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Substantiation the technology and parameters of the “paraplau” type soil dredger for a two-tier plow

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Abstract. The purpose of the study was to substantiate the technology and parameters of the “paraplau” type soil dredger for a two-tier plow. The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. Sub-tillage loosening of the most compacted layers of the soil of the fields from under the cotton must be carried out in a strip way along the line of the middle of the irrigation furrows between the rows. It is established that for the implementation of strip loosening of the sub-arable soil layers of fields from under cotton, the width of the two-tier plow should be a multiple of the width of the row spacing. At the same time, for loosening the compacted subsurface layers of the middle of the row spacing of cotton with one working body, the soil dredgers are installed behind each even lower body in the plane of the field edges of the odd bodies. In the case of sub-tillage loosening of the middle of the row spacing by two soil dredgers with an inclined stand, one soil dredger is installed behind each lower body. An analytical relationship is obtained to justify the relative position of the plow bodies and the soil dredgers, as well as their parameters. Experimental studies have established that the resistivity of a two-tier plow decreases (in comparison with continuous loosening) when the most compacted layers of the middle of the row are loosened with a pointed paw by 17.56%, two soil dredgers with inclined posts by 24.04%, and one soil dredger with an inclined post by 23.24%.

1 Introduction

Loosening of the subsurface layers of the soil is the most energy-intensive process. To reduce energy costs, a strip method of loosening fields from under cotton and a soil dredger of the "Paraplow" type to a two-tier plow are proposed. The results of experimental studies of plows with different soil dredgers are presented [1-4].

In the cotton-growing zone, with the current system of annual basic tillage at 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 equipment, a strong compaction of the subsurface horizons occurs, reaching

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1.4-1.6 g/cm^3 in the main root-feeding zones, which is much higher than the optimal values for cotton, alfalfa, corn and other crops (1.2-1.3 g/cm^3). Studies 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 roots and the entire plant as a whole. In the compacted layers of the soil, the penetration of irrigation water and the root system is difficult [5-12].

It is known that subsurface loosening is one of the most effective ways to eliminate the harmful effects of compaction. The treatment of the sub-arable horizon creates a more powerful root layer of the soil. This contributes to an increase in the yield of cultivated crops. At the same time, the specific value of the yield growth value varies depending on the conditions and technology of deepening the subsurface horizon [13-20].

Sub-tillage loosening can be carried out separately or simultaneously with plowing. Currently, loosening during plowing with a plow with a soil dredger is widely used [21-28]. Research has established that sub-tillage loosening is the most energy-intensive process. For example, with a plowing depth of 30 cm and simultaneous loosening of the subsurface layer by 10-12 cm, the total traction resistance of the two-tier plow PD-3-35 increases by almost 1.6-1.8 times. Reducing energy costs can be achieved by improving the method of sub-tillage loosening of the soil and working bodies for its implementation. Currently, there are mainly two types of sub-tillage loosening: solid and strip. Continuous testing should be carried out in exceptional cases, as it is the most energy-intensive and uneconomical. In addition, with continuous loosening, due to a decrease in the load-bearing capacity, the subsurface layer is rapidly compacted due to the mass of the overlying soil layers and the compacting effect of tractors in agricultural machines [29-34].

The purpose of the study is to substantiate the technology and parameters of the “paraplau” type soil dredger for a two-tier plow.

2 Methods and Results

The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. Strip processing of the sub-arable compacted layers of cotton fields can be carried out with a combined two-tier plow, the width of which is a multiple of the width of the row spacing. In this case, as a loosening working body, one can use a pointed paw or a soil dredger with an inclined stand.

Let us consider the process of loosening the subsurface layers in the middle of the row spacing of cotton with a combined two-tier plow, the width of which is a multiple of the width of the row spacing, i.e., the width of the plow bodies $b_k=B_M/2$. Also, the condition satisfies plows PYA-4-30 and PD-2-45. To carry out strip processing for each even case, in the plane of the field edges of odd cases, one pointed paw is installed (Fig. 1) or a soil-dredging paw with an inclined stand (Fig.2). If the loosening width is insufficient, two soil-dredging lamps with inclined posts can be used to decompress the middle of each row of cotton (Fig. 3). In this case, one soil-dredging paw is installed behind each body.

The main design parameters of the loosening working bodies and their relative position relative to the plow bodies are determined depending on the required width of the loosened strip bp and the width of the row spacing B_M. From Fig. 1 we have

$$b_l \leq b_p-2(H-h)ctg\psi_2 \qquad (1)$$

where b_l – is the width of the grip of the pointed paw; h is the height of the wings of the paw from the plane passing through the toe.

The width of the bit b_g of the soil-dredging paw with an inclined stand when loosening the subsurface layer of the row spacing with one working body

$$b_l \leq b_p-2Hctg\psi_2 \qquad (2)$$

two working bodies (Fig. 1)

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$$b_g \leq \frac{b_p}{2}(H + h_r)ctg\psi_2 \tag{3}$$

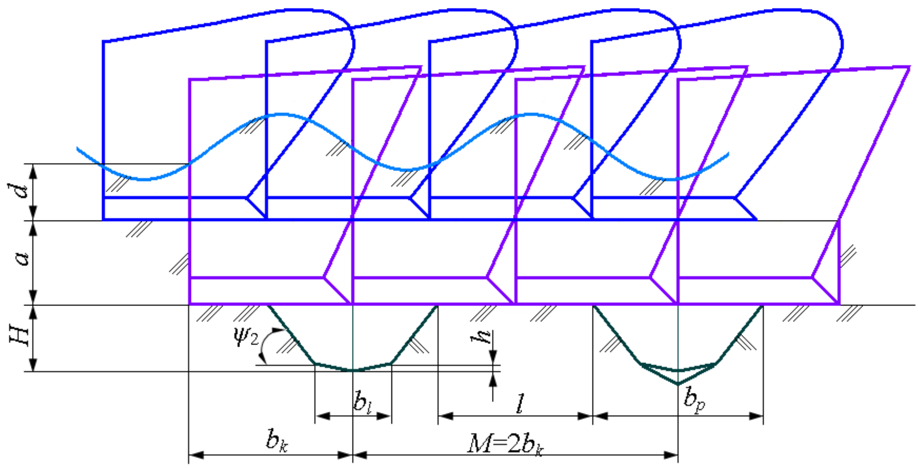

Fig. 1. Scheme for the justification of the mutual arrangement of the plow bodies and the pointed soil dredger: 1 – the relief of the cotton field; 2 – the upper body; 3 – the lower body; 4 – the soil dredger

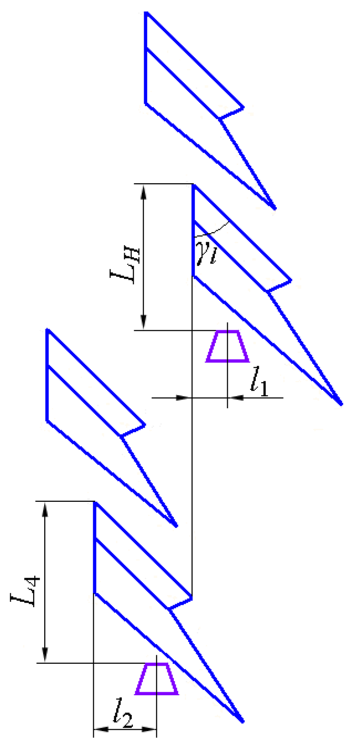

Fig. 2. Scheme for determining the relative position of the plow bodies and the soil dredgers when the middle of the row spacing is loosened by two soil dredgers with an inclined rack: 1 – the upper body; 2 – the lower body; 3 – the soil dredger

The value of the row spacing *M* when loosening the subsurface layer of the row spacing by two working bodies is equal to

$$M=b_g+2h_r ctg\psi_2 \quad (4)$$

The distance l between the loosened strips is determined by the following dependencies: when loosening with a pointed paw

$$l=B_M-b_l-2(H-h)ctg\psi_2 \quad (5)$$

when loosening with one soil-dredging paw with an inclined stand

$$l=B_M-b_g-2Hctg\psi_2 \quad (6)$$

when loosening with two soil-dredging paws

$$l=B_M-2b_g-2(H+h_r)ctg\psi_2 \quad (7)$$

When loosening the subsurface layer of the row spacing with one working body, the minimum longitudinal distance from the ploughshare toe to the soil dredger is determined (Fig.2) according to the formula:

$$L_{min}=b_k ctg\gamma_l+Hctg\psi_1 \quad (8)$$

For the implementation of subsurface loosening with two loosening working bodies, the soil-dredging paw is installed behind the odd bodies at a distance (Fig. 3)

$$L_H=(\frac{b_g}{2}+h_r ctg\psi_2)ctg\gamma_\wedge+Hctg\psi_1 \quad (9)$$

$$l_1=b_g/2+h_2 ctg\psi_2 \quad (10)$$

and behind the black buildings in the distance

$$L_4=(b_k-\frac{b_g}{2}-h_r ctg\psi_2)ctg\gamma_l+Hctg\psi_1 \quad (11)$$

$$l_2=b_k-b_g/2+h_r ctg\psi_2 \quad (12)$$

To compare the energy indicators of plows with continuous and strip loosening of the subsurface soil layers, experimental studies were conducted in the following variants: 1 - plow PYA-4-30 without soil dredgers; 2-plow PYA-4-30 with two pointed soil dredgers installed behind each even plow; 3-plow PYA-4-30 with four pointed soil dredgers; 4-plow PYA-4-30 with two soil dredgers with an inclined stand; 5-plow PYA-4-30 with four soil dredgers with an inclined stand.

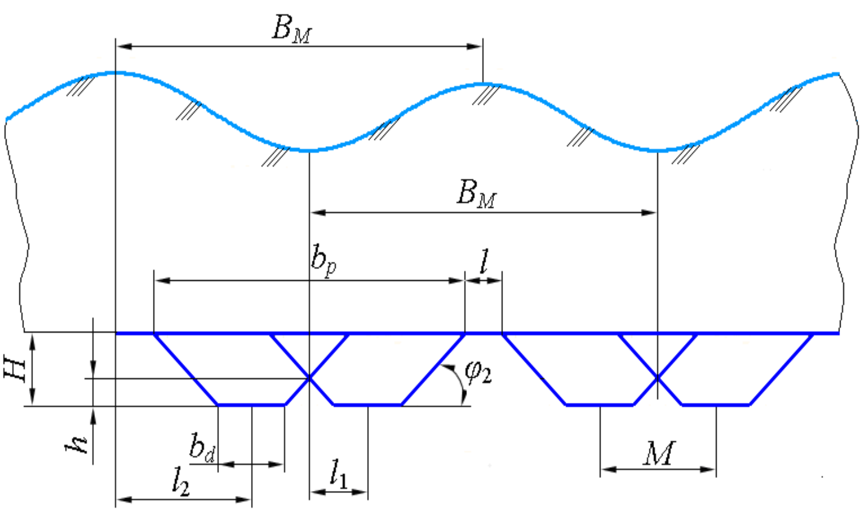

Fig. 3. Sub-arable loosening of the middle of the row spacing by two soil dredgers: 1 – the relief of the cotton field; 2 – the loosened sub-arable layer

On a two-tier plow, a pointed paw with a width of b_l-0.22 m, a crumbling angle of α=300 and a solution angle of γ=750 was installed. The parameters of the soil dredger with an

inclined stand were as follows: the bit width b_g=0.05 m, the crumbling angle a_g=150, the angle of inclination of the stand in the transverse-vertical plane $\beta_{ПОП}$=450, in the longitudinal-vertical plane β_{PR}=45º, in the longitudinal-vertical plane β_{PR}=200. The field for the experiments had a density of the subsurface horizon (0.30-0.50 m) in the middle of the irrigation furrow between the rows ρ=1.61 g / cm^3 and in the middle of the ridge ρ=1.53 g/cm3. The installation depth of loosening of the soil dredgers was 10 cm.
The background is a cotton field with a row spacing of 60 cm, previously cleared of cotton stalks. Humidity in the arable layer is 14.3-15.8%, in the sub-arable layer-16.7-18.1%. The soil is medium-loamy serozem.
As the results of experimental studies, Table.1 shows the specific traction resistance of the plow PYA-4-30 when installing pointed soil dredgers behind each body (continuous loosening) that increased by 33.94, when the most compacted subsurface layers were loosened in the middle of the row with two sterlet legs – by 16.38, two soil dredgers with an inclined stand by 9.9, and with one – 5.7%.

Table 1. Change in the traction resistance of plows depending on the type and number of soil dredgers

Variants	Plowing depth, cm	Plow grip width, cm	Traction resistance of the plow, kN	Plough resistivity, kPa	Increase in energy consumption, %
1	29.8	120.1	27.1	75.27	-
2	30.1	120.6	31.8	87.6	16.38
3	30.3	120.2	36.7	100.82	33.94
4	30.1	120.5	28.7	79.06	5.7
5	30.3	120.7	30.3	82.79	9.9

Thus, strip loosening of the most compacted soil layers is the least energy-intensive and most economical.

3 Conclusions

1. Sub-tillage loosening of the most compacted layers of the soil of the fields from under the cotton must be carried out in a strip way along the line of the middle of the irrigation furrows between the rows.
2. Continuous loosening should be carried out when plowing fields to a small depth, as well as when processing fields with closely lying pebbles, sand, gypsum and other layers that have unfavorable physical and mechanical properties.
3. It is established that for the implementation of strip loosening of the sub-arable soil layers of fields from under cotton, the width of the two-tier plow should be a multiple of the width of the row spacing. At the same time, for loosening the compacted subsurface layers of the middle of the row spacing of cotton with one working body, the soil dredgers are installed behind each even lower body in the plane of the field edges of the odd bodies. In the case of sub-tillage loosening of the middle of the row spacing by two soil dredgers with an inclined stand, one soil dredger is installed behind each lower body. An analytical relationship is obtained to justify the relative position of the plow bodies and the soil dredgers.
4. It is established that the resistivity of a two-tier plow decreases (in comparison with continuous loosening) when the most compacted layers of the middle of the row are loosened with a pointed paw by 17.56%, two soil dredgers with inclined posts by 24.04%, and one soil dredger with an inclined post by 23.24%.

References

1. F. M. Mamatov, E. Eshdavlatov, A. Suyunov, The Shape of the Mixing Chamber of the Continuous Mixer, *J Adv Research in Dynamical & Control Systems* **12**, 2016-2023 (2020)
2. F. Mamatov, I. Ergashev, S. Ochilov, X. Pardaev, Traction Resistance of Soil Submersibility Type "Paraplau", *J Adv Research in Dynamical & Control Systems* **12**, 2154-2161 (2020)
3. N. Aldoshin, F. Mamatov, I. Ismailov, G. Ergashov, Development of combined tillage tool for melon cultivation, *In Proceedings: 19th International Conference on Engineering for Rural Development*, Jelgava (2020)
4. U. Umurzakov, B. Mirzaev, F. Maмatov, H. Ravshanov, S. Kurbonov, A rationale of broach-plow's parameters of the ridge-stepped ploughing of slopes, *IOP Conf. Series: Earth and Environmental Science* **403**, 012163 (2019)
5. B. Mirzaev, F. Mamatov, D. Chuyanov, X. Ravshanov, G. Shodmonov, R. Tavashov, X. Fayzullayev, Combined machine for preparing soil for cropping of melons and gourds, *IOP Conf. Ser.: Earth Environ. Sci.* **403**, 012158 (2019)
6. B. Mirzaev, F. Mamatov, I. Ergashev, H. Ravshanov, Sh. Mirzaxodjaev, Sh. Kurbanov, U. Kodirov, G. Ergashev, Effect of fragmentation and pacing at spot ploughing on dry soils, *E3S Web of Conferences* **135**, 01065 (2019)
7. F. Mamatov, B. Mirzaev, M. Shoumarova, P. Berdimuratov, D. Khodzhaev, Comb former parameters for a cotton seeder, *International Journal of Engineering and Advanced Technology* **9**, 4824-4826 (2019)
8. F. Mamatov, B. Mirzaev, Z. Batirov, S. Toshtemirov, O. Tursunov, L. Bobojonov, Justification of machine parameters for ridge forming with simultaneous application of fertilizers, *IOP Conf. Series: Materials Science and Engineering* **883**, 012165 (2020)
9. B. Mirzaev, F. Mamatov, I. Avazov, S. Mardonov, Technologies and technical means for anti-erosion differentiated soil treatment system, E3S Web of Conferences **97**, 05036 (2019)
10. N. Aldoshin, O. Didmanidze, B. Mirzayev, F. Mamatov, Harvesting of mixed crops by axial rotary combines, *In Proceedings: 7th International Conference on Trends in Agricultural Engineering*, Prague, Czech Republic, 20-26 (2019)
11. B. Mirzaev, F. Mamatov, N. Aldoshin, M. Amonov, Anti-erosion two-stage tillage by ripper, *In Proceedings: 7th International Conference on Trends in Agricultural Engineering*, Prague, Czech Republic, 391-396 (2019)
12. B. Mirzaev, F. Maмatov, I. Ergashev, Y. Islomov, B. Toshtemirov, O. Tursunov, Restoring degraded rangelands in Uzbekistan, *Procedia Environmental Science, Engineering and Management* **6**, 395-404 (2019)
13. Z. U. Uzakov, F. M. Mamatov, O. Begulov, Implementation of object-oriented Programming technology in the one-dimensional oil displacement problem, *International Conference on information Science and Communications Technologies*, Tashkent, Uzbekistan (2019)
14. F. Mamatov, B. Mirzaev, P. Berdimuratov, Kh. Turkmenov, L. Muratov, G. Eshchanova, The stability stroke of cotton seeder moulder, *IOP Conf. Series: Materials Science and Engineering* **883**, 012145 (2020)
15. F. Mamatov, B. Mirzaev, O. Tursunov, A Justification of Broach-Plow's Parameters of the Ridge-Stepped Ploughing, *E3S Web of Conferences* **97**, 05035 (2019)
16. B. J. Ahmedov, B. S. Mirzaev, F. M. Mamatov, D. A. Khodzhaev, M. K. Julliev, Integrating of gis and gps for ionospheric perturbations in d- And f-layers using vlf receiver, InterCarto, *InterGIS* **26**, 547-560 (2020)

17. F. Mamatov, B. Mirzaev, O. Tursunov, S. Ochilov, D. Chorieva, Relief, physico-mechanical and technological properties of soil in the cotton growing area, *IOP Conf. Series: Earth and Environmental Science* **614**, 012169 (2020)
18. Z. Shamsutdinov, Sh. Ubaydullaev, N. Shamsutdinov, B. Mirzaev, F. Mamatov, N. Chorshabiyev, The concept of the phytogenic field: theory, research experience and practical significance, *IOP Conf. Series: Earth and Environmental Science* **614**, 012164 (2020)
19. U. Umurzakov, F. Mamatov, N. Aldoshin, B. Mirzaev, Exploration of tillage technologies in the Republic of Uzbekistan, *IOP Conf. Series: Earth and Environmental Science* **614**, 012168 (2020)
20. F. Mamatov, N. Aldoshin, B. Mirzaev, H. Ravshanov, Sh. Kurbanov, N. Rashidov, Development of a frontal plow for smooth, furless plowing with cutoffs, *IOP Conf. Series: Materials Science and Engineering* **1030**, 012135 (2021)
21. F. Mamatov, B. Mirzaev, Sh. Mirzahodzhaev, Z. Uzakov, D. Choriyeva, Development of a front plow with active and passive working bodies, *IOP Conf. Series: Materials Science and Engineering* **1030**, 012164 (2021)
22. F. M. Mamatov, E. Eshdavlatov, A. Suyuno, Continuous Feed Mixer Performance, *Journal of Advanced Research in Dynamical and Control Systems* **12**, 2195-2200 (2020)
23. F. Mamatov, I. Ergashev, B. Mirzaev, X. Pardaev, D. Chorieva, Research of the Penetration Process of the Frontal Plow, *Journal of Physics: Conference Series* **1779**, 012002 (2021)