INNOVATION SOIL-PROTECTING WORKING ORGANS OF A UNIVERSAL CHISEL PLOW

ИННОВАЦИОННЫЕ ПОЧВОЗАЩИТНЫЕ РАБОЧИЕ ОРГАНЫ УНИВЕРСАЛЬНОГО ЧИЗЕЛЯ

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Abstract: *In this article there were studied the factors of the origin of anthropogenic soil degradation in the result of its processing with soil-processing tools of different types and there were presented the results of carried out researches. There were worked out the recommendations on decrease of their influence on processing soil horizons and there was offered the innovation working organ decreasing the negative influence on soil.*

Keywords: *chisel plow, working organ, soil processing, reproduction of fertility, anthropogenic degradation***.**

Аннотация: *В данной статье изучены факторы возникновения техногенной деградации почвы в результате ее обработки почвообрабатывающими орудиями разных типов и представлены результаты проведенных исследований. Разработаны рекомендации по снижению их влияния на обрабатываемые почвенные горизонты и предложен инновационный рабочий орган, уменьшающий отрицательное воздействие на почву.*

Ключевые слова*: чизель, рабочий орган, обработка почвы, воспроизводство плодородия, техногенная деградация.*

1. Introduction

The most important task of rational use of soil is provision of reproduction of fertility, one of the conditions of which is a creation of a deep loose layer, the presence of which allows to shorten the amount of following processing of the layer and remultiplex of the layer, to provide the conditions to accumulate the humus.

The remultiplex of the layer depends on humus content and physical clay in soil, it is explained by their colloidal properties [1].The counter-compaction manifests itself when a sufficient amount of organic matter and moisture. In the zone of insufficient moistening the processes of mineralization of humus prevail over its formation, so the remultiplex increases the density of soil.

2. Preconditions and means of solving of the problem

When working moldboard plows, the density of soil in blocks in 1.24 times higher than in the same layer before processing, and the solidness of soil of the bottom furrow in 1,5...2,0 times more than before processing with a moldboard plow [2].

Remultiplex of soil is able to lead to physical degradation which present the process of negative transformation of the layer's structure with micromorphometric side, the result of which is a decrease of agronomically valuable aggregates amount. Without treatment the layer under prolonged condition in the regime of deposits can no longer thin out to the natural state, but the density of soil is able to decline from 1.40 to 1.50 to 1.20.....of 1.28 g/cm3 [3].

With increase of organic matter in soil the optimum of density of arable layer is shifted in the direction of decrease of its values. According to the regulations of changes of physical properties of chernozems depending on the nature of human impact the ranges of values of optimal density of the arable layer is 1.10...1.25 g/cm3, the critical one – more than 1.35 g/cm3 when the content of humus 3,5...4,5% [4].

According to mechanical (particle size) composition the ordinary chernozems belong to light-clayey soils with the content of physical clay of 63.3 - 66.7%, dust – to 57.4-62.6%, sand – 4,6-6,3% (Table 1).

Silty fraction which is one of the main structure-forming factors is comparatively high in soil – 30,9-37,5%. The high content of dust explains the insufficient stability of soils to mechanical influence during the processing. According to sums of fractions the soils concern to silty-dusty light clays.

A positive feature of black soil is that they do not hinder the deepening of the root system of cultivated cultures, have a good structure, units are characterized by weak cohesion (cohesion), water and air in these soils are not antagonists. From 13 to 15% of its common stock in the meter layer comes to the share of unavailable moisture for the plant.

A negative feature is that a large % of dust fractions (of 57.4 66.7%) are contained in the processing layer.

The content of water-proof units (Table 2) is increased with the growth of depth of sampling of a soil pattern and is determined by the characteristics of the structure of solid phases, a number of organic substances that is formed as the result of irreversible coagulation.

Table 1 – Results of granulometric analysis of soil (in average)

Depth pattern, cm	Fraction content, %					
	water-proof units (0,25-5,0 mm)	agronomically valuable units (0,25-10,0 mm)	silt (< 0,001 mm)	clay (< 0,01 mm)	dust (0,05-0,002 мм)	sand (1-0,05 mm)
chernozems ordinary poor humus high light clayey on forest-type clays						
5-15	70,6	72,0	30,9	63,3	62,6	6,3
15-25	58,0	64,9	36,6	66,7	57,4	6,0
25-35	75,2	75,0	37,5	66,7	57,9	4,6

The water-proof of the bottom half of arable (15-25 cm) and sub-arable (25-35 cm) of soil layers is highly expressed. So at a depth of 15-25 cm, the amount of water-soluble units by 17.4% higher compared to the layer of 5-15 cm, at a depth of 25-35 cm – 24.6%.

It follows from the foregoing that the deepening of arable layer and its mixing with subsoil layer is reasonable on black soil, because the structural layers with more water-proof units are introduced into the culture and microbiological processes are accelerated.

Table 2 – Physical properties of soil (in average)

Depth of pattern, cm	Hygroscopic moisture, %	Soil density, g/cm^3	Density of solid phase, g/cm^3	Porosity,%
5-15	4,7	1,19	2,68	56
15-25	4,4	1,34	2,69	50
25-35	4,6	1,32	2,68	51

Common chernozem has a high absorption capacity. The largest part of absorbed bases comes to calcium cations in the processed layer. It promotes the formation of proper soil structure, is favorable to its water-air regime. The density of the processed layer is 1,19-1,34 g/cm^3, specific mass (density of solid phase) 2,68-2,69 g/cm^3 shows the provision of soil with organic substance (Table 2), ability to resist to remultiplex of the layer.

The density of soil in the layer 5-15 cm is the least and amounts 1,19 g/cm^3, it corresponds to the loose condition, below profile the degree of compaction increases to 1,32-1,34 g/cm^3. The lower part of the arable layer and the subsurface layer has almost an equal density. The same applies to the porosity, and the density of the solid phase, on the contrary, are almost identical in all layers (2,68-2,69 g/cm3).

The analysis of structural content of soil before treatment showed that the content of agronomically valuable units (0,25...10 мм) is the most in soil layer 25-35 cm (75%), the least – in the layer 15-25 cm (65%), and in the upper one 5-10 cm amounts (72%) (Table 3).

Table 3 – Data on structural content of soil

Depth of taking of a sample, cm	*content of fractions in % from absolutely dry soil*								*Agronomically valuable air-dry units, 0,25-10 mm*
	>10mm	*10-5 mm*	*5-3 mm*	*3-2 mm*	*2-1 mm*	*1-0,5 mm*	*0,5-0,25 mm*	*<0,25 mm*	
Chernozems common weak humus powerful light clayey forest-type clays									
Before processing									
5-15	*17,7*	*16,7*	*11,5*	*8,4*	*14,6*	*10,4*	*10,4*	*10,3*	*72,0*
15-25	*32,9*	*28,1*	*16,8*	*7,5*	*6,7*	*3,4*	*2,4*	*2,2*	*64,9*
25-35	*21,6*	*27,9*	*18,8*	*9,5*	*10,0*	*5,2*	*3,6*	*3,4*	*75,0*
Hinge-fixed claws (depth 27 cm)									
5-15	*11,5*	*17,4*	*16,7*	*12,1*	*16,1*	*9,5*	*8,8*	*7,9*	*80,6*
15-25	*21,0*	*24,0*	*14,5*	*8,6*	*11,2*	*8,2*	*6,6*	*5,9*	*73,1*
25-35	*31,3*	*23,0*	*12,4*	*7,5*	*9,4*	*6,2*	*5,4*	*4,8*	*63,9*
Without claws (depth 34 cm)									
5-15	*53,1*	*9,5*	*5,6*	*4,9*	*8,4*	*6,7*	*5,9*	*5,9*	*41,0*
15-25	*25,8*	*20,6*	*11,4*	*7,6*	*11,1*	*8,4*	*7,8*	*7,3*	*66,9*
25-35	*11,8*	*29,6*	*19,0*	*11,*	*11,8*	*6,9*	*5,1*	*4,8*	*83,4*

With the prevalence of agronomically valuable units in the structure of the reservoir the moisture through pores is distributed within the soil and is retained in it. Under these conditions, the decomposition of organic matter by anaerobic bacteria is accompanied by the formation of vegetable acid.

In pores which are present on surface of structural soil, the aerobic processes are present in them, it accompanies by the formation of humic acid. The formation of vegetable and humic acids promotes to the structuring of micro-units of soil under interaction with the calcium ion. This process is irreversible and destroyed by mechanical influence of the soil structure can be restored at the presence of fresh humus.

It is reasonable periodically to carry out the deep soil treatment. There was used the soil with expressed structure, with agronomically valuable water-containing units improving the physical-mechanical properties in the whole layer and it leads to the increase of processes of microorganisms' life. The working organs must be soil-protecting and the technological process must be energy-saving.

3. Solving of the problem

The present innovation working organs of the chisel plow (Figure1) contain hinge-fixed claws, the corner of the installation relatively to the pole with the chisel in cross-vertical plane is determined by the action of forces of soil resistance and the destruction of the layer is made by differently directed shifts of movable elements (claws).

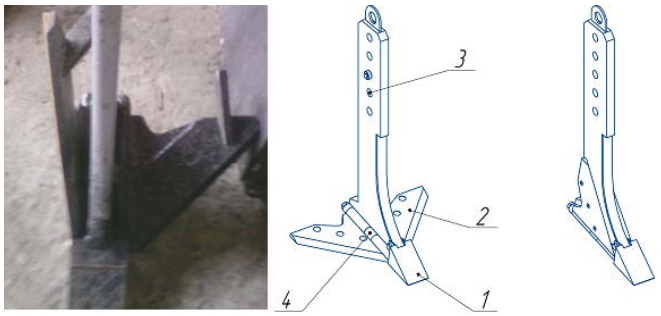

Figure 1 – Scheme of the working organ of the chisel plow: 1 – chisel plow; 2 – flat-cut claw; 3 – hole for changing of depth; 4 – hinged junction for self-adjustment of claws under the angle of soil chip

A comparative analysis of the structural composition of the soil before and after treatment with the chisel plow (Table 3) indicates an increase in the content of agronomically valuable units in layers 5-15 cm and 15-25 cm by 8.2% and 8.6% when using the innovation of the working organ with hinged claws.

The sharp decrease in the content of agronomically valuable units occurs under no claw tillage, on the contrary, in the layer of 5-15 cm there (from 72,0 to 41.0%), in the layer of 15-25 cm – remains the same (and 64.9, and 66.9%), and increases by 8.4% in the layer of 25-35 cm at the depth of the passage of the chisel plow.

So, it is possible to note the increase in the number of agronomically valuable units in layers 5-15 cm and 15-25 cm under the soil treatment by the chisel plow with hinged claws and in the layer of 25-35 cm without claws.

The comparison of a number of agronomically valuable units before and after chiseling to the depth of 34 cm shows that the soil structure deteriorates after processing in the layer of 5-15 cm and improves in the layer of 25-35 cm, being almost constant in the middle layer (15-25 cm).

The destruction of the layer with innovative working organs with hinged claws is carried by the way of the least resistance due to the self-adjustment at the natural angle of the soil chip.

It is confirmed by the reduction of traction resistance (by 12.27%) and specific energy consumption (1.14-fold) in the use of innovative working organs with hinge-fixed claws (table 4) compared with the flat-cutter [5-8], obtained from the experimental studies (Figure 2).

4. Results and discussion

Table 4 – Results of experimental research of energetic indexes of the chisel plow with innovation working organs

Title of index	Value of the type of the working organ	
	Hinge-fixed claws	Flat-cutter
Mode of work: speed, km\h, depth, cm	6,10 27	6,10 27
Traction resistance, кН	32,52±3,2	37,07±3,8
Decrease of traction		

resistance of the chisel plow, %	12,27	–
Specific energy capacity, KWt·h/ga	33,21	37,76
Decrease of specific energy capacity	1,14	–

Figure 2 – Experimental research of the chisel plow

This is confirmed by the theoretically obtained pattern [9-12] of changes of traction resistance of the chisel plow with innovative working units with hinged claws:

$$P_T = f \cdot G + (k + \varepsilon\upsilon^2) \cdot (((n-1)M + b)a - ((n-1)(\frac{(M-b)^2}{4} ctg\frac{\omega}{2} + (M-b) \cdot l' \cdot \sin\beta)) \quad (1)$$

where P_T – traction resistance, кН; f, k, ε, – coefficients; υ – velocity, м/с; G – weight, кН; n – amount of working organs; M – distance between working organs; B_K – construction of width of the chisel plow capture; $в$ – width of the chisel plow; a – depth of layer tillage; ω – angle of working organ; h_0 – length of exposed part of the chisel plow (relatively claws) (Figure 3).

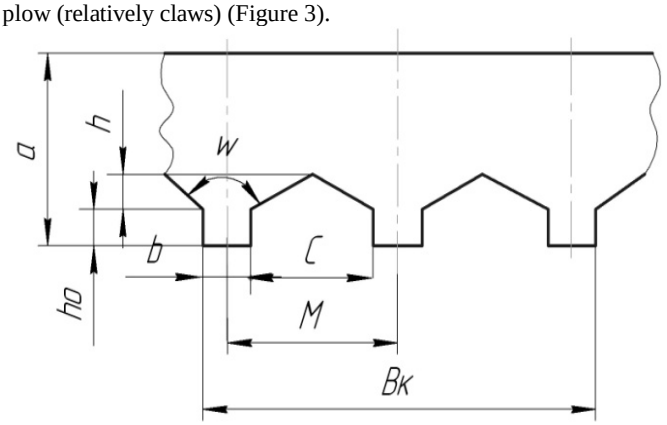

Figure 3 – Scheme of transversal section of the layer under operation of the chisel plow

From the comparison with the same regularity (2) for the flat-cutter, it follows that the reduction of traction resistance of the chisel plow with innovative working units with hinged claws is observed due to the decrease of cultivated area of the cross section of the layer.

$$P_T(плоскорез) = f \cdot G + (k + \varepsilon\upsilon^2) \cdot ((n-1)M + b)a \quad (2)$$

Results of the calculation are presented in the Table 5.

Table 5 – Results of researches of the traction resistance of the chisel plow with different types of working organs

Type of working organ	Traction resistance, кН	
	Teoretical	Experimental
Flat-cutter	37,05	37,07
Hinge-fixed claws	33,26	33,72

Comparative analysis of data of Table 5 allows you to set the relative error not more than 1.5%, indicating the adequacy of the theoretical results to the real process.

Thus, the deep tillage by the moldboard chisel with innovative working organs with hinged claws [13] is agrotechnologically appropriate, energy-saving and soil-protecting technique of soil treatment directed to the ensuring of the reproduction of its fertility.

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