Innovative ridge tillage of soil with simultaneous sowing of seeds of industrial crops and with laying of drip irrigation hose on ridge

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Abstract. The article presents the results of research on the development of technology for comb cultivation of industrial crops with targeted and uniform moistening of the root system of plants. Innovative ridge tillage of the soil with simultaneous sowing of seeds of industrial crops and with the laying of a drip irrigation hose on the ridge, the accumulation of moisture is excluded, which leads to the pollination of the soil, destruction of the structure and formation of a soil crust, this contributes to the production of friendly seedlings, good plant development and obtaining a high yield of raw cotton with early ripening.
The drip irrigation system allows you to provide plants with water and fertilizers. The drip irrigation system, with the laying of flexible perforated irrigation tapes on ridges along its entire length, is carried out simultaneously with the sowing of cotton seeds, which eliminates the manual layout of irrigation hoses, and eliminates time-consuming manual operation during feeding and further watering. The use of drip irrigation guarantees higher yields, as well as provides savings in labor, water, and energy resources.

1 Introduction

In recent years, tillage has been developed in theory and practice. The regularities of moisture movement in the soil and its evaporation were studied in more detail, optimal parameters for agricultural crops were determined, the issues of differentiation of different parts of the arable layer by fertility were clarified, etc. Tillage tools became more advanced; combined tillage units appeared that simultaneously performed several technological techniques. Considerable work has been done to develop new effective tillage systems adapted to specific soil and climatic conditions. The systems of basic, pre-sowing tillage and crop care have been improved, the need for differentiation of the depth and number of treatments in crop rotation has been brought, and a system of soil protection treatment has been developed for areas where water and wind erosion are manifested [1-3].

However, all adapted tillage systems have one common drawback – they are very

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energy-intensive, which has led to the need to develop and implement low-cost energy-saving and soil-protective technological processes of tillage and sowing, providing for a reduction in several previously independently performed technological operations by combining them in one pass of the unit or eliminating part of them.

Analysis of the development of resource-saving tillage technologies and techniques shows that the prevailing method of tillage remains mechanical, taking into account the diversity of soil conditions, the presence of plain, slope, and contour farming, the possibility of combating wind and water erosion, the implementation of soil, moisture and energy conservation. The introduction of technologies in conservation agriculture contributes to reducing labor and energy costs, restoring the structure, composition, and biological diversity of soils, and minimizing environmental pollution [2].

The analysis of soil protection systems of soil treatment allows us to identify the most common.

Minimum zero processing (no tillage) provides for only one contact of tillage tools with the soil during the growing season – during sowing. Sowing is carried out, as a rule, in narrow grooves with a width of 2.5–7.5 cm simultaneously with one or more additional operations. Herbicides are intensively used to control weeds. With a zero treatment system, fuel economy can reach 70-80%.

Ridge treatment (ridge village). In this case, the soil is not treated before sowing. Simultaneously with sowing, 1/3 of the soil surface is treated with pointed paws or row cleaners, forming ridges. Sowing is carried out in ridges 10-15 cm high. Herbicides are used in combination with cultivation to control weeds.

Band processing (strip tillage). As in the case of comb processing, about 30% of the soil surface is processed with milling, disk working bodies, or passive rippers. As a rule, this operation is combined with sowing. Weeds are destroyed by herbicides in combination with cultivation.

Mulching treatment (mulch-tillage). Before sowing, soil loosening is carried out with simultaneous grinding and preservation of large-stem residues of rowed precursors on the soil surface. The cultivated crop determines the depth of processing.

In the conditions of irrigated agriculture in Central Asia, in spring, due to low air temperatures and often precipitation, soil warming is always insufficient. Consequently, the germination of cotton seeds is significantly delayed. Therefore, agricultural techniques that contribute to at least some increase in soil temperature in the spring are very appropriate and deserve attention.

In recent years, cotton growers in Uzbekistan have faced great difficulties during the sowing season due to unfavorable weather conditions (heavy rains, frosts on the soil, etc.). Because of this, cotton has to be replanted in part of the area, which leads to a decrease in its yield, a delay in harvesting, and an increase in the cost of production. In this regard, the cotton growers of our Republic faced a task - to change the technology of growing cotton, which would allow for high-quality sowing at an early date, complete harvesting in October, and thereby make it possible to carry out all the necessary field work in full for the next year's harvest, before the onset of rainy days [3].

To avoid the influence of adverse weather conditions on the growth and development of cotton in several areas, ***our Republic began sowing along the ridges*** instead of sowing cotton on a smooth field [4]. With this technology, puddles do not form over the seedbed after heavy precipitation. The bulk mass of the soil on the ridges when sowing cotton on them and watering along deep furrows, the long vegetation period remains within favorable limits. At the same time, on crops on a smooth field after the first watering, the density of addition in a layer of 10-30 cm reaches the initial value. This is seen from the experimental data in Tables 1-3.

Table 1. Dynamics of volume mass of soil during usual preparation of field and when making ridges, g/cm, (row spacing width 90 cm)

Experiments on crops in the field	Depth, cm							
	0-10	10-20	20-30	30-40	0-10	10-20	20-30	30-40
	Before sowing				After the 3rd watering			
smooth control	1.17	1.25	1.36	1.48	1.28	1.53	1.53	1.50
smooth	1.12	1.30	1.40	1.45	1.15	1.48	1.49	1.49
comb	1.18	1.21	1.26	1.39	1.12	1.26	1.30	1.40

Table 2. Growth and development of cotton with different technologies of soil preparation and sowing on row spacing of 90 cm.

Experiments on crops in the field	Number of sheets pcs. 1.06	Height of the main stem, cm			Number of sympodial branches, pcs		Number of boxes, pcs.	
		1.06	1.07	1.08	1.07	1.08	1.09	1.09
smooth	2,4	6.6	17.0	74.0	5.5	14.5	1.9	7.8
comb	2,8	6.9	28.1	76.0	6.2	15.2	2.5	10.2

Table 3. Yield of raw cotton with various technologies of preparation and sowing of cotton, c/ha (row spacing width 90 cm

Experiments on crops in the field	Years				Average harvest in 4 years	deviation	
	2015	2016	2017	2018		c/ha	%
smooth	24.0	36.2	38.8	34.8	33.0	0.3	1.0
comb	27.8	39.2	44.2	37.4	37.2	4.5	11.7

When the ridge is moistened, the heat of the inner layers of the soil will increase several times. It should not be forgotten, however, that in the case of giving the surface such a wavy mesorelief, there will also be an increase in evaporation. Such beds will dry faster, being physical analogs of small "wicks" that evaporate moisture much faster than a leveled soil surface. Hence, irrigation of the ridge from above is considered appropriate.

Organize sowing using this technology, currently in the fall to cut the ridges, and before sowing to prepare their top to perform this work, and all this entails significant labor and material costs, dramatically reducing the effectiveness of this technology.

Modern seeders must ensure high-precision execution of technological processes because the accuracy of the depth of seed embedding and their location depends on the yield (within 5-20%).

In addition, as the experience of sowing cotton along the ridges has shown, it is very difficult to carry out it with existing sowing units since the seeder's coulter does not have the necessary support here [5].

According to the results of the analyses of the experiments on row–to-row processing of industrial crops, the following conclusions can be drawn [6]:

- deep row-to-row processing (especially cultivation with hoeing) is accompanied by great damage to the root system - significantly reduces the accumulation of roots in the area of impact of processing tools;

- with the depth of row-to-row processing, the morphology of the cotton root system characteristic of normal development changes. Damage to the lateral roots located in the area of action of the processing tools leads to a decrease in the diameter of their propagation and elongation of the taproot. Such a change is not beneficial from the practical side since the use of nutrients in the arable layer by plants is limited;

- the physiological activity of the roots damaged during row–to-row processing is

disrupted - the rate of excretion sharply decreases, and the stronger, the lower the soil moisture. The normal flow of xylem juice occurs on the tenth day after the treatment.

This period is quite long; it is very close to the beginning of the next row-to-row treatment with the same negative effect on the growth and function of roots and the development of terrestrial organs. In addition, due to technical reasons, the necessary depth and width are often not observed during row-to-row treatments (deviation of the working organs in one direction or the other up to 5 cm or more), which can increase root damage.

To prevent the negative effects of working organs on the root system, reducing the number of row-to-row processing is necessary. This can be achieved by forming a stable agricultural background when cultivating cotton on ridges using drip irrigation [7].

The data obtained clearly show that row-to-row processing does not affect the air regime of the soil and, provided that the fields are cleared of weeds, the plant is provided with water, and the topsoil is maintained in a loose state, it is possible not to spend a long time or **avoid row-to-row treatments altogether**.

To eliminate these shortcomings, it is necessary to develop such a device for sowing cotton on the ridges, which would allow, at the lowest cost, to obtain early and healthy seedlings without replanting and, most importantly, to protect these crops from rain flows and, if necessary, to carry out feeding watering [8-10].

2 Methodology of research implementation

To implement innovative strip tillage in conjunction with ridge tillage of the soil with simultaneous sowing of seeds of industrial crops and laying on the crest of a drip irrigation hose, a design scheme of a combined unit has been developed (Fig.1).

Strip tillage in conjunction with ridge tillage of the soil. In this case, the soil is not treated before sowing. At the same time, before sowing, the soil surface is treated with a soil cutter (active) at a depth of 10-12 cm. With the help of spherical disks, ridges with a height of 15-20 cm are formed. The formation and compaction of the ridges on the top and on the sides are carried out using a roller, the shape of the surfaces along the longitudinal section of which has the shape of a trapezoid. Sowing is carried out in ridges 12-18 cm high with seeder coulters. Herbicides are used to control weeds in combination with absorbent irrigation using a drip irrigation hose.

Since the soil milling cutter is active and rotates in the unit's movement direction, with its help, part of the traction resistance is compensated. The number of revolutions of the milling cutter shaft is 300-350 rpm.

The weight of the combined seeder is 1250 kg, which is enough to seal the ridges from above. At the same time, the seeding organ can be different.

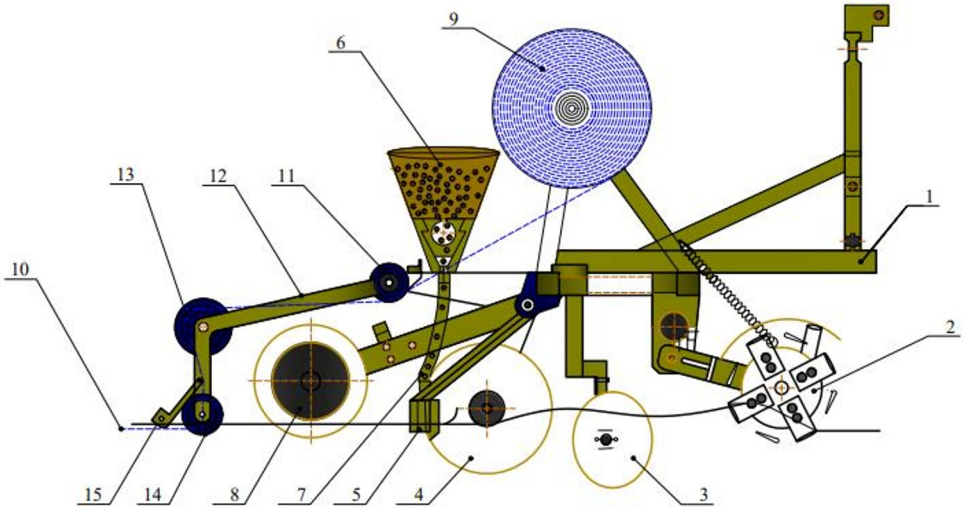

Fig. 1. Constructive scheme of technical means of innovative ridge tillage of soil with simultaneous sowing of seeds of industrial crops and with laying of drip irrigation hose on the ridge: 1 is frame; 2 is milling cutter; 3 is spherical discs; 4 is comb shaper; 5 is coulter; 6 is seeding machine hopper; 7 is seed line; 8 is rolling roller; 9 is coil with drip irrigation hose; 10 is drip irrigation hose; 11,13 are guide rollers; 14 is rolling roller; 15 is harrower.

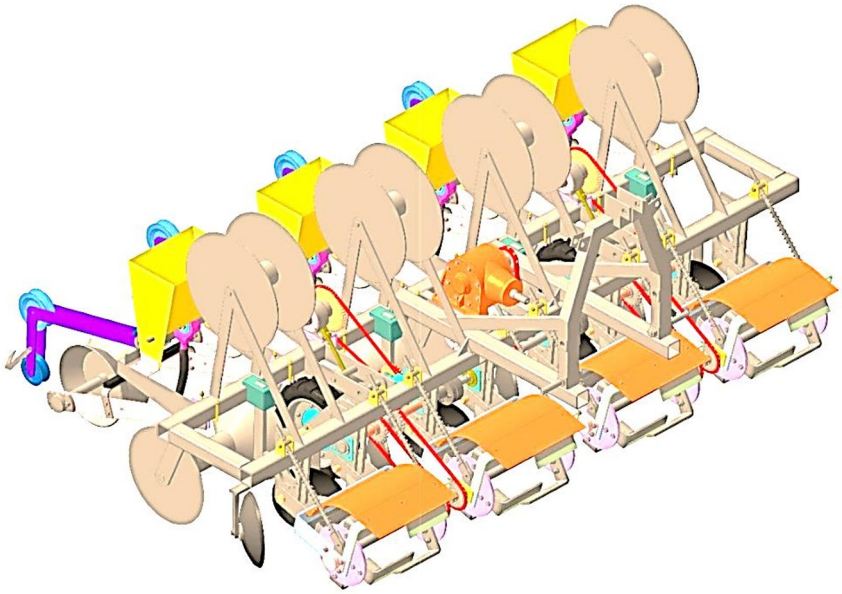

Fig. 2. General view of combined sowing unit with installation of drip irrigation hose (CSUD -4)

After sowing the seeds, flexible hoses for drip irrigation are laid behind the rolling roller on its grooves with the help of a rolling roller 14 and sealed with soil 1-2 cm thick [11-16]. With drip irrigation over the ridges, the "onion-shaped" moist contour inside the ridge does not leak out on the sides, which helps prevent the formation of a crust outside and the growth of weeds. Hence the reduction in the number of cultivations for row-to-row

processing. The irrigation hose has a relatively simple design with a through hole. The ratio of the diameter of the holes to the diameter of the hose 1/ (30...40) allows for uniform water flows along the irrigation hose at low pressure. Because the hose filled with water is located with water outlets downwards, the irrigation water jet reduces the pressure due to soil resistance, and the irrigation effect turns out to be adequate for watering with drops, that is, the soil in contact with the dropper compensates for the pressure of the jet [10].

The best option for laying the hose is considered to be laying with the location of the outlets along the normal (perpendicular) to the soil surface. At the same time, experiments [11] conducted in the Yangiyul district, at the landfill of the State Center for Certification and Testing of Agricultural Machinery and Technologies under the Cabinet of Ministers of the Republic of Uzbekistan showed that the contact of the water outlet with the soil (due to deformations of the soil and hose) is also achieved when the axis of the water outlet is deflected to the soil surface by 150.

3 Conclusions

1. The volumetric mass of soil on the ridges when cotton is sown along them and irrigated along deep furrows for a long period of vegetation remains in favorable limits. At the same time, on crops on a smooth field, the density of addition in a layer of 10-30 cm reaches the initial value already after the first irrigation.

2. To eliminate the existing shortcomings, it is necessary to develop such a device for sowing cotton on ridges, which would allow, at the lowest cost, to obtain early and healthy seedlings without reseeding and, most importantly, protect these crops from rain flows and, if necessary, carry out recharge irrigation.

3. On the basis of the analysis of soil protection systems of tillage, an innovative ridge tillage of the soil was developed with simultaneous sowing of seeds of industrial crops and laying a drip irrigation hose on the ridge.

4. With strip tillage and ridge tillage, the soil is not cultivated before sowing. At the same time, before sowing, the soil surface is cultivated with a tiller (active) at a depth of 10-12 cm. With the help of spherical discs, ridges with a height of 15-20 cm are formed.

5. Using this technology, you can:

- organize absorbent irrigation with simultaneous application of selective herbicides for the destruction of weeds in the protective zone and fertilizers;
- at the end of the growing season, along with the last irrigation, a liquid desiccant is applied to defoliate plants.

6. The prospect of further research within the framework of the stated problem lies in the fact that in the conditions of risky farming in Central Asia, research is needed on using this technology for various crops.

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