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Increasing the effectiveness of aggregates for planting sugar beet stecklings to receive elite seeds

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Abstract. Planting sugar beet stecklings with planting machine is one of the stages in the technological process of producing elite seeds. The analysis of the experience of using planting units for planting stecklings showed a number of disadvantages: poor quality of planting stecklings without spacing stability and the absence of parameter control; unregulated applying nutrients and granules of water preservation to the roots negatively affect the development of plants. The aggregate having openers of the planting device was designed, and the system of supplying the spray of nutrients and growth stimulator is envisaged. The technological process is conducted in the following way: during the movement of equilateral triangles of the planting cones mechanism the root is planted in the soil. To eliminate the drawbacks while planting stecklings, the openers of the planting device for the roots having the diameter of 50–120 mm were designed. Owing to them free falling roots in the soil is ensured and their lifting together with the cone to the soil surface is prevented. The research has shown that root plant spacing depends on the angular and forward velocities of the device.
The draft resistance of furrow openers and soil compaction depend on the furrow width and depth and the distance between the axes of quadrangles and the unit rear compaction wheels.
Improving the planter, taking into account biological peculiarities of plant development, meeting the requirements of energy saving and economic expediency was proved.

Key words: accumulated energy consumption of production, growth stimulators, planter, parameters of the aggregate.

INTRODUCTION

Manufacturing ecologically safe products using energy saving technologies is a strategic direction for the economics of agrarian countries. To increase sugar production it is necessary to provide the manufacturer with high quality seeding material and highly productive technical means.

At present, about 30% of the world output of sugar is obtained from sugar beet (Balan, 2012; Gizbulin, 2012). Ukraine is among the main producers of sugar beet, however, the sowing of sugar beet with seeds grown in this country has decreased to 8% during the recent years. That is why solving the problem of seed production development in Ukraine is topical and economically expedient.

One of the important technological process operations is receiving sugar beet seed from stecklings. The existing mechanization methods do not enable to plant stecklings properly at different spacing within the row, depending on their size and agro-climatic conditions. To solve the problems, the task was set by the authors to develop and test the installation for planting sugar beet stecklings with the aim to obtain high yields of high quality seeds.

ANALYSIS OF THE LATEST PUBLICATIONS

The analysis of Ukrainian scientific sources confirms that sugar beet cultivation requires intensive technology of seed production (Kockelmann & Meyer, 2006; Method of Fertilizing…, 2007; Installation for Preparing…, 2010; Method of Determining…, 2010; Method of Choosing..., 2013). Planting stecklings of sugar beet to obtain elite seeds, which in the past was done by hand, is a responsible and labor-intensive operation.

Planting method presupposes cultivating stecklings, harvesting, and piling them for winter storage during the first stage, followed by further planting in the soil in spring, cultivating, mowing, and threshing seeds. Planting stecklings with planter is an important operation while manufacturing sugar beet by planting method (Samoilov, 1968; Fursa, 2015).

At present there are no parameters of planting stecklings depending on their size. The analysis of the existing planters is given in the following articles (Samoilov, 1968; Installation for Preparing…, 2010; Lapenko, 2011). While cultivating seed plants, the productivity and conducting operations in optimal agro-technical terms together with preserving quality indices are not ensured (Hendrick & Gill, 1971; Miller & Tolley, 1989; Anderson & Larson, 1991; Miszczak, 2005).

The experiments held in England demonstrated that using machines for planting stecklings does not ensure yield increase (Swick & Perumpral, 1988; Renner, 1990; Evenson, 1991; Larue & Ker, 1998; Fielke, 1999). According to the estimation of the leading foreign firms and companies engaged in selection and seed breeding (Germany, France, and the USA), the system of sugar beet seed production functioned in Ukraine, which enabled to mechanize its main technological processes (Thankur & Godwin, 1989; Haitiner, 1990; Sharifat & Kushwaha, 2000; Kockelmann & Meyer, 2006; Rueda-Ayala et al., 2010).

According to the methods of patent research, the proto-types of planters have been determined. The installation for planting roots having the frame with rotor planting device and bin for accumulating seed plants is known (Method of Determining…, 2010).

The installation for delivering stecklings to the planter, including pan conveyor with pusher-off of roots from cones was the following development, but there was no automatic delivery of roots to the rotor planting device in it (Installation for Preparing…, 2010).

The scientists of the State Ukrainian Scientific-Research Institute of Machinery Testing named after L. Pohorilyi (Ukraine) designed the installation for planting roots, including the bin, frame, wheels, and the device for single piece root feeding (Davydiuk, 2011).

Stecklings are delivered in the hollow of the installation, after that they are held down to immovable frames and delivered upward. Due to shifting on the extreme lower stars of draft elements, the movable frames are placed on the pin conveyor belt, making dihedral angle with immovable frames, the vertex of the angle is directed at the side opposite to the direction of movement. When the tilt angle of the traction elements is increased, the roots, which are not held down to the immovable frames, fall into the bin. The movable frames, while turning on the upper direction stars, are placed on the pin conveyor belt, and the held down roots are freed and directed to the orientation device by the rarified stream. Further on, the process is repeated.

Planters are characterized by: a low quality at different schemes during unstable plant spacing of stecklings; the absence of parameter control of applying fertilizers and water preservation granules to the roots.

Biological peculiarities of the seed plant root system development should be taken into account during elite beet seed production.

According to the data of O.N. Sokolovskoho Institute of Soil Science and Agro-Chemistry, during the first year of sugar beet cultivation, it is necessary to apply: 7.26 mg of phosphorus, 22.5 mg of nitrogen, and 31.8 mg of potassium; and for the root – 26.8 mg, 138.3 mg, and 145.5 mg correspondingly (Fursa, 2015). During vegetation period, the roots require steady supply of nitrogen, potassium, and moisture supply. For example, during the vegetation period, the area, planted with stecklings, loses 17–24 t ha^{-1} of moisture per day, and the area under sugar beet of the first year – 16–20 t ha^{-1}. It has been established, that one beetroot requires up to 2 dm^3 of water per day. The plant root system is located in the soil at the depth of 50 cm and gets more than 90% of moisture. Beet seeds are characterized by a short vegetation period, so seed plants cannot use precipitation moisture, that is why moisture deficit during the initial period of seed-bearing plant development is undesirable and it can lead to a considerable decrease of seed yield (up to 17%) (Dankov, 2011; Fursa, 2015). Applying fertilizers during planting roots supplies the plants with nutrients and regulates the development processes resulting in obtaining maximal yields and optimal quality of seeds. At present there are no dosed applying fertilizers and growth stimulators in the root zone in the process of planting that is why it is a promising direction of research.

The conducted short analysis of the modern state of creating planters, scholars' research in this field, and also the main drawbacks enabled to determine the aim and task of the present research.

THE AIM AND TASKS OF THE RESEARCH

The aim of the research is investigating the technological aspects of raising the efficiency of producing elite seeds of sugar beet.

To achieve the set goal, the following tasks were set:

1. To conduct a short analysis of the modern state concerning the designing of planting machines for planting parent roots of sugar beet.
2. To establish the dependence of the number of injured roots on the type of the opener of planting units.
3. To substantiate the technological parameters of the aggregate and the expediency of planting sugar beet roots for seeds.
4. To investigate the rotational planting unit with planting cones for ensuring the quality of planting parent roots of sugar beet.
5. To investigate the dependence of plant spacing on the number of planter rotations and the unit forward speed.

6. To determine the dependence of the frequency of planter rotations on plant spacing on different tractor gears.

7. To establish the dependence of the density of sugar beetroot planting on the distance between compaction wheels at opening furrows by ristle for the small and medium fractions of roots.

8. To investigate the dependence of planting depth on the distance between the axes of planting tetrahedrons and compaction wheels.

9. To establish the dependence of the verticality of planting on the tilt angle of the planting cone.

10. To determine draft resistance of the furrow opener and ristles on the run depth, width of the raised furrow and parent roots' spacing of sugar beet.

11. To substantiate the dependence of the rotary moment on plant spacing: with the ristle and furrow opener.

12. To substantiate the optimal parameters and operating conditions of the planting unit and the aggregate on the whole.

13. To conduct production testing of planting aggregate in Poltava region during planting parent roots of sugar beet with different plant spacing.

MATERIALS AND CONDITIONS OF THE RESEARCH

The aggregate with planting unit opener was designed to investigate the parameters of the technological process for planting parent roots of sugar beet for elite seeds. The spray system of delivering fertilizers and growth stimulator was also envisaged (Method of Choosing…, 2013). The state of the object is characterized by the parameter control of planting roots. The aggregate conducts measuring the object parameters, memorizing and controlling of switching on the monitors while determining angular and forward velocities, the frequency of the planting unit rotations, the density of and depth of planting parent roots, and draft resistance of furrow openers. The obtained information is transmitted to the computer, equipped with the corresponding software for processing the results (Lapenko, 2011).

Parent root of sugar beet undergoes harvesting, transporting, calibrating, putting to storage, removing from piles, loading, transporting, and planting the following year. The cycle of mechanized work leads to injuring the roots, which negatively influences the germination energy, germination capacity, and results in decreasing the yield of seeds. The results of testing confirm that injuring the beet crown during planting in the existing planting machines exceeds the established indices of agro-technical requirements.

To eliminate the drawbacks the openers in planting units have been designed. The sizes of roots to be planted according to the existing agro-technical requirements (Lapenko, 2011) (having the diameter of 50–120 mm and weight 100–800 g (Dobrotvortseva, 1986)) were taken as a basis for the testing. The injuries of planted beet crowns, which had not to exceed 1.5% were also taken into account. The size of the opener diameter excludes the probability of root sticking in the planting cone and ensures opening of the back fold at the moment, when forced movement of the root along the axis of the cone finishes. It ensures the free falling of roots into the soil and prevents their elevation with the cone on field surface. In order to prevent root injure, the opener is made like depressed semi-sphere with a fixing of porous rubber, the opener grips the beet crown and centers it in the cone. The porous fixing of the opener, having the diameter of 70 mm, excludes injuring the beet crown. Planting unit openers, designed by the authors, are presented in Fig. 1. The first one has the whole semi-sphere with porous fixing, and the second one – the central opening.

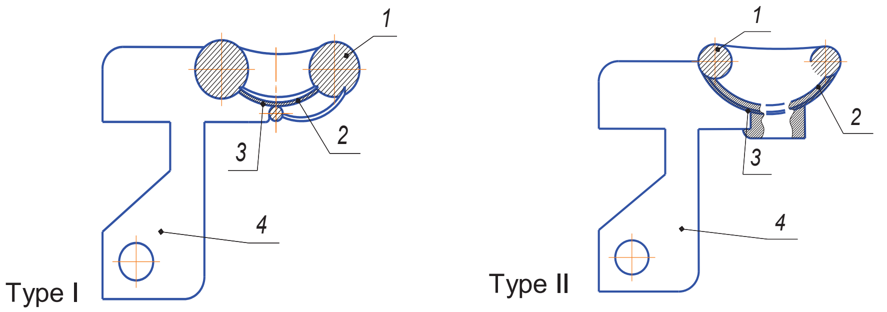

Figure 1. The designed openers of planting unit: 1 – metal ring; 2 – porous fixing; 3 – semi-sphere; 4 – hanger.

Laboratory and field testing of the designed openers, installed on planting units of SP-4M planter (modernized sugar planter), was conducted. The opener of the planting unit USP-4 (universal sugar planter) was also tested for comparison. The obtained results of testing are presented in Fig. 2, and they show, that the opener of the first type injures the roots less.

The opener of type I is made in the form of a metal ring with a porous fixing, and it decreases the number of injured roots in comparison with USP-4 machine (universal sugar planter). The opener of type I, made like a semi-sphere with a porous fixing, decreasing root injuring to 1.0–1.5%, was the most efficient. The conditions of conducting trials corresponded to agro-technical requirements. The number of injured roots (in the crown zone) was determined visually according to the standard methods for each type of the opener. The observation of the root injuries of 120 roots was conducted visually for each type of the opener.

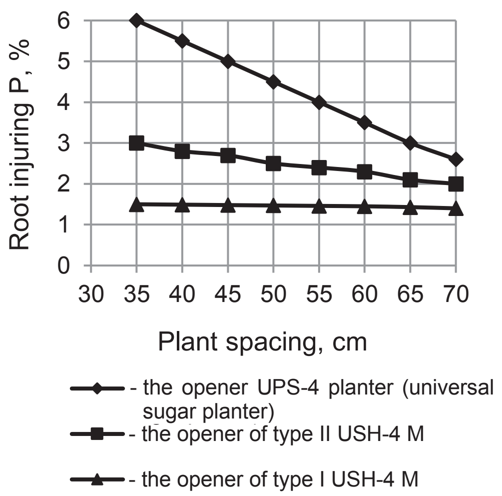

Figure 2. The dependence of root injure on the type of the opener.

The suggested opener of type I installed on SP-4M planter (modernized sugar planter), which had state trials, ensures the sufficient quality of planting parent roots at different spacing and practically excludes root injuring, resulting in raising the yield of sugar beet.

The system of spray delivery of nutrients and growth stimulators through the cup to the roots having the diameter of 50–120 mm, the length 150–250 mm, and the average weight 2.5–4.3 kg is envisaged. The liquid comes to the measuring device by changing the movement of the star with the flute, causing the measuring device lever move, and it enables to ration the liquid depending on the speed of the mechanism movement and deliver the liquid from the reservoir through rubber pipeline. Mineral fertilizers and water preservation granules are delivered in the device having a double-section bin with the pipeline rationing mechanism, directing top and is delivered in the furrow having the depth of fluffed soil 300 mm, moisture 25–40%, beginning from upper layers, and field relief sloping no more than 10°. At the same time, nutrients and growth stimulators are delivered to the cup with a cover and owing to the internal spiral-like surface of the injector the mixture is sprayed on the root (Medvedovskyi, 1988; Balan, 2012; Method of Choosing..., 2013).

The technological process is conducted in the following way: furrow is made by the furrow opener, and planting cones enter there. During the movement of equilateral triangles of the planting cones' mechanism and interaction with the opener, the root is planted in the soil, and the gauge compaction wheel fixes the root in vertical position. The speed of the triangles' movement per one rotation and planting cones in the process of planting is not constant and it changes in a wide range (0.1–0.7 m sec^{-1}) with the help of eccentric star which is set on the shaft with the given eccentricity. It slows down the movement, decreases the speed to a complete stop of the planting cone at the moment of filling the root in it. Creating the planting unit having equilateral triangles presupposes the contact of the cones with soil at the moment of filling. The system of spray delivery of nutrients and growth stimulators directly to roots is envisaged on the installation (Dobrotvortseva, 1986).

The research was conducted on the installation for planting root crops. The area of the plot was 0.5 ha; the type of soil – ordinary, low-humic black soil; the depth of the preliminary soil tillage – 300 mm. The depth and soil wetness content were determined by the standard methods (Lapenko, 2011). The surface slope of the fluffed layer was determined with the help of a metal ruler in three points diagonally. Soil firmness was defined relatively across the field 3–5°, with Reviakin penetrometer (State technical requirements 5096:2008. Soil quality. Determining soil firmness with Reviakin penetrometer). The length, diameter, and mass of roots were determined with standard accuracy and recorded with data significance of 95%. In accordance with agro-technical requirements, the roots having the diameter of 50–120 mm and length 150–250 mm were used. While investigating the quality of planting roots the following diameters were chosen: small – 50–70 mm; medium – 71–100 mm; large – 101–120 mm; having the length of: 150–180 mm, 181–210 mm, and 211–240 mm; and the weight 50–150 g, 151–300 g, and 301–500 g.

THE RESULTS OF INVESTIGATING THE PARAMETERS OF AGGREGATES FOR PLANTING SUGAR BEET STECKLINGS FOR ELITE SEEDS

At simultaneous planting stecklings and applying liquid fertilizers, the optimal rate of the substance consumption is 50 L ha^{-1}. Water preservation granules which can absorb and keep 90% of moisture in its volume were used in our research. The granules keep melted and rain moisture without changing its properties and 95% of it is used rationally during plant vegetation period.

After disintegration the granules are degraded into nitrogen compounds – carbon dioxide and water, which enriches the soil with nutrients.

Theoretical research (Samoilov, 1968; Davydiuk, 2011; Lapenko, 2011) has shown, that plant spacing of roots is set by measuring the angular and forward velocities of the unit (Fig. 3), which is achieved by:

a) changing the star with different number of tines on the reducing gear of the drive shaft;

b) changing the forward (operating) speed of the tractor.

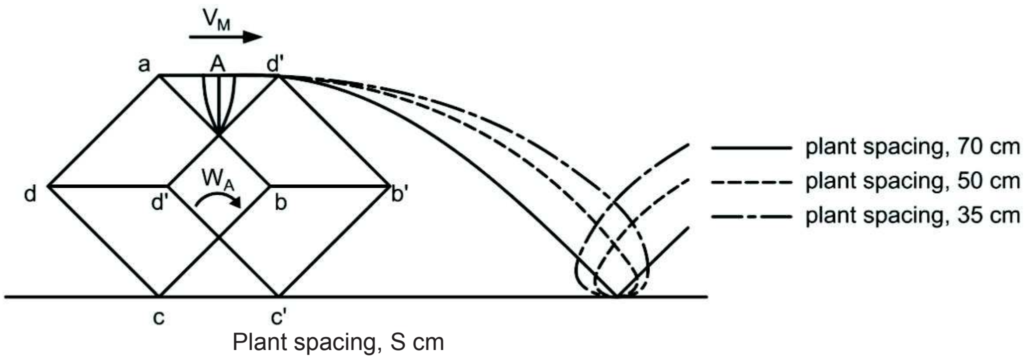

Figure 3. The trajectory of the planting cone movement at different plant spacing while tractor's moving on the second gear with speed reducing gear.

As it is seen from Fig. 3 the value of the 'loop' made by the cone in the process of planting increases together with decreasing plant spacing and reaches the maximum at plant spacing 35 cm (curve *V*).

The experiments were conducted according to the standard methods using medium size roots. The real speed and the number of experimental planting unit rotations at each gear were determined by the stop-watch at passing the definite way (Fig. 4). The graph was made according to the results (Fig. 5).

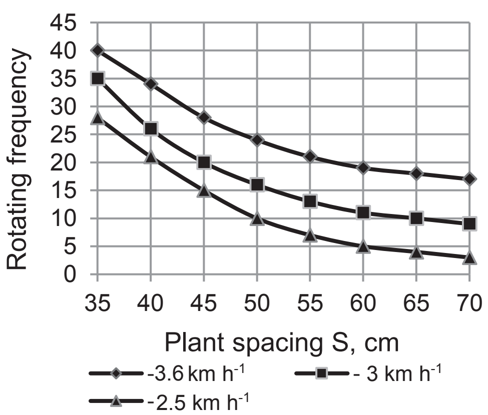

Figure 4. The dependence of the planting unit rotating frequency on plant spacing at different tractor gears.

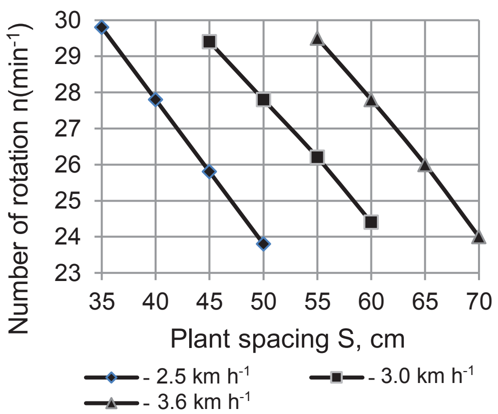

Figure 5. The dependence of plant spacing on the number of the planting unit rotations.

The dependence of plant spacing on the planting unit kinematic parameters is expressed by the dependence

$$S = \frac{k \cdot V_m}{Z_x \cdot n_r} K_s \tag{1}$$

in which S is plant spacing; V is the speed of the machine movement; Z_x is the number of tines in the changeable star of the reduction gear; n is the number of rotations of the tractor engine power take-off shaft; K_s is the experiment coefficient which takes into account the deviations of the real plant spacing from the calculated one; K is the experiment coefficient.

$$K = \frac{60 \cdot Z_{np}}{Z_x \cdot i_1 \cdot i_2} \tag{2}$$

in which Z_{np} is the number of tines in the star of intermediate shaft; Z_x is the number of planting; i_1, i_2 is the gear box ratio and the ratio of the intermediate valve to the planting unit.

At decreasing plant spacing as a result of the considerable discrepancy of the forward and angular velocities of the planting unit, different loadings (17.3–19.2 kH) on the planting cone occur. That is why the necessity to solve this problem constructively by changing planting unit and developing furrow opener arises. Such furrow opener would provide the furrow of the corresponding configuration and sizes for planting cones. While choosing the main design parameters of furrow opener we decided that that furrow depth had to be not less, than the root length, the width – not less than the root diameter, and the tilt angle had to be equal the angle of the planting cone.

The task of the research was establishing the optimal sizes of the raised furrow and the distance between compaction wheels for conducting the planting with the given density, decreasing the loading on the planting mechanism, decreasing energy consumption. At first, the compaction and fixation of roots by gauge wheels (D = 400 mm, B = 10 mm; β = 15 °) of the planting mechanism were conducted. The following stage of soil compaction after planting roots was conducted by compaction wheels (D = 700 mm, B = 150 mm; β = 7 °).

The influence of the distance between the rear compaction wheels and the density of planting roots was studied. The range of changing every 20 mm from 100 to 180 cm was made by the adjusting screw. The analysis of dependencies (Fig. 6) showed, that during furrow raising with ristle the density of planting increases and exceeds the upper limit of agro-technical requirements by 18.7%. That is why the improved furrow opener for raising furrow of the operational width was used. This furrow opener has the ristle with movable and immovable folds assisting to regulate furrow width with the screw and such design excludes overloading of the planting unit arising at discrepancy of angular and forward velocities. Using the improved design of the furrow opener ensured the following of agro-technical requirements concerning the density of planting by the compaction wheels' screw.

In case of water-logging soil the quality of planting deteriorates because of adhesion between the wheels that is why the distance between the rear compaction wheels 140 ± 5 mm should be considered optimal. The estimation of soil compaction quality was defined around the planted root by the reference portable dynamometer of the 3d category. The results of the research are presented in Fig. 7.

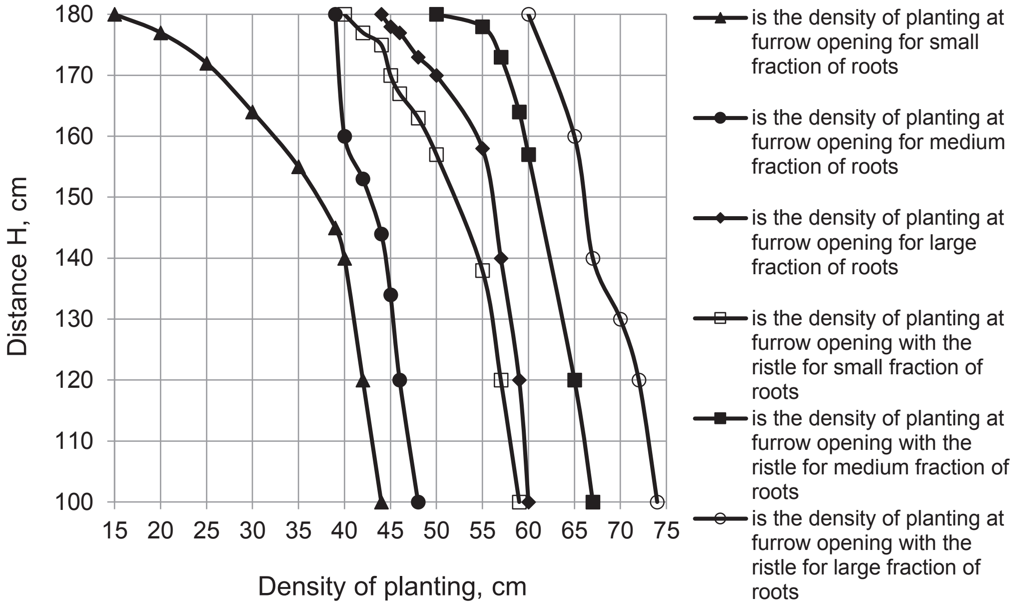

Figure 6. The dependence of the density of root planting on the distance between the rear compaction wheels.

The necessary density of planting small and medium roots is ensured at furrow width 110–140 mm.

The depth of planting roots was changed owing to: changing the distance between the axes of planting tetrahedrons of the planting unit compaction wheels, which was achieved by a special wheel regulation screw within 380–460 mm. Graduation was made on the movable and immovable frames of the compaction wheels. The motion depth of the furrow opener was constant – 250 mm. The results of the research are shown on the graph (Fig. 8).

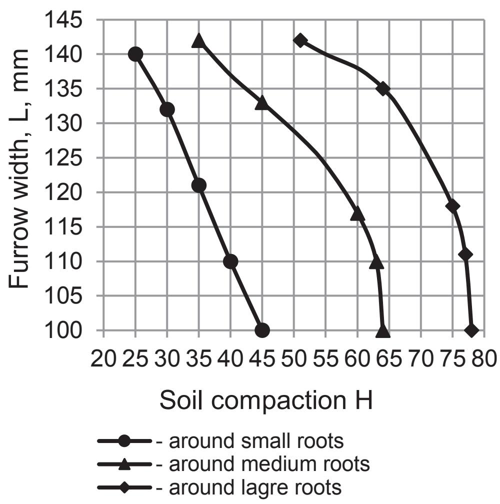

Figure 7. The dependence of soil compaction on the width of the raised furrow.

The analysis of Fig. 8 showed that planting depth grows in proportion to increasing the distance between the axis of trihedrons and compaction wheels and according to agro-technical requirements it is ensured at 405–440 mm, which is determined at test planting.

Increasing the planting depth depending on the motion depth of the furrow opener is noticed. The planting depth of roots is affected by furrow depth. Changing the motion depth is achieved by the reinstallation of the furrow opener vertically on fixing frames. The depth range with the interval of 30 mm from 200 to 290 mm was changed at constant inter-axis distance (420 mm) of the planting unit. Increasing furrow depth for small roots affects the quality of planting.

During the research the tilt angle was regulated with the chaser of the planting cone within 10–20° and the interval of 2.5° using angle meter in case of discrepancy of the forward and angular velocities of the planting unit. Other parameters remained optimal. Plant spacing for the roots having the diameter of 70, 60, 50, and 40 mm was investigated.

It was established by the results of the research, that root sizes practically do not affect the verticality of planting. The optimal conditions for every plant spacing were chosen provided that agro-technical requirements were followed – not less than 90% of roots with the tilt up to 10°. The results of the research are presented in Fig. 9 by the curves of vertical root distribution depending on the tilt angle of the planting cone for large roots with spacing 70 cm. The tilt angle of the planting cone for the specified spacing is equal –2.5°.

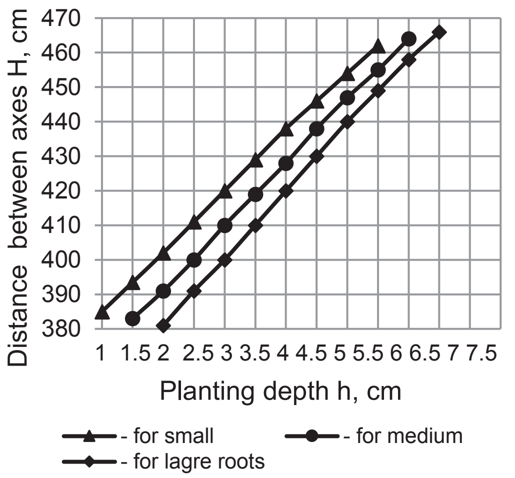

Figure 8. The dependence of planting depth on the distance between the axes of planting trihedrons and compaction wheels correspondingly.

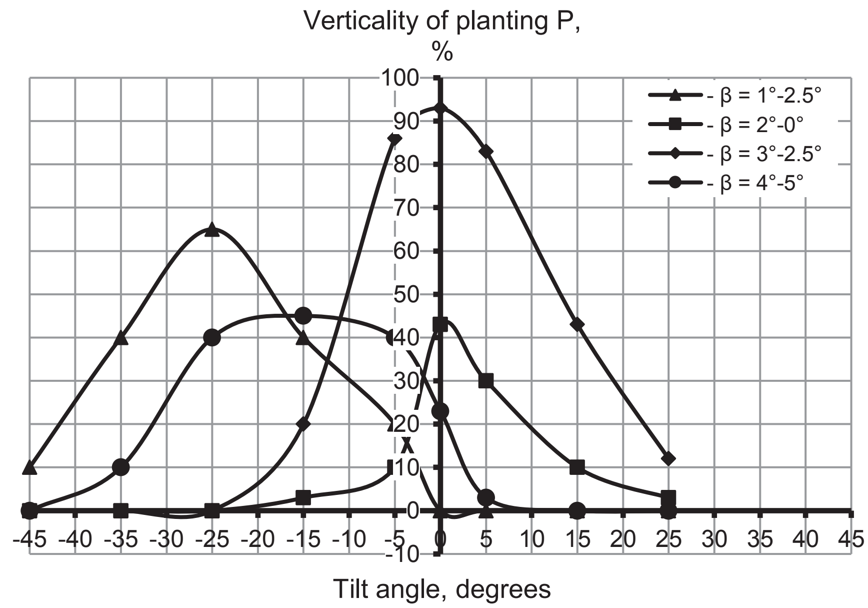

Figure 9. The dependence of planting verticality on the tilt angle of the planting cone β.

Openers with porous fixing, central opening and enlarged diameter were used in the experiments. Optimal indices were achieved in openers with porous filling: the beet crown and flank surface of the root may be injured up to 15%.

During energy testing the following information was determined in succession:

1) draft resistance;

2) moving the investigated sample on idle run;

3) ristles and furrow openers;

4) rotary moment on driving shaft;

5) the real speed of the investigated sample.

Draft resistance of the furrow opener was determined by the dynamometer of the 3d category at different values of running depth and the width of the raised furrow (Fig. 10, 11). The impact of the furrow width on draft resistance was investigated while changing its value by the adjusting screw, with spacing of 10 mm within 100–140 mm. The curve is presented in Fig. 7. The parameters are chosen depending on the conditions and sizes of roots.

As it is seen in Fig. 10, draft resistance grows by 2.7–4.6% while increasing the running depth of the furrow opener.

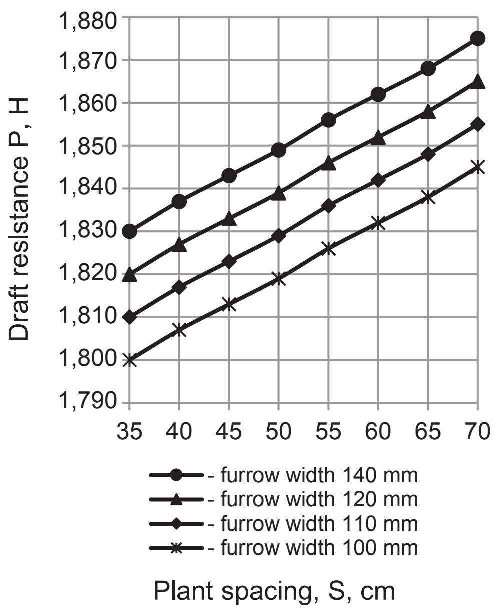

Figure 10. The dependence of draft resistance of furrow openers on plant spacing.

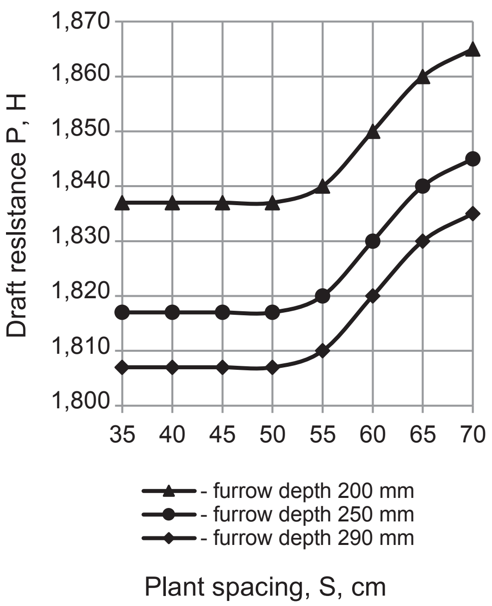

Figure 11. The dependence of draft resistance of furrow openers on plant spacing.

The dependencies of draft resistance of ristle and furrow opener are presented in Fig. 12.

During furrow opener operating draft resistance in not much higher than 2.9–4.7%, than with the ristles.

The dependence of the rotary moment on the machine driving shaft upon plant spacing and operating mode is presented in Fig. 13.

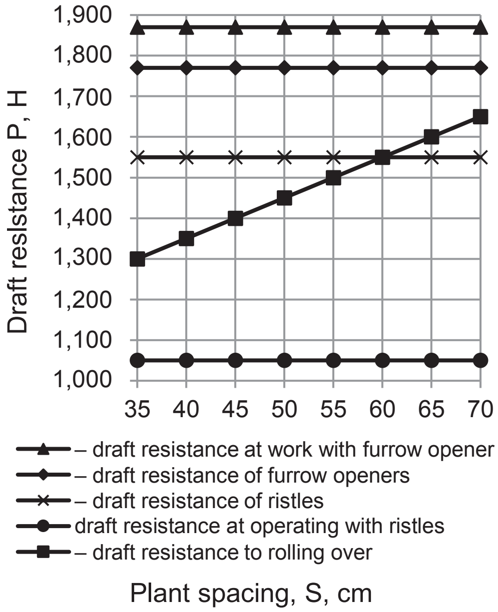

Figure 12. The dependence of draft resistance on plant spacing.

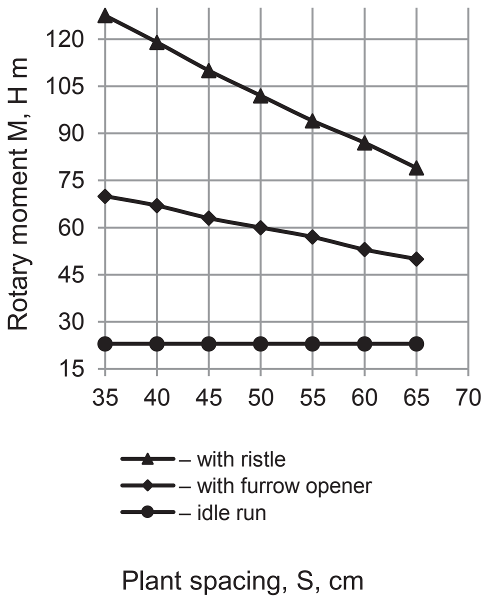

Figure 13. The dependence of the rotary moment on plant spacing.

At raising furrow with the ristle, the rotary moment on the driving shaft of the experimental planter sample grows from 70 to 120 Hm with decreasing plant spacing from 70–35 cm correspondingly. During using furrow opener, the rotary moment decreased considerably (by 10–50 Hm).

As a result of conducted research, the optimal parameters and operating modes of the planter at different planting patterns were established (Table 1).

Table 1. Optimal parameters and operating modes of planter at different planting patterns

Indices	Planting pattern, cm			
	70×40	70×50	70×60	70×70
Root diameter, mm	50–70	71–100	71–100	101–120
Root length, mm	150–180	181–200	181–200	201–220
Planter rotation frequency, min^{-1}	20–35	10–25	7–22	5–20
Furrow width, mm	100	130	160	180
Soil compaction, Hm	105–135	115–140	110–140	100–130
Sugar beet seed yield (bunker weight), t ha^{-1}	3.45	3.63	3.35	3.70

The indices of planting quality were determined by the standard methods (Dankov, 2011; Davydiuk, 2011; Lapenko, 2011). The experimental sample of the installation can change plant spacing together with ensuring the necessary quality and enables to use optimally the area of additional fertilizing depending on root sizes and specific agro-technical conditions. It enables to raise the seed yield, which is confirmed by the experimental data, entered in Table 2.

The production trials of the installation have shown that the following factors are ensured: plant spacing of planting roots is 40–70 cm, which corresponds to agro-technical requirements; the evenness and dynamics of plantlets, the development of seed-bearing plants with their simultaneous ripening; favorable conditions for mechanized seed harvesting. The optimal root planting pattern for Poltava region 70×50 cm was determined. Moreover, the yield increase is 3.9–5.4 hundred weights ha^{-1} comparing to the classical scheme 70×70 cm. Planting quality indices were determined according to the State Standard System 6053:2008.

Table 2. The yield of sugar beet seeds (bunker weight), t ha^{-1}

Year of research	Planting pattern			
	70×40	70×50	70×60	70×70
	Yield of sugar beet seeds, t ha^{-1}			
2013	2.14	2.27	2.43	1.54
2015	3.45	3.63	3.35	3.17
2016	3.24	3.54	3.82	3.36

It has been established that at applying nitrogen, phosphorus and potassium directly in the bunch the yield was 5.4 hundredweight/ha higher, and it replaced the double amount of fertilizers at tilling with simultaneous applying and decreased the percentage of injuries on roots at considerable concentration and unevenness of fertilizers' application.

Soil moisture content was determined with moisture indicator RIXEN MTR-732 at the depth of 100–150 mm 12, 20, and 40 days after planting and the indices were the following: 81%, 78%, and 69% correspondingly, which is optimal for the development of these crops. According to the results of the research energy saving technology of cultivating sugar beet for seeds was developed, including the sequence of operations, chosen in such a way, that the resource spending (plants, fertilizers, herbicides, hand labor, and investments) was minimal for ensuring the maximal harvest.

DISCUSSING THE RESEARCH RESULTS OF THE PARAMETERS OF AGGREGATES FOR PLANTING SUGAR BEET STECKLINGS FOR ELITE SEEDS

The aggregate with planting unit opener was designed to investigate the parameters of the technological process for planting parent roots of sugar beet for elite seeds. The spray system of delivering nutrients and growth stimulator was also envisaged (Method of Determining…, 2010; Lapenko, 2011).

The opener excludes the probability of root sticking in planting cone. It ensures the free falling of roots into the soil, root fixation, and minimizes parent beet crown injuring. The opener is made like depressed semi-sphere with a fixing of porous rubber with the possibility of centering the root in the cone. The opener ensures the sufficient quality of planting parent roots at different spacing (from 40 to 70 cm depending on the size of stecklings) and practically excludes injuring the roots. The suggested aggregate with the openers of the planting unit has quality control and parameter registration, which sufficiently ensures applying different fertilizers and water preservation granules to the roots.

The problem of mechanized root delivery to the planting cone has not been solved yet. Its positive solution will result in decreasing the number of workers.

It is expedient to conduct trials of the unit in different zones with different roots under the conditions of long-lasting maintenance, which will also enable to determine the reliability of assemblies and mechanisms. Wear-resistant materials (manganese steels) should be used for making the planting cones of the aggregate. The biological peculiarities of crop root system have not been studied sufficiently in connection with receiving elite seeds of sugar beet. Matrix experiment planning to broaden the field of research should be envisaged taking into account the determined new factors.

The results of the research can be used while modernizing the existing and designing new planting machines for planting sugar beet stecklings to obtain elite seeds in agro-industrial complexes of Ukraine.

CONCLUSIONS

1. The analysis of the scientific-technical information concerning the designing of planting machines for planting sugar beet stecklings to receive seeds has been made. The analysis has revealed the drawbacks and advantages of such information.

2. The dependence of the number of injured roots on the type of the opener has been established. It is recommended to use the opener of the first type.

3. The technological parameters of the aggregate and the expediency of planting sugar beet roots for seeds with the following spacing have been substantiated: 40–70 cm and 50–60 cm.

4. The rotational planting unit with planting cones for ensuring the quality of planting sugar beet stecklings has been adopted.

5. It has been confirmed by the research, that plant spacing of roots is regulated by changing angular and forward velocities of the unit, which is envisaged by:

- changing the star with different number of tines on the reducing gear of drive shaft;
- changing forward (operating) velocity of tractor.

6. The dependence of the frequency of planting unit rotations on plant spacing at different tractor gears and the aggregate speeds was determined: 2.5 km h^{-1}, spacing 35–40 cm; 3.0 km h^{-1}, spacing 50–55 cm; 3.6 km h^{-1} and spacing 35–70 cm.

7. The dependence of the density of root planting on the distance between the rear compaction wheels at raising furrows by the furrow opener and ristle for the small and medium fraction of roots is confirmed at furrow width of 110–140 mm with the constant running depth of the furrow opener 250 mm.

8. The dependence of planting depth on the distance between the axes of planting tetrahedrons and compaction wheels has been investigated for roots. The distance grows in proportion and according to agro-technical requirements and is ensured at 405–440 mm. The depth range with the interval of 30 mm from 200 to 290 mm was changed at constant inter-axis distance (420 mm) of the planting unit.

9. The dependence of vertical planting on the tilt angle of the planting cone has been established β: –2.5°; 0°; –2.5°; 4.5°, which was regulated by the chaser within 10–20 ° with the interval of 2.5°. Root sizes do not affect the verticality of planting at optimal conditions – not less than 90% of roots with the tilt of 10°.

10. Draft resistance of the furrow opener and ristles depending on the motion depth within 200mm, 290 mm, the width of the raised furrow within 100–140 mm, and plant spacing of sugar beet parent roots 40–70 cm has been determined.

11. The dependence of the rotary moment on plant spacing: with the ristle from 40 to 120 Hm; and furrow opener from 40 to 60 has been substantiated.

12. As a result of the conducted research the optimal parameters and operating modes of the planting unit and the aggregate on the whole have been determined.

13. The results of laboratory testing have been confirmed by production trials of the planting aggregate in Poltava region during planting sugar beet stecklings with plant spacing from 50–70 cm and yield growth 5.4 hundredweight/ha in comparison with the classical scheme 70×70 cm.

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