Agricultural traffic effect on maize (Zea mays L.) yields in the Argentinean Pampas

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Introduction

In the Argentinean Pampas agricultural soils are degraded. In recent decades, a widespread alternative to recover degraded lands was the adoption of the direct sowing system (DS). However, after many years of continuous DS, crop yields tend to decrease. This decrease results from the use of randomized traffic and the increase of the machinery weight that caused soil compaction to increase. The adoption of controlled traffic farming was proposed as an alternative to recover the soil quality. This system confines all traffic compaction to the least possible area called permanent traffic lanes. However, soil compaction may extend to the sides of the traffic lanes and reduce root growth and thereby crops yield. Consequently, differences in crops yield may depend on the distribution of soil compaction in the traffic lanes and surrounding areas. In Argentina, maize is grown mainly in loamy-clay and silty-loam soils, which are very susceptible to compaction. Despite this, there is no information about how compaction in the traffic lanes and surrounding areas affects crop yield. The objective of this study was evaluate how the distribution of compaction caused by controlled traffic farming affects maize yield in an Argiudol of the Argentinean Pampas region.

Material and methods

Experimental site and crop operations

The work was carried out on a Typic Argiudoll located in the State of Santa Fe (Argentinean Pampas). The soil at the experimental site has been under direct sowing for 10 years in a typical crop rotation: winter wheat (Triticum aestivum L.) followed by soybean (Glycine max L.) and then maize (Zea mays L.) in summer. The maize variety used was “Dkb 7210 VT3PRO”, the seeding date was 7 January 2016 with a rate of 80000 plants ha⁻¹. The space between lines was 70 cm. The accumulated precipitation during the cycle of the crop was 951 mm, which represents the total rainfall in a normal year in the region.

Treatments

At the beginning of the experiment, field compaction was eliminated by subsoiling the soil. Then, nine plots (50 x 7 m each) were defined. Afterward, permanent traffic lanes with different compaction levels were generated in each plot. For that, different numbers of passes of a harvester were made. Thereby, 3 treatments with 3 replicates were defined: T0: without passing the harvester (the traffic line was defined for the seeding operation); T1: lines compacted until reaching 2 MPa; T2: lines compacted until reaching 4 MPa. After that, maize was seeded using direct sowing system and all treatments received the same management.

Determinations

The equivalent of 1 m⁻² was harvested manually in different positions related to the traffic lanes (a: crop located in the traffic lane; b: crop located in the border of the traffic lane; c: crop located between traffic lanes- without compaction). Undisturbed soil samples (5 cm x 5 cm cores) were collected in each position to determine bulk density (Bd) in the surface horizon (3-8 cm) (Blake and Hartge, 1986). Relative soil compaction (RC) was calculated relating the measured soil bulk density at each position to the soil critical density determined
by the Proctor test (ASTM, 1982). The statistical analyses were performed with Infostat software (Di Rienzo et al., 2015).

**Results and discussion**

Machinery traffic effectively resulted in soil compaction, evidenced by significant changes in RC between lane positions and non-traffic zones (Table 1). Soil critical bulk density was 1.43 Mg m\(^{-3}\). The average of RC of \(a\), \(b\) and \(c\) positions were: 98, 96 and 88\%, respectively. Significant differences were only found between \(a\) and \(c\) positions, being RC in \(a\) 10 \% greater than in \(c\). No significant differences were found between positions \(a\) and \(b\), and \(b\) and \(c\), indicating soil compaction gradually decreases from the center to the side of the traffic lines.

The effect of soil compaction by agricultural traffic on maize yield varied between treatments and positions. The lowest yield was found in T2 position \(a\), whereas no significant differences were found between \(b\) and \(c\) positions in this treatment. Similar behavior was observed in T1 even though in the \(a\) position maize yield was significantly greater than in the \(a\) position of T2. In T0 no differences in maize yield were found amount positions, and no differences in yield were found in the \(a\) position between T0 and T1. The lack of difference between \(b\) and \(c\) positions indicates that plants located in the \(b\) position someway compensated the negative effect of soil compaction. They probably developed a greater root system to the side without compaction, which allows plants uptake sufficient resources (water, light and nutrients) for producing a yield similar to those of plants located in the \(c\) position. This kind of compensation was found in experiments carried out in greenhouses in pots by Kelvin et al. (2001).

Table 1. Maize yield (Mg ha\(^{-1}\)) for three treatments and crop line positions, and relative compaction (\%) for positions.

<table>
<thead>
<tr>
<th>Position</th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
<th>Contrast position</th>
<th>(p)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>5.88 ab</td>
<td>4.49 b</td>
<td>2.13 c</td>
<td>a vs (b)</td>
<td>0.93 0.747</td>
</tr>
<tr>
<td>(b)</td>
<td>7.11 a</td>
<td>7.05 a</td>
<td>6.37 ab</td>
<td>a vs (c)</td>
<td>10.00 0.004</td>
</tr>
<tr>
<td>(c)</td>
<td>6.59 ab</td>
<td>7.27 a</td>
<td>6.93 a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Different letters indicate a significant difference for the different traffic treatments and crop line positions (\(p < 0.05\)).

**Conclusion**

The distribution of the soil compaction caused by controlled traffic farming affected differentially maize yield according to the compaction intensity and the position in relation to the center of the traffic lane.

**References**

