RESEARCHES ON OBTAINING HIGHER QUALITATIVE INDICES FOR SOWING WORK

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Abstract. The paper presents the experimental research conducted on a stand and in the field for a precision seeder, separately or simultaneously with applying liquid herbicides or insecticides. In order to increase the precision degree for the measurements, the compaction wheels were moved sideways by 20 cm, so that they do not cross the seed row. The experiments were performed for three different working speeds, placing one or two corn seeds in each pocket.

Keywords: sowing, precision seeder, seed-metering device.

Introduction

In order to obtain a uniform distance between plants in the row, precision seeders manufactured so far were equipped with different types of seed metering devices. Efforts for continuous improvement of seed metering devices had the aim of maximizing the yields of sowing crops [1-3]. To achieve perfect spacing between plants, each seed must be separated (singulated) and then launched from the seed metering device into the leading tube into the ditch opened by the seed coulter, after precise and repeatable period of time and trajectory [5-7].

To assess the performance of a pneumatic seeder for seeding and fertilizing weeding plants equipped with a pneumatic distribution device with vertical discs and holes of various sizes, researches were made in the field and in laboratory. Laboratory research was conducted on a stand with fixed seeding section, and the seed distributor disc was driven at rotary speeds appropriate to the conditions of the seeder movement in operation, without slippage. The results obtained in the experimental researches have shown a seeding precision as the distance between seeds in a row with values less than 90 % normal ranges for working speeds higher of 1.94 $m \cdot s^{-1}$. [4] Through the research conducted in the field and in laboratory, the authors aimed at improvement of the technology to establish weeding crops, so that the market of agricultural machinery benefits from high-performance technical equipment, which meets the quality requirements. Also, the experimental results obtained allow the development of useful recommendations for farmers using this technical equipment.

Materials and methods

The machinery is equipped for simple seeding works as follows:

- the tractor PTO is engaged;
- the blower is put into function through the trapezoidal belt transmission;
- thus negative pressure (vacuum) in the vacuum chamber of each seed meter through a flexible rubber tube is created;
- due to the negative pressure, the seeds in the supply chamber, which is on the other side of the distributor disc, are caught by its holes;
- the distribubtor disc is driven through a wheel and chain transmission by the compaction wheel by its movement on the ground, and the seeds are caught in the holes if the disc is brought by its rotation over the upper mouth of the coulters, where it ends the channel of the vacuum chamber;
- due to their own weight, seeds fall through the body of the coulter into the soil from a small distance, thus achieving precision sowing seed by seed into the pocket, depending on the chosen distributor disc.
- The number of seeds in a row is established by:
- choosing the distributor disc with the appropriate number of holes and the diameter of the hole choice number corresponding to the holes;
- choosing the transmission ratio between the compaction wheel (drive) and the disc.

Distributor discs have holes smaller than the respective seeds, so that they do not pass through them, and their number varies from crop to crop, according to the average distance between seeds in a row. Characteristics of the distributor discs, for corn crop, and the theoretical distances between seeds in the row depending on the number of holes on the distributor disc and on the transmission ration for corn crop are presented in Table 1.

Table 1

Theoretical distances between seeds in a row depending on the number of holes on the distributor disc and depending on the gear ratio for corn crop

No. of teeth of the wheel on the axis of the distributor disc	No. of holes of the distributor disc	Holes diameter, mm	Theoretical distances between seeds in the row, mm			
			Sprocket on the axis of the compactin wheel			
			9 teeth	10 teeth	11 teeth	16 teeth
30	7	5.5	600	540	500	336
	14		300	270	250	168
	16		260	238	218	148
	6x2		700	630	580	390
22	7		448	400	360	250
	14		224	200	180	125
	16		196	173	157	108
	6x2		520	465	420	290

Sprockets that can be changed are:

- on the axis of the compaction wheel, those with 9,10,11 and 16 teeth;
- on the axis of the distributor disc, those with 30 and 22 teeth.

Thus, the following transmission ratio is obtained: 0.3; 0.33; 0.36; 0.53; 0.4; 0.45; 0.5; 0.72. In Figure 1 the diagram of the working process of the installation for applying herbicides is presented.

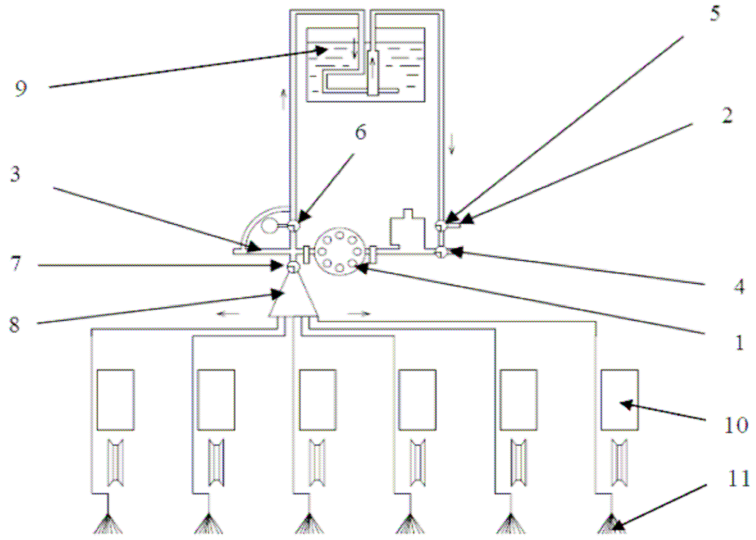

Fig. 1. **Diagram of the working process of the installation for applying herbicides:**
1 – pump; 2 – filling connection; 3 – safety valve; 4, 5, 6, 7 – three-way valve; 8 – distributor; 9 – tank; 10 – row unit; 11 – nozzle

Experimental researches have considered the following qualitative work indices:

- precision of sowing as the number of seeds in the pocket relative to that for which the seeder has been adjusted;
- seeding precision as the distance between the pockets in a row and seed settlement in the pocket;
- lateral deviation of the pockets towards the row axis and seed breaking.

To assess the performance of herbicide and insecticide equipment of the pneumatic seeder for seeding and fertilizing sowing plants, researches were carried out in laboratory on a special stand, pursuing the following parameters: pump flow; pump flow through the nozzles; determining of the flow coefficient of the nozzles; flow coefficient of the nozzles and norms of liquid per hectare.

The researches were carried out on a track with sand, with a length of 30 m. The characteristics of the seeds used in the experiments are presented in Table 2.

Table 2

Characteristics of corn seeds used for experimental research

Dimensions of seeds			Weight of 1000 seeds	Purity	Adjustments for 1 seed in the pocket		Adjustments for 2 seeds in the pocket	
Length	Width	Thickness			Distance between seeds	Disc no. of holes and diameter	Distance between seeds	Disc no. of holes and diameter
mm	mm	mm	g	%	mm	mm	m	mm
10.14	7.39	5.12	237	98.3	330	7 holes (Φ 5.5)	390	6x2 (Φ 5.5)

Seeder coulters were adjusted to touch the ground only with the tip of the compaction wheel to obtain sowing of the seeds. To carry out measurements with high precision, the compaction wheels were moved laterally from the coulters by cm, so that they do not trample on the seed row. Each test was carried out in three repetitions at working speeds of 5, 8, 11 km·h^{-1}.

Flow coefficient of the nozzles (Q) was calculated with the equation:

$$Q = \frac{q_r}{q_t} = \frac{q_r}{A \cdot \sqrt{2 \cdot g \cdot p}}, \tag{1}$$

where q_r – real flow through the nozzle, cm^3·min^{-1};
q_t – theoretical flow through the nozzle, cm^3·min^{-1};
A – area of the hole, m^2;
g – acceleration of gravity, m·s^{-2};
p – pressure, mm col H_2O.

The calculations of norms of liquid per hectare were made with the equation:

$$N = \frac{60 \cdot q}{0.1 \cdot L \cdot v}, \tag{2}$$

where N – norm of liquid, l·ha^{-1};
q – liquid flow of the seeder, l·min^{-1};
v – working speed, km·h^{-1};
L – working width, m.

Results and discussion

Seeding precision, as the number of seeds in the pocket, is the percentage of the number of pockets containing the number of seeds initially adjusted (1 or 2) reported to the total number of pockets distributed on the sample length that includes seedless pockets. Figure 2 shows the results of determining this index for adjustments with one and two seeds in the pockets.

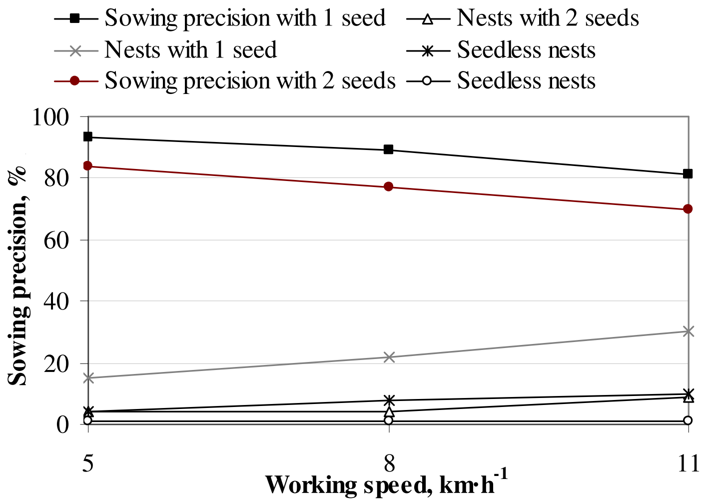

Fig. 2. **Seeding precision as the number of seeds in the pocket for adjustments with one seed in the pocket and two seeds in the pocket**

Seeding precision as the distance between the pockets represents the number of distances between the seeds (pockets) that are situated in an area of precision, based on the total number of distances on the given length (expressed as percentage). For corn, the area of precision is given by the actual distance (theoretical distance + slippage = 33 cm), plus or without the limits of the distance depending on the crop (± 5 cm). Thus, the area of precision for corn is in the range 28 - 38 cm.

Shorter distances between the pockets in the row are considered the distances that have lower values than the lower limit of the area of precision, relative to the total measured distance, expressed as percentage. Greater distances between the pockets in the row are considered the distances that have higher values than the upper limit of the area of precision, relative to the total number of measured distances, expressed as percentage. In Table 3 the results of measurement variation of seeding precision as the distance between the pockets, depending on the working speed of the seeder, are presented.

Table 3

Seeding precision as the distance between the pockets, depending on the working speed of the seeder

No. of repetition	Working speed	Adjustments for 1 seed in the pocket			Adjustments for 2 seeds in the pocket		
		Precision as distance between pockets	Lower distances	Higher distances	Precision as distance between pockets	Lower distances	Higher distances
	km/h	%	%	%	%	%	%
R1	5	92.0	3.1	4.9	91.3	3.1	5.6
R2		90.3	2.5	7.2	91.6	2.9	5.5
R3		93.8	2.9	3.3	92.3	1.8	5.9
Average		*92.03*	*2.83*	*5.14*	*91.73*	*2.6*	*5.67*
R1	8	73.5	7.2	19.3	78.3	8.7	13
R2		69.8	9.9	20.3	74.9	9.9	15.2
R3		70.9	11.3	17.8	76.1	10.8	13.1
Average		*71.4*	*9.47*	*19.13*	*76.43*	*9.8*	*13.77*
R1	11	60.1	15.2	24.7	68.4	13.2	18.4
R2		62.8	19.7	17.5	70.3	14.6	15.1
R3		58.3	19.2	22.5	66.2	10.7	23.1
Average		*60.4*	*18.03*	*21.57*	*68.3*	*12.83*	*18.87*

To assess the alignment index of seed into the pockets, field measurements were made to determine the distance between extreme seeds of the pocket in transverse direction. Thus, the lenght and widht of the pockets were established, which were grouped into 3 categories: 0-5 cm; 5-10 cm; 10-15 cm, both for the length and for the width. The measurement results are presented in Figure 3.

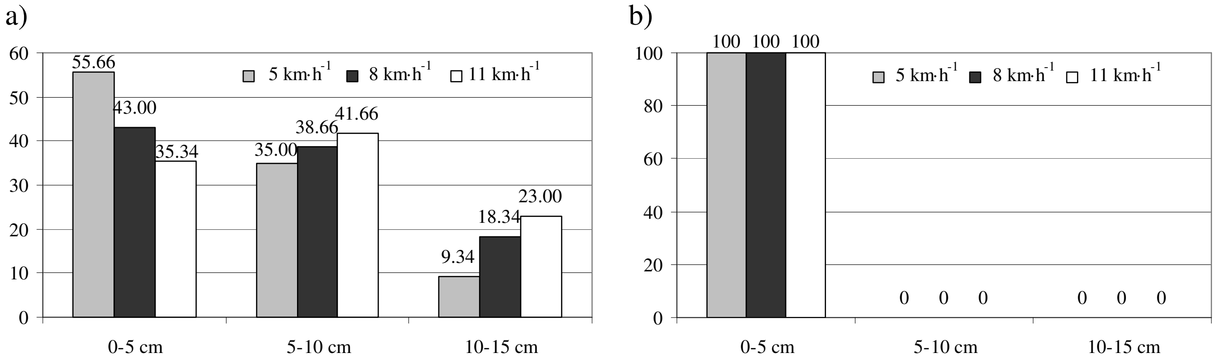

Fig. 3. **Assessing of seed settlement in the pockets depending on their:** a – lenght; b – width

Lateral deviation of the pockets from the axis of the row was determined by measuring the distance from the farthest seed of the pocket to the axis of the row on the left and right side. Measurement data were grouped in the categories: 0-2.5 cm; 2.5-5 cm; over 5cm, being expressed in percentage.

To determine the flow of the pump of the herbicide and insecticide equipment of the pneumatic seeder the distribution head was dismantled and in its place a nozzle was mounted, which flowed through a hose in a glass tank with graduated level. The safety and adjustment valve was completely closed, so that the entire amount of liquid entered into the reservoir.

Table 4

Measuring the lateral deviation of the pockets relative to the row axis

Working speed, km·h^{-1}	Lateral deviation of the pockets from the axis of the row, %		
	0-25 mm	25-50 mm	> 50 mm
5	94.2	5.8	0
8	96.3	3.7	0
11	96.4	3.6	0

Measurements were made for 0.8; 1; 2; 3; 4; 5 kgf·cm^{-2}.

Pressure variation was obtained by operating the valve found before the discharge connection. Each test lasted 1 minute and it was carried out in 3 repetitions. In Figure 4 the variation of flow depending on the pressure is presented.

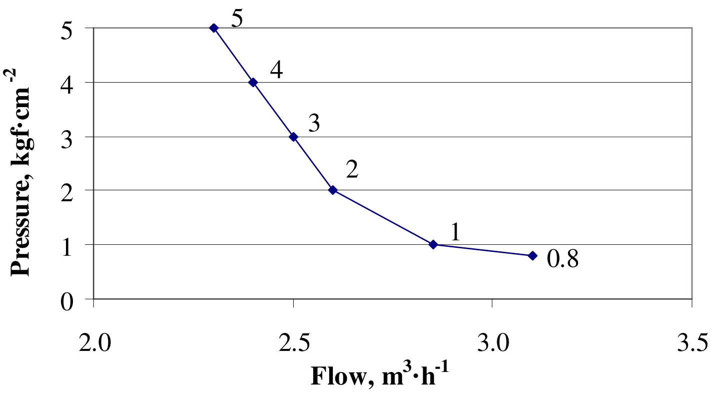

Fig. 4. **Variation of the flow with the pressure**

Hourly flow through the nozzles was determined by the volumetric method. The pump was mounted on the stand, being driven by an electrical motor at a speed of 780 rot·min^{-1}. Measurements were performed for simultaneous operation of 6 nozzles at a discharge pressure of the pump of 2, 3, 4, 5, 6, 7 and 8 kgf·cm^{-2}. Time of the test was of 1 minute, in 3 repetitions. In Table 5 the average flows for each nozzle and the percentage positive and negative deviations towards the average value of the flows for one nozzle are presented.

Table 5

Mean flow for each nozzle

Pressure, kgf·cm^{-2}	Flow, cm^3·min^{-1}						Mean flow for 1 nozzle, cm^3·min^{-1}	Maximum deviation, %	
	1	2	3	4	5	6		+	-
2	1277	1262	1212	1292	1462	1239	1290	13.2	6.0
3	1478	1472	1393	1512	1645	1442	1490	10.3	6.5
4	1665	1712	1605	1689	1865	1669	1700	9.6	5.6
5	1862	1862	1795	2012	2086	1775	1898	9.8	6.5
6	2067	2088	2012	2132	2292	2032	2103	8.9	4.3
7	2279	2279	2216	2318	2472	2232	2299	7.5	3.6
8	2452	2462	2304	2472	2662	2464	2469	7.8	6.6

Thye measurement results of the flow coefficient of the nozzles (Q) are presented in Figure 5.

Norms of liquid per hectare were established for 3 speeds of the equipment, respectively: 5, 8, 11 km·h^{-1}, for working pressures between 2 to 8 kgf·cm^{-2}, for liquid distribution on the row and on the entire surface. Norms of liquid per hectare were established for distances between coulters of 1000, 900 and 800 mm. Values of the norms of liquid per hectare, distributed into stripes on the row, the distance between the coulters being of 1000, 900 respectively 800 mm are presented in Table 6.

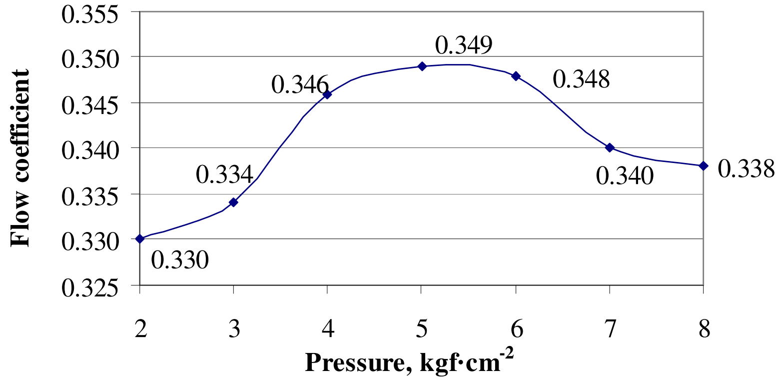

Fig. 5. **Variation of the flow coefficient of the nozzles depending on the pressure**

Table 6

Norm of liquid per hectare, distances between coulters of 1000, 900 respectively 800 mm, distributed into stripes on the row

Distance between coulters, mm	Working speed, km/h	Norm of liquid, l/ha at pressure, kgf/cm² of:						
		2	3	4	5	6	7	8
1000	5	164	188	213	237	262	285	306
	8	107	122	137	152	168	182	195
	11	81	91	103	114	125	136	145
900	5	189	207	236	262	289	315	339
	8	117	133	150	168	184	199	213
	11	88	99	112	124	136	148	158
800	5	202	233	264	294	325	354	380
	8	131	149	168	187	207	225	241
	11	98	111	126	140	153	167	178

In Figure 6 the norms of liquid at distribution on the entire surface are presented. Breaking of the seed consists in quantitative determining of the broken seeds relatively to the quantity of seeds used for sowing and it was determined along with the seeding precision. There were not obtained broken seeds in any of the tests carried out.

Norms of liquid that can be achieved by the machinery range between 81 and 380 l/ha for distribution on stripes, and for distribution on the entire surface, the machinery achieves norms between la 243 and 918 l·ha^{-1}.

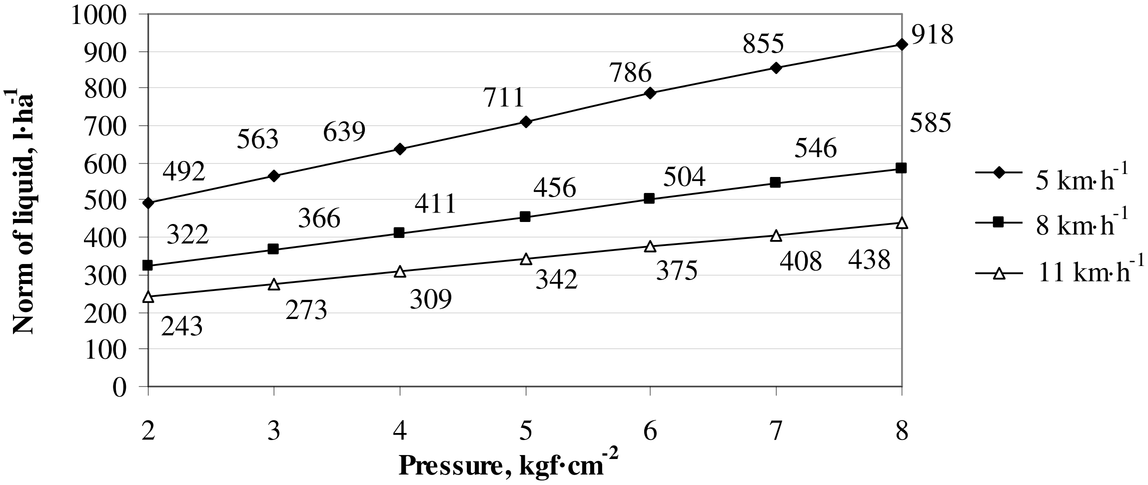

Fig. 6. **Norms of liquid at distribution on the entire surface**

Conclusions

1. Seeding precision as the number of seeds in the pocket decreases with the increase of the working speed for all crops due to the larger percentage of pockets without seeds, following the increased rotation of the distributor disc.

2. The same was found in case of seeding with 2 seeds in the pocket, where for higher speeds it increases the percentage of pockets with 1 seed, due to the same reason.
3. Seeding precision as the distance between rows decreases as the speed increases, while the percentage of smaller distances and larger distances increases. This can be explained by the fact that at higher speeds, while falling, the seeds bounce off the walls of the coulter and fall irregularly on the soil, at higher or smaller distances.
4. It was found that the length of the pockets increases with increasing the working speed due to slippage. Thus, while the pockets of 0-5cm decrease from 55.66 % to 35.34 % for speeds of 5, respectively 11 km/h, the pockets of 10-15cm increase from 9.34 to 23 %.
5. Lateral deviation of the pockets from the axis of the rows in range of 0-2.5cm is in proportion of 94.2-96.4 % showing a good settlement of the seeds in the pocket.
6. There are flow irregularities of up to 13.2 % plus deviation and 6.6 % minus deviation from the average value of the flows.
7. Flow coefficient is low due to the losses through the nozzles.

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