Results of determining the agrotechnical indicators of a flat cutter for fine tillage

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Abstract. In modern conditions, most soils are exposed to erosion processes. In this regard, it is necessary to control the amount of dust particles in the surface layer of the soil. Fine tillage with flat-cutting working bodies solves this issue by creating a finely cloddy soil structure of the upper fertile layer. The article considers the developed original design of a flat cutter for fine tillage. The results of experimental studies on the determination of agrotechnical indicators for the treated background and untreated stubble background are presented. In the course of the research, such indicators were established as: the average actual working depth, the standard deviation of the working depth from the given one, the coefficient of variation in the working depth, crumbling of the soil by the working bodies, the moisture content inside the reservoir, the number of erosion-dangerous particles in the surface soil layer. As a result of the research, it was found that the flat cutter qualitatively performs the specified depth of tillage with an acceptable deviation, the ridge size is in the range of 3.6-3.9 cm, which is allowed by agrotechnical requirements, the number of lumps up to 25 mm in size after the passage of the working body is 82-85% . With shallow tillage with a flat cutter, the removal of wet layers to the soil surface is not observed. The flat cutter can function qualitatively on an untreated stubble background as part of a combined unit that is not equipped with disk working bodies.

1 Introduction

Fine tillage is carried out by working bodies without turning the layer to a depth of 8-16 cm.

The qualitative indicators of the technological process of fine tillage performed by the working bodies include obtaining a fine-cloddy structure of the cultivated layer; uniformity of loosening depth; removal of the lower wet layer to the surface of the field is not allowed.

In addition, in regions affected by erosion processes, it is necessary to control the amount of dust particles, the size of which does not exceed 1 mm, on the soil surface (0-5

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 https://doi.org/10.1051/e3sconf/202341302046

cm), which will reduce the loss of the fertile layer from the impact of wind and water flows [1-11] .

Due to the interaction of the soil with the working bodies, dust-like particles can be formed, and they are already contained in the untreated formation.

By creating a fine-cloddy soil structure, dust-like particles that are on the surface of an uncultivated field and formed during interaction with the working body wake up inside the layer.

The control of the amount of erosive dust-like particles is carried out during soil cultivation by working bodies.

At the same time, it is necessary and sufficient to require that the amount of erosive dust particles does not increase after tillage.

The working bodies that allow dust-like particles to wake up inside the formation during tillage include a flat cutter.

2 Materials and methods

An original design of a flat cutter for fine tillage has been developed. The fine tillage flat cutter (picture 1) has different shank and mortar angle options (pictures 2 and 3) that have been optimized. According to the criterion of minimum energy consumption, while maintaining the quality of the minimum tillage, the following parameters of the flat cutter were chosen as optimal: the sharpening angle of the stand is 50 degrees, the opening angle is 104 degrees.

Fig. 1. Flat cutter for fine tillage

Fig. 2. The angle of sharpening stand flat cutter

Fig. 3. The angle of the opening of the flat cutter blades

3 Research results

The obtained qualitative indicators of shallow tillage with a flat cutter are shown in tables 1 and 2.

Table 1. Qualitative indicators of a flat cutter for fine tillage on a treated stubble background

Indicator	Indicator value								
Set speed, km/h	6,84	8,20	11,37	6,84	8,20	11,37	6,84	8,20	11,37
Target depth, cm	8,0	8,0	8,0	12,0	12,0	12,0	16,0	16,0	16,0
Actual depth on average, cm	9,8	9,6	9,2	13,6	12,8	12,6	16,8	17,0	17,2
The greatest deviation of the depth from the given, ±cm	2,0								
Depth standard deviation, ±cm	0,45	0,89	0,45	0,89	0,84	0,89	0,84	1,0	2,0
Depth variation coefficient, %	4,56	9,32	4,86	6,54	6,56	7,06	5,0	5,88	11,63
Combing average, cm	3,7	3,7	3,7	3,6	3,8	3,7	3,9	3,8	3,9

Soil crumbling – the number of clods less than 25 mm in size, %	84	82	84	85	84	84	83	82	83
Soil crumbling – number of lumps larger than 25 mm, %	16	18	16	15	16	16	17	18	17
Moisture content inside the formation before tillage, %	25,4								
Moisture content inside the formation after the passage of working bodies, %	25,1	25,3	25,6	25,4	25,4	25,5	25,2	25,1	25,5
The number of erosion-hazardous particles in the surface layer of the soil before processing, %	23,8								
The number of erosion-hazardous particles in the surface layer of the soil after the passage of the working bodies, %	23,5	23,6	23,4	23,5	23,6	23,4	23,5	23,6	23,4

From the analysis of the data obtained, given in Table 1, it follows that the flat cutter qualitatively performs the specified depth of tillage with a permissible deviation (up to 2 cm).

The limit value of the deviation is observed at the greatest depth and speed of movement of the working body (16 cm and 11.37 m/s, respectively), which does not exceed the allowable.

In the above mode, the highest coefficient of variation of this indicator (11.63%) is observed.

The evenness of the field surface after shallow tillage with a flat cutter, characterized by such a quality indicator as ridgedness, is within the limits allowed by agrotechnical requirements (less than 4 cm) and amounted to 3.6-3.9 cm.

According to the crumbling of the soil (the number of lumps of the permissible size), the flat cutter fulfills the agrotechnical requirements.

The number of lumps up to 25 mm in size after the passage of the working body was 82-85% with the required not less than 80%.

The value of this qualitative indicator, as well as the previous one, is approximately in the same range for all variants of the experience of shallow tillage with a flat cutter.

There is practically no change in the moisture content inside the formation before and after shallow tillage with a flat cutter, which indicates its preservation inside the formation, which is ensured by the design of the working body.

Thus, the removal of wet layers to the soil surface was not observed during shallow tillage with a flat cutter.

The number of erosion-hazardous particles after tillage with a flat cutter does not increase, even slightly decreases (within 0.4%), which corresponds to agrotechnical requirements.

The obtained qualitative indicators, given in Table 1, were determined on a stubble background, pre-treated with disk working bodies.

Thus, the technological process of a combined unit with sequentially arranged disks and a flat cutter was simulated.

 https://doi.org/10.1051/e3sconf/202341302046

Series of experiments was also carried out on an untreated stubble background (table 2).

Table 2. Qualitative indicators of a flat cutter for fine tillage on an uncultivated stubble background

Indicator	Indicator value								
Set speed, km/h	6,84	8,20	11,37	6,84	8,20	11,37	6,84	8,20	11,37
Target depth, cm	8,0	8,0	8,0	12,0	12,0	12,0	16,0	16,0	16,0
Actual depth on average, cm	8,6	9,8	9,2	12,6	13,6	13,6	16,8	16,8	16,8
The greatest deviation of the depth from the given, ±cm	2,0								
Depth standard deviation, ±cm	0,89	0,45	2,0	0,89	0,89	0,89	0,84	0,84	0,84
Depth variation coefficient, %	10,40	4,56	15,21	7,06	6,54	6,54	5,0	5,0	5,0
Ridgeness on average, cm	3,9	3,9	4,0	4,0	3,9	4,0	4,0	4,0	3,9
Soil crumbling – number of lumps smaller than 25 mm, %	85	83	84	85	84	84	83	82	85
Soil crumbling – number of lumps larger than 25 mm, %	15	17	16	15	16	16	17	18	15
Moisture content inside the formation before tillage, %	30,1								
Moisture content inside the formation after the passage of working bodies, %	29,9	29,8	29,8	30,0	30,4	29,9	29,8	29,8	30,0
The number of erosion-hazardous particles in the surface layer of the soil before processing, %	12,6								
The number of erosion-hazardous particles in the surface layer of the soil after the passage of the working bodies, %	12,5	12,5	12,3	12,5	12,9	12,5	12,5	12,1	12,8

Comparing the data obtained in tables 1 and 2, it should be noted that the quality indicators of shallow tillage with a flat cutter to a depth of 8-16 cm, when operating on an untreated stubble background, have not changed, they are still at a high level that meets agrotechnical requirements.

It should be noted that the content of erosion-hazardous dust-like particles in the upper soil layer of an uncultivated field against a stubble background is lower than in a disked one.

Before the passage of the flat cutter, erosion-dangerous dust particles less than 1 mm in size were contained almost 2 times more in the 0-5 cm soil layer pre-treated with disk working bodies compared to the untreated stubble background.

That is, disk working bodies lead to soil spraying, and a flat cutter provides an anti-erosion structure of the upper fertile layer.

Thus, a flat cutter can function qualitatively on an untreated stubble background as part of a combined unit not equipped with disk working bodies. Excessive grinding of the formation with disk working bodies can lead to drying out, loss of structure and degradation of overdried soil.

Excessive grinding of the soil layer by working bodies has a negative impact on the development of cultivated crops, resulting in a decrease in their yield [12-19].

Therefore, the proposed flat cutter as part of a combined unit without disk working bodies has undeniable advantages. At the same time, the metal consumption and traction resistance of the unit are significantly reduced due to the lighter design.

4 Conclusion

The flat cutter qualitatively performs the specified depth of tillage with an allowable deviation.

The ridge content is within the limits allowed by agrotechnical requirements and amounted to 3.6-3.9 cm.

The number of lumps up to 25 mm in size after the passage of the working body was 82-85%.

The removal of wet layers to the soil surface was not observed during shallow tillage with a flat cutter.

The flat cutter provides an anti-erosion structure of the upper fertile soil layer.

The flat cutter can function qualitatively on an untreated stubble background as part of a combined unit that is not equipped with disk working bodies.

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