

## SOWING QUALITY INDICATORS FOR A SEED DRILL WITH OVERPRESSURE

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### Abstract

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The main goal of sowing is the distribution of seeds at an optimal depth with adequate seed spacings. The results of the optimal sowing, in both horizontal and vertical directions, are better germination and sprouting, as well as increased yield and reduced influence of plants on each other's space for growing, regarding the available light, nutrients and moisture. Quality of horizontal and vertical seed distribution is influenced by the distance between rows, sowing depth, pre-sowing preparation, seed drill, seeding mechanism, sowing density, and operator's skills.

The arithmetic mean of spacing ( $A_m$ ), standard deviation for spacings between the plants ( $SD$ ) and coefficient of variation ( $CV$ ) are usually used for representation of sowing evenness. Assuming that the seeds are of good germination quality, the yield is directly dependent on the sowing quality and organization of plants per unit of surface area.

A well prepared plot was sown with 20 corn seed hybrids from different FAO maturity groups. The sowing was performed with precision pneumatic seed drill INO Becker Aeromat 2, which ejects individual seeds by using the overpressure. After sprouting, no statistically significant differences were found between the sowing of hybrids from different FAO maturity groups and their characteristics. When the yield is concerned, biological characteristics of hybrids are much more influential than the quality of sowing. This is true only if the tractor implement for wide row planting is properly adjusted.

Keywords: corn sowing, overpressure, seeding mechanism, seeding disk, quality

### INTRODUCTION

Advantages of sowing corn seeds with precision seed drills are seeds saving, less working hours, uniformity of spacings in the row and depth of sowing, which consequently leads to more stable yield with even increase, which is a precondition for high yields. After conducting the research, Paris *et al.* (2003) was convinced that the main precondition for even growth and development of plants is the uniformity of seed distribution in the row. On the other hand, Bauer *et al.* (2002) and Searle (2006) claim that surface tillage and sowing

conditions are very important for the sowing depth and distance between the ejected seeds in the row. Paris and Braci (2003) believe that the seed ejection height is important for uniform sowing, but Bauer (2002) sees the coulter as an important factor for efficient sowing. Conventional seed drills for corn have the possibility to copy the terrain, but the ejection height is conditioned by the design of the seeding mechanism and the coulter (Tao *et al.*, 2012).

Liu *et al.* (2004) claim that uniform sowing in the row and between the rows is not as important as the organization, that is, the number of plants per

unit of surface area. Small, uniform group of plants in a row and between the rows can never produce a yield which is higher than the yield produced by a bigger group of plants, no matter how good the seed distribution is. He implies that qualitative sowing is provided by the group of plants, which is at the same time the key to successful sowing, and this was confirmed by Rahman *et al.* (2003) and Singh *et al.* (2005). Meši *et al.* (2008) emphasizes that the precision of mechanical seed drills is highly dependent on the uniform size and dimensions of the seed as well as the working speed, when compared to mechanical pneumatic seed drills. Meši (2000) defines the 'working rhythm' as a particularly influential factor. The said author explains it as an irregularity in the work regime of the seed drill transmission which occurs due to imperfect design of seed drill components and wearing of the seed drill during its exploitation. He also analyzed tillage which had significant influence on the percentage of the sprout seeds (Meši *et al.*, 2010). Besides the seeding mechanism, uniformity of seed distribution also depends on the speed of sowing, adjustments and operability of a seed drill, terrain, pre-sowing preparation, shape and size of seeds... (Findura *et al.*, 2012; Turan, 2011).

Paning *et al.* (2000) points to fundamental difference between sowing under laboratory conditions and in the open field. Sowing in the open is affected by numerous factors, and this number of factors is minimized when laboratory conditions are concerned. While testing the prototype for an optical electronic seed sowing control, Kostić *et al.* (2011) concluded that the error in the operation of the system was related to the type of seeds and not the sowing speed. This error ranged up to 4.5% with soybean, 0.92% with maize and 1.88% with sunflower.

Wilkins *et al.* (1991) introduced the sowing quality indicator called the Spacing uniformity index. This index quantitatively describes the sowing quality by using the seed spacing in the row. This is just one of the numerous names for the Coefficient of precision which is, today, generally accepted coefficient that stands for the quality of sowing. The Coefficient of precision is defined by ISO standard and it includes *ISO Miss index* and *ISO Multiples index*. Smith *et al.* (1991) and Searle (2006) explain the Coefficient of precision as percentage of seeds sown maximally at  $\pm 1.5$  times with respect to theoretical spacing. *ISO Miss index* is defined as *absence of seeds at places where they should be*. The same term is defined by ISO as the *spacing which is 1.5 times bigger than theoretical spacing*. Another index, *ISO Multiplex index*, ISO defines as *the presence of two seeds at places where only one seed should be*, which is actually the seed sown at less than a half of the defined spacing. It should be noted that higher index of precision coefficient means that sowing is more uniform and that *ISO Miss indices* and *ISO Multiplex indices* are smaller. Both ISO indices are

expressed in percentages and they show deviation from theoretical seed spacing.

Laboratory for Farming Machinery, Department for Agricultural Engineering at the Faculty of Agriculture, University of Novi Sad, tested the seed drill INO Becker Aeromat 2 in spring 2014, during sowing of corn seeds. The objective of this testing was to determine the quality of sowing of several different hybrids from the FAO group with identical spacing. The testing was performed at a locality of CM Čenej, near Novi Sad. The objective was to sow corn hybrids at identical spacings, under the same sowing conditions and with the same seed drill for wide row planting.

## MATERIAL AND METHOD

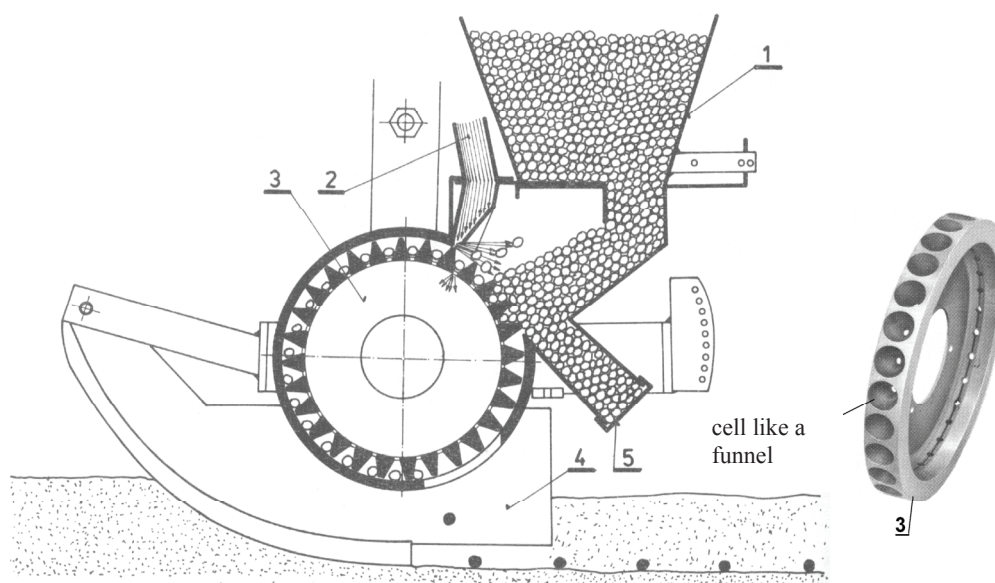
Sowing of corn was performed on April 11 and 12, 2014 by Agricultural expert and advisory service from Novi Sad. The plot was located in the vicinity of Čenej village, between two road directions, Novi Sad-Čenej and Novi Sad-Bački Jarak. The surface area of the plot was 10.94 ha. Smaller part of the plot, which was around 2.8 ha in size, was used for the experiment.

Previous crop was soybean. Prior to basic tillage, the soil was fertilized with 100 kg/ha of NPK fertilizer. The basic tillage was performed in accordance with agrotechnical requirements. The furrows were closed in spring, when the pre-sowing preparations were also completed. On April 5, 2014 another pre-sowing preparation was done, a few days before the sowing and fertilization in the amount of 350 kg/ha. Pre-sowing preparation made the soil loose up to 0.08m with small deviations. Pre-sowing preparations were of excellent quality which ensured sowing of hybrid corn seeds without any problems. Level of soil moisture in the sowing layer was good for sowing and sprouting, which was determined by measuring.

A total of 20 hybrid seeds from different FAO maturity groups were sown. All hybrids were from FAO 300, FAO 400 and FAO 500 maturity groups and they were sown with spacings of 0.2m. The hybrids were marked with letters and the author is familiar with their characteristics.

Pneumatic seed drill with overpressure INO Becker Aeromat 2 for wide row planting was used for sowing of corn seed hybrids. The rigid frame is equipped with 4 seeding mechanisms at 70 cm distance. The seed drill width at transportation is 3 m, it weighs 650 kg and has the power of 33 kW. The seeding mechanisms were powered by the drive wheels from which power was transmitted through gear box, sprocket system and seeding shaft, and then by chain drive to the seeding mechanisms. This transmission was adjusted to sowing spacing of 20 cm. Theoretical number of plants, or the set number of sown seeds was 71428 seeds/ha.

The seed drill which operates based on the principle of air pressure consists of a disc with cells which are shaped like funnels, Fig. 1.



1: Pneumatic seed drill using air pressure for operation: 1 – seed tank; 2 – air intake through diffuser; 3 – seeding disc (plate) with cells; 4 – coulter furrow opener; 5 – opening for seed ejection from the tank

The cell has a small opening at its bottom. The seed from the tank (1) falls into a cell which is positioned at certain distance in the perimeter of the disc (3) during rotation. Several seeds fall into cells. For example, each cell in the disc for sowing corn has 3 to 5 seeds which fall inside. While the disc is rotating, the cells filled with seeds pass the diffuser (2) which directs the air pressure from the fan onto seeds stored inside the mentioned cells.

This ejects all the seeds out of the cell, except the seed at the bottom of the funnel. The seed above the bottom opening of a cell that has a shape of a funnel is pressed by air pressure to a small ejection opening. The rotation forces the seed out of the cell and into the furrow which has been previously opened by coulter opener (4). The seed is ejected through opening by the ejector which can be changed together with the seeding disc for the purpose of adjustment to different types of seeds.

Electronic sowing control was performed by INOtronic PS200. The sensor of the device for control of speed and travelling distance was positioned on the left wheel which was not the drive wheel (less slippage), and each seeding mechanism was installed with a sensor that controls the seeds passing from the seeding plate to the coulter. They were molten in plastic which excludes the possibility of being covered in dirt, blockage, or any other damage.

The control unit was positioned so that the driver could easily see it inside the cabin and it showed all operating regimes of the seed drill and results of seeding (working speed, travelled distance, number of ejected seeds for each seeding mechanism, number of PTO rotations, etc).

The described seed drill was attached to IMT 565 tractor which technical and exploitation characteristics met the requirements of the seed drill. All important working parameters were adjusted and checked (number of PTO rotations, 540 rpm), as



2a: Position of the sensor



2b: Control unit of sowing electronic control

well as operating pressure of pneumatic installations of the seed drill (120 mbar), all joints were sealed and lids of seeding mechanisms were checked, the pressure in tires and position of tracks on tires (opposite with respect to drive wheels of tractor) were checked, the lengths of markers were adjusted, and the sowing spacing was set to 20 cm. The quality of sowing and spacing in the row was measured after sowing, but the measure which was taken was the spacing between hybrids after sprouting because the yield indicators are sprouted seeds, corn. The spacings were measured for all seeding mechanisms, in a sufficient number of replications. All measuring was performed in accordance with ISO 7256 (2010).

## RESEARCH RESULTS AND DISCUSSION

Sowing was performed without any difficulties and interruptions, and its parameters were achieved by the end of sowing of corn seed hybrids, that is, by the end of the experiment. Travelling speed was 7 km/h which was within the recommended speeds of the seed drill manufacturer. The seed drill was capable of meeting all sowing requirements. None of the technical-exploitation parameters of the seed drill affected in any way the sowing procedure, which is the main precondition for obtaining accurate field data on sowing. Information about technical reliability of the system for sowing corn was available all the time from the device for electronic control of sowing.

The following information was collected for all sown seeds: percentage of doubled seeds, percentage of missed spots, spots with 0.5 to 1.5 theoretical spacing (%), percentage of sprouted seeds, spacing (m), standard deviation, variation coefficient. All parameters are presented in Tab. I, and the quality was determined based on the coefficient of variation. When coefficient of variation is less than 20% it means that the sowing quality is excellent. If the said coefficient is over 20% but less than 25%, it means that the sowing quality is not that good but still within the limits of acceptable quality. Unacceptable level of sowing quality occurs when the variation coefficient is over 25%.

Germination of hybrids in field ranged from 85.40% (hybrids J and M) to 95.20% (hybrid C). Hybrids J and C belong to FAO 400 maturity group. Besides the hybrid C, hybrid A also had the largest number of seeds sprouted at set spacings, 97.06%, or 100% of spots which ranged between 0.5 and 1.5 of theoretical spacing. Half of the sown hybrids had more than 90% of spots with 0.5 to 1.5 of theoretical spacing, while the other half had less than 90%. The hybrid S from FAO 400 maturity group had the least sown seeds at spots which ranged from 0.5 to 1.5 of theoretical spacing, and it was 79.69%. D and J hybrids had the most missed seed spots, 11.29% with respect to other hybrids. These hybrids did not have most of the doubled seed spots because U and E hybrids had the same percentage of doubled

I: Sowing quality of corn seed hybrids

HYBRID	A	B	C	D	E	F	G	I	H	J	K	L	M	N	O	P	R	S	T	U
group	400	300	400	400	400	400	400	300	300	400	500	400	300	300	400	500	500	400	400	400
1*	0.00	1.59	0.00	3.23	6.45	0.00	6.15	1.61	0.00	4.92	1.49	0.00	1.64	2.99	1.54	3.17	0.00	9.38	3.08	6.45
2*	0.00	6.35	2.94	11.29	9.68	9.68	7.69	11.29	7.69	11.48	4.48	4.84	8.20	2.99	4.62	7.94	1.54	10.94	7.69	8.06
3*	100	92.06	97.06	85.48	83.87	90.32	86.15	87.10	92.31	83.61	94.03	95.16	90.16	94.03	93.85	88.89	98.46	79.69	89.23	85.48
4*	91.00	88.20	95.20	86.80	86.80	86.80	91.00	86.80	91.00	85.40	93.80	86.80	85.40	93.80	91.00	88.20	91.00	89.60	91.00	86.80
5*	0.2188	0.2237	0.2163	0.2366	0.2284	0.2348	0.2174	0.2356	0.2251	0.2334	0.2164	0.2302	0.2338	0.2152	0.2218	0.2254	0.2185	0.2202	0.2168	0.2292
6*	3.31	4.18	3.77	4.25	5.17	4.17	5.16	3.93	3.10	4.06	3.10	3.25	4.37	3.56	4.00	4.37	4.55	5.07	5.20	4.28
7*	15.13	18.68	17.43	17.97	22.64	17.76	23.75	16.66	13.78	17.38	14.31	14.12	18.69	16.54	18.03	19.37	20.81	23.05	23.97	18.67

1\* – Percentage of doubled seeds, (%); 2\* – Percentage of missed seed spots, (%); 3\* – spots within 0.5 to 1.5 of theoretical spacing (%); 4\* – Percentage of sprouted seeds, (%); 5\* – Actual spacing (m); 6\* – Standard deviation; 7\* – Coefficient of variation, %.

## II: Variance analysis nested design

Univariate Test of Significance for Y Over-parameterized model Type III decomposition; Std. Error of Estimate: 4.169561					
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	425382.3	1	425382.3	24468.01	0.000000
f	10.2	2	5.1	0.29	0.746584
h(f)	136.4	17	8.0	0.46	0.969289
Error	19853.9	1142	17.4		

\* Dependent variable is marked Y, FAO groups are marked *f* and independent variable, hybrids, are marked *h*.

spots, 6.45%. All hybrids had bigger spacing than the set one. The actual spacing ranged from 21.51 cm (K corn seed hybrid) to 23.66 cm for D hybrid, which was the hybrid with most missed seed spots. During sowing, 20% of hybrids had standard deviation of over 5%, more precisely 5.17 for hybrid E, and 5.16 for hybrid G, and 5.2 for hybrid T. This was the biggest standard deviation recorded. Hybrid K had the smallest spacing and the lowest standard deviation which was 3.1, the same as for hybrid H. The sowing quality for 25% of hybrids was acceptable because the variation coefficient ranged from 20.81% to 23.97%, which were the highest values. Hybrids G and T had the highest standard deviation, and they also had the highest coefficients of variation which were 23.75% and 23.97%, respectively. The best sowing quality was achieved with the hybrid H from FAO 300 maturity group because it had the lowest value of standard deviation, as well as the lowest coefficient of variation, 13.78%; out of total sown hybrids, 75% had coefficient of variation less than 20%. According to the sowing

quality, that is germination, this hybrid has the best possibilities to achieve high yield.

Statistical analysis of data was done by *StatSoft Statistica 12*. The spacing between the plants is dependent variable (Y), and independent variables are FAO maturity groups and hybrids. The experiment was set according to the nested design (Mason *et al.*, 2003). Statistical significance for all FAO maturity groups was analyzed (f) for different hybrids (h) where the hybrids were grouped according to FAO maturity groups h(f). F-tests were used to determine the existence of statistically significant differences between average values of coefficients of variation with respect to the analyzed factors, and Duncan's test was used for comparison of arithmetic means of treatment pairs.

In Tab. II, according to parameter p, there is no statistically significant difference between the hybrids of different FAO maturity groups. Since there is no statistically significant difference, Dunnett's test was not necessary.

## CONCLUSION

Pneumatic seed drill with overpressure INO Becker Aeromat 2 for wide row planting was used for sowing 20 corn seed hybrids from different FAO maturity groups. All hybrids were from FAO 300, FAO 400 and FAO 500 maturity groups and they were sown at 0.2 m distance. The sowing layer, sowing conditions and sowing procedure were adequate, that is, appropriate.

After sprouting, spacing between the sprout seeds was measured and following conclusions were made:

- half of the sown seeds had over 90% of spots with 0.5 to 1.5 of theoretical seed spacing, and the other half had less than 90%;
- all hybrids had bigger actual spacing in the row in comparison to the set spacing;
- K hybrid had the smallest actual spacing and the lowest standard deviation which was 3.1, same as for H hybrid;
- the best sowing quality was achieved with hybrid H from FAO 300 maturity group because, besides its lowest standard deviation, it also had the lowest variation coefficient which was 13.78%;
- out of total sown hybrid seeds, 75% had variation coefficient less than 20%.

Statistical analysis of data showed that there were no statistically significant differences between sowing hybrids from different FAO maturity groups and their characteristics. This implies that it is the biological characteristics of hybrids which have much more influence on the production of future yield and not the quality of sowing. This is true only if the tractor implement for wide row planting is properly adjusted, and its exploitation is within the framework of good agricultural practice.

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