Impact of changes in groundwater regime on crop yields

Aliakbar Khojiev 1*, and Tolib Khalmuradov 2

1 “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers”, National Research University, Tashkent, Uzbekistan
2 Tashkent State Agrarian University, Tashkent, Uzbekistan

Abstract. In Uzbekistan, groundwater use in agriculture is 3-5 km$^3$ per year. This creates the basis for achieving high yields of agricultural crops in conditions of low water. The article presents the results of scientific research on the impact of groundwater level, salinity, amount, and rate of irrigation on the yield of winter wheat in the Syrdarya region in an area with a groundwater level of 1-3 m and a mineralization of 1-3 g/l. The experiments were carried out in slightly, medium, and highly saline areas of the Syrdarya region. As a result, at a groundwater level of 1.5 m in areas with high salinity, the yield was 26.8 q/ha, in areas with medium salinity – 51.2 q/ha and in areas with low salinity – 58.5 q/ha.

1 Introduction

The socio-economic development of our country, as in other regions, largely depends on natural resources, particularly water resources. Today, the rational use of water has become one of the key issues for the sustainable development of our country. This is becoming increasingly important and relevant in the new economic, political, social, and environmental processes taking place in the region due to the shortage of water resources [2-4]. Studies show that with the introduction of water-saving technologies in the use of water resources in the country, the reduction of water consumption, the regulation of river flow, with a constant increase in the efficiency of irrigation and drainage systems, as well as the creation and planting of drought-resistant crop varieties, it is possible to mitigate water shortages [5-7].

Along with this, to solve these problems, the most rational way is to improve the method of managing the reclamation regime of irrigated lands, as well as the method of directing groundwater for irrigation of agricultural crops, to mitigate the shortage of water resources [2, 3, 8, 9, 10]. An important task in research is to improve the methods of managing the reclamation regime of irrigated lands and the possibility of directing groundwater for irrigation of agricultural crops on meadow soils of the Syrdarya region [2, 3, 11, 12].

* Corresponding author: aliakbar-x@mail.ru
2 Materials and Methods

In conditions of low water, experiments were carried out on subirrigation of winter wheat on the land farms of A. Khodzhaev, "Chinor", and "Baraka" of the Khavas district of the Syrdarya region. All experiments were carried out in four repetitions, and the area of the option was 2500 m² (50 m long and 50 m wide). In the plan, the plots were systematically arranged in four tiers (according to the groundwater level) [2, 3, 13, 14, 15].

![Diagram](image)

Conventions

- B - options
- T - field road
- 1, 2, 3 - repetitions
- 1, 2, 3, 4 - observation calodus
- 1, 2, 3, 4 - collector locking device
- 1, 2, 3, 4 - collector

Fig. 1. Schemes for conducting experiments

To determine the level and degree of groundwater mineralization in the experimental plots, 4 wells were drilled in the form of an envelope to the depth of groundwater, and during the season, every 10 days, measurements were made using a Progress-2 conductometer [2;3;16;17;18].

3 Results and Discussion

In particular, in the zone with increased salinity of the farm "Chinor" with a groundwater level of 1.5 m, the yield was 26.8 q/ha, in areas with medium salinity – 51.2 q/ha and in areas with low salinity – 8.5 q/ha (Fig. 2). Along with this, on moderately saline soils of the Baraka farm, with a groundwater level of 2.0 m, the wheat yield was 54.8 q/ha, with a groundwater level of 0.8-0.9 m – 51.7 q/ha [2, 3].
Fig. 2. Changes in yield of winter wheat depending on level of groundwater

On the sown areas of A. Khodzhaev's farm with low salinity, the average wheat yield was 56.4 t/ha at a groundwater level of 2.5 m and below, and at a groundwater level of 0.7–0.9 m, the yield was 51.7 t/ha (Fig. 3).

When studying the change in the yield of winter wheat on the degree of soil salinity on highly saline soils of the Chinor farm at a groundwater level of 2.3 m, the yield of winter wheat according to the FAO was 2–12 dS/m or 80–100% of the total yield.

On moderately saline soils of the Baraka farm, with a groundwater level of 2.3 m, the yield of winter wheat was 4–16 dS/m or 57–100% of the crop, and on slightly saline fields of A. Khodzhaev's farm, with a groundwater level of 1.8 meters, the average yield was 2–12 dS/m or 80–100% of the total yield.

Fig. 3. Changes in yield of winter wheat depending on soil salinity
Figure 4 shows that when winter wheat was irrigated 2-3 times on highly saline soils of the Chinor farm, the average yield was 23.0 q/ha, according to FAO 16 dS/m or 57% of the total yield.

Fig. 4. Change in yield of winter wheat depending on number of irrigations

On the sown areas of medium salinity of the Baraka farm, when winter wheat was irrigated 3-4 times, the average yield was 38.8 t/ha, which was 8 dS/m according to FAO or 98% of the total yield. In addition, in the fields with low salinity of the farm of A. Khodzhaev, when winter wheat was watered up to 5 times, the average yield was 62.0 q/ha, according to FAO - 4 dS/m or 100% of the total yield.

On highly saline soils of farms of WUA im. Kh. The average yield of Norchaeva, with an irrigation rate of 2100 m³/ha, in the farm “Chinor” – 28.8 t/ha, in the farm “Baraka” – 34.5 t/ha, in the farm of A. Khodzhaev – 39.7 t/ha.

Fig. 5. Change in yield of winter wheat depending on irrigation rates
With an irrigation rate of 2800 m$^3$/ha, the average yield of winter wheat was: on the farm "Chinor" – 36.3 t/ha, "Baraka" – 40.6 t/ha and A. Khodzhaev – 44.9 t/ha (Fig. 5).

Based on the above, the following dependence is obtained:

$$ Y = f \left( \frac{h_{gw}}{H_{dr}} \cdot C_T \cdot n \cdot M \right) $$

Here:

- $h_{gw}$ is the ratio of the depth of groundwater to the depth of horizontal drainage;
- $C_T$ is the degree of salinity of the soil, dS/m;
- $n$ is the amount of watering;
- $M$ is the irrigation rate of irrigation, m$^3$/ha.

Based on this, the formula for predicting the yield of winter wheat has the following form:

$$ y = h^n \cdot S^\beta \cdot n^\gamma \cdot M^\delta $$

Here:

- $\alpha = 20.95 + 2.628 \ln n \ln M - 16.93 \ln S - 1.713 \ln n \ln M$;
- $\beta = 4.295 + 0.4155 \ln n \ln M - 2.882 \ln n - 0.63 \ln M$;
- $\gamma = 13.835 \ln S \ln h - 21.17 \ln h - 0.4 - 0.0041 \ln M$;
- $\delta = 1.172 + 2.117 \ln S \ln h - 2.658 \ln h$.

In studies conducted during 2019-2021, when the groundwater level was 1.0 m, precipitation was 2860-3540 m$^3$/ha, the irrigation rate was 950-1150 m$^3$/ha, with the volume of groundwater inflow of 1562-1718 m$^3$/ha, the amount of evaporation and transpiration was 5015-5287 m$^3$/ha, the amount of salts per 1.0 ha was 6.7-7.6 t/ha. When the groundwater level was 2.0 m, the irrigation norm was 2213-2248 m$^3$/ha, in the absence of groundwater inflow, with constant precipitation, as well as evaporation and transpiration of salt intake to the cultivated areas, was not observed. In conditions of a groundwater level of 2.0 m, when the amount of irrigation water is 3.0 m is 2604-2624 m$^3$/ha, in the absence of groundwater inflow, in the absence of precipitation, as well as in the absence of evaporation and transpiration in the soil, the accumulation of salts in the cultivated areas was not observed.
The plot of salt changes in the subsurface soil layer is as follows:

The dynamics of salts in the depth of the arable layer during the non-development of the root system during the growing season and 3.63 dS/m. The end of watering soil salinity was, respectively, 3.26 dS/m. The dynamics of moisture in the arable layer in depth was 3.13 dS/m. In the experiment, soil salinity at the beginning of irrigation (groundwater level 2.0 m) was 3.30 dS/m, the end of irrigation, soil salinity in the control variant (groundwater level 3.0 m) was 3.24 dS/m. At the end of irrigation, soil salinity in the control variant was 3.62 dS/m.

In 2021, moisture and salt exchange are given, taking into account the theoretical studies on moisture and salt exchange, determined as follows:

Change of salts in the root layer by depth during the non-development of the root system during the growing season and 3.63 dS/m. In 2021, the change in the humidity of the subsurface soil layer looks like this:

The distribution of moisture from the root layer is as follows:

Change of salts in the root layer by depth during the non-development of the root system during the growing season and 3.63 dS/m. In 2021, the change in the humidity of the subsurface soil layer looks like this:

The dynamics of moisture in the depth of the arable layer.
The results of the study of the influence of the number of irrigations on the yield of winter wheat showed that on sown areas with high salinity, the average yield was 23\*10^{-1} /ha, with 3 times of irrigation, the average yield was 62\*10^{-1} /ha, and with 5 times watering, the average yield was 80\*10^{-1} /ha. It should be noted the patterns of irrigations on the increase of the groundwater level, soil salinity, the number of irrigations with the average yield of winter wheat at a groundwater level of 1.5 meters was 26\*10^{-1} /ha, in medium saline soils 51\*10^{-1} /ha, and slightly saline soils 2\*10^{-1} /ha, respectively. The irrigation rate showed that: in highly saline soils, the yield of winter wheat at a groundwater level of 1.5 meters was 0, in medium saline soils, 56\*10^{-1}, and in slightly saline soils, 80\*10^{-1}. A relative value of moisture absorption by plant roots was calculated by the formula: 

\[ N_r = \left( \frac{\beta}{D_n} \right) \left( \theta_r + R \theta_l \right) \left( \frac{\beta}{D_K} \right) + R \left( R \theta R \phi \right) e^{R \phi} - P P \theta \phi e^{P \phi} + N_e \]

\[ G = D D \left[ z - (\delta + u) \right] + D D \left( \delta + u \right) + D D \left( L - z \right) \]

\[ G = W_{fr} - W_{in} - B_{in} \left[ e^{B L} - e^{B z} \right] - A_{in} \left[ e^{A z} - e^{A (\delta + u)} \right] - A_{D in} + E_{in} \left( \delta + u \right) - E_{D in} \left( \frac{z - (\delta + u)}{D} - \frac{L - z}{D} \right) \]

4 Conclusions
The conducted experiments make it possible to predict the number of irrigations up to a certain point. When studying the effect of irrigation rates on the yield of winter wheat, the average yield of irrigated crops in highly saline fields at a seasonal irrigation rate of 2100 m\(^3\) significantly increases. Further rise in irrigation volume leads to a slight increase in winter wheat yield. It is noted that the yield of irrigated crops, grown on medium saline soils, rapidly increases with the increase in irrigation rate up to 2800 m\(^3\) and, in the subsequent increase, it slightly increases. In moderately saline fields, the yield was 28 q/ha, in slightly saline lands 39.7 q/ha. It should also be noted that the yield of crops, grown on hydromorphic soils, shows a more positive reaction to increased irrigation. In these conditions, the yield increased by 14.6 q/ha, from 15.1 to 29.7 q/ha.

The yield of irrigated crops, grown on slightly saline lands, was 36 q/ha. It should also be noted that the yield of crops, grown on hydromorphic soils, shows a more positive reaction to increased irrigation. In these conditions, the yield increased by 14.6 q/ha, from 15.1 to 29.7 q/ha.

References

- Some issues of effective land use in WUA with a shortage of water resources
- Influence of irrigation of winter wheat by subirrigation method on the reclamation regime of lands
- Modeling of water and salt transfer in the initial period of plant development
- Changes in the exchange of salt and moisture in groundwater management
- The changes of cotton seed-lint yield in parts of furrow length under different irrigation scheduling
- Influence of cotton subirrigation irrigation on cotton yield in hydromorphic soils
- Improving water resources management in the irrigated zone of the Aral Sea region
- Rational use of collector-drainage water
- Irrigated of the cultivated area with groundwater from vertical drenage wells
- Construction of vertical drainage wells using corrosion resistant materials
- Production of Plant Product as a Process of Functioning Biotechnical System
- Ways to improve the water availability of irrigated lands
- Problems of formation and regulation of collector-drainage flow in the Aral Sea basin. Improving the efficiency of common pool.
resources management in transition: keys study of irrigation water and pasture

Modeling the absorption of nutrients by the roots of plants growing in a salted soil

Fundamentals of Effective use of Water Resources of Irrigated Lands in South Karakalpakstan

The role of the irrigation network in the efficient use of water

Assessment of the land reclamation condition using GIS techniques and environmental variables: case study in Kulavat canal irrigation system

Moisture and salt transfer in the initial period of plant development.

The importance, methods of land leveling and analysis of equipment for their implementation.