before pollinating, you can verify the emasculated florets' state by removing the glassine crossing bag to inspect the whole spike. The normal view is when the not-fertilized florets have opened up a bit and the stigmas look larger.

Now inspect the male parent's spike selected earlier by removing its bag. Keep in mind that anthers near the center will be more mature. They have exposed white anthers. But try to use the less mature anthers from neighboring spikelets located up and down.

If the male spike has long awns, cut them short. Using your thumb and fingers, rub the male and female spikes to stimulate their opinions. This causes the floor to open up to allow better access inside the florets. You will note that in a few minutes, the male florets will open to expose anthers. Now you will be able to use your forceps to collect (extract) anthers from these male spikelets. Then grab forceps with anthers on

each female floret to fall pollens and land on stigmas. Continue this kind of pollination upward from floret to floret. Once you reach the top, continue downward along the opposite side of the spike (photo 200).



Photo 198, 199, 200. **Cutting off florets, emasculation and pollination.**

Try to leave at least one other in each floret to ensure the male spikes self-pollinate. By this way, you may also ensure continued seed setting from the male parent's spike. You can bag this male spike to protect out crossing and label it with its bag again with records of needed information: number from crossing book, name of variety diversity, and date of self-pollination.

Completely write the information on the bag of female spikes, adding the name of the male plant, and bag it. If this hybridization is being conducted in the greenhouse, you can bag male and female spikes together for a period of 48 hours. And do flick the bag time by time to release the pollens and move the female spike around to face the opposite side also.

Forceps are needed to be sterilized with ethanol to avoid cross-pollination when performing successive pollinations with multiple male parents.

After four or five days of pollination, the fertilized ovary will begin enlarging and forming seeds. You can do it by removing crossing bags from all pollinated spikes. And count the numbers of seeds forming, write their numbers in the crossing book for statistical treatment, and place the bags on their spikes.

Chapter 7. Assessment methods of triticale breeding materials

Varieties, hybrids, mutated diversities, introduced variety diversities, and even new lines or introduced samples of triticale are subjected to testing for assessment of their traits and properties by one of the procedures: correct, incorrect, field, green house, background, provocation, and others. All these assessment procedures have been directed to better utilize the genetic potential of the triticale diversities in scientific programs or in production.

Testing according to the method of the State Variety Trial of Agricultural Crops (1989) and its methodic recommendations for any grain crop variety in the conditions of experiment field plots located in the regions where the variety is intending to extend is guessed to be a more precise assessment, and the results will be commonly acknowledged.

The State variety trial embraces competitive and widened competitive testing on the following indexes: germination, suitability to intensive production technology, cold resistance, tillering, plant height, resistance to lodging, susceptibility to diseases and pests, environmental stresses (drought), period of vegetation, grain productivity, grain shedding, grain sprouting on the root, grain ratio to hay, weight of 1000 grain, grain nature (weight of 1 liter of grain), content of protein and gluten (grain quality), technical quality of flour.

Fixing the germination of triticale seedlings begins when the first unfolded true leaves appear on 75% of the recording plants. The density of the **plant stand** is recorded on the probe area with a size of 1\12 m², isolating in two replications (on three areas per lot). The counting of plant stands is conducted twice: at the time of full germination (on all varieties) and at the picking up of probe bundles for lab analysis before harvesting, on the varieties whose productivity is not lower than the checking (standard) variety.

The suitability of the varieties to intensive cultivation and production technology is expressed by the sum of assessments on the loss of seed quality at the time of seeding, plant damage at the time of cultivation, and grain qualities in harvesting, transporting, and storage (bunch of photo 201). At this point, the assessment of farmers and reprocessing organizations has prevailing significance.

Assessment of cold resistance is conducted in autumn before going of plants to winter and in spring after starting the leaves to

grow in every replication in marks: *5-mark when the state is excellent (plantation is in its required plant stand, not re-grown, good tillering; tillering coefficient -3-4; yellow leaves state is absent.

*4-mark: the plants' state is good; plant stand is 71–80%; plants are not regrown; tillering is not completed; there are no signs of infection or damage from the activity of pests.

*3-mark, at middle state, plant stand -61–71%. Weak tillering or plants re-grown in autumn are in the middle of diseases and pests.

*2: The plantation state is not good; the plant stands at -51-60%. Tillering in the autumn was not started because there was damage caused by infection and pests, and the and the soil pressed with a lot of trenches.

*1-mark: plantation state is not good in the autumn; plant stand is -31–51%; the plants are weak.

*0-mark: plants have been lost; the number of left plants is not more than 30%.



Bunch of photo 201. **Cultivating and production agro-technologies of grain crops.**

The beginning of tillering is marked since the first leaf of the side shoots out of the node of the leaf on the main stem.

The height of the plant is measured before harvesting by measuring the distance from the soil surface to the top of the main stem without taking into account the awn tip. Bended plants are corrected. Measuring is conducted in the five places of a lot in the two replications and displays the average value of the indicator.

Assessment of lodging is carried out in the field on the five-mark scale. Absence of lodging is fixed by the 5 mark; weak lodging (the stems are bended slightly): 4 mark; middle lodging (the corner of the bend to the soil surface is at 45°) – 3 mark; considerable lodging is valued with the mark of 2; and very strong lodging when mechanical harvesting is impossible: 1 mark.

Resistance to diseases. Rust is evaluated in the various natural-climatic zones, and its infection varies year by year. Resistance of

triticale varieties can be evaluated in the field by taking into account the grade of their damage at the time of the strongest spreading of infection. If there is no such condition, apply artificial infection to plants. Suspension spores collected from infected plants are sprayed at a ratio of 10 liters per 100 m² of the plot. Accurate assessment of the rust resistance of varieties is possible at the artificial infection by the clean races.

The grade of resistance to rust is defined by the percentage of leaf area infected by specific spots. Usually, for this, the scales (classic 5-mark system) are used to identify the infections of wheat leaves by brown rust (figure 63).

By the point 0, resistant plants are marked when there are no signs of disease; by the marks 1, 2, 3, and 4 (correspondingly, very weak, weak, mean, and stronger infection of plants).

Pest resistance is evaluated using the example of the turtle bug, which equally damages grain across all diversities of grain crops. For locusts, there are no differences in plant species or genus diversities. The grade of resistance of varieties is defined through the calculation of the average number of damaged plants (stems) or the number of harmful insects per unit area (1m²).

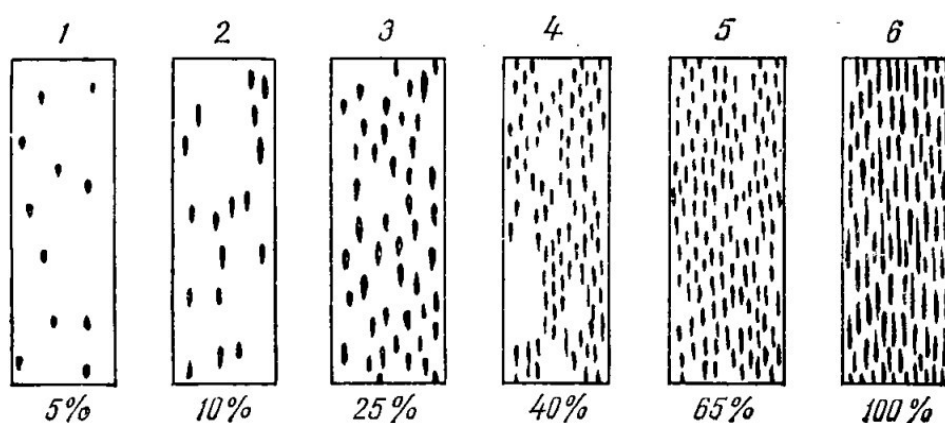


Figure 63. Immune type and infection grade of wheat by brown leaf rust. (Gulyayev, G.V., Dubinin, A.P., 1980).

Resistance to drought. The resistance of 11 varieties of triticale to drought was evaluated through the physiologic method at the Andijan Institute of Agriculture and Agro-Technologies (Gaybullaeva M.Kh., 2022).

This method of assessment involves the use of sterilized Petry dishes, filltr papers, thermostats, slender tubes, pipets, and lab dishes in

“Determination of triticale resistance to relative drought through seeds’ germination and growth of seedlings in the osmotic solutions (Vir’s methodic instruction, L.1970.10.6.)

Seeds of the samples were placed in the sterilized Petry dishes, with 50 seeds on each one. Two standard glasses were filled with 250 units of 10 ml distilled water, then nistatin was added nistatin. A 10 ml sacharoza solution of 17.6% was poured into the experiment (to establish 16 atmospheric pressure) in three glasses.

The prepared glasses were kept for 5 days in the thermostat at 21°C oC..

Germination degrees of standard (check) seeds consisted of more than 96%. The germination of experimental seeds was studied comparatively with the checking share, and according to the taken data, the germination of sample seeds was grouped as follows: 1-group: 0-20% (not constant); 2-group: 21-40% (weak resistant); 3-group: 41-60% (mean constant); 4-group: 61-80% (resistant); and 81-100% (high group of resistant).

Studied samples based on their number of resistances to the definite drought were divided into four groups: weak (2 variety samples), mean resistant (3 samples), resistant (4 samples), and highly resistant (2 variety samples). Sardor and To’yimli triticale varieties could show highly resistant varieties within the studied variety samples. Their advantages have been at 100% root formation and seed germination in the condition of sachoroza solution with 16 atmospheric pressure. Therefore, they were recommended to be used in the triticale breeding programs for creating drought-resistant genotypes. Valentin and GuLDu varieties belong to the weak resistance group and have less than 41% of germination degree.

The period of vegetation is counting from the day of full germination to wax maturity (farming, harvesting).

Heading is marked when the spike, approximately its half, gets out of the node of the upper leaf.

Milk maturity is marked when grain from the middle part of the ear is extracted with thick liquid milky light at the pressing between fingers. Plants are still green; getting yellow is noted only on the lower leaves of the stem.

Full maturity in grain crops is marked when the grain becomes hard at the pressing with knife splitting. At the shaking of the ear, the grain is shedding. Full maturity is registered if the harvesting is started at its beginning.

The suitability of a triticale variety to mechanical harvesting is evaluated at the harvesting time, which depends on a range of traits (resistance to lodging, ripening uniformity, height of plants, shedding, and others):

*5: the variety entirely fit for mechanical harvesting, fully harvested without losing;

*4: Mechanical harvesting is partly difficult.

*3: Mechanical harvesting is possible with the availability of special mechanisms (to harvest lodged plantations), and at this point, crop losses are possible.

*2: Mechanical harvesting is possible only in one direction with special mechanisms to harvest lodged plants;

*1: Mechanical harvesting is impossible.

Grain productivity of triticale varieties partially connected with the grain of an ear (on tetraploid triticale) is determined in the developing stage of wax maturity, or a bit early. It takes a probe of 50 ears along the length of a lot in one replication and is analyzed that day. Ears are inspected by sides, counting total number of shriveled (empty or puny) spikelets.

Percentage of through the grain is equal to

$$X = \frac{b}{a}$$

where, a-total number of spikelets and b-number of spikelets without grain.

The most simple and widespread method of determining **resistance varieties to grain shedding** is to assess them by leaving them alone. For this, a part of the registered lot at the end of the of the protective path in two replications will be left without harvesting. In 5, 10, and 15 days, every left area is picking up a definite number of ears and is counting the percentage of fallen grains.

The content of **sprouts on the root grains** is identified on two 50-gram-weighted grains. Extracted grown grains is weighed and determined their existence in per cent with the preciseness up to 0.1%.

The grain ratio to hay is calculated from the part of the straw bundle of a variety that is cut off at the level of height out of the harvester's cutting. The straw is weighed with precision up to 1 g and

threshed. Counting out the percent of grain and, accordingly, the percent of hay in the bundle sample.

Hay productivity is calculated using the formula:

$$X = \frac{a \cdot b}{c}$$

where, a-grain productivity, ton\ha; b-hay content in the total mass, % and c-grain content in the total mass, %.

Grain quality: moisture, weight of 1000 grains, presence of grown seeds, grain nature, grain damage by bests, and diseases are identified at the variety trial plot and variety stations (details about their analysis can be found in the manual of this text book: <http://library.ziyonet.uz/uz/book/126706>).

The new triticale samples are also evaluated for their **ecological sustainability** through ecological variety testing. Recently, I.U. Egamov and V.T. Khamdamova reported (2023) the results of ecological variety testing carried out in the triticale collection nursery of the Grain Bean Crop Scientific Research Institute.

The collection nursery is used for assessment works on new triticale lines from other regions, introduced varieties, and samples from all continents of the world (table 59), which entirely differ from each other on their place of origin and grown conditions.

On October 21, 2021, the seeds of 185 varieties and samples were sown without replication in an area of 1m² each and studied. In the second year, they were sown in an area of 2-3m² with 3 replications.

Table 59. Geographic origin of triticale variety and samples.

№	Geographic origin	Countries	Number of samples
1	Eastern Europe	Russia, Hungary, Serbia	88
2	Western Europe	France, Italia, Denmark	30
3	Central Asia	Uzbekistan, Kyrgyzstan, Kazakhstan	20
4	Southern Asia	Turkey, Syria	37
5	Central America	Mexico	10
Totally			185

Introduced varieties of Krasnodar: Sergiy, PopTSAZ-44, YArillo, Romes, Sotnik, Brat, KNINEX-6, KNINEX-70, FRIZO-6, yeRIZO-49, RANV-17, POLMER-17, PASSI-8-60, HIPPO-4, SITER-77-170, Sloser-49, 578884, 578894, 100519, 100557, 100597, 114216, 117429, 118156, 118198, 118759, 118947 were selected for their early maturing and productivity properties to conduct ecological variety testing.

Adaptation potentials and resistance to environmental stresses have also been taken into consideration in the assessment of this ecological study.

The varieties were planted by using the seeder SN-16 (photo 202), on November 15, 2023. The area of the ecological test nursery is 100 m² in one belt (photo 203) with a seed sowing rate of 4.0 million vital seeds per hectare. Seeding depth was 4-5 cm.



Photo 202, 203. **Modern grain seed drill and ecological testing nursery.**

The soil was fed before seed sowing with mineral phosphorus at the norm of 90 kg and mineral calcium at the norm of 60 kg.

Full germination of world collection samples took 8–12 days. The first tillering (March 10) was watched in the Sergey and 114-216 varieties; the late tillering belongs to the Polmer-17 and 100-597 varieties and lines. Tubing was watched for the first time in the Pomes variety and FRIZO-16 line on April 18–19. The late tubing is noted in the RANV, PPOLMER varieties, and 118–119 lines on May 3–5. The early heading was in the variety of KNINEX on May 21; here, the latest one was 118–119 line on May 18; and so on.

The ecological assessment of 118 world triticales collections has made it possible to know that their vegetation period ranges from 205 to 225 days.

Chapter 8. Seed production of triticale

Considering the fodder crops, triticale is the indispensable fodder and hay-producing crop within grain crops. Seeds of triticale vigorously germinate and overwinter at 6-12°C oC. The root system develops well and is resistant to cold. It requires more water at tubing, booting, and until the starting of the heading (ear emergence) stage of development. If there is no adequate water at this time, the seeds form smaller, and the maternal plant has a lowered seed yield. It has the same self-pollinating (as wheat) and outcross (as ray) biologic behaviors. These two crops pass through developing stages such as germination, tillering, tubing, heading, flowering, milk maturity, wax (dough) maturity, and full ripening (figure 64).

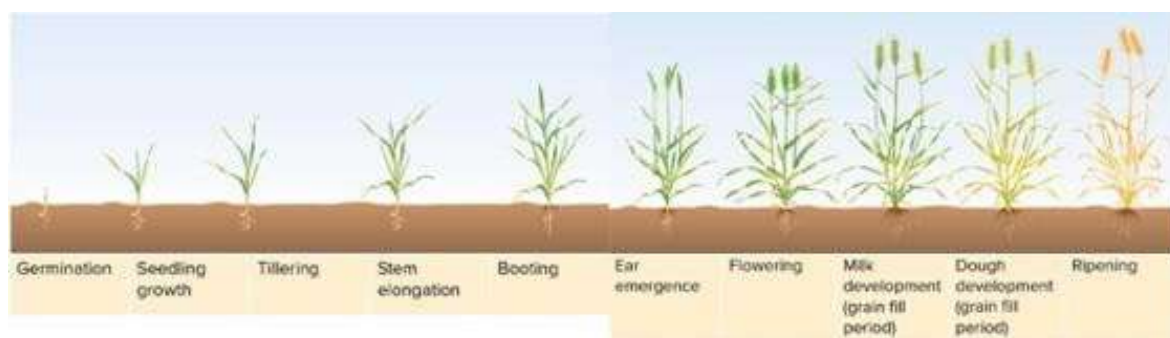


Figure 64. **Growing and development stages of triticale (Alejandro del Pozo and others., 2023).**

According to this figure, the seeds start germinating at a temperature of 3-4°C. The required temperature for full germination makes up an average air temperature of 20-22°C and in 6–8 days, the germination ends. After that, seedlings until tillering require 34–37 days. In Uzbekistan, tillering takes place in the autumn, and 2–6 new stems form on one plant. Tillering activates when the plant stand per area is low. Triticale withstands -18 and -20°C colds. The transition from tillering to stem elongation (tubing) takes place 140–145 days after germination. Increased demand for water by plants has begun since the beginning of tubing. Heading in triticale starts in 154 or 163 days and flowers in 161–176 days. Milk maturity in the ears begins in 184–202 days.

Cutting for green mass begins after specialists' allowance. Transition to the wax (or dough) maturity stage starts in 196-218 days after germination. To reach full ripening, it requires 206-225 days, depending on the variety's biological features.

An appropriate triticale seed production method worked out on the basis of modern crop cultivating technologies ensures getting high-quality seeding seeds from cultivating varieties and stabilizes the production of green mass or bumper grain crops annually.

In 2014, a group of scientists, breeders, and seed producers of fodder-hay crops gathered and elaborated an instruction on the seed production of fodder- and hay-producing crops for irrigated land in Uzbekistan. In particular, the instruction brings into light the biologic response of triticale seeds to physical factors of the environment to grow and develop under optimal specific agro-practices to produce high-quality seed stock (seeding seed) from triticale varieties.

A brief agro-practice to produce seeding seeds of triticale varieties. The soil is prepared in the autumn before planting. The plowing depth is 25–28 cm, and 60 kg of phosphorus and 60 kg of calcium fertilizer per hectare are applied to the soil prior to plowing (photo 204, 205).

The seeds of triticale are sown in the last decade of September in the northern regions, in the first decade of October in the central regions, and at the end of October in the regions of the southern regions of Uzbekistan. 160–170 kilograms of triticale seeds are seeded per hectare with the help of grain seeders (photo 206). Just after planting, water tranches (rows) with mechanic cultivators and water.



Photo 204, 205, 206. **Feeding the soil before ploughing and seed sowing.**

In spring, nitrogen fertilizer in the amount of 60–70 kg per hectare is applied before seedlings are developed, watered again (photo 207) and chemicals sprayed to control disease and pests if needed (photo 208). The second feeding is done with nitrogen (90 kg per hectare) at the developing stage of tubing and watered a third time (photo 209). The following watering (forth and fifth) will be done during the flowering stage and milk maturity.



Photo 207, 208, 209. **Feeding seedlings, using chemicals and watering.**

Method, system, and scheme of triticales elite seed production.

Agricultural scientific-research institutes, elite seed-producing farms, cluster-based farms, and private farms produce various categories and classes of triticales.

In general, the seed production method (individual selection, mass selection, or their modifications) is recommended by the originators of a definite triticales variety.

Preliminary seed production. The first generation of seed material, or super elite or elite seeds, is produced by the Agricultural Scientific-Research Institutes (SRIs). Selection of typical ears from typical plants is carried out in agricultural SRIs and in private seed-producing companies if they are the originators of the varieties. The method of seed production in primary seed production is repeated in elite seed production.

Elite seed production. The next generations of seeds are produced on the elite seed-producing farms and other seed-producing farms.

The following seeding seed production **system** is used to produce triticales seeds in our republic:

*Seed nursery of the first year selection: selected of 2000–3000 best ears out of many promising lines (depending on the amount of seed production). **The scheme** of seed production involves the seeding of seeds out of every ear in the seed beds (rows) and all surveys (phenologic inspections and biometric measurements) in the vegetation period, recording the resultative data in the experiment book, including the sensitivities of elite plants to diseases.

*Seed nursery of the second year of selection: each selected family, after rejection in the first year of selection, is sown on an area of 10 m² and evaluated for resistance to diseases (photo 210).



Photo 210. Dislocation of triticale families in the seed nursery of the second year selection.

* Seed reproduction nursery of the first year: representative planting is conducted with the recording of conditions in the farmer's plots and continued evaluation of the reaction of plants to diseases.

*Seed reproduction nursery of the second year uses the same procedure as in the first year; it is carried out in the experimental farm of the institute.

*Seeds of the super elite (breeding seeds) were produced in the central experimental point of the institute, in the farms on the elite seed production, and in the private cluster farms. These seeds are used to produce elite seeds.

*Elite seeds: they are produced in the farms on the production of elite seeds and cluster farms. Individual-family selection remains the basic method in the production of elite seeds. Massive selection can also be used according to the recommendation of the originator.

*Seeds of F1 are produced in the farms for the production of elite seeds, private and cluster farms.

*Seeds of F2 are produced in the farms on the production of elite seeds, private and cluster farms.

In terms of production, elite seed production methods embrace two periods: the primary part of seed production and reproduction seeds (until elite). The first part involves selection based on typicality and productivity, and the second part involves rapid reproduction.

An isolation distance of 150 m should be used between different reproduction nurseries and varieties of triticale in the process of seeding seed production.

Usually, attentively inspected phenotypic features of plants in the first and second-year selection nurseries. Then selected ears and mass crop threshed, counted the productivity, and evaluated the grain and seeding quality. The best seeds of families are united and transferred to the sowing in the reproduction nurseries.

So, there is a seed-improving movement: the seeds harvested from the reproduction nursery after cleaning, drying, and sorting are used to produce super-elite seeds. And superelite seeds are also used to produce elite seeds.

Agro-practices have to ensure optimal growing conditions in all seed-producing nurseries.

Questions on the studied themes:

1. What crop is a tritcale within grain crops?
2. Do you know about the advantages of tritcale in our farming conditions?
3. Is there a disadvantage to tritcale?
4. Can you remember the best rate and term of tritcale seed sowing?
5. What breeding methods are being used to improve the cultivation of oat varieties?
6. Do you know countries where oat breeding has advanced?
7. What is vernalization in the developing stages of tritcale and other grain crops?
8. Do oat breeders use intervariety hybridization in their breeding process?
9. Can you remind me about the chromosome set of tritcale and its makeup?
10. What properties of tritcale materials are assessed during the breeding process?
11. Is resistance of tritcale important to plant diseases?
12. What pests are harmful to a much higher tritcale crop?
13. Can you explain the grain quality traits of tritcale?
14. What is the response of Triticaly to growing conditions?
15. Where is carried out seed production of tritcale varieties?
16. Do you know about the seed production system and the scheme of tritcale?
17. Can you differentiate elite seeds from super-elite seeds of tritcale?

Chapter 9. Triticale approbation

Approbation and its procedure for Triticale seed plantations were taken from the instructions on the approval of variety plantations (approved on May 5, 1994, and Seed Production, 2014). According to these instructions, variety purity of triticale is determined by analyzing plants by root or on the approbation bundles (photo 211) picked up from the seed plantation plot when the plants achieve their wax maturity.



Photo 211. Approbation bundles taken from triticale seed producing fields.

An approval bundle with at least 1,500 straws is formed at 150 points of isolated 450 hectares in the seeding seed production field (Appendix 5). At this stage, the plant bundle is fully analyzed by disassembling stems into the following groups:

- *main variety of approbating crop;
- *other species, diversities, and varieties of appreciating crops (variety mixes);
- *main crop, damaged by different species of smut, fuzarium, and other diseases;
- hardly separating cultural plants;
- hardly separating weeds;
- *wild weeds;
- *toxic weeds;

*quarantine weeds;

*underdeveloped stems of the main crop.

The availability of quarantine weeds (dodder, ragweed, and others) is not permitted in the seed plots; the seed plots have to be excluded if there are some plots with these weeds, and the crop from these plots will be used in accordance with the agreement with local state inspections on the quarantine plants.

The number of straws (stems) in all groups is counted after the analysis of plants on the root at all points, or bundle disassembly and analysis of all of them.

The percentage of **variety purity** is identified by the ratio of the number of fruit-bearing stems of the main variety to the total number of developed stems of approved crops.

Percent of infection of plantations with smut (Appendix 2), fuzarious diseases, and other diseases is defined for every species of smut and diseases individually and calculated as a ratio to the total number of developed stems of main crops (including stems, infected diseases).

Percent of plantation contamination with hardly separating cultural plants and weeds is identified by the ratio of the number of fruit-bearing stems out of these groups to the total number of fruit-bearing stems of main crops, including stems of determining groups for exclusion of stems and infected diseases.

For example, in the result of the analysis of triricale plants of the variety Pirag srebsistiy, it was identified that the stems of the main variety were 1,600, other varieties and diversities were 17, hard-separated cultural plants were 10, infected by Smut-3, and so on.

To account for the **percentage of variety purity**, use the following equation:

$$\frac{1600 \times 100}{1600 + 17} = 98,94\%$$

Making round the share of hundred on the rule making round, and in the statement of approval indicates variety purity (98.9%). To account for the percentage of contamination of plantations with **barely separating cultural** plants (oats), the following equation is used:

$$\frac{10 \times 100}{1600 + 17 + 10} = 0,6\%$$

Contamination of plantation with **hard separating weeds** is calculated similarly. The percentage by **dust smut** is calculated with the using the next equation:

$$\frac{3 \times 100}{1000 + 17 + 3} = 0,2\%$$

Infection of the plantation with other kinds of smut is calculated as the calculation of dust smut. The taken data is entered in the section of the approval statement, “Results of Analysis.” At this point, the quarantine weeds, numbers and names are written.

Oat and ray belong to the hardly separated cultural crops in the triticale plantation. If total contamination by hardly separating cultural plants does not exceed 3%, the authority gives instructions to farmers about thoroughly cleaning seeds; if it exceeds 3%, the plantation recognizes it as unfit to use for seed purposes.

Sophora, foxtail, cephalaria, wild oats, and others belong to carefully separated weeds. If total contamination with all hardly separated weeds exceeds 3%, the plantation is recognized as unfit for seed purposes.

The variety certificate accompanying the seeds must indicate the availability or absence of quarantine for toxic and harmful weeds on the plantation. The seed plantations of Triticale are excluded (but elite) from seed provision if they have different species of hard smut and rust on the stem summarily exceeding 0.5% or 2-5% (correspondingly to the instructions).

The following documents were composed on the basis of the analysis of the approval:

- *statement of approval on Form 193 (Appendix 8): reproduction plantations; the seeds of those are intended to be used for their own needs;

- *statement of approval on Form 195 (Appendix 9): reproduction plantations, the seeds of which are intended to be sold;

- *statement of approval on Form 197 (Appendix 10): plantations of original seeds and for elite;

- *statement of approbation on Form 199—for all registered variety plantations;

*statement of rejection on Form 200 (Appendix 12) for unfitted plantations to seed provision recognized in the result of approbation.

Part X. Major laws of agriculture to regulate plant breeding and seed production in Uzbekistan.

Chapter 1. State Law “About Achievements of Plant Breeding”

The law “**About Achievements of Plant Breeding**” was accepted on August 30th, 1996. In the passed years of its functioning, subjected to many revises and on August 29th, 2002 has been approved its new addition.

The purpose of this law is to regulate attitudes in the field of creation, loyal protection, and the use of plant breeding achievers. It has 6 chapters and 45 articles.

The chapters relate to the provisions of:

- I. General provisions.
- II. Patentability of breeding achievements.
- III. Taking a patent to breeding achievement.
- IV. Right of the patent owner.
- V. Patent termination.
- VI. Final provisions.

In the first chapter of the law, the basic concepts (breed, employer, licensor, licensee, variety, patentee, applicant, legislation on selection achievements, organizational basis for the legal protection of selection achievements, author of the selection achievements) were scientifically formed in the breeding process and extension of selection achievements in the new realities.

In the second chapter of the law, it is widely interpreted as the as the patetibility of breeding achievements and its requirements: conditions providing legal protection of selection achievements, novelty of the breeding results and their distinctiveness, uniformity, stability (like DUS in the international law of “The Protection of Intellectual Property”), and name of the selection achievements.

The third chapter of the law is devoted to the formation of patents for breeding achievers, patent rights, filing a patent application, content of the application on getting a patent, priority of breeding achievements, state expertise of the selection achievements, formal examination of the application, terminal protection of selection achievements, examination of the novelty of breeding achievements, testing of the declared achievements of selection, conclusion of a patent application, registration of selection achievements, official publication of

information about breeding achievements, issuance of a patent, protection of selection achievements, and patent fees.

Patent owner's rights have been considered in the fourth chapter of the law. In detail, it has brought into light the provisions of the exclusive right of the patent holder, exceptions to the right of a patent owner, exhaustion of the right of the patent holder, and violation of the patent owner's right.

Patent termination conditions are set in the fifth chapter and identified as provisions for invalidating a patent, early termination of a patent, patent revocation, patent relinquishment, and restoring the validity of a patent for a selection achievement.

In the final provision of Chapter 6 of the law, such kinds of provisions as transfer of rights to a selection achievement, granting the right to use a selection achievement, compulsory license, rights of foreign legal entities and individuals, dispute resolution, and responsibility for violation of legislation on breeding achievements are identified.

A great deal of attention in the law is focused on the taking of patents to breeding achievement (in the III-Chapter) and the rights of the patent owner (in the IV-Chapter). A patent is issued for selection achievement, in particular for newly created varieties (photo 212) of grain crops. At this, it is especially remarked that patents are issued on breeding achievements meeting criteria of patentability and belong to botanic genera and species protected by the Republic of Uzbekistan.

Chapter 2. State law “About Seed Production”

The final version of the law “**About Seed Production**” was approved on February 16, 2019. The law has four chapters with thirty-nine articles to regulate attitudes in the field of seed production. The chapters are:

1. General provisions.
2. State regulation in the field of seed production.
3. Organization of activities in the field of seed production.
4. Final provisions.

The first chapter embraces the purpose of the law, which is the regulation of attitudes in the field of seed production. This chapter also contains legislation on seed production, main conception (about approval, hybrid seed, original seed, patentee, licensor, population, reproduced seed, seeds, genetic quality of seed, planting quality of seed, seed batch, seed production, elite seed), seed category (original, elite, reproduction), seed production objects (variety, hybrid, population, seeds, seed plantations used to produce seeds), seed production entities (author of variety, seed producer, seed seller, seed consumer, organization serving to define genetic and planting quality), right of seed subjects, and responsibility of seed production entities.

State regulation in the field of seed production is considered in the second chapter and consists of the main directions of the state policy in the field of seed production (creation favorable condition to attract investments, development of infrastructure and service, development of scientific-research works and integration modern form of activities, maintaining genetic (variety) quality at the production of seeds, creating efficiency systems of seed reproduction and providing by them seed customers (users), stimulation the activities if entities of seed production and development of international cooperation in the field of seed production), powers of the Cabinet of the Republic of Uzbekistan in the field of seed production, powers of the Ministry of Agriculture of the Republic of Uzbekistan in the field of seed production, powers of State committee of the Republic of Uzbekistan on the Forestry farming in the field of seed production, powers of Center on the development at the Ministry of Agriculture of the Republic of Uzbekistan in the field of seed production, powers of Local state organs in the field of seed production, State organ on the certification and seed quality control (which has become inspector for agro-industry complex at the Cabinet

of Ministries of the Republic of Uzbekistan and in its territorial departments), powers of Inspection on the control for agro-industry complex at the Cabinet of Ministers of the Republic of Uzbekistan in the field of seed production and the right of staff of inspection on the control for agro-industrial complex at the Cabinet of Ministers of the Republic of Uzbekistan.

The chapter of three has organization of activity in the field of seed production and **determining genetic (variety) seed quality** (where pointed out that variety quality of seed defines in the result of approbation, ground assessment of seed plantations using to produce seeds, laboratory seed testing), approbation of seed plantations using to produce seeds, laboratory variety seed testing, **determining planting (sowing) quality of seeds** (where underlined that planting seed quality is defined through carrying out of analysis of seeds out of selected probes (samples) from seed batches; selection of probe from seed batch, conducting their analysis and identifying planting quality of seeds are implemented by the inspection on the control for agro-industry complex at the Cabinet of Ministries of the Republic of Uzbekistan; on the result of defining planting quality of seeds on the standard seed are issued a certificate of conformity and report of testing with indicating planting quality of seeds, on non-standard seeds – the result of tests, approving the planting quality of seeds), **seed certification** (seeds used for sowing subject to certification, certification of seeds, used to sowing includes: filling application for certification and its consideration, identification, selection and delivery of samples to laboratory, testing samples in the laboratory, analyze of taken results, issuance of a certificate of conformity or refusal to issue it and registration of certificate conformity in the State register for National system certification of the Republic of Uzbekistan), register of seed producers, seed production, procurement, processing, storage and usage, seed realization, guarantees for sold seeds, seed import and export, additional processing, utilization and destruction of seed, **insurance seed fund*** (insurance seed fund is created by the Cabinet of the Ministers of the Republic of Uzbekistan in order to ensure the supply of varietal seeds for replanting in the cases of natural disasters and in other purposes), scientific researches in the field of seed production, and intellectual property in the field of seed production (patentee as well as legal and physic entities having license have right on the production and use seed of varieties and hybrids protected by patent).

* According to the textbook “Basics of Plant Breeding and Seed Production” (Ostanakulov T.E., 2013), the insurance fund prepares at 100% in regard to all seed demand: 100%: super elite; 50%: elite; and R1: 25–30%.

The following questions of seed production are being clarified in the fourth chapter of the Final Provisions: financing of activities in the field of seed production, dispute resolution, responsibility for violations of legislation in the field of seed production, recognition of some legislative acts of the Republic of Uzbekistan, ensuring execution, communication, clarification of the essence and meaning of this law, bringing the legislation into compliance with this law, and entry into force of this law.

Questions on the studied themes:

1. On what instructions approbation of triticales seed fields carried out?
2. Into what groups are the stems of the plant bundle dissected to analyze them?
3. What is variety purity, and how is it defined at the base of approbation plant bundle?
4. Explain the designation of the state law “**About the achievements of plant breeding.**”?
5. When was published the law “**About Seed Production**” and what are its objects?
6. Do you know about the seed insurance fund and its amounts?

Part XI. Variety and seed supervision

Variety and seed supervision (control) is the system of measurements involving field approval inspections to determine the variety grade of cereal-grain crops grown in the SRIs, agricultural experimental farms, and seeding seed (seed stock) producing farms and clusters (Instruction for Fodder and Hay Crops' Seed Production, 2014). Controlling variety-grade plants to get seeds for seeding is divided into **state and on-farm controls**.

“Uzagroinspeksiya” is a single state organization (photo 213) controlling the activities of individuals and legal persons engaged with republican agricultural crops' variety and seed production and their correspondance with the requirements of the law “About Seed Production” of the Republic of Uzbekistan.



Photo 213. Agro-industry complex servc center (Uzagroinspeksiya).

“Uzagroinspeksiya” has been charged with the following offenses: control the fulfillment of state policy in the genetic variety purity, seeds' variety, and planting quality of agricultural crops;

-in the sphere of accreditation to certificate seeds, leading control over the works on remarking seed quality and control, it does not matter their producers or consumers.

“Uzagroinspeksiya” and its regionally distributed departments fully cover controlling seeds’ variety and planting quality indexes of agricultural crops cultivating in our Republic according to the law of “About Seed Production”, harvesting, reprocessing, storage, and use for sowing, and leading state policy on the quality of agricultural crops.

Chapter 1. State control

Ministry of Agriculture of Karakalpakistan, agricultural governances of regions, Karakalpakistan Republic, and regional agro-industry complex service center, "Uzagroinspeksiya," former "Uzdavurug'nazoratmarkaz," and with the participation the specialists of its district governances, on the basis of an order issued by the Ministry of Agriculture of the Republic of Uzbekistan, are carrying out state control and field approbation inspections on variety grades of plantations planted for seed provision at the SRIs, in experimental stations, and in seed-producing farms.

Variety control is also continued in all variety seed-producing technologies, including cultivating variety plants, harvesting, crop collection, and reprocessing processes. The main object is to detect the reasons causing the worsening of the seed sowing quality of variety seeds having high economic biologic traits and properties at the time of vegetation, harvesting, reprocessing time after harvest, period of selection, collecting of crops, and during storage.

Overall supervision over the main internal structure of on-farm control, which includes field approval, registration of variety crops, laboratory control and control over the regulations, and observing the correct document composing variety seeds.

Inspection in the farm measurements directed to the variety control methods applying in the improving variety quality of crops cultivating for seed stock provision, to compose reports about breaches in the conducting of production methods, control over observing the rules of seed producing agro-practices, weeding works in the variety and typical fields, preventing biologic and mechanic contamination, and so on.

Field approval of variety crops is one of the main basics of variety grade control. For example, seed production and preparation works are inspected in the conduct of corn and sorghum appraisals and evaluated for variety and quality of hybrid seeds to sow for the purposes of seed production.

Field approvals for other grain crops were also conducted as control documents for bought seeds, their storage prior to seeding, field surveys of plantations on the good-bred and locally extended varieties, and so on, providing farms with the needed equipment and tools in the production of seeds based on their planting qualities and variety grades to meet state requirements.

Simultaneously, crops' variety quality and hardly separating weeds (photo 214) within crops, including quarantine, poison, and weeds in the open fields, are identified.

As well as regularly controlling the crop plantations in terms of the worsening grade of the plants' state as a result of the consequences of agricultural diseases and pests. The fulfillment of preventing sanitary measurements by the individual farms to produce high-quality, biologic-perfect seeds, observing all instructions of the agro-practices and organizational works (plant rotary, distance limiting, weeding, soil smoothing, feeding and opening trenches to watering, insecticide and pesticide application, field monitoring, preparing to harvest, harvest, transportation, drying, sorting, cleaning, preparation of grain warehouses, sheds, shelters, and elevators) Their fulfillment and current state are inspected and evaluated.

“Uzdavagroinspeksiya” is carried out according to the instruction (2006) on variety crops' approbation. Annual approval attracts the following objects:



Photo 214. Oat plants within triticale plantation.

Scientific production experimental farms use the production of seeding seeds, SRIs, training experimental farms of agricultural colleges, and variety crops from specialized seed production farms. Including varieties and hybrids of agricultural crops cultivating in the regions of the Republic of Uzbekistan into state registration.

Conducting field surveys on the simple, two-pair line, three-line variety line, and inter-varieties hybrids of the first generation, hybrid area.

Grain crops are registered instead of approbation of the first hybrid generation of corn and sorghum crops in the remaining fields of corn and sorghum crops; the documents of planted crops are revised, and approbation is conducted on the basis of inspection of straw without picking up of approbation bundles (photo 215).

References are registered as the results of the survey on the basis of Form 199 and documented.

Approbation is carried out on all crops at the SRIs, training-experimental farms, and elite seed production farms in the reproduction nursery of elite seed production farms. Provision of variety seeds at the fulfillment of the state plan, commercialized varieties (mainly deficit), not lower than 4th reproduction according to standard, as well as seeds of perspective varieties according to some of the agreements on seed production with seed producing farms and handing them over to state seed warehouses are also involved in the goals of approval.



Photo 215. Example of innovative method of approbation without plant bundles.

Chapter 2. On-farm control

Indeed, the agronomists of the agricultural crop-cultivating farms of the Republic serve both purposes: crop product with sowing seed production and crop product with technical seed production. They are the leading part of the variety control system and responsible specialists in the accurate implementation of continuous (annual) farm control.

The structural parts of the variety control system (scheme) are: conducting (or engaging in) field appraisals of variety crops meeting the strict requirements of state standards; selecting plots designated to produce seed material; and fulfilling other related works in correspondence with accepted seed-producing technology.

Conducting weeding works depending on the weed types and on the crop variety grades, Warn of the contamination of seeds between varieties and between different reproduction seed nurseries; admit the fulfillment of seed harvest, thrashing, sorting, storage, and transportation works by specialists.

Be a participant in the selection of seed probes (photo 216, 217, 218) for laboratory analysis. Taking severe attention to seed selection rules in all processes of seed production is the main object of on-farm variety control. The weakening of on-farm control causes a worsening of all seed-producing processes on the farm, an increase in rejections of the variety grade of elite plants, and so on in grain seed planting quality. Bringing the farm's internal documents into order is very important for producing variety seeds. Often, to provide orderly seed production works on every farm, it needs to adopt them in a required order to save high-quality planting materials.



Photo 216, 217, 218. Time and places to take needed probes of seeds.

Often, it causes a decrease in seed quality depending on the organization's state of harvesting, drying on the squares, transportation,

and storage. Tags, posters, and labels are foreseen to prevent mechanical mixing of seeds of different origins and generations. They have a farm name, a crop and variety name, a seed progeny name, and a and a crop rotation.

The seed production order in the above-listed subsequences ensures where to place the seeds of new grain batches from the new harvest. There is no additional problem, but only replace the labels. Also, the planting seed materials at the times of transportation from the field to drying squares, warehouses, elevators, and back to sowing in the next spring or autumn have to be accompanied by the necessary seed documents and attached labels (take a look at the manual of this textbook: <http://library.ziyonet.uz/uz/book/126706>).

Chapter 3. Requirements to seed quality indexes and using aspects.

Seed quality. The seeds of cultivating crops must be passed through laboratory analysis on their indexes of variety grade and planting qualities in order to get the most germinated seedlings and harvest bumper crops.

Reprocessed seeds but not improved up to conditioned seeds, not checked seeds of agricultural crops do not admit planting. According to state standards, in the following grain crops, the contents (purity) of the main crop, infected seed mixes, injured seeds, moisture, germination, and other indexes' rates have been identified. According to these indexes, the seeds of agricultural crops are divided into classes meeting these requirements (table 60).

Table 60. The main seed indexes of grain crops on the state standard rates (on the republican DOST).

Crops	Class	Contents of main crop, at least, %	Contents of other crops, not more than piece\kg		Germination, not less, %
Triticale	I	99	20	10	92
	II	97	200	70	87
Barley	I	99	10	5	95
Oat	II	98	80	20	92
Ray**	III	97	300*	70	90
Corn, for grain	I	99	5	0	96
	II	98	5	0	90
Sorghum	I	99	12	7	90
	II	97	35	20	85
	III	95	150	100	80

*On the standard, III class of ray does not have more than 200 seeds of other crops\kg:

**Barley, oat, and ray infected with smut will not be included in the I and II classes of seeds; in the III class, only seeds with not more than 0.002% infection will be admitted; on the barley and oat seeds with spore diseases, the following classes will be admitted: 0.01% (I), 0.03 (II) and 0.05 (III); on the ray, 0.03%, 0.05%, and 0.07%, respectively.

The broken seed grade of oats is shown with the following indexes: 2.0 (I), 3.0 (II) and 5.0 (III).

***Up to 20 pieces of infected corn germ per 1 kg of seeds are admitted in the first class of seeds.

A restricting rate of moisture was set in many crop seeds. A single moisture rate of 13% has been set for all classes of sorghum: corn (14%), triticale (15%), barley, oats, and ray (14%). Quarantine plants, wild plants, pests, and diseases approved by the state quarantine governance of the Republic of Uzbekistan: seeds of poison weeds (*Atropa belladonna*, *Conium maculatum*, and *Cicuta virosa*) are not admitted to sowing. III class of seeds may be let to sow if these seeds contain not more than 20 pieces of live pests and their cocoons per kg.

Take a look at the manual of the textbook if you want to know about methodical procedures to determine seeds' planting quality indexes in the laboratory.

The use and exchange of seeds at the local and international level with world-known labels is important for the development of the agricultural industry in our country, and it depends on the perfection of local seed production. In order to improve local seed production, a Center for Improvement of Seed Production was established at the Ministry of Agriculture of the Republic of Uzbekistan in 2018 (photo 219). It leads the “national seed production policy,” meets international requirements, and elaborates a short- and long-term seed production development strategy.



Photo 219. Entrance of the Center for Improvement of Seed production.

The main responsibilities of the center are:

-establishing seed production clusters on the basis of state-private share-holder agreements, including small seed production organizations, supporting their activities, and promoting their development;

-taking into account global market conditions, to remark types and varieties of agricultural crops suitable to soil conditions of the republic, specialization of regions, procurement of their seeds and seedlings, usage, and to build a contemporary system for export, to develop the national brand of “Uzbek seed.”

-establish preliminary seed production of national and foreign bred varieties, bio-technologic and untraditional drop-type varieties, as well as the development of seed and seedling production;

modernization of the financial-technic base of subjects’ activity in the fields of plant breeding and seed production; extension of resource-saving innovative technologies through attracting foreign investors and state-private share-holding system potentials;

-monitoring of seed-producing areas of all farms, including farmer households, organizations, enterprises, firms, and seed-producing fields of entrepreneurs engaging with the seed production of agricultural crops in the Republic.

Quarantine system of seeds. In 1934, the Uzbek state quarantine service was established to prevent the penetration of pathogens of new diseases and pests from abroad into the Republic of Uzbekistan. It has a loyal right to restrict the importing of seeds, seedlings, and plant products from foreign countries. Its priority has grown year by year. For example, it had six branches across the Republic in its early years, and nowadays their number has reached more than 13 branches. It controls the seeds (all introducing, importing, exporting, and passing by transit seeds) to undergo phytosanitary and veterinary control in correspondence with the law of plant protection (2000), veterinary control (2003), and regulations of seed and plant product certifications (2004).

Chapter 4. State variety trials of agricultural crops.

System of state variety trial net: comprehensive assessment of new varieties of crops, study, and testing system with the goal of checking their fitness for cultivation in a certain soil-climatic condition. The newly released varieties at the plant breeding institutes are transferred to the State Variety Trial Network (SVTN) after finishing their testing processes.

The SVTN makes up state variety testing stations and plots' complex to implement state variety trials (SVT). The SVT is being conducted by specialized state trial organizations according to accepted methods and terms (from 3 to 10 and 15 years).

The establishment of the first SVTN in Uzbekistan took place in 1914 at the Mirzachul experimental station. At that time, we tested 82 cotton plant varieties and selected 12 out of them in the Andijan agricultural experiment station. In 1924, the SVTN functioned under the governance of the former Soviet Land Affairs Commission. Since 1926, this organization has been under the guidance of the All-Union Plant-Growing SRI (VIR). After 1937, it was gradually transferred to the Ministry of Agriculture and named the State Commission on the testing of agricultural crops.

Since 1937 to 1989, a single state commission has worked on the testing of varieties of grain crops, oil-bearing and fodder-hay crops, technical crops, and cotton plant varieties.

Since the 1990s, with the acceptance of the Republic's laws "About plant breeding achievements" and "About seed production" (1996), the tasks of the SVTN have also widened to test all types of agricultural crops. Its name changed from the State Commission on the Testing of Varieties of Agricultural Crops to the Center for Testing Varieties of Agricultural Crops (CTVAC) in 2018 (photo 220).



Photo 220. **Entrance of the Center for Testing Agriculture Variety.**

The CTVAC leads the state register and gives a certificate to the variety included in the state register. According to the law of “about seed production,” including the variety in the register gives the right to reproduction; importing and exporting, as well as the seed reproduction fields, are subjected to approbation and take the seed certificate of accordance.

The inclusion of the varieties into the state register and the exclusion are fulfilled according to the decision of the CTVAC and approved by the order of the Ministry of Agriculture of the Republic of Uzbekistan.

Stations and plots of the STV conduct four types of field experiments:

broadened competitiveness (main);

- competitive (main),
- production and
- technologic-material.

The main object of the broadened **variety test** is to decrease the study term, determine the reaction of the variety to environmental stress, grade and sustainability of quantitative and qualitative indexes, determine resistance to diseases, and identify in a short period of time its fitness to be the main product of the production technology.

The object of **competitive variety testing** is to study new varieties comprehensively and their fitness for industrial production in terms of productivity, product quality, and resistance grades to diseases and pests in comparison with standard varieties and prepare recommendations about the new varieties' suitability for a definite region.

The main object of **the production variety testing** is to fully determine the fitness of the new variety as the base of the production technology in comparison to the standard variety and its economic efficiency.

The main object of the **technological material testing** is to determine the fitness of the testing varieties to energy-saving technologies of production and to find out the possibility of taking secondary products through storage and reprocessing.

Every regional variety station (VTS) and variety testing plot (VTP) of the CTVAC embraces all climatic-soil territories of our republic, and depending on the uniformity of the climatic conditions, they deserve 4–8 government districts. Usually, they have been organized on the advanced farms. They are continuously provided with ploughed land ranging from 40 to 250 hectares and adequately secured with techniques and working staff.

The total number of the VTS and VTPs reaches up to 55 and 2 special laboratories:

*In Karakalpakstan Republic: Khujayli VTS, Ellikkala VTS, Nukus VTS and Chimbay VTS.

*In the Andijan region: Oltinko'l VTS, Andijan VTP, Korgantepa VTP, Shahrihan VTP and Khujaobod VTP.

*In the Bukhara region: Bukhara VTS, Vobkent VTP, Karakol VTP and Gijduan VTP.

*In the Jizzakh region: Jizzakh VTS, Gallaaral VTP, Zomin VTP and Pakhtakor VTP.

*In the Kashkadarya region: Shahrisabz VTS, Karshi VTP, Kamashi VTP and Mirishkor VTP.

*In the Navoiy region: Khatirchi VTS, Kiziltepa VTP and Navbakhor VTP.

*In the Namangan region: Uychi VTS, Mingbulak VTP and Namangan VTP.

*In the Samarkand region: Samarkand VTS, Kattakurgan VTP, Nurabad-chol VTP, Nurabad VTP and Urgut VTP.

*In the Surkhandarya region: Termiz VTS, Denov VTP, Denov-mutadil VTP and Sherobod VTP.

*In the Syrdarya region: Boyout VTS, Okoltin VTP and Syrdaryadon VTP.

*In the Tashkent region: Chinaz VTS, Kuyichirchik VTP, Piskent VTP, Ortachirchik VTP, Yukorichirchik VTP, Okhongoron VTP, Bustanlik VTP and Tashkent VTP.

*In the Farghana region: Koshtepa VTS, Besharik VTP, Bag'dad VTP, Farghana VTP and Vodil VTP.

*In the Khorezm region: Khiva VTS, Gurlan VTP and Urganch VTP.

*In Tashkent city: Tashkent cotton fiber technologic laboratory and Tashkent chemical technology laboratory.

The state VTSs are divided into several types:

*Complex stations on the field crops, vegetable and potato, subtropic crops, molbery, rice, tabaco.

* Special entomo-phytopathologic variety testing.

*Agro-practice variety testing stations.

Cotton plants, grain crops, vegetables, potatoes, and other crops may be tested in the complex variety testing stations. The VTSs and VTPs are setting in irrigated and rain-fed conditions.

The use of complex variety testing stations has dominated in the last few years. Testing of varieties is fulfilled in correspondence with commonly accepted methods by the State Variety Testing Commission (in particular, the method of the State Variety Trial of Agricultural Crops, 1989). Testing varieties compared with widely commercialized and spread in this region variety- standards.

The new varieties developed at the SRIs or by breeders are accepted into the SVT subject to the following conditions:

1. A new variety has superiority over a locally commercialized variety (standard) in terms of productivity and product quality.

2. A new variety has superiority over the standard in terms of product quality and biologic traits.

3. The new variety successfully passed through 3 years of selection (competitive) variety testing and 1-2 years of production variety testing at the SRI.

4. A new variety has its own name to submit the SVT.

Also: a) statement to accept the new variety into the SVT; b) decision of the scientific council of the recommending SRI for submitting the new variety into the SVT; c) detailed characteristics of the new variety in a form of the SVT and approved by the seal of the SRI; d) the document of the characteristics has to have a true copy of the

flower and grain (0.5 kg and 15 ear or panicle); e) 2-4 kg grain to determine the product quality of the variety;

The plant breeding SRI or breeder has to accumulate a definite amount of seed (grain) at the time of submitting the new variety to the SVT.

The commission of the SVT, after accepting the new variety into the SVT, sends written information about the seed amount to be sent to what state VTS or VTP. The commission of the SVT also considers the breeder's desire to test his new variety.

The SVTN takes the seeds of self-pollinating plants (as wheat) from the breeder only for the first year. In the next few years, the seeds will be taken from our own experimental plants' crop.

The seeds of the outcrossing plants should be sent to the SVTN by the breeder annually or organized at one of the VTS to reproduce the seeds of this variety. Every VTS reproduces its own seed fund on the not yet tested varieties.

The area of every nursery usually makes up 100–200 m² with 4-6 replications. And every variety is tested for at least three years and passes through production tests for two to three years. The variety sown superior to the standard variety in these two kinds of testing is recommended to be included in the state register.

The VTS annually composes a report on the data taken from main and production variability tests. Testing outcomes were announced for the first time in the meetings of district specialists and governors and later in the agronomists' council of the region organized by the regional field crop varieties testing inspection. This council elaborated a variety extension (introduction) project for the years to come. It also prepares a proposal about the exclusion of the old varieties from production and sends it to the Republican State Variety Testing Commission.

As underlined above, the CTVAC is the single state organ leading the state register. Since 2021, the varieties of agricultural crops may be included in the register for their 1-year testing results, according to the conclusion of the expert commission. The certificate about the registered variety will be given to the breeder for three years.

*-Collegial organ (photo 221) gathered from ministers and governances concerning the field to consider proposals on including varieties in the state register or exclusion in the results of tests conducted by the CTVAC.



Photo 221. Working activity of the expert commission at the CTVAC (2021).

Part XII. Achievements of plant breeders in grain crops' selection and their seed production

As mentioned in the part about wheat breeding and its seed production, wheat grain has historically been the most important daily source of bread for our people.

The importance of wheat grain has grown tremendously since 1991, when Uzbekistan became independent. In the past period, when republic was a part of the Soviet Union, its demand for wheat grain had been satisfied on account of wheat grown in the Ukraine, Belorussia, and Kazakhstan republics.

In that period, from 500 000 to 1 million tons had been produced in our republic, while the demand of our people was 4.5–5.0 million tons (Tursunkhodjaev P.M., Uljaev Sh.M., 2007).

Since the first days of the republic's independence, state has paid great attention to this by issuing several laws and decisions for the creation of local, highly productive wheat varieties in a short period of time and to reach grain independence.

Scientists working at the Grain Crop Breeding and Seed Production SRIs have utilized all scientific opportunities in the implementation of the of the above-mentioned state decisions to fully provide our nation with grains of local wheat varieties and developed highly productive wheat varieties resilient to the growing conditions of the republic. Herein, a bumper crop of 5.5 tons per hectare was harvested on account of new varieties (Abdurakhmanova Malohat., 2022), which consists of 6.5-7.8 million tons of gross productivity in the last five years.

Efficient activities are being led by many of local scientists with the plant breeding of wheat varieties. They are S.K. Baboev, R.I. Siddikov, I.U. Egamov (photo 222) and others. Saidmurad Kinsanbaevich Baboev, a doctor of biological science and professor of the Institute of Genetics and Experimental Biology of Plants of the Academy of Science of the Republic of Uzbekistan with 40 years of experience in this field, deserves special attention. S.K. Baboev is a is a well-known scientist in the fields of wheat genetics and wheat breeding. Genetic resistance of wheat was the basic question in his scientific research and led researchers to create varieties resistant to yellow rust disease, which had a greater impact on wheat productivity in the last 20 years and was a great problem in the cereal production of Uzbekistan.

As a result, varieties Ok marvarid (2013), Bardosh (2015), Pahlavon (2017), Qayraqtosh (2017), and Ezoz (2019) resistant to wheat rust disease in the condition of Uzbekistan have been developed and extended widely into production.

It is known in the plant-growing industry of agriculture that creating resistant varieties is a cheaper and more suitable way to combat any stress factor. A variety of bardosh is resistant to brown rust disease and requires less water. The productivity in comparison with biologic winter wheat is higher by 0.5–0.8 tons per hectare, it has good bread baking quality, the raw gluten content is an average of 30–32 percent, and the IDK index is equal to 65.

This variety was planted widely in 2015 in the fields of the Tashkent, Syrdarya, Ferghana, and Surkhandarya regions of the republic.

Genes in the wheat varieties grown in Uzbekistan controlling resistance to rust diseases have been analyzed under the guidance of S.K. Baboev. The list of efficient and inefficient genes was composed and introduced into the wheat breeding process.



Photo 222. S.K. Babaev (third on the right) in the monitoring of Central Asian wheat variety accessions with teachers and students of Khorezm State University (2023).

To date, blood deficiency disease in the organisms of pregnant women and kids is progressing as a result of eating bread, which has an

inadequate amount of microelements. The colleagues of S.K. Baboev are implementing the creation of varieties that have an adequate amount of microelements—iron and zinc—for the purpose of deciding this challenge or instead of artificial fortification.

Since 2001, S.K. Babaev has led cooperation with international organizations such as SIMMUT and ICARDA. Annually participated in his lectures about the results of wheat diseases at international events. For example, 2003 in the Almaty, 2005 in the Beshkek, 2007 in Argentina, 2010 in Sankt-Petersburg, 2011 in the Aleppo city of Syria, and 2013–2017 in the city of Urumchi, China.

S.K. Baboev, for many years, was chairman of the council on graduating diploma works of students in the department of plant breeding and seed production of agricultural crops at the Tashkent State Agrarian University and, up to date, has prepared nine doctors of philosophy in agricultural science.

Doctor of agricultural science, Egamov Ilkhomjon Urayimjanovich, is the next well-deserved scientist with 26 years of experience in wheat breeding and its seed production. He leads his wheat breeding research at the Grain and Bean Crops Scientific Research Institute in the Andijan region. Under his guidance, hybridization works with 450–500 combinations comprising more than 100 varieties and lines of winter soft and hard wheat possessing different biologic and economic traits and properties are carried out annually at the institute to create new winter wheat varieties and hybrids.

35 new varieties, resistant to drought, salinization, yellow rust disease, and high yield with quality grain, have been developed in his co-authority, and to date, varieties of Davr (photo 212), Zvezda, Asr, Chilgisi, Yog'du, Navbakhor, Uzbekistan-25, Aziz, Nodir, and Qadr are planted over 250–300 thousand hectares of land in Uzbekistan. Some of the leading farmers are getting 9.0–10.0 tons per hectare as a result of planting these wheat varieties.

He is taking active part in the annual international meetings devoted to wheat diseases and wheat breeding. For example, in 1998 in Syria, in 2003 in Alma-Ata, in 2008 in India, and in 2019–2021 in Belorussia and Russia. Today, I.U. Egamov and his colleagues are taking on the creation of varieties resistant to rust disease, drought, heat, and productivity with high bread baking quality, as well as extension into production, in order to solve the main problem of today, standing before wheat breeders in Uzbekistan.

In rice breeding, M. Uklonskaya, N. Mannikov, A. Shin, N.L. Kosarev, E.L. Svejakova, P. Pulina, V.F. Shupovskaya, T.E. Iskhakov, S. Rihsieva, G.S. Berkinova, T. Asilov, Kh.A. Baraev, M. Sattarov, B. Kalandarov, M. Khayitov, M. Akhmatov, M. Rakhmanov and U. Abdullaev have achieved remarkable achievements.

Within them, scientific activities and the achieved results of Urazbay Abdullaev have special attention. He started his scientific research in 1976 at the Karakalpakistan branch of the Uzbek Scientific Research Institute of Rice Growing. And in the years of 1986-2023 has also been a head of the laboratory of rice. And since 2023, he has been a consultant to the director of the Association of Grain and Rice Production. He is the author of the rice varieties Gulzor, Jayhun, Nukus-70, Guliston, Sanam, and Utkir, which are early-ripening, productive, and adopted to the conditions of Karakalpakistan. In 2003, he was awarded the title of “Deserved Inventor and Rationalizer in the Republic of Karakalpakistan.” Beside this, he has many other breast marks granted by the government.

Professor I.V. Massino (1938–2017) has been conducting research in the field of corn breeding since 1961. He protected his philosophy doctor dissertation in 1966, his doctoral dissertation in 1986, and in 1988 he became a professor. Since 1991, he has become a correspondent of the Agricultural Academy of Uzbekistan (photo 223). He was the author and coauthor of 19 commercialized corn, sorghum, and other fodder crops’ varieties. In the years 2000–2012, I worked in the department of plant growing at the Tashkent State Agrarian University, where I prepared 21 magister students on the profession of “grain farming” and together prepared 14 doctors of philosophy in agricultural science. He worked in cooperation with colleagues of international organizations: ICARDA, ICBA. ICRASAT and with scientists from Russia, Kazakhstan and Tajikistan.



Photo 223. Farmers and specialists from South Korea (COICA) and our scholars in the seminar on triticale growing led by I.V. Massino (seventh on the right).

Questions on the studied themes:

1. Do you know about the purposes of the variety and seed controls?
2. What kinds of variety controls are there?
3. Is there any difference between state control and on-farm control?
4. What are the tasks of “Uzagroinspeksiya” in our republic?
5. Have you heard about the approval of small grain crops without pipping up plant bundles?
6. What is farm control and its objects?
7. List the standard requirements for grain crop seeds.
8. Do you know the lowest admitted seed germination based on the standard requirements?
9. Tell me about the tasks of the SVT and its SVTN.
10. Do you know about deserved breeders and their achievements in the breeding and seed production of grain crops?

Glossary of some key terms.

Name of terms	English	Uzbek	Russian
Approbation –	Research is conducted in the field with the purpose of determining the genetic purity rate (grade) of plants, resistance to diseases and pests, and the general state of seeds designated for planting.	O'simliklarning genetik (nav) jihatdan kanchalik toza ekanligini, kasalliklarga, zararkunandalarga chidamligi va ekishga mo'ljallangan urug'likning umumiy holatini aniqlash maqsadida dalada o'tkaziladigan tadqiqot.	Исследование, проводимое на поле с целью определения генетической (сортовой) чистоты растений, устойчивости к болезням, вредителям и общего состояния семян, предназначенных для заготовки посевных семян.
Biological impurity of the variety –	Natural pollination of the variety with another variety or crop takes place as the result of accidental mutations.	Navning boshqa ekin navi bilan tabiiy changlanishi va kichik mutatsiyalar natijasida kechadigan ifloslanish.	Загрязнение, происходящее в результате естественных скрещиваний одного сорта с другим сортом или культурой и случайных мутаций.
Bred variety –	The variety, developed at the scientific research enterprises on the basis of scientific selection methods.	Ilmiy-tadqiqot muassalarida seleksiyaning ilmiy usullari asosida yaratilgan nav.	Сорт, созданный в научно - исследовательских учреждениях на основе научных методов селекции.
CMS –	Cytoplasmic male sterility (infertility), that is pollen grains inability to impregnation.	Sitoplasmatik erkak sterilligi (pushtsizligi), yani chang donachalarining naslsiz (puch) bepusht bo'lishi.	Цитоплазматическая мужская стерильность (неспособность к оплодотворению), то есть, пыльцевые зерна неспособные к

			оплодотворению (шуплые).
Coefficient of propagation –	Ratio of conditioned seed stock yield to the amount of planted seed stock.	Konditsiyali urug'lik hosilining ekilgan urug'lik miqdoriga nisbati.	Соотношение урожая кондиционных семян к количеству посеянных семян.
Dominancy –	The privilege of one over another on allele traits in the heterosis organism.	Geterozigota organizmda allel belgilardan birining ikkinchisidan ustun turishi.	Преимущество одного над другим по аллельным признакам в гетерозисном организме.
Elite –	Seed stock, produced from propagation of the best plants, belonging to the variety, which inherited all characteristics to the next generation.	Navga hos eng yahshi o'simliklarning tanlab, ko'paytirib olgan urug'ligi bo'lib, navning barcha irsiy belgi va husissiyatlarini keyingi bo'ginlarga o'tkazadi.	Семена, полученные путем отбора и размножения от наиболее типичных для сорта растений, которые передают все наследственные признаки и свойства сорта следующему потомству.
Emasculation –	Nipping off (removing) grain pollens from flowers of a maternal plant.	Ona sifatida olingan o'simlikning gulidagi changdonlarni terib olish (yulib tashlash).	Удаление пыльников из цветков материнских растений.
Family –	Progeny of one cross pollinating plant, taken via propagating.	Chettan changlanuvchi bitta o'simlikni ko'paytirib olingan avlodi.	Потомство одного перекрестно опыляемого растения, полученного путем размножения.
Heredity –	Transferring of trait and	Organismdagi belgi va	Передача признаков и свойств

	properties of the organism from generation to generation.	hususiyatlarning nasldan naslga o'tishi.	организма от потомства к потомству.
Heterosis –	Becoming vigorous, viability and productivity of the first hybrid generation (F ₁) comparing with parental organisms.	Birinchi bo'g'in (F ₁) duragayining ota va ona organismlarga nisbatan kuchli, hayotchan va mahsuldor bo'lishi.	Мощность, жизнеспособность и продуктивность первого поколения гибридов (F ₁) по сравнению с родительскими организмами.
Hybrid –	A new generation, distinguishing with hereditary traits and properties taken by crossing of two and more organisms.	Irsiy belgi va xususiyatlari bilan farq qiladigan ikki va undan ortiq organismlarni chatishtirib olingan yangi bo'g'in.	Поклоение, полученное путем скрещивания двух и более организмов, отличающихся по наследственным признакам и характеристикам.
Hybrid population –	Totality of organisms differing from each other on hereditary sign, taken in the result of crossing.	Chatishtirish natijasida olingan irsiy jihatdan bir-biridan farqlanuvchi organismlar to'plami.	Совокупность организмов, полученных путем скрещивания, отличающихся друг от друга по наследственному признаку.
Hybridization of remote forms –	Hybridization of plants different in their species and genus.	Turlari yoki turkumlari boshqa boshqa bo'lgan o'simliklarni duragaylash.	Гибридизация растений от разных видов и родов.
Industry based seed breeding –	Specialization, seed stock material concentration in a specialized production,	Nav, urug'lik va hosil sifatleri bo'yicha davlat standarti va tehnik talablarga javob	Специализация, концентрация производства семенных материалов в особо

	meeting the requirements of the State standards on variety, seed stock and crop quality, and also seed breeding organization on the base of all technological processes of mechanization and automation, using the least labour expenditure.	beradigan urug'lik materiallar mahsus ixtisoslashgan ho'jaliklarda ishlab chiqarishni ixtisoslashtirish, konsentratsiyalash, barcha tehnologik jarayonlarni mehanizatsiyalashtirish hamda avtomatlashtirish asosida eng kam mehnatni sarflab urug'chilikni tashkil etish.	специализированных хозяйствах, отвечающих техническим и государственным стандартам по сортовому, посевным и урожайным качествам, а также организация семеноводства на основе механизации и автоматизации всех технологических процессов, используя наименьшие затраты труда.
Insurance seed fund –	Seed reserve (stock), established at the state depositories or directly in the farms to use at the time of natural disasters. Its amount is different, depending on the various sections of the seed stock system. For example, the insurance fund in the primary seed sections makes 100% in ratio to seed stock necessity;	Tabiiy ofatlar vaqtida foydalanish uchun to'g'ridan-to'g'ri ho'jaliklarda yoki davlat jamg'armalarida yaratilgan urug'lik zahirasi. Uning miqdori urug'lik tizimining turli zvenolarida har hil bo'lib, masalan, birinchi urug'lik zvenolarida ehtiyot fondi urug'likka bo'lgan ehtiyojga nisbatan 100% miqdorda, superelita uchun 50%, elita va 1 reproduksiya	Запас посевных семян, созданный из непосредственно хозяйственных или государственных закромов, для их использования во время природных катастроф. Его объём различается в зависимости от звеньев в системе семеноводства. Например, объём набора страхового фонда в звеньях первичного семеноводства составляет 100% от их нужд в

	depositing amounts are consisted of super elite (50%%, elite, and 1 reproduction (25-30%).	uchun 25-30% miqdorda jamg'ariladi.	посевных семенах, для супер элиты 50%, для элиты и 1 репродукции 25-30%.
Intensive type variety –	The variety, possessing high photosynthesis capacity, the possibility of effective use of environmental factors (soil, water, fertilizer, and light), and being resistant to lodging, diseases, pests, and adverse external stresses, gives capability to bumper crop with quality products.	Fotosintetik qobiliyati yuqori bo'lib, tashqi muhit omillaridan (tuproq, suv, ug'it va yorug'likdan) unumli foydalana oladigan, hamda yuqori agrotehnika sharoitida yotib qolishga, kasallik, zararkunanda va boshqa noqulay tasirlarga chidab, mol hosil va sifatli mahsulot beradigan nav.	Сорт с высокой фотосинтетической способностью, отзывчивый к условиям внешних факторов (почва, вода, удобрения и свет), устойчив к полеганию, болезням, вредителям и другим стрессам и способный дать большой урожай и качественную продукцию.
Introduction –	Bringing of the species and varieties of plants from other territories.	O'simliklarning tur va navlarini boshqa joylardan keltirish.	Привоз видов и сортов растений из других территорий.
Mechanical contamination of the variety –	Seed stock's mixing (pollution) with other varieties or crops at harvest, renewing, purification, and transportation processes.	Hosilni yig'ish, yangilash, tozalash, tashish kabi jarjayonlarda urug'likning boshqa nav yoki ekin urug'iga aralashib ketishi (ifloslanishi).	Загрязнение посевных семян семенами других сортов или культур во время сбора урожая, обновление, очищение и транспортировки.

Modification variability –	Not hereditary (phenotype) variability.	Irsiy bo'lmagan (fenotipik) o'zgaruvchanlik.	Ненаследственная (фенотипическая) изменчивость.
Mutational variability –	It arises from external influences and does not transmit from generation to generation.	U tashqi sharoit tasirida yuzaga kelib, bo'g'indan-bo'g'inga berilmaydi.	Она возникает под влиянием внешней условия, но не передается по наследству.
Mutation –	A sudden (by spasmodic way) hereditary altering of traits and properties in the organism.	Organismdagi belgi va hususiyatlarning tasodifiy (sakraash yoli bilan) irsiy o'zgarishi.	Случайная (неожиданная), наследственная изменчивость признаков и свойств организма.
Phenotype –	Sum of external and internal traits (properties), formed together in the organism in the result of interactions of organism's genotype and environmental conditions.	Organism genotipi bilan tashqi sharoitning o'zaro tasiri natijasida organismda shakllanadigan tashqi va ichki belgilar (husisiyatlar) yig'indisi.	Совокупность внешних и внутренних признаков (свойств), сформировавшихся в результате взаимодействия генотипа организма и условий окружающей среды.
Population –	A group of plants, spreading in a certain areal (territory), belonging to one species, freely mats within species, but differs in regard of heredity.	Muayyan arealda (hududda) tarqalgan, bir turga mansub bo'lgan, o'zaro erkin chatishadigan, lekin bir-biridan irsiy jihatdan farq qiladigan o'simliklar to'plami.	Группа растений, распространённых в определенном ареале (территории), относящихся к одному виду, свободно скрещивающиеся между собой, но наследственно

			отличающиеся друг от друга.
Polyploids –	Hereditary variation depending on multiply increasing the haploid chromosome sum of organism.	Organism gaploid hromosomal yig'indisining karrali ortishi bilan bog'lik bo'lgan irsiy o'zgaruvchanlik.	Наследственная изменчивость, связанная с кратным увеличением гаплоидных наборов хромосом организма.
Reproduction –	It means copy taking, that is, a consecutive seed obtained by propagation of elite seeds, taking of 1-reproduction through planting of elite seed stocks, and from it to produce the 2-reproduction, from this to produce the 3-last reproductions.	Nusha ko'chirish degan manoni bildirib, elita urug'larni ko'paytirib olingan urug'lik, yani elita urug'lik ekilib 1-reproduksiya urug'lik, undan esa 2-reproduksiya, undan 3 va so'nggi reproduksiya urug'liklar olinadi.	Означает снятие копии, т.е. последовательное получение семян, посевная от размножения элиты, 1-репродукция от посевов элиты, далее 2-репродукция, 3-и последняя репродукции.
Seed control –	A system of measures, directed to inspect seed sowing suitability at the time of producing, storage and releasing from warehouses.	Urug'ni etishtirish, saqlash va amborlardan chiqarish vaqtlarida urug'likning ekinboplik husisiatlarini tekshirishga qaratilgan tadbirlar tizimi.	Система мероприятий, направленных на проверку посевных свойств семян во время выращивания, хранения и выноса их из хранилищ.
Seed production –	It is the special branch of agricultural production, the	Qishloq ho'jalik ishlab chiqarishining mahsus	Являясь специальной отраслью производства сельского

	main aim of which is to mass multiplication of zoned and registered into state register seeds of growing varieties in peasant, farmer, and community farms through maintaining their variety purity, biologic, and farm properties.	tarmog'i bo'lib, uning asosiy maqsadi dehqon, fermer va jamoa ho'jaliklarini rayonlashtirilgan, davlat reestiriga kiritilib ekilayotgan navlarning urug'ini nav tozaligi, biologic va ho'jalik hususiyatlarini saqlab ommaviy ravishda ko'paytirish.	хозяйства, её основной целью является сохранение сортовой чистоты, биологических хозяйственных свойств и массовое размножение сортов семян, районированных в дехканские и фермерские хозяйства, включенных в государственный реестр.
Seed production scheme –	A complex of interlinked nurseries and seed stock plantations, designed to renew (reproduction of seed stock) the variety via purposeful order of selection and propagation.	Muayyan tartibda tanlash va ko'paytirish bilan navni yangilab turishga (urug'likni qayta etishtirib turishga) qaratilgan o'zaro bog'langan pitomniklar va urug'lik ekinzorlarining majmui.	Комплекс связанных между собой питомников и семенных посевов, направленных на сорта - обновление с определенным порядком отбора и размножения (перепроизводство посевных семян).
Seed production system –	A complex of interlinked production nets, providing all crop plantations with excellent quality seeds of one or several crops. according to the state plan.	Davlat planiga/rejasiga muaffiq barcha ekin maydonlarining bir yoki bir qancha ekinlarning a'lo sifatli urug'lari bilan ta'minlab turadigan, bir biri bilan o'zaro bog'langan ishlab chiqarish	Комплекс производственных отраслей, связанных между собой и обеспечивающих все посевные площади высококачественными семенами одной или нескольких культур,

		tarmoqlarning majmui.	соответственно с государственным планом.
Strain –	Progeny of one, self-pollinating plant.	O'zidan changlanuvchi bitta o'simlikning avlodi.	Потомство одного самоопыляющегося растения.
Strain changing –	Changing of one elder variety of the crop, grown in the industry, by the new more productive and fine quality product variety.	Biror ekinning ishlab chiqarishda ekib kelinayotgan eski navini serhosil va mahsulotning sifati yahshiroq bo'lgan yangi navi bilan almashtirish.	Замена старого сорта одной из культур, высеваемого в производстве, новым сортом с лучшими по урожайности и качеству продукции характеристиками.
Super elite –	Seed stock of superior productivity, grade and planting attributes. It is produced from the nursery of family multiplication, established at the process of elite seed production.	Mahsuldorligi, nav va ekinboplik hususiyatlari eng yuqori bo'lgan urug'lik. U elita urug'lari etishtirish jaroyonida tashkil etiladigan oilalarni ko'paytirish pitomnigidan olinadi.	Посевные семена с наивысшими продуктивными, сортовыми и посевными свойствами. Она получается путем размножения семей, созданных в процессе производства семян элиты.
The plant breeding –	The creation of the new varieties (hybrids) in the farming branch and the science about the methods of improving the varieties under production.	Dehqonchilik sohasida yangi navlar (duragaylar) yaratish va ekilib kelinayotgan navlarni yaxshilash usullari to'g'risidagi fan.	Наука о методике улучшения высеваемых сортов и создания новых сортов (гибридов) в отрасли земледелия.
Triticale –	56 and 42 chromosomal wheat - rye amphidiploids.	56 va 42 hromosomal bug'doy-javdar	Амфидиплоиды пшеницы и ржи, состоящие из 56 и 42

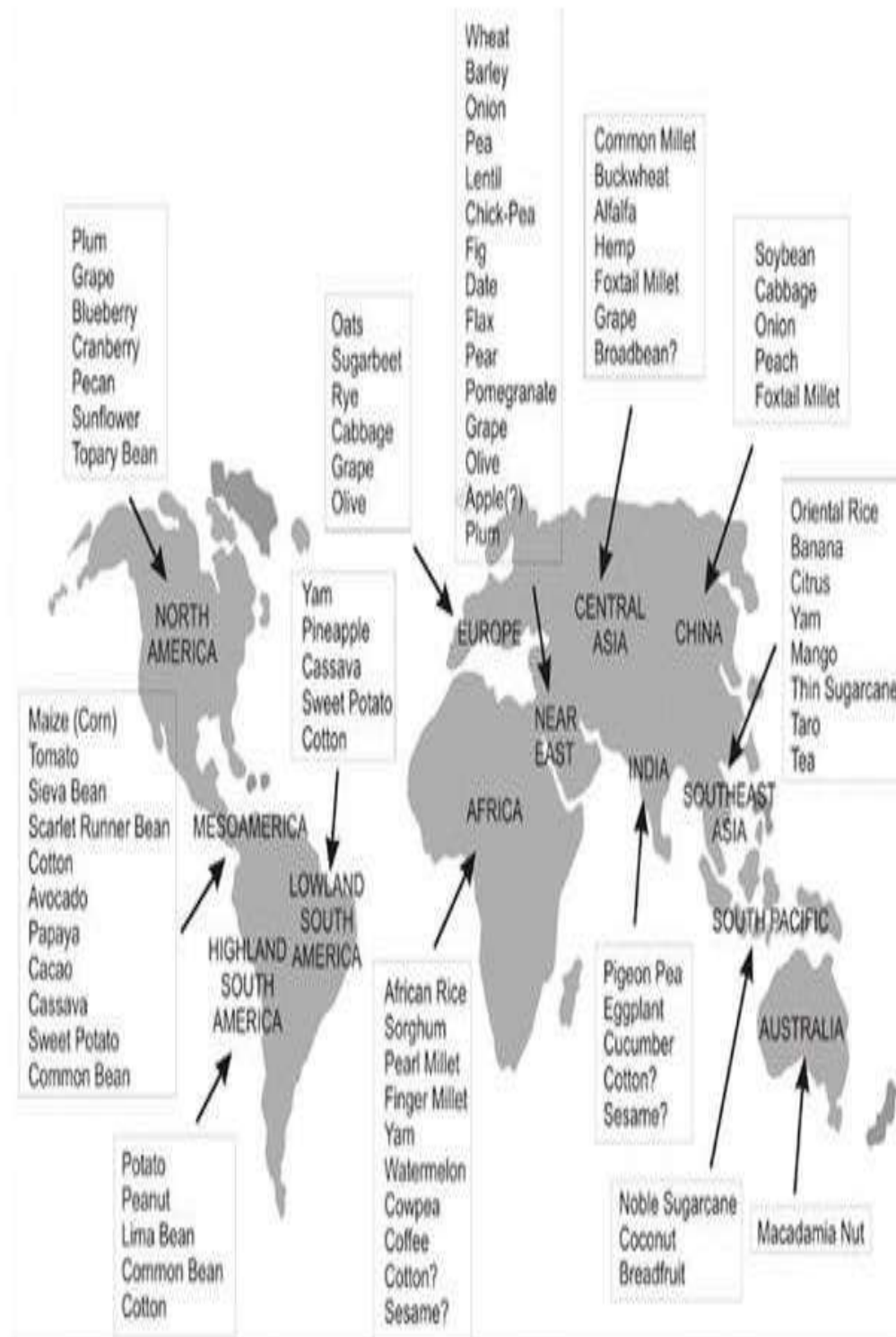
		amfidiploidlari.	хромосомов.
Variation –	Quality and quantity altering of traits.	Belgining sifat va miqdor jihatidan o'zgarishi.	Качественные или количественные изменения признаков.
Variability –	Difference of organism progeny from own ancestors on some characteristics and properties.	Organizm avlodining o'z ajdodlaridan qandaydir belgi yoki hususiyatlar bilan farq qilishi.	Отличие потомства организма от своих предков по каким-нибудь признакам и свойствам.
Variety –	A group of plants, created by the method of selection, that have a certain hereditary, morphologic, farm, biologic trait and attribute	Seleksiya usullari bilan yaratilgan, aniq irsiy morphologic, biologic, ho'jalik belgi va hususiyatlarga ega bo'lgan o'simliklar guruhi.	Группа растений, созданная методом селекции, обладающая определенной наследственностью, морфологией, хозяйственно биологическими признаками и свойствами.
Variety control –	A system of measures directed to the full provision of all cropping fields with high-quality seed stock on the basis of state standard requirements, realized with the help of approval.	Dala aprotasiyasi yordamida amalga oshiriladigan barcha ekin maydonlarini davlat standart talablari asosida yuqori sifatli urug'lik bilan to'la ta'minlashga qaratilgan tadbirlar tizimi.	Система мероприятий, направленных на полное обеспечение всех посевных площадей культурами с высококачественными семенами, на основе государственных стандартов, осуществляемых путем апробации.

Variety renewing –	Rotation of high-planting-quality seeds of the same variety after diminishing its crop, seed planting qualities, and biological attributes as a result of growing in the industry.	Bir nav ishlab chiqarishda ekilib, uning hosili, urug'likni ekish sifatleri va biologik hususiyatlari pasayganidan so'ng shu navning urug'lik sifati yuqori bo'lgan urug' bilan almashtirib ekish.	Замена семян сорта, высеваемых в производстве, после того как у них понизилась урожайность, посевное качество и биологические свойства, семенами этого же сорта, обладающих высокими семенными качествами.
Variety trials –	Conducting preliminary (small), competitive (enlarged), ecologic industrial, dynamic and state trials in the process of new variety creation.	Yangi nav yaratish jarayonida shu navni dastlabki (kichik), konkurs (kata), ecologic ishlab chiqarish, dinamik va davlat nav sinashlaridan o'tkazish.	Проведение предварительных (станционный), конкурсных (расширенный), производственно-экологических, динамических и государственных сортоиспытаний в процессе создания нового сорта.
Vernalization	Vernalization is the induction of a <i>plant's</i> flowering process by exposure to the prolonged cold of winter.	Tinim davri – o'simlik gullashi uchun kerak bo'ladigan davriy past qish harorati ta'siri.	Яровизация – это необходимое требование для инициации процесса цветения, при котором посев подвергается длительному воздействию низких температур.

Appendixes.

Appendix 1.

Centers of origin of cultivated crops.



Appendix 2.

Wheat diseases in Uzbekistan.

Wheat hard smut (*Tilletia caries*)



Dust smut (*Ustilago tritici* Jens)



Septoriosis (*Septoria tritici*).

Brown rust (*Puccinia recondita* Rab. et Desm.).



Yellow rust (*Puccinia striiformis* Vest). Powdery mildew (*Erysiphe graminis* DC).

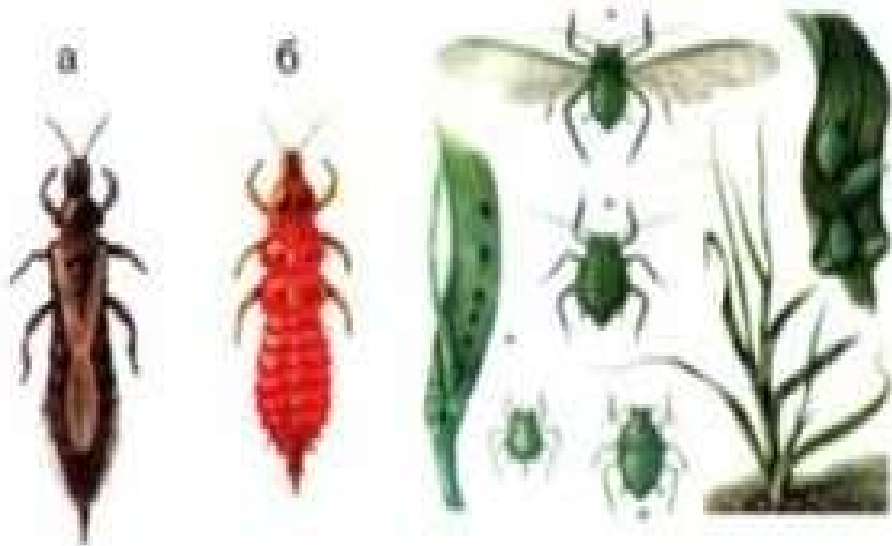


And root rot.



Pests of grain crops.

Wheat thrips: a-imago; b-larva. Cereal aphid: eggs, larva, imago and its harm.



Bug pest cereal: eggs, imago and its harm.



Cereal leaf beetle: imago, larva, cocoon and its harm.



Appendix 4.

The regions to plant agricultural crops recommended in Uzbekistan.

<u>Name of regions</u>	<u>Numbers of regions</u>
Republic of <u>Karakalpakistan</u>	1
<u>Andijan</u> region	2
Bukhara region	3
<u>Jizzakh</u> region	4
<u>Kashkadariya</u> region	5
<u>Navoiy</u> region	6
Namangan region	7
Samarkand region	8
<u>Surkhandariya</u> region	9
<u>Sirdariya</u> region	10
Tashkent region	11
Fergana region	12
<u>Kharezm</u> region	13

Appendix 5.

Instructions on the selection of bundles (probes) to inspect plants at the approbation of grain crops.

Crop.	Development stage.	Limit area to inspect plants or probe selection, ha.	Number of inspection points to take probe.	Number of analyzing stalks from all areas (at least).	Norm of spatial isolation, m.
Winter and spring wheat, barley and oats	At the beginning of wax maturity	450	150	1500	*
Triticale	Wax maturity	450	150	1500	150
Rice	Availability of full maturity	100	100	1000	-

Winter and spring rye	Not early of milk maturity	450	100	500	300**
*Seed producing plantations of winter hard wheat are to be placed not nearer 200 m from soft wheat. **Spatial isolation between plantations of rye varieties with dominant low stem original varieties, elite and reproduced is to be not nearer 1000 m, and between plantations of different categories of one low stem rye variety – at least 200 m.					

Appendix 6

Weeds of grain crops.



Winter wheat contaminated with ryegrass and brome.



Contamination with mustard.



Oats in the barley or rye field.

Appendix 7.

Plant nurseries of the experimental field and their map of the laboratory for genetics of grain crops at the Institute of Plant Experimental Biology. Durman experiment station, Kibray district, Tashkent region, 2024.



Upper path of the experimental field.				
Seed beds of 1m each sown 500 ear seeds out of variety Kayroktosh, individually.	Preliminary winter chickpea reproduction.	Local varieties.	** **	Local variety diversities – Landrace, local wheat varieties.
		Kayroktosh x Tanya (reproduction)		Plant nursery for drought background.
		Kuma x Bardosh Tanya x Bardosh (reproduction)		MAGATE accessions subjected to ray

		Ezoz x Kroshka Ezoz x Pamyat.	F2 hybrids in the 14-17 th seed beds.	500 ears selected from Pakhlav on variety and sown individually in the
		Grom x Pakhlavon Pakhlavon x Grom.	F1 hybrids in the 12-13 th seed beds, GWAS materials.	
Hybrids of Bardavon		F4 hybrids of Grom x	20 selected varieties from	

variety.		Bardosh Bardosh x Grom.	commercialized varieties in the republic.	seed beds.
Selective wheat varieties. Ecological variety testing nursery.		20 artificial varieties. In 2.5 m seed beds each one with 3 replications. Preliminary seed reproduction of selected varieties.	GWAS** selected varieties, on 20 ears, each one sown in the 1 m seed beds.	
			Ok marvarid EFS* .	
			F3 hybrids, 1 m seed beds. On 10 ears.	
			F2 hybrids. 1 m seed beds. On 20 ears.	
Variety Sharof 100.			F1 hybrids (Samara x Bardosh).	

*Selected ears via electrophoretic specter. ** Genome-Wide Association Study (GWAS). *** Specific boarder for drought background

Lower path of the experimental field. 

Appendix 8.

№193-form

“Approve”

State Seed Control

_____region

Republic of Uzbekistan

_____ “ _____ ” 20 _____

Inspected statement

Position

Signature

Republic, region, district	
Confirming of planting	_____
	reproduction

	grade

№ _____ - approbation statement
_____ district _____ residents
meeting _____ PS

In the farm of _____
(farmer) _____

_____,
_____20_____,

Family name, first name, surname
Commitment _____ of _____ approbatory

Position, place of work
_____ is a
representative of

Position, family name, first name, surname
to conduct approbation on the seed plantations

Composed statement data

1.	_____	Variety
name	_____	
2.	_____	Botanic
type	_____	

2. Planted place: № _____ plot, № _____ field, area
_____ ha

3. Size of approbation area _____ ha

4. What kind of seed was used _____

Own or introduced from other (organization)

5. Name of document to planted seed variety index,
order _____ number _____ and
day _____

6. If the seed of plant was from its own crop, then when and who had participated
in _____ its
reproduction _____

7. In what year the elite seed had been released from plant
breeding-experiment institution _____

8. Variety quality of planted seed: reproduction (generation)

_____ category

And so on

Appendix 9.

Form № 195

Agricultural enterprise _____ Proved by the Ministry
_____ of Water Resources and
region, land, republic Ariculture

Statement has been done _____
position, sign

Seed plantation _____ reproduction
by the sign

plantation has been recognized _____
position, sign

APPROBATION STATEMENT № _____

_____ y. by me (us) practician (s) _____
_____ full

names, position

At the attending of farm representatives as _____

name and position

Approbation of plantations have been conducted on _____
crop

In the farm _____
district _____

According to the data of approbation were set up

1 Name of the variety (hybrid, strain) _____
selection number

if it has conformed variety

Botanical diversity _____

2. Total plantation area of crop under approbation in the farm _____ ha, including seed plantation _____ ha, out of variety seeds planted and subjected to approbation _____ ha.

3. Location of seed approbation plantation:
 field № _____, team № _____, plot № _____.

4. What seeds were planted _____
 own or imported

if the seeds imported, to point out the exporter organization

5. Name, number and date of seed document to the planted seeds _____

6. If planting was made by the seeds of own seed crop, point out when and from whom they have been received for planting _____

7. In what year the seeds of elite released from selection-experiment establishment _____

8. Variety quality of planted seeds: reproduction (generation) _____, category _____, variety purity (uniformity) _____%.

9. Do other varieties or populations exist in neighbouring farm boarding with crop plantation under approbation: name and area, occupied or in _____ y. _____

10. Space isolation from other varieties (for cross pollinator crops) _____
 observed unobserved and makes up _____ m.

11. Predecessors of plantation (crops, varieties and area under them) _____

Appendix 10.

Form 197.

Statement checked _____ (position, signature)

_____ (organ on the certification)

Plantation recognized _____ (place of seal)

S T A T E M E N T № _____

approbation of original and elite seed plantations

_____ "____" 20 ... Commission with the staffs of plant breeders

_____ (given name, surname of institutions)

_____ (seed producer, experiment field)

Certificate № _____ (institution, name of plant breeding centers)

_____ (agronomist of elite seed farm).

Approbation of plantation has conducted _____ (name and code of plants)

place in the fields _____ (elite seed farm, district, region)

to get seeds: _____ (original, elites).

At the approbation was identified: botanic

1. Name of variety _____ diversity _____ code of variety _____

patent owner _____ certificate _____

2. Place of plantation _____ (rotation, № of fields) area _____ ha.

3. Seeds sown _____ (data of seed certificate and seed quality)

4. If the seeds were purchased, from where taken, agreements, seed documents.

5. What is the kind of plant breeding and seed production works with variety

6. Space isolation was observed _____

7. Are there other varieties of this crop in the farm _____ (name and areas)

8. Predecessor of plantation _____

9. Development stage at the time of approbation _____

10. Contamination with weeds (on the scale) _____

11. Application of herbicides (name and dose) _____

12. Anticipating crop per hectare _____

Grain seed seeders and harvesters for experimental fields.



Appendix 12.

Form № 200

Physical (juridical) person _____
 (region, land, republic)
 Executor of the statement _____
 (position, signature)
 seed plantation, other plantations (unnecessary delete)
STATEMENT № _____
 culling of plantation out of the fitted ones for use to seed purposes _____
 20 ____ y. under my (our) practician (s) _____

 (full names and positions)
 with attendance of farm representatives _____
 (full name and position)
 crop plantations _____
 Varieties, hybrid, strain _____
 belong to the farm _____
 district _____
 recognized unfit for seed purposes and culled.
 1. Culled plantation is located in the field № ____ the area of ____ ha.
 2. Result of analysis:
 a) approbation bundle (plants)

№ of bundle	Developed stock of the main variety		Compositions of variety impurities						Number of undeveloped stocks of approbated crop
	unit	%	Name and amount					Totally	
1									
2									
3									
4									
5									

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BREEDING AND SEED PRODUCTION OF GRAIN CROPS

Textbook

Editor M.Talipova
Proofreader N.Niyazova
Layout designer B.Khaidarov

Signed on 27.02.2025. 60x84 1/16 format.
Times headset. Office paper. Risographic printing
31.75. p.s., Circulation 50. Order No. 27-02/108
Phone: (77) 865 24 11; (77) 300 99 09

Printed in the printing house of IMPRESS MEDIA LLC
Tashkent, Yakkasaroy, Kushbegi str., 6