# Soil protection technologies on medium saline irrigated lands

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**Abstract.** Factor that hinders cotton growth and development, deep rooting of plants, are soil salinization. Currently, intensive measures to combat soil salinization are a very important issue in the field of agriculture. Soils are one of the priceless natural resources that plays an important role in the agricultural production of food in the region. The role of soils is also important in water storing and filtering and increasing resistance to floods and droughts. Stabilization of the food security of the region and increase in crop yields, which mainly depends on the soil, therefore intensive tillage and increasing the content of essential nutrients in the soil is an urgent problem today. Currently, technologies and methods of sustainable and effective intensification of production systems in the direction of increasing production capacity have been developed and are gradually being implemented into production. One of such approaches is soil-protective and resource-saving agriculture. Therefore, in the direction of increasing the production capacity, on the experimental basis of the Agricultural Experimental Station of Cotton and Melon Growing, scientific research was conducted to reduce the content of harmful salts and increase the content of nutrients in the soil.

## 1 Introduction

In conditions of irrigated agriculture, the main salinization cause is mainly anthropogenic factors, such as obsolescence of vertical drainage wells, soil salinization and violation of scientifically based cotton crop rotations, and untimely implementation of agrotechnological measures

In the Message of the Head of State of Kazakhstan Qasym-Jomart Toqaev "A Fair State. One Nation. Prosperous Society", special attention was paid to the development of agriculture. The issue of agricultural development remains one of the main issues. It is particularly noted that this important industry is in dire need of advanced modern technological solutions, therefore, a deep introduction of advanced technologies into production is necessary [1].

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Thus, one of the important problems of farmers in the southern region of Kazakhstan engaged in cotton cultivation is the need to improve the agro-reclamation conditions of irrigated lands by deeply introducing new effective and rational soil safety and protection technologies into production, which currently makes this technology extremely necessary.

Agriculture and, in particular, irrigation account for 70% of all freshwater intake in the world and 90% in the hard developed regions. By diverting water, farmers can meet the water needs of crops, diversify crop production, increase food production, meet the growing demand for food, ensure food stability, and increase their incomes and rural well-being. The downside is widespread degradation of soil and water resources, especially in regions with water scarcity, due to poor irrigation water management [2-5].

Soil salinization is a serious problem for irrigated agriculture in arid and semi-arid regions of the world, since excessive content of soil-soluble salts inhibits plant growth, inhibits microbial activity and reduces soil productivity [6,7].

The main purpose of deep tillage technology is to loosen the layer in which the plant roots are concentrated, in that the plant grows intensively on loose soil under the effect of moisture in the deep soil layer. Due to the technology, soil density decreases, moisture increases, and agrophysical properties are improved. With a lack of irrigation water, the deep tillage technology is carried out every 3 years, only then it will have a great impact on increasing the land capacity, as well as the yield of cotton and grain crops [8-10].

## 2 Materials and Methods

All field and laboratory studies were carried out according to the methodology "Methodology of field experiments with cotton under irrigation conditions" [11].

In the course of scientific work, the domestic cotton variety Maktaaral-4017 was grown, phenological observations of cotton growth and development were carried out.

Based on this experiment, the following types of agrochemical laboratory analyses have been determined:

Determination of nitrate nitrogen in the soil (NO3) was carried out by the Granwald-Liege colorimetric method. Determined (NO3) in spring and autumn to a depth of 60 cm, in layers 0-20, 20-40, and 40-60 cm in all variants in 2-fold repetition.

Determination of mobile forms of phosphorus ($P_2O_5$) was carried out by the method of carbon-ammonium extraction according to Machigin, phosphates were determined in spring and autumn to a depth of 60 cm, in layers 0-20, 20-40, and 40-60 cm in all variants in 2-fold repetition.

To obtain characteristics of the total salinity of soils, analyses were carried out on the content of the percentage of dense residue in the soil, in layers 0-20, 20-40, and 40-60 cm in all variants in 2-fold repetition. The method for determining the dry residue consists in evaporating part of the leakage and considering the resulting residue after drying in a thermostat.

Determination of chloride-ion by the Mohr's method, in layers 0-20, 20-40, and 40-60 cm in all variants in 2-fold repetition.

In the experiment, options based on the use of agro-reclamation measures and biological fertilizers were studied. Scheme of experiment: 1) Traditional cotton cultivation technology; 2) Application of deep soil loosening and biofertilizers; 3) Application of laser soil leveling and biofertilizers; 4) Application of deep loosening, laser soil leveling, and biofertilizers.

The total area of the experiment is 2304 $m^2$. The size of the plots is 7.2 m (width) x 20 m (length) = 144 $m^2$. 144 $m^2$ x 4 variants = 576 $m^2$. 576 $m^2$ x 4 repetitions = 2304 $m^2$. Cotton variety, domestic variety Maktaaral 4017.

## 3 Results and Discussion

One of the essential factors determining the effectiveness of tillage with the use of mineral fertilizers is the movement and absorption of nutrients in the soil. The content of mobile forms of nitrates ($NO_3$) and phosphates ($P_2O_5$) in the soil is of great importance for cotton growth and development.

According to the results of experimental work, Table 1 shows the seasonal dynamics of mobile forms of nitrates in the soil, depending on the application of agro-reclamation measures.

For cotton cultivation under the traditional cotton cultivation technology conditions, a less favorable nutritional regime is created according to mobile form $NO_3$. Thus, at the beginning of the growing season, in the variant without agromelioration, the $NO_3$ content was only in the horizon 0-20 cm in spring 9.0 mg/kg, in the horizon 20-40 cm – 7.2 mg/kg, and in the layer 40-60 cm – 3.1 mg/kg of soil, in autumn 5.5 mg/kg, 3.4 mg/kg, and 3.0 mg/kg of soil, respectively (Table 1).

**Table 1.** Content of mobile forms $NO_3$ and $P_2O_5$ in soil, mg/kg.

| Options | Layers, cm | $NO_3$ | | $P_2O_5$ | |
|---|---|---|---|---|---|
| | | spring | autumn | spring | autumn |
| Traditional technology - $N_{120}P_{80}$ | 0-20 | 9.0 | 5.5 | 26.0 | 14.4 |
| | 20-40 | 7.2 | 3.4 | 22.5 | 13.2 |
| | 40-60 | 3.1 | 3.0 | 14.3 | 7.6 |
| | 0-60 | 6.4 | 3.9 | 20.9 | 11.7 |
| Deep loosening of soil and biofertilizers - $N_{100}P_{60}$ | 0-20 | 10.7 | 7.8 | 34.6 | 18.6 |
| | 20-40 | 7.8 | 5.0 | 27.5 | 15.2 |
| | 40-60 | 5.0 | 4.0 | 18.5 | 8.6 |
| | 0-60 | 7.8 | 5.6 | 26.9 | 14.1 |
| Laser soil leveling and biofertilizers - $N_{100}P_{60}$ | 0-20 | 10.4 | 7.2 | 32.3 | 17.4 |
| | 20-40 | 7.5 | 4.4 | 26.1 | 14.2 |
| | 40-60 | 4.7 | 3.4 | 17.1 | 7.2 |
| | 0-60 | 7.5 | 5.0 | 25.1 | 12.9 |
| Deep loosening, laser soil leveling, and biofertilizers - $N_{100}P_{60}$ | 0-20 | 11.2 | 8.2 | 35.6 | 19.2 |
| | 20-40 | 9.1 | 5.8 | 28.0 | 15.8 |
| | 40-60 | 5.3 | 5.0 | 20.3 | 9.0 |
| | 0-60 | 8.5 | 6.3 | 27.9 | 14.6 |

As you can see, the nitrification process proceeded more actively in the soil during agro-reclamation activities - deep loosening of the soil and laser leveling (variant 4). In this agro-reclamation field, the highest content of assimilable forms of $NO_3$ is noted. According to the spring term of determination, the amount of nitrates was greater than in other variants. The highest $NO_3$ content in the 0-20 cm layer reached 11.2 mg/kg, and in the 20-40 cm soil layer 9.1 mg/kg, and in the 40-60 cm horizon was 5.3 mg/kg, and at the end of the growing season, the nitrate content was found in low amounts of 8.2 mg/kg, 5.8 mg/kg, and 5.0 mg/kg according to soil horizons.

It was found that the nitrate content in the average 0-60 cm of the soil layer in the fourth variant (8.2 mg/kg), compared with the traditional technology (6.4 mg/kg), was 24.7% higher (Figure 1).

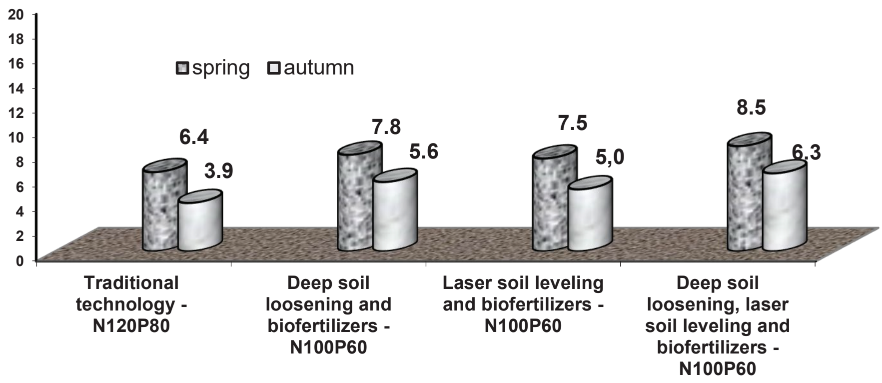



**Fig. 1.** Dynamics of change of mobile nitrogen - $NO_3$, in soil layer of 0-60 cm, mg/kg.

Along with the study of nitrates, the dynamics of assimilable phosphorus content in the soil - $P_2O_5$, - was determined in the experiment. Cultivation of cotton against the background of agro-reclamation measures, the content of assimilable forms of phosphorus in the soil is maintained. The phosphorus used had more effect on the seasonal dynamics of the assimilated forms of phosphorus.

A high content of mobile forms was found in variant 4 - with the use of deep tillage in combination with laser soil leveling. So, in spring, the phosphate content in the 0-20 cm layer was 35.6 mg/kg, 20-40 cm – 28.0 mg/kg, and 40-60 cm - 20.3 mg/kg (Table 1).

The minimum content of mobile forms $P_2O_5$ was determined in the control variant, i.e. in the variant in which the traditional technology was carried out. At the beginning of the growing season, on soils where agromelioration was not used, the content of $P_2O_5$ was only in the horizon 0-20 cm in spring 26.0 mg/ kg, in the horizon 20-40cm – 22.5 mg/kg and, in the layer 40-60 cm – 14.3 mg/kg of soil, and in autumn 14.4 mg/kg, 13.2 mg/kg, and 7.6 mg/kg of soil, respectively.

According to the results of the fourth version of the scientific work, it was found that the average content of mobile phosphorus in the soil layer of 0-60 cm was determined at 27.9 mg/kg, that is, relative to traditional technology, 25.1 percent contained highly nutritious phosphorus elements (Figure 2).

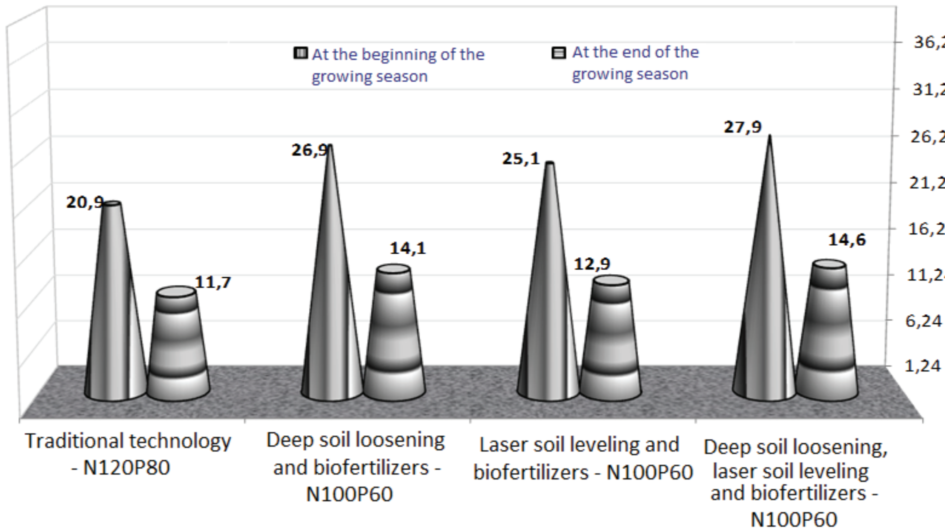



**Fig. 2.** Dynamics of the change in mobile phosphorus - $P_2O_5$, in soil layer of 0-60.

The dynamics of changes in the content of harmful and toxic salts depending on agro-reclamation measures was determined at the experimental site. The effect of washing on the salt regime of the soil, the effectiveness of autumn-winter washing of cotton fields on soil salinity, as well as on the change in the nature of soil salt regime dynamics are established.

At the experimental site, in horizons 0-20, 20-40, and 40-60 cm, soil samples were taken and laboratory analyses were carried out on the content of dense residue and chloride-ion in the soil, before and after washing.

Analyses of changes in salts in the soil, i.e. on the basis of recultivation of irrigated lands, deep tillage in combination with laser leveling, revealed changes in harmful salts in the soil.

After flushing irrigation at a rate of 2000 $m^3$/ha, it turned out that there were significant changes in the content of harmful salts in the soil in the areas where agro-reclamation measures were carried out.

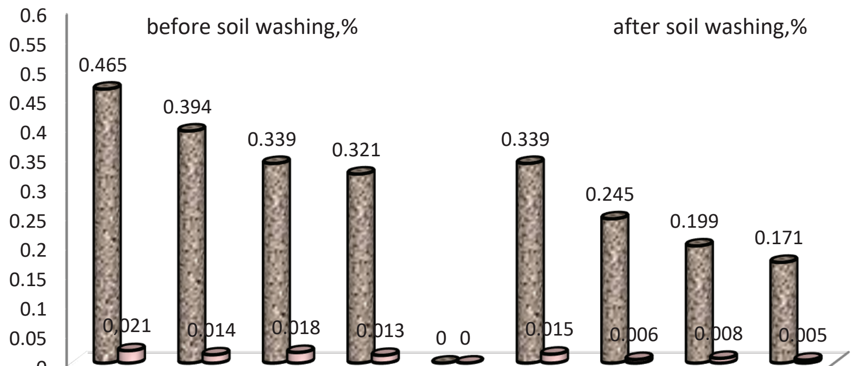
The de-salinization effect of agromeliorative measures was determined against the background of deep tillage in combination with laser soil leveling. According to the dense residual composition of harmful salts before washing in the 0-20 cm soil layer was 0.321%, and after washing, this indicator averaged 0.171% (Table 2).

**Table 2.** Content of dense residue and chloride-ion, before and after washing, %.

| Options | Layer, cm | Watering rate $m^3$/ha | Before washing, % | | After washing,% | | Washout of salts, % | |
|---|---|---|---|---|---|---|---|---|
| | | | dense residue | chloride-ion | dense residue | chloride-ion | dense residue | chloride-ion |
| Traditional technology - $N_{120}P_{80}$ | 0-20<br>20-40<br>40-60 | 2000 | 0.465<br>0.716<br>0.842 | 0.021<br>0.069<br>0.049 | 0.339<br>0.540<br>0.634 | 0.015<br>0.030<br>0.040 | 28.5<br>24.5<br>24.7 | 25.0<br>56.5<br>18.3 |
| Deep soil loosening and biofertilizers - $N_{100}P_{60}$ | 0-20<br>20-40<br>40-60 | 2000 | 0.394<br>0.648<br>0.766 | 0.014<br>0.021<br>0.041 | 0.245<br>0.397<br>0.560 | 0.006<br>0.008<br>0.020 | 37.8<br>38.6<br>26.9 | 57.1<br>61.9<br>51.2 |
| Laser soil | 0-20 | 2000 | 0.339 | 0.018 | 0.199 | 0.008 | 41.3 | 55.5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| leveling and biofertilizers - $N_{100}P_{60}$ | 20-40<br>40-60 | | 0.642<br>0.605 | 0.029<br>0.024 | 0.412<br>0.484 | 0.011<br>0.019 | 35.8<br>20.0 | 62.1<br>20.8 |
| Deep loosening, laser leveling, and biofertilizer - $N_{100}P_{60}$ | 0-20<br>20-40<br>40-60 | 2000 | 0.321<br>0.539<br>0.559 | 0.013<br>0.026<br>0.029 | 0.171<br>0.310<br>0.273 | 0.005<br>0.006<br>0.012 | 46.7<br>43.0<br>51.2 | 61.5<br>76.9<br>58.6 |

It was found that the content of harmful salts in the soil decreased by 46.7% compared to the initial indicator, and compared with traditional technology, the content of harmful salts was 39.0% less (Table 2, Figures 3 and 4).




| | Traditional technology | Deep soil loosening | Laser soil leveling | Deep soil loosening and laser leveling | | Traditional technology | Deep soil loosening | Laser soil leveling | Deep soil loosening and laser leveling |
|---|---|---|---|---|---|---|---|---|---|
| dense residue | 0.465 | 0.394 | 0.339 | 0.321 | | 0.339 | 0.245 | 0.199 | 0.171 |
| chloride-ion | 0.021 | 0.014 | 0.018 | 0.013 | | 0.015 | 0.006 | 0.008 | 0.005 |

**Fig. 3.** The effect of agro-reclamation measures on the change of salts in the soil, %.

According to the content of dense residues in the soil, it was found that the washout of the highest salts was carried out very intensively in the fields where agro-reclamation measures were carried out, that is, dense residues were intensively washed out by 46.7 percent, and chloride-ion compounds - by 61.5 percent (Figure 4).

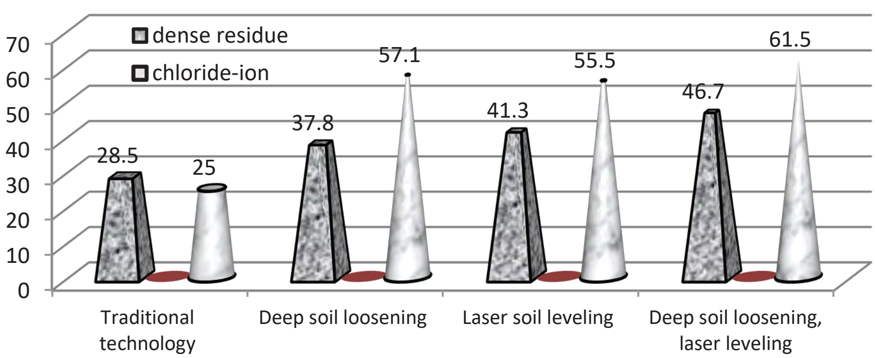



**Fig. 4.** The effect of agro-reclamation measures on the leaching of salts from the soil.

On average, it was 0.465% for the dense residue before washing in the 0-20 cm layer, and averaged 0.339% for the chloride-ion and 0.021%-0.015% for the soil after washing, respectively. The amount of washout in terms of the dense residue content was only 28.5% and chloride-ion - 25.0%.

Agromeliorative measures, that is, when using laser leveling compatible with deep soil loosening, the content of harmful salts, in particular chloride-ion, in the soil layer 0-20 cm before washing amounted to 0.013%, and after washing this indicator averaged 0.005%. That is, compared with the initial indicator, there was a decrease in the content of chloride-ions in the soil by 61.1%, and compared with traditional technology, a decrease in the content of chloride-ions by 66.5% was found.

## 4 Conclusions

The formation of the maximum amount of the assimilable form of nitrates and phosphates in the soil is realized as a result of intensive application of agro-reclamation measures (application of phosphorus, deep tillage, plowing by 40 cm and field leveling) and more active decomposition of crop and root residues containing a significant percentage of small, more active roots. These data give grounds to assert that the best mobilization of nitrate and phosphorus occurs on the basis of recultivation of irrigated lands and contributes to the creation of a more favorable nitrogen-phosphorus regime of plant nutrition in the soil. In the fields, where agromeliorative measures were carried out, intensive leaching of harmful salts in gray soil was established.

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