Initial results of watering plants via sub-irrigation technology

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Abstract. In this developing world, saving water is the main problem for agricultural sciences. So, in this field, scientists are using many methods to save water-for instance, traditional irrigation, drip irrigation, sprinkler irrigation, sub-irrigation, and others. Solving irrigation and the problems in this article demonstrated the sub-irrigation method for agriculture plants in the Uzbekistan regions. According to watering theory in the field condition and compared to drip irrigation in the region, scientifically experiment was done. According to the results of the study, this method will automate the stability of soil moisture in the irrigation of agricultural crops: save 4 ... 5 times water and prevent soil salinization; the cost of processing plants and fuels and lubricants with the help of technical means is sharply reduced; land use coefficient increases; hardening of crop rows and the number of their processing is sharply reduced; it is guaranteed to increase crop yields by mixing the juice with water; environmental pollution and soil salinity are sharply reduced. In the case of drip irrigation of agricultural crops, flexible plastic pipes with a diameter of 16… 20 mm are laid on the soil near the crop stalks, from which water holes or cracks are formed at certain intervals, from which water drips and irrigates crops. It is also possible to mix the juice of chemical and local fertilizers with water.

1 Introduction

In the Decree of the President of the Republic of Uzbekistan Sh.M.Mirziyoev dated July 10, 2020, № 6024 "On approval of the Concept of development of water resources of the Republic of Uzbekistan for 2020-2030", as well as on August 11, 2020 "On efficient use of water resources and land management in Jizzakh and Syrdarya regions. Resolution № 4801 "On urgent measures to improve the reclamation status" reiterated the need to develop water-saving technologies.

Given the shortage of water in Central Asian countries, it requires water-saving technologies for the irrigation of agricultural crops. Water-saving technologies include irrigation of agricultural crops on film, rain, drip, and subsoil. The article presents the technical and technological solutions for wet irrigation of agricultural crops, the diameter of the pipe, the depth and slope of the pipe, the distance between the pipes, water pressure indicators are determined by field experiments, and the technology of its application.

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2 Methods

According to the results of the study, this method will automate the stability of soil moisture in the irrigation of agricultural crops:

− save 4 ... 5 times water and prevent soil salinization;
− the cost of processing plants and fuels and lubricants with the help of technical means is sharply reduced;
− land use coefficient increases;
− hardening of crop rows and the number of their processing is sharply reduced;
− it is guaranteed to increase crop yields by mixing the juice with water;
− environmental pollution and soil salinity are sharply reduced.

In the case of drip irrigation of agricultural crops, flexible plastic pipes with a diameter of 16… 20 mm are laid on the soil near the crop stalks, from which water holes or cracks are formed at certain intervals, from which water drips and irrigates crops. It is also possible to mix the juice of chemical and local fertilizers with water.

The advantage of this method is that it saves a lot of water and increases productivity due to the juice.

The disadvantages of this method are:

− (annual) costs for installation and assembly of the pipeline;
− evaporation of water, at least in part;
− ineffectiveness in root crops, in which the receiving roots are directed upwards and do not ensure the stability of the stem;
− clogging of drainage holes or cracks, the cost of their timely cleaning;
− if the water contains salt and irrigation is on hot days, cover the holes and cracks with salt due to water evaporation.

Another cost-effective technology of land irrigation is the technology of wet irrigation of plants, which we offer, which is a new technology that eliminates the shortcomings of the above irrigation methods.

In this technology, plastic pipes 4 are laid at certain intervals and depths using special trench digging machines connected to each other. One end of the pipe is connected to the central water distributor 2 using a water opening, and closing device 3, the other end of the pipe is closed using a plug 5 (Figure 1).
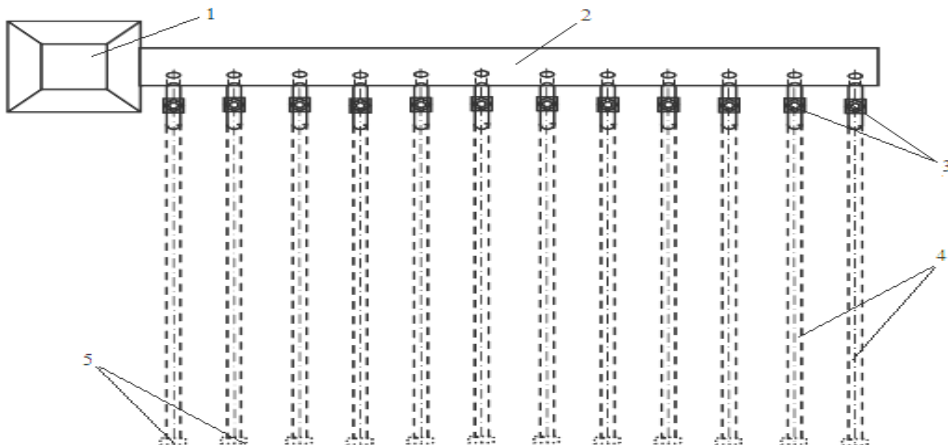

Fig. 1. Scheme of sub-irrigation under the soil.

The central water distributor can be a groove or a pipe. Irrigated water is taken from canals or ditches, placed in a special container 1, and collected, and mineral or local fertilizers are mixed into this water to form juicy water.

Currently, irrigation automation technology is being developed in this way. In this case, special humidifiers are installed on the humidifier heads, which can be controlled from one place.

To irrigate the lands in this way, trenches with a depth of 50… 60 cm and a width of 10 (15 cm are dug at certain intervals (60 or 120 cm) from the planted areas, and plastic pipes 1 are laid and buried in them (Figure 2).
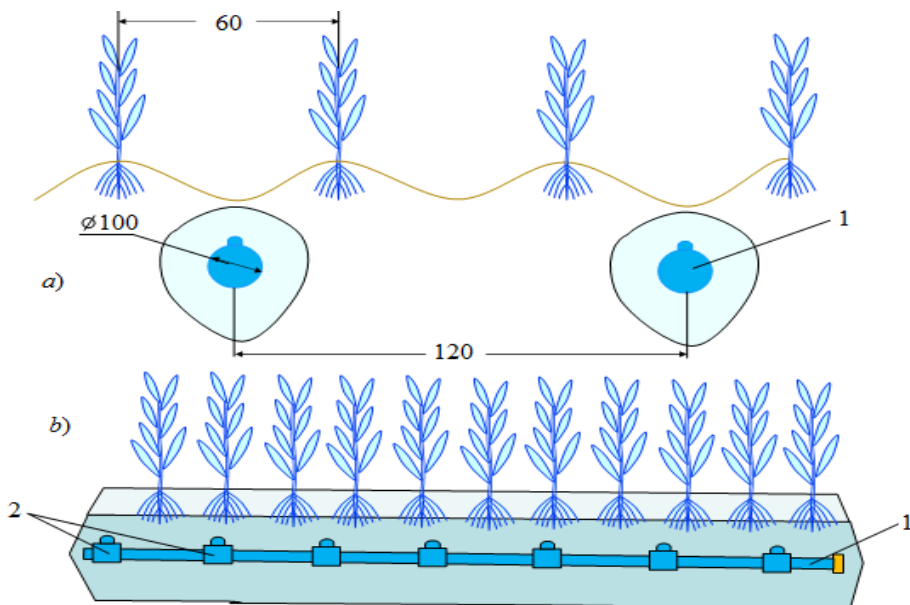

Fig. 2. Humidifier installation scheme: a is cross-section of the humidifier pipe; b is the longitudinal section of the humidifier; 1 is humidifying tube; 2 is humidifiers.

If the cotton fields are irrigated, the distance between the pipes should be 120 cm, when the cotton row spacing is 60 cm, and the pipe spacing should be 180 cm if the row spacing is 90 cm.

As a result of repeated watering of the plants, sand and other minerals in the water settle to the bottom of the humidifier pipes as sediment 2. Sedimentation is particularly high in areas irrigated by water from the Amudarya (which contains a large amount of sand). This sediment is washed out of the pipe plug and can be used as fertilizer.

Subsurface irrigation of the fields is carried out until the soil moisture reaches the norm (this can be determined by observing the top layer of soil). The water is alternately closed using a special water opening and closing device. It opens again when moistening is needed.

Irrigation in this method results in 6… 8 times less water consumption than in irrigated irrigation.

Due to optimal irrigation and nutrition, the yield increases by 30-40%.

Practical testing of this technology was carried out on the farm "Gumbulak Chorvasi" in Zarbdor district of Jizzakh region on an area of 450 m^2 with a width of 15 m and a length of 30 m, with two parallel pipes 6 mm with a diameter of 100 mm, dug to a depth of 50 cm. and a 12 cm wide trench was placed in 11 larvae (*Fig. 3*).
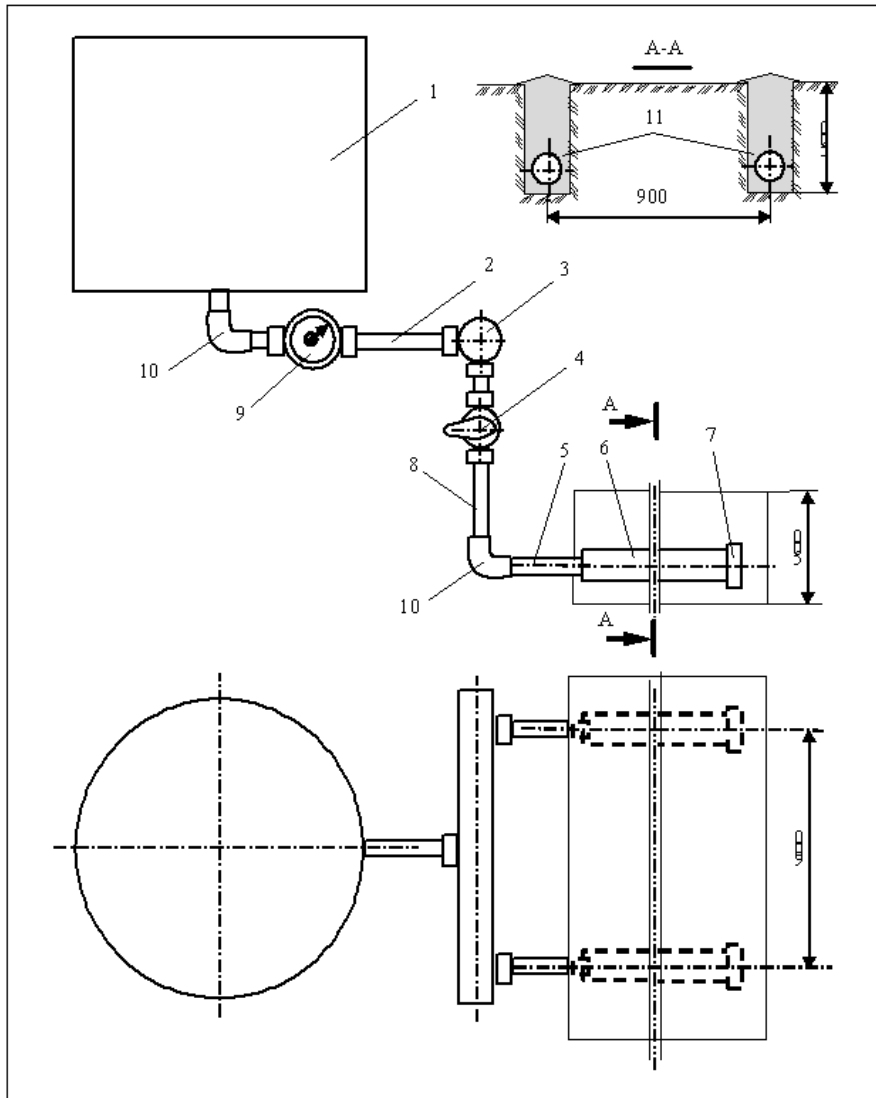
Fig. 3. Scheme of sub-irrigation of crops from the ground.

Subsurface irrigation of the fields is carried out until the soil moisture reaches the norm (this can be determined by observing the top layer of soil). The water is alternately closed using a special water opening and closing device. It opens again when moistening is needed. Irrigation in this method results in 6… 8 times less water consumption than in irrigated irrigation. Due to optimal irrigation and nutrition, the yield increases by 30-40%.

3 Results and Discussion

In this case, the cracks cut parallel to its axis on one side of the pipe should be directed upwards, and at the end of the pipe, its cover 7 should be fastened. The other end of the pipe is connected to pipe 5, which is connected to pipe 8 via connector 10. A water tap 4 is installed between the pipe 8 and the pipe 3.

During the excavation of the trench, the design of the ETS-165 excavator was improved (Figure 4), an additional pipe 4 installation box 3, a trench burial trench 2, and a buried soil compaction roller 1 were installed.
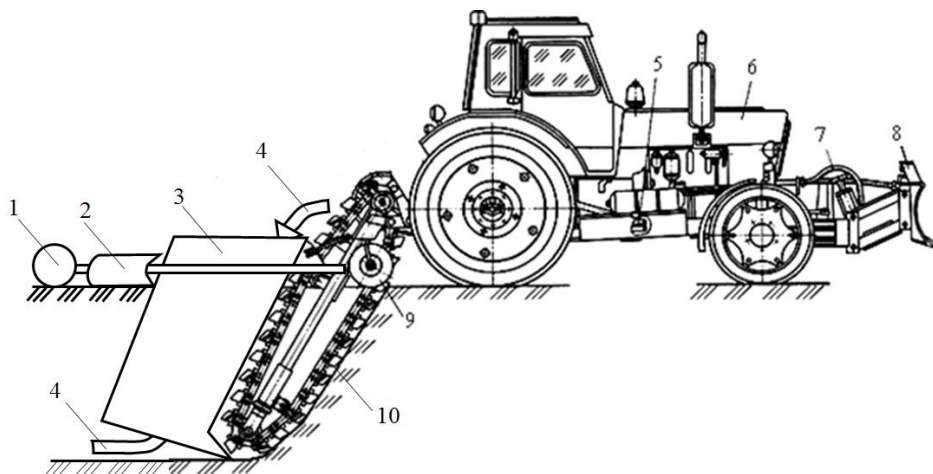

Fig. 4. General view of developed excavator ETS 165

A chain hoist mounted on the rear of the tractor 6 digs 10 trenches and lifts the soil upwards. Augers 9 mounted on both sides of the chain hoist place the soil on both sides of the trench. Inside the box 3 mounted on the chain work device is mounted a special tarnov, which directs the pipe 4. The soils removed from the trench are re-buried using otval 2 s, and the re-buried soil is compacted using roller 1. The tractor is equipped with a speed reducer 5, a bulldozer shaft 8, and a hydraulic cylinder for lifting and lowering it. The technical efficiency of the machine can be determined by the following formula:

$$U_t = 0.06 \cdot q \cdot n_z \cdot \frac{k_h}{k_g} \ m^3 / h \qquad (1)$$

where q is the geometric capacity of the shovel, liter (1 liter in the selected machine); n_z is number of buckets poured into the soil for a minute, pieces/minute; k_h is the coefficient of utilization of the volume of the bucket, ($k_h = 0.8...1.2$); k_g is the coefficient of soil softening, ($k_g = 1.0 ... 1.2$).

For a minute, the number of shovels that spilled the soil can be determined by the following formula:

$$n_z = \frac{60 \cdot \vartheta_z}{\ell_{pb}} \ units \ / \ min \qquad (2)$$

where $- v_z$ is chain speed, m/s, ($v_z = 2 \ m/s$); l_{pb} is pitch of the buckets, m, ($l_{pb} = 0.1 \ m$). If we put these values in the formula (2), it follows that

$$n_z = \frac{60 \cdot 2}{0.1} = 1200 \ units \ / \ min.$$

If we put the determined values in formula (1)

$$U_t = 0.06 \cdot 1 \cdot 1200 \cdot \frac{1.2}{1.2} = 72 \ m^3 / h$$

The walking speed of the car is determined using the following formula:

$$\vartheta_{yu} = \frac{U_t}{b \cdot h} = \frac{72}{0,15 \cdot 0,5} = 1000 \ m \ / \ h$$

where b is the width of the trench 0.15 m; h is the depth of the trench is 0.5 m.
To irrigate the crops, water is taken from the ditch, poured into a water tank 1, and mixed with mineral or local fertilizers to form juicy water. The natural moisture content of the soil in the experimental area is $W_t = 12\%$. Assuming that the surface area of the experiment is $S = 450 \ m^2$, irrigation depth $h = 0,5$ m, irrigation humidity $W_s = 20\%$, the volume of water used for irrigation can be determined using the following formula:

$$V_{ss} = \frac{(W_s - W_t)}{W_s} * V_m = \frac{(W_s - W_t)}{W_s} * S * h = \frac{20 - 12}{20} * 450 * 0.5 = 90 \ m^3$$

In this farm area, cotton was planted this year, 20 days later than the cotton planted in the adjacent area traditionally, and the result was high.

4 Conclusions

The results obtained include:
- the average number of shovels in the cotton planted traditionally is 15, the average number of shovels in the proposed method is 21 (Figure 4d);
- in the proposed method, the cotton stalk is strong, has many stalks and almost no weeds (Figure 4s);
- water consumption in the proposed method is 4.5 times less than in the traditional method;
- the cost of softening cotton row spacing is 1.5 times less than the traditional method in the proposed method.
− If the proposed technology is implemented, the following results will be achieved:
- the method of wet irrigation of plants reduces the rate of seasonal irrigation, prevents the loss of water-soluble mineral and mineral fertilizers, washing in ditches and collectors;
- water resources are saved up to 4-5 times;
- automation of soil moisture stability leads to water conservation and prevention of soil salinization;
- the cost of processing plants and fuels and lubricants with the help of technical means is sharply reduced;
- irrigation techniques and technology will be improved;
- land use coefficient increases;
- irrigation significantly increases labor productivity;
- removal of bullets and their demolition, covering the head of the trenches with various materials, and other redundant works are not carried out;
- hardening of rows between crops and the number of their processing is sharply reduced;
- in the process of wet irrigation of the soil is guaranteed to increase crop yields by mixing the juice with water;
- as the field of application is simple, any farmer will be able to use it independently.
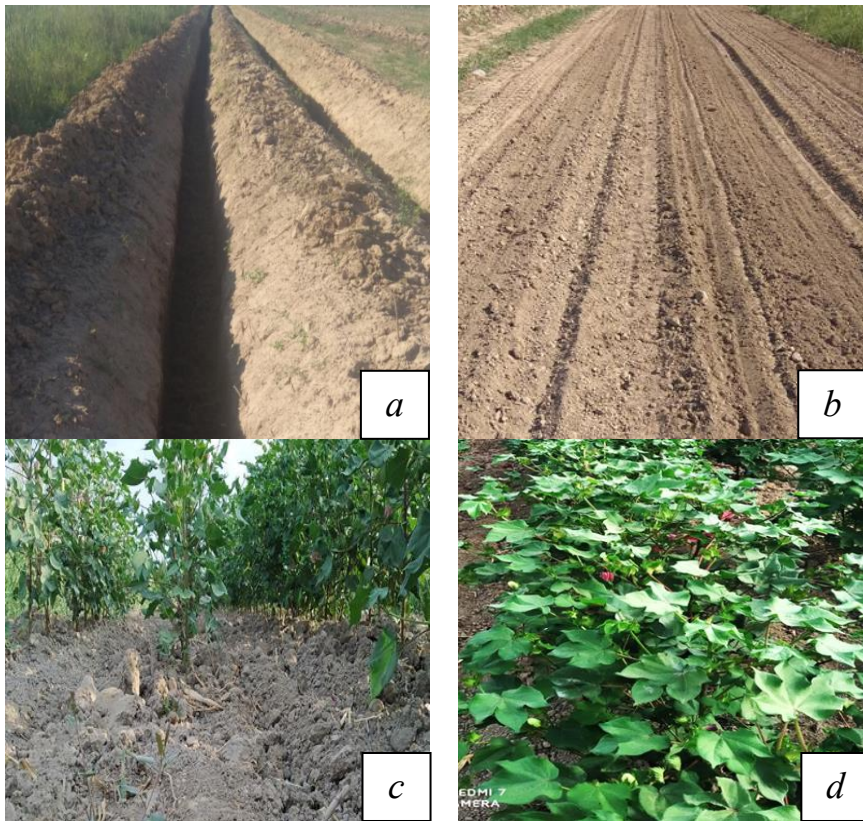
Fig. 4. Moist irrigation under the soil: a is trench dug for a pipe; b is seeds are planted area; c is cotton row; d is cotton flowers and buds.

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