SUSTAINABLE CONTROL OF CARBON MINERALIZATION AND NITRATE CONCENTRATION IN SOIL, BASED ON TILLAGE AND SEEDING PRACTICES IN A SEMIARID MEDITERRANEAN AGROSYSTEM

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INTRODUCTION

In recent years, tillage and cropping systems have been changed to reduce soil erosion through sustainable practices involving less intensive cultivation. In particular, the *band seeding* method is modifying the usual forms of soil management in extensive crops with the aim of improving soil moisture and fertilizer uptake. No extensive studies have been carried out about the extent to which the mineralization rates of soil organic matter depend on the tillage practices. In conventional tillage systems, a rapid flow of microbial activity immediately after plowing has been reported (Blevins *et al.*, 1984). In no-tillage soils, however, the observed increased levels of organic carbon and moisture (Dick *et al.*, 1998) should also provide an improved habitat for enhanced biological activity over a long period of time. The present experiment was designed in order to determine, in the course of the growing season, the effect of tillage and seeding practices on the resistance of organic matter to mineralization and on the accumulation in soil of NO_3–nitrogen.

MATERIALS AND METHODS

The experiment was carried out in the CSIC experimental farm "La Higueruela" located in Central Spain, under continental Mediterranean semiarid climate (in average 6°C in winter and 23°C in summer; 400 mm yr^{-1} rainfall). The soil is a Calcic Haploxeralf (USDA). A three replicate randomized block was designed with two blocks and three tillage treatments: (1) Conventional plow tillage (CT); (2) Chisel (minimal) tillage (MT); (3) No-tillage (NT). Two blocks were designed to examine the effects of the seeding methods: block I (row seeding) with 16-cm rows and block II (band seeding) with groups of 3 rows (16 cm each) separated by 49-cm non-cultivated soil bands in a chickpea (*Cicer arietinum* L.)/barley (*Hordeum vulgare* L. cv. Aramir) rotation. Plot size was 40×9 m. In the NT plots, volunteer barley plants and weeds were sprayed with 0.54 kg ha^{-1} glyphosate before seeding. From February to June 1998, five soil samples were collected from each plot at two depths (0-7.5cm; 7.5-15 cm) for NO_3-N evaluation.

A 15-day incubation experiment was carried out to monitor the respiratory activity of soil samples in laboratory-controlled conditions. Erlenmeyer flasks of 500 cm^3 containing 100 g of soil moistened to 60% of the water holding capacity were kept at 25 ± 1 °C. The CO_2 released was periodically measured with a Carmhograph-12 gas analyzer. Soil respiration was measured at three stages during the growing barley season (emergence, tillering, and heading).

Results and Discussion

Results for soil NO_3-N concentration at five different stages during the barley growing season (Fig. 1) show similar patterns in both seeding methods at two depths.

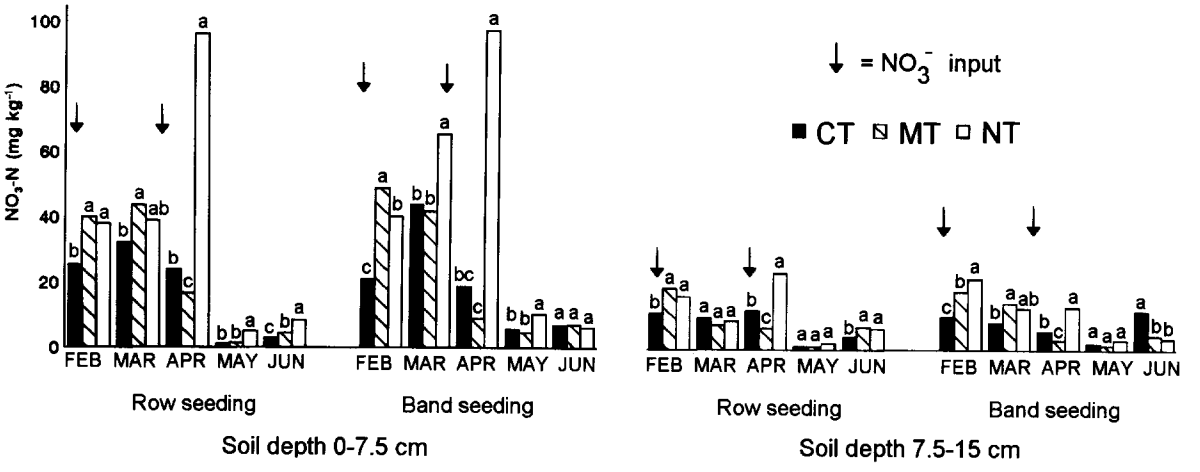

Fig. 1. *NO_3-N concentration at two soil depths in plots subjected to conventional tillage (CT), minimum tillage (MT) or no-tillage (NT), and using two seeding methods. Significant differences between tillage methods are indicated with letters on the bars.*

The highest concentrations in soil of NO_3-N in the top layer (0-7.5 cm) occurred during February and March, coinciding with barley emergence and tillering. In general, the plots subjected to CT showed significantly lower values than in MT and NT systems. In April, when the NO_3-N concentrations in CT and MT plots were lower than in preceding months, the NT plots showed the maximum NO_3-N values, which were up to 4-times higher than in CT and MT plots. This indicated that tillage practices involving no mechanical perturbation of the topsoil (NT) may lead to the accumulation of external N-inputs in soil. In subsequent months, there was an abrupt decrease in NO_3-N concentration in all the treatments: the NT system showed the highest values with significant differences with the MT and CT systems. The only exception was in plots under band seeding, with similar values in all systems.

Concerning the 7.5-15 cm layer, the concentrations of NO_3-N from February to April were approximately 50% lower than those obtained in the top layer, while in May and June the concentrations were similar in both layers.

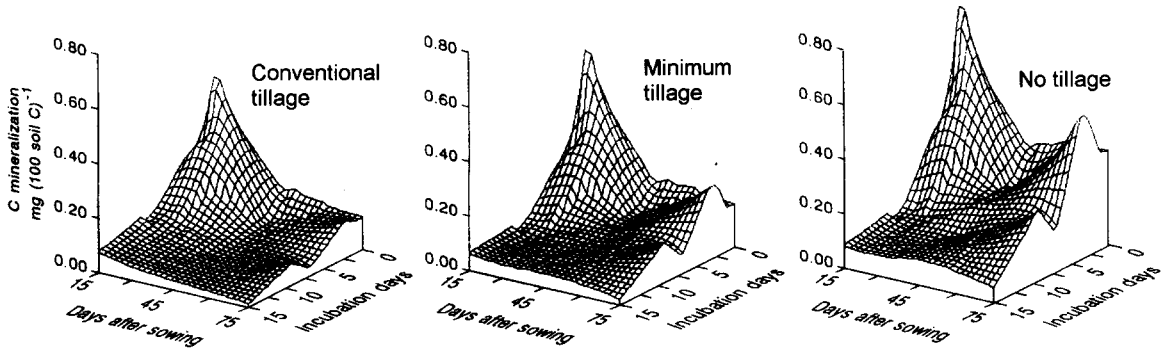

Fig. 2. *Carbon mineralization surfaces (CO_2 release* vs. *incubation time and* vs. *sampling season) of soil samples from row seeding plots.*

The profiles for CO_2 release (Fig. 2, *"Incubation days"* axis) suggested two phases of activity which could be considered to reflect: (1) an initial and rapid phase for the 3 first days when microbial biomass develops and the most readily biodegradable compounds are consumed, (2) a further phase in which incorporated plant residues are colonized and mineralized. In general, the greatest mineralization rates occur with the tillage practices involving minimal perturbation of the topsoil. As a whole, the respiratory surfaces indicate the progressive decline in the C-mineralization in the successive crop growing stages, as a probable effect of the depletion of C and mineral nutrients (Fig. 2, *"Days after sowing"* axis). Nevertheless, one additional difference between tillage practices consists of a secondary enhancement of the CO_2 release after external N-inputs (March: 45 days), which was more marked in the case of the NT soils, as could correspond to a more effective response to fertilization of soil microbial biomass in this situation where the organic matter remain undisturbed in the soil.

LITERATURE CITED

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