Evaluation of chosen indicators of intermittent seeder´s work quality

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Abstract: *As crop and animal production are interconnected, they together form the basic branch of agriculture. A great sense in the process of replacing cultivated crops is the cultivation of sugar beet, which can act as a breaker in planting of narrow row crops, livestock feed or green manure. In addition to seed development, cultivation technology has also been improved, and by that the technique has been modified. During cultivation, it is difficult to prepare the soil before sowing together with a good settlement of seeds in the soil, which creates suitable conditions for germination and subsequent emergence of plants. In the submitted article, we have focused on the evaluation of chosen indicators of intermittent speeder's work quality. The measurements have been performed in accordance with the ISO 7256/1 standard for the evaluation of sowing equipment with intermittent sowing. The vertical distribution of the seed in the soil for field emergence at the seed base of the seeder Kverneland Accord Monopill S, at different working speeds, has been observed. The experiment was performed on aluminous-sandy soil with a soil moisture of 18.2%. In measuring the sowing depth, there were used two measuring systems, the so-called contact (inductive) sensor and non-contact (ultrasonic) sensor in connection with A / D converter with storage in IM memory card. Based on the obtained results, we can state that by increasing the travel speed from 1.11 m.s^{-1} to 3.33 m.s^{-1}, the depth of the sowing foot was reduced on average by 19.61 mm.*

Key words: *SEEDING, WORKING SPEED, ISO STANDARD*

1. Introduction

Sowing represents an important work operation, where for its correct execution, correct setting of the seeder and the control of its operation, it is crucial the technical discipline of operation. The quality of the sowing is than given by the required surface (horizontal) and deep vertical placement of the seed in the soil with minimal damage (Findura & Košičiarová, 2020).

The vertical distribution of seeds is given by its deep placement, the so-called sowing depth. According to the Slovak standard (STN) 46 54 51, the term sowing depth means the distance from the lower edge of the seed to the soil surface above the seed after it has been deposited in the soil. In sowing beets, that definition needs to be clarified. It is true that the sowing depth (h) is given not only by the depth of seed placement in the soil (which is the distance between the lower edge of the seed and the original soil surface), but also by the height of soil loading above the seed. The depth of the seed coulter can vary depending on the soil conditions (Turan et al., 2019). Soil compaction caused by frequent passes of the technique, especially in the spring, has a secondary effect on the resistance of the soil to the deepening of the seed coulter (Findura et al, 2018). A certain solution is the use of soil bio stimulation, which improves the physical and mechanical properties of the soil, i.e. higher porosity, soil structure, better infiltration and consequently lower tensile resistance in tillage (Kocira et al, 2018).

The main factor in choosing the optimal depth is the contact of the seed with the water-conducting layer of the soil (Kretschmar, 1983; Brunotte, 1986; Kästner, 1992).

The aim of the paper is to evaluate the vertical distribution of seeds in chosen seed bases forming a row seed at different working speeds and also to evaluate the conditions under which experimental measurements were performed in accordance with ISO 7256/2 at a chosen seed KVERNELAND Monopill S. The paper was solved within the project VEGA 0102/21 Reducing chemical loads and degradation of agricultural and forestry soils by selecting appropriate agri-technology with regard to climate change.

2. Material and methods

For the methodology of the work, we have used the laboratory technology which is a part of the measurement technology of the Department of Machines and Production Biosystems of the Faculty of Engineering SUA in Nitra. We could divide this methodological part into laboratory measurements and field experiments.

Within the laboratory measurements, we have:

- monitored the properties of the used seeds,
- analysed the soil samples taken in the experimental field.

Within the field measurements, we have:

- monitored the soil condition, this is characterized by several indicators such as soil type, soil structure, soil specific gravity, soil bulk density, soil porosity, soil moisture and penetrometric soil resistance.

In evaluation of soil properties, we have started from the ISO 7256/1 standard for testing the seed drills for precision sowing resp. seeders with intermittent sowing in field conditions and we have used the usual methods of determining the soil properties using Kopecký rollers with sampling after loosening and rows after sowing at depths of 0-30 (15), 30-60 (45), 60-90 (75) with three repetitions.

The structure of the soil as a grouping of individual soil particles and aggregates was monitored by taking samples from a depth of 0-30 mm and processing them by a standard sieve method with gradation of soil fractions from <0.125 mm; 0.125 - 0.063 etc. up to 8 - 16 mm; 16 - 32 mm and over 32 mm after the pre-sowing loosening of the soil.

Figure 1 Apparatus for measuring the soil penetrometric resistance

Description and technology of the machine´s work

The seeder is made as a mounted machine, as the entire weight of the machine during transport rests on the tractor's hydraulic arms. The basic parts of the machine are a frame with a three-point attachment, seeding units, support and drive wheels, gears, markers and accessories.

When the seeder moves, the individual sowing units connected to the frame by means of a parallelogram are adjusted in height to the unevenness of the soil surface. The front depth wheel evens out the soil surface. The seeds are pushed through a narrow middle wheel and covered with soil wrappers. The rear push wheel closes the sowing process.

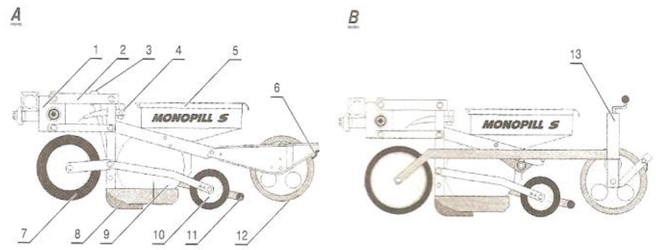

*Figure 2 The sowing unit of Monopill S seeder: **A** - with front depth wheel, 1 - mounting the seeding unit on the frame, 2 - parallelogram, 3 - sowing depth adjustment, 4 - lifting device, 5 - hopper, 6 - squeegee, 7 - front wheel, 8 - heel, 9 - sowing device, 10 - middle push wheel, 11 - wrapper, 12 - rear push wheel; **B** - with tandem wheel arrangement, 13 - sowing depth adjustment*

Depending on the accessories, precise sowing of the seed can be combined with the application of granular pesticides or with belt spraying. The machine is designed for sowing within the conventional technology with pre-sowing soil preparation, but after the adjustment of the sowing feet it is also able to sow into mulch. In the "S" version it is a mechanical version with mechanical gears, and in the "SE" version it is a version with electric drive of sowing units.

Table 1 *Technical parameters of the tested seeder Monopill S*

number of rows		curb weight in kg		sowin g depth	optimum working speed	optimum working speed in sowing into mulch	seed spacing in a row	required power of the tractor engine
P - fixed frame	S- folding frame	P- fixes frame	S- folding frame	mm	km/h	km/h	v mm	v kW
6, 12, 18	12, 18	400 (6)	2 180 (18S)	0 - 65	5 - 7,5	5 - 5,5	118 - 278	35 - 120

Methodology for measuring the depth of the seedbed in the soil

Soil is an important natural and economic resource in agriculture (Rovný et al., 2017). It is a crucial natural resource in Slovakia with commodity and non-commodity potential for economic and eco-social development of our society. It defines the territory – it is the principle of statehood, mostly in private ownership and is important for all inhabitants of the state (Findura & košičiarová, 2020). While in the past, soil was considered to be the basic means of production in agriculture, nowadays it is rather understood as a crucial component of the environment, which conditions the agricultural development (Bujnovský et al., 2009).

The quality of seed storage in the soil is given by its vertical distribution, which is the depth and uniformity respectively the variability of its horizontal distribution in the sown rows. We have monitored the seeder at four working speeds of 8, 10, 12, 14 km. h^{-1} and three repetitions (Figure 3). We have performed the measurements in accordance with the ISO 7256/1 standard for the evaluation of sowing equipment with intermittent sowing.

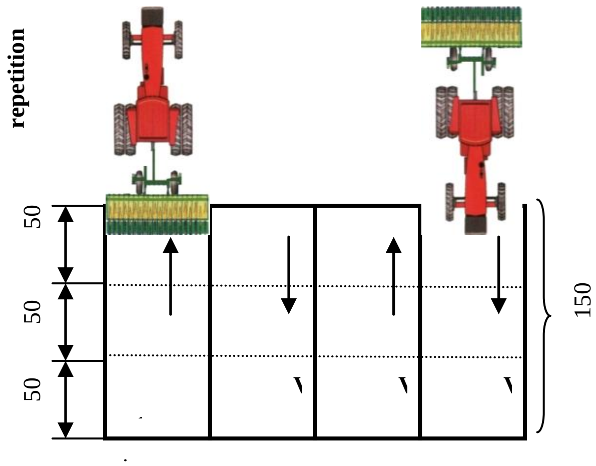

Figure 3 Display of the movement of seeder along defined measuring sections

The term sowing depth in the sense of standard STN 46 5451 means the distance from the lower edge of the seed to the soil surface above the seed after its deposition in the soil. We have used two measurement systems, the so-called contact (inductive) sensor and non-contact (ultrasonic, optical) sensor in connection with A / D converter with storage in IM memory card. The aim was to design a measuring device that allows mounting on various sowing units of monitored seeders. The sowing depth measurement was performed by the continuous measuring of the distance between the seed coulter position and the soil surface.

3. Results and discussion

Results of soil properties

The measurements were performed in temperate conditions in the region of western Slovakia in the district of Nitra on the plots of the university farm VPP Oponice. The experiment was performed on aluminous-sandy soil. The standard for sowing quality evaluation shows to characterize the conditions under which the experiment was performed. Soil is an important indicator and therefore we have evaluated its condition.

From these properties we have monitored the soil type, soil structure, soil bulk density at depths of 0-105 mm, soil penetrometric resistance at depths of 0-200 mm and soil surface balance, etc.

All measurements were performed on aluminous-sandy soil with a percentage of grains smaller than 0.01 mm in the range of 22-33%.

As part of the measurement, we have compared two variants on the soil. Variant A, which is the soil unaffected by the passage of equipment and variant B, where the soil is affected by the wheel of the tractor.

Based on the obtained results, we can state that by increasing the depth of moisture measurement, the humidity has gradually increased. Even for the variant affected by the wheel of the tractor (variant B), a higher average humidity was measured, which can be caused by the rising of water into the soil.

Table2 *Results of evaluation the soil properties*

Plot I mm (ø)	Mass moisture of the soil, %		Porosity, %		Specific weight of soil, t.m-3	
	A	B	A	B	A	B
0-30 (15)	18,04	18,47	58,33	54,33	2,628	2,643
15-45 (30)	19,99	21,31	55,34	50,01	2,638	2,627
30-60 (45)	21,03	22,06	51,48	49,01	2,643	2,637
45-75 (60)	22,35	26,20	50,21	47,96	2,645	2,680
60-90 (75)	23,41	24,18	48,73	46,54	2,653	2,680
75-105 (90)	24,30	24,57	46,87	43,49	2,628	2,663

Another evaluation criterion of soil condition was the measurement of soil porosity. There was a positive trend of higher porosity with a higher content of capillary and non-capillary pores. This has a positive effect on soil infiltration, especially in irregular excessive precipitation. All results listed in Table 2 were evaluated in the laboratory and were collected at predetermined sampling points.

From the Figure 4, it can be seen the compaction of the soil in the individual soil horizons. At the depth of 30-50 mm, there can be seen the effect of soil compaction by the push system of the seeder, which has to support the soil uptake. At the same time, there can be seen the subsequent decrease of the penetrometric resistance, which can be observed up to the place of compacted so-called "dead soil" located below the depth of tillage.

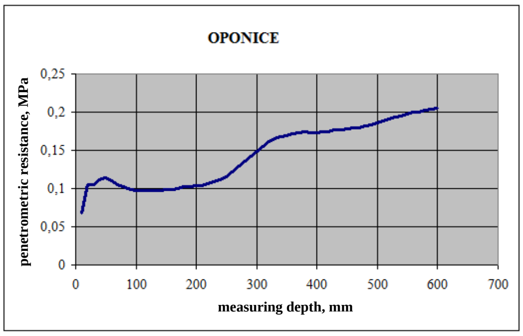

Figure 4 Process of soil penetrometric resistance

Results of dimensional and shape properties of used seeds

Since the 1990s, genetically single-germinal sugar beet seeds have been supplied to the Slovak market (Horská et al., 2010). We require an approximately spherical to lenticular shape. The individual dimensions of the seeds affect the quality of the sowing, depending on the choice of a suitable sowing device.

Table 3 Properties of used seeds

Seed (calibratio)	Germination	Seed dimensions			Shape coefficients				Weight of 1000 seeds
		Length $\bar{d}$	Width $\bar{s}$	Thickness $\bar{h}$	$k_1 = \frac{\frac{l+s}{2}}{h}$	$k_2 = \frac{s}{h}$	$k_3 = \frac{l}{h}$	$k_4 = \frac{l}{s}$	
mm	%	mm	mm	mm	-	-	-	-	g
Continental (3,5-4,75)	98	3,92	3,71	3,56	1,072	1,042	1,101	1,057	28,60

$\bar{d}, \bar{s}, \bar{h}$ - average length, width and thickness of seeds, k_1, k_2, k_3, k_4 - shape coefficients of seeds

We have expressed the shape properties using the shape coefficients k_1-k_4, the more balanced the mutual values of the coefficients, the more ideal (round) shape the seed will have. Table 3 shows the average values of length, thickness, width and shape coefficients of the seed used for both seeders.

Based on the measured results, we can state that Continental seed was used for the experiment, in the germination test in the laboratory we have achieved 98% germination. Regarding the values of the average length, we have achieved an average value of 3.92 mm, an average width of 3.71 mm and the smallest dimension thickness of 3.56 mm.

The shape coefficient tells us how the shape of the seed approaches the ideal spherical shape. Its determination is based on the basic dimensions, namely length, width and thickness. Based on these coefficients, we can state that there are minimal differences between the shape coefficients and the largest difference is between the coefficient k_2 and k_3.

Results of the evaluation of sowing depth

In the evaluation of the the seedbed depth, for the credibility of the results, there were used two systems. The non-contact system was secured by means of an ultrasonic sensor and a contact system, which was connected to the frame of the seeder by means of a reptile, where each change in the recess was manifested by a change in induction when the core was inserted into the inductive sensor housing.

The task of sowing is to ensure the area and depth distribution of seeds in the soil so as there will be created the most favorable conditions for germination, emergence, development and harvesting of beets. The parameters that affect the distribution of seeds in the soil are mainly the properties of the soil, the parameters of the seeder and its working speed.

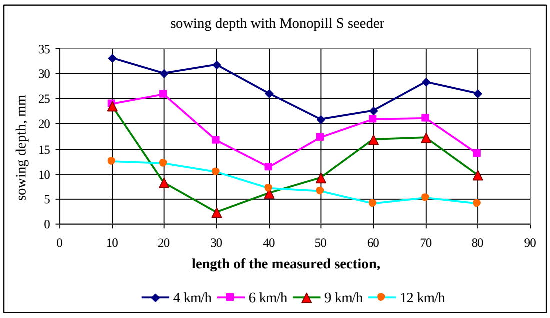

Figure 5 Sequence change of the seed coulter depending on the travel speed

Table 4 Statistical indicators for the evaluation of sowing depth

	1,11m/s	1,6 m/s	2,5 m/s	3,3 m/s
Average	27,33	18,85	11,66	7,69
Mistake of the Mean value	1,51	1,76	2,46	1,21
Median	27,22	19,01	9,48	6,79
Standard deviation	4,27	4,98	6,96	3,43
Selection variance	18,20	24,81	48,47	11,77
Spiky	-1,05	-0,97	-0,44	-1,70
Sloppiness	-0,23	-0,13	0,54	0,43
Difference max - min	12,14	14,57	21,23	8,40
Minimum	20,86	11,23	2,35	4,07
Maximum	33,00	25,80	23,58	12,47
Sum	218,63	150,79	93,28	61,50
Largest (1)	33,00	25,80	23,58	12,47
Smallest (1)	20,86	11,23	2,35	4,07
Reliability level (95.0%)	3,57	4,16	5,82	2,87

Based on the measured and evaluated results, we can state that the working speed of the seeder has a significant effect on maintaining the depth of sowing. The set sowing depth was 30 mm, which is the ideal sowing depth for the given humidity conditions. At a speed of 1.11 $m.s^{-1}$, the deviation was minimal, with increasing working speed, the sowing depth gradually decreased. Such non-compliance with the sowing depth may, in the case of adverse climatic conditions, affect the germination and emergence of the plants. The largest deviation from the set sowing depth was recorded at a speed of 1.11 $m.s^{-1}$, only 7.69 mm.

4. Conclusion

Farmers often attribute the failures in sugar beet cultivation to unfavourable climatic conditions, or low-quality seed, but the true is, that the technical parameters of the seeder can be also perceived as a significant factor. They affect both, the horizontal distribution of the seed and its vertical placement to the required depth. We tried to prove the above mentioned with our own measurements in the given field. Based on the obtained results, we can state that:

- All measurements were performed on aluminous-sandy soil with a percentage of grains smaller than 0.01 mm in the range of 22-33%.
- Another evaluation criterion of soil condition was the measurement of soil porosity. There was a positive trend of higher porosity with a higher content of capillary and non-capillary pores. This has a positive effect on soil infiltration, especially in irregular excessive precipitation.
- In the depth of 30-50 mm, the effect of soil compaction can be seen with the push system of the seeder, which is intended to support the soil uptake. At the same time, we can see that subsequently the penetrometric resistance decreases to the place of compacted so-called "dead soil" located below the depth of tillage.
- Based on the measured results, we can state that in the case of Continental seed, which was used for our experiment, in the germination test (in the laboratory)

there was achieved 98% germination. Regarding the values of the average length, we have achieved an average value of 3.92 mm, an average width of 3.71 mm and the smallest dimension thickness of 3.56 mm.

- At the speed of 1.11 m.s^{-1}, the deviation was minimal, with increasing working speed, the sowing depth gradually decreased. Such non-compliance with the sowing depth may, in the case of adverse climatic conditions, affect the germination and emergence of the plants. The largest deviation from the set sowing depth was recorded at a speed of 1.11 m.s^{-1}, only 7.69 mm.

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