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Anti-Erosion Technology of Comb-Step Plowing and a Plow for its Implementation

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Abstract: The article discusses the rationale for the new anti-erosion technology and the design of the plow, which helps to conserve moisture and prevent water erosion on sloping lands. The objects of the study are the anti-erosion technology of ridge-step plowing and a plow for carrying out this method of tillage. A new anti-erosion technology of ridge-step plowing has been proposed, which contributes to the displacement of the soil down and up the slope, incomplete rotation of the formation alternates with full (180° within the furrow). The plow consists of stepwise arranged screw plow housings and guide plates with working surfaces facing the ploughshare surfaces of the housings. Odd-numbered hulls are equipped with short guide plates, paraglaw-type soil dredgers are installed behind even-numbered hulls. After the passage of the plow, a stepped bottom of the furrow is formed with a ridge profile of the surface of the arable land, rainwater is trapped and accumulated. The occurrence of water erosion is prevented. As a result of experimental studies, the following optimal parameters were determined: the length of the odd–case hood was 75 cm, the length of the odd–case hood was 93 cm; the longitudinal distance between the housings was 50 cm. It has been established that an effective method of ridge-step plowing of slopes is the alternation of an incomplete turn of the formation with a complete one within the furrow by 180° in combination with strip under-arable loosening. A description of the rational design scheme of a plow for a comb-step plow is given. It is noted that with a longitudinal distance of 0.5 m between the housings, the required high-quality incomplete turnover of the plates is provided with the lowest energy costs with a length of 75 cm.

Keywords: water erosion, moisture conservation, technology, plow, ripper, slope.

Introduction. Erosion causes significant damage to agriculture in Uzbekistan. Excessive tillage leads to the spread of wind and water erosion of soils. There Are More Than 70 In Uzbekistan % of the sown area is subject to erosion [1].

In Uzbekistan, more than 20.4% of the arable land is located on slopes of a steep 3° or more. With a high degree of ploughing and increasing intensification of agriculture, the area of eroded land on the slopes increases annually. The problem of water erosion and the shortage of soil moisture is acutely felt on rain-fed sloping lands. In Uzbekistan, soils suitable for rain-fed agriculture amount to 2,130 million hectares, of which arable land is 814.5 thousand hectares. 700.4 thousand hectares of arable land on rain-fed lands are subject to water erosion, of which 416.5 hectares are severely and moderately [2].

One of the factors influencing water erosion is the technology of tillage and technical means. The applied technologies and technical means for basic soil treatment in Uzbekistan not only do not prevent, but also contribute to the emergence and development of water erosion processes, since the existing farming system does not provide for measures to prevent water erosion of soils.

Therefore, the tasks related to the development of woodworking machinery that meets the requirements of measures to prevent water erosion of soils are relevant.

The purpose of the work is to develop technology and a plow that helps to conserve moisture and prevent water erosion on sloping lands. To do this, it is necessary that the plow form a stepped bottom of the furrow and a ridged surface of the arable land.

The objects of research are: the technology of comb-step plowing and a plow for the implementation of this method.

Results. The technological processes of the plow were studied in laboratory and field conditions, according to literary sources, patents, and test results of the developed machine. The research was carried out in 2012-13 in the Kashkadarya region of Uzbekistan on the stubble of winter wheat. When determining the qualitative performance of the plow, we were guided by the program and methodology for testing agricultural machinery according to OST 104.2–89.

It is known that with the annual when plowing with standard plows at the same depth, a plow sole is formed in the subsurface layer, the density of which is 2 or more times higher than the density of the arable layer. This leads to a deterioration in moisture absorption by the lower sub-arable soil layer. As a result, there is intra-soil runoff and water erosion on the slopes. It has been established that the subsurface runoff can be regulated by deep treatment, step plowing, ridge-step plowing, mowing, crevice, etc. [3].

The authors of the article for improvement the quality of processing and prevention of water erosion in sloping fields have developed various technologies and design schemes of a plow for comb-step plowing based on a linear-step plow that performs smooth plowing with a 180° rotation of layers within its own furrow. One of the most effective methods is a method in which an incomplete rotation of the formation alternates with a complete (180° within its own furrow) rotation of the formation, and the subsurface layers of the formation are loosened (Fig. 1).

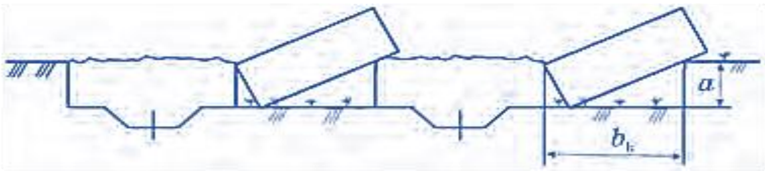

Fig. 1. The transverse profile of the furrow after processing with a plow for comb-step plowing

This method is carried out by a plow for comb-step plowing (Fig. 2), consisting of a frame 1, screw plow housings 2 and 4, guide plates 3 and 5 with working surfaces facing the ploughshare surfaces of the housings [4]. Odd-numbered housings 2 are equipped with short guide plates 3, and type 6 soil dredgers are installed behind even-numbered housings 4 "paraglider".

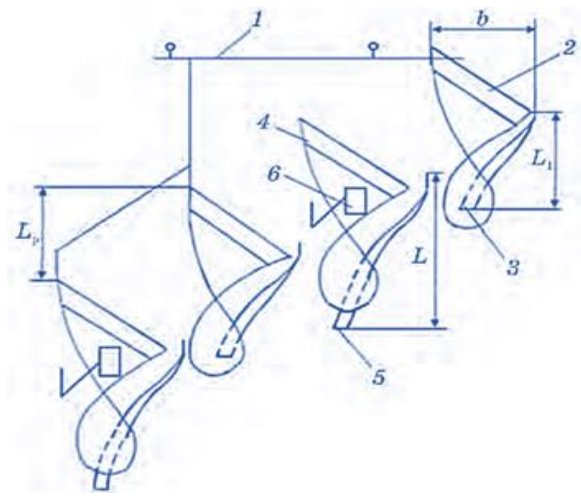

Fig. 2. The design diagram of the plow for comb-step plowing

During operation, the odd case 2 interacts with a short guide plate 3 and wraps the formation by 135°, followed by an even case

4 interacts with a long guide plate 5 and performs trimming, rotation and laying of the formation 180° into its own furrow. Simultaneously with the turnover of the layers with black hulls, the soil dredgers 6 carry out under-tillage loosening. After passing the plow, a stepped bottom of the furrow and a ridged surface of the arable land are obtained. The combination of the stepped bottom of the furrow with the ridge surface of the arable land helps to retain water and prevent soil flushing after heavy rainfall [5-9].

One of the main parameters affecting the quality of plowing and the energy consumption of the plow for comb-step plowing is the longitudinal distance between the housings and the length of the guide plate.

An experimental plow was manufactured to determine the optimal parameters of the guide plate and the longitudinal distance between the housings. The experiments were carried out in a rain-fed area on a wheat field. The longitudinal distance between L_p plow housings varied from 0.1 to 0.7 m for smoothness of step plowing. Experiments to determine the effect of the longitudinal distance between the hulls on the quality and energy parameters of the plow were carried out at the set processing depth of the hulls a = 22 cm, their capture width b_k = 50 cm, and the rate of aggregation 1.68 m/s [10, 11].

The experimental results showed that on the stubble of winter wheat, a plow with frontally mounted housings (L_p = 0) does not work well, it is often clogged with soil and plant residues. The increase in L_p improves the quality of the hulls and the turnover of the formation. When working, the layer wrapped in an even case should not touch the elements of an odd case. Observations have shown that this is achieved at an arbitrary distance between the buildings 0.50-0.55 m. With an increase in L_p from 0 to 0.5 m, the traction resistance decreases intensively. With a further increase in Lp, the traction resistance of the plow decreases slightly. With an increase in L_p, the degree of sealing of plant residues and the stability of the plow stroke improves. Therefore, the minimum longitudinal distance between the housings should be 0.5 m.

Experiments to identify the effect of the length of the guide plate of an odd body on the quality and energy parameters of the plow were carried out with an installation depth of processing of the housings a = 22 cm and a longitudinal distance between the housings of 0.5 m at a unit speed of 1.68 m/s.

The results of the experimental studies show, that the length of the guide plate has the main influence on the turnover of the formation and the profile of the arable land. When the body is working without a guide plate, the formation is superimposed on an adjacent formation, and an open furrow (depression) with a width of 31.6 cm, a depth of 19.8 cm and a ridge height of 14.1 cm is formed on the left side, a lack of formation was observed. When the length of the guide plate was increased to L_1=50 cm, there was also a lack of formation [12-20]. A depression was formed with a width of 23.6 cm, a depth of 12.8 cm and a ridge with a height of 17.5 cm. With the length of the guide plate L_1 = 75 cm, a reliable technological process of formation turnover was carried out. The depth of the depression is small - 5.6 cm, the height of the ridge is 12.5 cm. At $L_1 = L$ = 93 cm, the surface of the arable land is almost leveled, the height of the ridge is 5.8 cm. This is due to the fact that the guide plate acts on the formation from the beginning to the end of its revolution. In this case, the formation turns 180° within its furrow without transverse displacement of its center of gravity [20].

As the length of the guide plate increases, the traction resistance of the plow decreases. Since in the absence of a guide plate, the formation is under the influence of the casing until the formation rotates by 90°, then the formation is further pumped by inertia. With an increase in the length of the guiding plate, a certain amount of energy is spent on overcoming the forces of resistance and friction on the surface of the plate.

Conclusion

An effective plowing method that prevents water erosion in sloping fields is a method in which an incomplete rotation of the formation alternates with a full one (180° within its own furrow), and the sub-arable layers of the latter are loosened. A plow for comb-step plowing has been developed, which implements the proposed method. It has been established that the longitudinal distance between the plow housings should be at least 50 cm, odd housings should be equipped with short guide plates, and paraglaw-type soil excavators should be installed behind even housings.

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