DETERMINING THE PARAMETERS OF THE DEVICE FOR INERTIAL REMOVAL OF EXCESS SEED
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ВИЗНАЧЕННЯ ПАРАМЕТРІВ ПРИСТРОЮ ДЛЯ ІНЕРЦІЙНОГО ВИДАЛЕННЯ ЗАЙВОГО НАСІННЯ

Lect. Ph.D. Eng. Vasylkovska K.V.[1], Prof. Ph.D. Eng. Vasylkovskyi O.M. [1], Prof. Dr. Eng. Sc. Sviren M.O. [1], Lect. Ph.D. Eng. Petrenko D.I. [1], Prof. Dr. Eng. Sc. Moroz M.M. [2]
[1] Central Ukrainian National Technical University / Ukraine;
[2] Kremenchuk Mykhailo Ostrohradskyi National University / Ukraine
Tel: +380667103625; E-mail: vasilkovskakv@ukr.net

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ABSTRACT

The quality of seed dosage to the furrow depends on the uniformity of seeds location on the seed disk. A new design of a seeding machine which provides better sowing was suggested at the Department of Agricultural Machinery of Central Ukrainian National Technical University. The main feature of the new seeding machine is the application of the seed disk with a peripheral arrangement of cells with the blades on its inner surface. The blades are used for the forced seizure of the seeds by the disk in the working chamber and their further transportation to the dropping zone.

In order to determine the rational parameters of the seed cells of the seed disk, an experimental appliance was made and studies were conducted to determine the desired value of the coefficient of filling cells with seeds of different sizes. The experiments were conducted using disks with cell radii of 5.0 mm and 6.0 mm which correspond to their areas of 9.6 mm^2 and 16.3 mm^2, respectively. The vacuum in the vacuum chamber was 0.2 kPa and the peripheral velocity of the cells was 2 m/s.

Taking into account the experiments conducted, it can be stated that in order to ensure the seeding of sugar beet, the radii of the cells' rounding should be within the limits of 5...6 mm which in general is consistent with the results of theoretical studies. According to them the radius of the whole is 5.7 mm.

РЕЗЮМЕ

Якість дозування насіння до борозни залежить, в першу чергу, від рівномірності розташування насінин на висівному диску. На кафедрі сільськогосподарського машинобудування Центральноукраїнського національного університету запропоновано нову конструкцію висівного апарата, який забезпечує більш якісне дозування насіння. Головною особливістю нового висівного апарата є використання висівного диска з периферійним розташуванням комірок, за якими на його внутрішній поверхні розмішені лопатки для примусового захоплення насіння диском в робочій камері та подальшого його транспортування до зони скидання.

З метою визначення раціональних параметрів комірок висівного диска виготовлена експериментальна установка і проведені дослідження по визначенню потрібного значення коефіцієнта заповнення комірок насінням різних розмірів. Досліди проводили, використовуючи диски з радіусами твірних комірок 5.0 мм та 6.0 мм, які відповідають їх площам 9.6 мм^2 та 16.3 мм^2 відповідно. Розрідження у вакуумній камері становило 0.2 кПа, а колова швидкість комірок – 2 м/с.

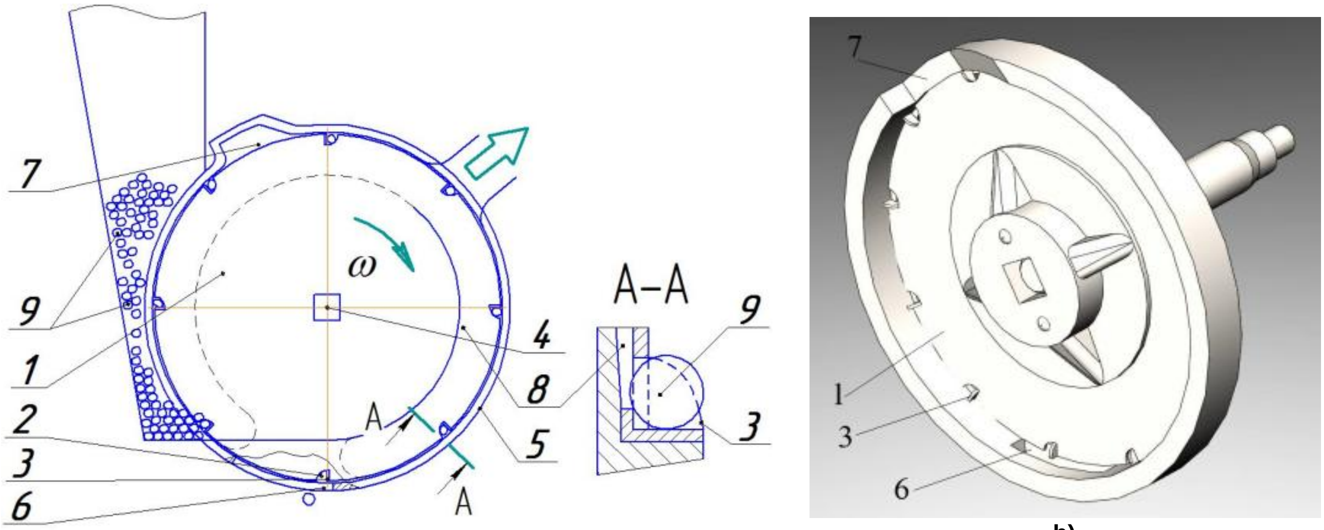
На підставі проведених дослідів можна стверджувати, що для забезпечення висіву насіння цукрового буряку, радіуси заокруглення твірних комірок повинні знаходитись в межах 5…6 мм, що в цілому узгоджується з результатами теоретичних досліджень, згідно з якими визначений радіус твірної становить 5.7 мм.

INTRODUCTION

The exact seeding - is a necessary condition for obtaining evenly placed on the area of the field of plants, which in this case have the same area plant nutrition and developing well. The quality of seed dosage to the furrow depends on the uniformity of seeds layout on the seeding disc. That is why the approach for selection the form of the holes on the disc is the determinant initial condition for equal dosage (*Sysolin P V., 2004; Vasylkovska K., 2014*).

The main characteristic of the new seeding machine (fig. 1) is the use of the seeding disc with peripheral location of the cells. Behind them, on the disc internal surface, there are blades for the forced taking of the seeds by the disc in the working chamber and their further transportation to the release zone (*Mursec B., 2007; Petrenko M. M., 2011; Petrenko M. M., 2013*).

The main parameter of the cell of the experimental disc is the bending radius of generatrix which influences not only the hole area and seeds' suction process but also the capability of a suctioned seed to leave the cell at release location right in time without any delay or wedging.



a) b)

Fig. 1 - Suggested pneumatic and mechanical sowing apparatus

a) the drawing; b) the three-dimensional model

1 – seeding disc; 2 – cell; 3 – blade; 4 – driving shaft; 5 – housing; 6 – seeds exit;
7 – passive appliance for extracting excessive seeds; 8 – vacuum chamber; 9 – seeds

MATERIALS AND METHODS

The proposed seed disk, due to the presence of blades, allows more securely seize and move of the seeds to the discharge zone at elevated rotational speeds of the cells. However, the question arises of defining their parameters.

To prevent seeds from sticking and moving into the vacuum chamber, we shall use the following formula:

$$S_{\kappa} < S_{S} \tag{1}$$

where S_{κ} – is the area of cell suction, [m^2];

S_s is the area of the projection of the seed, [m^2].

Using the well-known formulae proposed by A. Budagov (*Budagov A., 1971*) and V. Chichkin (*Chichkin V., 1984*), we shall write:

$$S_{\kappa} = 0{,}7 \cdot S_{S} \tag{2}$$

We shall determine the approximate area of suction of the cell:

$$S_{\kappa} = \frac{\pi \cdot r_{\kappa}^{2}}{4} - S_{1} \tag{3}$$

where r_{κ} is the radius of the rounding of the cell, [m];

S_1 is the cross-sectional area of the standout, which is defined as $S_1 = r_{\kappa} \cdot h$, [m^2];

where h is the height of the rack in the case of the seeding machine between the working chamber and the chamber of dilution, h=0.002 m (fig. 2).

Then:

$$S_{\kappa} = \frac{\pi \cdot r_{\kappa}^{2}}{4} - r_{\kappa} \cdot h \tag{4}$$

For seeds of sugar beets, the area of the projection of the seed S_s is taken in the form of a circle.

Therefore, taking into account (4), the expression (2) will take the following form:

$$\frac{\pi \cdot r_{\kappa}^{2}}{4} - r_{\kappa} \cdot h = 0{,}7 \cdot \frac{\pi \cdot d_{S}^{2}}{4}$$

where d_s is a conditional diameter of the seed, [mm].

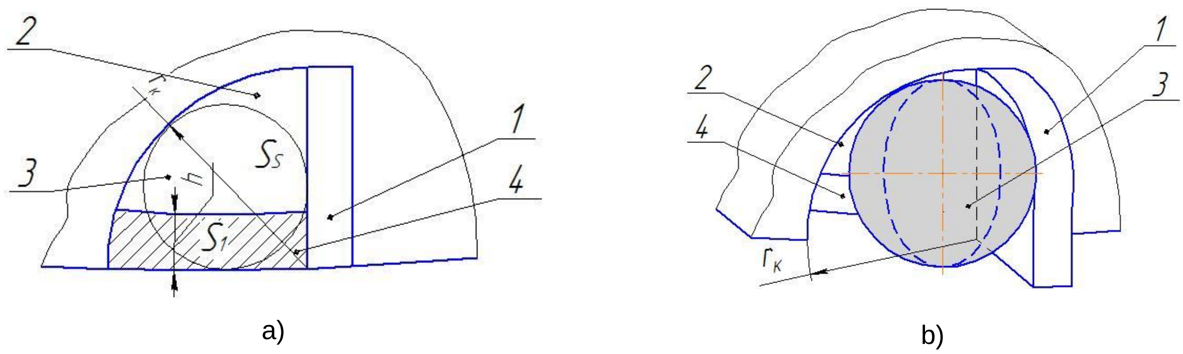


Fig. 2 - Scheme for determining the suction area of a peripherally located cell
a) the view of the cell with a seed; b) the three-dimensional model
1 - blade; 2 - cell; 3 - seed; 4 - rack

The radius of a rounding cell will be:

$$r_\kappa = \frac{2 \cdot \left(h + \sqrt{h^2 + \pi \cdot \frac{0{,}7\pi \cdot d_s^2}{4}} \right)}{\pi} \quad (5)$$

The dependence of the cells' area for different types of cultivated crops was obtained (Table 1).

Table 1

Parameters of the cells for different types of cultivated crops

Seeds of perennial crops	Radius of rounding cells r_κ, mm	Area cell S_h, mm^2
Sugar beets	5.7	14.1
Soybean	7.4	28.2
Sunflower	7.6	30.2
Maize	8.5	39.7
Haricot	9.4	50.6

The dependence of the radius of the seeding disk cell of the experimental pneumatic and seeding machine on the conditional diameter of different types of cultivated crops seeds (Fig. 3) was identified.

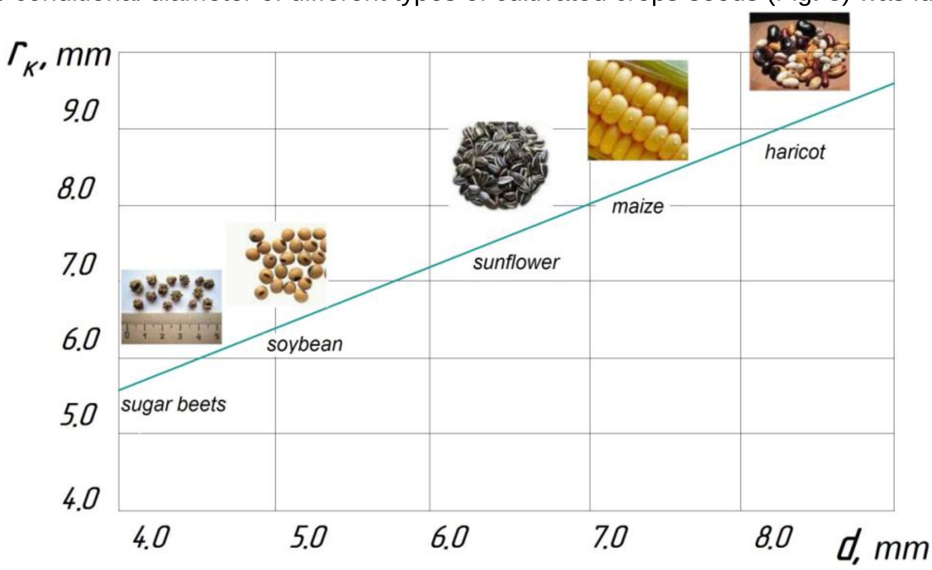


Fig. 3 - Dependence of the radius of the seeding disk cell on the conditional diameter of cultivated crops

The number of cells on the seeding disk is determined by their interval δ:

$$z = \frac{2\pi \cdot R}{\delta} \qquad 6)$$

By setting the step δ of cells location on the disk, the productivity of the seeding machine can be determined by the formula:

$$N = \frac{[V_{\kappa}]}{\delta} \cdot k \qquad (7)$$

where $[V_{\kappa}]$ is the maximum permissible rotational velocity of the cells.

It is obvious that when *k=const*, the increase in productivity of the seeding machine can be achieved either by increasing the rotational velocity of the cells, or by reducing the interval of their location on the seeding element. (*Rybar R.,1999; Voytyuk D.G., 2017*).

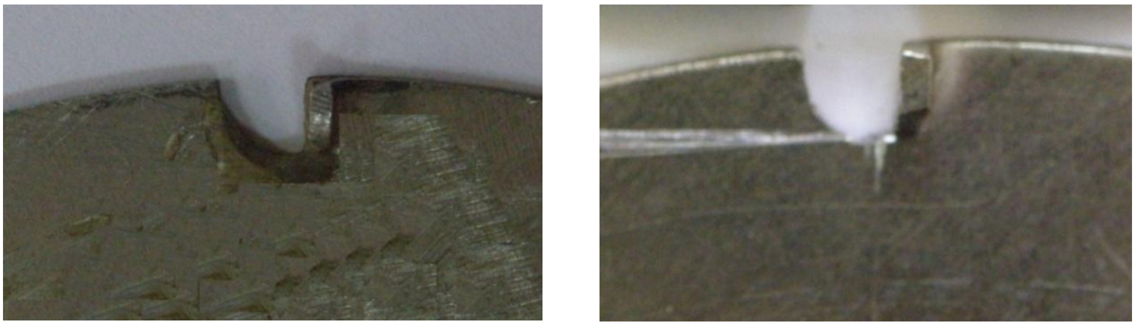
To confirm the theoretical assumptions made by us, experimental research was conducted to determine the optimal size of the seed disk cell for different seed types.

Characterization of rational parameters of seeding disc cells was done through calculation of the necessary coefficient value of filling the cells with seeds of various sizes. For that purpose, the sort seeds of sugar beetroot “Bilotserkivskyy odnonasinnyy 45” were divided into four sub-fractions with the help of sieves with round holes (3.5-4.0 mm; 4.0-4.5 mm; 4.5-5.0 mm; 5.0-5.5 mm) (fig. 4).

Fig. 4 - General view of sub-fractions of sugar beetroot seeds

Dilution ΔP in the vacuum chamber was 0.2 kPa, and peripheral speed of the cells V_{κ} – 2 m/s.

The experiments were carried out using discs with radiuses of tangent cells 5.0 mm and 6.0 mm, which correspond to their areas 9.6 mm 2 and 16.3 mm 2 correspondently (fig. 5).



a) ***b)***

Fig. 5 - General view of the cells on the sowing disc

a) the cell with the generatrix radius 5 mm; b) the cell with generatrix radius 6 mm.

RESULTS

The criterion for defining the rational parameters of sowing disc is the coefficient of cells filling by the seeds of corresponding sub-fractions (first – 3.5-4.0 mm; second – 4.0-4.5 mm; third – 4.5-5.0 mm; fourth – 5.0-5.5 mm).

To take into account the influence of the possible presence of twins, video recording of the seeding process was carried out (fig. 6).

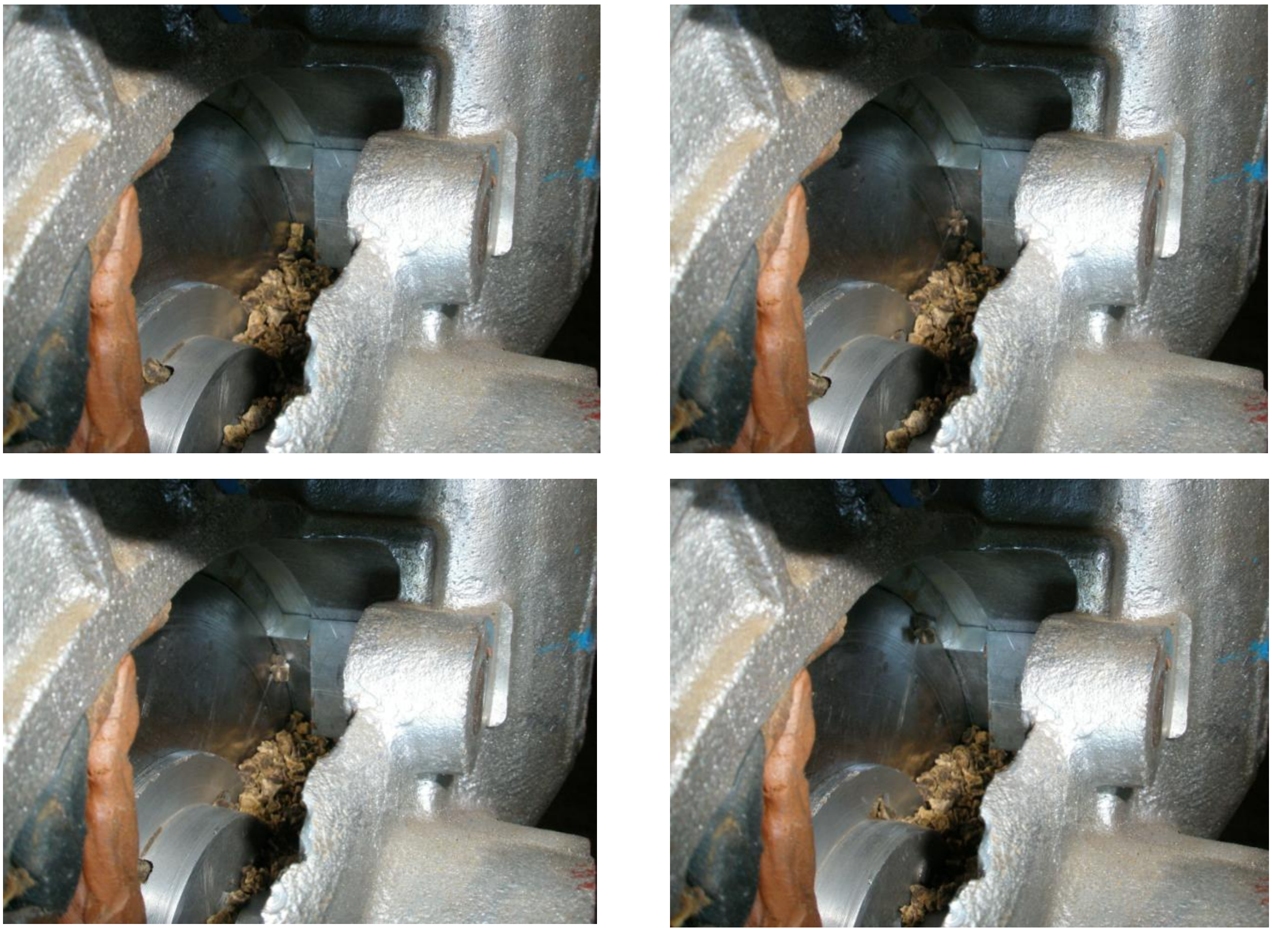
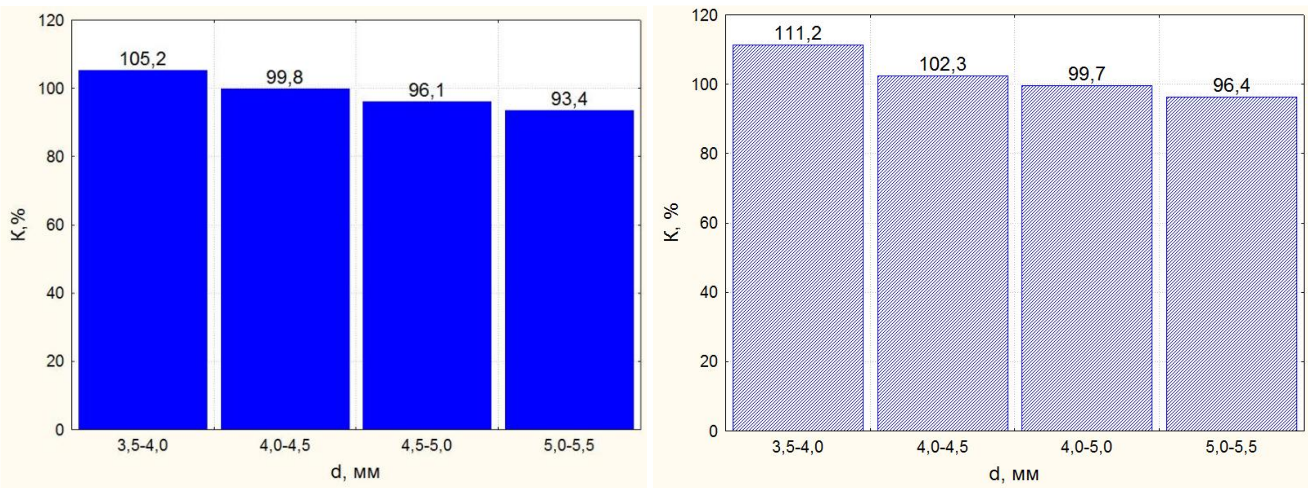


Fig. 6 - A general view of the process of filling the cells

According to the results of the research we got the dependence of the coefficient of cells filling of the sowing disc K for corresponding sub-fractions of sugar beets seeds for discs with radiuses of generatrix cells 5.0 mm and 6.0 mm (fig. 7) (*Borovikov V., 2003; Vukolov E.A., 2008*).

As seen from the diagram of the dependence of the coefficient of cells filling of the dilution in the vacuum chamber with the radius of generatrix cell of 5 mm and 6 mm, both discs are characterised by the presence of duplicates for the first sub-fraction (3.5-4.0 mm).



a) **b)**

Fig. 7 - Dependences of the coefficient of cells filling for corresponding sub-fractions of sugar beetroots with generatrix of cells as follows:
a) 5.0 mm; b) 6.0 mm

CONCLUSIONS

The disc with the radius of generatrix cell of 5 mm is characterised by nearly 100% of filling cells for the second sub-fraction (4.0-4.5 mm) and decrease of the filling coefficient for the third sub-fraction (4.5-5.0 mm) and the fourth sub-fraction (5.0-5.5 mm). The disc with the radius of generatrix cell of 6 mm is characterized by the presence of duplicates for the second sub-fractions (4.0-4.5 mm), almost 100% of cell filling for the third sub-fraction (4.5-5.0 mm) and the decrease of the filling coefficient for the fourth sub-fraction (5.0-5.5 mm).

Taking into account the experiments it is possible to state that in order to provide sowing of sugar beetroot, the bending radiuses of generatrix cells should be allocated within 5…6 mm, which generally corresponds to the results of theoretical research with the defined generatrix radius of 5.7 mm (*Mostypan M.I., 2017*).

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