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SUBSTANTIATION OF PARAMETERS OF PLOWING PART OF SMALL SIZED ROOT CROP HARVESTING MACHINE

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Abstract

Theoretical studies of the interaction between two-facet wedge and soil were carried out and the geometric parameters of the plowing part of the small-sized root crop harvesting machine were substantiated.

A mathematical expression for determining the traction resistance of a plowing part is obtained depending on the basic parameters of the "wedge-soil" system which can be used to obtain change patterns of traction resistance depending on certain parameters.

***Key words*: root crop, harvest, deformation, plow, wedge, crack.**

Introduction

The requirements for root crops lead to the development of such working parts which will ensure the safe removal of root crops with different physical and mechanical properties from the soil by destroying the soil layer.

Deformation of the soil with the working parts of root crop harvesting machines during the harvest is conditioned by the physical-mechanical properties of the soil as well as the type of the plowing part and its structural-technological parameters [1,2,5].

The root crop harvesting machine which is considered to be a two facet wedge, has a certain resistance during movement in the soil for the determination of which we will study the wedge-soil interaction.

During the work of the wedge, the soil mass is compacted in the first stage of deformation and the resistance gradually increases. In the second stage, the occurred strains exceed the temporary tensions of the soil (slip or bend), cracks occur in the soil and the soil decomposes.

Conflict setting

In the current work the constructive methods for the solution of the initial problem (1),

The aim of the research is to theoretically determine the resistance of the wedge movement depending on the main parameters and characteristics of the "wedge-soil" system, based on the results of studies on the interaction of the two facet wedge and soil as well as to substantiate the parameters of the plow breast.

During the research we take the following steps:

- the tuber mass is a homogeneous connected layer intertwined with plant roots,
- the soil removes with constant speed over the breast in the regime of stable movement.

The tracking resistance of the plow breast can be determined by the following expression (Fig.1).

$$R = R_{bl}+R_{def}+R_{G}+R_{in}, \tag{1}$$

where R_{bl}-is the resistance of cutting the soil with plow blade, N, R_{def} – ն is deformation resistance of the soil, N, R_{G}-is resistance by soil static pressure, N, $+R_{in}$-is the resistance of the furrow by inertia, N.

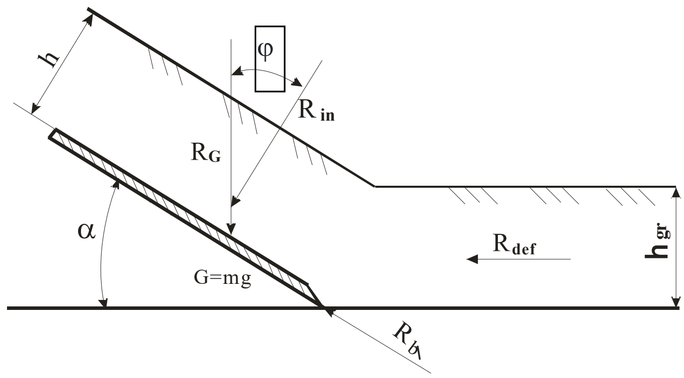

Fig. 1 Scheme of forces on the plow breast

R_{gl} resistance can be determined by the following expression [4].

$$R_{bl} = [\sigma] \cdot t \cdot B_{bl}, \tag{2}$$

where $[\sigma]$ –is specific resistance of horizontal pressure of the soil, N/m^2, t –is the blade thickness of plow breast, m, B_{bl}- is cover width of the working part, m, which can be determined according to the average width of the tuber with the following expression (Fig.2).

$$B_{bl} \geq b_c + 3\tau + 2c, \tag{3}$$

where b_c –is the average width of tuber, τ-is the average square deviation of the tuber width, c-is average permitted limitary value of side fluctuations of the machine in horizontal position.

Inserting (3) in the equation $b_c = 0{,}2$ m, $\tau = \pm 0{,}02$m, accepting $c = 0{,}03$m, we will get $B_{bl} \geq 0{,}32$m. The coverage width of the plow breast was chosen $B_{bl} = (0{,}33 \div 0{,}35)$m as a result of experimental studies.

The length of the plow blade (L_{bl}) will be $L_{bl} = \frac{B_{bl}}{sin\gamma}$, $\gamma -$ is the angle with cutting blade of the plow, $\gamma = 42°$ [3, 4]. Consequently, $L_{bl} = (0{,}36 \div 0{,}38)$ m.

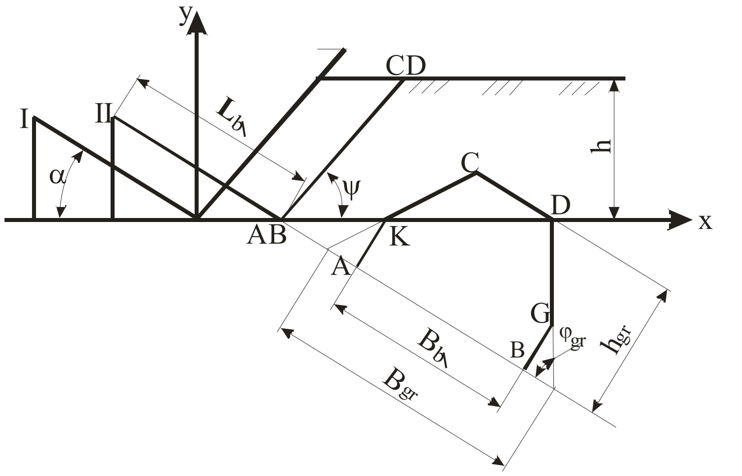

Fig. 2 Calculating scheme of determining tracking resistance

Let us determine soil deformation resistance using calculation scheme of Fig.2.

$$R_{def} = Q[cos\psi + fsin(\alpha+\psi)cos\alpha] \tag{4}$$

where Q – is soil removal resistance over AKCDGB surface, f-is the coefficient of contact between working surface of the plow and the soil, ψ -is spread angle of the crack to the horizon during the soil deformation.
$\psi = \frac{\pi}{2} - \frac{2(\alpha+\varphi_1+\varphi_2)}{2}$, α - is the angle of plow position, φ_1 and φ_2 –are correspondingly the angles of inner and outer soil contacts.

Soil removal Q resistance is determined by the calculation scheme of Fig.2 [4, 6].

$$Q = [\tau_k] \cdot F_{AKCDGB} \, , \tag{5}$$

where $[\tau_k]$-is limitary value of touching strains, N/m^2.

According to Fig.2

$$F_{AKCDGB} = \frac{[4B_{gr}h_{\text{rp}} - (B_{gr} - B_{bl})^2]tg\varphi_{gr} - h_{gr}^2}{4tg\varphi_{gr}}, \tag{6}$$

where B_{gr}-is the width of tuber mass furrow, m, h_{gr}-is the height of furrow, m.

According to (4)-(6) formulas, we obtain

$$R_{def} = [\tau_k] \frac{\left[4B_{gr}h_{gr} - (B_{gr} - B_{bl})^2\right]tg\varphi_{gr} - h_{gr}^2}{4tg\varphi_{gr}} \frac{sin\frac{1}{2}(\alpha+\varphi_1+\varphi_2) + fcos\frac{1}{2}(\alpha-\varphi_1-\varphi_2)cos\alpha}{sin\psi} \tag{7}$$

The resistances conditioned by static pressure and furrow inertia are determined by the following expressions taking into account the soil humidity

$$R_G = B_{bl} h L_{bl} \rho g tg(\alpha + \varphi_1)\left[1 + \frac{W}{100}\right] \quad (8)$$

$$R_{in} = \rho V^2 \frac{\left[4B_{\text{rp}} h_{gr} - (B_{gr} - B_{bl})^2\right] tg\varphi_{gr} - 4h_{gr}^2}{4tg\varphi_{gr} sin\psi} \frac{sin\alpha \sin(\alpha + \varphi_1)}{cos\varphi_1 cos^2\frac{1}{2}(\alpha + \varphi_1 + \varphi_2)}\left[1 + \frac{W}{100}\right] \quad (9)$$

where h-is the height of the soil moving over the plow breast, m, ρ-is soil density, kg/m^3, V-is speed of machine movement, W-is soil humidity, %.

Research results

Inserting $R_{bl}, R_{def}, R_G, R_{in}$ force values in (1), we will get the tracking resistance of the plow breast

$$R = [\sigma] \cdot t \cdot B_{bl} + \frac{\left[4B_{gr} h_{gr} - (B_{gr} - B_{bl})^2\right] tg\varphi_{gr} - h_{gr}^2}{4tg\varphi_{gr}} \times$$
$$\times \left[[\tau_k] \frac{sin\frac{1}{2}(\alpha + \varphi_1 + \varphi_2) + fcos(\alpha - \varphi_1 - \varphi_2)cos\alpha}{sin\psi} + \right.$$
$$\left. + \frac{\rho V^2 sin\alpha \sin(\alpha + \varphi_1)}{cos\varphi_1 cos^2\frac{1}{2}(\alpha + \varphi_1 + \varphi_2)}\left[1 + \frac{W}{100}\right]\right] + B_{bl} h L_{bl} \rho g tg(\alpha + \varphi_1)\left[1 + \frac{W}{100}\right] \quad (10)$$

From the analysis of expression (10) we conclude, that tracking resistance of working body of small sized root crop harvesting plow depends on plow parameters (L_p, B_p, t, α), tillage depth (h), movement speed as well as physical and mechanical properties of the soil ($[\sigma]$, $[\tau_k]$, φ_1, φ_2, ρ, W, f). Inserting in expression (10) $L_p = 0{,}38$m, $B_p = 0{,}35$m, t=0,0005ŭm, $[\sigma] = 1{,}44 \cdot 10^6$Ps, $[\tau_k] = 2 \cdot 10^4$Ps, $\varphi_1 = 27°$, $\varphi_{2°} = 40°$, $\rho = 1100$ kg/m,^{3} W=16%, $f = 0{,}576$, tracking resistance of the plow is 2,14kN.

Conclusion

1. Theoretical studies of the interaction of the two facet wedge and soil have substantiated the geometrical parameters of the working body of a small sized machine for harvesting root crops.
2. Theoretical research has obtained a mathematical expression for determining the traction resistance of a small-sized machine for harvesting root crops, which can be used to obtain patterns of change in traction resistance depending on certain parameters.

References

1. Kolchin N.N., Elizarov V.P. (2013) Reducing the level of damage to potatoes and vegetables in machine technologies // M: «Farming machines and technologies», No. 6, 2013, pp. 18-22. https://elibrary.ru/download/elibrary_21191473_19294106.pdf
2. Lobachevsky Ya.P., Slavkin V.I., Belov S.V., Chepurnoy A,I., Zhuravlev A.B., Vasykov A.A. (2012) Sustainability of the control system for the separation of the

tuberous mass of a potato harvester //M: «Farming machines and technologies», No.3, 2012, pp. 12-14. https://elibrary.ru/download/elibrary_17721187_82245767.pdf

3. Mkrtchyan H.D., Matevosyan A.A., Tonapetyan A.P., Mikayelyan G.M. (2020) Justification of the Parameters in the Working Parts of Small Root Crop Harvesters. Agriscience and Technology, N1 (69), ANAU, Yerevan, 2020. P.17-20. https://library.anau.am/images/stories/grqer/agro-tex/2020-/mkrtchyan_tonapetyan.pdf
4. Didenko N.F. Khvostov V.A., Medvedev V.P. Vegetable harvesting machines. M. Mechanical engineering 1984. 320p. http://publ.lib.ru/ARCHIVES/D/DIDENKO_Nikolay_Fedorovich/_Didenko_N.F..html
5. Matmurodov F.M. (2019) Mathematical simulation of potato harvesting machine drive mechanisms. Innovative technique and technology. №4 (21) Penza 2019 . p.42-45. https://innotechnika.files.wordpress.com/2019/11/2019_4_42-45.pdf
6. Uspensky I.A., Kiryushin I.N., Kolotov A.S. (2014) Explaining ratiional parameters of disk elements of undermining working bodies in a potato harvester. scientific journal of the Kuban State Agrarian University. Krasnodar 2014.–N02(96). p.323–333. http://ej.kubagro.ru/2014/02/pdf/24.pdf

References

1. Колчин Н.Н., Елизаров В.П. (2013) Снижение уровня повреждений картофеля и овощей в машинных технологиях //М: «Сельскохозяйственные машины и технологии», № 6, 2013. с.18-22. https://elibrary.ru/download/elibrary_21191473_19294106.pdf
2. Лобачевский Я.П., Славкин В.И., Белов С.В., Чепурной А.И., Журавлев А.В., Васьков А.А. (2012) Устойчивость системы управления процессом сепарации клубненосной массы картофельного комбайна //М. «Сельскохозяйственные машины и технологии», № 3, 2012, с.12-14. https://elibrary.ru/download/elibrary_17721187_82245767.pdf
3. Մկրտչյան Հ.Դ., Մաթևոսյան Ա.Ա., Տոնապետյան Ա.Պ., Միքայելյան Գ.Մ. (2020) Արմատապտուղների բերքահավաքի փոքրաչափ մեքենայի բանող օրգանի պարամետրերի հիմնավորումը: Ագրոգիտություն և տեխնոլոգիա, N1 (69), ՀԱԱՀ, Երևան, 2020թ. էջ 17-20: https://library.anau.am/images/stories/grqer/agro-tex/2020-1/mkrtchyan_tonapetyan.pdf
4. Диденко Н.Ф. Хвостов В.А., Медведев В.П. Машины для уборки овощей. М.: Машиностроение, 1984. 320с. http://publ.lib.ru/ARCHIVES/D/DIDENKO_Nikolay_Fedorovich/_Didenko_N.F..html
5. Матмуродов Ф.М. (2019) Математическое моделирование приводных механизмов картофелеуборочной машины. Инновационная техника и технология №4 (21) Пенза 2019, ст.42-45. https://innotechnika.files.wordpress.com/2019/11/2019_4_42-45.pdf
6. Успенский И.А., Кирюшин И.Н., Колотов А.С. Обоснование рациональных параметров дисковых элементов подкапывающих рабочих органов картофелеуборочных машин. Научный журнал КубГАУ. Краснодар 2014.–N02(96). с.323–333. http://ej.kubagro.ru/2014/02/pdf/24.pdf

ԱՐՄԱՏԱՊՏՈՒՂՆԵՐԻ ԲԵՐՔԱՀԱՎԱՔԻ ՓՈՔՐԱՉԱՓ ՄԵՔԵՆԱՅԻ ԽՈՓԱՎՈՐ ԲԱՆՈՂ ՕՐԳԱՆԻ ՊԱՐԱՄԵՏՐԵՐԻ ՀԻՄՆԱՎՈՐՈՒՄ

Մինասյան Ա.Ռ.[1], Տոնապետյան Ա.Պ.[1], Գասպարյան Ա.Պ.[2]
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[2]*Շուշիի տեխնոլոգիական համալսարան*

Երկնիստ սեպի և հողի փոխազդեցության տեսական հետազոտությունների արդյունքում, հիմնավորվել է արմատապտուղների բերքահավաքի փոքրաչափ մեքենայի խոփավոր բանող օրգանի երկրաչափական պարամետրերը: Ստացվել է բանող օրգանի քարշային դիմադրության որոշման մաթեմատիկական արտահայտություն, կախված «սեպ-հող» համակարգը բնութագրող հիմնական մեծություններից, որի հիման վրա կարելի է ստանալ քարշային դիմադրություն փոփոխման օրինաչափությունները:

Բանալի բառեր. արմատապտուղ, բերքահավաք, դեֆորմացիա, խոփ, սեպ, ճաք:

ОБОСНОВАНИЕ ПАРАМЕТРОВ ЛЕМЕШНОГО РАБОЧЕГО ОРГАНА МАЛОГАБАРИТНОЙ МАШИНЫ ДЛЯ УБОРКИ КОРНЕПЛОДОВ

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Проведены теоретические исследования взаимодействия двухгранного клина и почвы. Обоснованы геометрические параметры лемешного рабочего органа малогабаритной корнеуборочной машины. Получено математическое выражение для определения тягового сопротивления рабочего органа в зависимости от основных параметров системы «клин-почва», с помощью которого можно получить закономерности изменения тягового сопротивления в зависимости от основных параметров.

Ключевые слова: корнеплод, сбор урожая, деформация, лемех, клин, трещина.

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