Efficiency of complex agro-reclamation on irrigated lands

A M Tagaev¹,², K A Akshalov² and S P Makhmadzjanov¹

¹LLP "Agricultural experiment station of cotton and melon growing", Republic of Kazakhstan, Turkestan region, Maktaaralsky district, Atakent village, Laboratornaya Str., 1A
²LLP "A.I.Barayev Scientific and Production Center of Grain Farming, Republic of Kazakhstan, Akmola region, Shortandinsky district, Naychny village, A.I. Baraeva Str., 15

* E-mail: t.asanbai@mail.ru

Abstract. In recent years, due to the irrational use of land and the irregular implementation of agro-reclamation measures, there has been a rise in the level of mineralized groundwater and secondary salinization of soils, which has affected the decline in the seed-cotton yield. The area of nonsaline soils in this region is decreasing from year to year, and there is also a shortage of water resources. Irrigated lands are mostly plowed to a depth of only 30 cm. Such shallow basic tillage for such a long time contributed to the formation of a rigid "plow pan" in the arable layer and an increase in soil bulk weight and salinization, which negatively affected the yield of agricultural crops, including cotton. Currently, in serozems (grey earth), the basic tillage is carried out to a depth of 30 cm. Shallow soil plowing for many years affects the density formation in the soil layer, that is, an increase in the bulk weight of the soil and its salinization, which negatively affects the yield of cotton plantations. This complex of negative factors leads to a decrease in the fertility of serozems and soil erosion. Scientists of the Agricultural Experiment Station for Cotton and Melon Growing, in conditions of progressive dehumification and to prevent soil salinity, as well as to increase their soil fertility and cotton yield on irrigated gray-earth soils, scientific research was conducted based on the use of complex intensive agro-reclamation measures.

1. Introduction

In Kazakhstan, cotton is concentrated only in the Turkestan region and is one of the main export crops. Cotton production is not only an economic, but also a social problem, on the successful solution of which the well-being of the cotton-growing region population depends. Cotton growing is a business with a quick payback and it determines potential power along with bread, metal, energy, oil and occupies one of the leading places in the economy. We may not be among the major cotton powers, but we have our own cotton market niche, the demand for our fiber significantly exceeds the supply [1].

And in recent years, cotton plantations in the south of Kazakhstan need drastic changes. Turkestan producers of "white gold" need the use of new intensive technologies that increase soil fertility, yield and reduce costs.

In conditions of water scarcity, the main cause of salinization is mainly anthropogenic factors, such as dilapidated drainage system, secondary soil salinization, ecosystem degradation, and disruption of crop rotations and agrotechnological processes.
Currently, scientists and experts around the world say that if the processes of soil erosion and inefficient use of land and irrigation water are not stopped, then humanity may soon face the real problem of global hunger. All this has led to the fact that a new paradigm of agriculture is being formed in the world, the basis of which is a careful attitude to soil and water resources. Currently, a program for the rational use of water and land resources is underway all over the world.

In the Messages of the President of the country Qasym-Jomart Toqaev, special attention is paid to the development of the agro-industrial complex: "Agriculture is our main resource, but it is far from being fully used. Our task is to ensure the efficient use of land, it is also noted that it is impossible to create a competitive economy without developed agriculture. It is necessary to ensure legal and regulatory framework of this sphere, as well as to develop economic incentives for the introduction of modern technologies and innovations [2,3]."

Therefore, in conditions of progressive soil dehumification and with problems of water scarcity, as one of the ways to prevent salinity, as well as increase soil fertility and cotton yield, scientists of the Agricultural Experimental Station for Cotton and Melon Growing conducted scientific research based on the use of complex agro-reclamation measures in saline irrigated lands of Turkestan region.

One of the agro-reclamation measures aimed at optimizing the agrophysical properties of the soil is the deep tillage technology. The use of the technology of deep soil loosening to a depth of 60 cm contributes to a decrease in the soil bulk weight in the arable layer by 25.0-26.6% and an increase in the soil space by 30%, and soil moisture in the 0-100 cm soil layer increases to 50% [4].

Traditional deep tillage combined with soil loosening play a role in the destruction of the plow pan and reduction of the soil bulk weight, which can increase soil capacity to retain moisture, as well as reduces surface evaporation and promotes the effective use of soil moisture, reduces crop yield losses [5,6].

One of the most effective agromelioration is the technology of laser soil planning, when laser planning technology will reduce the cost of crop growing and harvesting. Laser land planning leads to a reduction in the consumption of pesticides, improves the use of nutrients and reduces the consumption of chemical fertilizers. In conditions of water scarcity, it reduces the amount of water consumption, promotes the uniform distribution of irrigation water and the use of mineral fertilizers and seeds. Also, land planning will lead to an increase in the cultivated area due to the available water supply and reduces the labor force and the number of various agrotechnological measures [7-10].

The depth of deep soil tillage and loosening is usually 25-35 cm, which effectively affects the agrophysical properties of the soil by reducing the bulk weight and improving the rate of infiltration, and the use of deep tillage to a depth of 1.0 m is carried out once every 3 years and contributes to increasing the productivity of irrigated lands and yields of cotton and wheat [11-13].

Regulation of negative soil processes, first, salinization of soils that hinder cotton cultivation, since this issue is very relevant in the conditions of intensification of irrigated agriculture in the south of Kazakhstan.

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2. Materials and Methods
A scientific study was conducted on the experimental field of Agricultural Experiment Station for Cotton and Melon Growing to study the reclamation role of deep tillage and laser soil planning in combination with the use of biological fertilizers on the dynamics of changes in the agrophysical properties of the soil.

Field experiments and experimental studies were carried out using generally accepted classical techniques: experiment and observation. Field and laboratory studies were carried out according to the methodology "Methodology of field experiments with cotton under irrigation conditions". Cotton variety, domestic Maktaaral 4017.

At this stage, the following types of agrophysical and agrochemical laboratory tests have been determined:
Soil moisture along the horizons 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm in spring and autumn in all variants, in double repetition. Soil bulk weight along the horizons 0-10, 10-20 and 20-30 cm in spring and autumn in all variants, in double repetition.

Determination of mobile forms of nitrates (NO3) in spring and autumn to a depth of 60 cm, in layers 0-20, 20-40 and 40-60 cm in all variants of double repetition.

In the experiment, options based on land reclamation with the use of various agro-reclamation measures and biological fertilizers were studied (Table 1).

### Table 1. Experiment scheme

| No. | Variants. | Min. fertilizer | Application of mineral and biological fertilizers, kg, l/ha |
|-----|-----------|-----------------|----------------------------------------------------------|
|     |           | N   | P | for plowing | in budding phase | in flowering phase | in fruit formation phase |
| 1   | Traditional technology (without agromelioration) | 120 | 80 | 80 | - | - | - |
| 2   | Application of deep soil loosening and bio fertilizers | 100 | 60 | 60 | 2.0 | 2.0 | 3.0 |
| 3   | Application of laser soil planning and biofertilizers | 100 | 60 | 60 | 2.0 | 2.0 | 3.0 |
| 4   | Application of deep loosening, laser soil planning and biofertilizers | 100 | 60 | 60 | 2.0 | 2.0 | 3.0 |

3. Results and Discussion

According to the reclamation state of the soil of the experimental site, it is weakly and moderately saline, the type of salinity is chloride-sulfate, the depth of groundwater moves during the growing season from 102.6 cm to a depth of 355.3 cm meters from the daytime surface (Figure 1).

In our studies, the ground water depth levels during the growing season were determined. The ground water depth level during the growing season was 236.1 m, respectively, and the ground water depth level in irrigated gray-earth soil was not very consistent in gradation.

![Figure 1. Dynamics of ground water depth level movement](image-url)
For example, in January, the groundwater level was 334.0 cm, February – 231.3 cm, March – 165.0 cm, April – 102.6 cm, May – 127.6 cm, June – 193.6 cm, July – 290.3 cm, August – 326.0 cm, September – 355.3 cm from the earth's surface. At the end of the growing season, for example in September, the groundwater level dropped to 355.3 cm.

It should be noted that from the data of the conducted studies in April and May, there is an increase in the ground water depth level and was within 102.6-127.6 cm to the earth daytime surface, at this time of occurrence, groundwater most closely approaches the soil surface. This is due to and is explained by the fact that in January and February, winter washing irrigation from harmful salts was carried out.

Due to the washing irrigation carried out to remove harmful salts in the irrigated gray-earth soil, the level of saline groundwater rises, and moisture evaporation occurs.

In the summer there is a tendency to shrink, groundwater goes deep into the soil, respectively, the soil absorbs precipitation faster.

**Soil moisture.** As the results of our research have shown, soil moisture varies significantly in experiment variants. The lowest amount of moisture in the soil was in the control variant (var. 1) - without the use of agro-reclamation measures, in the spring in a layer of 0-20 cm - 13.0% and in the autumn - 10.2%.

An increase in the moisture content in soils is observed under cotton crops based on the application of deep loosening and laser soil planning (var. 4). When using deep loosening in combination with laser soil planning, soil moisture in the 0-20 cm soil layer in spring was 17.3% and in autumn 14.0%, which is 4.3-3.8% more compared to the control (Table 2).

**Table 2.** Effect of agro-reclamation measures on the dynamics of changes in soil moisture, %

| Layer, cm | Traditional technology (without agromelioration) | Application of deep soil loosening and biofertilizers | Application of laser soil planning and biofertilizers | Application of deep loosening, laser soil planning and biofertilizers |
|-----------|-----------------------------------------------|----------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------|
|           | Spring | Autumn | Spring | Autumn | Spring | Autumn | Spring | Autumn |
| 0-20      | 13.0   | 10.2   | 14.7   | 12.2   | 14.4   | 12.0   | 17.3   | 14.0   |
| 20-40     | 17.4   | 14.0   | 19.1   | 15.4   | 18.2   | 15.0   | 18.7   | 16.2   |
| 40-60     | 19.3   | 16.2   | 21.8   | 17.4   | 21.1   | 17.0   | 23.1   | 19.2   |
| 60-80     | 23.7   | 20.2   | 28.1   | 24.6   | 27.7   | 22.6   | 28.5   | 26.0   |
| 80-100    | 25.8   | 24.5   | 30.3   | 26.4   | 28.4   | 25.4   | 29.9   | 27.0   |

It should be noted that in the variants with the use of agro-reclamation measures, in general, soil moisture increases in all variants. In the lower soil layers in the horizons of 60-80 cm and 80-100 cm, the differences in soil moisture between the variants are smoothed down.

Figure 2 shows soil moisture data on average in a soil layer of 0-100 cm, which in variants with the application of agro-reclamation measures, in general, in a meter-long 0-100 cm soil layer, soil moisture is higher in all variants. For example, according to the spring moisture reserves in the soil in variant 2, the moisture content in the meter 0-100 cm layer is 22.8% and in autumn – 19.2%, which is 13.1% - 11.4% more in comparison with the control, respectively.

According to the third variant, the moisture content in the spring in a meter-long 0-100 cm layer is 21.9% and in the autumn - 18.4%, which is 9.5%-7.6% more in comparison with the control, respectively. The greatest amount of stored moisture in the soil is observed in option 4, with the use of deep loosening and laser soil planning. The soil moisture indicators in the meter-long 0-100 cm layer were – 23.5% in spring and autumn – 20.5%, which is 15.7% – 17.0% more in comparison with the control, respectively (Figure 2).
From the above analysis results, the use of deep loosening and laser soil planning contributes to the preservation of the greatest amount of soil moisture.

Under conditions of high soil moisture, the root system of cotton develops intensively. The greatest accumulation and the best preservation of soil moisture was observed on cotton crops against the background of agro-reclamation measures.

![Figure 2. Effect of complex agromelioration on soil moisture, % (0-100cm)](image)

*Soil bulk weight.* A significant increase in the soil layer density was noted in the control variant without the application of deep loosening and laser soil planning. By autumn, the soil bulk densities had increased significantly. With increased anthropogenic impact, soil density increased from spring to autumn, and in all layers to the depth studied.

The general pattern here is an increase in the bulk weight in the control variant without soil loosening. In general, in all soil horizons, the content of the soil bulk weight has become more dense, both at the beginning and at the end of the growing season. For example, in the soil layers 0-10 cm, 10-20 cm, and 20-30 cm, in spring it was 1.34 g/cm³, 1.38 g/cm³, and 1.40 g/cm³, in autumn 1.36 g/cm³, 1.40 g/cm³, and 1.48 g/cm³, respectively to soil layers (Table 3).

| Soil layer | Experimental site variants |
|------------|----------------------------|
|            | 1. Traditional technology (without agromelioration) | 2. Application of deep soil loosening and biofertilizers | 3. Application of laser soil planning and biofertilizers | 4. Application of deep loosening, laser soil planning and biofertilizers |
|            | spring | autumn | spring | autumn | spring | autumn | spring | autumn |
| 0-10       | 1.34   | 1.36   | 1.30   | 1.33   | 1.33   | 1.35   | 1.28   | 1.31   |
| 10-20      | 1.38   | 1.40   | 1.32   | 1.36   | 1.35   | 1.37   | 1.32   | 1.33   |
| 20-30      | 1.40   | 1.48   | 1.34   | 1.38   | 1.36   | 1.39   | 1.34   | 1.35   |

At the experimental site, where the main processing was carried out to a depth of 32 cm, in combination with deep tillage to a depth of 50 cm, the density of the arable layer (before sowing) was formed within the optimal level for cotton cultivation. During the years of research, in general, for all variants of the experiment, against the background of deep soil loosening, fluffy consistence of the upper soil horizons (0-10 cm) was noted. For example, in variants 2 and 4, when using deep soil
loosening, the soil bulk weight content in the spring in the 0-10 cm layer was 1.30-1.28 g/cm³, respectively.

In Figure 3, seasonal changes in the soil bulk density in the average 0-30 cm soil layer are reflected. In gray-earth soil, the application of deep loosening to a depth of 55 cm and in combination with laser soil planning caused a decrease in bulk weight, for example, the optimal soil bulk density, in the spring in a layer of 0-30 cm was 1.31 g/cm³, which is 0.009 g/cm³ less, compared with the variants - without the application of agro-reclamation measures (figure 3).

Figure 3. Seasonal changes in soil density when using agro-reclamation measures, g/cm³ (0-30cm)

Carrying out deep loosening of the soil in combination with laser planning contributes to the formation of an optimal level of arable layer density. Quite often, this type of tillage is practiced in areas undergoing secondary salinization of the soil. This technology reduces the effects of interference in the soil environment, improves the structure, regulates the bulk weight of the soil, ground temperature and allows the soil to retain more moisture.

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