Impact of direct drilling on nascence in a cereal–vetch crop under excessive soil moisture


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Introduction

The Cañamero raña is a broad glacis–piedmont plateau a few hundred square kilometers in area with a longitudinal slope smaller than 1%. Rañas are a common feature in the West of the Iberian peninsula, where they are associated with quartzitic mountains and act as boundaries between river basins. The Cañamero’s raña soils are Palehumults and Palexerults (Soil Survey Staff, 1999) dating from the Middle Pliocene, and their morphology and properties were shaped by a subtropical wet pre-Quaternary climate (Espejo, 1987). These soils are highly acidic and weathered, and their exchange complex is dominated by Al, which increases with depth. At present, most of the cultivated soils (Palexerults) are highly degraded by effect of an inappropriate management, which has considerably reduced their organic matter (OM) content with respect to the uncropped soils (Palehumults) and has had a rather unfavorable impact on most of the soil quality-related physical and chemical properties (Mariscal et al., 2007, 2009). Recovering these degraded Palexerults would require the application of liming amendments to suppress Al toxicity and using conservation tillage methods to raise the OM content and improve soil quality. Soils in raña formations, which possess thick Bt horizons accumulating illuvial clay, in a very flat relief, tend to form perched water layers with the upper limit near the surface (10–20 cm), that lead to water saturation or near-saturation conditions in the upper layer of the Ap horizon — the horizon receiving crop seeds and thus being the most adversely affected as regards germination. This is particularly so in the autumn–winter period of especially rainy years. The aim of this work was to assess the impact of direct seeding on the germination rate and early growth stages of a vetch–cereal crop during the 2010–2011 agricultural season, where precipitation in the study area exceeded its mean historical value.

Materials and Methods

The study was conducted in an experimental field set up in 2005 in the Cañamero raña. The design involved split plots and four replications where the primary treatment was tillage (direct seeding, DD versus conventional tillage CT) and the secondary treatment the application of an amendment consisting of sugar foam waste and of red gypsum. Prior to seeding, each tilled plot received a moldboard pass followed by two rotavator passes. All plots were sown by using the same direct sower. The seeded crop was a mixture of forage species consisting of 56.5% of a local oat variety (Avena sativa), 17.4% triticale (Triticoscale) of the Trimour variety and 26.1% of a local vetch variety (Vicia sativa), and applied at a rate of 140 kg/ha. Fine earth in the Ap horizon (0–25 cm) was sandy loam (ISSS) and consisted of 28.5% coarse sand, 52.5% fine sand, 6% silt and 13% clay. This horizon contained up to 55% of coarse altered quartzite pebbles smaller than 4 cm as a rule. Soil samples for gravimetric determination of moisture content after drying at 105 °C were collected (when possible) at three different depths (0–5, 5–20 and 20–40 cm) during the first week of each month from October 2010 to April 2011, except in October which was at the
The hydraulic conductivity (K) under a constant load was determined in unaltered samples from the 0–5 cm layer of the Ap horizon collected by using steel cylinders 5 cm high × 5 cm wide. These samples were additionally used to determine the water retained at 0.05, 0.1 and 0.33 bar, the former two with a tension table and the latter with Richards' plate. The germination rate was determined in March by counting the number of plants per square meter (3 counts per plot) and the proportion of plant cover by using the software Sigmascan Pro-5 to process digital photographs from the plots.

Results and Discussion

Mean precipitation and temperature (P mm; T °C) during the study period were: Sept 2010 (9.8; 21.3), Oct (84.2, 14.9), Nov. (58.8; 9.1), Dec. (179.0; 7.9), Jan. 2011 (93.6; 7.3), Feb. (84.4; 8.2), March (60.0; 10.5), April (83.2; 16.4). Figure 1 shows the water content in the fine earth from 0–5 cm layer samples collected during the studied period. As can be seen, the moisture content of DD plots exceeded that of CT throughout; however, visual inspection during the sampling operations revealed a higher water content in the tilled plots. The data for January have been excluded because all tilled plots and 25% of the DD plots were water-saturated in situ. This figure also shows data of the hydraulic conductivity values in undisturbed soil samples from the 0–5 cm layer, which were significantly higher in DD plots. According to Hudson (1994), the differences can be ascribed to the increased OM content in the DD plots (6.6% in DD versus 5.6 % in CT). One other reason for these differences could be the presence in the DD plots of greater amounts of plant residues and root macro and medium bio-pores filled with root in process of humification. Thus, root pores increased every year in the DD plots but were broken or altered in the tilled plots. These bio-pores presumably increase water retention and facilitate water infiltration and also aeration. It should be noted that application of the Ca amendment had no significant effect on the water–soil relationship (data not shown). Figure 2 shows the amounts of water retained at 0.05, 0.1 and 0.3 bar by fine earth from undisturbed soil samples from the 0–5 cm soil layer. As can be seen, the water contents in the DD plots invariably exceeded those in the tilled plots, which suggests more marked development of large and medium pores resulting from the presence of crop roots and residues. Figure 3 shows the number of germinated plants per square meter and the percent area covered by the crops in March. The number of both cereal and legume plants was much greater in the DD plots than in the tilled plots, and so was the percent covered area. This was a result of the soil–water relationship and aeration conditions in the topmost 5 cm of soil being more favorable in the DD plots. There were no significant differences in the number of germinated plants between the amended and not amended plots. However, vetch plant growth in the unamended plots was very poor relative to the amended plots and they did not progress afterward.
Figure 1. Water content in fine earth and hydraulic conductivity in the 0-5 cm soil layer.

Figure 2. Water retained by fine earth at 0.05, 0.1 and 0.33 bar in the 0-5 cm soil layer.

Figure 3. Number of plants per square meter and percentage of soil cover on 5th March 2011.

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References