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Effect of controlled traffic farming on weed occurrence

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Abstract. Soil compaction caused by field traffic is one of the most important yield limiting factors. Moreover, published results report that soil over-compaction inhibits the uptake of plant nutrients and decreases their ability to compete with weeds. Controlled Traffic Farming (CTF) is technology which prevents excessive soil compaction and minimizes compacted area to the least possible area of permanent traffic lines. A long-term experiment was established at University farm in Kolinany (Slovakia) in 2010 with 6 m OutTrack CTF system. Random Traffic Farming (RTF) is simulated by 1 annual machinery pass crossing the permanent traffic lines. Aim of presented study was to assess the effect of CTF on weed infection pressure. To achieve this, weed occurrence at different traffic treatments was determined. Emerged weeds per square meter were counted, identified and recorded at 14 monitoring points. Results showed that higher weed infection was found at the area with one machinery pass compared to the non-compacted area. Following weeds were identified: *Bromus secalinus* L., *Stellaria media* (L.) VILL., *Veronica persica* POIR. in LAMK., *Poa annua* L., *Polygonum aviculare* L., *Convolvulus arvensis* L. Occurrence of these weeds could be used as soil compaction indicator. Based on these results it can be concluded, that CTF technology has potential to decrease weed infestation in comparison to RTF system due to ration of non-compacted to compacted area. Moreover, with exact localization of weeds in traffic lines together with exact identification of weed species, it is possible to target the application of herbicides.

Key words: Controlled Traffic Farming, soil compaction, weed infection.

INTRODUCTION

Technological development in agriculture heads to increasing the working width of the machines along with the increasing power of tractors. Strong and heavy machinery has a negative impact on soil and its properties (Rataj et al., 2014).

Slightly compacted soil is important for water and nutrient supply. For better seed germination, the soil should be loosened in the top layer, and slightly compacted in the bottom of seed bed. (Pospíšil & Candráková, 2015). However, heavy machinery and its multiple passes may cause significant problems. Since 1966, the mean weight and power of agricultural machinery has increased three times (Kumhála et al., 2013). Moreover, most of the field operations are conducted in so called 'random traffic' system. In conventional tillage system, 88% of field is trafficked in one year. In minimum tillage, the trafficked area can be lowered to 65% (Kumhála et al., 2013; Rataj et al., 2014). Schjonning et al. (2016) has shown that multiple machinery passes have big influence on yield of arable crops. They also showed, that the first machinery pass did not have impact on yield. The yield loss was significant in compacted subsoil. Botta et al. (2016) determined the influence of heavy harvesting machines on growing soybean. Yield of soybean was influenced by weight of harvesting machines and design of wheels. Emergency of soybean was not affected by compaction of upper part of soil. Javůrek & Vach (2008) reported, that yield loss due to compaction in cereal was 10–20%, in corn – 10–15%, and in pulses – 15–20%. In dry conditions crop yields could be positively affected (DeJong-Hughes, 2001). Several measures can be taken to minimize machinery induced soil compaction. For example, Godwin et al. (2015) suggested that Low Ground Pressure (LGP) can avert soil compaction. In this system, special tires are used, that are able to operate at inflation pressure of 0.7 bar. Recently, Controlled Traffic Farming (CTF) is considered as a management method that could lower the trafficked area and optimize the growing conditions. CTF creates two zones: non-trafficked crop beds and cropped or non-cropped traffic lanes (Chamen, 2015). This system can be established also with normal machinery without special adjustment, with 68% non-trafficked area (Gutu, 2015). Botta et al. (2007) has shown, that with reduction of traffic intensity, yield increased by 29%, which resulted in increased income by US$134 ha^{-1}.

Weeds are generally more resistant to environmental constrains than arable crops and occurrence of some weeds can indicate actual soil properties and problems in soil structure. Some weeds cannot fully grow on compacted soil, but certain weed species are able to resist harder conditions and can compete with other weeds and plants. Those weed species can be used as indicators of soil compaction (Derr, 2000; Hill & Ramsay, 2005).

Excessive soil compaction inhibits nutrient uptake of arable crops and their ability to compete with weeds. Reintam & Kuht (2012) have shown that in compacted soil without fertilizer easily eliminable weeds are replaced by weed species that are hard to eliminate. The problem is in selection and competing ability of weed species. In extremely compacted soil even weeds are not able to grow, and available nutrient could pollute environment. Kuht et al. (2001) has shown, that in experiment with wheat nutrient uptake (N, P, K, Ca, Mg) in compacted soil occurrence of certain weed species was visible. Nutrient uptake of spring wheat was decreased by 30% in compacted soil by 4–6 passes. Lowered nutrient uptake of weeds was registered only on extremely compacted soil and still wasn't so significant. Reintam et al. (2006) has shown that soil compaction decreased competition ability of spring barley and increased weed infection from 20% to 53%. She has also stated, that the negative effect of soil compaction can be reduced by using fertilizer. Kuht et al. (2012) has also shown, that the adaptability of weeds on soil degraded by excessive compaction was remarkably strong, which resulted in decreased competitiveness of barley.

The aim of this work was to evaluate presence of specific weed species at Controlled Traffic Farming field with different traffic intensities areas.

MATERIALS AND METHODS

A long-term experiment with Controlled Traffic Farming (CTF) system was established at University farm in Kolinany (Slovakia) in 2010. The field size is 16 ha with silty loam (51% silt, 30% sand, 19% clay). A 6 m OutTrack CTF system is used. Further details can be found in Godwin et al. (2015). The field is cultivated using shallow non-inversion tillage practice. Crop rotation includes cereals, maize and oil-seed rape. Considering soil compaction, areas with no pass, one pass, and multiple passes can be found on experimental field. Random Traffic Farming (RTF) is simulated using 1 annual machinery pass in three strips as is indicated in Fig. 1 left. The orthophotograph (Fig. 1 – right) was taken in early April during vegetation of winter wheat. There is visible difference in coverage between compacted and non–compacted area that was caused mostly by weed emergency. This information was the first impulse to conduct this study and was used to target the monitoring points where weed infection was evaluated.

Figure 1. Satellite image (left) showing 1 pass (compacted) area for RTF simulation and orthophotograph (right) during vegetation with visible difference in compacted and non-compacted area.

Monitoring points were targeted at areas with different traffic intensities: non-compacted area and area with one machinery pass. The characteristics of the soil structure at these two areas is well documented with significant difference in penetration resistance measured in the depth of 0–40 cm as shown in Fig. 2. These are average data for the two areas with different traffic intensities measured in year 2012 (left), 2013 (middle) and 2015 (right) at the experimental field within other research activities. The average dry bulk density in depth 10–20 cm was 1,506 kg m^{-3} for non-compacted area and 1,560 kg m^{-3} for 1x compacted area in year 2015.

For this study, 14 monitoring points were selected (7 at compacted and 7 at non–compacted area). Samples were taken randomly with 5 replications at each point.
Emerged weeds were counted from area of 1 square meter and each weed species was identified. Weed infestation during experiment in 1x compacted area is shown in Fig. 3.

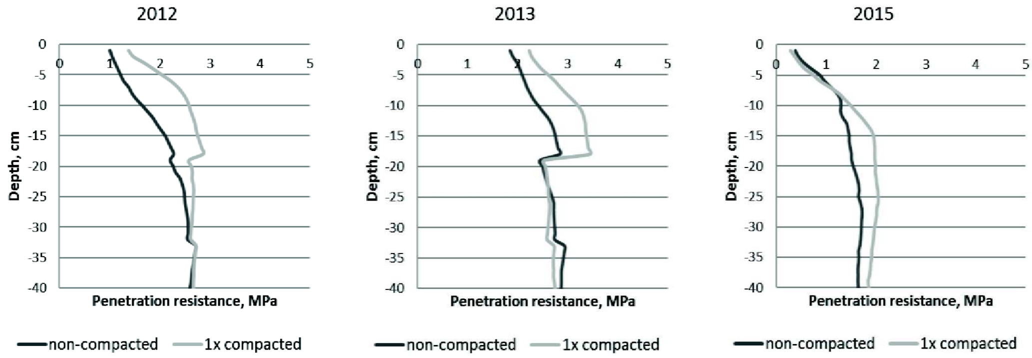

Figure 2. Penetration resistance in depth of 0–40 cm for years 2012, 2013 and 2015.

Figure 3. Weed infection in 1x compacted area.

RESULTS AND DISCUSSION

On experimental field with CTF technology 10 species of weed were found. The most frequently present weed was Annual Bluegrass (*Poa annua* L.) with 3,236 pcs and Chickweed (*Stellaria media* (L.) VILL) with 824 pcs. Some weeds were represented by a little number, such as Creeping Thistle (*Cirsium arvense* L. Scop.) with 8 pcs, Goosegrass (*Galium aparine* L.) with 4 pcs, and Common Dandelion (*Taraxacum officinale* (L.) Weber ex F.H. Wigg.) with 4 pcs. The number of these weed species is not significant, so they will not appear in further results.

Comparison of number of weeds at our two experimental locations is presented in Fig. 4. Almost all of the weed species have bigger numbers at area with one machinery pass compared to non–compacted area. The biggest counts at compacted area have Annual Bluegrass *(Poa annua* L.) with 2,728 pcs, and Chickweed (*Stellaria media* (L.) VILL.) with 808 pcs. Only Common Horstail (*Equisetum arvense* L.) has bigger number in non-compacted area (172 pcs). That could indicate the sensitivity of this weed to soil compaction and all of the soil properties that are typical for compacted soil.

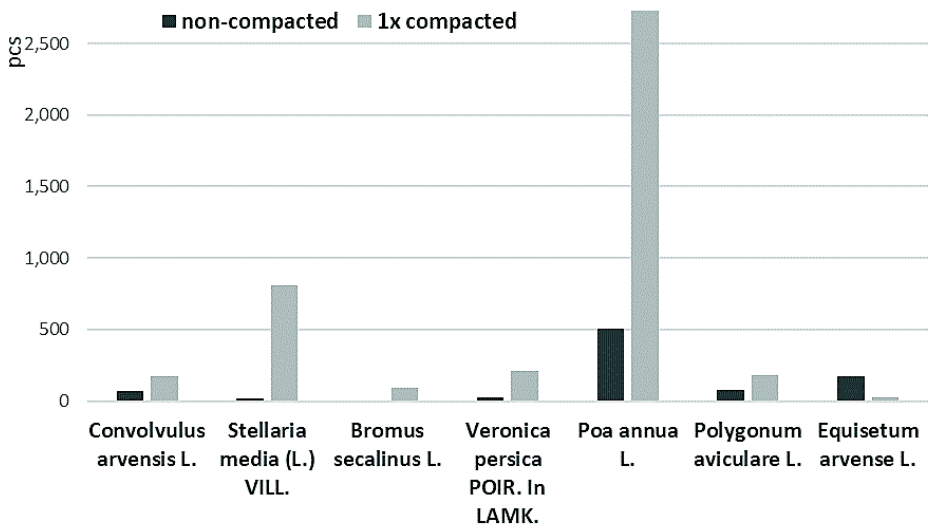

Figure 4. Weed counts in non-compacted and 1x compacted area.

Percentage composition of weed species at non–compacted and at area with one machinery pass is shown in Fig. 5. Results show that some weeds were present only at compacted area. These are Chickweed (*Stellaria media* (L.) VILL.) and Rye Brome (*Bromus secalinus* L.). All of the other weeds except Common Horstail (*Equisetum arvense* L.) grew mostly at compacted area with a minimum percentage share of 70%.

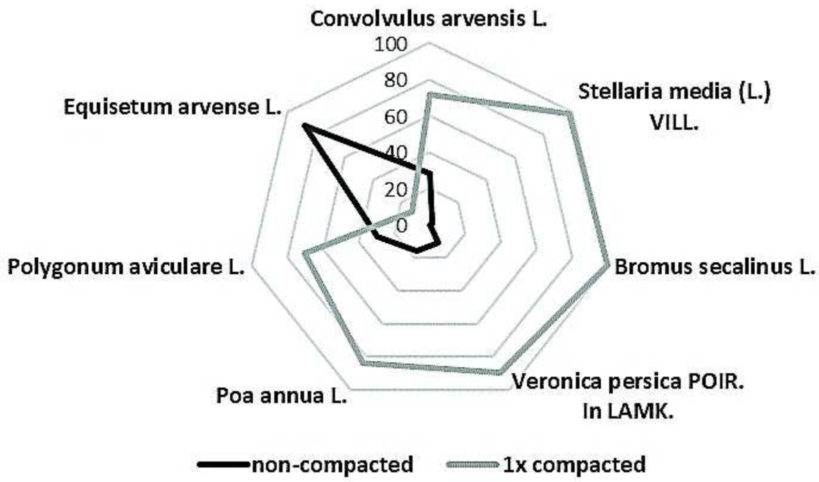

Figure 5. Percentage composition of weeds in non-compacted area and 1x compacted area.

It was found out that most of these weed species grew mostly at compacted soil with one machinery pass. This could indicate, that those weed species need growing conditions that appear after the soil is compacted. In comparison, at non–compacted area only 24.8% of weeds was identified in total. These results also indicate, that it is possible to reduce weed infection and growth by reducing field traffic and soil compaction.

CONCLUSIONS

Soil compaction caused by heavy agricultural machinery has big impact not only on soil properties, but also on composition of grown plants and weeds. At area with one machinery pass, weed numbers were 4–times higher than at non–compacted area. Some of the weed species grew mostly at compacted area. Based on these knowledge, we can assume that those weeds could be used as indicators of soil compaction and soil health.

CTF technology minimizes compacted area by concentrating traffic on specific field lines. Based on this study it can be concluded, that CTF technology suppress weed growth in comparison to Random Traffic Farming. This could have big environmental effect based on lowering herbicides application, or even precisely applying herbicides only on compacted areas (track lines), also with the effect of lowering input costs in crop growth.

Effects of CTF system may be evident after some time from establishment. This experiment indicates, that soil compaction caused by traffic has a big impact on weed emergence and growth, and it is necessary to continue with this study to fully explain this problem.

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