LABORATORY AND FIELD EQUIPMENT WORKINGOUT AND THE RESULTS OF EXPERIMENTAL STUDIES OF PRE- HARVESTING SUGAR BEET FIELD CONDITIONS

РАЗРАБОТКА ЛАБОРАТОРНО-ПОЛЕВОЙ УСТАНОВКИ И РЕЗУЛЬТАТЫ ЭКСПЕРИМЕНТАЛЬНОГО ИССЛЕДОВАНИЯ СОСТОЯНИЯ СВЕКЛОВИЧНОГО ПОЛЯ ПЕРЕД УБОРКОЙ

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Abstract: *Described in the scientific literature the results of experimental studies and performance test of the technological process of sugar beet harvesting conducted in recent years have shown that modern sugar-beet harvesters manufactured in Europe and America work with significant losses of sugar-bearing plant materials. These losses are due to generally poor topping quality of sugar beet on a root. Therefore, nowadays the search of technical solutions enabling to avoid these losses is of great to importance as it increases the yield of sugar-bearing plant materials per hectare of crops. The purpose of research is to reduce the losses of sugar-bearing plant materials in the course of separation process of sugar beet tops from heads of root crops on a root. While conducting research the methods of field experimental research on the measurement of physical parameters of the technological process were used, as well as methods of statistical processing of the measurement results with the use of computer. New experimental equipment was designed for the field experimental studies being equipped with modern electronic equipment with data transfer to a PC. As a result of the experimental investigation of the distribution heads heights above the ground of sugar beet roots confirmation has been received hypothesis that it does not deny the law of the normal distribution. The results of the multiple measurements enabled set limits of changes in their statistical characteristics, which are as follows: average statistical deviation σ = 20 ... 30 mm, the expectation m = 40 ... 60 mm. A new design of the laboratory equipment and results of the experimental studies, conducted on it, have given every reason to design and develop a new system of automatic adjustment of the height of cut tops, which can be used in designs of modern sugar-beet harvesting machines.*
KEYWORDS: SUGAR BEET, HARVESTING MACHINES, EXPERIMENTAL STUDIES, LOSSES, SUGAR-BEARING PLANT MATERIAL, STATISTICAL DISTRIBUTION.

1. Introduction

The sugar beet production has undergone a substantial reduction in the world. There are many reasons for it, and this mechanism is rather complicated. The most significant among them need to be highlighted:

- hard competition in performance with other sugar crops;
- import of cheap sugar and chemical substitutes;
- the lack of exports to foreign markets;
- high cost of sugar beet under economic conditions of many countries compared with cereals;
- the absence of substantial support sugar of sugar beet producers.

Despite this decreasing, the world's production of sugar beet and, accordingly, the technical means for its mechanization remains relevant and cost-effective. That is why we compare the sugar beet production costs in Germany and Ukraine. As a result it was found that a profit of about 400-600 Euro per hectare of crops. Despite this, the problem on sugar-bearing plant material loss is quite severe and requires immediate solutions. Our task is to reduce these losses.

2. Preconditions and means for resolving the problem

2.1. Analysis of recent research and publications

An analysis of numerous designs of working bodies for removing sugar beet tops has been considered in detail in the works of scientists: L.V. Pogoreliy, V.M. Bulgakov, N.V. Tatyanko, R.B. Hevko, V.Ya. Martynenko, M.M. Khelemendyk, Ya.I. Kozibroda, S.V. Siniy, et al. But nowadays there are no designs of topper that would satisfy the agro-technical requirements of sugar-bearing plant materials losses [1-6, 12-14].

We have concluded that modern machines mainly use cutting without copier, that is why it is necessary to determine the main factors of sugar-bearing plant materials losses to determine the main ways to reduce them.

2.2. Purpose of the study

Reducing the sugar-bearing plant materials losses in the separation process of sugar beet tops from root crop heads, creates the prerequisites for automatic correction of the foliage cutting height.

2.3 Materials and Methods

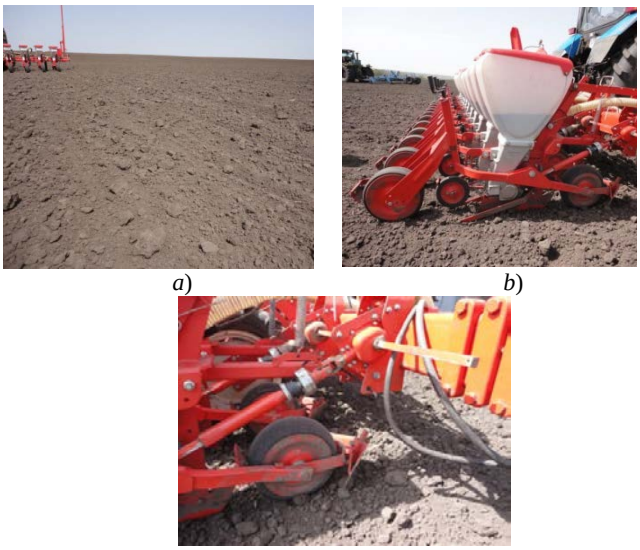
The object of this study is the process of topping on a root used cutting without copier. The study was conducted using methods of probability theory and mathematical modeling [10]. The results of the measurements have been processed by statistical methods using a personal computer. All experiments were carried out on the pre-developed plans experiments. Distribution of root crop heads was determined by means of specially designed laboratory equipment.

3. Results and discussion

To solve this problem of reducing the sugar-bearing plant materials losses we studied the availability of machinery in sugar beet producers, since the final state of height above ground distribution of root crop heads and their losses are formed during vegetation for the period from soil cultivation to the time of harvesting of root crops. It was established to ensure adequate machinery for soil preparation and sowing operations, as well as equipment for the protection and harvesting of sugar beet [7, 11].

Although, our task was to investigate the conditions of operation of equipment and quality of work in order to findout the problems. As for the sugar beet growth the primary parameters being formed by tillage operations are soil hardness and density, they were chosen as those under testing. The results of research showed that at sowing time these parameters did not meet to the agronomic requirements (fractional composition of the soil). In particular even the image (Fig. 1a), you can see a huge structural soil units being twice more than permissible requirements.

Therefore, the following colters and rollers operations (Fig. 2a and 2b) can not be performed according to agronomic requirements as for seeding depth, which results uneven heads height above ground of root crops. The above situation takes place in most companies. Thus at this production stage of sugar beet there is a problem that requires immediate solution, but it is impossible to do it quickly and effectively, as experience shows that any change in the technological or technical terms at the enterprise possesing of the acreage ten thousands hectares is possible to be realised for several years, but in most cases not possible at all. Despite the situation mentioned there is need to find ways of leveling influence of tillage on the harvesting process of sugar beet and weight loss of root crops.



a) *b*)

c)

Fig. 1. Typical condition of field surface before sowing sugar beet: a – poor quality of the soil processing in terms of soil aligned and lumpiness; b, c – the work of sowing drills sections under unsatisfactory conditions

It was found that seeding quality indicators did not meet the agronomic requirements (sowing depth of the sugar beet crop ranges from 3.6 - 4.8 cm, which does not correspond to agro-technical requirements equal to 2 - 3 ± 0.5 cm).

We monitor machinery quality indicators for sugar beet harvesting. The main problems that were found in the course of study of the working environment are improper adjustment of topping and cleaning units of sugar-beet harvester. As a result, there were considerable excess of agronomic requirements as for the losses of sugar-bearing plant materials and residues of foliage as well as damage to root crops heads.

In the design of modern machines the rotor type topping units offen used that cut off the head of root crops at the same level relatively to the surface of the soil. Selecting this cutting height is made according to the well-known recommendations, but in practice it is often difficult to adhere to it, sometimes even impossible, taking into account the probabilistic nature of the distribution of the heads height above ground of root crops.

Despite the information given consumers of sugar-beet harvesting equipment always have the problem of choosing the rational cutting height values under specific production conditions (various characteristics of sugar beet heads height above ground). In most cases, this problem can be solved by empirical methods (visual assessment of the work quality after a few working trips), which have to be repeated several times. This leads to unproductive expenditure of working time, which reduces harvesting performance. Under this conditions improper cutting height selectionmay take place increase in sugar-bearing plant materials losses.

Table 1. Holmer sugar-beet harvester performance under production conditions with extreme humidity of the soil

Indicators number	Indicators	Value, %
1.	Correctly topped roots	16
2.	Under topped roots	34
3.	Over topped roots	24
4.	Uncut roots	22
5.	Over topped roots below the sleeping cells level	2
6.	Severely damaged roots	68
7.	Slightly damaged roots	14
8.	Angled topped roots	14
9.	Roots with green heads	18
10.	Roots with broken tips	96
11.	Sugar-bearing plant materials losses at the cut heads	5,2
12.	Sugar-bearing plant materials losses due to cut heads	3,8
13.	Total sugar-bearing plant materials losses	9
14.	Tops comtamination (according to the sugar factory data)	6…8

Therefore it is expedient to carry out the development of automatic regulator, which would provide solution to the problem of establishing the cutting height automatically in the process of sugar-beet harvester. For the development of this type of control it is necessary to determine the statistical distribution of the sugar beet heads height above ground. This problem has been considered by a number of scientistsis [6-9] and most of them prefer the normal law of distribution for it. The reliability of their results is in question because of the inability to obtain a large number of samples by manual sampling. Therefore, for assessment of parameters of the sugar beet field (plant distribution in a row, the distribution of heads height above ground, and the determination of losses when harvesting) laboratory and field equipment has been developed (Fig. 2).

Functional-block diagram of this equipment includes: input and output module, unit for measuring block control, sensor unit for the registration of sowing parameters. Algorithm of the program for control of measurement process height above ground of root crop heads is also developed. Structural scheme of laboratory and field equipment has been developed.

System of gyroscopes and accelerometers to study the fluctuations impact of sugar-beet harvester on the stability of working bodies was designed. Measuring unit design was developed as well as electronic module for control process of measurement locations parameter of sugar beet heads above the soil surface was worked out. The measuring unit contains the probes to indicate the presence of roots, probes to identify the position of the machine and height of roots head above the soil surface.

Fig. 2. Laboratory and field equipment in course of experimental studies

The basic causes of sugar-bearing plant materials losses (Table. 1):

- improper (unreasonable) adjustment of working bodies as well as technical and technological modes of operation of the equipment;
- untimely operations conduct in the process of sugar beet cultivation;
- baseless and unsutable selected technological scheme of machines that are used for production of sugar beet (by types of working bodies).

All the above factors affect the yield of sugar beet and yield harvesting saving. To overcome this shortcoming, we propose the development of an automated system to establish the cutting height of sugar beet without copier. To achieve this goal, we have conducted research on the aforementioned laboratory equipment and received mechanical and technological prerequisites for establishing a system to prevent sugar-bearing plant materials losses.

Study of distribution of heads height above ground of root crops relatively to the level of the soil surface as a result of a large sample (50.0 thousand measurements) were processed using the developed program in Matlab software on the computer. According to the results of research it was found that the statistical distribution of heads height above ground of root crops corresponds to the normal distribution law. Change limits of statistical characteristics are as follows: the mean deviation $\sigma = 20 ... 30$ mm, the expectation $m = 40 ... 60$ mm.

The following parameters of sugar beet harvesting qualityhave been established: sugar-bearing plant materials loss - 4%, untopped roots - 2%, roots damage - 3%.

Using the developed mathematical model [5, 8], we have been received sugar-bearing plant materials losses depending on the cutting height of sugar beet head without copier.

The experimental studies have shown that it is possible to predict the mass loss of roots and tops contamination under specific conditions, having previously obtained the statistical distribution parameters (m, σ) as well as using a mathematical model presented in [5, 8]. This enables to automatically create the system for evaluating parameters of root crops and adjust height of the sugar beet topping in order to reduce sugar-bearing plant materials losses up to the level of agronomic requirements equals to 2%.

4. Conclusion

1. A new experimental equipment that allows carrying out field studies for plants distribution of sugar beet in a row, the heads height above the soil surface and possible loss of sugar beet at harvest.

2. As a result of the pilot study of heads height distribution of sugar beet heads above the soil surface confirmed the hypothesis that it obeys the normal distribution. The limits changes in the statistical distribution of characteristics that show the average deviation $\sigma = 20 ... 30$ mm, the expectation $m = 40 ... 60$ mm.

3. Experimental studies established the following best indicators of quality of sugar beet harvesting: sugar-bearing plant materials losses – 4%, tops on the remains of roots – 2%, roots damage – 3%.

4. The results of the pilot study have created the prerequisites for the creation of electronic system that automatically correct tops cutting height on the sugar-beet harvesters of modern technical level.

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