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DETERMINING THE SEEDS SOWN PER REVOLUTION OF THE SOWING APPARATUS

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Abstract

Increasingly, work is being done to replace the mechanical gearbox for driving the shaft of seed drills with electric ones. To achieve this, it is necessary to determine the transfer function of the drive system. A stage in its definition is to determine the quantity and volume of seeds sown per revolution of the sowing apparatus. In the present study, a tooth (pin) sowing apparatus was used for sowing wheat with a Saxonia A200 seeder. The seed density is 825 kg.m^{-3}. It was found that for 1 revolution of the sowing apparatus 29.77 g of seed were sown, and their volume was 0.0000360646 m^3.

***Key words**: sowing apparatus, seeds sown.*

INTRODUCTION

The sowing apparatus is one of the most important working bodies in the construction of the drill. It plays a major role in the dosing, distribution and supply of seed material (Firsov & Golubev, 2013). It is used to separate from the total mass of a certain number of seeds and their formation in the initial flow with certain parameters.
Sowing apparatus are different both in purpose and in their design (Klishin, 2003; Krasovskikh & Klishin, 2007). Conditionally can be divided into several groups: mechanical, hydraulic, electromechanical, pneumatic and electropneumatic. Currently, the most widely used are pneumatic and mechanical. Mechanical sowing apparatus do not withstand competition from modern pneumatic ones, as the latter have a number of advantages. Due to the lower mechanical impact, pneumatic sowing apparatus ensure minimal seed trauma.
Drum apparatus are universal and are used for sowing different crops. They have a relatively simple construction and are easy to adjust to different sowing rates. Their significant disadvantage, laid down in their principle of operation, is the uneven supply of seeds.
The uneven arrangement of the seeds on the field is also influenced by the working speed (Maga & Krištof, 2017). It has been established that the best uniformity and respectively the highest biological yield when sowing winter wheat is achieved at a speed of 12 km.h^{-1}.
Pin sowing apparatus are characterized by good uniformity of the sown seeds and are less affected by the influence of external factors (Syrkin et al., 2014). The feeding of the seeds in the devices of this type is carried out under the action of the friction forces in the surface of the pins and indirectly depends on the physical and mechanical properties of the seeds. The main disadvantages are: the pulsations of the seed flow, formed by the entrainment of the seeds by the moving pins and the use of large reducers to regulate the sowing rate.
When sowing cereals with a "merged" surface, an important parameter for adjusting the sowing rate is the bulk mass (Lovric, 2003).
According to (Malinovic et al., 1998) the volumetric dosing of seeds by seed drills satisfies the criteria for accuracy of the general norm and stability of seed flow as a function of speed. Central sowing machines with pneumatic transport and separation to the depositories achieve a high coefficient of variation in the transverse distribution.
When growing cereals, sowing is one of the most responsible operations, as the correctly chosen technology, the exact adjustment of the sowing rate depending on the specific soil and climatic conditions, determine future yields

(Kuvaytsev et al., 2014). Currently, one of the most common ways to change the speed of rotation of sowing apparatus is the use of replaceable gears and gearboxes (Antonov & Laryushin, 2011). Unfortunately, this method has a number of disadvantages that affect sowing and ultimately the harvest. Thus, one of the main disadvantages is the difficulty in regulating the sowing rate due to the abrupt change in gear ratio of the gearbox.

This shortcoming is eliminated by installing a variator (Antonov & Laryushin, 2011), with which the gear changes smoothly, steplessly throughout the control range. This allows you to more accurately select the mode in which optimal sowing is achieved.

Increasingly, work is being done to replace the mechanical gearbox for driving the shaft of sowing apparatus with electric drive (Gorobey & Tarimov, 2009). In this case (developed stand) the shaft is driven by a stepper motor and a motor driver (with modulations up to 200 step pulses in s).

The basis of the electric drive of the sowing machines and regulation of the sowing norm are the mechatronic systems. Existing control systems of sowing machines are intricate and not reliable enough (Aulin et al., 2019). In these systems, devices are connected by a variety of signal and power wires. This leads to a "problem of interfaces" and a decrease in the efficiency of the control process. The solution to this problem is based on the mechatronic approach or combining elements and control units into mechatronic modules. They are characterized by reliability, compact design and lower cost.

It is necessary to improve the functional and structural integration of the components of the control system by integrating them into the mechatronic module. The module for regulating the sowing rate based on the Arduino software and hardware platform has been developed. The work of the proposed management system in case of change of the sowing rate in the sowing system is studied.

When sowing oilseeds, the use (Brichagina et al., 2017) of sowing apparatus controlled by a mechatronic system is promising. It was found that for sowing rapeseed and other small-seeded crops, a seeder equipped with a mechatronic seed metering device satisfies all agro-technical requirements and works much better than those equipped with a mechanical transmission system. Practically does not damage the seeds, allows very precise adjustment of the required sowing rate, ensures sustainable sowing and even distribution of seeds in rows and between them.

To adjust the sowing rate, the gear ratio in the drive system must be precisely determined. An interesting methodology for this is offered (Lysy, 2015). According to this methodology, the volume of seeds sown per 1 revolution of the sowing wheel is:

$$V_0 = \pi . l . R^2 . sin^2\alpha \tag{1}$$

where l, R - width and radius of the drum, cm; α - angle of lifting the seeds from the drum relative to the vertical diameter of the apparatus.

This formula was developed assuming that the volume of seeds sown per 1 revolution of the drum depends on the height of their layer at the outlet of its exposed part. This should not be taken for granted, as the seed volume depends on the cross-section of the outlet in the seed drill box. This area is:

$$f = h_0 . l \tag{2}$$

where h_0 is the height of the hole.

As it is difficult to determine the speed of movement of the seeds in the layer passing through the outlet, it is assumed that its average speed is Vc = 0.5Vk (Vk - peripheral speed of the working surface of the drum). Then the volume of seeds sown by the sowing apparatus per unit time is:

$$V_0 = 0{,}5 . \beta . h_0 . l . V_k \tag{3}$$

where β is the correction coefficient.

The volume of seeds sown per 1 revolution of the drum is:

$$V_0 = \beta . h_0 . l . \pi . R \tag{4}$$

Knowing the volume V_0, the gear ratio required to realize a certain sowing rate can be calculated:

$$V_0 = \frac{2.\pi.b.Q.R_{CT}}{10^3.\gamma.i.(1-\varepsilon)} \tag{5}$$

where Q - sowing rate, kg/ha; b - row spacing, cm; Rct - static radius of the drive wheel, m; γ - seed density, kg.m^{-3}; ε - coefficient of wheel slip,%; i-gear ratio of the drive from the wheels to the shaft of the sowing apparatus.

The aim of the present study is to determine experimentally the amount of wheat seeds that are sown per 1 revolution of the sowing apparatus.

MATERIALS AND METHODS

The experiments are performed in laboratory conditions, in the Department of Mechanization of Agriculture at the Agricultural University, Plovdiv, with a Saxonia 200A seeder. The damper of the observed sowing apparatus is set to position 1, the movable bottom - also to position 1.
The drive of the sowing apparatus is provided by a transmission system consisting of 3 chain gears and a gear reducer, allowing 72 gear ratios. The movement from the right running wheel through the transmission system is fed to the sowing apparatus.
6 of the possible gears in the gear reducer are randomly selected. The movement from the right running wheel through the transmission system is fed to the sowing apparatus.
The crank is mounted on the drive wheel of the second chain gear. For each of the selected gears in the gear reducer, the gear ratio in the transmission system is determined by taking into account the number of revolutions of the crank, at which the shaft of the sowing apparatus performs 1 complete rotation. 42 revolutions are performed for each gear with the crank. The seeds sown from the observed sowing apparatus are collected and weighed on the scales.
The number of repetitions is determined at a level of significance $\alpha = 0.05$ and relative error $\delta = 5\%$ according to the authors' recommendations (Mitkov & Minkov, 1989; Bojanov & Vuchkov, 1983).
The quantity of seed sown per 1 revolution of the sowing apparatus **y** is determined by dividing the product by the quantity of seed sown per 42 revolutions of the crank **x** and the revolutions of the crank required for 1 revolution of the sowing apparatus n_{1ca} by 42:

$$q_{об} = \frac{x.n_{1ca}}{42} \quad (6)$$

The volume sown per 1 revolution of the sowing apparatus is obtained by dividing the amount of sown seeds by the density of the sown material:

$$v_{об} = \frac{q_{об}}{\gamma} \quad (7)$$

RESULTS AND DISCUSSIONS

The experiments were performed with wheat seeds with a density of 825 $kg.m^{-3}$.
Gears 111, 211, 231, 322, 431, 634 of the seed gear unit are selected at random. For each of them a different number of turns of the crank is made for one complete rotation of the sowing apparatus. The results of these preliminary experiments are presented in Table 1.

Table 1. Pre-determination of the number of turns of the crank for 1 turn of the sowing machine

Gear Number	Repetitions			Average value	Standard deviation	Coefficient of variation
	1	2	3			
111	141	140	141	**141.67**	0.577	0.410
211	70	71	70	**70.33**	0.577	0.821
231	44	44.5	44	**44.17**	0.288	0.654
322	22.5	22.5	22.5	**2.5**	0.00	0.000
431	11	11	11	**11.00**	0.00	0.000
634	2.5	2.5	2.5	**2.5**	0.00	0.000

It is noteworthy that for all gears the coefficient of variation is small. This speaks to a good grouping of data, without much distraction. The highest value of the coefficient of variation is in the gear number 211. Normally, the largest number of repetitions is needed here. For this reason, the number of repetitions for this gear is determined first. According to the methodology at significance level $\alpha = 0.05$, relative error $\delta = 5\%$ and coefficient of variation 0.821 the number of repetitions is 3. For each of the selected gears in the gear reducer, the number of repetitions when determining this indicator is assumed to be 5. After performing the final measurements, the results were obtained, reflected in Table 2.

Table 2. Number of turns of the crank for 1 turn of the sowing apparatus

Gear Number	Number of revolutions
111	**141.0**
211	**70.0**
231	**44.0**
322	**22.5**
431	**11.0**
634	**2.5**

The data in the second column in Table 2 represent the gear ratio in the transmission system of the drill from the second shaft (on which the crank is located) to the shaft of the sowing apparatus.
For each gear, 42 turns of the crank were made. The amount of wheat seeds sown was collected and weighed. The results of the experiments are reflected in Table 3.

Table 3. Quantity of seeds sown for 42 turns of the crank, g

Gear Number	Repetition					Mean
	1	2	3	4	5	
111	17	18	18	17	18	**17.6**
211	28	30	27	28	28	**28.6**
231	56	54	57	55	56	**55.4**
322	119	110	112	108	116	**113.0**
431	240	238	242	238	242	**240.0**
634	505	503	501	503	501	**502.4**

With a decrease in the gear ratio, an increase in the amount of sown seeds is observed (Table 2). This is logical, because reducing the gear ratio increases the speed of rotation of the sowing apparatus and, accordingly, more seeds are exported.
What has been said so far is visualized and confirmed in the Figure 1.

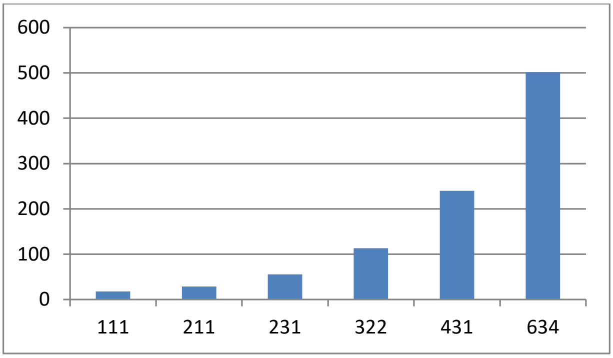

Figure 1. Variation of the sown quantity depending on the gear unit

Using formula 6, a certain amount of seeds is sown per 1 revolution of the seed drill. The following results are obtained for the individual gear ratio in the gear unit (Table 4):

Table 4. Quantities of seeds sown per 1 revolution of the sowing apparatus, g

Gear Number	Quantity of seeds
111	**30.17**
211	**29.38**
231	**29.61**
322	**29.68**
431	**29.86**
634	**29.90**

The average value of the amount of wheat seeds sown per 1 revolution of the seed drill is 29.77 g.
Variation analysis was performed with the data from Table 3 and the variance was determined (σ=0.074), the standard deviation (0.272) and the coefficient of variation (υ=0.915). From the performed measurements and statistical analysis it is established that the data are well grouped around the average value, with insignificant scattering.
For greater certainty in the obtained results, a check was made for gross errors in the measurements, according to the methodology

proposed by the authors (Mitkov A. and Minkov D., 1989). At the significance level α=0.05 and the number of measurements n=6, the limit value of the criterion for gross errors in the measurements is V_T=1.996. The calculated values of this criterion for the minimum (29.38) and maximum (30.17) quantities of seeds sown for 1 revolution of the sowing machine are respectively $V_{29,38}$=1.434 and $V_{30,17}$=1.618, which gives grounds to claim that there are no gross errors in the measurements made.

The density of wheat seed used is 825 kg.m^{-3}. According to formula 7, the volume of seeds sown per 1 revolution of the sowing apparatus is 0.0000360646 m^3.

CONCLUSIONS

Based on the conducted experiments and analyzes, it can be concluded that the sown amount of wheat seeds with a density of 825 kg.m^{-3} for 1 revolution of the sowing apparatus is 27.99 g with a volume of 0.0000360646 m^3.

The same should be done when determining the quantity and volume of seeds from other crops.

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