THE EVALUATION QUALITY OF SOWING INDEPENDENCE WITH SELECTED PROPERTIES OF SEEDS

Pavol Findura[1], Miroslav Prístavka[2*], Maroš Korenko[3], Peter Bajus[4]

Abstract: *sowing quality means required vertical (depth) and horizontal (spatial) spacing of seeds in the soil with minimal damage to the seeds. The spatial distribution of seeds (horizontal spacing) is given by distance between the rows and spacing of the seeds in a row. The objective of the study was the evaluation and comparison of the sowing quality of sowing machine jd maxemerge xp with mechanical filling of ladle holes with holding fingers within usage of seeds with different dimensional and shape attributes in agricultural conditions. Sowing machine jd maxemerge xp reached good results for the quality especially when using the angular seeds. It reached the sowing quality expressed by the standard deviation of 46.95 - 50.76 % when seeds pr 37 n01 and for seeds pr 37 n01 it is 47.43 - 48.73 %. Another evaluative criterion is dual sowing of seeds or plants (drr), it was reached the average value 3.65 - 2.45 % for angular seeds and the average of 1.54 – 3.71 % for approximately spherical seeds.*

KEY WORDS: *SOWING QUALITY, ATTRIBUTES OF SEED, MAIZE,*

INTRODUCTION

Efficiency of mechanized crop harvest is affected by the state of plants condition as well as whole range of other biological and technical factors. Therefore, the base for achievement of a generous harvest is achievement of high germination and uniform emergence of growth. In a common practise, farmers use seeds produced by a different manufacturers. These seeds are often dimensionally erratic and that affect, among other factors such as quality of soil preparation, the quality of sowing significantly (Gorzelany, 2009).

The spatial distribution of seeds (horizontal spacing) is given by distance between the rows and spacing of the seeds in a row. The distance between rows is adjustable within a sowing machine according to seeding crops. Final seedling emergence and the rate of speed of emergence are influenced by bulk density and aggregate size of seedbed (Dimitrov et al., 2012).

Precision sowing has been a major thrust of agricultural engineering research for many years; however, most of the research and development work has dealt with seeders for agronomic crops (Karayel et al., 2004). It was also stated that a seeders should place a seed in an environment in which the seed will reliably germinate and emerge. A number of factors affect the spacing of plants. The seed selection mechanism may fail to select or drop a seed resulting in large spacing between seeds. The mechanism may select and drop multiple seeds resulting in small spacings between seeds. Seed quality, soil conditions, seeder design and the skill of the operator all play a part in determining the final plant stand. Various types of cleaning, grading, separation and sowing equipment are designed on the basis of the physical properties of seeds. However, no model has been found to describe seeder parameters such as vacuum pressure related with physical properties of seeds.

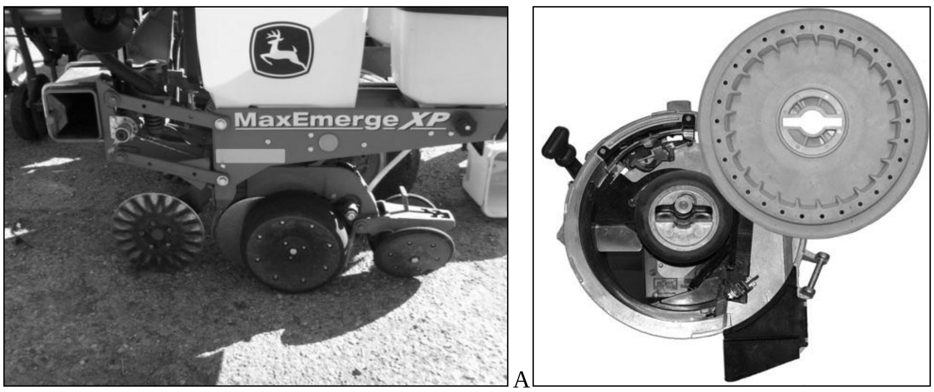
Later on Karayel and Özmerzi (2002) stated that the variability in seed spacing with precision vacuum seeders increased with increasing forward speed. They found that a forward speed of 1 m.s^{-1} consistently produced a better seed pattern than 1.5 and 2.0 m.s^{-1} for precision sowing of melon and cucumber seeds. Field tests showed that the nominal sowing depth of 60 mm was optimum according to sowing depth uniformity and emergence rate index.

In our case, we focused on sowing the maize (0.762 m). Since the distance between rows during sowing has not changed criterion for evaluation of accuracy of the horizontal spacing of seeds is the distance between seeds in a row (Findura et al., 2008). Seeds variability in the row is affected by soil preparation, physical attributes of seeds, parameters of sowing unit, working speed (Findura et al., 2008). According to (Páltik et al., 2002), following (a,b,c,d) technical parameters of the sowing-machine mostly affect the seeds' distance in row: a) fixing technique of the sowing unit on the frame of sowing machine (parallelogram); b) parameters of the sowing unit (shape of sowing foot, sowing speed within the seeds fall off sowing disc, etc.); c) type of sowing system; d) vertical acceleration of sowing unit and operating speed of the machine, etc (Streit et al., 1992).

The objective of the study was the evaluation and comparison of the sowing quality of sowing machine JD MaxEmerge XP (Fig.1) with mechanical filling of ladle holes with holding fingers within usage of seeds with different dimensional and shape attributes in agricultural conditions.

MATERIAL AND METHODS

Measurements were made on the farm Agrodivízia (Agro-division) Selice, Ltd. Process of soil cultivation produced the blackland soil type - mainly carbonated blackland, blackland "cernicka" and blackland's "arenicka". These soils are characterized as deep soils with deep humus horizon. They are clayey-sandy up to clayey soils with alternating graininess on the horizons of soil profile. Humus content in topsoil was determined at range 1.3 to 3 %. Soil reaction in topsoil was determined as pH 7.1 to 7.6. Soil samples were collected by soil measurement equipment NH-90 (Fig.2A). Measurement equipment was fixed on quadricycle Polaris 550 EFI X2. The samples were collected from soil depth 300 mm.



A B

Fig.1: A *- Sowing-machine JD MaxEmerge XP; B - Detail of sowing system*

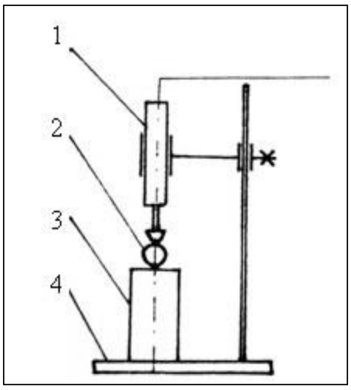


Fig.2: *Technique of measurement of grains dimensional characteristics: 1- induction sensor, 2- grain, 3- rest, 4- laboratory metal holder*

The sowing depth is also considered as one of the key factors. The best uniformity of sowing depth was obtained at the nominal sowing depth of 60 mm. For both seeders, either decreasing or increasing the nominal sowing depth from 60 mm resulted in a higher coefficient of variation for depth. The maximum emergence rate indices occurred when the nominal sowing depth was 40 and 60 mm, and the least mean emergence time was obtained at the nominal sowing depth of 40 mm. It can be concluded that the position of the seed in the soil effects mean emergence time and the emergence rate index of plants.

The sowing quality was evaluated within the sowing-machine JD MaxEmerge XP. This seeding machinery allows sowing of wide-rowed crops within the conventional as well as the soil conservation technologies. The sowing machine JD MaxEmerge XP operates on the principle of mechanical filling of ladle holes where seeds are drifted by holding fingers to the place of seeds falling. A variety of influences will affect the variability of seeds distances (later plants in the row) that will cause an inaccuracy of seeds placement to a larger or lower degree.

Apart from the impact of sowing system there will also operate other working parts of sowing unit within storage, covering and pushing the sow seeds into the sowing furrow. Unwanted seeds rolling and thus inaccuracy of seeds placement in the furrow also cause among the mentioned factors in introduction high of seeds falling (Table I).

Table I: *Selected technical data of tested sowing-machine*

Type of Sowing machine	JD MaxEmerge XP
High of seeds fallin,mm	505
Diameter od sowing disc, mm	370
Number of ladle elements	15
Fixing of sowing unit	paralleologram
Dept conduction of sowing foot	supporting wheel
Type of sowing foot	double disc

The procedures of shape and dimensional aspects of seeds, methodology of measurements and used devices in this study was obtained and adopted according to Findura at al. (2008). Shape and dimensional attributes of used seeds affect the reliable ladling of seeds and therefore also reaching symmetrical distances in the row. Device iM1610 and converter with amplifier were used for measuring the dimensional characteristics of grain. Our goal was to digitize the process of measurement. A/D converter MA-UNI with the amplifier and the measuring device with data-logger served as the base again. Sensor type W50 with high measurement accuracy (0.2 %), in this case, was used from the company HBM (Hottinger Baldwin Messtechnik). It is the sensor that works on the induction principle of measuring position. Data were automatically recorded into a data file individually in the order: depth, width and length after calibration of sensor and setting the programme NextView 2.5. This provides immediate digitization of information about the dimensional characteristics of the examined grains. It also caused a risk reduction of human failures within measuring for the reason of incorrect information reading (Fig.2).

Measurements were realized in according with the standard ISO 7256/1 in agricultural conditions where the average speed was 3.09 m.s^{-1}. Measured distances in the row b_{ri} within the evaluation of horizontal seeds placement are classified as following:

- Dual, where distance b_{ri} is
$0 \oslash b_{ri} < 0.5$ (EVR) – Number n_0 (1)
- Placement in desiderative distances
0.5 (EVR) $\oslash b_{ri} < 1.5$ (EVR) – Number n_1 (2)
- Singe omission
1.5 (EVR) $\oslash b_{ri} < 2.5$ (EVR) – Number $n_{2(}$3)
- Double omission
2.5 (EVR) $\oslash b_{ri} < 3.5$ (EVR) – Number n_3 (4)
- (k – 1) multiple omission
(k-1)(EVR) $\oslash b_{ri} <$ (k+0.5) (EVR) – Number n_k (5)

Where: EVR- is effective distance of plants that is determined by calculation of average value of measured distances $b_{ri.}$ Difference between the truly measured value b_{ri} and calculated effective distance of plants EVR are defined by standard deviation that formulates the variability of plant placement. Above methodology was adopted from mentioned standard and specification according to Páltik et al. (2002).

While study aim is focused on a) characterization of dimensional and shape attributes of seeds, and b) evaluation and comparison of sowing quality of sowing machine with mechanical principle of filling of ladle holes in agricultural conditions, a following seed hybrids was used. Seeds of maize from company Pioneer Hi-Breed Slovakia were used for measurements. It was hybrid PR 37N01. Average harvest of grain was 9.45 t.ha^{-1} during the test. Hybrid has a bountiful harvest in dry and also in wet years. It is designate for the production area of maize. It has a good resistance against the heat stress. Hybrid is able to keep an assimilative area in dry period longer. It grows on a green stalk which is one of the advantages in case of dry period or during the vermin's attack to plants. Quick initial phases of development and good tolerance to cold are reasons for predestination to early sowing. Seeds of big and medium fraction approximately with spherical and angular shape were used within experiments.

Statistical data processing was performed by the analytical software Statistica 10 (TIBCO Software Inc., USA). All of the observed parameters were sampled in min. 20 replication and LSD post-hoc tests were applied to compare mean values. Mean values are presented in the tables (Tab. II, Tab. III and Tab. IV) accompanied with specific standard deviations (in form ±s.d.). ANOVA test were applied to indicate contrast and statistical differences between tested variables and showed in tables as different letters (a,b,c). Specific parameters are presented in corresponding table legends below tables.

RESULTS AND DISCUSSION

Dimensional and shape attributes of used seeds

Table II shows the average values of length, width, depth and shape coefficients of used seeds are shown in table III. As it was observed that shape attributes have a significant effect on seeding quality and at the end it affects emergency and whole further growth of maize seeds. Shape attributes are defined by the shape coefficients $k_1 – k_4$, if the reciprocal values of coefficients are balanced then seeds will have more ideal spherical shape.

Table II: *Dimensional attributes of used seeds*

Variant (calibration)		PR 37 N01 LF (big angular)	PR 37N01 MF (medium angular)	PR 37 N01 LR (big spherical)	PR 37N01 MR (medium spherical)
Germinability %		99	98	99	99
Seeds dimensions, n=20	**lengt l**	^{a}10.98 ±0.12	^{a}10.75 ±0.11	^{b}10.11 ±0.25	^{c}8.89 ±0.14
	width s	^{a}8.78 ±0.09	^{c}7.87 ±0.12	^{a}8.84 ±0.08	^{b}8.01 ±0.11
	depth h	^{a}4.89 ±0.05	^{b}4.69 ±0.08	^{c}6.44 ±0.09	^{c}6.53 ±0.05

l, s, h - average length, width and depth of seeds; different letters (a,b,c) means significant difference; LSD test; α=0.05; s.d. – standard deviation; n=20

Orientation by pushing provides a fast, cheap, and robust way of quickly bringing seeds from a completely random orientation to a known orientation within narrow bounds that could be exploited in a planting mechanism. The results also highlighted that not all hybrids were equally well suited for seed orientation by pushing. Cuboidal or boxy kernel shapes behaved more predictively, rounder shapes exhibited more variability and weaker stable points, a property that could become more important once the unavoidable vibrations of a planter travelling down the field are considered in a seed oriented planting system.

Sowing quality evaluation of selected sowing-machines according to seeds placement

Therefore, precondition of success within this technology is among all others the usage of quality seeds that are placed in row into required depth and at required distance (Testa et al., 2016). The study was observed and concluded at the basis of the analysis of seeds falling trajectories, it was found that the variations of positive differential pressure (Δp) and release angle (θ) had significant effects on seeding uniformity. In order to analyse their effects on horizontal displacement, a coefficient of positive differential pressure variation (X_p) and coefficient of sowing angle variation (X_θ) were proposed and their values calculated (Zhang et al., 2016). In our study it was observed that regularity of the distances changes in dependence on surface roughness, technique of fixing the sowing unit and on working speed (Table IV).

Table III: *Shape attributes of used seeds*

Variant (calibration) mm ± s.d.		PR 37 N01 LF (big angular)	PR 37N01 MF (medium angular)	PR 37 N01 LR (big spherical)	PR 37N01 MR (medium spherical)
Weight of 1000 seeds, n=15 g ± s.d.		^{a}319.79 ±12.16	^{b}254.62 ±11.08	^{c}359.93 ±13.35	^{b}251.64 ±10.93
Shape coefficients, n=20	$k_1 = \frac{l+s}{2}/h$	^{a}2.04 ±0.01	^{a}2.00 ±0.02	^{b}1.49 ±0.2	^{c}1.31 ±0.1
	$k_2 = s/h$	^{a}1.81 ±0.02	^{b}1.69 ±0.01	^{c}1.39 ±0.02	^{d}1.24 ±0.03
	$k_3 = l/h$	^{a}2.26 ±0.03	^{a}2.31 ±0.02	^{b}1.58 ±0.02	^{c}1.38 ±0.03
	$k_4 = l/s$	*^{a}1.27 ±0.03*	^{b}1.39 ±0.02	^{c}1.16 ±0.02	^{c}1.12 ±0.02

k_1, k_2, k_3, k_4- shape coefficients of seeds; different letters (a,b,c) means significant difference; LSD test; α=0.05; s.d. – standard deviation; n=20-15, respectively

Standard deviation for sowing maize for distance in a row equal 200 mm should be at sowing system in the range of 18 to 30 mm depending on the operating speed, seeds and type of sowing unit (Páltik et al., 2002). The evaluative criterion of seeds, plants distance variability in the row was value of the standard deviation of measured distances in the row, a representation of the required and dual seeds placement and percentage representation of the omissions. As it was observed the satisfying quality of sowing maize is considered to be a value of standard deviation from 30 to 40 mm. It was also found out that as a result of these tests, a nominal sowing depth of 60 mm is considered optimum, according to uniformity of sowing depth and maximum emergence rate index (Özmerzi et al., 2002).

Tests on pneumatic and vacuum precise seeders were carried out to investigate the effects on sowing quality such as up to standard reseeding and miss-seeding etc. The experiment results indicated that the pneumatic seeder is more adaptable to the seed size and shape variation. It was observed that maize seed grading obviously affects the qualified index and reseeding index, but affects miss-seeding index and coefficient of variation little on condition that all the indexes reach the sowing quality requirements. Moreover, the qualified index of round seeds was 96%, which was higher than a flat seed with the qualified index was 87.4%. There was great distinction between them. The sowing quality of vacuum seeders was not so good whether the seed graded or not, and has not significant influence on the whole indexes of it. The experiment also shows that pneumatic seeders have better performance than the vacuum seeders (Liu et al., 2010).

Table IV: *Sowing quality parameters of monitored sowing system within different seeds attributes in agricultural conditions*

Machine	**Variant (calibration)**	**Running spped**	**PVR**	**EVR**	**s.d.**	**Placement of plants**				
						PRR	**DRR**	**JV**	**DV**	**TV**
		m.s^{-1}, ±s.d.	***mm***	***mm***	***mm***	**%**	**%**	**%**	**%**	**%**
JD Max Emerge XP	**JD Max Emerge XP PR 37 N01 LF (big angular)**	a3.12 ±0.68	*194*	*195.6*	*46.95*	83.12	3.65	10.12	4.11	1.54
	PR 37 N01 MF (medium angular)	*a3.18 ±0.49*	*194*	*191.1*	*50.76*	70.9	2.45	15.57	7.37	3.71
	PR 37 N01 LR (big spherical)	*a3.30 ±0.52*	*194*	*188*	*47.43*	74.33	0.75	17.73	4.9	2.29
	PR 37 N01 MR (medium spherical)	*a2.90 ±0.63*	*194*	*195.9*	*48.73*	77.15	2.24	14.23	3.74	2.64

Different letters (a,b,c) means significant difference; LSD test; α=0.05; PVR - required distance of plants, EVR - effective distance of plants, s.d. - standard deviation, PRR, DRR - required resp. dual placement of plants, JV, DV, TV - single, double, triple omissions

The value of standard deviation is in the rage from 46.95 to 50.76 mm for angular seeds within sowing machine JD MaxEmerge XP. Required seeds resp. plants placement with an average of 83.12 % for angular seeds and 74.33 % for spherical seeds results in better quality of sowing the angular shaped seeds (Table 4). Another evaluative criterion was dual sowing of seeds resp. plants (DRR), where the angular seeds achieved an average of 3.65 % and seeds with approximately spherical shape of 2.24 %. A similar trend was also reached for single omission resp. non-ladle of seeds, sowing with angular seeds reached 3.67 % and spherical seeds 17.73 %.

Özmerzi et al. (2002) emphasises that he importance of operating at the optimum depth has been shown by a number of researchers where sowing too shallow or too deep results in crop performance and yield losses. The speed of drill machinery on seeds distribution within rows was also studied by Ivančan et al. (2004). It was stated that uniformity of seed size and shape has a considerable effect upon the drill precision, notably on the performance of drills with a mechanical drilling unit. The drill operating speed has a decisive influence on the quality and efficiency of the seeding process. Attempts are therefore made to increase maximally the operating speed and still achieve satisfactory sowing quality. The range of optimal speeds should be defined for each crop separately. It was concluded that an increase of operating speed leads to changes of the values of the drill performance indicators. Thus, an increase in operating speed results in a decrease of drilling precision because the intra-row seed spacing becomes larger than that required. The set seed spacing increased from 7.5 to 8.3 cm in parallel with increasing the drilling speed by 1.8 to 5.2 km.h^{-1}, respectively. The best intra-row distribution of parsley seeds was recorded at the speed of 1.8 km.h^{-1} (Ivančan et al., 2004).

In addition stated that high-quality seeds can increase the germination rate. Directional seeding can make corn blades grow regularly and enhance ventilation and light energy utilization in the field.

CONCLUSION

Sowing machine JD MaxEmerge XP is able to sow all tested seeds in the required quality; b) Sowing machine JD MaxEmerge XP reached good results for the quality especially when using the angular seeds. It reached the sowing quality expressed by the standard deviation of 46.95 - 50.76 % when seeds PR 37 N01 and for seeds PR 37 N01 it is 47.43 - 48.73 %. According to the results of the field measurements for evaluation of mechanical sowing machine JD MaxEmerge XP in terms of sowing quality with usage of seeds with different dimensional and shape attributes we can express (a,b) following statement: a) Dimensional characteristics of seeds correspond to calibration which is prescribed by the manufacturer. Another evaluative criterion is dual sowing of seeds or plants (DRR), it was reached the average value 3.65 - 2.45 % for angular seeds and the average of 1.54 – 3.71 % for approximately spherical seeds.

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Contact

[1]Department of Machines and Production Biosystems, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, pavol.findura@uniag.sk

[2]Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, miroslav.pristavka@uniag.sk *(correspondence),

[3]Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, maros.korenko@uniag.sk

[4]Department of Machines and Production Biosystems, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, xbajus@is.uniag.sk