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THE RESULTS OF EXPERIMENTAL EVALUATION OF THE OPERATING CONDITIONS OF THE MACHINE FOR CONTACT WEED CONTROL

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Summary

The article presents the results of research carried out during the creation of a machine for contact weed control and clarification of the parameters of its operation.

The purpose *of the research, the results of which are set out in the article, is to prove experimentally the hypothesis put forward in the course of creating a machine for contact weed control about the effect of acceleration of the cut of the stem on which the working solution is on the value of unproductive losses of the working solution.*

Methods. *To achieve the goal of the work, experimental studies have been carried out. The experimental results were processed according to the method of a mathematical full-factor experiment on the MathCAD v.14 software product.*

Results. *In the course of experimental studies, it was found that the operation of the machine at a height of less than 0.2 m is inappropriate, because the accelerations during the oscillatory process of the stem reach significant values and lead to the dropping of the working solution from the stem of the plant. Based on the results of experimental studies, a regression equation was obtained, which reveals the dependence of the efficiency of weed control on the installation height of the machine, the diameter of the weed stems, and the cut angle.*

Conclusions. *In the process of experimental studies, it was found that the acceleration of the edge (cut) of the stem, on which the applied working solution is located, significantly affects the amount of unproductive losses of the working solution. A sharp increase in the acceleration of the tops of the stems when they move from the deflected position to the initial position leads to the discharge of the applied drop of herbicide from the cut of the stem. This is unacceptable for two reasons. First, the herbicide enters the soil and, as a result, leads to its pollution. Secondly, the effectiveness of weed control is significantly reduced due to losses and leads to the need to increase the doses of herbicides. This leads to increased financial costs for weeding. It has been experimentally established that it is advisable to cut plants at a height of at least 0.2 m. The introduction of the established requirement for the height of the machine location allows avoiding the indicated undesirable consequences.*

Keywords: *ecological aspect, weeds, chemicalization, destruction, machine, method of weed control.*

Introduction. Chemicals are now the mainstay of weed control. The application of the chemical method allows: to reduce labor costs by 6-8 times; reduce the amount of work by 50-80 % [M Green, Micheal D. and other, 2010; Stuebler H.; Kraehmer H. and other, 2008; Binimelis, R., Pengu and other, 2009] compared to the mechanical method; destroy the root system of the plant [Solovieva N, 2001; Adinyaev E. D., 2002]. Chemical compounds inhibit the development of a group of weeds or other harmful organisms and do not cause much damage to beneficial crops. Chemicalization in agriculture is developing [Ghimire Narishwar, Woodward Richard T., 2013].

The process of its development is characterized by the diversity of technical and technological, environmental and economic aspects, which are interrelated. It should be noted that the change of one of these aspects entails the change of others, and significantly affects the development of agriculture and human activity. Namely. The effect of the use of certain chemicals is temporary, because over time there is resistance to constantly used drugs. This, in turn, leads to an increase in the dose of chemicals and, as a consequence, to an increase in the negative impact on water resources, soil, people [Lysov A. K., 2012; Kraehmer H, Drexler D., 2009].

The technology of herbicide application by spraying leads to undesirable losses caused by wind, evaporation, falling, drops of working solution that settle on the soil [Wilson, C., Tisdell, C., 2001; Abhilash P.C., Singh N., 2008]. In addition, existing weed control processes are inefficient due to technical reasons and physical and mechanical characteristics of plants.

The technology of herbicide application significantly affects the yield and quality level of finished products, which in turn determines its economic feasibility and competitiveness. Weed control technology is closely related to the design of the equipment used in its implementation. The choice of equipment depends on many factors, in particular, the type of crop, arable land, etc. At the same time, it is necessary to ensure environmental protection requirements and optimize the loss of chemicals.

Problem Statemen. Analysis of literature sources [Lysov A.K., 2012; Bundza O. Z, Nalobina O. O. 2017 and other, R.Skuterud, A.Nordby, 2019; V.Partel, S. Kakarla, 2019] revealed in:

- the application of the method of application of herbicides by spraying has the following characteristic unproductive losses of the working fluid: losses on dripping (conventional spraying); wind demolition losses; losses due to the deposition of drops of working fluid on the soil surface; evaporation losses;

-the efficiency of the weed control process is influenced not only by the characteristics of the working equipment and the parameters of the process of interaction of the working equipment with the plant material, but also by the physical and mechanical characteristics of the plants and herbicide;

- one of the promising areas for solving these problems is the introduction of a contact method of weed control and the development of special contact machines [Lysov A. K., 2012; Bundza O. Z, Nalobina O. O. and other, 2017; Song Y., Sun H, and other, 2012; Song Y., Sun H., and other, 2015].

The last one is due to the fact that the technology of weed control with the use of known contact equipment cannot be implemented in areas overgrown with weeds, the stems of which are characterized by high rigidity.

Methods and Materials. In order to reduce unproductive losses, a contact action machine for weed control has been developed (Fig. 1).

Fig. 1 – Model: 1- tractor MTZ-80, 2- binding frame, 3- arrow, 4- рукоять, 5- hydraulic cylinder, 6- the cutting device with the drive, 7- tor, 8- sorter drive, 9- drum contact device, 10- drum drive, 11- feeder

The machine consists of three working bodies: a cutting device, a picker of cut vegetation and a device for contact application of herbicide. The design is based on the following tasks: ensuring effective application of the herbicide on the cut of the plant stem; low consumption of working solution and minimal unproductive losses.

In the process of developing the design of the machine, namely during the systematic analysis of the technological process of interaction of the working bodies of the machines with plant material, the authors substantiated the hypothesis of the impact on the magnitude of unproductive losses of the working solution. In order to test the hypothesis it was necessary: 1) to establish experimentally the dependence of the movement, speed and acceleration of the top of the weed stubble on time; 2) to establish experimentally the rational height of the machine.

The herbicide is applied to the site, which is formed on the stems of weeds under the influence of the cutting device. Applying the herbicide to the cut of weed stems should be done in such a way that the drops of working fluid do not slide down, but are kept on the site of the cut, which will create conditions for the penetration of liquid into the stem. To fulfill this condition, the stem should not deviate too much from the initial position of the cutting device and oscillate in the vertical plane.

The process of oscillation, namely the acceleration of the stem, we studied experimentally. Weed stems with significant stiffness of various diameters were used for the experiments. This is due to the following: stiffness index affects the elastic properties of weed stems; the stiffness index is affected by the size of the stem diameter.

Given that the stiffness index affects the elastic properties of weed stalks, it can be concluded that the acceleration of the top of the stubble will also depend on this figure. The stem was placed on the background of a sheet of thick white paper with grid which was formed of vertical and horizontal lines (Fig. 2).

Fig. 2 – Determination of the acceleration of the apex of the cut stem of the plant: 1-stem of the plant; 2-sheet of paper with a grid

Then, installing a camera with video recording function Canon Ixus S10 and tilting the plant stem at an angle of 30 ° -40 °, video recording of the fading oscillations of the plant stem was carried out. The resulting video was decomposed into individual frames with an interval of 0.02 s. Virtual Dub was used for this purpose. The position of the end of the stem at each time was recorded on a scale. After that, according to the obtained data, a graph of the movement of the top of the stem was built, where the cut plane is located, and on the basis of which the graphs of velocities and accelerations were obtained by the method of graphical differentiation. Each experiment was repeated at least three times. These studies allowed to substantiate the height of the machine, which provides optimal solution consumption and effective destruction of weeds.

The results of the experiment were processed according to the method of mathematical full-factor experiment and software product MathCAD v.14. In general, a mathematical model that describes the dependence of the initial factor (weed control efficiency) on the input factors (X_1, X_2, X_3) looks like:

$$Y = f(X_1, X_2, X_3), \qquad (1)$$

where Y – weed control efficiency, which was estimated as the number of weeds distracted in the experimental field, expressed as a percentage of their initial number; X_1 – angle of cut of stalks, grade; X_2 – stem diameter, mm; X_3 – installation height of the machine, m.

To detail the model, we apply the method of mathematical planning of the experiment [Ventzel E., 2007] and write the regression equation, neglecting the powers of factors above the first in the form:

$$y = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{13}x_1x_3 + \\ + b_{23}x_2x_3 + b_{123}x_1x_2x_3, \qquad (2)$$

where b_1, b_2, b_3, b_{12}, b_{13}, b_{23}, b_{123} – coefficients of the regression equation.

The solution of this model will make it possible to identify the influence of treatment height, stem diameter and the angle of cut on the technical efficiency of weed control. The reproducibility of the experiments was checked by the Cochren test, the significance of the coefficients of the equation - by the Student's test, the adequacy of the obtained mathematical description (regression equation) by the experimental data was checked by Fisher's test.

To assess the effectiveness of weed control at the experimental site, in several places bounded by a wooden frame measuring 1x1m, the number of weeds to be treated and the number of weeds destroyed were counted. The effectiveness of vegetation destruction was evaluated:

$$T = \frac{A - B}{A} \cdot 100\%, \qquad (3)$$

where T – efficiency indicator, %; A – the average number of weeds in the control area before treatment, pcs.; B – average number of weeds not destroyed after treatment after 20 days, pcs.

Obtained results. In this article we present the results obtained for the stems of orach. The height of the stems varied within 0.15... 0.25 m, and the diameter was 6 mm. The following is an experimentally obtained dependence of the displacement, velocity, and acceleration of the top of the weed stubble on the time counted from the time corresponding to the beginning of the top movement from the deflected position to the initial position. Moreover, during the deviation of the stems from the vertical position to a certain angle, which did not exceed the angle of fracture (the value of which was established by us previously experimentally), the force was applied at different heights. As a result of the study of the oscillating process of the top of the stubble, cut at a height of 0.15 m, it was found that: the oscillating process of the top of the stubble quiver with a diameter of 4... 7 mm has the character of damped oscillations and lasts 0.4... 0.7 s (Fig. 3);

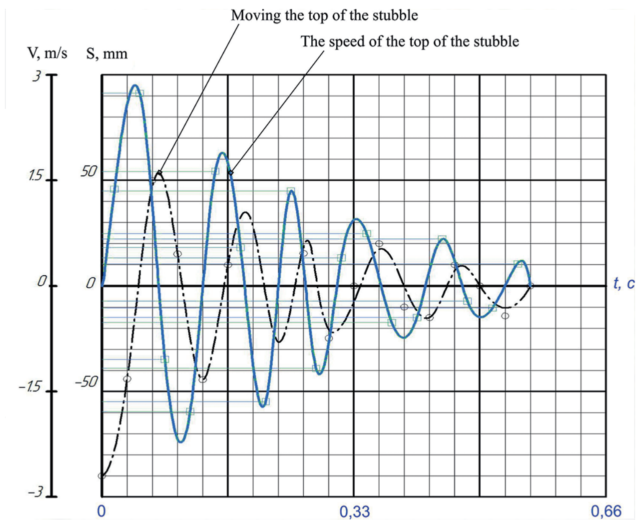

Fig. 3 – Graphs of movement and velocity of the top of the stubble quiver with a diameter of 6 mm, cut at a height of 0.15 m

1. The instantaneous velocity of the top of the stubble quiver reaches its maximum value during the first period of oscillation and is in the range of 1.8... 2.8 m / s;

2. acceleration of the top of the stubble can reach a maximum value of 52... 62 m / s2 in the first 0.15 s (or 1... 2 periods) of the oscillating process (Fig. 4);

3. the speed of movement and acceleration of the top of the stubble does not depend on

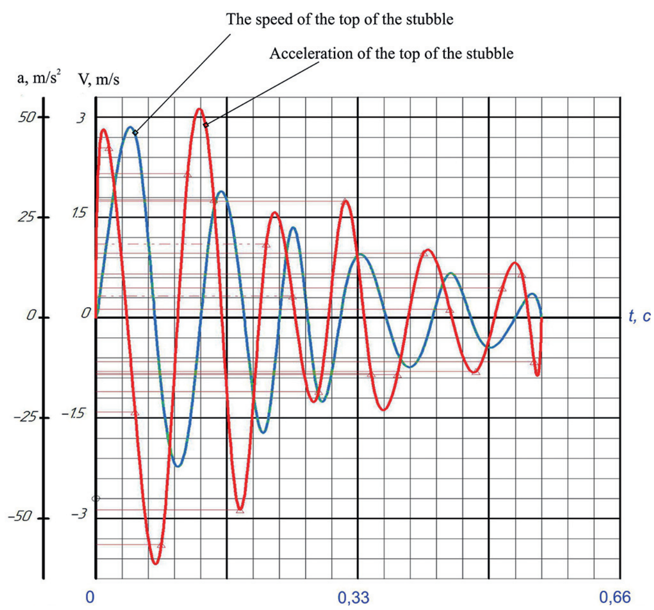

Fig. 4 – Graphs of speed and acceleration of the top of the stubble quiver with a diameter of 6 mm, cut at a height of 0.15 m

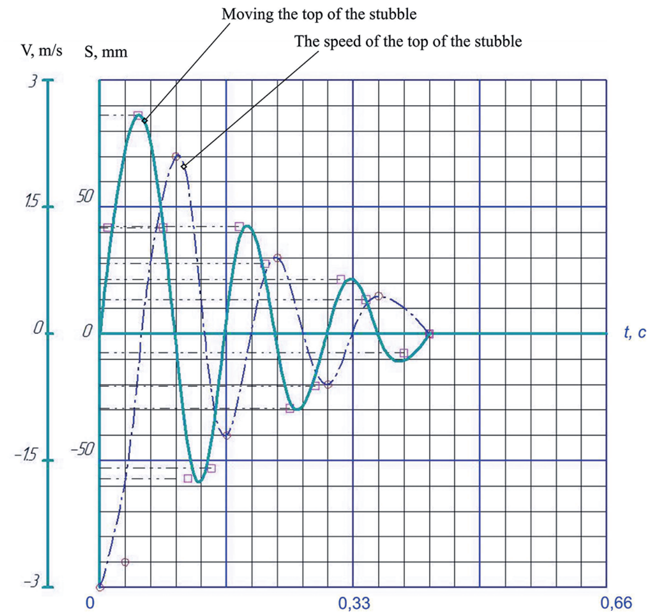

Fig. 5 – Graphs of movement and velocity of the top of the stubble quiver with a diameter of 6 mm, cut at a height of 0.25 m

the speed of movement of the working body.

Research of the oscillating process of the top of the stubble quiver with a diameter of 6 mm, cut at a height of 0.25 m, showed that: 1) the oscillating process of the edge of the terrestrial part of the quiver stem with a diameter of 4... 7 mm has the character of damped oscillations and lasts 0.4... 0.7 s (Fig. 4);

2) the instantaneous velocity of the top of the stubble quiver reaches its maximum value during the first period of oscillation and is in the range of 1.7... 2.6 m / s; 3) the acceleration of the top of the stubble can reach a maximum value of 32... 43 m / s2 in the first 0.15 s (or 1... 2 periods) of the oscillating process (Fig. 6); 4) the speed of movement and acceleration of the top of the stubble does not depend on the speed of the working body.

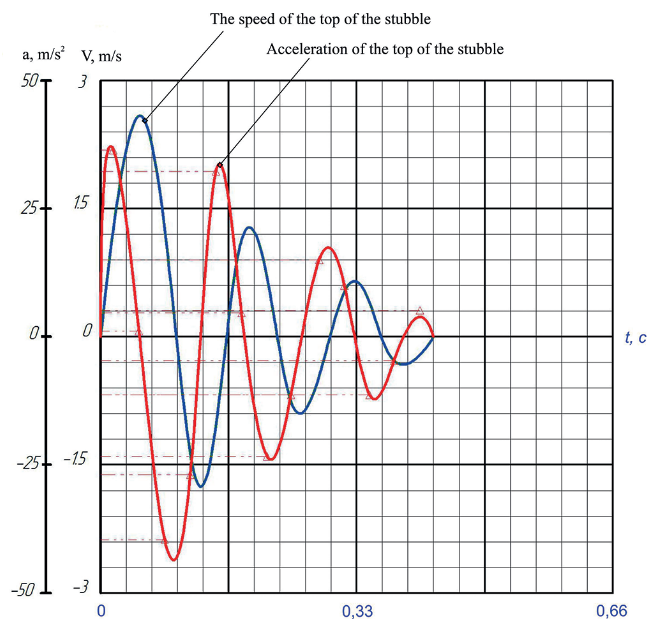

Fig. 6 – Graphs of speed and acceleration of the top of the stubble quiver with a diameter of 6 mm, cut at a height of 0.25 m

Taking into account the results obtained, it can be concluded that the operation of the machine at a height of less than 0.2 m is impractical, because the acceleration during the oscillating process of the stem reaches significant values and cause the discharge of the working solution from the plant stem.

The obtained regression equation, which breaks the dependence of the effectiveness of weed control on the height of the machine, the diameter of the weed stems, the cut angle has the form

$$T = 0{,}35 \cdot \varphi \cdot d - 9{,}05 \cdot d - 92{,}7 \cdot H - \\ - 2{,}05 \cdot \varphi + 9{,}17 \cdot \varphi \cdot H + 28{,}2 \cdot d \cdot H - \\ - 1{,}41 \cdot \varphi \cdot d \cdot H + 114{,}85 \quad (4)$$

The constructed response surfaces according to these equations are given in figure 7.

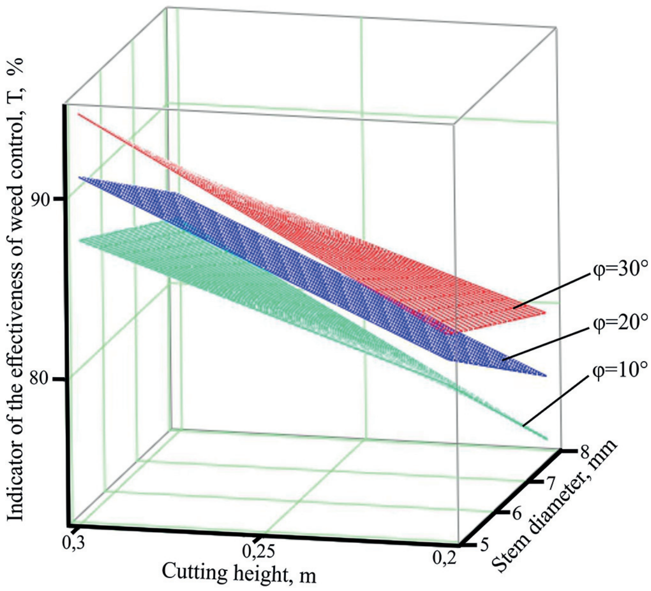

Fig. 7 – Change in the index T of the efficiency of weed control from the diameter of the stem, the height of the melting machine and the cutting angle

Conclusions. In the course of experimental research it was found that the acceleration of the edge (cut) of the stem on which the applied working solution is located has a significant effect on the amount of unproductive losses of the working solution. This fact must be taken into account when providing recommendations for the height of the machine.

The height of the drum installation depending on the conditions of its interaction with the plant material is substantiated. It is rational to install the drum of the contact device 0.02-0.028 m below the cutting height of the terrestrial part of the plant, starting from the phase of active vegetation and before the beginning of the aging phase.

Adherence to these recommendations will allow:

1) prevent the herbicide from entering the soil;

2) reducing the number of useful plants that die as a result of processing.

This, in turn, will reduce the negative impact on the environment and reduce the conflict between economic and environmental requirements for the development of agricultural production.

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РЕЗУЛЬТАТИ ЕКСПЕРИМЕНТАЛЬНОГО ОЦІНЮВАННЯ УМОВ РОБОТИ МАШИНИ ДЛЯ КОНТАКТНОГО ЗНИЩЕННЯ БУР'ЯНІВ

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Анотація

У статті викладено результати досліджень, виконаних у ході створення машини для контактного знищення бур'янів та уточнення параметрів її роботи.

***Мета досліджень**, результати яких викладено в статті, - довести експериментально висунуту у процесі створення машини для контактного знищення бур'янів гіпотезу щодо впливу на величину непродуктивних втрат робочого розчину прискорення зрізу стебла, на якому знаходиться нанесений робочий розчин.*

***Методи**. Для досягнення мети роботи проведено експериментальні дослідження. Результати експериментів оброблено згідно з методикою математичного повнофакторного експерименту та програмного продукту MathCAD v.14.*

***Результати.** У ході експериментальних досліджень встановлено, що робота машини на висоті меншій 0,2 м є недоцільною, тому що прискорення під час коливання стебла досягають значних величин і спричиняють скидання робочого розчину зі стебла рослини. Базуючись на результатах експериментальних досліджень, отримано рівняння регресії, яке розкриває залежність ефективності знищення бур'янів від висоти встановлення машини, діаметру стебел бур'янів, кута зрізу.*

Висновки. *У ході експериментальних досліджень встановлено, що суттєвий вплив на величину непродуктивних втрат робочого розчину має прискорення зрізу стебла, на якому знаходиться нанесений робочий розчин. Різке зростання прискорення верхівок стебел під час їхнього переміщення з відхиленого положення у початкове приводить до скидання нанесеної краплі гербіциду зі зрізу стебла, що не допустимо з двох причин. По-перше, гербіцид потрапляє в грунт і, як наслідок, приводить до його забруднення. По-друге, ефективність знищення бур'янів значно зменшується через втрати й веде до того, що виникає потреба у збільшені доз внесення гербіцидів. А це веде до зростання фінансових витрат на знищення бур'янів. Експериментально встановлено, що зріз рослин доцільно виконувати на висоті не менше 0,2 м Запровадження встановленої вимоги щодо висоти розташування машини допоможе уникнути таких небажаних наслідків.*

Ключові слова: *екологічний аспект, бур'яни, хімізація, знищення, машина, спосіб боротьби з бур'янами.*

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РЕЗУЛЬТАТЫ ЭКСПЕРИМЕНТАЛЬНОЙ ОЦЕНКИ УСЛОВИЙ РАБОТЫ МАШИНЫ ДЛЯ КОНТАКТНОГО УНИЧТОЖЕНИЯ СОРНЯКОВ

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Аннотация

В статье изложены результаты исследований, выполненых в ходе создания машины для контактного уничтожения сорняков и уточнения параметров ее работы.

Цель исследований*, результаты которых изложены в статье, - доказать экспериментальным путем выдвинутую в ходе создания машины для контактного уничтожения сорняков гіпотезу о влиянии на величину непродуктивних потер рабочего раствора ускорения среза стебля, на котором находится рабочий раствор.*

Методы*. Для достижения цели работы выполнены экспериментальные исследования. Результаты экспериментов обработаны согласно методике математического полнофакторного эксперимента на программном продукте MathCAD v.14.*

Результаты. *В ходе экспериментальных исследований установлено, что работа машины на высоте менее 0,2 м нецелесообразна, потому что ускорения при колебательном процессе стебля достигают значительных величин и приводят к сбрасыванию рабочего раствора со стебля растения. Базируясь на результатах экспериментальных исследований, получено уравнение регрес-*

сии, которое раскрывает зависимость эффективности уничтожения сорняков от высоты установки машины, диаметра стеблей сорняков, угла среза.

Выводы. *В процессе экспериментальных исследований было установлено, что ускорение кромки (среза) стебля, на котором находится нанесенный рабочий раствор, существенно влияет на величину непроизводительных потерь рабочего раствора. Резкое увеличение ускорения верхушек стеблей при их движении из отклоненного положения в исходное приводит к сбросу нанесенной капли гербицида со среза стебля. Это недопустимо по двум причинам. Сначала гербицид попадает в почву и, как следствие, приводит к ее загрязнению. Во-вторых, эффективность борьбы с сорняками значительно снижается из-за потерь и приводит к необходимости увеличения доз гербицидов. Это приводит к увеличению финансовых затрат на прополку. Экспериментально установлено, что срезать растения целесообразно на высоте не менее 0,2 м. Введение установленного требования к высоте расположения машины позволяет избежать обозначенных нежелательных последствий.*

Ключевые слова*: экологический аспект, сорняки, химизация, уничтожение, машина, метод борьбы с сорняками.*