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Short communication

Within cropping season changes in soil physical properties under no-till in Southern Brazil

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ABSTRACT

Although opening a narrow furrow for seed placement and fertilizer application is the only mechanical disturbance in soils under no-till (NT) production systems, the persistence of effects associated with that disturbance on physical properties throughout the growing season has not been widely quantified. This study tested the hypotheses that soil physical properties within the row (R) differ from those in the interrow (IR) zone under long-term NT, and that the disturbance effects on soil in the R zone persist during the soybean (*Glycine max*) growing season. The objective of this study was to determine soil physical properties under R and IR zones under NT soybean. Thirty undisturbed samples in each zone were obtained during the growth cycle at 15, 52 and 115 days after sowing. Soil properties monitored were bulk density (BD), total porosity (TP), soil water content and air-filled porosity at field capacity (FC and εa, respectively), air permeability (Ka), pore continuity index (K1) and saturated hydraulic conductivity (Ksat). There were significant differences in all soil physical properties among R and IR zones when measured 15 days after sowing (DAS). At the 52 and 115 DAS samplings, K1 and Ksat did not differ between R and IR positions, but significant differences persisted for BD, FC, εa, Ka and TP. BD in R and IR remained different during the soybean growing season. Despite that, the large difference for BD found in 15DAS (1.34 and 1.04 Mg m^{-3} for IR and R, respectively), tended to disappear, resulting in values of 1.15 and 1.07 Mg m^{-3} for IR and R at 115DAS, respectively. A long-term NT soil thus had different physical properties at R versus IR over a short term after sowing. Soil resilience was evident even over a short term, improving soil physical quality at IR position. The large contrast in soil physical parameters between R and IR positions was observed right after sowing, gradually decreasing over time and no longer being detectable by the end of the growing season.

1. Introduction

No-till (NT) system is a global strategy for conservation agriculture (CA), adopted on approximately 155 Mha (Pittelkow et al., 2015). The soil mechanical disturbance involved in a NT system is limited to that by furrow opening for seed placement and fertilizer application. Compared to tilled soils, higher soil organic carbon (SOC) accumulation (Lal, 2015), nutrient cycling, nutrient storage and biological activity (Mbuthia et al., 2015), soil aggregation (Six et al., 2004) and soil water storage (Jemai et al., 2013) are usually improved in soil under long-term NT management.

Data obtained from previous research also indicate differences in physical quality of soil within plant rows (R) and the interrow (IR) space (Betioli Júnior et al., 2014; Silva et al., 2014) under NT. Thus, it is probable that soil disturbance in the R zone, influenced by the furrow opening, may be a critical factor to improve soil physical quality (SPQ) under NT, an effect similar to that caused by superficial chiseling. High SPQ requires non limiting penetration resistance to plant roots as well as a balance between soil aeration and water availability (Letey, 1985).

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The effect of a limited disturbance on soil properties is a debatable issue. While some researchers believe that the effect of disturbance may not persist for a long time and therefore understanding the mechanisms of these alterations occurring during the cropping season is an important question. Ojeniyi and Dexter (1983) reported seasonal changes in macroporosity and the percentage of microaggregates within a cropping season, due to tillage and cover crops. In an experiment of 3 consecutive years in Brazil, Moreira et al. (2016) reported that the effect of tillage in the R zone did not persist in the subsequent crop season, and was less significant than that caused by soil wetting and drying cycles. Nonetheless, changes in SPQ in a CA system, where tillage is limited only in the R zone, has not been focused within a cropping season. Thus, it is critical to assess changes in SPQ in R and IR zones during a cropping season under NT.

This study was conducted to test the hypotheses that soil physical properties under R and IR zones differ during the soybean cropping season under long-term NT, and that the tillage-induced changes in the R position persist during the same period. The specific objective of this study was to assess tillage-induced changes in SPQ in the row and inter-row zone during the growing season of soybean in a Rhodic Ferralsol under long-term NT.

2. Materials and methods

Soil samples were obtained from a commercial farm in Maringá – PR, Brazil, at 450 m above sea level. The climate of the site is classified as subtropical humid mesothermic (Cfa) according to Köppen classification, with annual average temperature and precipitation of 22 °C and 1450 mm, respectively. The predominant soil class of the experimental farm is classified as a Rhodic Ferralsol (WRB, 2006). The particle size analysis indicated 750 g kg^{-1} clay and 200 g kg^{-1} sand content for 0-0.10 m layer, indicating a clayey texture.

Land area of 50 ha has been under NT since 1980, and cropped to corn (*Zea mays*)/oat (*Avena sativa*), soybean (*Glycine max* (L.) Merrill)/corn, and soybean/wheat (*Triticum aestivum*) rotations. The soybean crop was seeded on November 28th, 2012 at row spacing of 0.45 m. Fertilizers were applied in the plant row along with seeding by using a seed drill equipped with frontal cutting disc and parabolic shape rods. The rods had thickness of 20 mm and penetration depth of 0.10–0.12 m and inclined at 20° angle. The wheel traffic of tractors, harvesters and sprayers was randomized in the area, as is practiced by farmers in the region.

Soil samples were obtained at three times: beginning, middle and end of the 2012/2013 soybean cropping season. A transect of approximately 13.5 m was established perpendicularly to the soybean rows, where 60 undisturbed soil samples were obtained. Each sampling position (R and IR) resulted in 30 undisturbed soil samples, taken at 15 days after sowing (DAS). In each subsequent sampling time (52 and 115 DAS), soil samples were obtained for the same R and IR sites, around 0.5 m away from the initial transect. Stainless steel cores (0.048 m internal diameter and 0.05 m high) were used to obtain the undisturbed soil samples. Fig. 1 demonstrates the sampling procedure along the three samplings.

Soil samples were transported to the laboratory for measurement of bulk density (BD), soil water content and air-filled porosity at field capacity (FC and εa, respectively), soil air permeability (Ka), saturated hydraulic conductivity (Ksat), soil pore continuity index (K1) and total porosity (TP). Soil cores were placed in trays and saturated by capillarity by water immersion to about two-third the height of the cores. Saturated samples were weighed and subjected to the matric potential (Ψm) −10 kPa using a tension table (Ball and Hunter, 1988). At hydraulic equilibrium, each soil sample was weighed again to measure volumetric moisture content at −10 kPa. According to Reichardt (1990) FC is most appropriately represented when the soil water content is measured at −10 kPa, for tropical soils of this region. Because of that, FC data in this study followed this indication. Ka was determined using a constant air head permeameter (Figueiredo, 2010). K1 was calculated as proposed by Ball et al. (1988), and Ksat was measured using a falling-head method (Reynolds and Elrick, 2002). After the determination of Ka and Ksat, core samples were oven dried at 105 °C for 24 h, to determine BD according to Grossman and Reinsch (2002). The FC was obtained by the water content at −10 kPa (Richards and Weaver, 1944), TP according to Danielson and Sutherland (1986) and εa by the difference between TP and FC.

All statistical comparisons were performed using the PROC TTEST ($p < 0.05$) of the SAS/STAT analysis package (SAS Institute, 2004). Logarithmical transformation was performed when variables did not present normal distribution, as proposed by Ball et al. (1988) and used by Mentges et al. (2016).

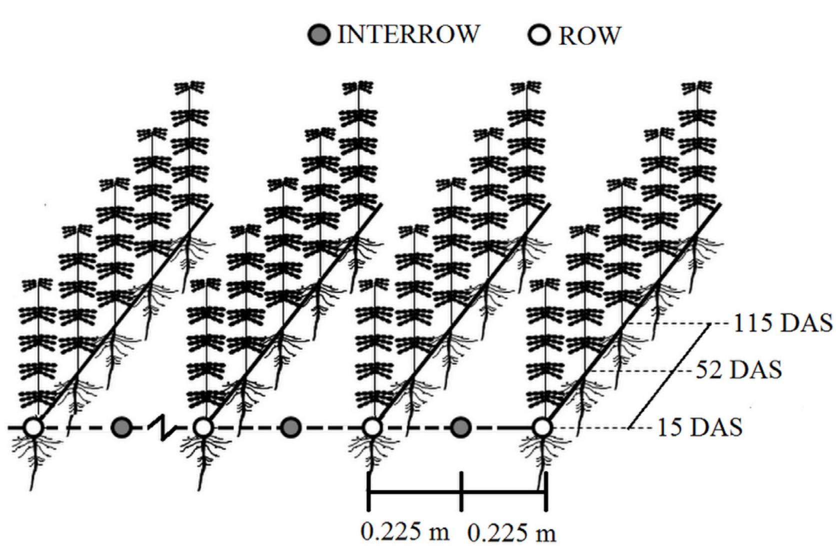

Fig. 1. Sampling methodology scheme of undisturbed soil samples along a transect perpendicular to the soybean rows in the sampling positions row (R) and interrow (IR) at 15 days after sowing (DAS), 52 DAS and 115 DAS.