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Technologies and Technical Means for Decompression of the Subsurface Soil Horizon

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ABSTRACT

The existing technologies and technical means for decompression of the subsurface soil horizon are analyzed. The classification of tools for decompression of the subsurface soil horizon is given. In the results of the analysis of technology and technical means for decompression of the subsurface soil horizon, it was found that the most promising is the strip decompression of the subsurface soil layer.

Introduction. In the cotton growing zone, with the current system of annual basic tillage to the same (mainly 30 cm) depth, carrying out spare, washing and vegetation watering (up to 6-10 times a year), multiple (up to 30 times a year) passes through the field of tractors and other agricultural machinery. There is a strong compaction of the sub-arable horizons, it reaches 1.4-1.6 g/cm^3 in the main root zone, which is much higher than the values optimal for cotton, alfalfa, corn and other crops (1.2-1.3 g/cm^3) [1].

Numerous studies [1-3] have established the negative effect of compacted subsurface layers on plant growth and crop yield. These dense layers create extremely unfavorable conditions for the growth and development of the roots and the entire plant as a whole. The penetration of irrigation water and the root system into the compacted soil layers is difficult. In Texas, for example, distortion of the cotton root system was observed on compacted and dried soils [3].

The effectiveness of loosening the subsurface horizon in the cotton-growing zone was studied by F. Mamatov [4, 7, 9, 10], B. Mirzaev [5, 6], I. Avazov [8, 11] and others. Their research was carried out in various soil and climatic conditions. They came to the conclusion that under the influence of cultivation of the subsurface horizon, a more powerful root-habitable soil layer is created. This leads to an increase in the yield of cultivated crops. At the same time, the specific value of the yield increase varies depending on the conditions and technology of deepening the subsurface horizon.

In the USA, by eliminating the plow "sole" by chiseling on light loam, a fourfold increase in the yield of raw cotton was achieved [9].

Separate loosening is the most energy-intensive and least economical. Therefore, we did not consider technical means for separate loosening. Loosening of the subsurface layers can be carried out during plowing, before or after it. Therefore, existing tools are divided into plows with tillers and special tools that loosen the under-arable soil layer (Fig.1).

To loosen the sub-arable layers on plows, various working bodies were used as soil excavators: a spear-shaped paw (plow TP-4U of the Rostselmash plant), spring rippers (Wentsky's plow), crumbling ploughshares (Dominus plow, plow according to A.S. No. 1387883). Soil excavators – wedge-shaped knives (ripper plow according to A.S. No. 178584), a flat-cut paw with loosening elements (plow according to A.S. No. 1447297), small plow bodies (plow B-204A [9], pointed paws (plow PNP-4-35, PD-3-35, PLP-6-35-7, PLP-4-35-5 etc.), working bodies with racks inclined in a transversely vertical plane (Huard plows) [10, 13], etc.

In recent years, after the advent of Paraglaw-type ripper plows, researchers and developers have begun to pay more attention to working bodies with an inclined transverse plane rack. In their opinion, the use of working bodies with inclined racks can significantly reduce the energy intensity of soil loosening due to, the fact that the racks at the same time work in the zone of soil deformed by a chisel.

One of the first applications for working bodies with racks inclined in a transversely vertical plane was submitted back in 1921 in Czechoslovakia [14], which protected the design of the working body for deepening the arable horizon and destroying the plow sole. The soil dredgers were mounted on the frame of the gun or attached to the rack of the main body of the plow. During operation, the soil dredger, located below the level of the ploughshare blade, produced chipping and loosening of the soil.

Currently, soil excavators are used on plows of the French company Huard, the stand of which is located at an acute angle to the vertical [14]. It is noted that the most preferred position of the rack is an angle equal to 45°.

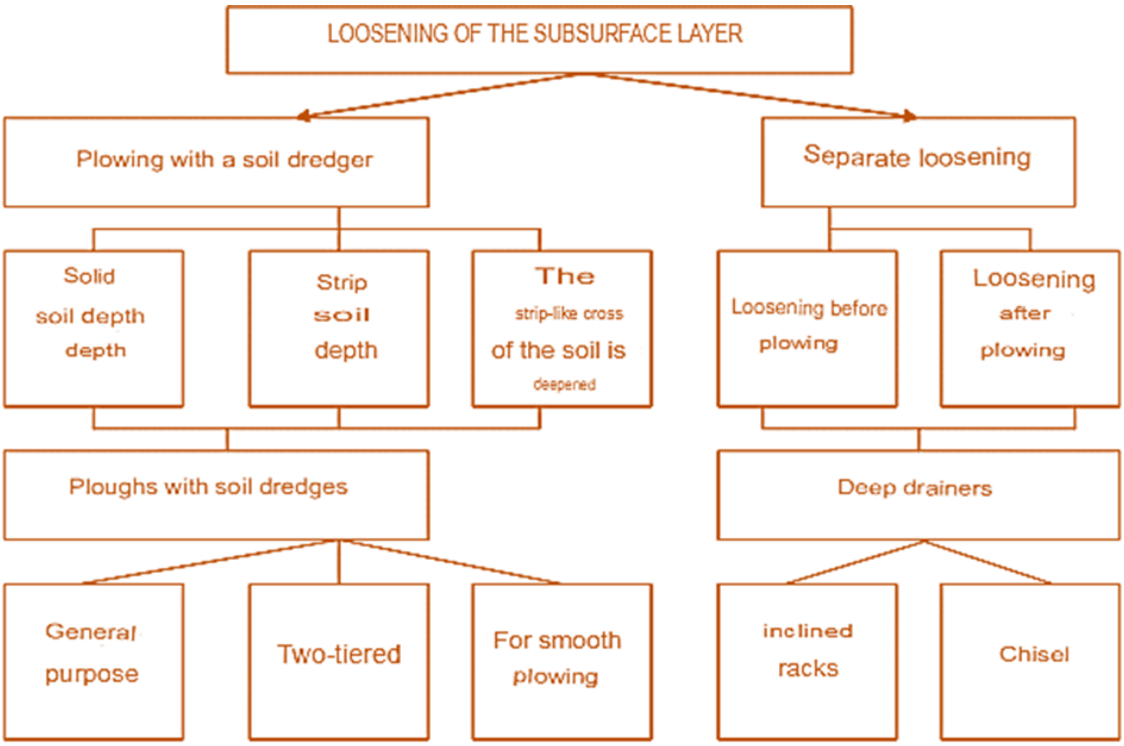

Fig.1. Classification of tools for basic tillage with working bodies for soil dredging

The firm "Dondesmell Engineering" (England) has developed the design of a soil dredger used on plows [15]. The stand of the soil dredger consists of vertical and inclined parts located at an angle of 45-600 to the vertical. The soil dredger is bolted to the rack of the ploughshare body or can be made as a single unit with a field board. The installation of a soil dredger to a depth of 12-15 cm below the level of the blade of the plowshare body ensures the chipping of the compacted soil layer over the entire width of the plow body.

The use of such a variety of working bodies as a soil dredger is caused by the desire to reduce the energy intensity of the process of loosening the subsurface layers, which in turn depends not only on the type and parameters of the working body, but also its location on the plow. Therefore, one of the areas of improvement of plows with tillers was to determine the rational location of the tillers.

At the very beginning, the soil dredgers were installed in front of the main body and loosened the subsurface layer behind the previous passage (plow "Apparatus 12") [16-18]. On the Schwartz plows, the soil dredgers were attached to the pillars of the main body from the side and also processed the bottom of the furrow of the previous passage.

Currently, the placement of soil excavators behind the main bodies of the plow has become the most widespread.

It should be noted that all of the above-mentioned plows with tillers were not intended for use in irrigation farming. Therefore, they are not widely used in this area.

The Altayselmash plant has produced prototypes of a two-tier PD-4-35S plow with soil excavators designed to work in the cotton growing area. PD-4-35S plows are available in semi-mounted and hinged versions. In the 4-body version, the plow works without soil dredgers. In the three-body version, the plow is equipped with soil-dredging paws installed behind the main bodies. The width of the paw grip when loosening to a depth of 7.5 cm or less is 350 mm; when processing to a depth of more than 7.5 cm – 300 mm. Serial two-tier PD-3-35 plows are equipped with the same soil dredgers.

Field experiments using a two-tier PD-3-35 plow with soil excavators have shown, along with the positive qualities, the negative sides of the plow operation. With a plowing depth of 30 cm and simultaneous loosening of the subsurface soil layer by 10-12 cm, the total traction resistance of the plow increases by almost 1.6-1.8 times. This leads to an overload of the T-4A tractor [19].

Ploughs for smooth plowing, which turn layers into their own furrows, were not equipped with soil dredgers. To date, such studies have not been conducted, although the short length, shorter in comparison with serial plows, specific energy and material consumption opens up great opportunities for creating combined tillage tools based on these plows, including with soil excavators.

Under-tillage loosening is carried out in the following ways: continuous, stripe and stripe-cross. Decompression of sub-arable horizons is an energy-intensive matter that requires high costs. Therefore, when choosing a method for loosening the subsurface soil layers, it is necessary to take into account the economic side of soil decompression, which includes [19]: 1–crop yield after soil decompression; 2-energy costs for processing over-compacted subsurface horizons; 3-reducing the service life of the main components of tillage tools (wear of working bodies, etc.); 4-economic damage from possible over-compaction of soils.

When eliminating the plow "sole" or compacted horizon, the American scientist M. Xalilov [20] recommends finding out the following: 1–a lack or excess of moisture is observed in this field; 2-surface loosening of the layer is required or, starting from the daytime surface, deep; 3-what we get as a result of this or that operation; 4- whether the loosened soil will be compacted again as a result of subsequent operations. The main disadvantages of continuous loosening are high energy consumption and over-compaction of the subsurface horizon. So, in Tajikistan, on old arable lands where cotton was grown, a compacted layer was formed annually, although plowing was carried out to a depth of 40 cm [20].

I.Temirov [18] believes that when the plow "sole" is eliminated, the elastic lattice of the earth, created over many years by roots, worms and other organisms, is destroyed. At the same time, favorable conditions are created for rapid compaction of the subsurface horizon.

With continuous loosening of the subsurface horizon, the traction resistance of the plow PYA-3-35 increases almost twice [18].

To eliminate these disadvantages, B.Tulaganov [19] proposed plowing with a ribbon deepening of the arable horizon up to 45-50 cm with an annual frequency or after 1-2 years. The second loosening is performed in the transverse direction with respect to the first, so squares with sides 120 x 120 cm or 150 x 150 cm remain unbroken. The width of the loosened part is 22-25 cm. With belt loosening with 175 cm tape intervals, the increase in the yield of spring wheat was 17.5%.

The ribbon-cross-stripe loosening of the sub-arable layers of cotton fields is proposed by B.Tulaganov [19]. When plowing with a plow PYA-3-35 and the width of the loosened tape is 25-30 cm, squares of 80 x 80 cm remain unbroken. It was found that strip-crossing and continuous loosening equally increase the yield of cotton by 2.5-3.0 kg/ha. The disadvantage of this method is that it is impossible to carry out a second loosening in the transverse direction, that is, perpendicular to the first, since in irrigation farming, mainly sowing is carried out in one direction. In addition, the distance between the loosened ribbons was chosen unreasonably.

Z.Batirov [20] suggests destroying the under-arable layer in strips through 60-80 cm to the required depth.

Thus, the width of the loosened and non-loosened parts, as well as the distance between the loosened tapes with strip and strip-cross methods of decompression of the subsurface soil layer, are insufficiently justified. Based on the above, it follows that continuous under-tillage loosening should be carried out in exceptional cases, since it is the most energy-intensive and least economical method. In addition, due to the decrease in load-bearing capacity, the subsurface layer is rapidly compacted due to the weight of the overlying soil layers and the compacting effect of tractors and agricultural machinery.

Conclusions. Continuous tillage should be carried out in exceptional cases, as it is the most energy-intensive and least economical. In the results of the analysis of technology and technical means for decompression of the subsurface soil horizon, it was found that the most promising is the strip decompression of the subsurface soil layer.

References

1. Mamatov F., Kodirov U. Energy-resourse saving machine for preparing soil for planting root crops on ridges // European Science Review, 125-1262016.
2. Mamatov F, Mirzaev B, Toshtemirov S, Hamroyev O, Razzaqov T. Study on the development of a machine to prepare the soil for cotton sowing on ridges// IOP Conference Series: Earth and Environmental Science 939 (1), 0120642021
3. Маматов Ф, Файзуллаев Х, Эргашев И, Мирзаев Б. Определение тягового сопротивления почвоуглубителя с наклонной стойкой// Международная агроинженерия 42, 2012.
4. Lobachevskij J, Mamatov F, Jergashev I. Frontal’nyj plug dlja hlopkovodstva// Hlopok 6, 35-37. 1991.

5. Fayzullaev K, Mamatov F, Mirzaev B, Irgashev D, Mustapakulov S. Study on mechanisms of tillage for melon cultivation under the film// E3S Web of Conferences 304, 030122021.
6. Mamatov F, Mirzaev B, Berdimuratov P, Aytmuratov M, Shaymardanov B. Traction resistances of the cotton seeder moulder// IOP Conference Series: Earth and Environmental Science 868 (1), 012052 2021.
7. Mirzaev B, Mamatov F, Tulaganov B, Sadirov A, Khudayqulov R. Suggestions on increasing the germination seeds of pasture fodder plants// E3S Web of Conferences 264, 040332021
8. Mamatov F, Mirzaev B, Avazov I. Agrotehnicheskie osnovy sozdanija protivojerozionnyh vlagosberegajushhih tehnicheskih sredstv obrabotki pochvy v uslovijah Uzbekistana// Prirodoobustrojstvo, 2014.
9. Toshtemirov S, Mamatov F, Batirov Z. Energy-resource-saving technologies and machine for preparing soil for sowing// European science review, 284-286. 2018
10. Лобачевский Я, Маматов Ф, Эргашев И. Фронтальный плуг для хлопководства// Хлопок, 35-37. 1991
11. Маматов Ф, Мирзаев Б, Авазов И. Агротехнические основы создания противоэрозионных влагосберегающих технических средств обработки почвы в условиях Узбекистана// Природообустройство, 86-88. 2014
12. Mamatov F, Karimov R, Gapparov S, Karshiev F, Choriyev R. Determination of the parameters of the canonical working body of the straw chopper// IOP Conference Series: Earth and Environmental Science 1076 (1), 012025. 2022
13. Маматов Ф, Эргашев И, Мирзаев Б, Мирзаходжаев Ш. Комбинированный фронтальный плуг// Сельский механизатор, 10-11. 2011
14. Mirzaev B, Mamatov F, Kodirov U, Shirinboyev X. Study on working bodies of the soil preparation machine for sowing potatoes// IOP Conference Series: Earth and Environmental Science 939 (1), 012068. 2021
15. Mamatov F, Karimov R, Gapparov S, Musurmonov I. Study of the parameters of the field of the cone-shaped working body straw chopper// IOP Conference Series: Earth and Environmental Science 1076 (1), 0120262022.
16. Маматов Ф, Батиров З, Мирзаев Б, Халилов М. Тяговое сопротивление глубокорыхлителя с тукопроводом-распределителем для трехслойного внесения удобрений// Молодой ученый, 252-255. 2013
17. Mamatov F, Mirzaev B. The new antierosion and water saving technologies and tools for soil cultivation under the conditions of Uzbekistan// Ekologiya i stroitelstvo, 2017.
18. Mamatov F, Temirov I, Berdimuratov P, Mambetsheripova A, Ochilov S. Study on plowing of cotton soil using two- tier plow// IOP Conference Series: Earth and Environmental Science 939 (1), 012066. 2021
19. Tulaganov B, Mirzaev B, Mamatov F, Yuldashev S, Rajabov N. Machines for strengthening the fodder of arid livestock// IOP Conference Series: Earth and Environmental Science 868 (1), 012062, 2021
20. Mamatov F., Batirov Z., Halilov M. Chisel-cultivator-fertilizer for forming ridges and applying fertilizers// European science review, 267-269. 2018