PAPER • OPEN ACCESS

Evaluating the effect of phytoameliorative measures on the land reclamation status

IOP Conf. Series: Earth and Environmental Science 1138 (2023) 012022 doi:10.1088/1755-1315/1138/1/012022

Evaluating the effect of phytoameliorative measures on the land reclamation status

Sh M Khamidova[1], U A Juraev[2], A K Juraev[2], and M Kh Khamidov[1]

[1] Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, National Research University (TIIAME) NRU, Kary-Niyaziy 39, Tashkent 100000, Uzbekistan
[2] Bukhara Institute of Natural Resources Management, National Research University, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 32, Gazli shokh ave., Bukhara, 105009, Uzbekistan

E-mail: ilkhom.urazbaev@gmail.comb

Abstract. This article presents the results of improving the land ameliorative condition of lands as a result of growing phytoameliorating plants as a secondary crop in conditions of water shortage. There is a scientific research aimed at saving water resources used for salt washing. White sorghum (*Sorghum Vulganell pers*) and mung bean (*Phaselus aureus Piper*) were planted as phytoameliorating crops and compared with uncultivated fields. During the experiments, when the effect of phytoameliorating crops on the number of chlorine ions contained in the soil was studied, initially, at the beginning of the vegetation period, the number of chlorine ions in the soil tillage layer (0–30 cm) increased by 0.015%. At the end of the experiments, the number of chlorine ions in the tillage layer (0–100 cm) was 0.012%. Chlorine ion content in the sorghum (*Sorghum Vulganell pers*) was 0.033% in the driving layer (0–30 cm) and 0.029% in the 0–100 cm layer, while chlorine ion content in the soil was 0.036 and 0.032% in the moss (*Phaselus aureus Piper*). In addition, the highest saline leaching rate in the experimental field was 5383 cbm/ha in the plowed field. And the seasonal salinity leaching rate was 2380 cbm/ha when sowing white corn (*Sorghum Vulganell pers*) as a phytoameliorant, and when sowing moss (*Phaselus aureus Piper*), 3403 cbm/ha. This is 37–56% less than the control or 1980–3003 cbm/ha.

1. Introduction

The problem of global climate change is urgent not only because of the average annual temperature rise on the planet, but also because of changes in geosystems, rising global oceans, melting ice and permafrost, increasing uneven rainfall, changing river flow patterns and other changes related to climate instability [1].

Due to global warming, the melting of glaciers in mountainous areas, their reduction in volume, the flow of rivers in the next 20 years, in particular, the Amudarya and partly the Syrdarya and Zarafshan, can be reduced by 25–30%, causing serious problems in the region. The annual amount can increase 1.5 times [2].

Observations of the temperature dynamics regime in Uzbekistan over the past 50 years have shown that the maximum temperature growth rate was 0.22 degrees per year, and the minimum was 0.36 degrees.

On this basis, after 20 years, the average annual temperature in the northern part of the Republic will increase by 2–3 degrees, and in the southern part by 1 degree. Climate change leads to an increase in the water consumption by 10–20% and an increase in the non-renewable water consumption by an average of 18%. This will undoubtedly complicate the further growth of agricultural production [3].

A. Khamidov and others conducted scientific research on the improvement of the land reclamation in the lower reaches of the Amudarya, as well as on the desalination of saline lands by phytoamelioration. For the study, gold species of Portulaca oleracea were selected in the salty areas of the Khorezm region as well as halophyte plants growing naturally in the salty areas of the Khorezm region. These areas assessed its sanctification by planting Tamarix hispida (TH), Apocynum lancifolium (AL), Glycyrrhiza glabra (GG), Alhagi pseudalhagi, Karelinia caspia (KC), and Chenopodium album (CA) [4].

When analyzing the effect of repeated sowing on the Salt regime of the soil of safflower and millet plants, the amount of chlorine ion in the soil before planting was initially equal to 0,019% in the tillage layer, 0.016% in the 0–100 cm layer. By the end of vegetation, in the plowed field, these indicators were 0.045% and 0.043%. When the bio-ameliorant crop was planted in the safflower dye as a repeat crop, this figure was found to be 0.032 and 0.029%, respectively, by 0.030 and 0.026% when growing millet. The accumulation of 0.013–0.014% was less saline than that in the plowed uncultivated field [5].

2. Materials and Methods

The Research Institute conducted scientific research studies on the effectiveness of phytoameliorative activities selection of cotton, seeds and cultivation agrotechnology. These are the "Methods of conducting field experiments" (UzCRI-2017) [6], studying water-physical properties of soils, agrochemical indicators and the amount of salts contained in the soil. "Methods of agrochemical analysis of soil and plants" (Tashkent, 1977) [7] was based on the accuracy and reliability of the data of the mathematical study on the method of dispersion analysis of B. A. Dospekhov (1985) [8]. Irrigation, feeding and other agrotechnical activities of crops in the experimental area were carried out according to the agrotechnology adopted for this area.

3. Results and Discussion

Experimental field observations to determine the effectiveness of phytoameliorative measures in improving the reclamation of lands in the conditions of saline and saline soils of Bukhara region were carried out under the following conditions. There was soil meadow alluvial; medium sand by mechanical level, moderately saline. The depth of groundwater is 1.5–2.5 meters. In areas with a salinity of 3–5 g/l, white sorghum (*Sorghum Vulganell pers*) and mung bean (*Phaselus aureus Piper*) were planted as secondary phytoameliorating crops, compared to the plowed, uncultivated field. As a phytoameliorant crop, local varieties of white corn (*Sorghum Vulganell pers*) "*Toshkent oq donlisi*" and varieties of mung bean "Navruz" were planted and cultivated. Experiments studying the impact of phytoameliorating plants on the reclamation of lands were carried out in the fields of the farm "Zarif ota" of the Association of Water Consumers "Choruq arigi" in Bukhara district of Bukhara region. During the research, experiments were conducted to study changes in land reclamation, groundwater levels and mineralization, changes in saline leaching rates and timing, as well as the impact of field on water and salt balance as a result of growing phytoameliorating crops.

Irrigation norms of white corn (*Sorghum Vulganell pers*) and mung bean (*Phaselus aureus Piper*) planted as phytoameliorating crops after winter wheat in the study field were measured and observed on the basis of the Scientific Research Institute of Agrotechnology of Seed Production of Cotton Breeding (UzCRI-2007). There were recommendations on determining its growth and development. Irrigation of phytoameliorating crops included pre-irrigation of the soil moisture irrigated 2 times in the 0–1–1 system at 70–75–65% relative to boundary field moisture capacity (LFMC). In the experiment, the norms and timing of irrigation on the options were calculated according to the formula of S.N. Rizhov, depending on the level of moisture in the soil.

In the case of irrigation of phytoameliorating crops, the duration and norms of irrigation according to the options were determined based on the amount of moisture in the soil. Depending on the growth phases of white corn (*Sorghum Vulganell pers*), irrigation was carried out during the ripening, milking and wax ripening phases. The irrigation norm of white corn (*Sorghum Vulganell pers*) was determined on the layer of the soil moisture of 50 cm in the pre-ripening phase, 70 cm in the ripening phase, 50 cm layer in the ripening phase of milk and wax. Irrigation norms were 830 and 1024 $cbm \cdot ha^{-1}$ per hectare. Mung bean (*Phaselus aureus Piper*) was irrigated during the flowering and ripening periods during the season, with an average irrigation rate of 860–960 $cbm \cdot ha^{-1}$. In the experiments, phytoameliorating crops were irrigated 1 time in the amount of 1100–1150 $cbm \cdot ha^{-1}$ in order to moisten the soil and quality plowing before planting. The irrigation of phytoameliorating crops was carried out from August to the end of September; the interval between irrigations was 22–28 days.

In the study of the analysis of groundwater levels in the cultivation of phytoameliorating crops, the control of experiments, i.e., in the 1st variant without plowing the field averaged 172–223 cm per month and 192 cm during the season. At the same time, white corn (*Sorghum Vulganell pers*) was grown as a phytoameliorating crop; in variant 2 the groundwater level was 172–219 cm during the experiments and 188 cm on average during the application period. And the amplitude of groundwater change was 46 cm. In variant 3, in which mung bean (*Phaselus aureus Piper*) was grown, the groundwater level was 172–217 cm during the months throughout the experiments and 189 cm on average during the season, with a change amplitude of 43 cm. Cultivation of phytoameliorating crops after winter wheat has a significant impact on the amount of salts in the groundwater.

In the conditions of the Bukhara oasis, it is important that the groundwater should fluctuate throughout the year. Based on the results of observations to determine the mineralization of the groundwater, an increase in the mineralization of the groundwater was observed as a result of irrigation of phytoameliorating crops and saline leaching. In 2009–2011, before planting, phytoameliorating plants had a chlorine ion content of 0.259 g/l in the groundwater before planting. It increased from 1 g/l to 3.710 g/l. In Option 2, where white oats (*Sorghum Vulganell pers*) were planted in the experiments, the chlorine ion content was initially 0.259 g/l, but at the end of the action-growth period it was 0.243 g/l, decreasing to 0.016 g / l compared to the initial result. The amount of dry residue can be seen to increase from 3.250 g/l to 3.520 g/l in option 2. In the experimental field where mosh (*Phaselus aureus Piper*) was grown as a phytoameliorant, the content of chlorine ions in the groundwater was 0.253 g/l at the end of the growing season, while the dry residue increased to 0.270 g/l at the beginning of the growing season and was equal to 3.520 g/l. The obtained results are presented in Table 1.

Table 1. Inerting the groundwater (g/l).

Variants	**at the beginning of vegetation**				**at the end of vegetation**			
	Cl	**HCO_3**	**SO_4**	**dry residue**	**Cl**	**HCO_3**	**SO_4**	**dry residue**
control (plow)	0.259	0.195	0.782	3.250	0.285	0.229	0.878	3.710
White corn (*Sorghum Vulganell pers)*	0.259	0.195	0.782	3.250	0.243	0.212	0.822	3.520
Mung bean (*Phaselus aureus Piper*)	0.259	0.195	0.782	3.250	0.253	0.220	0.837	3.615

In experiments, to study the effect of phytoameliorating crops on the amount of salts in the soil, the effect of cultivation of white sorghum (*Sorghum Vulganell pers*) and mung bean (*Phaselus aureus Piper*) planted as phytoameliorating crops on the soil salt regime was studied. In order to study the dynamics of the movement of salts in the soil, samples were taken from the cuttings from every 10 cm layer of soil to a 100 cm layer, and the amount of salts in the soil (Cl^1, SO_4, HCO_3, dry residue) was determined on the basis of laboratory analysis. The results obtained for the soil salt regime are given in Table 2.

When analyzing the results of data obtained to determine the effect of phytoameliorating crops on the amount of chloride ions in the soil, initially, at the beginning of the growing season, the amount of chloride ions in the driving layer of the soil (0–30 cm) was 0.015%. In the layer 0–100 cm it was 0.012%, at the end of the experiments, in option 1, that is, plowing. And in the uncultivated field the arable layer increased to 0.045%, while in the 0–100 cm layer this value was 0.040%. In variant 2, white corn (*Sorghum Vulganell pers*) was grown, mung bean (*Phaselus aureus Piper*) was grown at the end of the growing season when the chlorine ion content in the soil was 0.033 % in the driving (0–30 cm) layer and 0.029% in the 0–100 cm layer. In option 3, the amount of chloride ions in the soil increased by 0.020–0.21% compared to the initial result, which was 0.036 and 0.032%, respectively. This showed that the chlorine ion accumulated 0.008–0.009% less than that in the plowed and uncultivated control field.

Based on the results of studies on the effect of phytoameliorating plants on the amount of dry residue in the soil, the amount of dry residue in the topsoil (0–30 cm) layer was 0.187%, in the 0–100 cm layer – 0.163%. At the end of the growing season in option 1, the amount of dry residue in the uncultivated field was 0.445 and 0.412%, respectively. In variant 2, where white corn *(Sorghum Vulganell pers*) was grown, the amount of dry residue in the soil at the end of the growing season was 0.269% in the driving layer and 0.228% in the 0–100 cm layer. That was 0.75–0.183% less than that in the control variant. Also, in variant 3, grown as mung bean *(Phaselus aureus Piper*) as a phytoameliorating crop, the amount of dry residue in the soil was 0.312% in the driving layer, 0.302% in the 0–100 cm layer, and 0.109–0.123% less than that in the plowed and uncultivated field. The results of the observations for 2009–2011 are presented in Table 2.

Table 2. Influence of phytoameliorating plants on soil salt regime (2009–2011).

Options	**soil layer, cm**	**At the beginning of vegetation (%)**		**At the end of vegetation (%)**	
		Cl	**dry residue**	**Cl**	**dry residue**
control (plow)	0-30	0.015	0.187	0.045	0.445
	0-100	0.012	0.163	0.040	0.412
White corn	0-30	0.015	0.186	0.033	0.269
(*Sorghum Vulganell pers)*	0-100	0.012	0.175	0.029	0.228
Mung bean	0-30	0.015	0.186	0.036	0.321
(*Phaselus aureus Piper)*	0-100	0.012	0.175	0.032	0.302

3.1. Salt washing standard in the experimental field

In the autumn-winter season, saline washing was carried out in the field where phytoameliorating plants were grown as a secondary crop. In determining the norms of saline leaching, soil samples were taken from the plowed field in a layer of 0–100 cm, and the number of salts in the leaching layer was determined. Depending on the mechanical composition of the soil and the amount of salts in the soil, the norms and conditions of saline leaching were determined. The salt washing criterion was calculated theoretically on the basis of the formula recommended by V. R. Volobuev.

Table 3. Salt washing procedure in the experimental field.

Options	**Indicators**	**1st saline wash**	**2nd saline wash**	**3rd saline wash**	**Seasonal saline wash rate, cbm·ha^{-1}**
Plow yield	saline wash rate, cbm·ha^{-1}	1677	2172	1535	5383

White corn (*Sorghum Vulganell pers)*	saline wash rate, cbm·ha^{-1}	2380			2380
Mung bean (*Phaselus aureus Piper*)	saline wash rate, cbm·ha^{-1}	1869	1534		3403

Data on the saline washing operations carried out in the experimental field are given in Table 3. According to the table, the highest salinity wash rate was observed in the uncultivated field, which was plowed after the winter wheat. The lowest saline leaching rate was observed in the variant planted with white corn (*Sorghum Vulganell pers*) as a phytoameliorant.

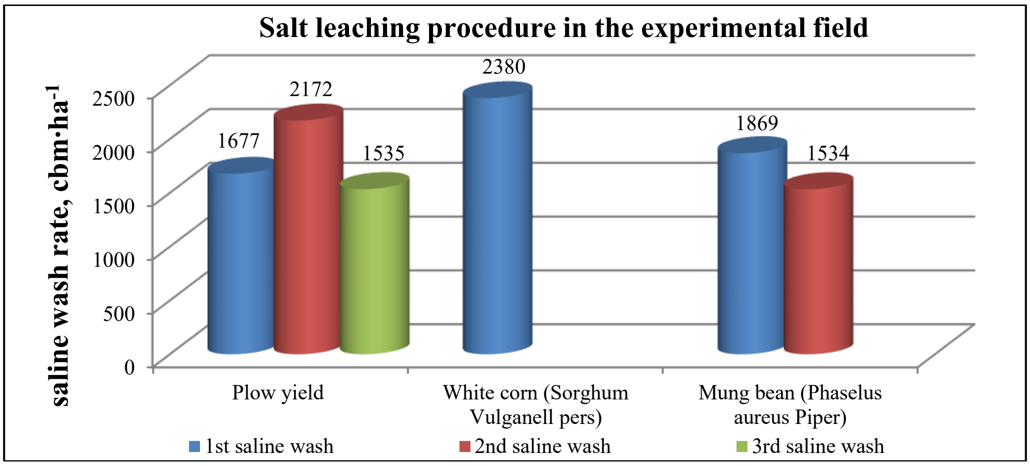

Figure 1. Influence of phytoameliorating crops on saline leaching norms.

During the study, the seasonal saline leaching rate in Option 1 averaged 5.383 cbm·ha^{-1} over 3 years, and saline leaching was carried out 3 times during the season. In option 2, where white corn (*Sorghum Vulganell pers*) was planted as a phytoameliorant, the saline leaching rate was 2380 cbm·ha^{-1}, which was 3003 cbm·ha^{-1} less than that in the control option. In this variant, the field was washed 1 time with salt. In the 3rd variant there was mung bean (*Phaselus aureus Piper*), the seasonal salinity wash rate was 3403 cbm·ha^{-1}, with water consumption less than 1980 cbm·ha^{-1} compared to the control variant. While in the 2nd variant there was white sorghum (*Sorghum Vulganell pers*) with 1023 cbm·ha^{-1} of water. In the field where mosh (*Phaselus aureus Piper*) was grown as a phytoameliorant, saline washing was carried out twice during the season. During the study, saline washing activities lasted from the third decade of December to the last decade of January, with a period between saline washes of 14–18 days.

4. Conclusion

Based on the research conducted in Bukhara region on the application of phytoameliorative measures to ensure an optimal reclamation regime of soils, to reduce water consumption in saline leaching, to increase productivity of irrigated lands, the following conclusions can be made:

1. Cultivation of white corn (*Sorghum Vulganell pers*) and mung bean (*Phaselus aureus Piper*) as a secondary crop from phytoameliorating plants in fields free of winter wheat in conditions of water shortage will improve land reclamation and increase land use efficiency. The irrigation of white corn (*Sorghum Vulganell pers*) after autumn wheat was at the rate of N 150, R100, K60 kg/ha. And the pre-irrigation soil moisture was at 70–70–65% relative to LFMC. The seasonal irrigation rate was 1808 cbm·ha^{-1}, 4.74 t/ha of grain and 22.62 t/ha of hay harvest and feeding mung bean (*Phaselus aureus Piper*) N 150, P 100, K 60 kg/ha at normal and pre-irrigation soil moisture relative to LFMC 70–70–

65%. The irrigation at a seasonal rate of 1840 cbm·ha^{-1} provides 2.18 t/ha of grain and 1.51 t/ha of hay harvest.

2. According to the analysis of the impact of water-saving phytoameliorating plants on the salt regime of the soil, if the amount of chloride ion in the soil was initially 0.015% in the arable layer and 0.012% in the 0–100 cm layer, by the end of the growing season, in the plowed field, these figures were 0.045% and 0.040%, respectively. When white corn (*Sorghum Vulganell pers*) was planted as a phytoameliorating crop, these values were 0.033 and 0.029%, when the mung bean (*Phaselus aureus Piper*) was 0.036 and 0.032%, and the chlorine ion was 0.008–0.012% less than that in the control field. The seasonal salt accumulation coefficient for the chlorine ion was 2.3 in the field planted with white corn (*Sorghum Vulganell pers*), 2.6 in the field where the mung bean (*Phaselus aureus Piper*) was grown, and 3.3 in the plowed and uncultivated field.

3. The highest saline leaching rate in the experimental field was 5383 cbm·ha^{-1} in the plowed control variant. As a phytoameliorant, seasonal salinity was 2380 cbm·ha^{-1} in option 2 planted with white sorghum (*Sorghum Vulganell pers*) and 3403 cbm·ha^{-1} in option 3 planted with mung bean (*Phaselus aureus Piper*). 37–56% or 1980–3003 cbm·ha^{-1} less water was used than that in the control option.

References

[1] Khamidov M and Khamraev K 2020 Water-saving irrigation technologies for cotton in the conditions of global climate change and lack of water resources *IOP Conference Series: Materials Science and Engineering* **883 (1)** 012077
[2] Bekmirzaev G, Ouddane B, Beltrao J, Fujii Y and Sugiyama A 2021 Effects of salinity on the macro-and micronutrient contents of a halophytic plant species (*Portulaca oleracea l.*) *Land* **10 (5)** 481
[3] Murodov O U, Kattaev B S and Saylixanova M K 2020 The use of sprinkler irrigation in the cultivation of agricultural crops *Proceeding of The ICECRS. Conference of Management of Islamic Education Leadership In The Era of Revolution 4.0* (Indonesia)
[4] Kovda V A 1937 *Origin and Regime of Saline Lands* (ANSSSR Publishing House)
[5] Legostaev V M 1959 *Reclamation of Saline Lands* (Tashkent)
[6] UzCRI-2017 *Methods of conducting field experiments of the Research Institute of Cotton Breeding, Seed Production and Agrotechnology*
[7] 1963 Methods of agrochemical, agrophysical and microbiological research in irrigated cotton areas (Tashkent)
[8] B Dospekhov 1985 *Methods of Field Experience (*Moscow: Agropromizdat)
[9] Jurayev A, et al 2021 Cultivation of corn as a repeated crop *European Journal of Life Safety and Stability (2660-9630)* **10** 49–51
[10] Pankov M A 1961 *Processes of soil Salinization and Desalinization of the Hungry Steppe* (Tashkent)
[11] Rabochev I S and Koroleva I K 1983 *Expanded Reproduction of Soil Fertility* (Moscow)
[12] S Ryjov 1953 *On the methods of determining the timing of irrigation of cotton* (Tashkent, publishing house: Academy of Sciences of the Uzbek SSR)
[13] Atabaeva H and Khudoikulov B 2018 *Botany* (Tashkent)
[14] Garkusha F and Yatsyuk M M *Soil solution. Soil Science with Fundamentals of Geology* (Moscow)
[15] Gedroits K K 1933 *The study of the absorptive capacity of soils* (Moscow)
[16] Saksonov U S 2022 The Relevance of Water-Saving Irrigation Technologies *Scientific Progress* **3 (2)** 1004–1009
[17] Juraev A K and Saksonov U S 2019 Scientific substantiation of terms and norms of winter wheat irrigation in bukhara oasis *Journal of Agro Processing* **6**