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IMPROVING THE PROCESS OF HARROWING AND SOWING CROPS

[1]Gennady Maslov, [2]Valery Lavrentiev, [3]Elena Yudina, [4]Alexander Taran

[1]Kuban State Agrarian University named after I.T. Trubilin, Kalinina str., 13, Krasnodar 350044, Russia.

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Abstract:

With regard to the new farming system on an agrolandscape basis, new means of mechanization have been proposed for harrowing the soil and crops, as well as sowing of cereal crops with simultaneous introduction of the main, starting fertilizer and rolling of the crops with a spiral-helix roller. The combination of these operations in a single pass of the multifunctional sowing unit proposed by the authors is based on working bodies such as dressing knives for the main application of mineral fertilizers, conventional double-disc coulters for sowing cereal crops and starting dose of fertilizers, as well as a spiral-helix roller pivotally fixed to the frame of the grain seeder , for rolling sown seeds to a predetermined depth in the soil layer with optimum density. The dependences of the specific traction resistance of the modernized spring harrow and the spiral-helix roller as a function of the operating speed under various operating modes are presented. A strategy has been proposed to mechanize the processes of pre-sowing preparation of the soil for sowing corn and caring for crops, in contrast to the well-known basic technology, and modernized working bodies of the machine unit based on a spring harrow have been developed. In the proposed strategy, taking into account the farming system, the technological complexes of machines for the cultivation of corn according to the basic and proposed technologies are justified.

Keywords: *mechanization, agriculture, harrowing, seeding, multifunctional unit, combination of operations, efficiency.*

Corresponding author:

Gennady Maslov,
Kuban State Agrarian University named after I.T. Trubilin,
Kalinina str., 13, Krasnodar 350044, Russia.

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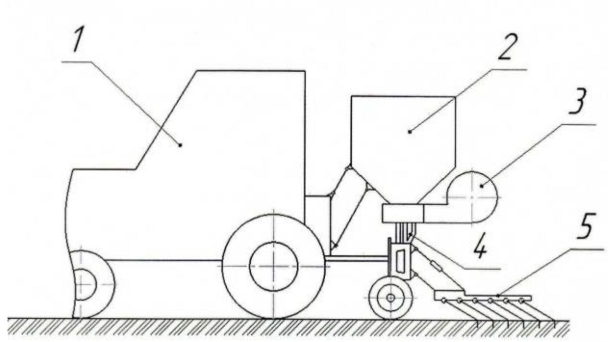
INTRODUCTION:

Improvement of production processes in field cultivation is the main reserve for improving the competitiveness of products. Reducing costs, increasing crop yields and labor productivity are the main tasks of field mechanization, which must strictly comply with the requirements of the zonal farming system [1]. The purpose of this article is to propose new directions for improving the mechanized processes of harrowing and sowing crops.

The main requirement of the farming system in the cultivation of agricultural crops is weed control, which can be destroyed by chemical methods by spraying [2, 3] and mechanical by pre-and post-harvest harrowing and continuous and inter-row cultivation. According to the [1] farming system, using harrowing, up to 70% of weeds can be destroyed and, thus, expensive chemical treatments can be replaced.

MATERIALS AND METHODS:

In order to improve the process of harrowing the soil and crops, we propose a strategy to mechanize the pre-sowing tillage for corn sowing and planting care, excluding from the machine complex the well-known cultivators for continuous and inter-row tillage and crops. In contrast to the well-known basic technology, only one spring harrow with a modernized [4] tooth is offered by us. Spring harrow with the proposed new spring teeth provides a reduction in traction resistance, energy consumption, fuel consumption and increased productivity. In addition, on the basis of this harrow, a multifunctional unit MFU was synthesized for harrowing the soil and crops, while simultaneously spreading solid mineral fertilizers with a special bunker on the tractor (Fig. 1). Thus, the MFU is equipped with a fertilizer hopper with a spring harrow with modernized [4] tines offered by us. Combining two technological operations in one run across the field, the proposed MFU reduces soil compaction, costs, increases labor productivity and complexity of work performed.



1 — tractor, 2 — bunker, 3 — fan, 4 — dispenser, 5 — spring harrow.
Figure 1: Technological scheme of the multifunctional unit

RESULTS AND DISCUSSION:

According to the proposed strategy of mechanization of the processes of pre-sowing tillage for sowing corn and caring for crops, the technical equipment of the proposed technology is significantly changing (Tables 1 and 2).

Analysis of variants of corn cultivation technologies (Tables 1 and 2) allows us to conclude that the proposed technology (Table 2) is much more efficient than the base one. Thus, according to the basic technology, six brands of machines are required (a tractor, a cultivator for continuous processing of the KPS-4, a corn seeder SUPN-12, an SG-21 coupling, ZBZSS-1 tine harrows and an inter-row cultivator KRK-5,6). The cost of labor per hectare of corn is 1.47 people. According to the proposed technology (Table 2), only three types of machines are required, i.e. two times smaller (tractor, seeder SUPN-12 and MFU on the base of the BP-24 spring harrow with modernized teeth). Labor costs for the cultivation of maize with the use of MFU are halved (Table 2). This year, the field experience will be laid on the proposed technology to bring to harvest. The expected economic effect is guaranteed even without a reliable increase in yield, but only by improving the harrowing process of the proposed MFU.

Table 1: The basic technology of pre-sowing soil preparation and care for corn crops

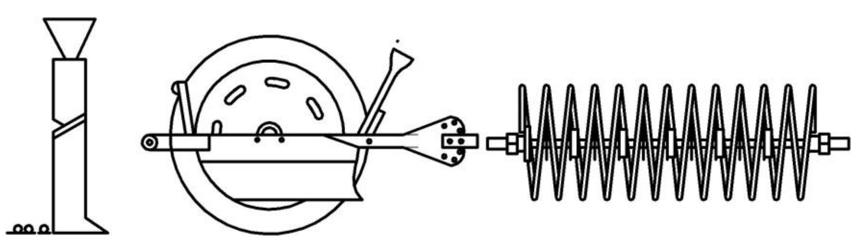
№	Job title	Composition of MTA	Productivity, ha / h	Labor costs, person-hours / ha
1	Presowing cultivation 6-8 cm	T-150 + 2KPS-4	6,3	0,16
2	Corn sowing	T-150 + SUPN-12	4,0	0,25
3	Pre-emergence harrowing of crops	T-150 + SG-21 + 3BZSS-1	12,1	0,08
4	Everyday harrowing of crops	T-150 + SG-21 + 3BZSS-1	10,7	0,09
5	1st interrow cultivation of crops at 8-10cm	MTZ-80 + KRK-5.6	2,4	0,48
6	2nd interrow cultivation of crops at 6-8cm	MTZ-80 + KRK-5.6	2,9	0,35
				1,47

Table 2: The proposed technology of pre-sowing soil preparation and care for corn crops.

№	Job title	Composition of MTA	Productivity, ha / h	Labor costs, person-hours / ha
1	Harrowing before sowing 6-8 cm	T-150+MFU	13,4	0,08
2	Corn sowing	T-150 + SUPN-12	4,0	0,25
3	Pre-emergence harrowing of crops	T-150+MFU	9,6	0,1
4	Everyday harrowing of crops	T-150+MFU	9,6	0,1
5	Harrowing crops	T-150+MFU	9,6	0,1
6	Harrowing crops	T-150+MFU	9,6	0,1
				0,73

Our second development is also based on a multifunctional unit, but combining the technological operations of the main and starting application of solid mineral fertilizers, sowing cereal crops and rolling the crops with a spiral-helix roller [5, 6]. The proposed multifunction sowing unit (MSU) also strictly takes into account the requirement of the [1] farming system for sowing cereal crops. Due to the above combination of technological operations, MSU will help to preserve the soil structure, increase labor productivity, reduce costs and increase grain yield [6].

According to the requirements of the [1] farming system, the main fertilizer should be applied for the main tillage, especially for phosphate and potash fertilizers, as they are absorbed by the root system of plants at the depth to which they are applied. Nitrogen fertilizers are more mobile. The MSU offered by us applies the main fertilizer to a depth of 16-18cm, and the starting dose to the depth of seed embedding, as implemented by a serial grain seeder. The working bodies of MSU for the implementation of its workflow are presented in Figure 2.



a) b) c)

a) dressing knife; b) double disc coulter; c) section of a spiral-screw roller

Figure 2: Working bodies for MSU operation

When creating MSU, our patent No. 178335 for the useful model "Device for introducing starting and main fertilizer simultaneously with sowing" [5] was used. A prototype model of the unit for experimental studies was created by us on the basis of the grain-driven seed drill NWT-3,6A. In the Kuban state farm of KubGAU, a small-plot experience has been laid with the sowing of winter wheat, the simultaneous introduction of the main and starting fertilizers and rolling. Experience brought to harvest. A reliable yield increase was 1.73 centners per hectare, with the least significant difference of experience with a control of 1.5 centners per hectare.

The optimal parameters and modes of operation of the MSU were determined using the developed mathematical model according to the optimization criterion of the minimum reduced costs of performing the work by our MSU.
The objective function of the model is (1):

$$E=\begin{bmatrix}\frac{205C_B^T}{790W}+\frac{250}{W}+\frac{198400B_w0,25}{145W}+\frac{\left(6,9N_e\left[1+0,03\left(V_w-5\right)\right]\right)}{W}+\\+0,15\left(\frac{1000C_B^T}{790W}+\frac{198400B_w}{145W}\right)\end{bmatrix}\rightarrow\min, \quad (1)$$

where C_B^T - carrying value of the tractor, RUB;
W – productivity of MSU, ha/h;
B_w - working width MSU, m;
N_e - tractor engine power, kW;
V_p - operating speed MSU, km/h;
790, 145 – annual load, respectively, tractor and MSU, h;
205; 250; 198400;6,9;0,03; 1000 – empirical coefficients.

The following values of the optimal MSU parameters are established: width of capture 3.6 m; working speed of 10 km / h; tractor engine power 67.9 kW; seed drill capacity for fertilizer 3 m^3; MSU productivity 3.1 ha for 1 hour of replaceable time; The minimum operating costs for the execution of work are 894 rubles / ha, and the reduced costs are 1295.4 rubles / ha. Other indicators, except for the above, will not provide the minimum cost at current prices and standards.

Modeling the MSU workflow and optimizing its parameters allow us to conclude that it is highly efficient and useful for production while observing the requirements of the farming system [1].

When modeling the operation of machine units, one of the main parameters is calculated - its traction resistance. Varying the width of the unit and, knowing its resistivity, determine the traction resistance of the entire unit and the optimum load of the tractor engine.

To determine the specific traction resistance of our multifunctional units, we conducted a dynamometer of these machines. The experimental setup for the dynamometer of the working bodies is hung on the hydraulic system of the tractor MTZ-80. A dynamometric link is pivotally mounted on the frame of the unit, which is connected to the working bodies under study for dynamometer through the traction dynamometer, on the dial of which the video camera is mounted. When dynamometering measured traction resistance of the working bodies of the studied machines and recalculated it in specific kN per 1 m of the capture of the machine. Measurement of traction resistance was carried out using a TD-3 traction dynamometer according to the standard technique [7] in the experimental section with a length of 20 m with steady movement of the unit.

CONCLUSION:

Analyzing the above, we can conclude that the technology of pre-sowing soil preparation and corn crop care has been significantly improved [8], which will not only provide economic benefits, but also eliminate two machines in the existing complex - a cultivator for continuous cultivation and inter-row. In subsequent experiments, it is planned to test the effectiveness of replacing these cultivators with a modernized spring harrow with the teeth offered by us, bringing the experience to harvest. The proposed multifunctional sowing unit due to the combination of technological operations provides an increase in the technical level of the machine [9-10], performing the main and field-sown application of fertilizers, leveling the soil and rolling the crops in one pass across the field.

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