Hexagonal disc working bodies for working soils subject to wind erosion

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Abstract. Necessary quality of soil cultivation is not always achieved by disk plough-harrows. To solve this problem the improved working unit - flat hexagonal disk was proposed. The aim of the investigation was to determine the dependence of the functional efficiency of the soil tilling implement with flat hexagonal working bodies on its mechanical and technological parameters. The technological process of interaction of the flat hexagonal disk working unit with soil and plant residues was a subject of investigation. To assess the quality of the tillage depending on the approach angle (θ = 15, 25, 35°), machine speed (V = 6, 8, 10 km/h) and processing depth (h = 60, 80, 100 cm) the laboratory tests in the soil channel and field researches at Siberian zonal machine-testing station were carried out. On the surface of the soil channel the stubble cover with weeds was simulated. The ratio of stubble conservation in the soil after the experiment to the weight of stubble used for imitation of the stubble cover served as a criterion of evaluation of the safety of stubble on the surface of the field. The relation of a difference in the weight of mulch, scattered over the soil surface before the test, and that, gathered after the passage of the machine, to the initial weight of mulch was used as a criterion of embedding of vegetative mass in soil. The prototypes of flat hexagonal disc carried out quality tillage with ridgeness no more than 4 cm, the stubble conservation 86…94 %, the chopped straw mass integrity 60 %. Reduction in the presence in soil of erosion-dangerous particles to 1 % allows using flat hexagonal discs in areas exposed to wind erosion

1 Introduction

Tillage is one of the most important technological operations in agricultural production influencing on volume of crop yields. Choice of tillage system is carried out according to the zonal conditions, it must be soil protective, energy saving, economically viable and harmful for the environment. Scientists such as A.I. Baraev, R.S. Shakirov, A.N. Kashtanov, N.A. Kachinsky, S.S. Sobolev and others have worked on the selection and justification of tillage system. The works about disk tools, reducing energy intensity and operating costs during the tillage of such scientists as G.N. Sineokov, F.M. Mamatov, L.S.Nartov, V.F. Strelbitsky, A.I. Kashirsky, I.D. Kobyakov have been analysed. Usage of

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hexagol disk tools for tillage exposed to wind erosion must provide carrying-out of the above-mentioned requirements [1].

The aim of our investigation is quality assessment of soil treatment with hexagonal disks implements.

2 Materials and methods

Stubble conservation assessment on field surface and incorporation of plant residues with flat hexagonal disks implements [2] is done by taking measurements in soil channel of the laboratory of agroengineering department [3-5]. In butt walls of the channel box rectangular ground entrance and exit windows are done for working tools that allow to set them in the required position. Supporting rollers of the cart move inside the shelves of double T-bar guaranteeing its permanent horizontal position.

Moving of the cart along the guides is done by means of electric motor with power 2.7 kwh and shaft speed n = 970 rpm. Gearbox of the ZIL-150 with transmission numbersc: I – 6.24; II – 2.32; III – 1.90; IV – 1.0; V – 0.81, allows the cart to set speed respectively 2; 3; 6; 9 and 12 km/h.

Flat hexagonal disks with offset cutting edges and flat round disks are fitted on the cart of soil channel (Figure 1) [1, 3, 6-12].

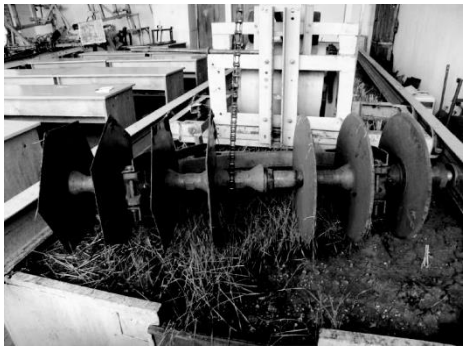

Fig. 1. The cart of soil channel with fitted working tools.

For cut vegetation conservation assessment on field surface in dependence upon the approach angle and movement speed the soil is prepared as follows. The stubble is imitated on the surface (Figure 2) on which the weed seeds were scattered to approxi-mate conditions of the experiments to those of the field.

Fig. 2. Imitation of field conditions in soil channel.

After emergence of weed seedlings the experiments were conducted and mass measurements of the stubble with subsequent calculation of its preservation were done according to the formula:

$$S = \frac{m_0 - m_1}{m_0} \cdot 100\% \quad (1)$$

Where m_1 – stubble mass collected from surface of the soil channel after experiment, kg; m_0 – total stubble mass applied to the soil channel, kg.

For evaluation of plant residues and straw incorporation into the soil in dependence on the approach angle and speed of the movement, mulch from the straw is scattered on the soil channel surface along the disks movement (Figure 3).

Fig. 3. The preparation of soil channel for conducting experiments on quality of plant residues incorporation.

Their length was the same but the width was equal to working width of the disc. The mulch is weighted before incorporation and after disking the residues were collected and weighted again (m_2). The indicator value of vegetation incorporation is defined according to the relation to mulch mass incorporated into the soil to the total mass:

$$S_1 = \frac{m_0 - m_2}{m_0} \cdot 100\% \quad (2)$$

Production experiment was carried out on the Siberian zonal machine-testing station using the unit consisting of the tractor MTZ-82 and experimental disker constructed in agroengineering department (Figure 4).

Fig. 4. Machine and tractor unit MTZ-82 with experimental disker.

For performing the experiments on STO AIST 4.2-2010 [13-15] the disker was equipped alternately with hexagonal and round disks. The depth of tillage for flat hexagonal disks was defined as medium between the maximum depth when the disk operates by the angle and minimum depth when it operates by the edges.

3 Results and Discussion

Amount of stubble on the field surface reduces as the speed of the machine and approach angle increases (Figure 5). According to the agricultural requirements the value of this indicator should not be less 75%. In our experiments with hexagonal disks minimum quantity of stubble on the surface was 96%. In addition, as the approach angle increases incorporation of free plant residues into the soil protecting it from blowing erosion-damaging particles and moisture evaporation increases. Maximum quantity of this indicator using hexagonal disks achieves 50%, round disks – 55% (Figure 6).

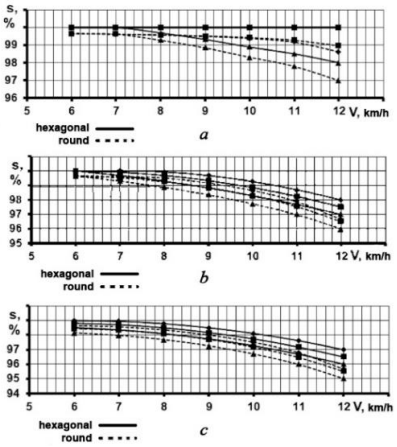

Fig. 5. The diagram of stubble protection dependence on the field surface on the angle of attack (θ), speed movement of the machine (V) and depth of soil treatment (h), mm.

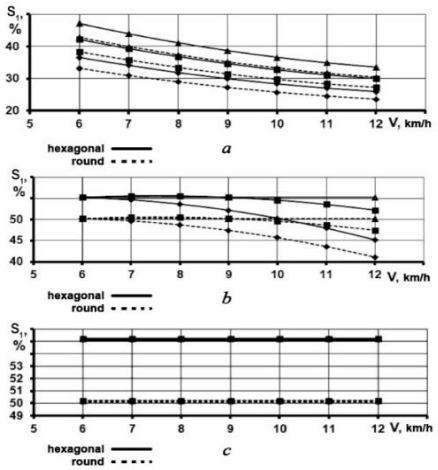

Fig. 6. The diagram of dependence of vegetation incorporation on approach angle (θ), speed movement of the machine (V) and depth of soil treatment (h), mm.

During field experiment it is established:

- The depth of soil treatment in dependence on set approach angle 15-35° varies from 6 to 10 cm.
- The height of ridge on the soil surface after passing flat hexagonal disks was not increased 4 cm (Figure 7).
- Cutting weeds by hexagonal disk was at the level 99-100%.
- Conservation of stubble was 86-94% (Figure 8), other plant residues left on the field surface as a mulch, - more than 60%.
- The content of erosion-damaging soil particles of size smaller than 0.25 mm in total mass after soil treatment with hexagonal disks didn't exceed 12.1-18.7%, and with round disks – 13.3-19.4%.
- Share of agronomically valuable aggregates of the size 3-10 mm was 26.4-29.0 and 24.9-27.2% respectively, 0.25-3 mm – 35.7-37.3 and 34.4-36.5%.

Fig. 7. The height of ridge: a) hexagonal disk; b) round disk.

Fig. 8. Stubble cover conserved after soil treatment with hexagonal discs.

4 Conclusion

Main functional indicators of quality soil treatment with flat hexagonal disks are established in the result of investigations: ridgeness not more 4 cm, conservation of stubble on the field surface – 86-94%, chopped straw mass – 60%. Usage of the flat hexagonal disks reduce presence of erosion-damaging particles in the soil up to 1% (from 13.3-19.4% by using round discs 12.1-18.7%).

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