Efficiency of use of magnetic water in drip irrigation of cotton

Dinara Ergashova[1*], and *Saltanat* Kasymbetova[2]

"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan

Abstract. The article presents the results of field research conducted on a cotton field of drip irrigation using magnetic irrigation water. The research aimed to study the effect of magnetic water on the growth, development, and increase in cotton yield in the meadow-serozem soil-reclamation conditions of the Chirchik-Akhangaran valley.

The authors provide an overview of the designs and the principle of operation of various magnetic devices used for irrigation in domestic and world practice.

In order to save irrigation water and study the effect on the growth, development, and increase in cotton yield, field studies were carried out using magnetized water during drip irrigation of cotton.

1 Introduction

In connection with the growing needs of industry and agriculture, the shortage of water, especially fresh water, is growing every year. In addition, due to changing climatic conditions, the shortage of fresh water is growing every year. Observations over the past hundred years show that the average annual temperature on the planet has increased by 0.7-0.8 degrees. Climate change leads to an increase in evaporation from the water surface by 10–15%, an increase in transpiration from plants, and an increase in water consumption for irrigation by 10–20%, which, under conditions of irrigation water deficiency, greatly impairs the development of agricultural production [10]. With the growing shortage of water resources in many regions, the problem of using water for irrigating crops with activated fresh and mineralized water has arisen.

The results of scientific research conducted by many scientists [1-8] showed the feasibility of using water treated with a magnetic field to irrigate crops and wash saline lands. In this direction, numerous studies were carried out by the following scientists: Singh O. P., Feng J., Novikova A.V., Kasymbetova S.A., Zhou B., Wei K., Zhang J., Bhattarai S., Shi K., Kong J., Yadollahi A. H., Yesuf H. M.

Based on the results of laboratory and field studies, many scientists have found that water treated with a magnetic field changes its properties, which contributes to the acceleration of the mobility of water molecules [4-10]. Reclamation scientists studied changes in the properties of water to stimulate its influence on the growth and development

* Corresponding author: dinarangel@mail.ru

processes, increase crop yields and dissolving capacity. Positive results have been obtained on magnetic water's effect on increasing plants' growth and development [7-15].

Using magnetic water to irrigate agricultural crops can significantly save its amount for irrigation and increase the yield of cultivated crops in arid climatic conditions. One of the topical issues is the use of modern intensive technologies in irrigating crops with magnetic equipment and using magnetic water to irrigate crops from reclamation systems. However, with the introduction of new irrigation equipment into production, resource-saving, and changes in irrigation regimes, it is necessary to study the effect of water magnetization on the growth and productivity of various crops.

Reclamation scientists have received positive results on the influence of magnetized water on increasing the energy of plant growth.

In the experiments of the Volga scientific research institute of hydroengineering and melioration (1971-1979), when irrigated with water passed through antiscale magnetic devices (AMD), an average long-term increase in the yield of radishes, peas, cucumbers, tomatoes, carrots, fodder beets, salt, corn and winter wheat by 20-40% [4, 5].

The use of a magnetic apparatus designed by the Novocherkassk plant of permanent magnets in the open field on the experimental plot of the Kuban Agricultural Institute gave an increase in rice yield by 20% compared to the control. Chemical analysis of the soil showed that the experimental plots were less saline than the control ones [6].

At the Kuibyshev Agricultural Institute, in the greenhouses of the state farm "Ovoshchevod"(vegetable grower), when irrigated with magnetically treated water, an increase in the yield of cucumbers up to 20% was obtained [7].

Studies on the use of water subjected to magnetic treatment for irrigation of winter wheat crops were carried out in the Andijan region of the Republic of Uzbekistan. The scheme of the experiment included various combinations of irrigation with magnetic and ordinary water (only one post-sowing and four vegetative irrigations). In the control variant with the same number of irrigations with ordinary water. Thanks to the magnetic treatment of irrigation water, the field germination of seeds, compared with the control, increased by 0.5 ... 4.3%, the safety of plants - by 0.9 ... 4.3%, the number of plants for harvesting - by 3,6...18.0 pcs/m2, productive stems - by 32...54 pcs/m2, spike length - by 1.2...1.5 cm, number of spikelets in an ear - by 2... 3 pcs., the number of grains - by 0.5 ... 1.3 pcs., the weight of grain from one ear in variants with vegetative irrigation with magnetic water - by 0.1 g. As a result, the average yield increase was 1.8 .. .5.7 centners per hectare [8].

Based on the results obtained and to study the impact on the growth, development, and increase in the yield of cotton, we conducted field studies using irrigation water treated with a magnetic field during drip irrigation of cotton on lands belonging to the TST "Agro Cluster" of the Kuyichirchik district of the Tashkent region. The research aimed to study the effect of magnetic water on the growth, development, and productivity of cotton in the conditions of meadow-serozem soils of the Chirchik-Akhangaran valley.

To determine the effect of magnetic water on the growth, development, and productivity of cotton, vegetation irrigations were carried out with magnetic and non-magnetized water during 2020-2022.

2 Materials and Methods

When conducting field experiments, the experimental methodology developed by scientists from the Scientific Research Institute of General and Inorganic Chemistry and the methodology for conducting field experiments (B.A. Dospekhov, 1985) were taken as the basis. Soil moisture was determined by the weight method, bulk density - cylindrically, total duty cycle - by calculation, and water permeability - by the frame method. The mechanical composition of the soil was determined at the beginning of the study by taking samples taken from the soil section. The content of fractions was determined according to the Kaczynski scale as a percentage.

When conducting field experiments, a magnetic device of the MPV MWS Dy 15 design was used to magnetize water (Table 1). At the experimental site, nine installations for the magnetization of water manufactured by Tekhnomag - Kazan LLC were installed (Fig. 1).

Table 1. Main technical parameters of the magnetic device.

Compound	**Dy 15. G1/2 inch**
Productivity, m^3/h	0.15 - minimum;
Operating pressure	1.0 - nominal;
Max pressure	1.7 - maximum;
Water temperature	10kgf/cm2
Connection type	12kgf/cm2
Installation	vertical or horizontal
Used and connected materials	brass, bronze
Magnet housing	stainless steel
Type of magnets	high energy magnets
Conservation of magnetic energy	280 kJ/m^3
Loss of magnetic properties	0.2% over 10 years

Fig 1. Magnetic water treatment device "MPV (magnetic water transformation) MWS Dy 15".

3 Results and Discussion

Field research was carried out in triplicate on a cotton field located on the left bank of the Chirchik River. The source of irrigation is the Chirchik River. Mineralization of water in June is 0.23g/l, and in September, it reaches -0.48g/l. The average annual mineralization of water is 0.32g/l. The composition is hydrocarbonate-sulfate-sodium-magnesium-calcium. The surface of the earth is a gently sloping plain, sometimes undulating. The general slope of the earth's surface is directed to the southwest, and the average slope ranges from 0.0005 ÷ 0.003. The natural-climatic, soil-reclamation, geological-hydrogeological, and economic conditions of the territory of the experimental site were studied. The natural-climatic, soil-reclamation, geological-hydrogeological, and economic conditions of the territory of the experimental site were studied. Before the start of the research, soil sections of the full profile were laid on the experimental plot. Table 2 provides a morphological description of the soil-ground layer (up to 1.5 meters).

Table 2. Morphological description of the soil-ground layer.

Genetic layer, cm	Morphological description
0-30	Gray, from above 0-5 cm dry, loose, lumpy-granular structure, medium loamy, there are remains of roots and a transition to the lower layer in color.
30-60	Light grey, medium moist, porous, medium loamy, granular, there are root remains of plants and transition to a dense layer.
60-100	Light grayish tint, less moist, dense build, heavily loamy, lumpy structure, rare earthworm passages, gradual transition to the lower layer.
100-150	Light grayish tint, less moist, dense, heavily loamy, indistinct structure, gradual transition.

The granulometric composition of the soils of the experimental plot was determined at the beginning of the research (table 3).

Table 3. Granulometric composition of the soil of the experimental plot.

Layer, cm	Content in % of fractions with size in mm								Granulometric composition, according to Kachinsky
	1-0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	0.005 - 0.001	<0.001	<0.01	
0-30	1.93	1.88	17.32	33.72	8.52	14.92	15.38	38.82	Medium loam
30-60	0.76	0.87	16.21	42.36	6.94	17.82	15.08	39.84	Medium loam
60-100	0.37	0.98	7.06	44.98	12.62	22.96	9.18	44.76	heavy loam
100-150	1.37	1.71	5.17	45.26	11.32	18.20	15.95	45.47	heavy loam

On the experimental plot, the volumetric mass of soils was determined before the research and at the beginning and end of the growing season of each year of research, with a depth of up to 1.0 m. The results are shown in Table 4.

Table 4. Dynamics of changes in the volumetric mass of the soil of the experimental plot, g/cm^3.

Layer, in cm	first year (2020)		second year (2021)		third year (2022)	
	start of vegetation	end of growing season	start of vegetation	end of growing season	start of vegetation	end of growing season
0-30	1.34	1.37	1.35	1.37	1.34	1.39
30-60	1.38	1.39	1.41	1.43	1.42	1.44
60-100	1.68	1.76	1.72	1.81	1.77	1.82

The water permeability of the soils of the experimental plot was determined at the beginning and end of the growing season using cylindrical circles. Over the years of growing cotton, the water permeability of soils decreases by 0.04 mm/min, especially under drippers (Fig. 2).

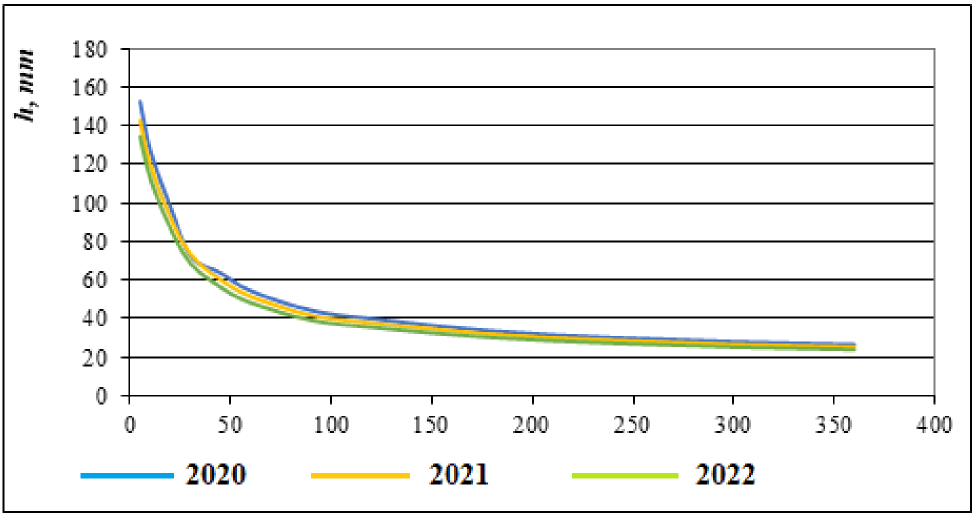

Fig.2. Water permeability of the soils of the experimental plot.

Throughout the growing season, systematic observations were made of the dynamics of moisture within the active soil layer, and the actual moisture content and moisture content before and after irrigation were established.

Fig. 3. Determination of soil moisture before watering.

Fig.4. Preparation for irrigation of cotton in the experimental area.

Fig.5. Irrigation pipeline with drippers

Fig.6. Preparation for harvesting cotton of the experimental plot.

The irrigation rate was determined by the formula:

$$M_{net} = 100 \cdot h \cdot a \cdot S \cdot (W_{mfmc} - W_{mmmc})$$

where: h is the depth of the calculated soil layer, m; a is the volumetric mass of soil, t/m^3; W_{mfmc} is the maximum field moisture capacity, % of the mass of dry soil; W_{mmmc} is the minimum molecular moisture capacity, % of the mass of dry soil; $W_{mmmc} = Z \times W_{mfmc}$; Z is the coefficient of pre-irrigation soil moisture in fractions of units (Z = 0.6 - 0.8).

During the study period, the flow rate of drip water outlets averaged 1.26 l/h in the experimental area. At the same time, the distance between droppers is 50 cm, and between irrigation pipelines is 180 cm (pipeline laying - through the furrow, row spacing - 90 cm). On the experimental site with drip irrigation, only 8 irrigations were carried out with an irrigation rate of 130 to 160 m^3/ha. The value of the irrigation norm when using magnetized water was 1245 m^3/ha, and when using non-magnetized water - 1500 m^3/ha.

4 Conclusions

The results of numerous studies prove that magnetic fields of varying intensity have a significant impact on the growth and development of various plant species. Magnetized water allows cells to assimilate water with maximum efficiency, and this water is close to the physiological fluids of plant tissues. Using magnetic water for irrigation can significantly save its amount for irrigation and increase the yield of cultivated crops in drought conditions. The magnetic device (MD) has opened up new avenues of research in agriculture. Safety, compatibility and simplicity, environmental friendliness, low operating costs, and no proven harmful effects are the main advantages of this technique. Irrigation water improvements, quality and quantity, yield, soil improvement, water scale prevention, and water saving are benefits of MD in agriculture. The results of field studies with drip irrigation of cotton on typical meadow-serozem soils indicate a positive effect of magnetic water on the growth, development, and increase in cotton yields and high ameliorative efficiency of this method with saving irrigation water by 15-20%.

References

1. Singh O. P., and Singh P. K. Effects of drip and alternate furrow method of irrigation on cotton yield and physical water productivity: A case study from farmers' field of Bhavnagar district of Gujarat, India. Journal of Applied and Natural Science, **13**(2), 677-685. (2021)
2. Feng J., Liu H., Wang G., Tian R., Cao M., Bai, Z., and He T. Effect of Periodic Winter Irrigation on Salt Distribution Characteristics and Cotton Yield in Drip Irrigation under Plastic Film in Xinjiang. Water, **13**(18), 2545 (2021)
3. Li N., Tung S. A., Wang J., Li J., Shi X., Hao X., Yang G. Non-film mulching comprehensively improved plant growth and yield of cotton in a deep-drip irrigation system under arid regions. Industrial Crops and Products, **184**, 115009 (2022)
4. Zhou B., Yang L., Chen X., Ye S., Peng Y., and Liang C. Effect of magnetic water irrigation on the improvement of salinized soil and cotton growth in Xinjiang. Agricultural Water Management, **248**, 106784 (2021)
5. Wei K., Zhang J., Wang Q., Guo Y., and Mu W. Irrigation with ionized brackish water affects cotton yield and water use efficiency. Industrial Crops and Products, **175**, 114244 (2022)

6. Bhattarai S. The physiology of water use efficiency of crops subjected to subsurface drip irrigation, oxygation and salinity in a heavy clay soil (Doctoral dissertation, CQUniversity). (2005)
7. Shi K., Kong J., Yue H., Huang Y., Wei X., and Zhangzhong L. Magnetized Water Irrigation Alleviates Emitter Clogging of a Drip Fertigation System. Agronomy, **13**(1), 108 (2022)
8. Yadollahi A. H., Khoshravesh M., and Gholami Sefidkouhi M. A. Effect of Regulated Deficit Irrigation with Magnetized Water on Quantitative, Qualitative Properties and Water Productivity of Green Pea. Journal of Water Research in Agriculture, **35**(4), 373-389 (2022)
9. Yesuf H. M., Xiaohong Q., and Jhatial A. K. Advancements in Cotton Cultivation. In Cotton Science and Processing Technology, pp. 39-59, (2020)
10. Novikova A.V., Kasymbetova S.A. Natural studies of washing saline lands with magnetized water. Research report for 1981-1982. Institute "Uzgiprovodhoz". Tashkent (1982)
11. Mirkhasilova Z., Irmuhamedova L., Kasymbetova S., Akhmedjanova G., and Mirkhosilova M. Rational use of collector-drainage water. In IOP Conference Series: Materials Science and Engineering, **883**(1), (2020)
12. Urazbaev I., Kasimbetova S., Akhmedjanova G., and Soniyazova Z. Development of agrotechnical methods and application of biomeliorant plants in the lower areas of Amudarya. European Journal of Molecular and Clinical Medicine, **7**(2), 844-849. (2020)
13. Ergasheva D., Kasimbetova S., Aynakulov S., Sharipov, D., and Khamraeva S. Development a mathematical model of a water-salt balance on irrigated lands of the Sirdarya area. In IOP Conference Series: Materials Science and Engineering, **896**(1), (2020)
14. Kasymbetova S.A., Akhmedzhanova G.T. Orositel'naya voda i otsenka prigodnosti yeyo k orosheniyu sel'skokhozyaystvennykh kul'tur. Science, Research, Development **17**(8), pp.28-32 (2019)
15. Kasimbetova S., Ergashova D., Akmedjanova G., Mardiez S., and Malikov E. Application of magnetized water on the washing of salted lands under the conditions of the low village of the Amudarya River. Journal of Advanced Research in Dynamical and Control Systems, **12**(S2), pp.127-130 (2020)