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TECHNOLOGY OF HARVESTING OF ROOT CROPS

The development of energy-saving technologies for agricultural crops production is a strategic and priority direction for further balanced development of the agro-industrial complex in Ukraine. In this aspect, an important task of scientific research is the development of the concept of a significant reduction in energy demands, which is spent during the technological process of harvesting the main mass of the tops of root crops. On the basis of the identification of technological processes and structural models of existing devices for harvesting tops of root crops, a new technology for harvesting the main mass of the tops of root crops and a device for its implementation is proposed – an improved energy saving module of root harvesters. The energy saving method, in contrast to the existing technology of stacking the cut and crushed tops with a screw conveyor on the collected field into a roll, involves the stacking the tops between rows of the root crops. Reducing energy demands is achieved by eliminating the operation of moving the tops with a screw conveyor.

Keywords: *module, rotary top cutter, guide channel, dividing plate, hinged baffle, energy demands.*

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ТЕХНОЛОГІЯ ЗБИРАННЯ ГИЧКИ КОРЕНЕПЛОДІВ

Розробка енергозберігаючих технологій виробництва сільськогосподарських культур є стратегічним і пріоритетним напрямком подальшого збалансованого розвитку агропромислового комплексу України. В цьому аспекті важливим завданням наукових досліджень є розробка концепції значного зменшення затрат енергії, які витрачаються під час технологічного процесу збирання основного масиву гички коренеплодів. На основі ідентифікації технологічних процесів і структурних моделей існуючих пристроїв для збирання гички коренеплодів запропоновано нову технологію збирання основного масиву гички коренеплодів і пристрій для його реалізації - вдосконалений енергозберігаючий модуль коренезбиральних машин. Енергозберігаючий спосіб, на відміну від існуючої технології укладання зрізаної і подрібненої гички шнековим транспортером на зібраний поле в валок, передбачає укладання гички в міжряддя коренеплодів. Зменшення витрат енергії досягається шляхом усунення операції переміщення гички шнековим конвеєром.

Ключові слова: *модуль, роторний гичкоріз, направляючий канал, ділильний диск, фартух, енергозатрати.*

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ТЕХНОЛОГИЯ УБОРКИ БОТВЫ КОРНЕПЛОДОВ

Разработка энергосберегающих технологий производства сельскохозяйственных культур является стратегическим и приоритетным направлением дальнейшего сбалансированного развития агропромышленного комплекса Украины. В этом аспекте важной задачей научных исследований является разработка концепции значительного уменьшению затрат энергии, которые расходуются во время технологического процесса уборки основного массива ботвы корнеплодов. На основе идентификации технологических процессов и структурных моделей существующих устройств для уборки ботвы корнеплодов предложена новая технология уборки основного массива ботвы корнеплодов и устройство для его реализации – усовершенствованный энергосберегающий модуль корнеуборочных машин. Энергосберегающий способ, в отличие от существующей технологии укладки срезанной и измельченной ботвы шнековым транспортером на собранный поле в валок, предусматривает укладку ботвы в междурядья корнеплодов. Уменьшение затрат энергии достигается путем устранения операции перемещения ботвы шнековым конвейером.

Ключевые слова: *модуль, роторный ботворез, направляющий канал, делительный диск, фартук, энергозатраты.*

Formulation of the problem. The root crops of sugar, fodder beet and root chicory are important technical crops of agricultural production. Sugar beet is the primary source for obtaining raw materials, from which sugar is produced as a strategic food product, which is in great demand in the world market and other important minor products of its processing. The root crops of fodder beet and tops are valuable components of the feed ration of farm animals. Fodder beet, in the feeds of the autumn-winter period, is the main type of juicy feed stuff that has a large amount of carbohydrate nutrients, especially useful for dairy cattle. Introduction in the diet of dairy cows of fodder beet helps to increase feed intake by 8...11%, increase the milk production of animals by 10%, assimilation of organic substances by 5...8% [1].

The roots of chicory are used in the pharmaceutical, coffee, alcohol and confectionery industries. The value of chicory is determined by the content of various kinds of saccharin's in root crops that is inulin, fructose, glucose, various kinds of acids and vitamins useful for the organism and rare in natural products, vitamins, and also trace nutrients including iron, copper, zinc, chromium. The products of two processing plants in Ukraine, which are loaded at 15...25% of the production capacity, are exported to France, Belgium, Hungary, Russia, the Republic of Belarus, the United States. Despite the growing demand for raw processing products of root chicory, the acreage of this strategically important

agricultural crop in Ukraine is annually reduced by 20...30% due to unsatisfactory provision of harvesting tools for root crops, such as harvesting of the tops and digging of root crops [2].

Analysis of recent research and publications. Analysis of well-known scientific works (3-6) showed that the existing technologies for harvesting the leaves are energy-consuming. The increase in energy costs occurs at the stage of transportation of the cut-off haul by a transverse screw conveyor. Significant cost reduction is achieved by eliminating this intermediate operation and laying the cut tops not in the cleaned field, but in between.

Setting goals. The purpose of the work is to reduce the energy costs of the technological process of harvesting the main body of root crops. The achievement of the goal is realized on the basis of the improvement of the technology and design of the module for harvesting the leaves.

Statement of the main material. In addition, the tops of sugar, fodder beet and root chicory are also one of the sources nutrient return to the soil after spreading the severed tops to the harvested field. Due to increase in energy prices in recent years, both in the world and in Ukraine in particular, as energy resources began to use biological fuel, which is produced from high-performance energy crops. One of the most advanced alternative sources of energy today is a solid biological mass of organic origin including vegetable, which is an environmentally friendly renewable energy source. The raw material for the production of such energy is agricultural and food products. The most important varieties of this fuel are biodiesel and bioethanol.

For the production of bioethanol, any raw materials containing a significant amount of sugar or materials that can be reformed to sugar, for example starch or cellulose, is used. Common sugar crops that are used as raw materials for bioethanol production are sugar and fodder beet, root chicory, sugar cane, sugar sorghum etc.

A special place in this list belongs to root crops, which for their agrobiological properties have a sufficiently high and stable energy potential among agricultural crops. With proper cultivation techniques, they can provide yields of up to 100 t/ha, and sometimes much more. Modern varieties and hybrids of root crops with a high yield potential give a large yield of clean energy and biogas. After the processing of root crops, energy carriers are obtained in the form of sugar, bioethanol or biogas, fig. 1 [7].

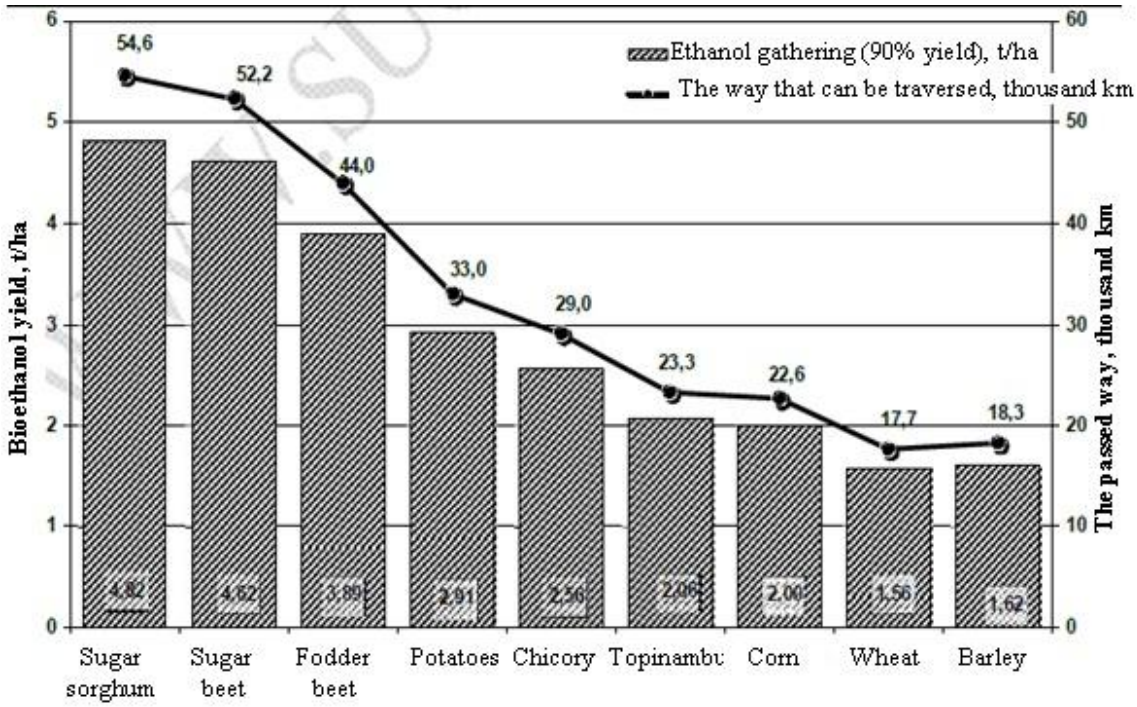

Fig. 1. **Potential yield of bioethanol per 1 hectare of crops**

An important criterion of obtaining benign raw materials for the processing and food industries of the agro-industrial complex is timely harvesting of root crops in in accordance with established agricultural quality indicators. Both late and early harvesting of root crops result in significant losses of many types of structural natural components, or a decrease in the quality of raw materials for its processing [8]. The sustainable development of the world agro-industrial complex is impossible without

the development of new progressive approaches to the creation of effective technologies and technical means for harvesting crops.

The mechanized harvesting of sugar root crops, fodder beet and root chicory is one of the most labor intensive and energy-consuming operations in the general context of crop production and processing raw materials not only in Ukraine but also in highly developed countries of the world community.

The choice of perspective layout schemes and the development of new designs of working bodies and technical means for harvesting the tops should in general be based on the world experience of reducing energy resources, considering the special aspects of domestic agrotechnical, technical and economic, ecological and other production requirements.

On the basis of the research of technological processes that realize the cutting of the tops of root crops and technological schemes of top harvesters and technical equipment of domestic and foreign production, it can be stated that at the modern stage the top harvesters compete harvesting of the tops without gauging capitulum of root crops [8].

The presence of a wide variety of layout schemes for the top harvesting mechanisms is directly related to both the top harvesting techniques (Fig. 2) or the use of tops (the use of haulm for food or as organic fertilizer by spreading it onto a harvested field) and with technological operations that realize Every single technology of its harvesting.

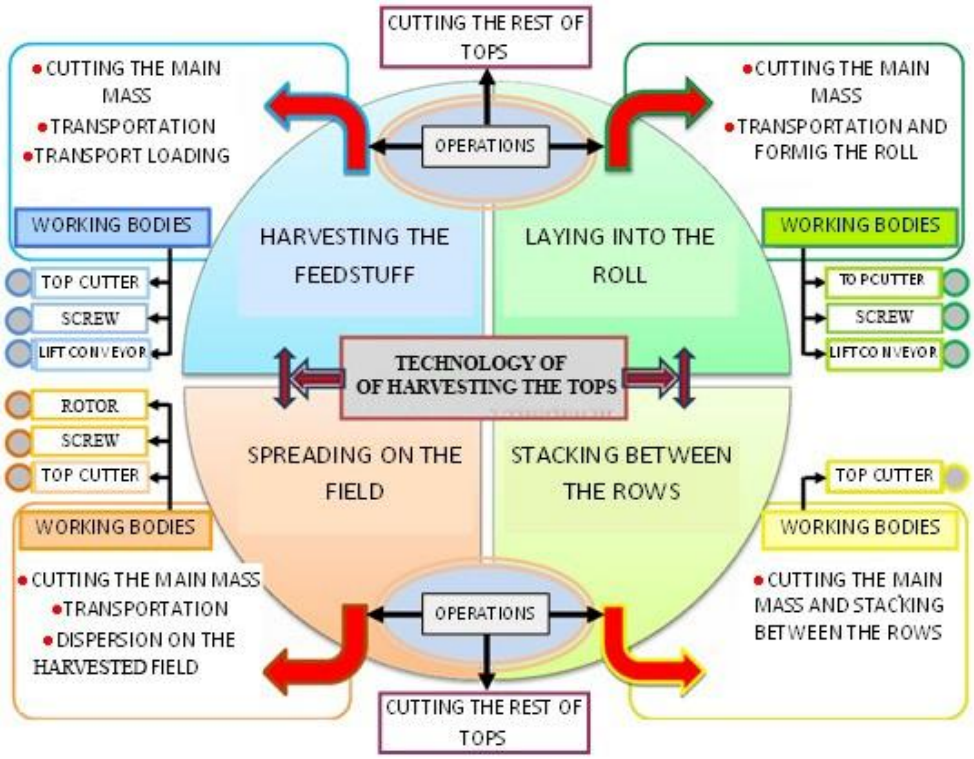

Fig. 2. **Technology and operations of harvesting the root crops**

Considering the specific biological characteristics of the tops of root crops (significant yields), mechanized harvesting of the tops can provide for five main adjacent technological operations: cutting the main mass of the tops, transporting the cut tops with forming into the roll or spreading it onto the harvested field, cutting off the deads of the tops from the capitulum of root crops, loading into the transport.

At this stage, cutting the main mass of tops is carried out without gauging capitulum of root crops, or by method of non- retaining cutting of the chisel blade with the use of working bodies of the rotor type (rotary top cutter) with a horizontal axis rotation of the rotor. Subsequently depending on the technology of harvesting the tops, the cut tops with the knives of the rotary top cutter used for appointment:

- for forming the roll of cut tops, a screw conveyor is used, which detrain the tops on the harvested field;

- for the spreading the cut tops onto the harvested field, a rotary top thrower is used which is installed at the similar end point of the screw conveyor;

- for loading the cut tops into the vehicle (when using the tops for feed) use a loading slat conveyor.

The first stage of single-phase harvesting of root crops, which is mainly used in the countries of the European Union and in most cases in Ukraine and the Russian Federation, is a two-stage harvesting tops by top harvester modules in composition of self-mobile hopper combine harvester: the first stage is the cutting the main mass of tops; second stage is the cutting the deads of tops from the capitulum of root crops

At the first stage, such operations are performed, Fig. 3a:

- cutting of the main mass of the tops with knives of the rotary top cutter withits with its simultaneous grinding;
- feeding the milled tops by the motion path to screw conveyor;
- transportation of milled tops with spiral by spiral turns of the screw conveyor
- delivering the tops by spiral turns through the discharge ring of the screw conveyor into the roll or spreading the tops to the harvested field by rotary top thrower which is installed behind the discharge ring of the screw conveyor.

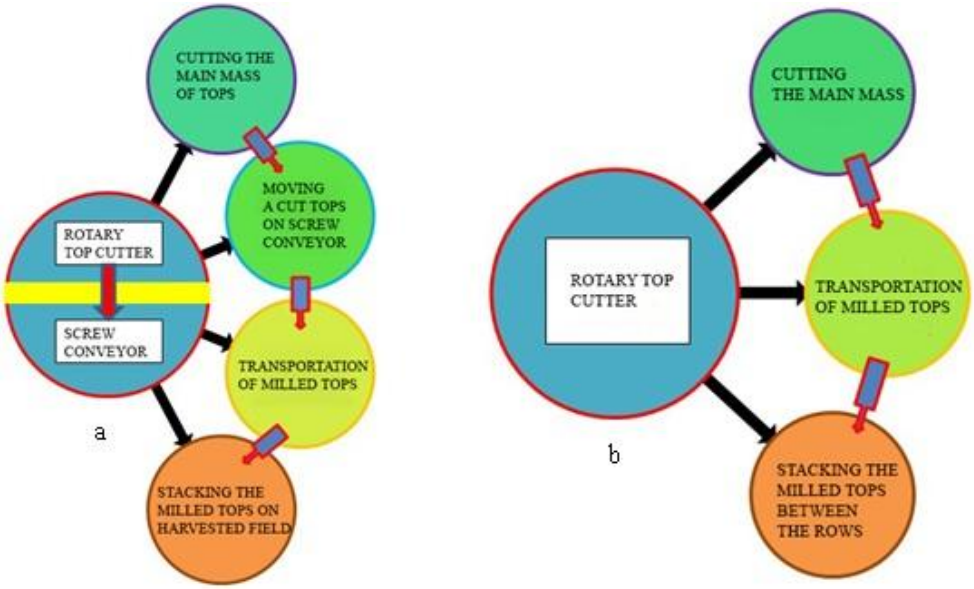

Fig. 3. **The operations of harvesting the main mass of the tops: a - the existing technology; b - advanced technology**

In the second consecutive stage, the deads of the tops from the capitulum of root crops are trimmed with various designs cutters which are made as a “passive passive-feeler chisel”

The disadvantage of this method of harvesting the tops are high energy costs for additional transport operations by the screw conveyor and spreading the milled tops by a rotary tops thrower.

Therefore, the development of new designs of technical means for harvesting tops of root crops should be based on world experience in reducing energy resources, taking into account the peculiarities of domestic agrotechnical, technical-economic, ecological and other production requirements.

The working hypothesis is based on the solution of the scientific task of reducing energy costs during the harvesting the main mass of tops, which provides for the elimination intermediate link in the design-layout scheme of the module for harvesting the tops in the form of transport element made in the form of a screw conveyor and installed in the guide channel.

Considering the world trend of a single-phase method of harvesting root crops by modern self-mobile vehicles, which provide for the block-modular principle of their construction, we proposed an improved method of harvesting the main body of root crops.

The method of harvesting involves three adjacent operations, Fig. 3b:

- cutting the main mass of the tops with chisel and with its simultaneous grinding;
- transportation of the milled tops in the guiding channels of the arcuated shell;
- stacking the milled tops between the rows of root crops to the area of the dividing plates.

Herewith the cutting of the main mass of tops and spreading the milled tops between the rows of root crops is carried out by one working body. To implement the method, we proposed an improved module for harvesting the main mass of root crops tops, Fig. 4.

The top harvesting module consists of a base 1, on which the support wheels 2 are sequentially installed, rotary top cutter 3 with a horizontal axis of rotation and an arcuated shell 4 is located at the rear and above the top part of the rotary top cutter.

The rotary top cutter is made in the form of a horizontal shaft 5 on which the sections 6 are mounted. Each section is made in the form of a roller 7, on which the chisel 8 are fixed. Each roller with a T-shaped chisels is located above a row of root crops 9. The rotary top cutter is installed in supports 10, that are mounted on base of the module. On each roller between the chisel are installed dividing plates, which are located between the rows relative to two adjacent rows of root crops. On the inner surface 12 of the arcuate shell guide channels 13 for transporting the milled tops, which have an input 14 and an output 15 throat, are installed. The hinged baffle is installed behind the output throat of each guide channel, and the output throat of each guide channel and hinged baffle is located between adjacent dividing plates. The horizontal shaft rotates at an angular velocity ω, the direction of movement is opposite to the direction of movement of the module for harvesting the tops of root crops.

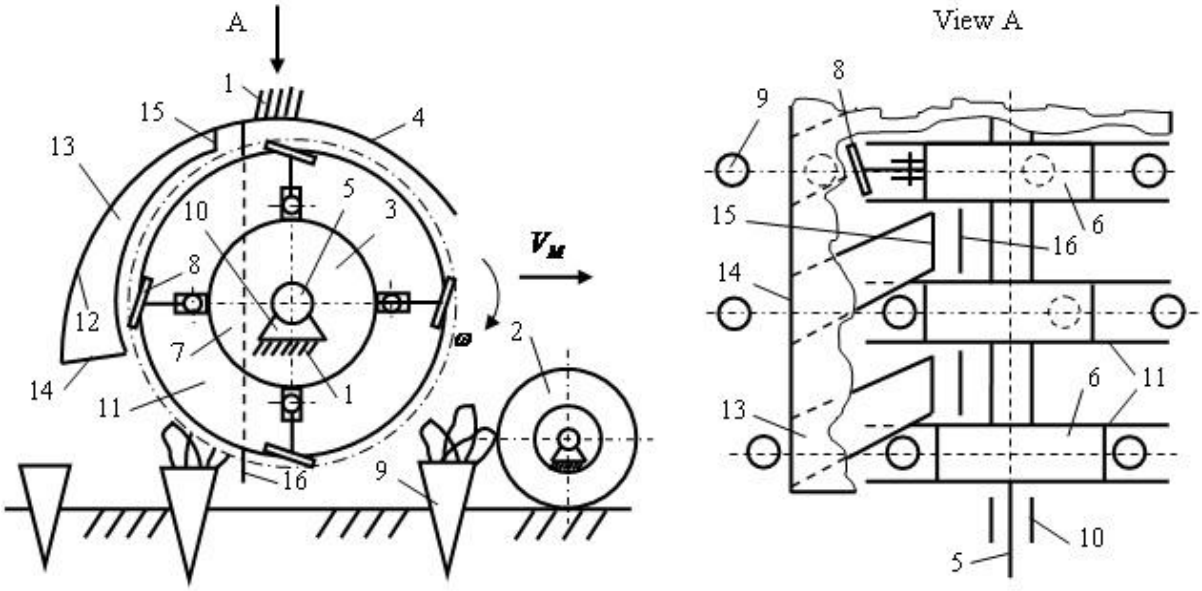

Fig. 4. **The constructive scheme of the improved module for harvesting the tops, side view: 1 – base; 2- support wheel; 3 – rotary top cutter; 4 – arcuated shell; 5 – horizontal shaft of top cutter; 6 – section; 7 – roller; 8 – chisel; 9 – row of root crops; 10 – support; 11 – dividing plate; 12 – inner surface of arcuated shell; 13 – guide channel; 14, 15 – input and output throat of guide channel; 16 – hinged baffle**

During movement of the harvesting module along rows, the chisels due to rotating the rotary cutter 3, cut the main mass of the tops and feed it along the path of movement to the input throat 14 of the guide channel 13. Due to T-shaped form air flow created by the rotation of the chisels, the cut and milled tops are transported along the guide channel 13 to its output throat 15, and then transported to the hinged baffle 16, where the milled tops are spreading between the rows to the location of dividing plates.

Conclusions. Thus, by eliminating the intermediate operation of transporting the cut and milled tops with a screw conveyor and then delivering it onto the harvested field the energy consumption for the implementation of the technological process for harvesting the main mass of the root crops tops is significantly reduced.

Therefore, a promising direction is the subsequent carrying out of in-depth theoretical and experimental studies to justify the rational parameters and operating modes of the improved top harvester module.

Complex evaluation of the parameters and operating modes of the module are prerequisites for the subsequent intensification of the energy consumption of the harvesting process for the main mass of root

crops tops, or optimization of the constructive-kinematic parameters and working conditions of the root harvester as a whole.

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