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Soil physical properties and soybean (*Glycine max*, Merrill) root abundance in conventionally- and zero-tilled soils in the humid Pampas of Argentina

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Abstract

In the humid Pampas of Argentina soybean is cultivated in different soil types, which were changed from conventional- to zero tillage systems in the last decade. Little is known about the response of soybean roots to these different soil physical environments. Pasture, and conventionally- and zero-tilled field lots cropped to soybean (R1 and R2 ontogenic stages) were sampled in February–March 2001 in a sandy clay loam and two silty clay loam Mollisols, and in a clayey Vertisol. In the 0–0.05 m layer of conventionally- and zero-tilled lots soil organic carbon represented 53–72% of that in pasture lots, and showed an incipient recovery after 4–11 years of continuous zero tillage. Soil aggregate stability was 10.1–46.8% lower in conventionally-tilled than in pasture lots, and recovered completely in zero-tilled lots. Soil relative compaction ranged 60.8–83.6%, which was below the threshold limit for crop yields (>90%). In change, soil porosity >50 μm ranged 0.91–5.09% soil volume, well below the minimum critical limit for root aeration and elongation (>10%, v/v). The threshold of soil resistance (about 2–3 MPa) was only over passed in an induced plough pan in the conventionally-tilled Bragado soil (5.9 MPa), and in the conventionally- and zero-tilled Ramallo soils (3.7–4.2 MPa, respectively). However, neither the low macroporosity nor the high soil resistances impeded soybean roots growth in any site. According to a fitted polynomial function, root abundance was negatively related to clay content in the subsoil ($R^2 = 0.84$, $P < 0.001$). Soybean roots were only abundant in the subsoil of the sandy clay loam Mollisol, which had <350 g kg^{-1} clay. Results show that subsoil properties, and not tillage systems, were the primary effect of root growth of soybean.

Keywords: Tillage systems; Relative compaction; Macroporosity; Soil resistance; Soybean root growth; Pampean soils

1. Introduction

Soybean is the most important cash crop of Argentina, and is mostly produced in the humid part of the Pampas region (Fig. 1). This large area is

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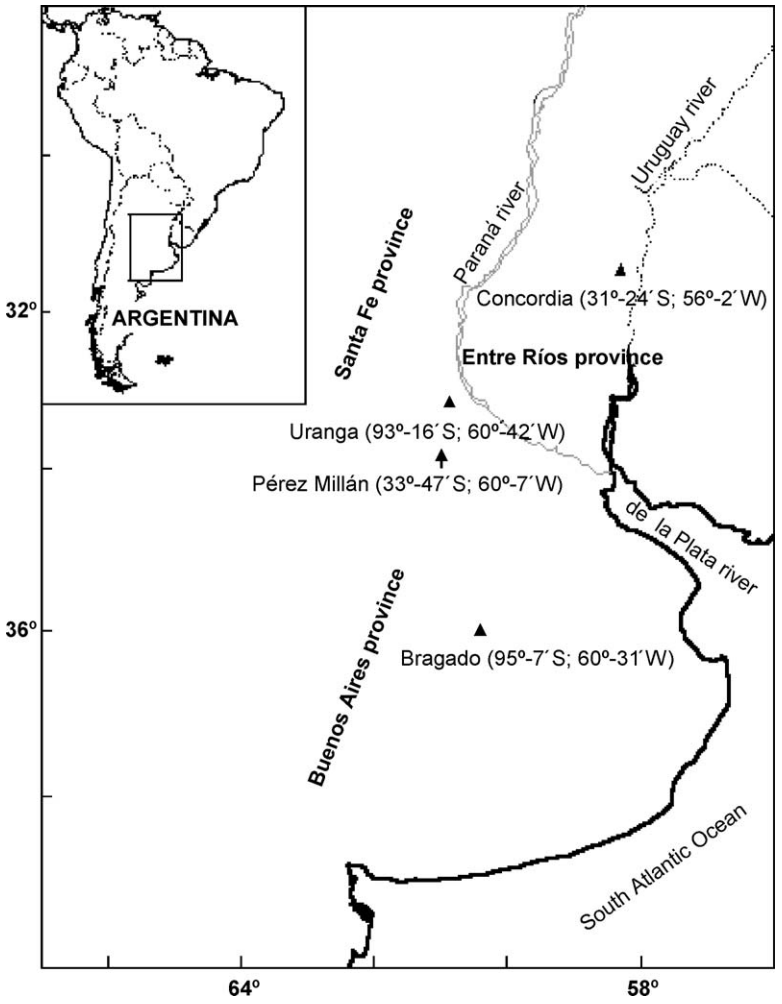

Fig. 1. Geographical location of the study sites.

covered by different type of Mollisols and, to a lesser extent, Vertisols. These soils vary greatly in their inherent properties, like morphology, texture and mineralogy of Bt horizons (Salazar Lea Plaza and Moscatelli, 1989). Soils were under grassland vegetation (pasture) up to about 150 years ago. Since then, they have different agricultural histories, which resulted in different degradation levels (Madonni et al., 1999; Senigagliesi and Ferrari, 1993). From the 1990 decade the farmers grew soybean using zero tillage (ZT) systems, which progressively replaced the more aggressive conventional tillage (CT) systems (Senigagliesi and Ferrari, 1993; Taboada et al., 1998). In this region, soil mechanical constraints were found to restrict the growth of maize roots (Cárcova et al., 1998; Senigagliesi and Ferrari, 1993). In contrast, little is known about their influence on soybean roots. Recently, Botta et al. (2004) found that increasing traffic intensities increased soil penetration resistance and bulk density and decreased soybean yields in a sandy loam of the region.

The diagnosis of soil physical constraints in the field is based on three different parameters, each one with its own critical limit, or threshold, in relation to the growth and yield of several grain crops:

(a) Soil relative compaction, RC: It results from the quotient between bulk density determined in the