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EXAMINATION OF A PLOUGH WITH INCREASED WORKING WIDTH OF THE LAST PLOUGH BODY

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Abstract

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The basic agro technical requirement for the ploughs is that they should turn over the soil layer. Through turning over the soil, the upper soil layer with damaged structure is found at the bottom of the furrow, while the lower layer with restored structure – on the surface. The widely used plough bodies with cylindrical form are not able to meet this requirement to a large extent. For this reason, the researchers' attention is turned towards the improvement of their technological characteristic features.

Plough PNO-2-35 has been examined, which has last right-turning plough body with higher working width for ploughing in 0.20 m depth. It has improved technological characteristics. By increasing the working speed of the plough from 2 to 6 km.h^{-1}, the sloping angle of the soil in relation to the horizon, the width of the furrow bottom and the tilling of the weeds, increase from 34° to 42°, from 0.36 to 0.40 m and from 95 to 100% respectively, while the crest height decreases from 0.14 to 0.03 m. The increase of the working speed of the plough within the abovementioned limits causes increase of the degree of turning over the upper half of the soil layer from 45% to 88.5%.

Key words: plough, plough body, soil layer, damaged structure

Introduction

The basic agrotechnical requirement for the ploughs is that they should turn over the soil layer. Through turning over the soil, the upper soil layer with damaged structure is found at the bottom of the furrow, while the lower layer with restored structure – on the surface. The widely used plough bodies with cylindrical form are not able to meet this requirement to a large extent. For this reason, the researchers' attention is turned towards the improvement of their technological characteristic features.

In order to improve the turning over of the soil layer, some of them modify the construction of the plough body, changing the slope of its flat edge (Gyachev, 1984), or making it window-type (Kirdin, 1988), others suggest two-ply ploughing and still others place active vertical discs in the front part (Bekana, 1993) or use coulters (Georgiev et al., 1985; Stanev and Shishkov, 1968). All these methods complicate the construction, without bringing significant improvement of the turning over of the layer. The analysis of the coulter performance proves that using it, it is impossible to achieve full turning over (Mandradjiev and

Kehayov, 2006).

It is possible to keep this requirement by reconstruction of the last plough body, increasing its working width (Mandradjiev and Kehayov, 2006).

The purpose of the present article is to analyze a plough, which has last plough body with higher working width.

Material and Method

The influence of two factors has been investigated – the ploughing depth and the advancing speed of turning over the soil layer. In order to establish the impact of the ploughing depth, it is necessary to manufacture plough bodies with adjustable height (Mandradjiev and Kehayov, 2006). So as to reduce the experiments, the working depth has been fixed a = 0.20 m, which also specifies the working width of the plough body.

The working speed has been selected in accordance with the actual working speeds when performing the ploughing process, whereas the speed range of the used tractor has also been taken into consideration – minimum speed V_{min} = 2 km.h^{-1} and maximum speed V_{max} = 7.2 km.h^{-1}.

The measured indexes are: sloping angle of the soil in relation to the horizon, width of the furrow bottom, crest height, tilling of the weeds and degree of turning over the soil.

The first four indexes have been measured in accordance with the standard methodology, and the last one – by preliminary placed blocks for the working depth on three levels and there are five blocks on each of the levels.

The type of soil of the experimental site is alluvial – meadow. The soil background is a weeded stubble-field.

The examinations have been carried out five times by the classical one-factor experiment and the hardness and dampness of the soil have also been controlled.

For the full turning over of the soil layer and a smooth ploughing, it is necessary to increase the working width of the last plough body. Plough PNO-2-35 has been used (Figure 1).

For this purpose, the plowshare and the tossing aside board of the second right-turning plough body

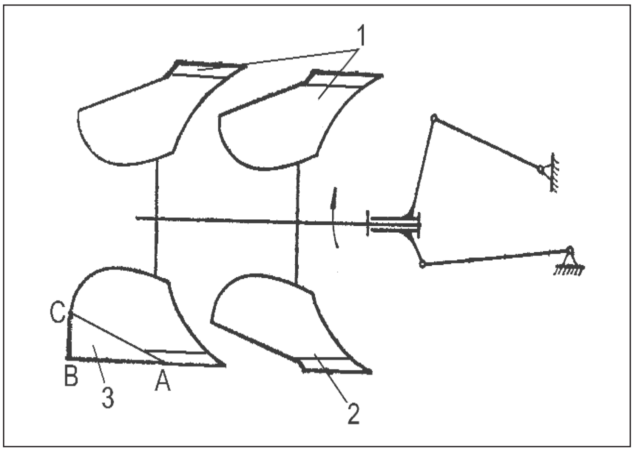

Fig. 1. Experimental plough PNO-2-35: 1 - left-turning plough bodies; 2 - right-turning plogh body; 3 - right-turning plough body with increase width

3 have been expanded by 0.44 m by means of the tossing aside surface ABC. In this way the right-turning plough bodies 2 and 3 have been prepared for work at depth a = 0.20 m. MTZ-80 tractor has been used.

Results and Discussion

The dampness of the soil at the time of the experiments for the layer of up to 0.10 m (Table 1) is 11.85% on the average, and for the 0.10 – 0.20 m layer – 16.51%, i.e. it is lower at the surface. The average humidity for the two days differs by 0.76% and can be practically considered as constant.

The soil hardness is lower at the surface layer (Table 1), where it is from 62.3.10^{-4} to 95.2.10^{-4} N.m^{-2}. The average values for the two days differ maximum by about 9%, which characterizes the soil as homogenous.

Table 1
Absolute humidity and hardness of the soil, %

Data	Humidity in horizon		Hardness in horizon	
	0.00 – 0.10 m	0.10 – 0.20 m	0.00 – 0.10 m	0.10 – 0.20 m
8.10.05	12.42	12.42	62.3	141.2
9.10.05	11.28	11.28	95.2	128.7

The experiment has been carried out at the following actual values of the advancing speed – I – 2.0 km.h^{-1}, II – 3.27 km.h^{-1}, III – 6.0 km.h^{-1} and IV – 7.2 km.h^{-1}. The working depth is a = 0.20 m.

The average values of the experimental data are given in Table 2.

The profile of the soil surface (Figure 2) has the shape of a rectangular trapezium, located with its smaller base downwards.

It is evident from Table 2 that with the increase of the advancing speed, the sloping angle of the soil δ_{no} increases, i.e. the side of the trapezium becomes steeper. The increase of δ_{no} for the individual speeds is from 1.07 to 1.14 times. This is explained by the greater shift of the soil aggregates in direction of the movement with the increase of the advancing speed (Table 3).

It is evident from Table 3 that this is the case for V_m = 2.0 ч 6.0 km.h^{-1} and for depth a = 0.00 ч 0.10 m. It is clear, that upon increasing the advancing speed and the working depth over the limits pointed above, the soil flows downwards and its moving forward becomes encumbered.

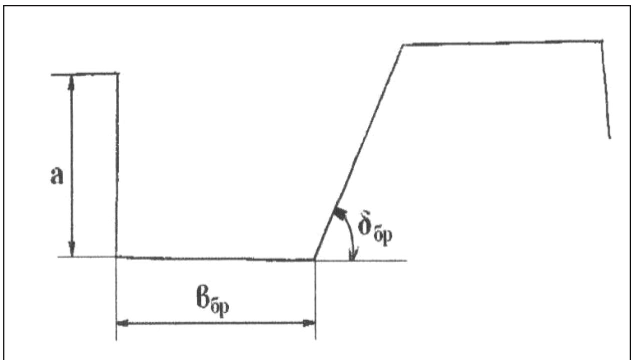

Fig. 2. Profile of the soil surface

The second index – the furrow width δ_{no} also increases with the increase of the advancing speed. Its increase for the separate speeds I between 1.1 and 1.20 times, which is commensurable with the increase of the sloping angle. This shows that with the increase of the advancing speed, the cross-section of the furrow tends to form a rectangle by expanding the lower base of the rectangular trapezium, while keeping almost constant length of the upper base.

The crest height decreases with the increase of the advancing speed, i.e. the soil surface is more leveled, which is logical.

The tilling of the weeds and vegetation remnants increases with the increase of the advancing speed, as the lowest value Yzpr = 95% > 90% = Yzpdop.

The degree of turning over the soil, depending on the working speed, is shown on Figure 3. It is obvious from the figure that with the increase of the speed, the degree of turning over Yzpr increases for all levels of working depth.

The highest degree of turning over has been registered at the upper soil layer and its value ranges from 73.5 to 88.5%. The degree of turning over at the lower soil layer is the lowest – from 16.5 to 30.0%. The degree of turning over the soil layer, depending on the working depth, is shown on Figure 4.

It is obvious from the figure that with the increase of the depth, the degree of turning over decreases. At the lowest speed (V_m = 2.0 km.h^{-1}) the degree of turning over shifts within the lowest limits – from 16.5 to 73.5%, whereas at the highest speed (V_m = 6.0 km.h^{-1}) – within the highest limits, from 30.0 to 88.5%.

In order to compare the work of the experimental plough, similar experiments have been carried out with a standard plough. The results are shown in Table 4.

If we compare the results from the different indexes from Table 2 and Table 4, it becomes obvious

Table 2
Average values of the experimental data

№	Indexes	Working speed, km.h^{-1}			
		2	3.27	6	7.2*
1	Sloping angle of the soil in relation to the horizon	34	39	42	48
2	Width of the furrow bottom, m	0.36	0.38	0.4	0.45
3	Crest height, m	0.14	0.1	0.03	0.02
4	Tilling of weeds, %	95	97	100	100
5	Degree of turning over the soil from depth, %				
	0.00 m	73.5	79	88.5	90
	0.10 m	45	66	88.4	25
	0.20 m	16.5	27.5	30	-

- not analyzed due to disturbed conditions of the experiment

Table 3
Longitudinal movement of the soil, cm

№	Movement of the soil from depth	Advancing speed, km.h^{-1}			
		2	3.27	6	7.2
1	0.00 m	43.6	43.8	48	42.8
2	0.10 m	33.6	37	41.2	34.2
3	0.20 m	24.3	22.5	10.5	-

that the newly created plough is characterized with a bigger sloping angle of the soil in relation to the horizon, wider furrow bottom and smaller height of the crests on the soil surface. The average value of weed tilling is 98.25%, while for the standard plough it is 64.07%, i.e. 1.53 times better. The average value of the turning over the soil for the newly created plough is 57.21%, whereas for the standard one it is 42.45%.

The turning over of the soil for the newly created plough is better by 14.76%.

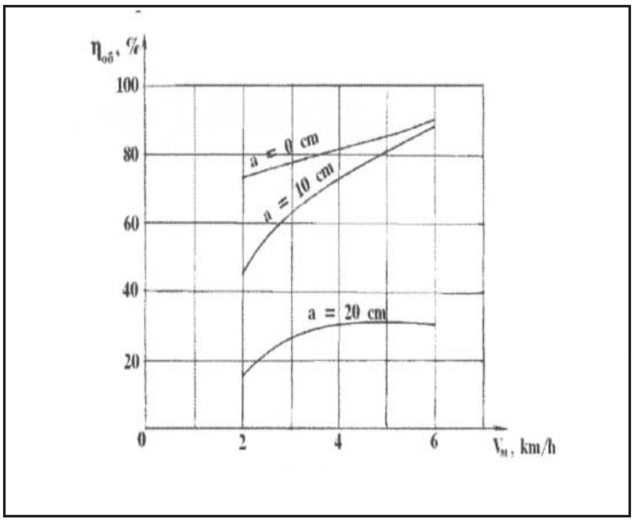

Fig. 3. Degree of turning over the soil layer, depending on the working speed V_m

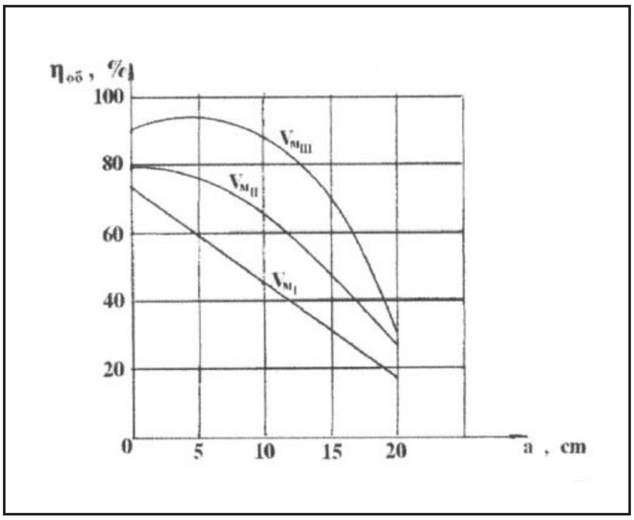

Fig. 4. Degree of turning over the soil layer, depending on the working depth

Table 4
Results from the experiments with a plough with standard plough bodies

№	Indexes	Working speed, km.h^{-1}			
		2	3.27	6	7.2
1	Sloping angle of the soil in relation to the horizon	32	30.8	28.9	28.9
2	Width of the furrow bottom, m	0.252	0.264	0.268	0.302
3	Crest height, m	0.222	0.178	0.164	0.106
4	Tilling of weeds, %	60.2	65.6	64.3	66.2
5	Degree of turning over the soil from depth, %				
	0.00 m	53.2	64.4	65.1	64.8
	0.10 m	42	43.2	42.8	42.9
	0.20 m	14.1	21.2	28.7	27

In conclusion, as a whole, the plough, in which the last plough body has a bigger working width, have better indexes than the standard one. In order this to be used for ploughing at different depth, it is necessary the last plough body to have adjustable working height.

Conclusion

Plough PNO-2-35 has been examined, which has last right-turning plough body with higher working width for ploughing in 0.20 m depth. It has improved technological characteristics. By increasing the working speed of the plough from 2 to 6 km.h^{-1}, the sloping angle of the soil in relation to the horizon, the width of the furrow bottom and the tilling of the weeds, increase from 34° to 42°, from 0.36 to 0.40 m and from 95 to 100% respectively, while the crest height decreases from 0,14 to 0,03 m. The increase of the working speed of the plough within the abovementioned limits causes increase of the degree of turning over the upper half of the soil layer from 45% to 88.5%.

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