

PHOTOSYNTHETIC ACTIVITY AND YIELD OF GREEN BIOMASS OF A COLUMBUS GRASS (SORGHUM ALMUM PARODI) IN THE CONDITIONS OF UZBEKISTAN AREA

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ABSTRACT--For the first time in the conditions of the Uzbekistan area photosynthetic activity and yield of green biomass of a Columbus grass (*Sorghum alnum Parodi*) are studied. Rates of formation of leaves, a sheet index, pure photosynthetic efficiency and yield of green mass during all vegetative period of plants are defined. It is noticed that in flowering of plants the size of a sheet index reaches the greatest size and the maximum of net productivity of photosynthesis is revealed. The effect of different quantity of mineral fertilizers on Columbus grass photosynthetic activity and its yield of green biomass had been analyzed.

Keywords: Columbus grass, photosynthetic activity, vegetation period, mineral fertilizers, nitrogen, phosphorus, potassium, green biomass, yield.

I. INTRODUCTION

The food problem has risen to the forefront as a result of population growth around the world and the demand for natural foods, meat and dairy products, as well as industrial raw materials - wool, leather and other quality products from livestock - is growing [2]. The world community is looking for measures to further develop animal husbandry in order to meet the needs of the population. The development of this sector is directly related to the provision of quality and nutritious fodder for livestock [15].

Due to the growing area of arid and saline soils in the world and the escalation of environmental problems, scientific and practical research is being conducted on nutritious plants suitable for cultivation in such soil-climatic conditions [1]. In this regard, it is important to increase the yield and nutritional quality of *Sorghum* species based on the determination of their physiological and biochemical properties for the cultivation of forage species in our region [23]. Accordingly, the determination of growth, development and physiological parameters of *Sorghum alnum Parodi* (Columbus grass) under different growing conditions and biochemical analysis of the nutritional value of green mass are great scientific and practical importance [8;17].

In Uzbekistan, the great attention is paid to increasing the volume and quality of fodder production for livestock, including the expansion of areas under forage crops, enriching the number of forage plants with non-traditional plant species, improving processing technologies [18]. Therefore, in the current conditions of water scarcity, varying salinity of soils, the study of biophysiological and agrochemical properties of non-traditional plants, as well as traditional fodder crops, the development and implementation of regional agrotechnology of their cultivation are urgent issues. One such non-traditional forage plant is Columbus grass.

Columbus grass (*Sorghum alnum Parodi*) is a perennial forage plant belonging to the genus *Sorghum* of the Poaceae family, native to Argentina. Introduced to science in 1943 by the Argentine botanist L. Parodi [4; 14]. Although the seeds of Columbus grass were first introduced to Central Asia in the 1960s, interests in the plant began mainly in the 1980s. In 1980-1984, Rajibkhandari planted and studied mainly in Turkmenistan, partly in the arid regions of Uzbekistan. We did not find any information on the possibility of growing Columbus grass in the irrigated climate of Uzbekistan.

The level of photosynthetic activity of plants is important in the processes of growth and development of agricultural crops and in the process of high yields from them. Because the photosynthetic activity of plants is one of the most important indicators that determine the level of their biological yield [11].

II. EXPERIENCES AND METHODS

Small scale field experiments were carried out in the Akdarya region of Samarkand province. Planting of seed was done at the end of second decade of April, when soil temperature at the depth of 4 cm was no lower than 18°C. The distance between plants was 60 cm, planting norm – 8 kg/h [13].

Physiological stage descriptions of seasonal development of plants were carried out according to I.A. Borisova [5]. Intensity of the photosynthesis and respiration were determined with using Plant Vital 5030 (INNO – Concept GmbH, Germany), oxygen content was analyzed with using Klark electrodes. Net photosyntecal productivity was determined by A.A. Nichiporovich et al [16] leaf area index – with using L.G. Tretyakov method [20]. Statistical data analyses were carried out according recommendations of B.A. Dospekhov [6].

III. MAIN PART

The Columbus grass requires certain conditions appropriate for the passage of physiological processes and the normalization of growth and development. Because Columbus is a plant native to the subtropical regions [23]. One of the most important environmental factors influencing the development of a species is the amount of temperature and precipitation. This species reacts differently to environmental conditions at different stages of plant growth [21].

Seeds germinate very well when the average temperature is 25-30⁰ C. After the seeds are sown or during the germination period, the decrease of temperature to 10-12⁰ C sharply reduces the germination rate of seeds and causes uneven germination. During other periods of vegetation, the optimum temperature is observed for the normalization of all physiological processes in the body of Columbus plants and the normal growth and development, the temperature is 20-25⁰C [10].

Branching of plants starts earlier and occurs intensively at higher temperatures, but lower temperatures causes to prolongation of this stage up to 10-15 days. Total vegetation period of Columbus grass depends from production conditions: application of mineral fertilizers and irrigation prolongs this period for 15-25 days, and may consist of 85-100 days (vegetation period under three time harvest may continue up to the end of October and consist of 170-200 days).

Successful adaptation of plants to different soil and climatic conditions and manifestation of maximal productivity depends from adjusting physiological processes, mainly photosynthesis, to the local conditions. Principal physiological and biochemical processes of plants directly depend from leaves function. In this regards, we studied the intensity of leaf formation in different conditions of mineral nutrition. On the basis of investigation. it was identified that leaf area is changed due to growth of plants as well as from applied mineral fertilizers.

Table 1.

Leaf area formation of Columbus grass, cm²/plant

The variants of experiment	Periods of vegetation					
	Branching	Tubing	Heading	Flowering	Silking	ripening
Control (non-fertilizer)	2516,6±6,5	6037,5±14,7	7085,1±16,8	7660,2±18,3	6442,8±15,2	6191,4±12,8
N ₁₀₀ P ₇₀ K ₅₀	2826,8±7,4	7148,7±16,5	7851,3±17,6	9126,9±20,1	7789,2±17,3	7340,4±16,3
N ₂₀₀ P ₁₄₀ K ₁₀₀	3904,2±9,6	7469,1±17,3	8981,4±18,7	9682,8±22,6	8616,9±19,4	8465,1±17,6
N ₃₀₀ P ₂₁₀ K ₁₅₀	3910,3±9,8	7434,3±17,1	8782,2±19,2	9581,1±21,4	8561,7±18,9	8157,3±17,2

The data from table 1 show us that leaf area is increasing due to growth of plants. Most intensive leaf area increase was observed at the flowering stage, with slow decrease in other physiological periods. In the branching stage leaf area of one plant was in average 2516 cm², in the flowering stage 7660 cm² and at the ripening stage it was 6191 cm².

We also studied the effect of mineral fertilizers to the growth, development and productivity of plants. It was shown that optimal doses of mineral fertilizers promote formation of larger leaf area. In our experiments the effect of mineral fertilizers was higher at the initial stages of plants developments (branching and tilling). The rate of mineral fertilizers N₂₀₀P₁₄₀K₁₀₀ was optimal for better formation of leaf area.

The main reason why all the studied variant plants have the lowest leaf level by the time of full maturity is that this period is the last stage of the ontogeny of Columbus grass plants. Therefore, during the period of full maturity, the lower leaves of Columbus grass plants dry out and begin to end plant life.

The leaf index also had the highest scores during the heading and flowering stages of the vegetation. Among the options, N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare was applied to 7.18 m² in the case of fertilizer application and 7.75 m² in the flowering stage, which is 1.51 m² and 1.62 m² more than the control option, respectively.

Data analyses on leaf area index of Columbus grass showed that at the beginning of vegetation in all tested variances leaf area increased according to growth stage. Thus, at the flowering stage of plants leaf area index achieved it's highest level (table 2).

Table 2

Leaf area index of Columbus grass

The variants of experiment	Periods of vegetation					
	branching	Tubing	heading	flowering	silking	ripening
Control (non-fertilizer)	2,01	4,83	5,67	6,13	5,15	4,95
N ₁₀₀ P ₇₀ K ₅₀	2,26	5,72	6,28	9,30	6,23	5,87
N ₂₀₀ P ₁₄₀ K ₁₀₀	3,12	5,97	7,18	9,75	6,98	6,77
N ₃₀₀ P ₂₁₀ K ₁₅₀	3,13	5,95	7,03	9,67	6,85	6,53

Later on, leaf area index (at the silking and repining) is decreasing gradually. It may be stipulated by decreasing of growth of plants. Formation of leaf area of plants totally depended from the level of mineral fertilization: at the branching stage the optimal rate of fertilizers was N₂₀₀P₁₄₀K₁₀₀. Further increase of fertilizers did not caused to the increase of leaf area index.

Net photosynthetic productivity of Columbus grass varied depending from conditions of mineral fertilization and from periods of plant growth. Net photosynthetic productivity increased from period of branching up to mass flowering with later on decrease (fig.1).

The total amount of organic matter formed and accumulated during photosynthesis depends on a number of factors, which vary depending on the specific ecological environment, the biological characteristics of the varieties, the results of applied agrotechnological measures [12]. Therefore, in the conditions of Samarkand region, the net productivity of the process of photosynthesis in the plants of Columbus grass was determined at different growing seasons. The results obtained are shown in Figure 1.

It was found that the net productivity of photosynthesis in Columbus grass plants varies at different stages of vegetation depending on its biological properties. From the initial accumulation period of vegetation to the flowering period, the net productivity of photosynthesis increased in all variant plants. At the end of the growing season, that is from the period of milk maturation to the period of full maturity, the net productivity of photosynthesis also decreased.

These values were 5,43 g/m².day in the control variant during the period of plant accumulation in accordance with the options, on average 6,03 g/m².day in the variant with N₁₀₀ P₇₀ K₅₀ kg of fertilizer per hectare, and 6,51 g/m².day in the variant with N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare, in the case of N₃₀₀ P₂₁₀ K₁₅₀ kg of fertilizer per hectare demonstrated the average 6,47 g/m².day. The net productivity of photosynthesis during the weeding of Columbus plants was 9,71 g/m².day in the control variant, while on average 11,28 g/m².day in the variant with N₁₀₀ P₇₀ K₅₀ kg of fertilizer per hectare; an average of 12,42 g/m².day in the variant where fertilizer was applied in the amount of N₂₀₀ P₁₄₀ K₁₀₀kg per hectare; N₃₀₀ P₂₁₀ K₁₅₀ kg of fertilizer per hectare was applied and the average was 11,86 g/m².day.

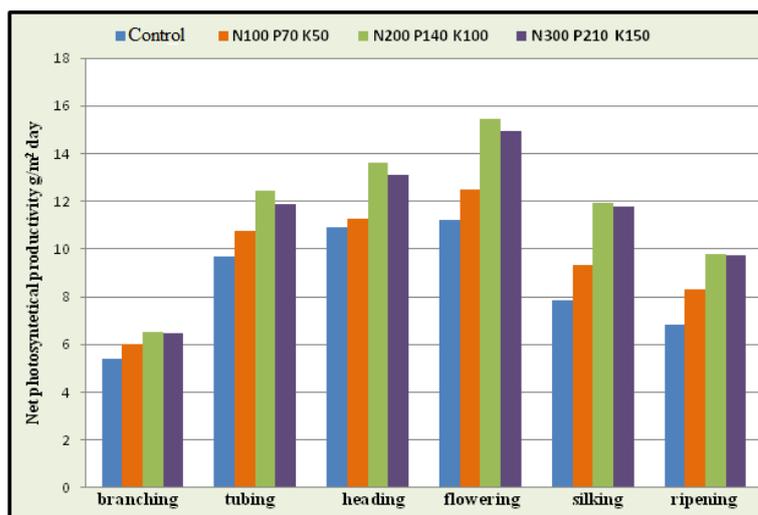


Fig 1. Net photosynthetic productivity of Columbus grass (g/m² day).

It was observed that the net productivity of photosynthesis was even higher by the time the plants matured. This figure was 10,92 g/m².day in the control variant, while the average in the variant with fertilizer application rate of N₁₀₀ P₇₀ K₅₀ kg per hectare was 11,28 g/m².day; an average of 13,65 g/m².day in the variant where fertilizer was applied in the amount of N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare; N₃₀₀ P₂₁₀ K₁₅₀ kg of fertilizer per hectare was applied with an average of 13,08 g/m².day.

The net productivity of photosynthesis of Columbus grass plants had the highest index during the flowering period. This figure was 11,20 g/m².day. Per day in the control variant. The variant where fertilizer was applied in the amount of N₁₀₀ P₇₀ K₅₀ kg per hectare was 12,51 g/m².day; In the variant where fertilizer was applied in the amount of N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare was an average of 15,47 g/m².day; N₃₀₀ P₂₁₀ K₁₅₀ kg of fertilizer per hectare was applied and the average was 14,94 g/m².day.

The net productivity of photosynthesis was observed to decline again from the milk maturation period to the full maturation period of the plants. This figure was 7,85 g/m².day in the control variant during the milk ripening period, on average 9,32 g/m².day in the variant with N₁₀₀ P₇₀ K₅₀ kg of fertilizer per hectare; on average 11,92 in the variant with N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare; N₃₀₀ P₂₁₀ K₁₅₀ kg of fertilizer per hectare was applied and the average was 11,78 g/m².day.

At full maturity, the net productivity of photosynthesis in plants was 6,82 g/m².day in the control variant; N₁₀₀ P₇₀ K₅₀ kg per hectare with an average fertilizer application of 8,30 g/m².day; an average of 9,81 g/m².day in the variant where fertilizer was applied in the amount of N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare; N₃₀₀ P₂₁₀ K₁₅₀ kg of fertilizer per hectare was applied, and the average was 9,76 g/m².day.

It is known that Columbus grass is grown mainly to obtain green mass as fodder in Central Asian conditions, it is possible to harvest plants planted in the spring three times and produce a high yield. Even the autumn season is warmer in some years, scientists informed that it is possible to harvest a fourth time and grow a quality green mass [18].

Low or high yields depend mainly on the adaptation of plants to the soil-climatic conditions of the region, the timely implementation of various agro-technological measures and the biological characteristics of the variety [9]. Therefore, the fact that the yield in Columbus grass is relatively low in the third crop, and high in the first and second crops, especially in the second crop, indicates that the plants have specific biological properties. Columbus grass which germinate from seed in the spring, reach the period of accumulation and form an average of 4-5 stems. After harvest, the number of clusters doubles to 8-10 stalks. Yields in the third crop are lower than in the first and second crops due to a decrease in the number of stalks collected in the third crop (7-8) and a decrease in temperature and growth rate in September.

During our experiments, in the conditions of Samarkand region, Columbus grass, planted as the main crop in the spring, was re-harvested three times between the end of the growing season and the beginning of the flowering period in order to grow a quality green biomass. 58-61 days after the Columbus herb sprouts from seed, the flowering period ends and the flowering period begins. In the second case, due to the relatively high air temperature, this period lasted shorter and lasted 48-52 days under the influence of the sum of useful temperatures. The green biomass yield of Columbus grass, planted as the main crop in the specific soil and climatic conditions of the republic, is given in Table 3.

Table 3 Green biomass yield of Columbus grass plants, (ts / ha)

The variants of	Years	

experiment	2016	2017	2018	On average
	Productivity			
Control (non-fertilizer)	1204,3	1260,2	1220,5	1228,3
N100 P70 K50	1902,2	1940,5	1916,1	1919,6
N200 P140 K100	2014,4	2120,3	2086,6	2073,7
N300 P210 K150	2006,5	2085,2	2002,7	2031,4
S _x %	0,07	0,06	0,06	
The smallest difference - 0,5	3,78	3,42	3,73	

The data in Table 3 show that the total green mass yield of plants in the three crops was relatively low in all variants in 2016-2018 and higher in 2017. It was also found that there were differences between the options depending on the fertilizer standards. According to the results of the experiment, in 2016 the green mass yield in the control (non-fertilizer) variant was 1204.3 ts / ha in three harvests, the green mass yield was 1260,2 ts/ha and 1220,5ts/ha in the years 2017 and 2018 the average yield was 1228,3 ts/3. It was observed that the green mass yield was higher in the variants using different amounts of mineral fertilizers than in the control variant.

The average yield was 1919.6 ts / ha in the case of N₁₀₀ P₇₀ K₅₀ kg fertilizer per hectare used option, 2073.7 ts / ha in the case of N₂₀₀ P₁₄₀ K₁₀₀ kg fertilizer per hectare used variant and 2031.4 ts / ha in the case of N₃₀₀ P₂₁₀ K₁₅₀ kg fertilizer per hectare used variant. There was also a slight decrease in the green mass yield of Columbus grass when high amounts of mineral were applied.

IV. CONCLUSION

As a result of our experiments, it was found that the growth and development rate and productivity of Columbus grass plants depend on the adaptation of various physiological processes, especially photosynthesis, to environmental conditions. Photosynthesis is one of the main processes in the plant organism, and its dynamic state is determined by the organic influence of internal and external factors. The growth period of Columbus plants, the formation of vegetative and generative organs, and their seeds and blue mass yields vary under different soil-climatic conditions, different latitudes, light regimes or short and long days and temperatures. This has led to differences in productivity over the years of the experiment.

Any change in environmental conditions primarily affected the intensity and direction of photosynthesis processes. This leads to changes in the growth, development, and pure productivity of photosynthesis in Columbus grass plants. In the maturation and flowering phase of Columbus grass, photosynthetic activity was higher in all variants than the other phases. Among the options, photosynthesis activity and green mass yield were found to be relatively high in the variant with N₂₀₀ P₁₄₀ K₁₀₀ kg of fertilizer per hectare. It has also been proved that in the conditions of Samarkand region it is possible to re-harvest Columbus grass three times, planted as the main crop in the spring, and to grow a quality green mass. It was scientifically substantiated that in soil-climatic conditions of Samarkand region it is important to sow Columbus grass as the main crop in the second half of April and fertilize the soil at the rate of N₂₀₀ P₁₄₀ K₁₀₀ kg per hectare at the end of the germination stage or the beginning of the flowering stage.

REFERENCES

1. Akinshina N.G., Azizov A.A., Karaseva T.A., Kloze E. New possibilities for plant state evaluation// Siberian ecological journal. Novosibirsk, 2008.-2 – P. 249-254.
2. Avutkhanov B.S., Safarov K.S. Photosynthetic activity of Columbus grass in introduction // Vestnik KKO Academy of sciences of Uzbekistan – Nukus, 2012, - n3. P. 28-36.
3. Avutkhanov B.S., Safarov A.K., Safarov K.S.Physiological peculiarities of Columbusgrass (Sorghum alnum Parodi) inSamarkand region conditions ofUzbekistan / European Sciences Review.Scientific Journal. 2016;7–8 (July–August).5-7.

4. Baba Mohammed, Ibrahim Abdullahi Gumel, Ibrahim Rakson Muhammad. Compatibility of Sorghum alnum (Columbus grass) with three forage legumes. *Journal of Aridland Agriculture*. Vol 1. 2015, 1:-Pp 1-5. doi:10.19071/jaa.2015.v1.202.
5. Borisova I.V. Seasonal dynamics of vegetation//Field geobotanic. – L.: Nauka, 1972. -P.5-94.
6. Dospikhov B.A. Field experiments handbook. – M., Agropromizdat,1985.-P.347.
7. Elizondo J. Consumo de sorgo negro forajero (Sorghum alnum) encabras//Agronomia Mesoamericana. -2004.- 15 (1). -P. 77-80.
8. Ermakov A.I. Methods of biochemical investigation of plants. Kolos,1972. -P.456.
9. <http://faostat.org>
10. Heuze V., Tran G., Baumont R. Columbus grass (Sorghum alnum). Feedipedia.org. A programme by INRA, CIRAD, AFZ and FAO. <http://www.feedipedia.org/node/378> Last updated on February 2.-2015.-P. 9-43.
11. Ishiaku Y.M., Hassan M.R., Tanko R.J., Amodu J. T., Abdu S.B., Ahmed S. A., Abubakr S.A., Lasisi O.T., Bala A. G., Bello, S. S., Ibrahim H. Effect of plant spacings on yield and quality of Columbus grass (Sorghum alnum) under rainfed in Shika, Nigeria. *Jurnal Animal Production Research*.- (2016) 28(1): -P.318-328.
12. Колов О.В., Костина Г.И., Буюнков А.Ю. Фотосинтетическая продуктивность различных видов сорговых культур // Кукуруза и сорго. -Москва, 2009.-№5.-С.7-8.
13. Methods of carrying out of field experiments – Tashkent, UzNIIH. 2007;147-P.
14. Muhammad I.R., Abdullahi B., Mohammed A.K., Tanko R.J., Kallah M.S and Alawa J.P. Influence of irrigation intervals on dry matter yield, concentration of crude protein, calcium and phosphorus in Lablab purpureus and Sorghum alnum fodder in the Sudan Savannah zone of Nigeria. *Nigerian Journal of Animal Production*, 32, 2005.- P.280–286.
15. Nxele X., Klein A., Ndimba B.K. Drought and salinity stress alters ROS accumulation, water retention, and osmolyte content in Sorghum plants // *South African journal of Botany*.-2017. – 108.-P. 261–266.
16. Nichiporovich A.A. Plant photosynthetic activities in the fields. M., 1961.- 131. P.
17. Olanite J. A., Anele U. Y., Arigbede O. M., Jolaosho A. O., Onifade O. S. Effect of plant spacing and nitrogen fertilizer levels on the growth, dry-matter yield and nutritive quality of Columbus grass (Sorghum alnum) in Southwest Nigeria // *Grass and Forage Science (The Journal of the British Grassland Society)*, 2010.-65.-P.369–375.
18. Safarov A.K. Biochemical Features of Perspective Forage Plants in the Conditions of Southern Part of Aral Sea. *Asian Journal of Biotechnology and Bioresource Technology*, (2017). Vol.:2(3),-P. 1-7.
19. Sivak E.E. Introduction efficiency of Columbus grass in central black soil region. Kursk: Kursk agrarian academy publish, 2006.- P.191.
20. Tretyakov L.G. Praktikum on plant physiology.- M; Agropromizdat,1990.-P.116-119.
21. Titei V., Muntean A., Cosman V. Introduction and agro economical value of Sorghum alnum in the republic of Moldova// *Research Journal of Agricultural Science*, 47 (2), 2015.-P.48-56.
22. Toderich K.N. & Wilgelm M.A. Salinity impact on growth and biomass accumulation of Sorghum under Kazakhstan Prearalei environments. *Agrarian Science of Kazakhstan*. Vol. 1(Plant Industry) Almata, 2009-P.336-339
23. Yumeng Z.R., Ambrose P. K. Structural characteristics of Sorghum Kernel: effects of temperature // *International journal of food properties*. -2016. -№10. -P. 1-23.