Quality of the seed placing in seeding of sugar beet

J. Páltik, L. Nozdrovický, P. Findura, J. Maga

Slovak Agricultural University in Nitra, Nitra, Slovak Republic

ABSTRACT: Evaluation of the quality of the sugar beet seeding in field condition is considered. Field experiments were conducted with the set of single seed drills (precision drills) in accordance with the international standard ISO 7256/1. The variability of plant spacing in the row and seeding depth were evaluated. The attention has been payed also to the soil condition and to properties of seeding material, which has been used. For the measuring of seeding depth the inductive and ultrasound sensor were used. According to the results obtained significant differences were observed among the precision drills, which were involved in field experiments. The variability of emerged plants was evaluated by standard deviation (δ) and best results were reached with precision drill Monopill S (δ = 17.8 mm) and the worst results precision drill Magicsem 4000 (δ = 44.0 mm). In general, precision drills with internal filling of gathering openings (Monopill S, Meca 2000 and others) allowed to obtain higher work quality when machine was moved at optimal forward speed and not at minimal forward speed. As far as seeding depth variability concerns, all tested precision drills caused the decreasing of the seeding depth by 10–15%, when increased forward speed was used. For all tested precision drills the lowest seeding depth variability was observed at the forward speed of 1.65–1.73 m/s (standard deviation δ = 5.08–7.69 mm).

Keywords: sugar beet; seeding; precision drills; plant spacing; seeding depth

The main aim of the seeding is to provide placing of the seeds in horizontal and vertical level in a way which allows to create optimal conditions for the germination, growth, inter-row cultivation and harvest of the crop.

The quality of the seed placing in the soil profile is considered in relation to the seedbed preparation, type of precision drills and drill forward speed.

REVIEW OF LITERATURE

Modern sugar beet growing systems with planting of the seeds on the final spacing (160–240 mm) require the lower variability of the plants in the row. The distance between two successive plants expressed by standard deviation is about 15–45 mm. The values of standard deviation up to 20 mm are considered as excellent, the values up to 30 mm belong to the group of satisfactory results and values over 30 mm are not satisfactory (Wilhem 1993; Schrödl 1997, 1998; Minx 1993; Páltik et al. 2000).

Placing of the seeds in the soil profile (depth of seeding) depends upon the soil and climatic conditions, seedbed preparation and type of precision drills. According to the recommendation of the literature the depth of 20–35 mm is considered as optimal (Brunotte 1986; Kästner, Jahns 1992; Collective 2000). In accordance with standard CSN (STN) 46 5451 the seeding depth is the distance from lower edge of the seed to the soil surface above the seed.

Without regard to the fact, that the depth of seeding affects the germination and seed emergency, the results published and concerning the field emergency changes due to the unevenness of the seeding depth and forward speed are differing widely (Isensee 1992; Páltik 1992; Streit, Papesh 1995; Schrödl 1998 et al.). The required seeding depth the on depends type of soil and on the water content. In light and dry soils the seeds should be placed deeper, while on heavy soil with higher water content the seeding depth should be less deep. Such information can be considered as a driving knowledge within precision agriculture when seed spacing and seeding depth are controlled on the basis of soil condition variability and yield variability maps (Rybka, Šťastný 1998 et al.).

Provided experiments are connected with Project VEGA No. 1/0587/03.

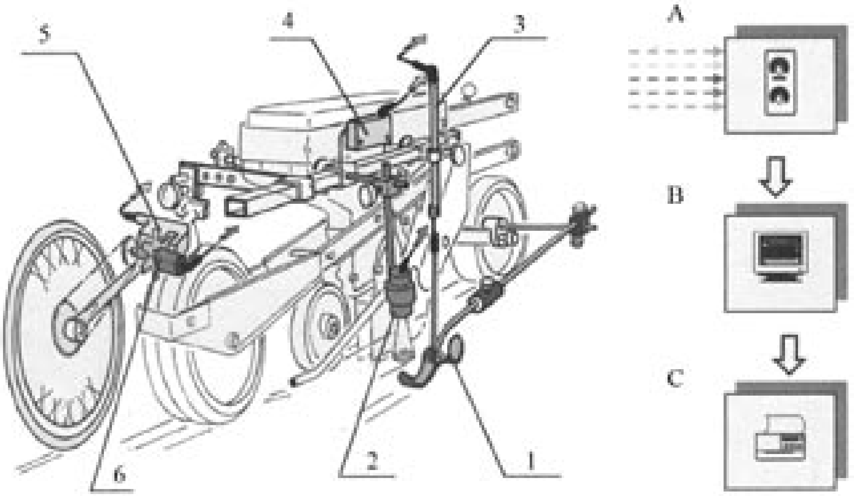

Fig. 1. Measurement of sugar beet seeding depth with inductive and ultrasound sensor: 1 – seeding shoe, 2 – ultrasound sensor, 3 – inductive sensor, 4 – sensor of the acceleration, 5 – sensor of the pulses, 6 – tachodynamo

MATERIAL AND METHODS

In order to evaluate the quality of seeding of the sugar beet in field conditions we have followed the standard ISO 7256/1. In the cropping system the conventional soil tillage practice was used. The attention was paid to following characteristics:

– soil conditions before seeding,
– size and shape parameters of the seeded seed,
– plant spacing variability in the row,
– seeding depth variability.

The following soil characteristics were considered: type of the soil, soil structure, specific soil weight, soil bulk density, porosity, soil water content, uniformity of the soil surface level and soil penetrometric resistance.

The properties of used seed were evaluated by its length, width, thickness and by calculation of shape coefficient.

Variability of plants spacings was evaluated by the number of multiples, number of correct plant spacings and number of misses. The accuracy of plant spacing was also evaluated by values of standard deviation of measured distances from the so called effective plant spacing (ISO 7256/1).

For the measuring of seeding depth variability, a measuring device was developed. The experimental equipment allows to mount two different seeding units (Fig. 1). Penetrating of the drill shoe to the soil was measured by contact (inductive) transducer and contactless (ultrasound) transducer. Both of them were connected with A/D

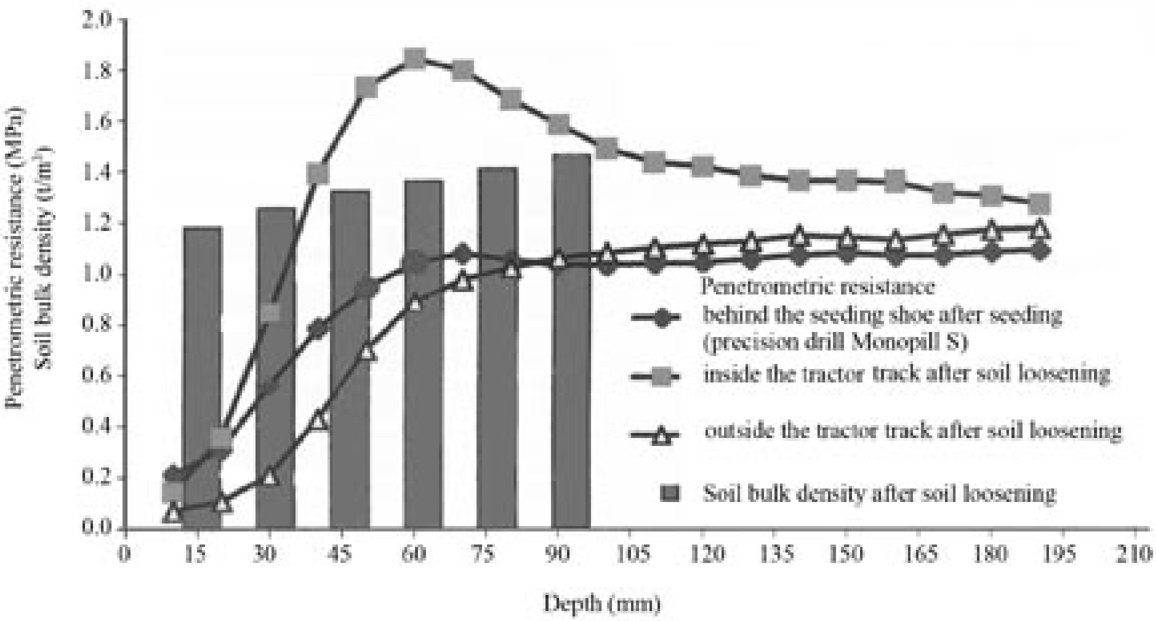

Fig. 2. Soil bulk density and soil penetrometric resistance in soil profile after seedbed preparation

Table 1. Required and measured distribution of sugar beet seeds in size groups (seed calibration 3.5–4.75 mm)

Parameter	Unit	Size distribution of sugar beet seeds in size groups (mm)						
		3.5–4.75	< 3.5	3.25–3.49	< 3.25	> 4.75	4.75–4.99	> 4.99
Required size limit*	%	min. 88	6.0	4.5	1.5	6	4.5	1.5
Measured value	%	96.5	3.5	3.5	0	0	0	0

*Required values of distribution in size groups

converter and the data obtained were stored in IM memory card.

RESULTS AND DISCUSSION

Characteristics of the soil conditions before seeding

In order to evaluate the quality of seeding after seedbed preparation in field conditions (done by Saturn 6), it is necessary to characterise soil properties (ISO 7256/1). Field experiments were conducted on loamy – sandy loamy soil where 30% of soil aggregates were less than 0.01 mm.

Structure of the surface soil layer (0–30 mm) matched the requirements of seedbed preparation. If the weight share of soil aggregates with the diameter at up to 10 mm is required to be minimum 50% (measured value 77%) and up to 40 mm at minimum 90% (measured value 100%), it is possible to state that seedbed preparation was provided in a correct way.

In order to identify the depth of seeding, the information about soil bulk density and soil specific weight should be known, especially in the depth

Table 2. Horizontal plant spacing in the row

Machine	Seed calibration (mm)	Forward speed (m/s)	Required (adjusted) plant spacing (mm)	Effective plant spacing (EPS) x_1 (mm)	Standard deviation of the plant spacing (δ) x_2 (mm)	Double multiples x_3 (%)	Single misses x_4 (%)	Double misses (%)	More than double misses (%)
Becker SE 4-049	3.5–4.75	0.88	190	189.1	30.6	1.0	13.4	2.9	0.9
		1.26	190	190.6	35.3	0.9	17.5	3.1	1.2
		1.73	190	190.8	39.4	2.1	12.4	2.4	0.1
		2.06	190	188.7	43.2	2.9	15.4	3.1	0.4
		2.68	190	188.6	49.8	3.6	15.9	1.2	0.5
		Average	190	189.6	39.7	2.1	14.9	2.5	0.6
Magicsem 4000	3.5–4.75	0.81	191	185.7	40.5	5.2	20.5	8.5	8.8
		1.33	191	188.1	39.0	3.1	23.9	8.6	6.8
		1.94	191	187.1	43.9	3.0	25.1	11.2	7.6
		2.51	191	191.0	44.0	5.6	23.7	9.0	6.4
		Average	191	188.0	41.9	4.2	23.3	9.3	7.4
Monopill S	3.5–4.75	0.68	177	178.3	22.8	0.8	16.3	5.9	1.0
		1.07	177	178.1	20.5	0.8	15.9	5.3	1.2
		7.71	177	178.2	20.3	0.9	15.3	3.9	3.1
		1.99	177	179.2	17.8	0.8	16.2	3.4	1.7
		2.43	177	179.2	20.3	0.9	19.5	3.7	2.0
		Average	177	178.6	20.3	0.8	16.6	4.4	1.8

x_1 – effective plant spacing (EPS) is the average plant spacing when multiples and misses are not considered
x_2 – statistic parameter characterising variability of the plant spacing around the value of effective plant spacing (ISO 7256/1)
x_3 – doubles, when plant spacing is less than 0.5 EPS
x_4 – single misses, when plant spacing is bigger than 1.5 and less than 2.5 EPS, etc.

effecting the creation of the seedbed (Fig. 2). The values of soil penetrometric resistance are given, too. Unevenness of the soil surface level before seeding in direction perpendicular to the seeding was expressed by standard deviation (5.5–9.4 mm) a variation coefficient (71.6–82%). The distance between measuring points perpendicular to the seeding was 100 mm.

Size and shape characteristics of the sugar beet seeds

Type of seeding mechanism used for seeding determines the requirements on size and shape characteristics of the sugar beet coated seeds. Even if at the moment there are no standards, there exists an agreement which specifies size and shape characteristics of the industrially manufactured sugar beet seeds. Table 1 gives required and measured values of the sugar beet seeds used in field experiments.

The seed which was used in field experiments matched given requirements and the following results were obtained: average seed length $\bar{l}$ = 4.21 mm, average seed width $\bar{s}$ = 3.83 mm and average seed thickness $\bar{h}$ = 3.61 mm when the weight of 1,000 seeds was 26.4 g. Shape coefficient (relation of the seed width to seed thickness) was 1.1.

Variability of the plants spacing in the row

For the generally used row spacing (450 mm) the quality of horizontal plants spacing will be determined by variability of plants spacing in the row. Our goal was to compare 5 different single seed drills (precision drills) Meca 2000 (Monosem), Monopill S (Kverneland-Accord), Planter II (Kuhn-Nodet), Becker SE 4-049 (Agrometal Cífer) and Magicsem 4000 (Matermacc). Two of the mentioned precision drills are based on principle of mechanical gathering of the seeds (Meca, Monopill), two precision drills are based on vacuum principle (Planter, Magicsem) and last one (Becker) is based on air pressure principle.

The results given here will be related to following precision drills:

– precision drill Becker as the most common precision drill,
– precision drill Monopill S with internal mechanical gathering of the seeds,
– precision drill Magicsem with vacuum seeding system (Table 2).

As far as plant variability concerns (evaluated on average by the standard deviation $\bar{\delta}$) the best results were recorded with precision drill Monopill S ($\bar{\delta}$ = 20.3 mm) followed by the precision drills Meca 2000, Planter II, Becker SE4-049, Magicsem ($\bar{\delta}$ = 41.9 mm). Significant differences of plant spacing variability can be explained by:

– different values of seed falling height (h), for example precision drill Monopill S (h = 32 mm), precision drill Magicsem 4000 (h = 413 mm),
– differences between machine forward speed ($\bar{v}_p$) and horizontal component of peripheral speed of the seed released from seeding disk ($\bar{v}_{ox}$), i.e. $\bar{v} = \bar{v}_p - \bar{v}_{ox}$, (if $\bar{v} \approx 0$ so vertical fall occurs without consecutive rolling of the seed after reaching the furrow).

When the forward speed was increased the precision drills with the pneumatic seed gathering

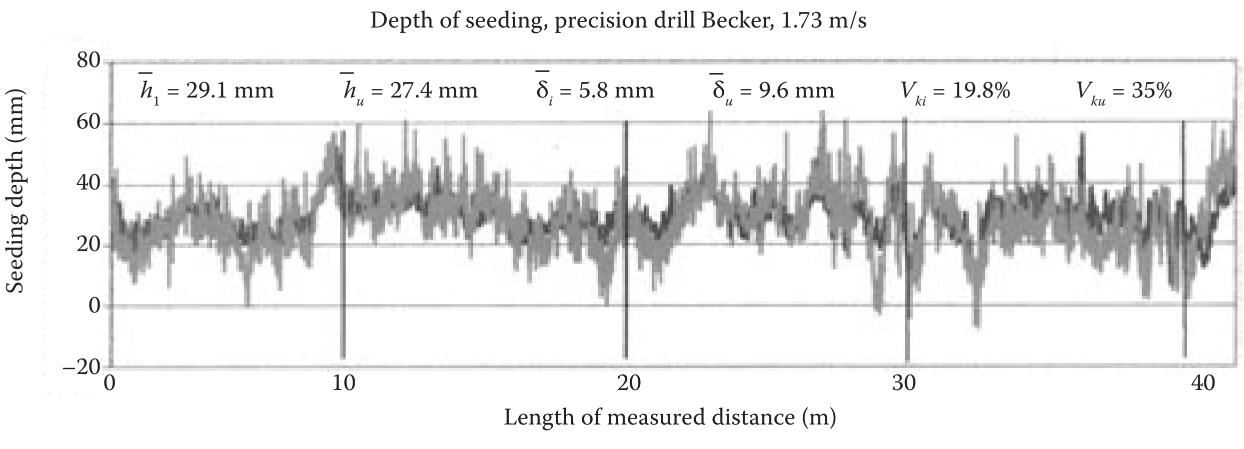

Fig. 3. Record of the changes of seeding depth values when precision drill Becker SE 4-049 have been used at the forward speed 1.73 m/s

i – inductive sensor, u – ultrasound sensor

$\bar{h}_i$, $\bar{h}_u$ – average value of the seeding depth, $\bar{\delta}_i$, $\bar{\delta}_u$ – average value of the standard deviation, V_{ki}, V_{ku} – variation coefficient

(Becker, Magicsem, Planter) responded by higher plant spacing variability. On the other side, precision drills with mechanical gathering of the seeds (Monopill S, Meca 2000) have reached higher quality of plant distribution not at the minimal, but at the optimal forward speed 2 m/s, what corresponds with SCHRÖDL (1997) and ANONYMUS (1999).

Seeding depth variability

Measuring of the seeding depth was provided on three precision drills. Type of the soil and sort of the seed were characterised in accordance to standard ISO 7256/1. After the foregoing calibration of the measuring device, seeding depth was continuously measured by inductive sensor and ultrasound sensor (Fig. 1). As an example, the record of seeding depth measurement is given for precision drill Becker SE 4-049 at the forward speed 1.73 m/s when both sensors have been used (Fig. 3).

For the evaluation of quality of seed placing in the depth of soil profile, the following statistic characteristics have been used:

- average value of the seeding depth ($\overline{h}_{si}$, $\overline{h}_{su}$),
- average value of the standard deviation ($\overline{\delta}_i$, $\overline{\delta}_u$),
- variation coefficient of the seeding depth (V_{ki}, V_{ku}).

The results obtained have shown that increasing of the precision drills forward speed has caused the decreasing of the average seeding depth (Fig. 4). In the range of widely used values of forward speed during sugar beet seeding (from 1.7 to 1.8 m/s) the decreasing of seeding depth is about 10% when compared with the seeding depth at the forward speed 1 m/s. Such results corresponds with those received by WILHEM (1993).

Compliance of the most even seeding depth as possible with the minimal variability is an important assumption of the quality of the seeding process. Information about the seeding depth variability can

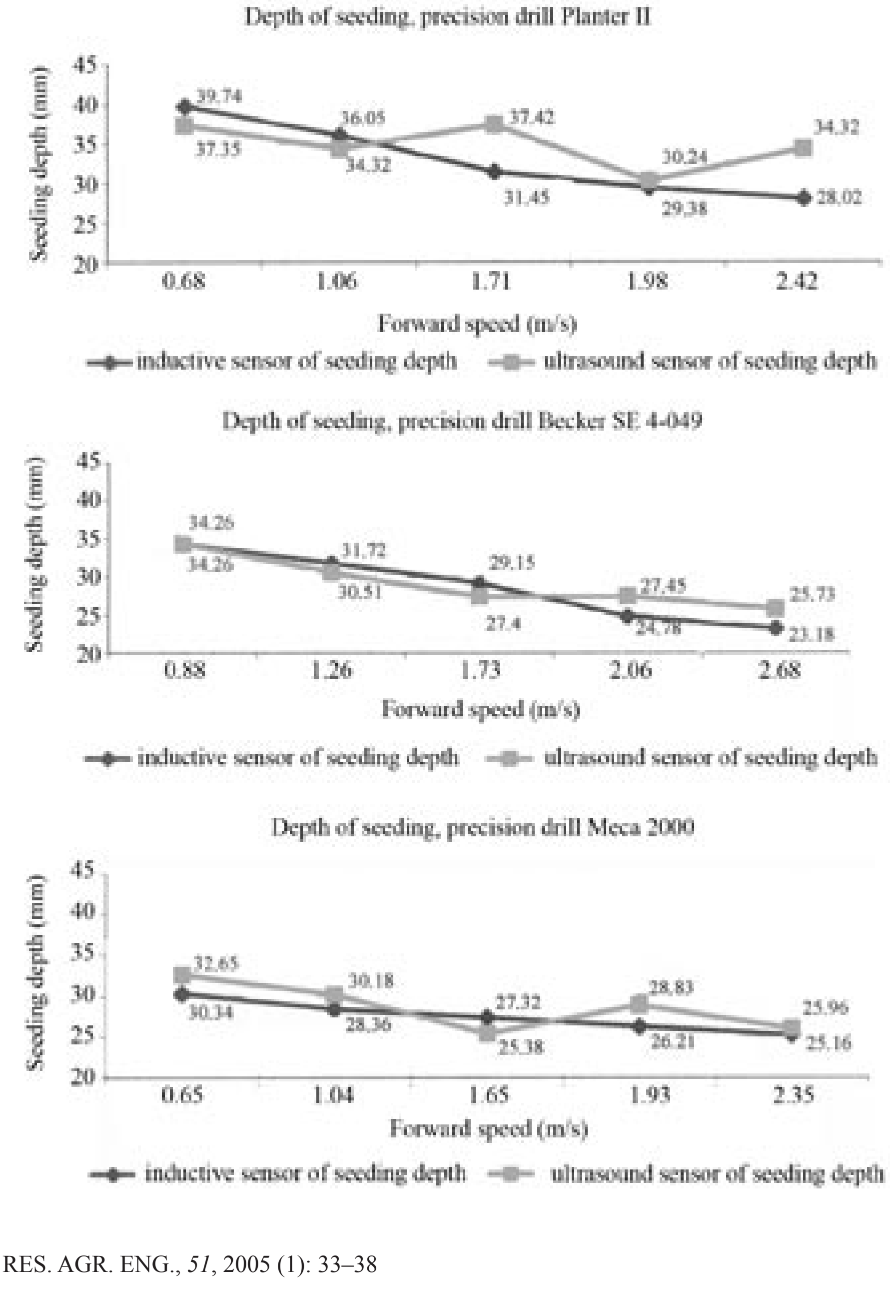

Fig. 4. Effect of forward speed of the precision drills Planter II, Becker SE 4-049 and Meca 2000 measured by inductive sensor and ultrasound sensors

be used in site-specific seeding of the sugar beet together with information coming from nutrition supplies and yield maps.

Seeding depth variability was expressed by standard deviation ($\bar{\delta}$). For all precision drills involved in field experiments, the lowest values of seeding depth variability were observed within the range of forward speed 1.65–1.73 m/s, when the values of standard deviation varied within the range from $\bar{\delta}$ = 5.08 mm (precision drill Planter II) up to $\bar{\delta}$ = 7.69 mm (precision drill Becker SE 4-049). The highest varying of the seeding depth was observed within range from $\bar{\delta}$ = 9.04 mm (precision drill Planter II) up to $\bar{\delta}$ =11.32 mm (precision drill Meca 2000) at the forward speed 1.98–2.06 m/s. Obtained results partially confirmed the rule known in practice, that the highest quality of sugar beet precision seeding can be reached at the forward speed around 1.7 m/s (Páltik 1992), when the highest plant emergency is also observed.

References

ANONYMUS, 1999. Prüfbericht DLG 4857.

BRUNOTTE J., 1986. Einzelkornsaat von Rüben – Anforderungen und vergleichende Untersuchungen von Druckrollen. Landtechnik, *41*: 128–130.

COLLECTIVE 2000. Definition und Einordnung der Einzelkornsaat KTBL-Arbeitsblatt. Landtechnik, *55*: 31–38.

ISENSEE E., 1992. Saatgutablage. In: KTBL – Ergebnisse von Versuchen zur Bodenbearbeitung und Bestellung. Darmstadt, KTBL: 113–119.

KÄSTNER B., JAHNS M., 1992. Spätaufläufer und ihr Ertragsverhalten. Zuckerrübe, *41*: 220–223.

MINX L., 1993. The effect of row spacing on the productive utilization of distances between plants by the sugar-beet stand. Rostlinná výroba, *39*: 531–541.

PÁLTIK J., 1992. Vplyv pracovnej rýchlosti sejačky Becker na rozmiestnenie semien v riadku a vzchádzavosť cukrovej repy. Acta Technologica Agriculturae, *3*: 29–39.

PÁLTIK J. et al., 2000. Kvalita sejby cukrovej repy sejačkami s mechanickým naberaním semien. Acta technologica agriculturae, *3*: 31–36.

RYBKA A., ŠŤASTNÝ M., 1998. Precizní zemědělství. In: Zemědělská technika a stavby, Praha, ÚZPI: 30–32.

STREIT K., PAPESH J., 1995. Die Pille in die Rille. In: Zuckerrübe, *44*: 305–309.

SCHRÖDL J., 1997. Einzelkornsämaschinen für Zuckerrüben. Zuckerrübe, *46*: 24–28.

SCHRÖDL J., 1998. DLG – geprüfte Einzelkornsämaschinen für Zuckerrüben. Zuckerrübenzeitung, *34*: 8–9.

WILHEM W., 1993. Qualität der Saatgutteinbetung bei Zuckerrüben. In: KTBL – Ergebnisse von Versuchen zur Bodenbearbeitung und Bestellung. Darmstadt, KTBL: 120–127.

Received for publication January 24, 2005
Accepted after corrections February 17, 2005

Kvalita rozmiestnenia osiva pri sejbe cukrovej repy

ABSTRAKT: Príspevok sa venuje sledovaniu, meraniu a hodnoteniu kvality sejby cukrovej repy v poľných podmienkach. Merania sa uskutočnili na súbore presných sejačiek v súlade s normou ISO 7256/1. Sledovali sme variabilitu vzdialenosti rastlín v riadku a variabilitu hĺbky sejby po predchádzajúcom určení pôdnych podmienok a vlastností vysievaného osiva. Hĺbku sejby sme merali indukčnostným a ultrazvukovým snímačom. Z výsledkov vyplývajú veľké rozdiely v kvalite sejby. V oblasti variability vzdialenosti rastlín, ktoré sme hodnotili štandardnou odchýlkou (δ), najlepšie výsledky z hodnotených sejačiek vykazovala sejačka Monopill S (δ = 17,8 mm), najhoršie sejačka Magicsem 4000 (δ = 44,0). Vo všeobecnosti platí, že lepšiu kvalitu práce vykazujú sejačky s vnútorným plnením naberacích otvorov (Monopill S, Meca 2000 a i.), a to nie pri minimálnej, ale pri optimálnej rýchlosti stroja. Pri hodnotení variability hĺbky sejby všetky merané sejačky vykazovali pri zvýšených pracovných rýchlostiach zníženie hĺbky o ca 15–20 %. Najnižšia variabilita hĺbky sejby sa dosahovala u všetkých sledovaných sejačiek pri rýchlosti 1,65–1,73 m/s (štandardná odchýlka δ = 5,08–7,69 mm).

Kľúčové slová: cukrová repa; sejba; sejačky; vzdialenosť rastlín; hĺbka sejby

Corresponding author:

Prof. Ing. Jaroslav Páltik, Ph.D., Slovenská poľnohospodárska univerzita v Nitre, Mechanizačná fakulta, Katedra strojov a výrobných systémov, Tr. A. Hlinku 2, 949 76 Nitra, Slovenská republika
tel.: + 421 376 508 425, fax: + 421 377 417 003, e-mail: Pavol.Findura@uniag.sk