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Technologies and Technical Means for Smooth Plowing

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Abstract: The farming system includes a whole range of different activities, among which one of the main places is occupied by the tillage system. The existing technologies and technical means for smooth plowing are analyzed. In the results of the analysis of technology and technical means of basic tillage, it was found that the combined frontal plow is of the greatest interest, simultaneously performing smooth, rowless plowing, sub-tillage loosening of the compacted layers of the middle of the cotton row spacing and the formation of ridges on the structural layers of the soil. On the basis of frontal plows, it is possible to develop combined wide-reach tools for energy-saturated tractors that perform several technological operations, taking into account the characteristics of the cotton field. The introduction of a new technology of smooth plowing and frontal plows for its implementation in the cotton growing area is at this stage a timely, important and relevant task of great scientific and practical interest.

Keywords: soil, technology, smooth plowing, plow, revolving plow.

Introduction. The farming system includes a whole range of different activities, among which one of the main places is occupied by the tillage system. A rational processing system is designed to ensure an increase in the potential fertility of soils, high and sustainable yields of agricultural crops with minimal labor and money per unit of output. Cotton and its accompanying crops are cultivated in specific soil and climatic conditions on irrigated lands, the area of which in the region occupies more than 8 million hectares [1-3], and the scientific development of mechanical and technological foundations and technical means for their mechanical processing is a major scientific problem of important national economic importance.

Results. The peculiarity of the technological process of traditional plows used in the cotton growing zone, based on the fall-off of layers into the neighboring furrow, causes the formation of collapsible furrows and pile ridges in the cultivated fields. Thus, according to the results of numerous studies conducted at the Scientific Research Institute of Agricultural Mechanization in Uzbekistan [4], including ours [4], it was found that after plowing, pile ridges with a height of 28-30 cm, a width of 120-150 cm and collapse furrows with a depth of 30-36 cm, a width of 120-210 cm remain in the fields. These irregularities are usually leveled with the same plows that plowed the field, in four or more passes. At the same time, each passage of the arable unit requires additional adjustment of the plow. The number of additional passes of the unit is directly related to the number of detachable furrows and pile ridges on the field and varies widely, depending on the area of the field, the length of the rut and the width of the paddock. This amount of work spent on leveling the pile ridges and split furrows is the equivalent of plowing an additional area, which leads to a sharp decrease in the actual (replaceable) productivity of arable units.

Pile ridges not only disrupt the alignment of arable land, but also form zones with fine processing, which leads to a decrease in yield. Meanwhile, it has been established that the total

area affected by the negative impact of collapsing furrows and pile ridges on the yield of various crops ranges from 6.5 to 19.5% of the total field surface [4].

For better leveling of camber furrows and pile ridges, special tools are also used – grader knives GN-2, 8 and GN-4, as well as long-base planners P-2, 8A [4].

Additional operations of leveling the field surface not only lead to increased energy costs, but also delay the time of preparing the soil for sowing, to more intensive drying and compaction soil [3, 4] and, as a result, to a decrease in crop yields, and in conditions of irrigated agriculture require an increase in the cost additional irrigation.

The use of smooth plowing technology in basic tillage makes it possible to eliminate the above disadvantages. The use of plows for smooth plowing makes it possible to eliminate significant irrational costs for carrying out additional passes of the unit for leveling pile ridges and camber furrows, to abandon the costs associated with splitting the field into paddocks, to improve the working conditions of agricultural machinery in subsequent operations. At the same time, the volume of annual planning work can be reduced by 30% or more [5].

Plows for smooth plowing can be divided into two main groups according to the way they affect the soil (Fig.1.1) [5]:

- plows that perform tillage using traditional classical technology;
- plows that perform plowing in fundamentally new ways.

The design schemes and principles of operation of rotary, sectional, keyboard and balancing plows are given in the sources [6]. The most common of these plows abroad are revolving ones. The revolving plows PON-3-40/45, PPO-5/6-40, etc. developed in our country have not found wide distribution due to the unsuitability of energy resources for shuttle operation, unsatisfactory quality of work on some soil backgrounds.

In the Scientific Research Institute of Agricultural Mechanization of Uzbekistan, together with Odessapochvomash, prototypes of revolving plows PON-3-40, PON-4-40, PON-3-45 were created, designed to carry out smooth plowing in cotton growing areas [6]. However, a number of fundamental design disadvantages of revolving plows (high metal consumption, increased energy consumption, insufficient reliability of the turnover mechanism, low maneuverability), identified during tests, called into question the expediency of their further use in cotton farming.

Rotary plows [7] are under development, which also carry out classic smooth plowing. A characteristic feature of these ploughs is the pivoting bearing beam, on which special plough housings are fixed. At the same time, each pair of left and right-turning plow housings has one rack, which allows you to slightly reduce the weight of the plow in comparison with the reverse ones.

The technological process of plowing is carried out alternately by left and right-turning housings, which are installed in the working position by turning the bearing beam. Noteworthy is the 4-body rotary two-tier plow developed in VIM for smooth plowing, equipped with single-shaft symmetrical rotary housings of the upper and lower tiers, each pair of which is pivotally fixed on a separate ridge [7].

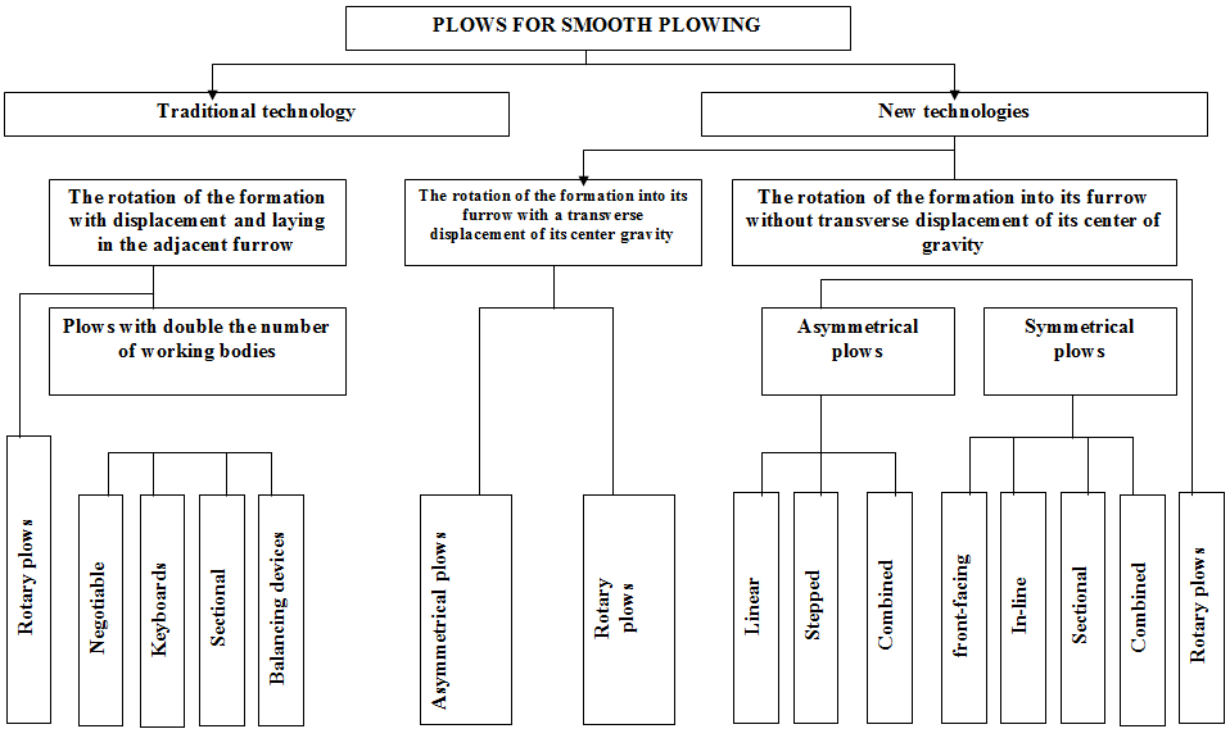

Fig.1. Classification of ploughs for smooth plowing

The housings are brought into working position by means of a special mechanism when turning the load-bearing beam. However, the equipment of the above-mentioned plows with turning mechanisms has served the design of the plow. The design of plow hulls has also become more complicated. The use of plows with rotary symmetrical housings is significantly limited by the fact that housings of this type can only have a cylindrical surface, which, as is known, has good crumbling ability, but does not wrap the formation sufficiently.

The main disadvantage of plows carrying out the classic method of smooth plowing is that in the process of their operation, the soil layer falls off to the side – into the neighboring furrow. The displacement of soil layers to the side has no agrotechnical justification and leads to significant energy costs [7].

The above-mentioned significant structural (long length and material consumption, complexity of the structure) and technological disadvantages do not allow the creation of combined machines based on them, hinders their widespread implementation.

Constant research by scientists and researchers has led to the emergence of a new method of smooth plowing in tillage, in which soil layers, turning around, fit into their own furrows [8-10].

Attempts to implement this method have led to the creation of plows of various designs. During the operation of plows [11], during the turnover and laying of the soil layer, its center of gravity is shifted in the transverse direction and returned to its original position. And plows [11] carry out the turnover and laying of soil layers in their own furrows without transverse displacement of their center of gravity. From an energy point of view, the latter are more promising.

Plows that rotate the formation into their own furrow without transverse displacement of the center of gravity can be rotational, asymmetrical and symmetrical in design. A detailed analysis of rotary plows for smooth plowing is given in [12]. A comparative characteristic of symmetrical and asymmetrical plows is given in [12]. A characteristic feature of asymmetrical ploughs is the presence of only right or left-swinging housings. At the same time, on some plows, the plow housings are located on the same front line. In this arrangement of the hulls, the conditions of the formation turnover by the rightmost hull differ from the conditions of the formation turnover by the other hulls. In the latter case, as noted by Fridatov [13], the layers in the lifting phase turn out to be in a closed zone formed by the ploughshare and the chest of the blade on one side and the

rear part of the adjacent hull on the other. Field studies of plow PL-2 and plow B Mirzaev have shown the performance of these plows at a depth of up to 25 cm only on flat areas of the field with insignificant content of plant residues on the surface [16]. With an increase in the depth of processing over 25 cm, the technological process of plowing was disrupted, the sealing of the plant mass turned out to be unsatisfactory, there were cases of soil unloading and soil unloading and clogging of the working bodies of plows. In order to eliminate these disadvantages, a constructive scheme of an asymmetric plow for smooth plowing is proposed, based on classical methods of placing working bodies [16]. According to the authors, the stepped arrangement of the plow hulls creates the necessary space for the turnover of the formation, reducing the likelihood of clogging.

Plows [17] have significant advantages over the plows described above, which are distinguished by the symmetrical arrangement of the working bodies of the same name relative to the longitudinal axis of the arable unit and the presence of left and right-turning housings. The design schemes of symmetrical plows are given in [17]. Symmetrical plows have a lower energy consumption in comparison with non-symmetrical ones due to the mutual balancing of lateral reactions of the soil on the working bodies and the elimination of torques relative to the tractor hitch. However, frontal symmetrical plows, in which the plow housings are located on the same line, are very sensitive to an increase in processing depth. At a great depth of processing, there is soil unloading in front of the hulls and clogging of the plow. This is due to the fact that the turnover of the formation is carried out in conditions of a furrow closed on both sides and is accompanied by crumpling of its ribs. In the description of the Alice-Chalmers plow [18], it is noted that the area of the deformation zone is 2.2% of the cross-sectional area of the formation, the ratio of the width of the formation to its thickness was equal to two. This circumstance was also highlighted in the works.

In order to reduce the volume of crushed soil while increasing the depth of cultivation, thereby improving the conditions for turning the formation into its own furrow, sectional [19] and two-tiered symmetrical plows were proposed. According to the authors, the arrangement of adjacent plow hulls with a longitudinal displacement creates a condition for the formation to turn in a furrow open on one side, which reduces soil deformation at the beginning of the formation rise, and improves the condition of its passage between adjacent hulls.

The short longitudinal dimension of the frontal plows creates favorable conditions for the development of combined tillage tools based on it, performing such operations during basic tillage for cotton, as plowing – soil deepening-loosening, ridge formation, etc. In this regard, a frontal plow equipped with soil excavators with an inclined stand [19] deserves attention, which in one pass performs smooth plowing with a turn of the formation into its own furrow and loosening of the sub-arable horizon, as well as combined devices containing devices for crushing cotton stems.

In our opinion, the most interesting is the combined plow [20], which simultaneously performs plowing, sub-tillage loosening of the compacted layers in the middle of the rows of cotton and the formation of ridges on the structural layers of the soil. Thus, on the basis of frontal plows, it is possible to develop combined wide-reach tools for energy-intensive tractors that perform several technological operations, taking into account the characteristics of the cotton field. In connection with the above, the introduction of a new technology of smooth plowing and frontal plows for its implementation in the cotton growing area is at this stage a timely, important and relevant task of great scientific and practical interest.

Conclusion. It has been established that the combined frontal plow is of the greatest interest, simultaneously performing smooth, rowless plowing, sub-tillage loosening of the compacted layers in the middle of the rows of cotton and the formation of ridges on the structural layers of the soil. On the basis of frontal plows, it is possible to develop combined wide-reach tools for energy-saturated tractors that perform several technological operations, taking into account the characteristics of the cotton field.

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