Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 12, 2020

GROUND WATER MODES REGULATION DURING IRRIGATION BY THE WATER-SAVING METHOD

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Received: 22.03.2020 ***Revised: 26.04.2020*** ***Accepted: 08.05.2020***

Abstract
Studies conducted on irrigated lands located on the right-bank floodplain terraces of the Syr Darya River have showed that ground water regulation for irrigation purpose using the "subirrigation (groundwater level irrigation)" method as an irrigation method is applicable in research object conditions. This question is investigated in comparison with irrigation method by furrows. Technical and economic calculations showed that cotton irrigation by "subirrigation" method is advisable to carry out in years when there is a water resources shortage suitable for irrigation. Soil salinity level in "subirrigation" method during the cotton growing season is not out of range.

Keywords: Syr Darya, ground water, subirrigation, water deficit, cotton yield, salinity, furrow irrigation method, water saving.

DOI: http://dx.doi.org/10.31838/jcr.07.12.160

INTRODUCTION

In arid areas growing agricultural crops isn't available without irrigation. For that reason, economic and rational use of water resources in arid areas is quite actual issue.

While irrigating with "subirrigation" method, ground waters is using to irrigate crops with various drainages. Wherein, the drainages are used as technical feature of irrigation. Drainage type is selected according to the hydrogeological conditions of the irrigated lands.

We chose old irrigated lands located on the right-bank floodplain terrace of Syr Darya river. Ground water in research area has salinity up to 2 g/l, and their depth varies between 0.5 - 3.0 m. Subirrigation has not been investigated as a method of irrigation in conditions of irrigated land of above mentioned area.

The main factor affecting the soil water-salt regime during subirrigation is ground water regime. When irrigating crops, with above mentioned method, favorable water-salt regime should be created in soil by regulating ground water regime with using drainage.

MATERIALS AND METHODS

The study of ground water regime influence on the soil water-salt regime was carried out by V.A. Kovda, V.M. Legostaev, V.V. Egorov, M.I. Kaplinsky, N.F. Bespalov, Oxana Savaskul, Iskandar Abdullaev, David Molden, Mohan Reddy, K. Jumaboev, B.Matyakubov, Sh. Kenjabaev, Hans Georg Frede and other researchers [1 - 12]. Currently, the research is being carried out with the goal of purposeful and programmed regulation of soil water-salt regime of aeration area using irrigation and drainage systems.

With close occurrence to the earth surface of weakly saline ground water, we investigated ground water level (GWL) control during subirrigation in order to study the following issues:

1) Ground water regime during the growing season by irrigating using the "subirrigation" method;
2) Soil water - salt regime in the regulation of water treatment GWL;
3) Cotton yield dynamics;
4) Cost-effectiveness of measures.

To study aforementioned issues we selected stationary soil sites in four replicates on light and medium loamy soils, which are located at 30 meters far from the open collector-drainage network. GWL regulation on soil sites during subirrigation was carried out using blocking structures with a flat metal shutter installed on the collector-drainage network.

The distance between the partitioning structures is determined based on the maintaining groundwater levels condition within the irrigation area at such depths, the difference between them would be no more than 10 cm.

The formula for determining the distance between the partitioning structures is as follows (1):

$$L = 0{,}1i^{-1} \quad (1)$$

where i is surface slope.

The dehumidification and humidification system during subirrigation consists of drains and collectors regulating network, which serve both to draining and moisturizing the land, a drainage collector, a water intake, and regulatory facilities on the system.

The distance between the drains - humidifiers was determined by B.G. Heitman's formula (2):

$$B = 2\sqrt{\frac{K_f}{q}h(2 \cdot H - h)} \quad (2)$$

where: K_f - filtration coefficient, m/day; q - ground water evaporation rate, m/day; H - water drainage depth, m; h - also, in the middle distance between the drains, m.

Calculations showed that the distance between the drains - humidifiers for research object conditions, depending on soil filtration coefficient and crops type varies between 50 - 100 m.

In the conditions of research object on non-saline irrigated lands in GWL regulation for subirrigation purpose we used the term "optimal depth" of ground water which ensures maximum use of groundwater by plants, minimum water supply and optimal water-air regime of aeration area. The value of the optimal depth of fresh ground water during subirrigation is variable over time. The main factors influencing the optimum ground water depth variability during the growing season are air temperature and transpiration. Air temperature and transpiration dynamics causes a change in evaporation from groundwater surface. Air temperature increase enhances evaporation from the ground water surface. Cotton growth and development (from May to the second half of August) also lead to an increase in transpiration. Therefore, evaporation increase from the ground water surface requires a decrease in GW depth in order to cover soil moisture deficit by increasing the ground water recharge.

When adjusting the groundwater level for subirrigation purpose soil humidification rate will depend on the magnitude of ground water lift, free porosity and soils capillary properties. With this irrigation method, it is not the norm of moistening that acquires greater practical significance, but the provision of the necessary GWL increase (3):

$$h_{under} = H_0 - h'_0 \quad (3)$$

where, H_0 – ground water depth before GWL increase, m; h'_0 - ground water depth after increase, which ensures optimal soil moisture in the calculation layer, for conditions, when (4)

$$q_0 \neq E_0 \quad (4)$$

where: q_0 - water evaporation rate from the soil surface (evapotranspiration); E_0- evaporation rate with open water surface. q_0 - may be higher, equal or less than E_0.

If we assume that in soil moistening is close to the lowest moisture capacityq $\approx q_0$, то (5)

$$h'_0 = h_0 \quad (5)$$

With GWL increase is high than h_0 excess moisture appears in the soil therefore, it is necessary to keep GWL lower than h_0.

On soils with a small capillary raise, in order to provide plants with moisture by feeding them with ground water, it is necessary to maintain their level very close to the surface. However, this can cause root system flooding and lower yield. Therefore, on such soils, it is advisable to maintain the groundwater level at a depth equal to active soil layer thickness. The time required to raise the water level to GWL depth h_p, can be determined by the following formula (6):

$$t = \mu \frac{h_p + \Delta h}{g_{pp}} \quad (6)$$

or

$$t = \mu \frac{h_p}{g_{п.п} - q(t)} \quad (7)$$

where Δh - GWL lowering depth due to evaporation from ground water surface (soil evaporation and transpiration); g_{pp} – underground tributary providing GWL raise; q(t) – ground water evaporation during the billing period; μ – free porosity of soil.

The aforementioned GWL regulation method can be applied on irrigated lands where drainage and humidification systems are built or on arrays and where an underground inflow against inactive drainage background provides an increase in water supply to the required depth.

GWL regulation during subirrigation is carried out according to the groundwater regime established in advance taking into account the climatic conditions.

h_0- value varies with quantitative q_0/E_0 values и can be defined as the average value per vegetation, and for its individual periods (decade, month, crop development phases).

RESULT AND DISCUSSION

Based on research results synthesis, in similar conditions, numerous scientists (Akhmedjanov G., Khakimov A., Usmanov A.) and own research determined decade values q_0/E_0 ratio and ν for C-6524 cotton growing season [13]. Based on their known values, the following functional dependence was derived for light and medium loamy soils:

$$h_0 = f\left(H_k, \frac{q_0}{E_0}, \nu\right)$$

Graphical representation of theoretical dynamics of groundwater level during subirrigation confirms a decrease in GW depth as air temperature rises and cotton grows. In order to cover the cotton water consumption in July, August and September GWL should be supported in light and medium loamy soils, respectively, at 0,36 (0,40); 0,14 (0,16) and 0,22 (0,25) m depths. As its known, with GWL close location to the earth's surface, deteriorate the water, air, thermal and nutrient regimes of the calculated soil layer, occurs water logging, hampers agrotechnical work in the irrigated area and crop productivity sharply drops. Even short-term flooding of the active soil layer leads to a decrease in plant productivity. Therefore, in order to create a favorable reclamation regime and increase the cotton yield, to maintain the GWL in cotton development phases - flowering, fruit formation and ripening at a depth of 0.5 m and if it is necessary to irrigate. In order to accelerate raw cotton ripening, it is advisable to reduce the GWL 10 - 15 days before the start of defoliation to a critical depth.

In the cotton - growth - budding development phase, water consumption can be covered by replenishment with groundwater. At the same time, an unfavorable reclamation regime is not created in the active soil layer.

Groundwater levels at experienced industrial sites during the growing season, average supported at 0,76 (light loams) m and 0, 80 (medium loams) m depths. Over the years, depending on climatic and agricultural conditions, the average vegetation depths are different. According to them, in contrast, water-salt regimes of soil occur each year. The appropriateness of subirrigation use is justified not only by ground water depth, at which the optimal soil water regime is created, but also with a salt regime in which soil salinization does not occur above the permissible level.

The main task of regulating the water level during subirrigation is to cover the plants water consumption by feeding ground water. Especially during the period of agricultural crops maximum water consumption, the water level must be maintained close to the earth surface. In this case, naturally, salts accumulate in the active soil layer. The accumulation and dissolution process of salts in the calculated soil layer was studied by us on soil sites organized to study soils water-salt regime during subirrigation. The determining purpose of salt regime limit change is to assess the harmful effects of toxic salts on cotton productivity.

A number of researchers have found that moisture and moisture reserves dynamics in the aeration area depends on the groundwater level depth, soil and ground structure and the water-physical properties [8], [9], [10],[11],[12],[14], [15].

Our observations of the target GWL rise and the soil moisture dynamics in the calculation layer showed that when the GWL regime is regulated, the soil and soil moisture content and moisture reserve increase in July, because during this period the cotton consumption is fully covered by groundwater recharge. Starting in July, the GWL is maintained on average at 0.5 m depth. But to cover the cotton water consumption only by feeding this depth is not enough. Therefore, in July and subsequent months there is a decrease in soil moisture and a decrease in moisture in the calculation layer. In August, the moisture supply in the calculation layer decreased to the lower limit of the optimal moisture supply, i.e. watering was required. On light loamy soils, watering the norm 500 m^3/ha, and on medium loamy soils the norm is 650 m^3/ ha (at efficiency of furrow irrigation technique is 0, 70). In the absence of cotton machine harvesting (cotton defoliation), it is recommended to perform a second watering: on light loamy soils the norm is 500

m^3/ha, and on medium loamy soils the norm is 700 m^3/ha [16], [17].

When capillary feeding from below, the upper horizons (0 - 0.20 m) are subject to intense drying, as a result of which the soil moisture drops to 0.32-0.41 LMC (least moisture capacity), i.e. below the minimum allowable limit (0.65 LMC). A.S. Naloychenko noted that a decrease in true horizons humidity below the minimum permissible limit creates the conditions for capillary upward currents rupture on the earth surface, resulting in several times or moisture complete loss by evaporation [18]. But, in our opinion, the moisture evaporation cessation when the GWL is close to the earth's surface is an illusion. Moisture evaporation does not stop under such conditions. It does not come from the soil surface, but from it.
In the dry years, the first irrigation at the experimental production sites was carried out at the beginning of August, and the second irrigation (in conditions without cotton machine harvesting) was required at the end of that month.

In the “wet” years, the first watering is shifted by mid-August, and the second watering by the beginning of September.

The total evaporation value and groundwater recharge also depends on year “dryness”: in wet years they decrease, and in “dry” years increase. The selenium accumulation intensity in the active layer also depends on the meteorological conditions of the year. In dry years, salt accumulation in the soil occurs more intensively than in wet years.

The salt regime dynamics of soil of experimental production sites during subirrigation was studied at each experimental site in four replicates. Samples were taken to the groundwater level at the horizons of 10 cm at the beginning, middle and end of the growing season.

The study of soil salt regime during the groundwater levels regulation shows that by the end of the growing season a small amount of salt accumulates. The amount of solid residue increased from 0,15 - 0,23 to 0, 24 - 0,40 % by weight of dry soil. From the captions, Ca and SO_4 anions noticeably increased. The salinization type at the beginning of the growing season was sulfate and after the growing season it remains unchanged. Long-term field studies have shown that the salts accumulation in the active soil layer when using groundwater to replenish the moisture deficit is washed back into groundwater during the non-growing season due to pre-arable and moisture recharging irrigation, as well as atmospheric precipitation during the same period. In addition, accumulated salts are partially washed out by irrigation carried out during the growing season. Irrigation water has 0,5 – 1,1 g/l mineralization. Reduction of salts after irrigation occurs over all horizons, especially noticeable in the upper horizons (0,1 - 0,3 m). This nature of the salt regime dynamics indicates the presence of water downward currents during irrigation.

One of the necessary conditions for conducting research on subirrigation is to study cotton yield dynamics by research years, depending on the GWL.

Observations made at pilot production sites showed that cotton yields are variable according to research years, depending on climatic conditions. In this case, the cotton yields dynamics during subirrigation is approximated with cotton yields determined by the regression equation (which was derived for GWL without regulation), but larger than it.

Studies in pilot production sites showed that cotton yields on light loamy soils with controlled subirrigation compared to managed subirrigation are more than 1,11 c / ha, and when drainage was used only for drainage on the same soil, the yield was higher than that for managed subirrigation at 0,8 c / ha. A similar picture was observed on medium loamy soils, but when drainage was used for drainage on these soils, cotton yield decreased by 0,7 c / ha [19, 20].
The annual economic effect of managed subirrigation can be determined in comparison with the annual economic effects of uncontrolled subirrigation and drainage.

The economic effect of managed subirrigation introduction can be obtained by improving the following technical and economic indicators:
- decrease in unit annual costs;
- maintaining soil structure;
- increase crop yields;
- improving agricultural products quality;
- irrigation norms reduction and water consumption per unit of agricultural products;
- increasing labor productivity in irrigation;
- environmental impact reduction.

Annual economic calculations effect from controlled subirrigation introduction showed that it is more effective than uncontrolled subirrigation, and at the same time, the efficiency was mainly achieved by increasing of cotton yield. Managed subirrigation proved to be ineffective compared to drainage operation condition only for drainage. Moreover, the drainage efficiency, which works only for drainage, was obtained by increasing the cotton yields of the first and second charges. And the proceeds from raw cotton sale during drainage work for drainage are obtained more than with controlled subirrigation. With water resources shortage, a decrease in irrigations number or under-irrigation leads to a decrease in cotton productivity from 10 to 25 % (table 1). Long-term experiments carried out in various areas of cotton planting have established that with a decrease irrigations number by only one against the optimum during budding time, sales revenue decreases from 720 thousand to 1440 thousand sums per 1 ha of cotton sowing. Therefore, controlled subirrigation use with irrigation water deficit was effective in comparison with the condition that the drainage works only for drainage.

Table 1. Comparison of managed subirrigation with other methods of regulating water pollution by annual economic effect, thousand sums/ha

№	Soil	Uncontrolled subirrigation	Furrow irrigation with drainage		Furrow irrigation with insufficient water supply for irrigated land
			Horizontal open (existing)	Vertical (optimal reclamation mode)	
1	Light loams	- 0,271	+ 1,189	+ 1,586	-0,528
2	Medium loams	-0,155	+ 0,851	+ 1,088	-0,715

Note: the “+” sign controlled subirrigation is ineffective, the “-” is also effective. 1 USD = 1000 sum.

CONCLUSION
1. The results of the studies showed that under the right-bank floodplain terraces conditions of Syr Darya river, controlled subirrigation is quite applicable without significant damage to the cotton crop and soil with groundwater salinity up to 2.0 g/l.

2. Managed subirrigation refers to such a targeted change in fresh groundwater level by hydraulic structures in order to create an optimal water regime in the active soil layer.

3. Calculations and studies have revealed that in July, August and September, the GWL during subirrigation to cover water consumption deficit of cotton should be maintained very close to the earth surface. With such a close location of the groundwater level (< 0.5 m) to the earthy soil surface, conditions close to anaerobic are created. As you know, under

such conditions, cotton productivity drops sharply. Therefore, it is recommended to maintain the GWL at 0.5 m depth months above and reduce the GWL to a critical depth 10 - 15 days before the start of defoliation.

4. When maintaining GWL at 0.5 m depth, covering the cotton water consumption only by feeding it with groundwater is not enough. Therefore, starting from the month of July, an intensive decrease in the moisture supply in the active layer is observed, and in August, the moisture supply decreases to the lower limit of the optimal moisture supply. In machine harvesting conditions of raw cotton, it is required to produce one irrigation on light and medium loamy soils respectively with the norms of 500 and 650 m^3/ha. When manually picking raw cotton without defoliating the cotton, it is necessary to irrigate the second watering with the norm: on light loamy soils 500 m^3/ ha, and on medium loamy soils 700 m^3/ ha.

5. A study of active soil layer salt regime dynamics showed that during the growing season salts accumulate from spring to autumn. The coefficients of salt accumulation amounted to 1.6 - 1.74. During the non-growing season, the active soil is desalinated by atmospheric precipitation, arable and water-recharge irrigation.

6. Annual economic effect calculations showed that controlled sub-irrigation is effective compared to furrow irrigation carried out against drainage background, which works to drain during insufficient years of water supply.

REFERENCES

1. Kovda V.A. “Fundamentals of the theory and land reclamation and development practice of saline soils in the arid areas”. // The salinization problem of soils and water sources. - M.: Academy of Sciences of the USSR, I960.- p. 60-85.
2. Legostaev V.M. “Soils drainage norms of irrigated lands of the republics of Central Asia”. // Theory and struggle with salinization of irrigated lands. - M.: Kolos, 1967. - p. 37-49.
3. Egorov V.V., Zakharyina G.B. “Salinization size dependence of soils upper horizons on the depth of groundwater”. // Reports of the USSR Academy of Sciences. -1956. - T. 109. - No. 4. - p. 27-31.
4. Kaplinsky M.I. “On the methodology of technical and economic comparison of drainage various types”. // Hydrotechnics and land reclamation. - 1977.- No. 12. - p. 78-88.
5. Bespalov N.F. “Hydro-modular zoning and irrigation regime of agricultural crops in crop rotation”. // Tashkent: Uzbekistan, 1971. - 79 p.
6. Oxana S. Savaskul, Elena V. Chevnina, Felix I. Perziger, LudmilaYu. Vasilins, Viacheslav L. Baburin, BakhtiyarMatyakubov, Danshin Alexander I. “Water, Climate, Food, and Environment in the Syr Darya Basin”.// Adaption strategies to changing environments, July 2003., - 62 p.
7. Abdullaev I., Molden D., Matyakubov B. “Best water conservation practices and their impact on water productivity in the Syr Darya River Basin”. // Proceedings of International Conference, Kazakh Institute of Water Management, Kazakhstan. 2005, - p. 33-41.
8. Matyakubov B. “How efficient irrigation can ensure water supply in the Lower Amudarya basin of Uzbekistan”.// International Water and Irrigation, 23 (3), p. 26-27.
9. MatyakubovB.Sh. “Efficient water use and water productivity in the lower reaches of the Amudarya”. // Bulletin of Agrarian Science of Uzbekistan, 1 (19). Tashkent 2005, - p. 49 - 54.
10. Matyakubov B. “Efficient use of water in the Khorezm Oasis”. // International journal of innovations in engineering research and technology [IJIERT], ISSN: 2394-3696 VOLUME 5, ISSUE 11, Nov.-2018., p. 44-49.
11. Mohan Reddy, Jumaboev K., Matyakubov B., Eshmuratov D. “Evaluation of furrow irrigation practices in Fergana Valley of Uzbekistan”. // Agricultural water management. 2013, - p. 133-144.
12. Kenjabaev Sh., Hans Georg Frede, Begmatov I.,Isaev S., Matyakubov B. “Determination of actual crop evapotranspiration (etc) and dual crop coefficients (kc) for cotton, wheat and maize in Fergana Valley: Integration of the FAO-56 approach and budget”. // Journal of Critical Reviews ISSN- 2394-5125 Vol 7, Issue 5, 2020, - p. 340-349.
13. Usmanov A.U. “Regulation of irrigation regime in the area of groundwater non-wedging”. // Irrigation issues. Materials of the II conference of young scientists on land reclamation and hydraulic engineering. - Kiev: Harvest, 1969. - p. 139-143.
14. Poberezhsky L.N. “Water balance of aeration zone under irrigation conditions”. // M.: Gidrometeoizdat, 1977. -p. I75-I78.
15. Suyumbaev D.A. “The pattern of changes in moisture reserves in the aeration area”. // Water issues. - Frunze, 1970. -Vy.24. - p. 14-16.
16. Imamnazarov O.B. “Water regime of soils and cotton yield”. // Theoretical and practical principles of water-saving technology for irrigation of agricultural crops; Abstracts - Tashkent, 1990, - p. 68-69.
17. Imamnazarov O.B. “Study of the water regime of the calculated soil layer during cotton irrigation”. // International scientific journal “Scientific knowledge of the present”, issue No. 6, 2017. - p. 69-73.
18. Naloychenko A.O. “Features of the use of bilateral regulation of the water regime of the soil in the arid zone”. //Abstract of the dissertation of the candidate of technical sciences - Novocherkassk, 1981. - p. 25-29.
19. Imamnazarov O.B. “Regulation of the reclamation regime during irrigation using the subirrigation method.” // International scientific journal “Scienestime”. Issue No. 7, 2018, -p. 39-43.
20. Matyakubov B., Isabaev K., Yulchiyev D., AzizovSh. “Recommendations for improving the reliability of hydraulic structures in the on-farm network”.// Journal of Critical Reviews ISSN- 2394-5125 Vol 7, Issue 5, 2020, p. 376-379.