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EXPERIMENTAL RESEARCH OF THE MODULE FOR GATHERING PLANT OF CHICORY ROOTS

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***Summary**. Reduction of energy consumption, which creates hygienic root crops, is achieved with the use of expanded boxes of new technologies and improved pick-up modules, which is an urgent scientific task. Tests of the energy-saving method of growing plants are given and what is more, the scheme of experimental installations (put into operation of the plant harvesting module) and the methods of experimental field factors used in roots have been provided. Analytical and empirical dependencies are obtained, which characterize the change of the second feed and the specific mass of the cut and chopped knife of the rotary saw cutter, depending on the velocity of the module, the yield capacity and the density of chicory root crops plantation. The specific mass of the plant harvested from 3 rows of root crops are, respectively, in the range from 17 to 36 (kg/s) and from 19 to 27 (kg/m^2). The results of the experimental studies were processed using Statistics 10, the confidence level P = 0.95, the Fisher F-criterion F = 100.8> Frit and the t-alpha criterion t = 2.05. Based on the graphical constructions it was established that the discrepancy between theoretical and experimental values of the second feed and the specific gravity of the ridge ranges from 10 to 15 (%).*

***Key words**: method, plant cutter, separation disk, spacing of root crops, plant feed.*

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Statement of the problem. Chicory root crops are used in the pharmaceutical, coffee, alcohol and confectionery industries. The products of two processing plants in Ukraine, which are loaded at 15–25% of the production capacity, are exported to France, Germany, Belgium, Hungary, the Republic of Belarus and the USA. Despite the growing demand for raw chicory root products, the sown area of this strategically important agricultural crop for Ukraine is reduced by 20–30% annually due to unsatisfactory provision with the means of mechanization of harvesting root crops, both harvesting tops and digging root crops [1, 2].

In addition, chicory root crops are also one of the sources of nutrient revert to the soil after cut plants are scattered on the harvested field. In relation to the rise in the price of energy carriers in recent years, both in the world and in Ukraine, in particular, they began to use biological fuel, which is produced from high-performance energy crops, as energy resources. The raw material for the production of such energy is agricultural and food products [3].

A special place in this list belongs to chicory root crops, which due to their agrobiological properties have a fairly high and stable energy potential among crop plants. Modern varieties and hybrids of root crops with a high harvesting potential give a large yield of clean energy and biogas. After processing root crops, saturated energy carriers are obtained in the form of bioethanol or biogas [4].

Analyses of available investigations. In general, the selection of building layout schemes and the development of new designs for the working bodies as well as the technical means for harvesting plants should be based on world experience in reducing the use of energy resources, taking into account the peculiarities of domestic agricultural, technical, economic, environmental and other performance requirements [5]+.

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The first stage of single-phase harvesting of large chicory root crops, which has a wide application in present days, is a two-stage harvesting with a plant-picking module in a self-propelled bunker harvester [6]. At the same time, mechanized harvesting of a chicory root crop involves performing two consecutive and related technological operations or stages [7], they are cutting off the main array of the plant and trimming the remains of the branch from the heads of the roots with the cutters [8]. On the basis of the research of technological processes that implement cutting tops of root crops and technological patterns of harvesting machines and technical equipment of domestic and foreign production, it can be stated that at the present stage, the harvesting devices cut the main mass of tops on the principle of «growing crop», which perform the harvesting of tops without copying the heads of root crops [9, 10].

Statement of the problem. An important condition for obtaining high-quality raw materials for the processing and food industries of the agro-industrial complex is the timely harvesting of root crops in accordance with established agrotechnical quality indicators. Late harvesting along with early harvesting of root crops can result in significant losses of many types of structural natural components, or a decrease in the quality of raw materials for its processing [11]. Sustainable development of the global agro-industrial complex is impossible without the development of new progressive approaches to the establishment of effective technologies and technical means for harvesting chicory root crops.

Materials and methods. Depending on the further use of the cut plant, there are two ways of harvesting the majority of the plant: loading the plant that has been cut by the disk working bodies (Fig. 1) or using it for animal feed; and spreading the plant which has been cut and chopped by rotary cutter knives on the surface of the field as siderates or fertilizers [12, 13].

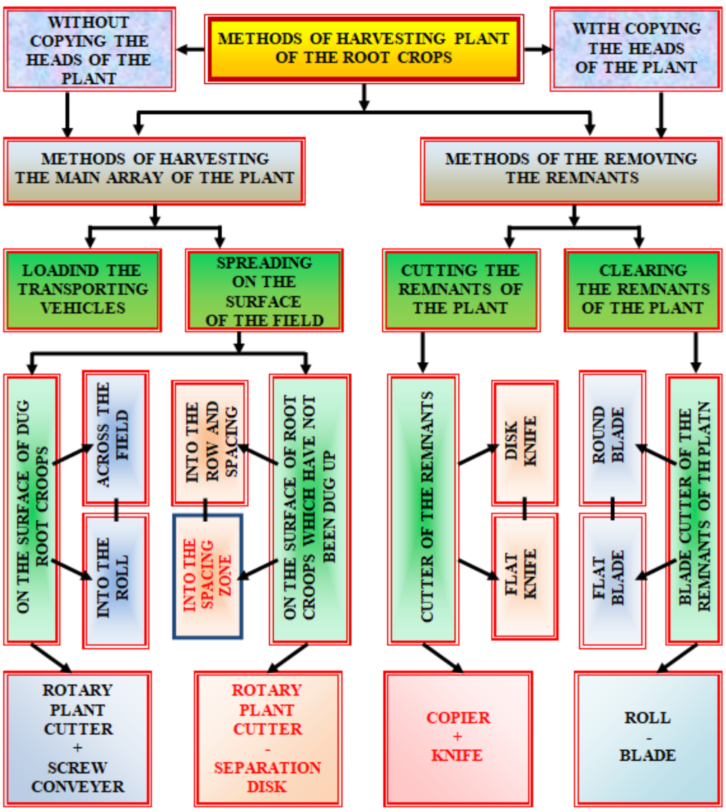

Figure 1. Classification of methods for harvesting plant of root crops

The spreading of the plant on the surface of the field is organized according to two classification criteria: the spreading the crushed plant from which the roots were dug on the surface of the field; scattering of crushed plant on the surface of the field into the spacing of the roots which have not been harvested. The first criterion involves unloading plant which was cut and shredded using a knife of a rotary saw cutter with a screw conveyor on the surface of the harvested field in a longitudinal roll regarding the movement of the harvester, or spreading the plant with a rotary picker on the surface of the harvested field.

The second criterion involves the spreading of a cut plant on the surface of and non-harvested field into a row and the spacing of the roots which have not been harvested. Unloading of the plant which was cut and shredded with a rotary cutter knives on the harvested field in the longitudinal roll regarding the movement of the harvester, or spreading the plant to the surface of the harvested field is implemented by cutting off the main array of the plant with the swivel knives while shredding and feeding over the trajectory to the screw conveyor which transports the shredded plant and unloads it from the output end of the auger into the roll [14, 15].

Spreading a cut plant on the surface of an non-harvested field into a row and the spacing of the roots which have not been harvested is implemented by the means of cutting the main array of the plant with the knives of the rotary plant cutter while simultaneously shredding and feeding the shredded plant into a row and the spacing of the roots which have not been harvested. However, the main disadvantages of the two ways of harvesting chicory root crop are the spreading of the cut plant within the row of root crops – in the first case, the loss of the plant during the cutting it with the rotary knives, and in the second – the loss and technological movement of the plant into the rows of on-harvested roots. The presence of a plant on the surface of a field of non-harvested root crops significantly reduces the technological capabilities of the rooting machine in the context of compliance with agrotechnical requirements to the indicators of the quality of their work [16–18].

It is presumed that at the core of solving this scientific task of reducing energy costs when harvesting the main array of plant lays a hypothesis, which includes the elimination of a module for cleaning tops of the intermediate link or transporting element in the constructive and building scheme. The module is embodied in the form of a screw conveyor, which is installed in the guiding chute.

The harvesting method involves three related operations: cutting the main array of plants with knives of a rotary cutter while simultaneously shredding and transporting the plant in the guiding channels of the rotary cutter casing; laying cut plants in the spacing of the roots rows in the area of the location of separation discs. In this case, the cutting of the main array of plant and scattering of ground tops in the spacing of root crops is carried out by one working body – rotor plant cutter.

During the movement of plant harvesting module along the rows of the root crops 1 (Fig. 2) knives 5 due to the rotation of a rotary plant cutter 3 cut the main array of plant and then it is fed over the trajectory to the entry throat 9 of the guiding channel 8. Due to the L-shaped air flow created by means of the rotation of the knives, cut and shredded plant is transported by the guiding channel to the outlet throat 10, and then to the deflector 11 where shredded plant 12 is laid in the spacing of the roots between two adjacent disks 6. It is advisable to carry out the substantiation of the parameters of the harvesting module on the basis of the definition and theoretical analysis of the number of cut plant 5 (Fig. 3), which is cut by means of 4 rotary cutter 3 and laid on the surface of the field into the spacing of the roots which have not been harvested 1.

If plant is cut simultaneously from several rows, and the number of the rows is denoted by n_k, then the mass of the cut plant M_p (kg) is equal to the sum of the masses of the cut plant from the each row $M_p = m_{1p} + m_{2p} +,...,+ m_{np}$. The mass of the cut plant m_{ip} is nothing but the feed of cut plant $\Pi_{ip}(t)$ (кg) from each i row of root crops for a period of time t (s), which depends on the total number of root crops K_{iz} (pc.) from which the plant is cut by means of the rotary cutter and the yield capacity of the plant of each individual i row of root crops U_{ip} (kg/m^2), or $\Pi_{ip}(t) = U_{ip} K_{iz}(t)$ (kg), while:

$$K_{iz} = L_\vartheta k_{iz} = \vartheta_M t k_{iz} = \vartheta_M t b_k \Gamma_{ik}\ ;\ \Pi_{ip}(t) = \frac{dL_\vartheta}{dt} t b_k \Gamma_{ik} U_{ip}\ , \tag{1}$$

where L_ϑ – the distance that the plant harvesting module will pass during the time t (m);
k_{iz} – the number of root crops per one meter in each i row (pc.);
ϑ_M – velocity of the module (m/s);
b_k – width of the spacing of the root crops (m);
Γ_{ik} – density of the root crops plantation in each i row during the harvesting (pc./m^2);

$$\Pi_p = \frac{dL_\vartheta}{dt} t b_k \left(\Gamma_{1k} U_{1p} + \Gamma_{2k} U_{2p} +,\ldots,+ \Gamma_{nk} U_{np}\right). \tag{2}$$

Cutting height of the main array of the plant is determined by the nature of the location of the roots above the level of the soil surface and the principle of selecting the main array at the level of the highest placed heads of the roots. In this case, after cutting the plant the remnants of the plant remain on some root crops that are located relatively to the level of the soil surface below the main array of root crops [19] (Fig. 3) on the heads of the roots 1. To reflect these remnants the coefficients $k_{iг}$ is added, which is corrected by the reduced feed Π_{ip} of the cut plant from each i row. Given the significant volatile change in plant yield capacity $U_{ip} \pm \Delta U_{ip}$ (kg/m^2) and density of the root crops plantation $\Gamma_{ik} \pm \Delta\Gamma_{ik}$ (kg/m^2) on the field, the equation (2) will become

$$\Pi_p = \frac{dL_\vartheta}{dt} b_k t\left[\left(\Gamma_{1k} \pm \Delta\Gamma_{1k}\right)\left(U_{1г} \pm \Delta U_{1p}\right)k_{1г} + \left(\Gamma_{2k} \pm \Delta\Gamma_{2k}\right)\left(U_{2p} \pm \Delta U_{2p}\right)k_{2г} +,\ldots,+ \left(U_{np} \pm \Delta U_{np}\right)k_{1n}\right]. \tag{3}$$

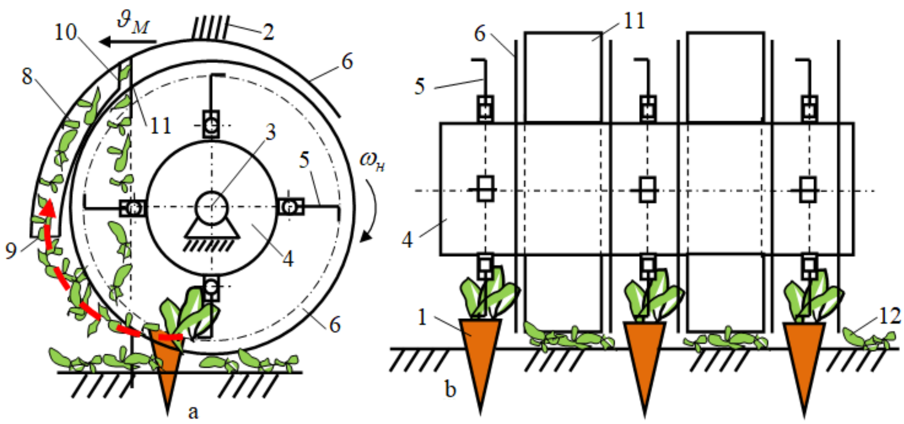

Figure 2. Scheme of the plant harvesting method in the spacing of the roots which have not been harvested
a – side view; б – side at the back; 1 – root vegetables with plant; 2 – frame; 3 – rotary cutter; 4 – reel; 5 – knife; 6 – separation disk; 7 – cover plate; 8 – guiding channel; 9, 10 – entry and outlet throat; 11 – deflector; 12 – shredded plant which is laid in the spacing

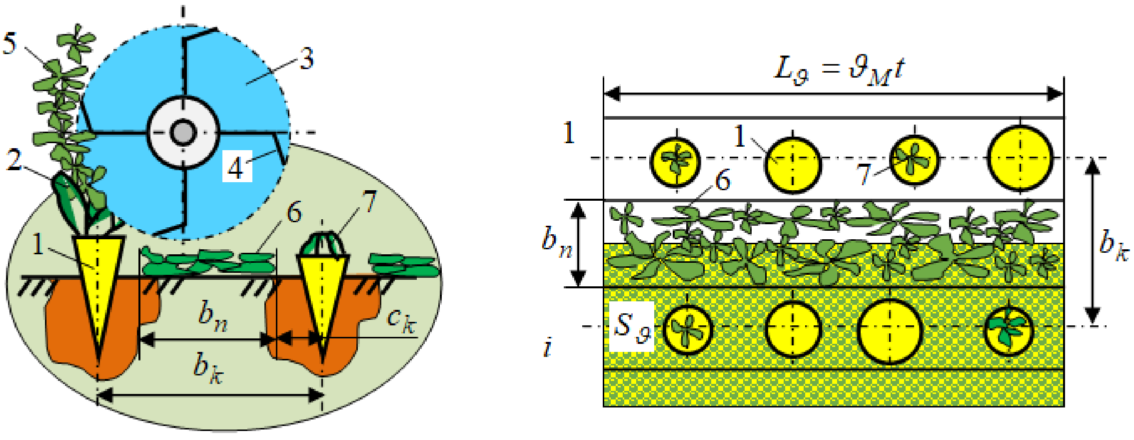

Figure 3. Scheme for the calculation of technological feed of the plant cut with a rotary plant cutter
1 – root crops; 2 – plant; 3 – rotary cutter; 4 – knife; 5 – cut plant; 6 – plant laid in the spacing of the roots which have not been harvested; 7 – remnants of the plant on some root crops

The specific mass M_{np} (kg/m^2) of the cut plant 12 (Fig. 2, Fig. 3), which is laid on the surface of the field into the spacing of the roots which have not beenharvested1, or into the zone between two separation disks 6 is given by the formula

$$M_{np} = \frac{2b_k}{b_k - b_n}\left[(\Gamma_{1k} \pm \Delta\Gamma_{1k})(U_{1г} \pm \Delta U_{1p})k_{1г} + (\Gamma_{2k} \pm \Delta\Gamma_{2k})(U_{2p} \pm \Delta U_{2p})k_{2г} +,...,+(U_{np} \pm \Delta U_{np})k_{1n}\right] \quad (4)$$

,

where b_n – the distance between two separation disks (m).

For the convenience of practical application of the equations (3) and (4) it can be assumed that the density of plantation $\Gamma_{ik} \pm \Delta\Gamma_{ik}$ yield capacity of the plant $U_{ip} \pm \Delta U_{ip}$ root crops and correction factor $k_{iг}$ of each i row equal to the average value for a particular variety of chicory root crops, or $\Gamma_{ik} \pm \Delta\Gamma_{ik} = \Gamma_k \pm \Delta\Gamma_k$, $U_{ip} \pm \Delta U_{ip} = U_p \pm \Delta U_p$, $k_{iг} = k_г$.

Then equations (3) and (4) have the final form:

$$\Pi_p = \frac{dL_M}{dt} b_k t n_k (\Gamma_k \pm \Delta\Gamma_k)(U_p \pm \Delta U_p); \; M_{np} = \frac{b_k k_г}{b_n}(\Gamma_k \pm \Delta\Gamma_k)(U_p \pm \Delta U_p). \quad (5)$$

In order to check the adequacy of the empirical models (5) experimental studies of a 3-row plant harvesting module was obtained (Fig. 4) based on the construction and implementation of the planned factor experiments. Schematic diagram of 3-x 3-row plant harvesting module of the root crops planted with row spacing width $b_k = 0.45$ (m) (module grip width – 1.35 (m)) is indicated in Fig. 2. The experiments were performed on the experimental fields of root crops of Sophiyivskiy chicory 7. To obtain the regression equation that characterizes the change in the time of the feed Π_p (kg/s) and the specific mass M_{np} (kg/m^2) of the plant, the symmetric plan of a planned three-factor experiment at three levels of factors variation has been selected.

In this case, the variable factors were the velocity of the module $\vartheta_M = 1.2 - 1.4 - 1.6$ (m/s), yield capacity of the plant $U_p \pm \Delta U_p = 1.4 \pm 0.2 - 1.6 \pm 0.2 - 1.8 \pm 0.2$ (kg/m^2), and density of chicory root crops plantation $\Gamma_k \pm \Delta\Gamma_k = 7 \pm 2 - 9 \pm 2 - 11 \pm 2$ (t. pc./m^2); after the module has passed, a plant which has been cut and laid in the spacing of the roots which have not been harvested between two adjacent separation discs was manually selected and weighed with precision ± 0.1 (kg); momentary feed Π_p was determined according to the formula $\Pi_p = M_p / t$, where M_p – mass of the picked plant (kg) on the area of the spacing $S_e = \vartheta_M t b_n n_k$, (м^2); specific mass of the plant M_{np} was determined according to the formula $M_{np} = M_p / \vartheta_M t b_n n_k$.

Figure 4. General appearance of a plant harvesting module

The order of implementation of the field experimental studies to determine change of the time of feed Π_p and the specific mass M_{np} of the plant was performed by standard methods with three times the repetition of each experiment. The processing of the obtained experimental data set was performed according to well-known methodologies and methods of statistical processing using correlation and regression analysis.

Results and discussion. Under initial conditions $b_k = 0.45$ (m), $k_{гс} = 0.9$, $b_n = 0.3$ (m), $n_k = 6$ (pc.) and in accordance with equations (5) theoretical dependencies of the change, respectively, of the momentary feed Π_p (kg/s) and specific mass M_{np} (kg/m^2) of the cut plant were formulated as a function: $\Pi_p = f_\Pi(\vartheta_M; U_p \pm \Delta U_p)$, (Fig. 5 a); $M_{np} = f_M(\vartheta_M; U_p \pm \Delta U_p)$, (Fig. 5 b).

On the basis of the analysis of graphical constructions (Fig. 5 a) it is established that:

- within the change of the velocity ϑ_M of the plant harvesting module from 1.2 to 1.6 (m/s) and changes in the yield capacity of the plant from $U_p + \Delta U_p$ from 1.5 + 0.2 to 2 + 0.2 (кг/м^2) the momentary feed of the plant Π_p, which was cut by means of the knives of the rotary cutter is in the range: at the density of chicory root crops plantation $\Gamma_k + \Delta\Gamma_k = 9 + 2$ (t.pc./m^2) – from 56.6 to 94.1 (kg/s); at the density of chicory root crops plantation $\Gamma_k + \Delta\Gamma_k = 7 + 2$ (t. pc./m^2) – from 37.7 to 75.3 (kg/s);
- within the change of the velocity ϑ_M of the plant harvesting module from 1.2 to 1.6 (m/s) and changes in the yield capacity of the plant from $U_p - \Delta U_p$ from 1.5 – 0.2 to 2 – 0.2 (kg/m^2) the momentary feed of the plant Π_p, which was cut by means of the knives of the rotary cutter is in the range: at the density of chicory root crops plantation $\Gamma_k - \Delta\Gamma_k = 9 - 2$

(t.pc./m^2) – from 23.1 to 42.3 (kg/s); at the density of chicory root crops plantation $\Gamma_k - \Delta\Gamma_k = 7 - 2$ (t. pc./m^2) – from 18.9 to 34.7 (kg/s).

On the basis of the analysis of graphical constructions (Fig. 5 b) it is established that:

- within the change of the velocity ϑ_M of the plant harvesting module from 1.2 to 1.6 (m/s) and changes in the yield capacity of the plant from $U_p + \Delta U_p$ from 1.5 + 0.2 to 2 + 0.2 (kg/m^2) the momentary feed of the plant M_{np}, which was cut with the knives of the rotary cutter and laid between two adjacent separation discs is in the range: at the density of chicory root crops plantation $\Gamma_k + \Delta\Gamma_k = 9 + 2$ (t. pc./m^2) – from24.3 to 32.6 (kg/s); at the density of chicory root crops plantation $\Gamma_k + \Delta\Gamma_k = 7 + 2$ (t. pc./m^2) – from18.5 to 26.7 (kg/m^2);

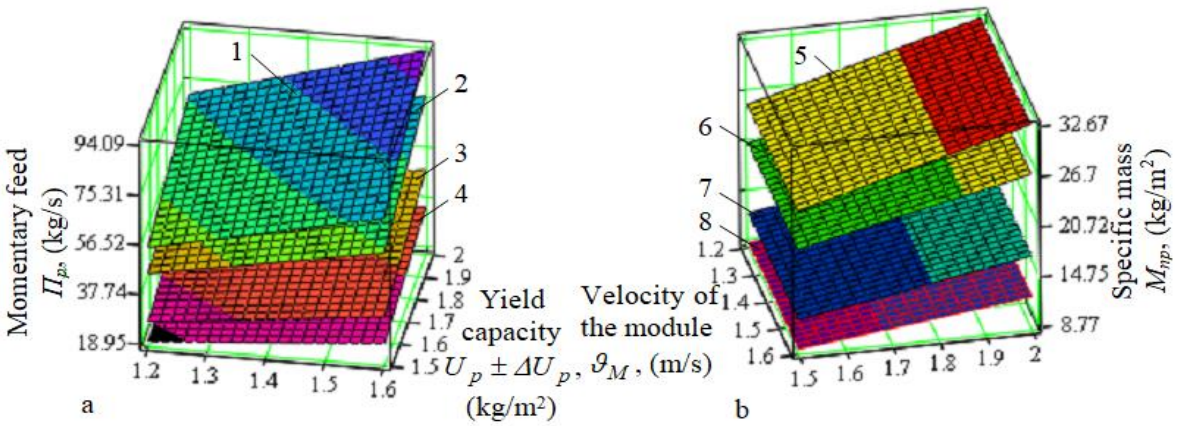

Figure 5. Dependencies of change: a – $\Pi_p = f_\Pi(\vartheta_M; U_p \pm \Delta U_p)$;
b – $M_{np} = f_M(\vartheta_M; U_p \pm \Delta U_p)$; 1, 5 – $\Delta U_p = +0.2$ (kg/m^2), $\Gamma_k + \Delta\Gamma_k = 9 + 2$ (t. pc./m^2);
2, 6 – $\Delta U_p = +0.2$ (kg/m^2), $\Gamma_k + \Delta\Gamma_k = 7 + 2$ (t. pc./m^2); 3, 7 – $\Delta U_p = -0.2$ (kg/m^2),
$\Gamma_k - \Delta\Gamma_k = 9 - 2$ (t. pc./m^2); 4, 8 – $\Delta U_p = -0.2$ (kg/m^2), $\Gamma_k - \Delta\Gamma_k = 7 - 2$ (t. pc./m^2)

- within the change of the velocity ϑ_M of the plant harvesting module from 1.2 to 1.6 (m/s) and changes in the yield capacity of the plant from $U_p - \Delta U_p$ from 1.5 – 0.2 to 2 – 0.2 (kg/m^2) the momentary feed of the plant M_{np}, which was cut with the knives of the rotary cutter and laid between two adjacent separation discs is in the range: at the density of chicory root crops plantation $\Gamma_k - \Delta\Gamma_k = 9 - 2$ (t. pc./m^2) – from11.8 to 16.7 (kg/m^2); at the density of chicory root crops plantation $\Gamma_k - \Delta\Gamma_k = 7 - 2$ (t. pc./m^2)– from 8.7 to 12.7 (kg/m^2).

After processing the experimental data set an approximate dependence that functionally describes the change in the momentary feed $\Pi_p^{\pm}$ and specific mass $M_p^{\pm}$ of the plant depending on the change in input factors was found as a linear model with the highest value of the coefficient of determination *D* and correlations (*R* = 0.964) at the reliability level of *P* = 0.95. After checking the adequacy of model on the F-testand the (*F* = 100.8) significance of the Student's coefficients (*t* = 2.05**)**, the regression equation in the form of a linear model for the natural values of the factors was obtained:

- momentary feed of the plant of the chicory root crops, respectively, *D* = 0.929; 0.963:

$$\Pi_p^+ = -39.38 + 18.67\vartheta_M + 14.81(U_p + \Delta U_p) + 2.11(\Gamma_k + \Delta\Gamma_k); \quad (6)$$

$$\Pi_p^- = -42.26 + 11.17\vartheta_M + 11.36(U_p - \Delta U_p) + 2.81(\Gamma_k - \Delta\Gamma_k); \quad (7)$$

- specific mass of the plant $M_p^{\pm}$, which was cut with the knives of the rotary cutter and laid in the spacing of the roots which have not been harvested between two adjacent separation discs, respectively, D = 0.973; 0.949:

$$M_{np}^+ = -17.05 - 2.52\vartheta_M + 19.11(U_p + \Delta U_p) + 14.81(\Gamma_k + \Delta\Gamma_k); \quad (8)$$

$$M_{np}^- = -35.51 - 0.91\vartheta_M + 14.39(U_p + \Delta U_p) + 19.49(\Gamma_k + \Delta\Gamma_k). \quad (9)$$

According to the regression equations (6), (7) and (8), (9) a response surface is formulated. It characterizes the functional change of the momentary feed of the plant $\Pi_p^{\pm}$ and of the specific mass of the plant $M_p^{\pm}$, which was cut with the knives of the rotary cutter and laid in the spacing of the roots which have not been harvested between two adjacent separation discs depending on the velocity of the harvesting module ϑ_M, yield capacity of the plant $U_p \pm \Delta U_p$ and density of chicory root ropsplantation $\Gamma_k \pm \Delta\Gamma_k$, (Fig. 6).

With a variable increase in the yield capacity of the plant $U_p + \Delta U_p$ in the range from 1.4 + 0.2 to 1.8 + 0.2 (kg/m^2) and density of chicory root crops plantation $\Gamma_k + \Delta\Gamma_k$ in the range from 7 + 2 to 11 + 2 (t.pc./m^2), momentary feed of the plant Π_p^+ at the velocity of the harvesting module $\vartheta_M = 1.2...1.6$ (m/s) changes in direct proportion to the increase of each factor in the range from 17 to 36 (kg/m^2) (Fig. 6 a).

With a variable decrease in the yield capacity of the plant $U_p - \Delta U_p$ in the range from 1.4 – 0.2 to 1.8 – 0.2 (kg/m^2), and density of chicory root crops plantation $\Gamma_k - \Delta\Gamma_k$ in the range from 7 – 2 to 11 – 2 (t.pc./m^2) momentary feed of the plant Π_p^+ at the velocity of the harvesting module $\vartheta_M = 1.2...1.6$ (m/s) changes in direct proportion to the increase of each factor in the range from 10 to 26 (kg/s) (Fig. 6 b).

The shifts within the dominant factors lead to a significant changes in the specific mass of the plant $M_{np}^{\pm}$, which was cut with the knives of the rotary cutter and laid in the spacing of the roots which have not been harvested between two adjacent separation discs is in the range $M_{np}^+ = 19...27$ (kg/m^2) (Fig. 6 c) and $M_{np}^- = 9...18$ (kg/m^2), (Fig. 6 d) at the velocity of the harvesting module $\vartheta_M = 1.2...1.6$ (m/s). These factors are yield capacity of the plant $U_p \pm \Delta U_p$ and density of chicory root crops plantation $\Gamma_k \pm \Delta\Gamma_k$:

- with the changing increase of the yield capacity of the plant $U_p + \Delta U_p$ in the range from 1.4 + 0.2 to 1.8 + 0.2 (kg/m^2) and density of chicory root crops plantation $\Gamma_k + \Delta\Gamma_k$ in the range from 7 + 2 to 11 + 2 (t. pc./m^2) specific mass of the plant M_{np}^+ on average is increased, respectively, by 5.5…6.5 (kg/m^2) and 6.5…7.5 (kg/m^2), (Fig. 6 c);

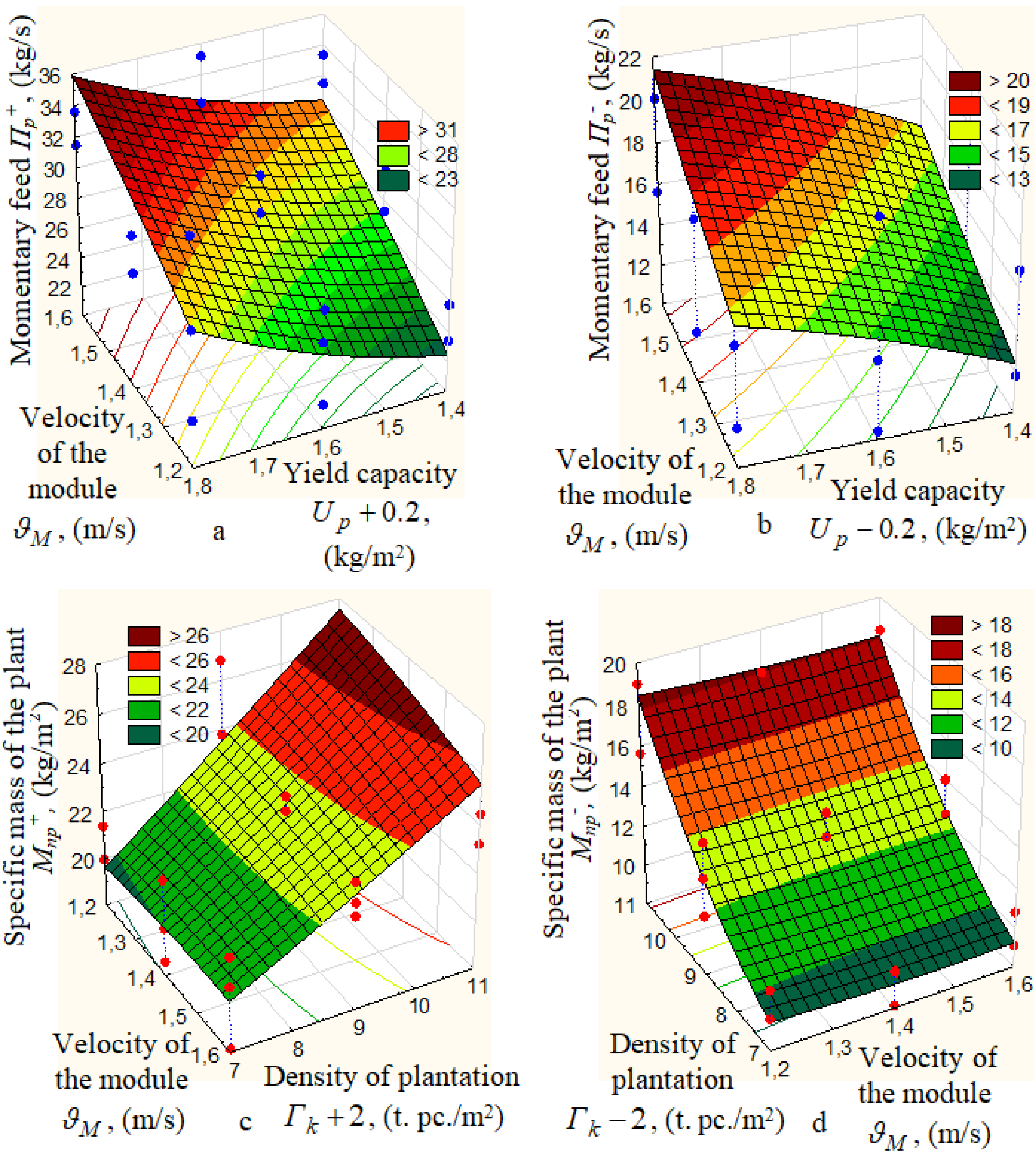

Figure 6. Response surface of the change of momentary feed of cut plant as a function

a – $\Pi_p^+ = f_\Pi(\vartheta_M; (U_p + 0.2))$; b – $\Pi_p^- = f_\Pi(\vartheta_M; (U_p - 0.2))$;

c – $M_{np}^+ = f_M(\vartheta_M; (\Gamma_k + 2))$; d – $M_{np}^- = f_M(\vartheta_M; (\Gamma_k - 2))$

- with the changing decrease of the yield capacity of the plant $U_p - \Delta U_p$ in the range from 1.4–0.2 to 1.8–0.2 (kg/m^2) and density of chicory root crops plantation $\Gamma_k - \Delta\Gamma_k$ in the range from 7–2 to 11 – 2 (t. pc./m^2) specific mass of the plant M_{np}^- on average is increased, respectively, by 3.5…4.5 (kg/m^2) and 8.5…9.5 (kg/m^2), (Fig. 6 d).

The velocity change ϑ_M of the plant harvesting module of 1.2 to 1.6 (m/s) has an insignificant effect on the increase in the specific mass of the plant $M_{np}^{\pm}$ – the increasing is 0.3…0.5 (kg/m^2).

Conclusion. An advanced technological process of harvesting root crops is suggested, which provides a reduction of energy consumption due to simultaneous cutting, grinding and laying cut plant on the surface of the field between two separation disks, which are fixed on the drum of the rotary plant cutter and are located in the spacing of the roots which have not been harvested. Reducing the energy intensity of the process is achieved by simultaneously combining the operations of cutting and transporting the cut plant with an active (rotary cutter) and passive (guiding channel) working bodies.

Analytical and empirical models have been developed describe the change in the momentary feeding of the plant and the specific mass of the plant, which is cut off by the blades of the rotary cutter and enclosed in the spacing of the roots which have not been harvested between two adjacent separation discs, depending on the velocity of the module, irregular changes of the yield capacity and the density of the plantation.

Based on the analysis of the graphics, it was established that the momentary feeding and the specific mass of the plant harvested from 3 rows of root crops are, respectively, in the range from 17 to 36 (kg/s) and from 19 to 27 (kg/m2). The discrepancy between the theoretical values of the momentary feeding and the specific mass of the plant, which are discovered according to formulas (5) and the experimental values, which are established according to the regression equations (6), (7) and (8), (9) are from 5 to 15 (%).

The obtained results of the analytical and empirical studies of the momentary feeding and the specific mass of the plant will be applied for the further justification of the structural and kinematic parameters of the diggers and cleaners of the pile of root crops of root-harvesting machines on the basis of matching the capacity of their working bodies.

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ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ МОДУЛЯ ДЛЯ ЗБИРАННЯ ГИЧКИ КОРЕНЕПЛОДІВ ЦИКОРІЮ

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Резюме. *Коренеплоди цикорію кореневого є цінною лікарською та харчовою культурою. Після переробки коренеплодів цикорію отримують різні види лікарських препаратів і харчових продуктів, які насичені мікроелементами. Зменшення енергозатрат збирання основного масиву гички коренеплодів цикорію досягається на основі розроблення нових способів збирання та удосконалених гичкозбиральних модулів, що є актуальним науковим завданням зниження затрат енергії під час збирання гички. Зниження затрат енергії досягнуто за рахунок усунення проміжної операції транспортування зрізаної гички шнековим конвеєром на зібране поле. Запропоновано після зрізування гички ножами роторного гичкоріза укладати зрізану гичку у міжряддя невикопаних коренеплодів. Наведено опис енергоощадного способу збирання гички, схему експериментальної польової установки (удосконаленого гичкозбирального модуля) та методику проведення експериментальних польових досліджень процесу збирання основного масиву гички коренеплодів цикорію. За результатами теоретичного аналізу процесу зрізування гички коренеплодів цикорію та опрацювання експериментального масиву даних отримано аналітичні та емпіричні залежності, які характеризують зміну секундної подачі й питому масу зрізаної та подрібненої ножами роторного гичкоріза гички залежно від швидкості руху модуля, урожайності та густоти насадження коренеплодів цикорію. На основі графічних побудов встановлено, що розбіжність теоретичних і експериментальних значень секундної подачі та питомої маси гички становить від 10 до 15%. Результати дослідження є подальшим кроком удосконалення методології та методики розрахунку, проектування та обгрунтування раціональних параметрів робочих органів гичкозбиральних модулів машин для збирання коренеплодів цикорію.*

Ключові слова: *спосіб, гичкоріз, ділильний диск, міжряддя коренеплодів, подача гички*.

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