Impact of soil compaction in sowing on development and crops of sugar beet

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Abstract: Putting together work operations minimizes the number of machine passes across the plot, which helps to reduce negative soil compaction and to save fuels. However, the combination of working operations also reflects in the increased weight of machines, which – on the other hand – can result exactly in soil compaction. This is why the potential adverse phenomenon can be compensated by using tyres with a larger contact surface with the base. In the case of sowing root crops, some problems may appear with the application of these tyres as a certain part of the stand has been sown in their track. The paper brings an assessment of the possibility to use twin assembly tyres on the tractor model Fendt 822 and on the sowing drill model Monosem NG plus with 18 drilling mechanisms. Parameters to be assessed were soil compaction, and the development of plants sown inside and outside the tractor track. Although the degree of soil compaction was higher in the tractor track, the biological characteristic of plants including yield reached more favourable criteria of assessment. The situation paradoxically resulted from the creation of more favourable moisture conditions in the soil.

Keywords: sowing; sugar beet; soil compaction; combination of working operations

Soil compaction is increasingly becoming a great problem but the problem solution as late as at its pathogenic stage would be a gross mistake. It is reported that some 40–50% of farming land in the Czech Republic are endangered by soil compaction, of these up to 45% by technogenic soil compaction (MZe ČR 1999). Yield loss due to technogenic soil compaction in our country and in the world is estimated at 10–30% (Lhotský 2000). Prevention starts to play the most important role. In order to be able to have the prevention as efficient as possible, we have to be able to discern risk factors for soil compaction from factors that are not risky although looking harmful for soil health condition. One of partial goals was therefore included in the Project No. NAZV 46 038 in order to find out soil compation during the sowing of sugar beet into compacted soil by using a tractor twin assembly. The objective was to demonstrate a possible negative effect of using the twin assembly in rows sown into its rut. Compaction in the rut can have the same effect as a sowing into soil with reduced tillage when a significant sugar beet yield reduction were detected in a long-term experiment with the reduced tillage near Göttingen. Sowing is – with respect to stand establishment – the most important operation and any negative factor caused by its incorrect implementation can be hard to eliminate before the harvest.

METHODOLOGY OF MEASUREMENTS

Soil compaction in sugar beet sowing was measured in the Bohuňovice Agricultural Enterprise in April 2004. The sowing was made by the sowing drill model MONOSEM NG plus with a possibility of additional fertilization under coulter boot and with the sowing drill enabling also the strip-sprinkler irrigation and the application of granulates. The engagement of the sowing drill was 18 rows and its weight without fillings amounted to 6200 kg. The machine was equipped with a special locating disc which served for the subsequent navigation of weeding machine. This sowing drill was aggregated with the tractor model FENDT Favorit 822 equipped with a twin assembly on the front and rear axles. The twin assembly consisted of 480/70 R34 tyres on the front axle and 580/70 R42 tyres on the rear axle. The width of one rear tyre was 580 mm. Total weight of the tractor was 9950 kg which means that a total weight of the unit was 16 150 kg. The sowing was made to a depth of 30 mm and to a final spacing of plants in the row of 160 mm, i.e. 1.39 sowing unit (SU) per hectare. The variety used was Merah. The fertilizer applied during the fertiseeding was Agrosem at a dose of 100–300 kg/ha. The herbicide spraying with Goltix and Flirt was applied at a dose of 1.3 and 1.0 l/ha, resp. The application of Mesurol sneckekorn granules at 2 kg/ha came as the last treatment.

The structure of the experiment was based on three factors, viz. soil compaction prior to the sowing, soil compaction after the passage of the sowing unit, and soil compaction after the passage of the tyre and the sowing unit. The measurements were made in three different localities in three repetitions. Soil compaction was measured by the soil penetrometer model TS 10, sowing bed compaction was measured by means of a small manual penetrometer. Penetrometry dwells on a knowledge of soil resistance to the penetrating body being proportional to compaction (Letocha 2001). Each repetition was combined with the bulk soil sampling in order to determine the soil moisture content which was analyzed gravimetrically in the laboratory. The aim of the measurements was to find out a seeding capacity of the sowing drill when combining more working operations – with using twin assemblies, i.e. without the application of cultivation tyres. The use of cultivation tyres would have been technically unfeasible due to the high weight of the sowing machine and also with respect to soil compaction that could have reached extreme figures.

The measurement was made on 6 April 2004 in the Bohuňovice Agricultural Enterprise in the Olomouc region. Moisture content of the plots ranged from 20–25% of soil moisture with average soil moisture being 22.9%. The first two experimental plots contained typical Luvisols and the third plot contained Orthic Luvisol which is – according to the soil classification by Kopecký – a soil kind of medium bulk density. The first step was to measure the penetrometric soil resistance prior to sowing. The penetrometric soil resistance in drilled rows was measured after the passage of the sowing machine (inside and outside the tractor track) by the large and small penetrometers in five repetitions at three places randomly selected in each strip of field. Soil compaction and field germination were measured in all localities under study during the month of May. Sugar beet plants were at the developmental stage of 4–6 leaves of growth stage according to BBCH. Soil compaction was classified according to penetrometric soil resistance. Field germination of the stand was classified according to the methodology *Biological control of sugar beet production* (Minx 1986). Soil compaction up to a depth of 0.40 m was measured by the penetrometer model TS 10.

The classification variants were as follows:
(a) stand in the tractor twin assembly rut at sowing;
(b) stand outside the rut;
(c) rut of the plant treatment machine.

Variant (c) was included in order to illustrate the increasing soil compaction in the rut during the treatment in the growing period. There were three representative measurement points chosen in each locality where the measurement was made in three repetitions. Basic stand parameters to be classified were as follows: relative field germination of the stand, average spacing of the plants, gappiness (irregular stand canopy) and the number of twins. The classification of stand field germination was made in all studied localities in the variant rows in the twin assembly rut at sowing and in the variant outside the twin assembly in the stand without the previous soil compaction. Each variant had five repetitions. The proper measure-

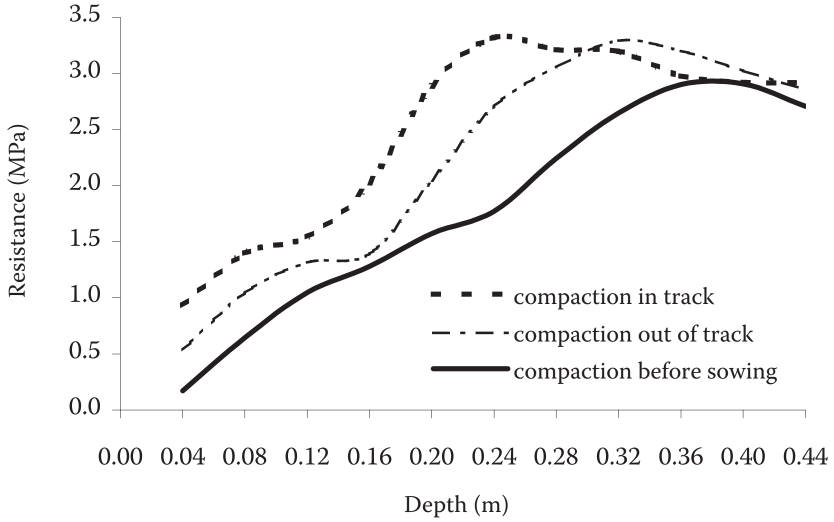

Figure 1. Dependence of soil resistance on depth

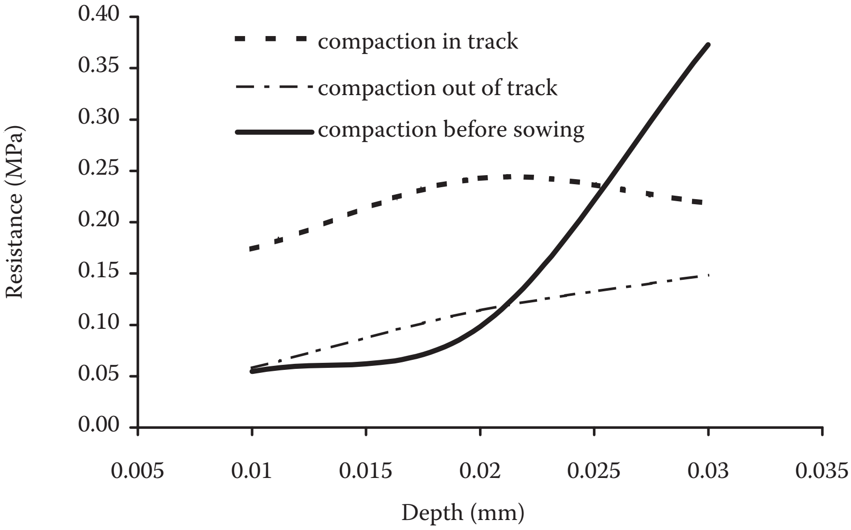

Figure 2. Soil compaction in the sowing bed

ment consisted in the alignment of a section of 22.22 m (i.e. 10 m² with respect to row spacing of 0.45 m). Biological yield was evaluated at the end of October. Stand parameters to be classified were as follows: yield, plants per hectare, average beetroot weight, sugar content and percentage of bulbs with abnormal root branching (Benda *et al.* 1985). The used methodology was that of *Biological control of sugar beet production* (Minx 1986). In each variant, 10 m² were sampled from the plot of 11.111 × 0.9 m aligned in the stand. Assessed plants were those sown in the rut of the tractor twin assembly, plants outside the twin assembly rut, and plants next to the rut developed due to subsequent stand treatment. All plants were lifted by hand. Beetroots were subjected to dry mechanical cleaning and leaves were separated. Individual beetroots were counted, weighed and the percentage of bulbs with abnormal root branching was determined. All variants were subjected to the selection of representative bulbs which were mixed to give a mixed sample for the individual variants. These mixed samples were then analyzed for sugar content.

RESULTS AND DISCUSSION

Soil moisture was determined gravimetrically, by a standard method of desiccation at 105°C for 5 hours, which corresponds to the drying out to a constant weight. Values of penetrometric resistance are presented in the following graphs. In Figure 1, the graph shows a penetrometric soil resistance measured by the soil penetrometer. The soil resistance was measured in the intervals of 4 cm.

It follows from the graph that soil resistance in the rut is double as compared with rows outside the rut and up to five-times greater as compared with the soil compaction before the passage of the sowing unit. The difference decreases at a depth of 0.12 m but then it increases again down to the subsoil layer. The greatest difference in soil resistance between the variants of inside and outside the rut can be found

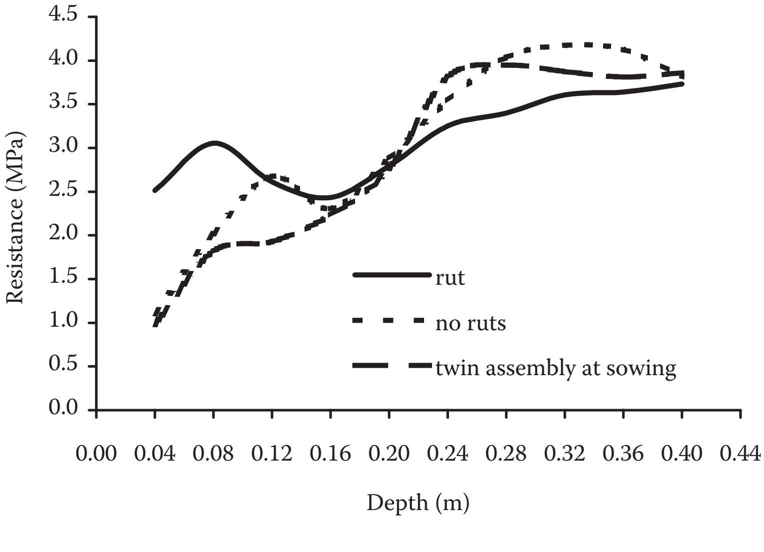

Figure 3. Soil compaction – locality 1

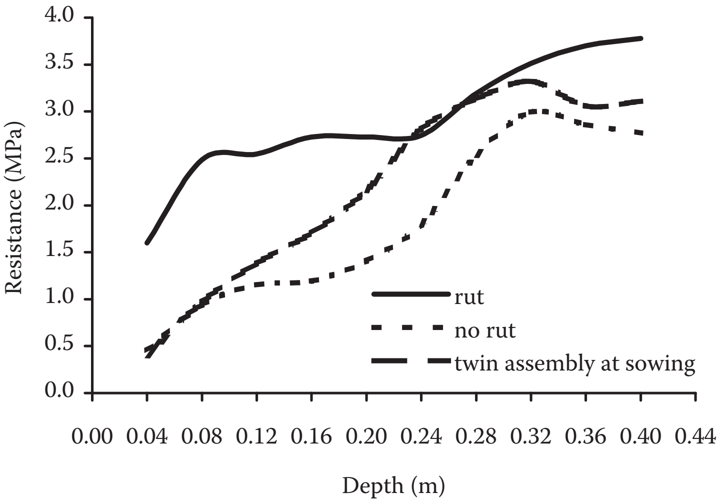

Figure 4. Soil compaction – locality 2

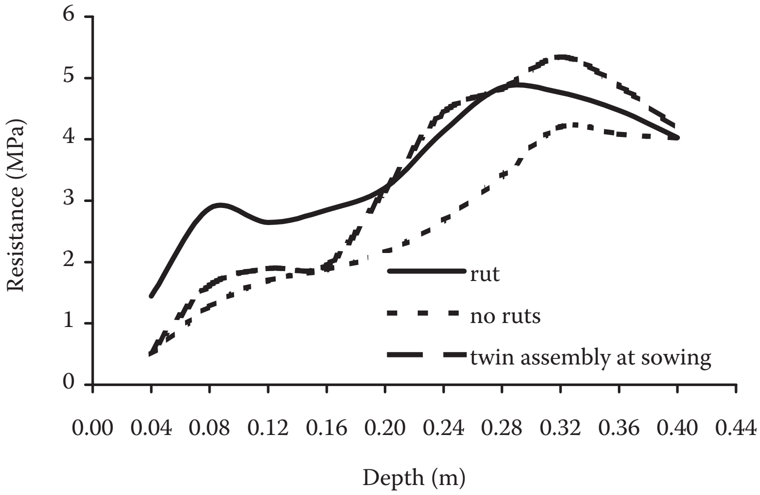

Figure 5. Soil compaction – locality 3

at a depth of 0.18 m (> 1 MPa). Figure 2 shows the penetrometric resistance of sowing bed as measured by a special penetrometer.

The measuring of sowing bed compaction revealed that compaction in the rut is more conspicuous than that outside the rut. It can be seen in Figure 2 that the pre-sowing preparation of the sowing bed was made to a depth of 25 mm since the compaction dramatically increases at greater depths. Soil resistance in stand control was measured by the large soil penetrometer as in the sowing. Results from the respective localities are presented in the following graphs (Figures 3 to 5). Individual soil resistances from all localities translated into a graphical form are illustrated in Figure 6.

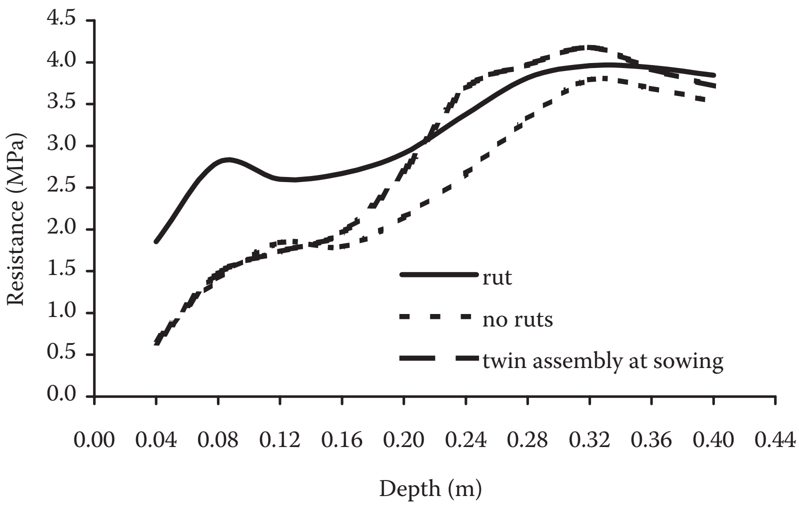

Figure 6. Total soil compaction – all localities

Table 1. Biological control of stands

Parameters	In twin assembly at sowing	Outside the rut
Sowing spots (10 m²)	13.90	13.90
Emerged plants (10 m²)	11.70	11.00
Rel. field germination of the stand (%)	84.00	79.00
Average spacing of plants (mm)	190.00	202.00
Stand gappiness (10 m²)*	4.00	5.44
Twins (10 m²)**	0.00	0.20

*Stand gappiness is the number of gaps over 400 mm in width
**Twin is understood to be a cluster of two or more plants; the cluster is counted as one plant

Figure 6 shows an obvious difference in the compaction of soil to a depth of 0.2 m. This depth interval exhibits a markedly higher soil compaction in the rut of the vehicle used for stand protection treatment. Soil compaction in the part of stand compacted by the twin assembly at sowing and soil compaction of uncompacted part of the stand were balanced. In the depth interval of 0.2–0.32 m, a balance can be seen of soil compaction in the rut of vehicle used for the stand protection treatment but an increase is shown of soil compaction at the place of twin assembly at sowing. None of the studied variants exhibited a more significant difference from a depth of 0.32 m and the variants exhibited similar levels of soil compaction. Results of biological control are presented in Table 1 with average values from all localities.

Relative field germination of sugar beet stand detected by the biological control was 84% in the variant with the sowing into the rut of tractor twin assembly, and 79% with the sowing outside the tractor rut. This parameter also links to the average spacing of plants, which was in the first variant smaller than in the second one. Important was the finding of a considerably high stand gappiness while the number of twins was negligible. Results of biological yield for the respective experimental variants are presented in Table 2.

Sugar beet plants established in the tractor twin assembly track reached the lowest number of bulbs with the high number of plants that remained nearly unchanged since the biological control of the stand in the spring. The average weight of bulbs determined on the basis of yield and number of plants was lowest in this variant. Surprising was the low number of branching beetroots and the highest sugar content. Plants sown without soil compaction at sowing exhibited a lower number of individuals per unit area, which follows out from the biological control. The variant showed a higher percentage of branching beetroots and an approximately identical sugar content. The highest biological yield was detected in the third variant which was represented by the rut of vehicle for plant protection. This variant also exhibited the highest average weight but the lowest sugar content and the highest percentage of branching beetroots.

CONCLUSION

Sowing without the use of cultivation discs, be them single or in twin assemblies, is applied ever more frequently. High-performance seed-sowers combining work operations require ever more energy. The use of cultivation twin assemblies in high-performing tractors is not possible. The issue of sugar beet sowing divides into two basic trends. The first one combines work operations similarly as in our experiment; the second trend is the use of light-weight sowing machines without attached implements, which makes it possible to use a low-performance tractor of lower weight. The use of light-weight tractor enables the application of simple cultivation discs. Preliminary experimental results presented above indicate that although there are differences in penetrometrical

Table 2. Results from the biological control of sugar beet stands

Variant	Yield (t/ha)	Plants (per ha)	Average weight of beetroots (kg)	Root branching (%)	Sugar content (%)
Twin assembly rut	84.6	116 000	0.73	15.00	19.30
Outside the rut	86.2	106 000	0.81	20.50	19.26
Rut of plant protection treatment vehicle	86.5	101 000	0.86	31.00	18.90

resistances measured in the tractor rut and outside the rut at sowing, the variance is not significant up to a depth of 160 mm. As far as soil compaction is concerned a balance was achieved between the variant with the sowing into the rut of twin assembly and the sowing into uncompacted soil. This only to a depth of 0.2 m. Soil compaction at a depth of 0.2–0.32 m exhibited permanent differences among the experimental variants.

Biological control of experimental stands revealed an increased number of plants in the variant of sowing into the rut of twin assembly. The relative field germination of the stand was higher by up to 5% in this variant The higher field germination of plants could have been resulting from the increased soil compaction that could have shown a positive effect on increased capillary attraction of water column and hence result in a better water supply to plants. This situation could have occurred on condition that the soil compaction by twin assembly could be still tolerated by the plants. The size of soil compaction at sowing can be seen in the graph presented in Figure 1. It was corroborated in the autumn measurements that soil compaction by tractor twin assembly at sowing has no statistically significant impact on the yield of beetroots and does not effect beetroot branching. Plants in the vicinity of ruts developed after the passage of vehicles used for plant protection treatment were affected by the ruts. Although the yield reached the highest figures, the plants in these rows exhibited a lower sugar content and the percentage of branching beetroots was highest in this variant.

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Abstrakt

Uhlíř V., Mareček J., Červinka J. (2006): **Vliv utužení půdy při setí na vývoj a výnos cukrovky**. Res. Agr. Eng., **52**: 11–16.

Spojování pracovních operací minimalizuje počet přejezdů po pozemku; tím dochází ke snížení negativního utužování půdy a k úsporám pohonných hmot. Spojováním pracovních operací ale zároveň dochází ke zvyšování hmotnosti strojů, což může naopak způsobit utužení půdy. Proto je nutné tento možný negativní jev kompenzovat použitím pneumatik o větší styčné ploše s podložkou. V případě setí okopanin může docházet k problémům s možností použití těchto pneumatik, neboť část porostu je zaseta do jejich stopy. Článek hodnotí možnost použití dvoumontážních pneumatik na traktoru Fendt 822 a se secím strojem Monosem NG plus s 18 výsevními ústrojími. Hodnotí se utužení půdy a vývoj rostlin vysetých ve stopě traktoru a mimo stopu traktoru. Ve stopě traktoru bylo zjištěno vyšší utužení půdy, ale biologická charakteristika rostlin (včetně výnosu) dosahovala příznivějších hodnocených kritérií. Tento stav byl paradoxně způsoben vytvořením příznivějších vláhových podmínek v půdě.

Klíčová slova: výsev; cukrovka; utužení půdy; spojování pracovních operací

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