Resource efficient and erosion preventive integrated high- and lowland aggregate

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Abstract: *The article proposes a fundamentally new design of a resource-saving, anti-erosion unit that significantly improves the quality of soil tillage in cultivating agricultural crops, improves the productivity of the plow, significantly eliminates soil erosion and reduces the fuel consumption of the tractor by reducing the traction resistance.*

The construction of the unit and the principle of its operation are described in detail. It can be successfully used both in plain and in mountainous terrain.

Characteristic similarity criteria and a criterion equation for studying the traction force of the proposed unit are obtained and their physical meaning is revealed

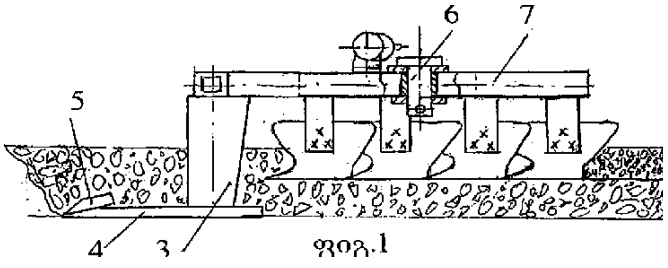
KEYOBWORDS*: SOIL EROSION, UNIT, PRODUCTIVITY, FUEL CONSUMPTION, MECHANIZATION, SIMILARITY CRITERION, CRITERION EQUATION .*

It is known that at basic tillage with common ploughshare is created the dense bottom surface of the soil that can hold water and causes water erosion. As a result, the crop productivity and soil looseness quality are reduced.

Based on the results of the research conducted it is determined that the primary tillage with chisel plow completely or significantly avoids the cultivated soil erosion phenomenon on the slopes. Due to high pressure area on the chisel ploughshare surface, the soil bottom dense layer is completely destroyed and break surface is formed which allows to penetrate in greater depth and to maintain soil humidity that contributes to better development of the root system and sharp increase of crop yield. Due to the received results it is defined that by using the mentioned tillage method the crop yield of the corn is by 35% higher than at tillage by common ploughshare [1,2,3]. It is also known that productivity of smooth tillage plough is 23-43% higher than the mould board-double furrow tillage ploughs, fuel consumption is reduced by 28-39%, and area of cultivated land is higher by 7 - 8% [4].

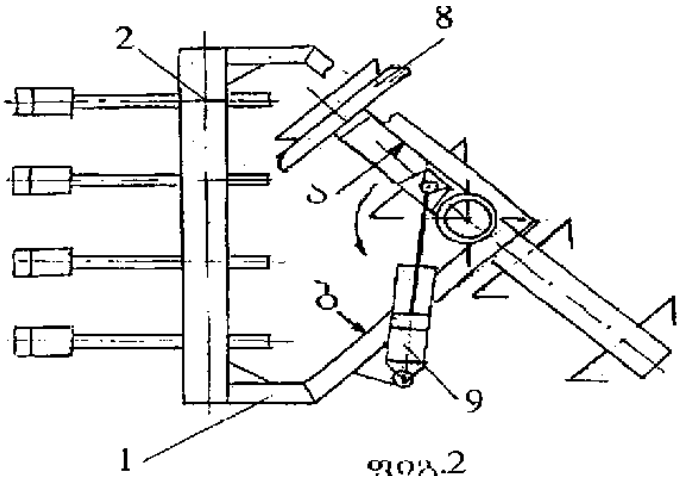
Problem is rather important and essential as the large part of agriculturally used areas in Georgia are located in small contour areas and slanting slopes that stipulates the advisability of mention areas tillage by chisel plough.

Novelty of the question lies in the fact that there will be developed completely new component insertion construction of resource efficient and erosion preventive integrated high - and lowland agricultural aggregate which is registered with the National Intellectual Property Centre “Sakpatenti"[5, 6]. The basic essence of this aggregate is that it has a frame, chisel poles with attached abutments and ploughshare and plough wings. The chisel poles are installed frontally on the frame crossbar, while the plough wings are symmetric and are installed sequent on rotational beam jointly connected with rear frame of chisel poles. In addition, with the aid of hydro-cylinder, the beam has the possibility of rotating around the connected with the frame juncture (Fig. 1 and 2).



ფიგ.1

Fig. 1



ფიგ.2

Fig. 2

1. Frame; 2. Crossbar; 3. Chisel pole; 4. Abutment; 5. Plough-share; 6. Joint;
7. Rotational beam; 8. Plough symmetrical wing; 9.Hydro-cylinder.

Constructional novelty of the offered aggregate lies in the fact that chisel poles with abutments and ploughshare are rigidly attached to the frame crossbar, while the chisel plough symmetrical wings are successively located behind chisel poles and are installed on the rotational beam.[5,6]

The plough’s symmetric wings are working both in left and in right positions through turning rotational beam with the aid of hydro-cylinder, thus it is carried out the upper productive soil layer turn-over by smooth tillage principle that significantly improves the quality of tillage, increases capacity and reliability of the aggregate, decreases erosive processes and the tillage time, reduces fuel consumption.

Scientific and engineering innovation of the tasks set is the technology concept of functioning of the offered aggregate, its completely new constructional compatibility that stipulates the innovative approaches to execution of works and coping with the challenges stated in, aggregate appropriation, application area, working conditions and determination of stated technical requirements in accordance with its basic parameters and technical performances.

To study the performance of this unit, we used the theory of similarity and variability, which allows you to plan targeted experiments in advance and take into account the simultaneous influence of various factors on the parameter being studied ..
Based on the analysis of literary sources [7,8,9], we established the main factors that significantly affect the performance of the unit (tab. 1)

Table .1: *The list of factors affecting the performance of resource-saving anti-erosion unit*

#	Optimization parameter and factors	Designation	Dimension in SI system	Dimension expressed by symbols of values
1	Unit Performance	W	m^2/s	L^2T^{-1}
2	Working width	B	m	L
3	Processing depth	*h*	m	L
4	Soil resistivity	K	n/m^2	$ML^{-1}T^{-2}$
5	Plowing speed	V	$m \cdot s^{-1}$	LT^{-1}
6	Traction force	P	n	MLT^{-2}

The functional dependence between the optimization parameter and factors acting on it has the form:

$$W = f\ (B, h, K, V, P) \ldots \qquad (.1)$$

This dependence can be expressed in the form of similarity criteria. We use the $\pi -$ theorem for this:

$r = N - n$= 6-3=3

r - is the number of criteria, N- the number of factors, n – the number of main factors. We choose B, V and P as the main factors. Their dimensions are:

$$[V] = LM^0T^{-1}$$
$$[B] = LM^0T^0$$
$$[P] = LMT^{-2}$$

The determinant of powers of their degrees must not be equal to zero.

$$D = \begin{vmatrix} 1 & 0 & -1 \\ 1 & 0 & 0 \\ 1 & 1 & -2 \end{vmatrix}$$

$D = -1 = 0$ \

The similarity criteria are equal:

$$\pi = WV^{\alpha}B^{\beta}P^{\gamma} = 1$$
$$\pi_1 = hV^{a_1}B^{\beta_1}P^{\gamma_1} = 1$$
$$\pi_2 = K_1V^{a_2}B^{\beta_2}P^{\gamma_2} = 1$$

$WV^{\alpha}B^{\beta}P^{\gamma} = L^2T^{-1}\ L^{\alpha}T^{-\alpha}L^{\beta}L^{\gamma}M^{\gamma}\ T^{-2\gamma} = L^0T^0M^0 = 1$

We obtain the linear equations:

$$2 + \alpha + \beta + \gamma = 0$$
$$-1 - \alpha - 2\gamma = 0$$
$$\gamma = 0$$

Their solution results in: $\alpha = -1;\ \beta = -1;\ \gamma = 0$

Therefore, the similarity criterion to be determined is equal:

$$\pi = \frac{W}{BV}$$

Similarly, we obtain the other determining criteria:

$$\pi_1 = \frac{h}{B};\quad \pi_2 = \frac{KB^2}{P};$$

The standard form of the criterion equation has the following mathematical expression:

$$\pi = \varphi(\pi_1, \pi_2,) \ldots \qquad (2)$$

or

$$\frac{W}{BV} = \varphi\left(\frac{h}{B}, \frac{KB^2}{P}\right) \ldots \qquad (3)$$

The obtained criterion equation is the basis for the purposeful designing ; we have designed trials according to it. The functional dependencies between the similarity criteria have the form

$$\frac{W}{BV} = c\left(\frac{h}{B}\right)^x;$$
$$\frac{W}{BV} = c_1\left(\frac{KB^2}{P}\right)^{x_2};$$

After taking of logarithm of the obtained expression and summing we will obtain:

$$2lg\frac{W}{BV} = lgc + lgc_1 + xlg\frac{h}{B} + x_1lg\frac{KB^2}{QV}$$

We take antilogarithms of the latter expression and obtain:

$$\frac{W}{BV} = A\left(\frac{h}{B}\right)^a\ \left(\frac{KB^2}{P}\right)^b \ldots (4)$$

where $A = \sqrt{c \cdot c_1 \cdot c_2}$;

$$a = \frac{x}{2};\ b = \frac{x_1}{2};$$

Constant coefficients c, c_1 and exponents x, x_1 characterize the simultaneous influence of individual factors on the performance of a resource-saving anti-erosion aggregate

Findings

1. A fundamentally new design of a resource-saving, anti-erosion aggregate is proposed, which significantly improves the quality of soil cultivation when cultivating crops, increases the productivity of the plow, significantly eliminates soil erosion and reduces tractor fuel consumption by reducing traction resistance.
2. The unit we offer can be successfully used both on the plain and in mountainous terrain.
3. Characteristic similarity criteria and a criterion equation for the study of the proposed unit are obtained and a technique for targeted experiments is developed.

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