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Modelling effects of irrigation with collector-drainage water on second crop productivity in sample of mung beans

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Abstract. Syrdarya region of the Republic of Uzbekistan mainly grows cotton, winter wheat, rice, corn, oats, and barley. Each type of plant requires a certain amount of moisture, nutrients, temperature, solar energy, and other factors.

Although the plants listed above are resistant to a certain level of mineralized water resources, improper use of ditch water will worsen the reclamation condition of the soil.

Therefore, the study and modeling of the impact of irrigated water quality on productivity are one of the pressing issues.

To parameterize the CropSyst model, the plant under study is grown under stressless conditions, and all the observed parameters are included in this model. For example, it requires regular and timely irrigation, proper care, adequate fertilizer application, soil reclamation management, and phenological observations during each growing season.

In the next validation phase, the selected replanting mung bean is grown under altered conditions, such as changing the irrigation regime or applying different amounts of fertilizer. These modified parameters are entered into the model and constructed by comparing the results shown in the model with the results obtained in practice. If the results shown in the model are the same as the results obtained from the field experiment, then this model is considered to be correctly parameterized. In the application section, we will again test the model and recommend it to farmers for use.

1 Introduction

Today, the issue of food security has become one of the priorities in all countries of the world. In particular, due to the global warming process on our planet, floods are occurring in some areas and extreme water shortages in some areas, the increase in various natural disasters is hurting the agricultural sector in the first place. Due to favorable soil and climatic conditions in the country, corn, mung bean, soybeans, and various vegetables are planted as a repeat crop for 120-130 days in more than one million irrigated areas, freed from cereals every year. This allows growing high and quality crops up to twice a year. Currently, the country pays great attention to grain, legumes, and oilseeds and expands its

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arable lands. Great opportunities have opened up for the development of agriculture and the efficient use of land. One of the most pressing issues today is the protein issue, which is to meet humanity's demand for protein. The role of crops like mung bean of legumes in solving this problem is great. But to this day, the number of degraded land areas in agriculture is growing around the world: 4% due to compaction, 56% due to water erosion, 12% due to depletion of soil nutrients, salinization, and pollution, and 28% due to wind erosion, swamping and subsidence. As a result of these negative processes and the fact that 7 million hectares of arable land are lost to agricultural use every year due to water shortages in 80 countries around the world, food insecurity is a problem in the world. On the one hand, due to the lack of water resources, farmers are experiencing low crop yields due to the use of collector water. Using water resources with high mineralization leads to a decrease in crop yields and soil salinity.

Some countries have studied the rational use of water and its dependence on agriculture, for example, Israel, Singapore, the Netherlands, and Spain. For example, 87 percent of water in Israel is reused, about 90 percent of which is used for agriculture, and food is grown in the desert. In addition, two-thirds of the globe is covered by water, but 97.5% of it is saline and unusable. The remaining 2.5 percent is freshwater, of which 79 percent is glacial, 20 percent is groundwater, and 1 percent is rivers and lakes. Therefore, the rational use of water in agriculture is one of the most pressing issues today [2].

In fact that today the problem of water shortage is felt in our country, as well as in other countries around the world. Rational use of available water resources, saving water in the irrigation of secondary crops in agriculture, and the introduction of technologies to improve the quality of irrigation are becoming a requirement of the times.

In this case, it is important to properly organize mung bean in irrigating after winter wheat, to use water wisely and to increase the efficiency of irrigation, to ensure even distribution of moisture throughout the field, and to study the physiological requirements of each crop to water.

According to the International Institute of Water Management (IWMI.2007), 50% of the world's population suffers from water resources' physical and economic scarcity. Water scarcity mainly belongs to two reasons. The first reason is climate change, and the second is water resource misuse. Water scarcity includes 5 forms, below:

- physical scarcity - a lack of water resources in the natural geographical location;
- economic water scarcity - water scarcity under the influence of economic and anthropogenic factors;
- deficiency in water management - Improper management of water resources leads to water scarcity;
- institutional deficit - a shortage of water resources associated with the problems of institutions responsible for water resources;
- identifying the political causes of political scarcity is the main reason for the scarcity of water resources. (Example: transboundary water resources) [2].

Uzbekistan gets 80% of its water resources from transboundary sources, so the "water security" issue for the next 20-30 years is very important and relevant. We know that the size of the Aral Sea has been declining for many years. Causes are to misuse of water resources. Farmers use alternative water resources, such as collector-drainage water when there is a shortage of water. Improper use of water resources worsens the reclamation condition of the soil and affects the quality and yield of agricultural crops.

The Syrdarya region of the Republic of Uzbekistan mainly grows cotton, winter wheat, rice, corn, oats, and barley. Each type of plant requires a certain amount of moisture, nutrients, temperature, solar energy, and other factors.

Although the plants listed above are resistant to a certain level of mineralized water resources, improper use of ditch water will worsen the reclamation condition of the soil.

Therefore, the study and modeling of the impact of irrigated water quality on productivity are one of the pressing issues.

2 Materials and Methods

Our task is to study the impact of these alternative water resources on cotton yield, soil reclamation status, and composition, as well as to determine the limit of use for repeated mung bean grain yield after winter wheat according to the composition and volume of this collector-drainage water.

Fig. 1. The process of field experimentation (*Source:* Compiled by the authors)

Field experiments were adopted at the Cotton breeding, seed production and cultivation agrotechnologies research institute "Methods of agrochemical, agrophysical and microbiological research in irrigated cotton areas" (CBSPCARI, 1963 y.), "Methodology of field experiments with cotton" (CBSPCARI, 1981 y. and conducting field experiments, (Takent, 2007 y.) [3] based on methodical instructions Soil samples from Syrdarya region were analyzed, light gray soil, mechanical composition light sand, The groundwater level is 2.0 m deep, the content of humus in the aquifer (0-30 cm) is 0.948%, total nitrogen is 0.079%, phosphorus is 0.219%, and humus in the 30-50 cm layer is 0.860, total nitrogen is 0.066. and phosphorus - 0.211%.

The amount of nitrate nitrogen in the drive and underdrive layers 1 kg of soil contained 2.7–2.1 mg, mobile phosphorus 9.0–4.8, and exchangeable potassium 242–242 mg/kg.

Hence, it was found that the driving layer of the experimental field was very poorly supplied with low-phosphorus with mobile nitrogen and moderately supplied with exchangeable potassium.

3 System analysis

Based on the above, observations were made in the conditions of lightly irrigated light gray soils of the Syrdarya region. Scientific research was carried out at the farm "Nurli zamin tukhbasi" in the Gulistan district of the Syrdarya region.

Volume weights of soil at a depth of 50 cm at the beginning and end of the application period were determined using cylinders every 10 cm at the beginning and end of the application period for agricultural crops sown on the experimental plots, i.e., winter wheat and secondary mung bean. For example, in a field planted with winter wheat, the volume weight of 0-30 cm of the soil layer in option 2 was 1,22 g/cm3 at the beginning of the application period, while at the end of the application period, it was 1,31 g/cm3.

In the case of repeated mung bean after autumn wheat, in option 2, the volume weight of the soil was 1.21 g / cm3, ni, and 1.23 g / cm3, respectively, and It was that it was caused by irrigation of agricultural crops.

To determine groundwater's salinity (mineralization) in the experimental fields, groundwater samples were taken and analyzed in laboratories. The analysis shows that the level of mineralization of groundwater has increased from the beginning of the operation period to the end of the operation period. For example, the amount of nitrate in groundwater at the beginning of the operation was 0.820 l / g in the winter wheat field and 0.722 l / g in the secondary mung bean. By the end of the period, this figure was 0.862 l / g in winter wheat and 0.746 l / g in repetitive mung bean. The data obtained are presented in Table 1.

It was observed that the effect of irrigation on the salinity of groundwater increased during the application of crops.

Table 1. Depth of groundwater in the experimental fields and its mineralization, g/l

Sampling times	Depth of groundwater, cm	Mineralization of groundwater, l/ha		
		HCO_3	CI	Dry residue
20.07	131.3	0.722	0.142	3.52
10.08	132.2	0.737	0.141	3.82
28.08	141.9	0.780	0.149	4.39
Average	135.1	0.746	0.144	3.91

Source: Compiled by the authors

Many researchers are in the field of hydrogeology, O.K.Lange, M.A.Shmid, F.P.Savarensky, M.M.Krilov, N.M.Reshyotkina, B.M.Giorgievsky, A.G.Vladimirov, N.A. .Studied by Kenesarin, D.M. Katz, and other scientists. These scientists have studied groundwater formation, their reserves, and mineralization. Pakistani scientist Asad Sarwar Qureshi used the SWAP-Soil Water Atmosphere Plant model. He modeled cotton yield in Pakistan by irrigating it from various water sources, but this model only requires physical parameters. Uzbek scientists are also studying modeling and aiming to use it effectively. Dr. Kirsten Kiensler modeled the Sydarya-127 variety of cotton in the Sydarya region on its potential yield under stress-free conditions.

Modeling and explanation of the CropSyst model: modeling consists of 3 stages, namely: -parametering; -validation; -application.

A model is a mold; we make an analog of an object with its other appearance. We distinguish between mathematical, mechanical, and electronic types of modeling. Mathematical modeling is calculated based on linear equations, and in mechanical modeling, an object is made with its scale reduced. For example, in the mechanical modeling of a tractor, its layout is made by reducing the mass, speed, and other parameters by 100 times.

In modeling in the elective version, the model created by scientists includes the required parameters and is adapted to a continent. Some models require physical parameters such as the SWAP model, similar to the CropSyst; Aqua Crop models include physicochemical biological and management (irrigation, fertilizer application, processing) parameters [4].

4 Testing of system

To parameterize the CropSyst model, the plant under study is grown under stressless conditions, and all the observed parameters are included in this model. For example, it requires regular and timely irrigation, proper care, adequate fertilizer application, soil reclamation management, and phenological observations during each growing season.

In the next validation phase, the selected replanting mung bean is grown under altered conditions, such as changing the irrigation regime or applying different amounts of fertilizer. These modified parameters are entered into the model and constructed by comparing the results shown in the model with the results obtained in practice. If the results shown in the model are the same as the results obtained from the field experiment, then this model is considered to be correctly parameterized. In the application section, we will again test the model and recommend it to farmers for use.

Fig. 2. Experimental crop area (*Source:* Compiled by the authors)

The CropSyst model was developed by scientists Claudio Srockle and Roger Nelson at Washington State University. Weather data is entered first in the parameterization section because the model calculates evapotranspiration based on meteorological data. Evapotranspiration determines the growth and development of a plant. Figure 1 below shows the relationship between plant-atmosphere-soil.

The study found that 2019-2021 had the highest yields in Option 1 because no stress condition was observed for the recurrent moss plant.

Precipitation, irrigation, and air temperature provide the process of transpiration in the plant and evaporation in the soil. Transpiration is carried out correctly using the leaf axils when the plant is in a potential state, i.e., in a stress-free state, which determines the plant's development. When the mineralization of the plant is irrigated with high water, this leads to a shortening of the leaf axils, which slows down the transpiration process, slows down the development of the plant, and reduces its productivity. All these processes are taken into account in the model. These take into account not only water stress

but also the rate and type of fertilizer application, as each unit require certain nutrients during its growing season [4].

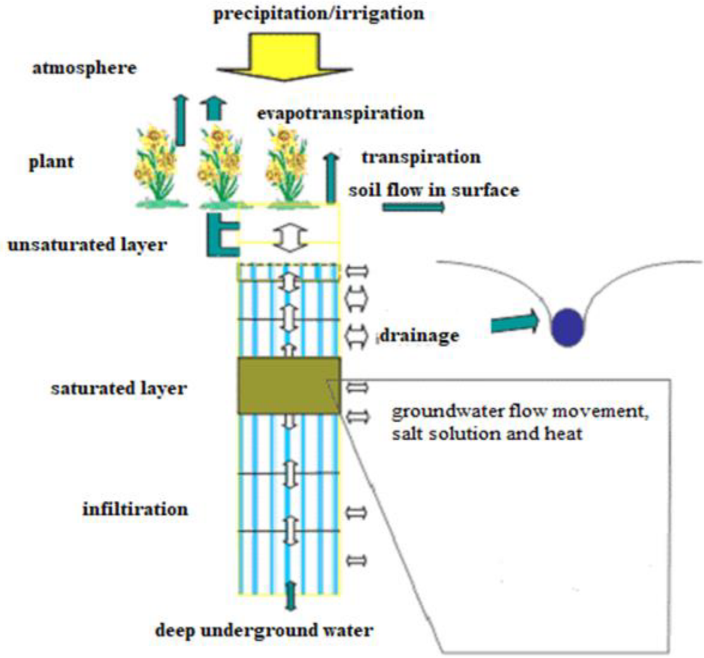

Fig. 3. Water use of the plants (*Source:* Compiled by the authors)

For modeling, experimental data on light gray soils in the lowlands of the Mirzachul zone of the Syrdarya region were obtained and parametrized, in which the crop model was calibrated based on the Marjon variety of the repeated mung bean. Hence, one of the factors influencing the repeat mung bean yield after winter wheat is water stress, the salinity level of irrigated water, and the changing dynamics of groundwater. The yield obtained in the output format is relatively equal to the yield obtained experimentally.

In subsequent variants of all years, salinity stress was applied to the repeat mung beans after the fall wheat, and a decrease in grain yield occurred. Salinity reduces leaf level, which in turn slows evapotranspiration. The slowing of evapotranspiration lags behind plant development, i.e., nutrient uptake is reduced, vascular development is slow, the plant lags behind in its growing season, and the potential osmotic pressure for soil mineral uptake decreases [5].

The repeated mungbean planted in the experimental field fully germinated on August 1, the first leaf of the mung bean appeared on August 4, the first flower of the mung bean appeared on August 27, and the mung bean bloomed 50% on September 3. Phenological observations were made on August 15 when the moss reached its peak, Table 2.

Table 2. Growth and development of repeated crop mung bean on experimental iterations

Options	Fertilizer rate, kg/ha			Plant height, cm				Average
				According to the returns				
	N	P	K	I	II	III	IV	
Pre-irrigation soil moisture is 60-65-65% relative to boundary field moisture capacity (BFMC)								
1	60	80	60	31.3	26.7	28.6	27.6	28.6
Pre-irrigation soil moisture 70-70-65% relative to boundary field moisture capacity (BFMC)								
2	60	80	60	33.2	28.3	29.3	25.9	29.3
Average				32.3	27.6	28.9	26.7	28.9

Source: Compiled by the authors

From the data in Table 2, it can be seen that no significant difference was observed between the norms of mineral fertilizers applied during this period of the growth and development of mung bean. The difference between the norms of mineral fertilizers applied in the growing phase of mung bean and the order of irrigation to BFMC was observed depending on the pre-irrigation soil moisture

In particular, when mineral fertilizers are applied at N-60, R-80, K-60 kg per hectare, the plant size is 41.5 cm, and the number of pods is 12.3. mineral fertilizers N. -60, R-80, K-60 kg/ha to BFMC 70-70-65% plant size 41.6 cm, the number of pods 13.4 consists of grains. This connection was maintained until the grains ripened in the mung bean.

In practice, the application of mineral fertilizers in the amount of N-60, R-80, K-60 kg per hectare and 60-65-65% of the BFMC in the amount of N-60, R-80, K-60 kg and 70% of the BFMC. An additional repeat mung bean grain yield of 1.6 ts/ha with mathematical reliability of 70–65 percent was achieved.

In particular, in variant 1, the yield of repeated mung bean was 20.1 ts/ha; in variant 2 this figure was 23.1 ts/ha, Table 3.

This connection was also maintained in terms of the yield of the mung bean pie and its nutritional value.

Table 3. Grain yield of repetitive mung bean according to experimental appearances.

Options	Repays				Average harvest
	I	II	III	IY	
Pre-irrigation soil moisture is 60-65-65% relative to boundary field moisture capacity (BFMC)					
1	21,3	23,1	17,6	18,6	20,1
Pre-irrigation soil moisture 70-70-65% relative to boundary field moisture capacity (BFMC)					
2	23,1	25,3	21,3	22,7	23,1
Average	22,2	24,1	17,9	19,1	20,8

Source: Compiled by the authors

Based on the above, after the winter wheat, depending on the average of two irrigation regimes, 20.8 ts/ha of grain was harvested from the secondary mung bean.

In the CropSyst model, water stress and fertilizer stress are considered. We can validate this stress state, but salinity stress can only validate up to a certain salinity level of irrigated water because equations 4 and 5 above evaluate the relative effects of salinity on evapotranspiration. Therefore, these equations are not appropriate for predicting evapotranspiration for specific days. Also, these equations do not consider the effect of other influencing factors, such as the ionic toxicity of irrigated water [5].

These equations are not valid for high salinity levels because ECe, crop yield, and Ks may not interact in a linear relationship. The use of equations 4 and 5 (ECe - ECethreshold) is limited to + 50b, as well as in the equation Ua = 0 if, Ks = O when Ky > 1 and vice versa. For this purpose, the SWAP (i.e., Soil Water Atmosphere Plant) model, which incorporates a soil, water, atmosphere, and plant model, is appropriate for our purpose. SWAP requires physical parameters [6].

5 Conclusion

Data for parameterization of the CropSyst model were obtained from the database of scientific research on the old irrigated light gray soils of the Syrdarya region. The model was parametrized, in which the crop model was calibrated after autumn wheat in a non-stress-free environment.

In the CropSyst model, it is possible to validate the stress state caused by water and nitrogen fertilizer application of repeated mung bean after winter wheat. Still, it is impossible to create a model under stressful conditions with a high salinity of irrigated water, as the model does not have this capability. To achieve this goal, it is appropriate to use another SWAP (i.e., Soil Water Atmosphere Plant) model, which incorporates a soil, water, atmosphere, and plant model. SWAP requires physical parameters.

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