Selection of the number of teeth of the sprockets of the soil seeder

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Abstract. Presowing tillage allows you to lay a solid foundation for friendly and healthy seedlings, as well as a high crop of crops. For its implementation, a whole range of work is required to prepare the soil, which is carried out by plows, cultivators, harrows, and other agricultural machines and implements.

In the soil and climatic conditions of Uzbekistan, soil preparation for cotton sowing is carried out in the spring, on autumn plowing, while depending on the state of the field, differentiated fields are cultivated: partial planning, subsurface cultivation, chiseling, cultivation, harrowing with praying. At the same time, the composition of the soil prepared for sowing does not always meet the required quality of the structural-aggregate composition, the soil becomes coarse, and the top soil layer is very compacted. This situation prevents the high-quality implementation of the technological process of sowing cotton seeds of a cotton seeder.

One solution to this issue is the active loosening of the soil in the area of cotton seeds with simultaneous sowing on one unit.

1. Introduction

The main task of pre-sowing tillage is to create favorable conditions for seed germination and in the further development of plants. Friendly and healthy seedlings of agricultural seeds can be obtained if the seeds of this crop are planted in well-loosened soil and at the same depth.

When preparing the soil for sowing cotton seeds under local conditions in the spring, the following work is performed over the autumn plowing, depending on the state of the field:

- in the absence of weeds in the field, partial planning is carried out, harrowing with malovovaniya;
- when there is a small clogging of weeds, cultivation is carried out to a depth of 6-8 cm or chiseling by plane-cutting working bodies to a depth of 10-12 cm, as well as harrowing with malovaniya;
- with large contamination of the fields on the field, subsurface processing is carried out to a depth of 16-18 cm, followed by harrowing and shortening. At the same time, the aggregate composition of the soil prepared for sowing does not always meet the requirements of agricultural technology, the structurally aggregate composition of the soil becomes coarse and the top soil layer is very compacted [1, 2, 3, 4].

Pre-sowing soil preparation in the main cotton-growing region of the USA, depending on soil conditions and agricultural technology rules, pays special attention to weed control using mechanical and chemical means. Wide weed cultivators, various tooth harrows, chisels, disk, and milling harrows are used for combing weeds [5, 6, 7, 8]. The technology of preparing the soil for sowing cotton seeds is similar in both cases. However, the traditional technology of pre-sowing preparation of soil for sowing under local conditions is hampered by the high-quality implementation of the technological
process of sowing cotton seeds in existing cotton seeders due to the strong compaction of the upper and coarse-clumped surface soil layer.

This situation during sowing prevents the deepening of the knives of the opener of the cotton seeder to a guaranteed depth, which results in disruption of the technological process of opening the groove for seeds, the formation, and compaction of its bottom, as well as the sowing of seeds to a predetermined depth. As a result of this, the uniformity of the depth of seed placement is disrupted and about 40-60% of the seeds are not sealed at a given depth [9]. This, in turn, prevents the obtaining of full, friendly seedlings and optimal plant stand density and ultimately affects yield.

High-quality sowing can be carried out with the help of a cotton seeder equipped with a soil-cultivating device, which ensures simultaneous active loosening of the soil in the seedbed and planting it at the same depth.

2. Methods
To test the working capacity and evaluate the quality indicators of the cotton seeder equipped with a soil loosening device, we developed a soil loosening device [3,4,5] (Fig. 1), providing loosening of the soil with a width of 12-15 cm and a depth of 8-10 cm in the zone bedding of cotton seeds, prepared for sowing.

Cotton seeder equipped with soil-cultivating devices (Fig. 1) consists of a frame 2, two support wheels 1, sowing sections 4, markers (not shown in the diagram) of the swaying working bodies 6, gearbox, and drive devices 3. The sowing section includes a metering device, a nesting device, a crawler opener, spring-loaded extrusion rollers, dumping earthing, and compacting cone roller.

The soil-cultivating device (Fig. 2 and 3) includes a ploughshare 2, a block of sprockets 3, rack 1, and a drive device. The block of loosening sprockets of the loosening device is driven from the tractor’s PTO by means of a chain drive, gearbox, and driveshaft, and the drive unit drives the sowing and nesting discs of the sowing section from the support wheel [11 – 16].

3. Results and Discussion
When the sowing unit moves along the field prepared for sowing, the ploughshare deepens to a depth of 8 – 10 cm and cuts off a soil layer 12 – 15 cm wide. In this case, the soil layer is additionally deformed, subjected to intensive processing in the gap between the working surface of the share and the block sprockets, the soil is loosened, soil lumps are destroyed, acquiring the optimal aggregate structure and fall back on their original place.

The sowing sections of the cotton seeder installed behind this device sow cotton seeds in loose soil with an optimal structure [16 – 23].

In the course of experimental studies, the influence of the number of teeth of the sprockets of the block and the cylindrical roller on the degree of loosening of the soil was determined.
We studied a cylindrical roller with a diameter of 200 mm and three variants of sprocket blocks with a sprocket diameter of 200 mm and, with the number of teeth 6, 8, and 10 pieces, while the distance between the sprockets of the block and the distance between the working surface and the sprockets were respectively set to 5 cm and 6 cm. The operability of the soil-cleaning device was checked with the kinematic mode of operation of the block of sprockets \( i = 1.32 \) and unit speed 5.2 and 6.39 km/h.

The degree of loosening of the soil was determined (at six multiple repetitions) using special frames for the depth of processing. Before the experiments, soil moisture and hardness were determined at a depth of 5, 10, and 15 cm following STATE STANDARD 20915-11 with 6-fold repetition.

The research work was carried out on the sidelines of the training and experimental station of Tashkent State Agrarian University. The soil of the educational-experimental farm is of the “Sugar loam” type, the relief of the field is even, the previous cultivation is autumn plowing, spring cultivation: chiseling, harrowing and malting. The results are presented in Table 1.

| Table 1. Main parameters of soil | Soil moisture\% | Soil hardness, MPa |
|---------------------------------|-----------------|-------------------|
| No. p/p                          | Depth of soil layer, cm | Arithmetic mean value | Standard deviation | Arithmetic mean value | Standard deviation |
|                                 |                   |                   |                   |                   |                   |

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From table 1 it can be seen that the soil moisture at different depths sharply differs from each other. At a depth of 5 cm, soil moisture varies between –8.7...14.7% and averages 10.92%, at a depth of 10 cm amount to 10.8...19.0%, an average of 15.58%, and at a depth of 15 cm, respectively, 18.2 ...26.2% and an average of 22.28%. The hardness of the soil has a similar pattern of change. The hardness of the soil at a depth of 5 cm was 0.246 MPa, at a depth of 10 cm. 0.86 MPa, and at a depth of 15 cm. 1.1 MPa.

The data obtained during experiments to study the effect of a cylindrical roller and the number of teeth of the sprocket of the loosening block on the degree of grinding of the treated soil are presented in table 2.

From the above data it is seen that after soil cultivation at an aggregate speed of 5.2 km / h, with a soil-cultivating device equipped with a cylindrical roller, its aggregate composition has the following indicators: aggregate composition with dimensions of 0.25-15 mm. accounts for 69.6%, with dimensions of 15-25 mm – 13.25%, more than 25 mm. - 18.3%. This indicates that the soil prepared for planting contains more than 18% of soil particles larger than 25 mm, which do not meet agricultural requirements.

At the same unit speed, the soil composition with a soil-cultivating device with a block of sprockets with 6 tooth sprockets changes slightly, soil particles with sizes of 0.25 -15 mm. it amounts to 83.2%, with dimensions of 15-25 mm -9.1%, and with dimensions of more than 25 mm -7.7%. With an increase in the number of teeth of the block sprockets by 8 and 10, the degree of loosening of the soil treated with a soil-cultivating device increases.

When treating the soil with a soil-cultivating device equipped with 8 tooth sprockets, soil particles with a size of 0.25-15 mm. reached 87.3%. In this case, the particles are 15 – 25 mm in size. and particles larger than 25 mm. accounted for 8.2% and 5.1%, respectively. The volume of the soil aggregate with dimensions of 0.25-15 mm. compared with the performance of the soil-cultivating device with 6 tooth sprockets, it increased by 4%, with a size of 15-25 mm. and more than 25 mm. decreased by 10 and 33%, respectively.

The same tendency is observed during the operation of the soil-cultivating device equipped with 10 tooth sprockets in comparison with the device of 8 tooth sprockets. The volume of soil with a size of 0.25-15 mm. increased by 2%, and with dimensions of 15-25 mm. and with a size of more than 25 mm. decreased by 20 and 10%, respectively.

With an increase in the speed of the unit from 5.2 km / h. up to 6.39 km / h the degree of loosening of the soil with soil-cultivating devices equipped with a cylindrical roller and with a block of 6, 8 and 10 tooth sprockets is improved. When processing soil using a cylindrical roller, the volume of soil with dimensions of 0.25 – 15 mm. increased to 76.2%. This is achieved mainly due to the increase in soil volume with a size of more than 25 mm.
| Number of sprockets and teeth sprocket block | The volume of soil particles size by fraction, % |  |
|---------------------------------------------|-----------------------------------------------|---|
|                                             | 0.25-15 mm.                                      | 15-25 | more 25 mm. |
|                                             | \(\text{M}_{\text{middle}}\) & \(\sigma\) & \(\bar{x}\) & \(\text{M}_{\text{middle}} \pm \text{t}_{\sigma} \bar{x}\) & \(\text{M}_{\text{middle}}\) & \(\sigma\) & \(\bar{x}\) & \(\text{M}_{\text{middle}} \pm \text{t}_{\sigma} \bar{x}\) & \(\text{M}_{\text{up}}\) & \(\sigma\) & \(\bar{x}\) & \(\text{M}_{\text{middle}} \pm \text{t}_{\sigma} \bar{x}\) |
| Cylindrical roller                          |                                               |   |
|                                             | \(69.6\) & \(3.85\) & \(1.72\) & \(74.39-64.80\) & \(12.1\) & \(1.57\) & \(0.70\) & \(14.05-10.14\) & \(18.3\) & \(0.78\) & \(0.35\) & \(19.27-17.32\) |
| At \(Z = 6\)                               | \(83.2\) & \(1.90\) & \(0.85\) & \(85.56-80.83\) & \(9.1\) & \(1.28\) & \(0.57\) & \(10.70-7.49\) & \(7.7\) & \(0.61\) & \(0.27\) & \(8.46-6.93\) |
| At \(Z = 8\)                               | \(86.7\) & \(1.95\) & \(0.87\) & \(89.13-84.26\) & \(8.2\) & \(0.46\) & \(0.20\) & \(8.77-7.62\) & \(5.1\) & \(0.64\) & \(0.28\) & \(5.89-4.30\) |
| At \(Z = 10\)                              | \(88.6\) & \(2.56\) & \(1.14\) & \(91.78-85.41\) & \(6.8\) & \(0.78\) & \(0.35\) & \(7.78-5.81\) & \(4.6\) & \(0.46\) & \(0.20\) & \(5.17-4.02\) |
| Cylindrical roller                          |                                               |   |
| At \(Z = 6\)                               | \(76.2\) & \(6.22\) & \(2.78\) & \(84.02-68.53\) & \(13.2\) & \(1.49\) & \(0.66\) & \(15.10-11.39\) & \(8.6\) & \(0.83\) & \(0.37\) & \(9.61\) |
| At \(Z = 8\)                               | \(87.3\) & \(1.06\) & \(0.47\) & \(88.61-85.98\) & \(7.8\) & \(0.73\) & \(0.32\) & \(8.58-7.06\) & \(4.9\) & \(0.45\) & \(0.20\) & \(5.46-4.33\) |
| At \(Z = 10\)                              | \(91.4\) & \(1.33\) & \(0.59\) & \(93.06-89.73\) & \(4.8\) & \(0.57\) & \(0.25\) & \(5.51-4.08\) & \(3.8\) & \(0.63\) & \(0.28\) & \(4.58-3.01\) |

*Table 2. The influence of the number of teeth of the sprockets of the block of the soil cultivating device on the degree of loosening.*

When the operating speed of the unit \(V = 5.2 \text{ km/h}\):

When the operating speed of the unit \(V = 6.39 \text{ km/h}\):
When treating the soil with a soil-cultivating device with blocks of 6, 8, 10 tooth asterisks in the soil, the soil volume with a particle size of 0.25 – 15 mm, respectively, it was 85.8, 87.3 and 91.4%. The volume of soil with dimensions of 15 – 25 mm. decreased from in the range from 0.4 to 2%, and the volume of soil with a size of more than 25 mm. ranging from 0.2% to 1.1%. The increase in soil volume of soil particles with a size of 0.25-15 mm. in the composition of the soil treated with soil-cultivating devices, it is achieved due to the intensive action of the sprocket teeth on the soil layer supplied in units of time.

An increase in the aggregate speed from 5.2 km/h to 6.39 km/h also leads to an increase in the degree of loosening of the soil by soil-cultivating devices equipped with blocks with 6, 8, and 10 tooth sprockets. In the composition of the soil, the volume of soil particles with a size of 0.25-15 mm. increases to 2.8%, and soil particles with sizes of 15-25 mm. and more than 25 mm. decreases to 2 and to 1.1%, respectively.

An analysis of the operation of a soil-cultivating device with a cylindrical roller showed that its quality indicators are relatively low, and do not meet the requirements of agricultural technology. Qualitative indicators of soil-cultivating devices equipped with a block with 6, 8, and 10 tooth sprockets do not differ significantly from each other since confidence intervals for general averages overlap. Therefore, for subsequent studies, a block of sprockets with 8 tooth sprockets was adopted. The research of a cotton seeder equipped with the production conditions offered by the soil-cultivating devices, the degree of loosening of the soil with the soil particle size of 0.25-145 mm was 89.13-84.26%, which corresponds to agrotechnical requirements. Moreover, the soil lumps interfering with the work of the semi-shaped openers of the seeder are completely absent. The depth of seed placement was within the requirements of agricultural technology, the number of passes was not observed. The number of seedlings compared with existing technology increased by 18-20%, which positively affects the yield.

4. Conclusions
1. Conclusion The cotton seeder is equipped with a soil-cultivating device, consisting of a block of loosening stars and plowshares, which makes it possible to additionally grind the soil and lumps in the zone of cotton seeds with a width of 12-15 cm and a depth of 8-12 cm and creates favorable conditions for high-quality seed placement at a given depth.
2. It is advisable to conduct further studies to improve seed placement in the direction of clarifying the parameters and operating modes of loosening blocks and placing it relative to the sowing section of the cotton seeder.

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