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SUBSTANTIATION OF PARAMETERS OF PLOWING TOOL FOR LAYERED CULTIVATION OF SLOPE SOILS

Aramayis M. Yesoyan
Armenian National Agrarian University
74 Teryan St., Yerevan, RA
esoyan.62@mail.ru
ORCID iD: 0000-0001-6028-340X
Republic of Armenia

Pargev A. Tonapetyan
Armenian National Agrarian University
74 Teryan St., Yerevan, RA
tonapetyan.pargev@mail.ru
ORCID iD: 0000-0002-1000-0720
Republic of Armenia

Pavlik Yu. Gasparyan
Shushi University of Technology
7 V.Vagharshyan, Stepanakert, RA
pavel64@yandex.ru
ORCID iD: 0000-0002-3764-6935
Republic of Artsakh

Anush P. Tonapetyan
Armenian National Agrarian University
74 Teryan St., Yerevan, RA
An7_777@bk.ru
ORCID iD: 0000-0001-5390-6867
Republic of Armenia

Abstract

One of the most important factors in increasing soil fertility is the correct choice of cultivation technology and appropriate technical solutions for its implementation.

A plowing tool was proposed for the layered cultivation of the slopes the optimal parameters of which were substantiated from the energy-technological point of view.

The use of a plowing tool for the proposed slopes reduces soil erosion, condensation of the inner layers, ensures water resistance of the loosened layer and increases soil fertility and crop yields.

Key words: slope, plowing tool, erosion, optimal, parameter, layered cultivation

Introduction

The requirements for tillage technologies are essentially the same: creating favorable conditions for crop life at low cost thus minimizing the harmful effects both on the external environment and the soil.

One of the requirements for the cultivation of slope soil is the regulation of the soil air-water regime, the creation of normal living conditions for crops, the prevention of erosion and weed control.

Numerous studies have shown that the solutions to these problems are organically related to each other. Modern land cultivation technologies do not allow to solve all these problems at the same time. Moreover, the solution of one of the problems has a negative impact on the other. For example, by eliminating weeds, more favorable conditions are created for wind and water erosion. On the other hand, incomplete control of weeds will not allow to provide normal living conditions for the crop.

The problem seems to be unsolved and when cultivating the land, one should give preference to one factor depending on the situation by “sacrificing” the other and adapting to the actual situation. However, it is necessary to take into account that no matter how much soil erosion is possible due to irreversible losses, the need to create favorable conditions for normal plant growth and development should not be ignored which is a guarantee of high yields.

To solve the problem, it is necessary to develop such a technology for cultivating the slopes and appropriate technical solutions for its implementation which will allow to contribute to the fulfillment of all the tasks set for the cultivation of the land to one extent or another.

Material and method of investigation

We have developed a plowing tool for slope layer cultivation the application of which will allow to

- stop the vegetation growth without destroying surface layer of the soil and removing the vegetation and to some extent to loosen surface layer,
- ensure opportunity that allow surface water to penetrate the lower layers of the soil to ensure fertility and water stability by creating deep chisel zones.

The plowing tool consists of a stand (1), digging pad (2) and digger (3) (Fig. 1).

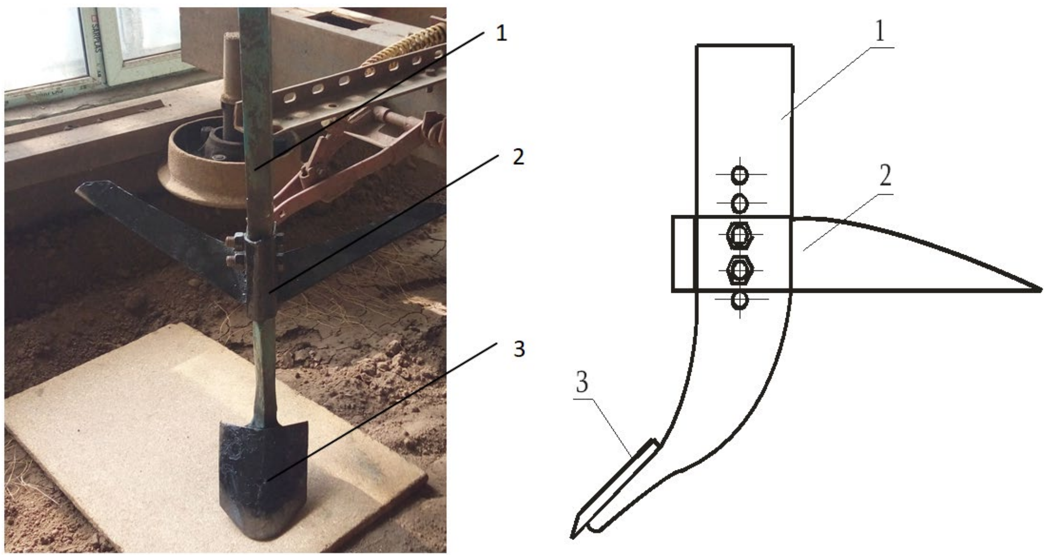

Fig. 1 Plowing tool for layered cultivation

The plowing tool is designed to work on both flat lands and slopes. When cultivating slopes it should move in the lateral direction of the slope. The working principle is as follows:

the stand of the plow is inserted into the ground with its pads. The digger penetrates into the soil to a depth of 40-45 cm and performs deep chisel loosening. The digging pad enters the soil to a depth of 10 cm; it is intended to cut the root system of weeds in the range of its coverage width depriving them of their vital activity. The surface layer of the soil is partially loosened without losing its integrity and the depleted vegetation maintains its physical existence on the soil surface thus helping to prevent wind and water erosion.

Since the plowing tool we offer is a combination of elements of different meanings, we will determine the parameters of those elements separately.

The height of the stand should usually be as short as possible due to the strength condition, and it should be long so as not to clog with weeds. The surface area of the stand H_1 must be larger than 200 mm [2,3].

The standing height must be sufficient to enter the ground and attach to the frame of the machine. If we choose the thickness of the frame as 10-12 cm, taking into account that the maximum depth in the soil is 45 cm, the length of the stand will be about 55 cm. Given the condition of non-clogging with weeds, as to exclude the contact of the machine frame with the ground surface, let us choose the height of the stand as 75 cm.

In terms of traction resistance, the thickness of the stand should be chosen as narrow as possible. The values of the standing width and thickness a and b are determined by calculations of strength. It is usually accepted a/b=1/3 [1].

Results and analysis

Substantiation of stand profile

Stand profile is characterized by its flight L (width of axes), radius of axis R, angle of stand nose α, height of axis H_R and length of direct part of the stand ℓ (Fig. 2).

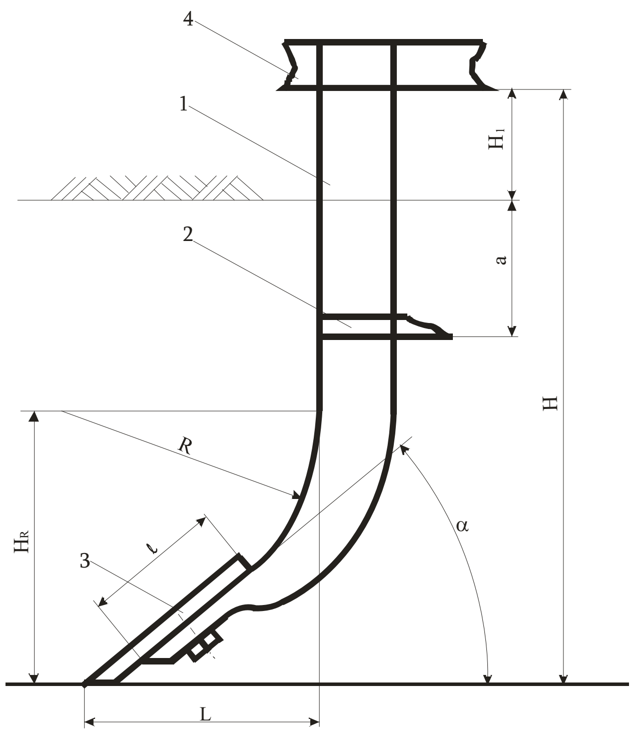

Fig. 2 Scheme of stand profile
1 - stand, 2 - digging pad, 3 - digger, 4 - frame

In practice, $H_R \geq 2a$, is adopted, where a - is the processing depth. Two depths of tillage were defined by the plowing tool: chisel $a_1 = 45$ cm and surface tillage a_2 =10 cm. The curved part of the stand is designed for chiseling, so the grounding of the axis should be considered at a depth of 45 cm. In this case, the condition $H_R \geq 2a_1$ is not realistic, as taking into account the mandatory condition of the machine frame to remain above the surface, the height of the stand will be very large, about 110 cm. Therefore, the height of the axis of the stand should be determined from the recommended values of the radius of axis R for the loosening stand, 123,5 or 250 mm [2,3]. From the point of view of stability and strength, it is expedient to choose a small value: R = 123,5 mm.

The length of the straight section is proportional to the length of the digger and depending on the machining depth it is 186 - 265 mm. From the point of view of traction resistance, let us choose the minimum value of the length of the straight part of the stand: ℓ = 186 mm.

The radius of the axis of the stand is determined by the following formula [2,3].

$$R = \frac{H_R - l sin\alpha}{cos\alpha}, \quad (1)$$

Where $H_R = Rcos\alpha + lsin\alpha = 123.5cos34^0 + 186sin34^0$=207 mm

The flight determining the stand profile L may be determined by the following formula

$$L = R(1 - \sin\alpha) + l\cos\alpha = 123,5(1 - \sin 34°) + 186\cos 34° = 209մմ$$

Usually L is chosen within 200-250 mm. The possibility of clogging the stands with weeds gets wider in the case of smaller flight. Bigger value of L will negatively effect on the strength of the stand, besides, it will not particularly decrease clogging.

Substantiation of the angle of stand location

The angle of stand location should be so that the opposite obstacle (soil, stone, crusts) can be taken out onto the surface by digger. This condition will be satisfied if T component of N is bigger than F contact force $T > F$ [6] (Fig. 3).

Taking into account that $F = Nf = Ntg\varphi$, where φ-is the contact angle, $T = Ncos\alpha$, we will write $Ncos\alpha > Ntg\varphi$, or $\alpha < 90° - \varphi$.

In order to ensure a small traction resistance of the digger, it is better to choose the smallest possible value of the standing angle, in case of which the horizontal component of the resistance will decrease intensively and the vertical component will increase less intensively. Traction resistance will decrease in total.

Consequently, it is purposeful to choose the minimum value of α angle in case of plowing tool of layered tillage.

It is stated by researches that the real value of contact angle fluctuates between 25-56 degrees. Hence, we will get α=90°-56° =34°.

The digger is attached to direct lower part of the stand which can be of two types: chisel and turning [6]. Taking into account the physical-technological properties of the RA soils (strength, large amount of crusts, rockiness etc), we choose a chisel digger for the plowing tool which is more expedient for the above-mentioned conditions. The digging chisel has the appearance of a two-sided wedge characterized by the angle of placement, width and length (Fig. 3).

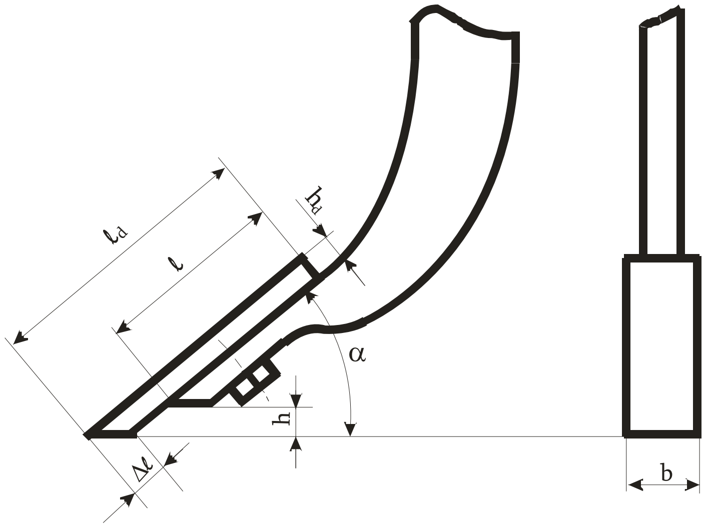

Fig. 3 Substantiation scheme of parameters of hoe

As a rule, the small width of chisel digger b = 2uŝ is chosen to provide the minimum traction resistance of hoe [2].

The placement angle of digging chisel should correspond to the angle of stand placement angle to horizontal area which was α = 34° according to stand parameters. The length of digging chisel depends on the length of straight section of lower part of the stand ℓ, the value of which we admit as 186 mm.

The length of chisel digger should be so that the stand stays h = 3 - 4 cm higher than the chisel floor. According to Fig. 3 it will be $l_d = \frac{h}{sin\alpha} + \Delta l$, $\Delta l = \frac{h_d}{cos\alpha}$, where h_d- is the thickness of chisel digger which must be 20 mm [4].

Hence, $\Delta l = \frac{20}{cos34°} = 30\ mm$, and $l_d = 186 + \frac{35}{sin34} + 30 = 278\ mm$

The calculation of parameters of flat digger

One of the important elements of the plowing tool for layered tillage is the flat-toed digger of total surface tillage which cuts the soil layer to a depth of 10 cm and partially compresses it, preventing significant movement of the surface soil and the weeds in it.

The main parameters of flat digger are: loosening angle α_1, cover angle 2γ, wing curve angle β, coverage width B and wing length ℓ_h (Fig. 4).

Serious demand to flat digger of plowing tool for layered tillage is not necessary. It should only loosen the surface layer of the soil for 0-10 cm without destroying its structure. That's why we choose the minimum α_1=9° from stated coverage α_1=9-10°[3] for angle values of loosening of flat digger hoe.

The coverage angle of flat digger hoe is substantiated by the view point of cutting the opposite root or at least it slides over it.For the weed root slides along the blade of flat digger it is necessary that T > F, where T and N are components of R resistance, F- is contact force between root and blade from N resistance [5, 6] (Fig. 4).

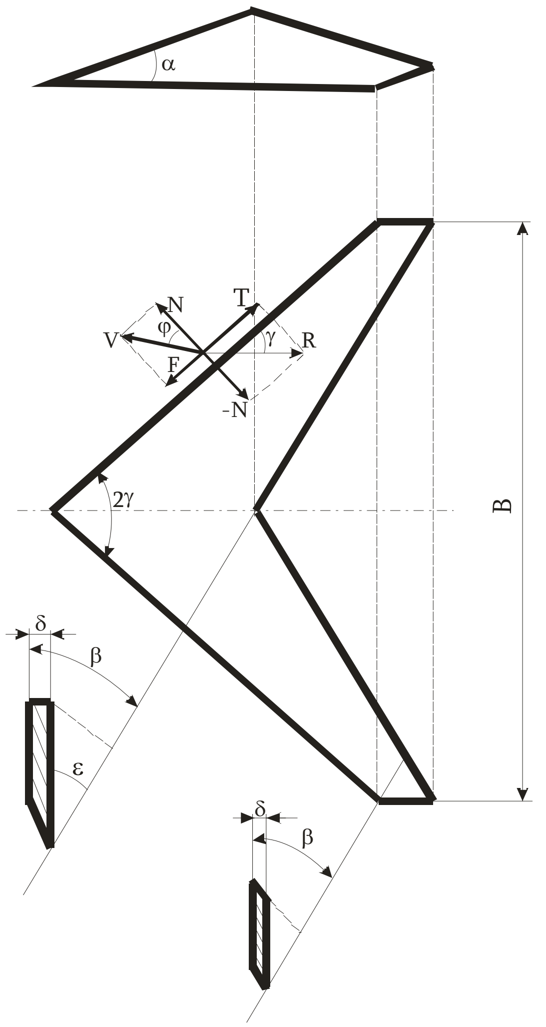

Fig. 4 Subtsantiation scheme of the parameters of flat digger of plowing tool for layered tillage

According to Fig. 4 we can write

$$T = Nctg\gamma, F = Ntg\varphi \text{, so } Nctg\gamma > Ntg\varphi \text{, or } \gamma < 90 - \varphi_{\max}$$

The real value of contact angle fluctuates between $\varphi = 25....56^0$

To make the plowing tool for layered tillage one sided, let us choose $\varphi_{max}=56^o$

As a result we will get $\gamma = 34^o$, and coverage angle of the hoe will be $2\gamma = 68^o$

β angle of wing curve has direct relation with the loosening degree of the soil. As the loosening of surface layer by plowing tool of layered tiillage is limited for there will not be particular movement of soil and removing of weeds, so we choose the minimum value of β angle as $\beta=18^o$ for flat digger hoes by various researches.

The idea of preventing water erosion on slopes lies in the basis for substantiating the width of the flat digger hoe. Stands on which flat hoes are attached should be placed at such a distance that the deep layered tracks opened by them can absorb surface water on the slopes not allowing water to flow on the surface.

Laboratory experiments on a plowed tool for layered tillage have shown that after crossing the stand, the soil in the surface layer loosens about 20 cm from the axis. It turns out that if the stands are placed at a distance of about S = 40 cm, the surface water will be absorbed by the deep layers opened by the stands preventing water erosion (Fig. 5).

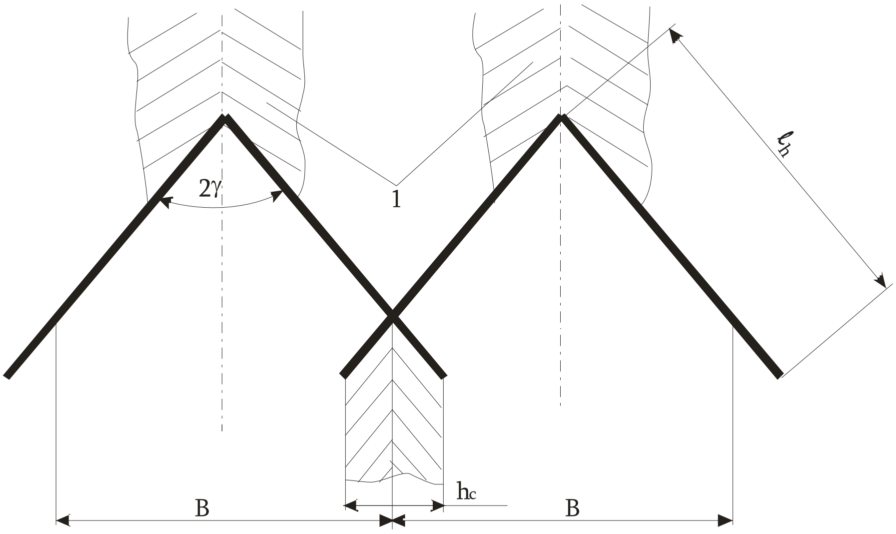

Fig. 5 Substantiation scheme for coverage width of flat digger hoe

1 - chisel zone

Taking into account the compulsory condition for flat digger hoes, we will get their coverage width determined by $B = S - h_c$ formula from Fig. 5 where h_c-is the width of coverage zone of flat digger hoes accepted 5 cm.

Consequently, B = 40 – 5 = 35 cm. The length of hoe wing will be

$$l_h = \frac{\frac{B}{2} + \frac{h_c}{2}}{sin\gamma} = \frac{\frac{35}{2} + \frac{5}{2}}{sin34^\circ} = 36\text{uш}$$

Conclusions

1. To prevent soil erosion as well as to ensure normal conditions for crop growth and development, a plowing tool has been proposed which simultaneously performs two technological processes by creating deep layered zones at a distance of about 40 cm and 10 cm deep surface cultivation thus preserving the completeness of surface soil and physical existence of wesds.
2. The deep wide zoning of slope soil by proposed plowing tool enables to:
   - surface waters penetrate into loosened layers of the soil preventing erosion and providing soil stability and fertility
   - deprive weeds from growing preserving them in surface layer of the soil by creating favorable conditions for crops and preventing conditions for soil erosion
3. substantiate optimal parameters of plowing tool for layered tillage according to energetic and technological point of view which have the following values: stand height 75 cm, hoe width b = 2 cm, placement angle α = 34°, loosening angle of flat digger hoe α_1 = 9°, coverage angle 2γ = 68°, wing width angle β = 18°, wing length ℓ = 36 cm and coverage width B = 35 cm.

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ԼԱՆՋԵՐԻ ՀՈՂԻ ՇԵՐՏԱՎՈՐ ՄՇԱԿՄԱՆ ԲԱՆՈՂ ՕՐԳԱՆԻ ՊԱՐԱՄԵՏՐԵՐԻ ՀԻՄՆԱՎՈՐՈՒՄ

Եսոյան Ա.Մ.[1], Տոնապետյան Պ.Ա.[1], Գասպարյան Պ.Յու.[2], Տոնապետյան Ա.Պ.[1]

[1]Հայաստանի ազգային ագրարային համալսարան

[2]Շուշիի տեխնոլոգիական համալսարան

Հողի բերրիության բարձրացման գործոնների թվում կարևորագույն նշանակություն ունի մշակման տեխնոլոգիայի և դրա իրականացման համար համապատասխան տեխնիկական լուծումների ճիշտ ընտրությունը:

Լանջերի մշակման համար առաջարկվել է հողի շերտավոր մշակման բանող օրգան, որի օպտիմալ պարամետրերը հիմնավորվել են էներգետիկական և տեխնոլոգիական տեսանկյունից:

Առաջարկված լանջերի հողի շերտավոր մշակման բանող օրգանի կիրառմամբ նվազում է հողի էրոզիան, ներքին շերտերի գերխտացումները, ապահովվում է փխրեցվող շերտի ջրակայունությունը, բարձրանում հողի բերրիությունն ու մշակաբույսերի բերքատվությունը:

Բանալի բառեր. լանջ, բանող օրգան, էրոզիա, օպտիմալ, պարամետր, շերտավոր մշակում:

ОБОСНОВАНИЕ ПАРАМЕТРОВ РАБОЧЕГО ОРГАНА ДЛЯ ПОСЛОЙНОЙ ОБРАБОТКИ ПОЧВЫ НА СКЛОНАХ

Есоян А.М.[1], Тонапетян П.А.[1], Гаспарян П.Ю.[2], Тонапетян А.П.[1]
[1]Национальный аграрный университет Армении
[2]Шушинский технологический университет

Одним из важнейших факторов повышения плодородия почвы является правильный выбор технологии обработки и соответствующих технических решений для ее реализации. Для обработки склонов был предложен рабочий орган для послойной обработки почвы, оптимальные параметры которого были обоснованы с энергетической и технологической точки зрения.

С применением предлагаемого рабочего органа для послойной обработки почвы на склонах снижается эрозия почвы, переуплотнение внутренних слоев, обеспечивается водоустойчивость взрыхленного слоя, повышается плодородие почвы и урожайность культур.

Ключевые слова: склон, рабочий орган, эрозия, оптимальный, параметр, послойная обработка.

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