Energy indicators of working bodies for tillage of steam fields in summer

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Abstract. Currently, one of the most important stages in obtaining high yields of the main crops is tillage of steam fields in summer. The article considers various variants of working bodies for tillage of steam fields to establish the energy indicators of the technological process. Experimental studies have been carried out to determine the energy indicators of the technological process of shallow tillage, with all variants of working bodies. During the research, such indicators were established as the traction resistance created by the working bodies, the specific traction resistance of the unit equipped with various variants of working bodies, as well as the specific fuel consumption during the main work. As a result of the research, it was found that working bodies in the form of a flat one-sided paw and flexible working bodies have significantly lower indicators of specific traction resistance. For an aggregate equipped with flat one-sided legs at a speed of 2.7 m/s, the specific traction resistance is 1950-2150 N/m, and for an aggregate equipped with flexible working bodies at a speed of 2.78 m/s, the specific traction resistance is 850-975 N/m. It was also found that the working bodies in the form of a flat one-sided paw contribute to the preservation and retention of moisture inside the soil layer and are less energy-intensive in terms of specific fuel consumption. In addition to tillage of steam fields in the summer, working bodies in the form of a flat one-sided paw can be used for pre-sowing soil preparation to the depth of seeding of grain, small-seeded and vegetable crops.

1 Introduction

Currently, one of the most important tasks of crop production is to obtain high yields of the main crops. Since the southern steppe zone of the Russian Federation is characterised by the presence of conditions of lack of moisture in the soil layers, guaranteed high yields of grain crops, including winter wheat, can be achieved by using steam fields in crop rotation. In this regard, one of the most important stages of obtaining high-quality food grain is the processing of steam fields in the summer and before sowing.

Depending on the soil and climatic conditions of cultivation of agricultural crops, at least four basic technologies of processing and preparation of fallow fields are used. These

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technologies, in turn, differ both in the method of basic tillage (waste tillage or zero tillage), in the time of its implementation, black steam if the main treatment is carried out in the autumn period, and early ones if the main treatment is carried out in the year of sowing of winter crops [1].

With existing tillage machines and implements equipped with working bodies in the form of wing paws, it is almost impossible to ensure the depth of tillage of steam fields in the summer period of 4-6 cm without removing wet soil layers to the daytime surface [2,3]. At the same time, the upper soil horizon is drying up, which leads to a deterioration in the conditions for sowing seeds in moist soil.

In this regard, there is a need to develop working bodies for tillage of steam fields in the summer to a depth of 4-6 cm. At the same time, providing levelling and mulching of the treated surface, reducing evaporation of soil moisture, complete destruction of weeds and contributing to the accumulation of moisture inside soil layers from atmospheric air, even in the absence of precipitation.

The aim of the study is a comparative assessment of the energy indicators of technological and technical solutions developed during the creation of working bodies for tillage of steam fields in the summer.

2 Materials and methods

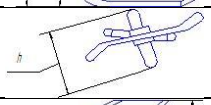
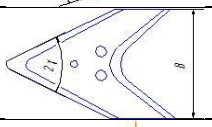
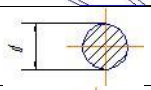
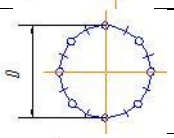
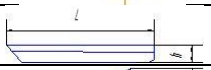
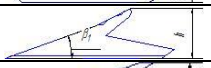
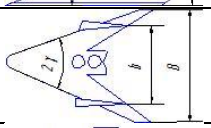
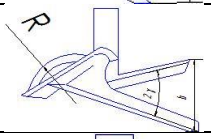
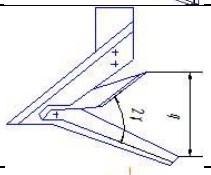
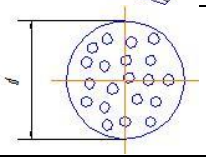
In connection with the above aim, a working body with flat one-sided paws has been developed in the Department of mechanisation of crop production of the "Federal State Budgetary Scientific Institution "Agrarian Research Center "Donskoy" (Table 1, variant I). The upper part of the developed working body is installed at an angle to the longitudinally vertical plane and is deflected backward from the vertical. The lower part of the working body is installed at an angle to the direction of movement. Working bodies of this type can be arranged in two rows (left and right) on sections mounted on the frames of disk huskers instead of disk batteries. Also in the research, working bodies were used in the form of a wide-reaching wing paw (Table 1, variant II), behind which a round rod is mounted, attached on a flexible rod to the posts of the rear row of paws. Following the rod, a light rotary roller is mounted.

For the completeness of the analysis of technical solutions used for tillage of steam fields in the summer, we considered the following variants of working bodies: a ploughshare working body (Table 1, variant III), which is three welded ploughshares, two of which have the nose cut off. A working body in the form of a pointed paw to a steam cultivator (Table 1, variant IV) [4-6].

Working bodies with stabilisers (Table 1, variant V), which are a curved stand, to which a wing paw with stabilisers is attached using a guide and a leash. The stabilisers, in turn, are made in the form of two vertical plates symmetrically arranged relative to the longitudinal axis of the working body. Segmental working body (Table 1, variant VI), consisting of a stand to which two one-sided paws (razors), left and right, are attached, and a chisel and a segment are attached to the front of the working body.

The cutting working body (Table 1, variant VII), consisting of a stand with a cutting knife mounted on it. In this design, the right and left plane-cutting wings are attached to the cutting knife. We also considered the working body for a wide-reach copying cultivator (Table 1, variant VIII), including a front knife, two rear knives, a flexible element: a steel rope, a screw for rope tension, as well as pins for attaching the rope to the back of the rear knives. All these elements make up the working body, which is attached to the frame. Up to 12 such working bodies are installed on the frame [7-9].

Table 1. Variants of working bodies under consideration for tillage of steam fields

Variant	Scheme of the working body	Technical characteristics			
		Name	Width of capture, cm	Depth of tillage, cm	Angle of crumbling, degr
I		Flat one-sided paw	18.0	4-6	15
		Link of the plume	10.0	2-3	variable
II		Flat-cutting wing paw	40.0	6-14	15
		Round rod	180-200	5-8	variable
		Rotary roller	180-200	0-2	0
III		Ploughshare working body	140	5	28
IV		Universal wing paw	33.0-38.5	6-12	28
V		Wing paw with shank and stabilisers	22.0	6-12	28
VI		Segmental paired one-sided paw	35.0	6-8	15
VII		Cutting paired one-sided paw	33.0	6-8	15
VIII		Flexible working body	200	5	-

When studying the energy indicators of the working bodies, the following parameters were calculated: the traction resistance created by the working bodies according to the variants, the specific traction resistance, and the specific fuel consumption during the main work [10].

3 Results of the research

Studies to determine the energy indicators of working bodies for tillage of steam fields in the summer were carried out in the fields of the FSBSI "ANC "Donskoy". From the analysis of the research conditions, it was found that the soil hardness in layers 0-5 and 5-10 cm was 0.20 and 0.48 MPa, respectively, while the soil moisture was 19% and 27%. The soil type is light low-humus Cisaucasian carbonate chernozem. The relief of the soil is flat, the microrelief is weakly pronounced with a height of 2.6 cm irregularities [11-14]. The number of weeds per 1 m^2 is 33.6 pcs. After processing, the soil was medium-moist and loose, which corresponds to zonal standards. The characteristics of weed plants did not differ from the average long-term data and were characteristic of the period of care for steam fields [15]. It should be noted that according to the botanical composition among the weeds, field bindweed, field mustard, and mat amaranth prevailed. The research was carried out on steam cultivation according to the accepted technology of winter wheat cultivation by steam.

All measurements of the energy indicators of the working bodies were carried out on agricultural machines in aggregation with the T-150K tractor.

The main energy indicators for the variants of the working bodies are presented in Table 2.

Table 2. Energy indicators according to the variants of the studied working bodies

Indicators	Value of indicators							
	I	II	III	IV	V	VI	VII	VIII
Working speed, m/s	2.7	2.83	2.83	2.83	2.10	2.83	2.85	2.78
Width of capture, m	14.5	8	4	4	11.7	4	4	24
Depth of tillage, cm	5	6.5	6.3	6.5	6	6.2	6.2	6
Traction resistance, kN	15.5	-	5.5	4.7	32.5	5.1	4.3	21
Specific traction resistance of the aggregate, N/m	1950	3510	3050	2490	3205	2845	2570	875
Specific fuel consumption during main work, kg/ha	1.24	-	3.11	-	3.06	-	-	-

When processing steam fields, the specific traction resistance of the unit with cutting paws when moving at a speed of 2.2-2.9 m/s was 2277-2650 N/m, which is 7.8-9.9% less than the unit equipped with pointed paws, this is achieved due to the lower drag resistance of the cutting paws. The specific traction resistance of the unit equipped with segmental one-sided paws when moving at speeds of 2.2–2.9 m/s was 2800-2900 N/m - 1-9.8% more than that of the unit equipped with a universal pointed foot. The ploughshare working bodies showed approximately the same specific traction resistance as the paws with stabilisers.

Significantly lower specific traction resistance was obtained when processing of steam fields with an aggregate equipped with working bodies in the form of a flat one-sided paw and flexible working bodies. For a flat one-sided paw at a speed of 2.7 m /s, the specific traction resistance is 1950-2150 N/ m, and for an aggregate equipped with flexible working bodies at a speed of 2.78 m / s, the specific traction resistance is 850-975 N/m.

More clearly, the data of the specific traction resistance is presented in the form of a graph (Figure 1).

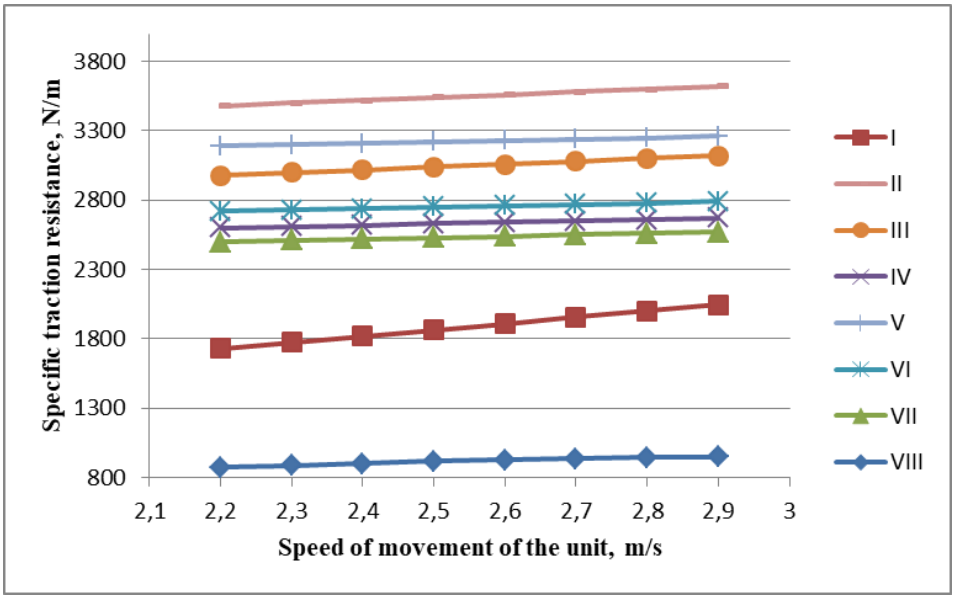


Fig. 1. Graph of the specific traction resistance of aggregates with various variants of working bodies

As it can be seen from the graph of the specific traction resistance, the lowest values are achieved for units equipped with flat one-sided legs and flexible working bodies.

4 Conclusion

As a result of research to determine the energy indicators of working bodies for tillage of steam fields in the summer, it was found that units equipped with flat one-sided paws and flexible working bodies have significantly lower specific traction resistance. Thus, for a flat one-sided paw at a speed of 2.7 m/s, the specific traction resistance is 1950-2150 N/m, and for a unit equipped with flexible working bodies at a speed of 2.78 m/s, the specific traction resistance is 850-975 N/m.

It should be noted that the working bodies in the form of a flat one-sided paw have the best performance when processing steam fields to a depth of 4-6 cm. They contribute to the preservation and retention of moisture inside the soil layer and are less energy-intensive in terms of specific fuel consumption.

In addition to tillage of steam fields in the summer, working bodies in the form of a flat one-sided paw can be successfully used for pre-sowing soil preparation to the depth of planting seeds of grain, small-seeded and vegetable crops.

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