

TILLAGE SYSTEMS FOR A SUSTAINABLE GROWTH OF BROAD BEAN (*Vicia faba* L. *major*) IN A SEMIARID REGION OF SOUTHERN ITALY

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Abstract

This study analyses the effects of different soil tillage methods on broad bean crops grown in semiarid conditions in southern Italy. The trial was conducted on an experimental farm in the province of Foggia in 1995 and 1997. Broad-bean crops were in rotation with durum wheat and subjected to four different tillage systems: conventional, two-layer, surface and minimum tillage. Soil characteristics and yield are reported including measurements of soil moisture, mechanical impedance, yield and grain yield components of the broad beans taken throughout the study period. In dry conditions, soil moisture levels tended to be higher for minimum tillage. In moister seasonal conditions, soil moisture tended to be higher with conventional tillage. In the drier of the two years, grain yields and biometric parameters were not significantly influenced by different tillage systems. These results demonstrate that minimum tillage can be applied successfully to broad bean crops cultivated in semiarid regions, reducing both production costs and environmental impact.

Additional Keywords: soil resistance, soil moisture.

Introduction

Improving the competitiveness of broad bean cultivation in southern Italy requires an updating of cultivation techniques according to the principles of more soil conservative agricultural. This entails an acceptable level of mechanization, a reduction of energy inputs as well as the adoption of highly stable and potentially productive cultivars (Thompson and Taylor, 1982; Bond, 1987; De Giorgio *et al.*, 1997).

One of the most influential technical factors on the outcome of a crop is the tillage method since it changes both the physical properties and moisture content of the soil (Thompson and Taylor, 1982; Varco *et al.*, 1989; Pilbeam *et al.*, 1990; De Costa *et al.*, 1997). This is particularly important in hot arid climates found in the Mediterranean Basin (De Giorgio *et al.*, 1998). In this area, cereal cultivation is dominant and continuous cropping is often cultivated. Legume cultivation requires a more demanding preparation of seedbeds. Hence, evaluating the possibility of adopting more moderate tillage methods in this area could facilitate a large-scale reintroduction of broad bean in different crop rotations. This could lead to a reduction in production costs and an increase in the availability of nitrogen, accumulated in the soil, for subsequent crops. Thus, the reintroduction of broad beans could bring about higher profits for growers and contribute to increased environmental protection due to a cutback in nitrogen applications. The following study was carried out by the Experimental Agronomic Institute of Bari. The aim was to determine the effects that different tillage systems can have on broad bean production. Both soil characteristics and yield performance are compared and reported.

Materials and Methods

Field sites and climate

The study was carried out from 1995 to 1997 in a semiarid Apulian plain known as the *Tavoliere Pugliese*, in southern Italy. The soil in the trial area is silty-clay textured and has moderate fertility. It is classified as Typic Chromoxerert by the Soil Taxonomy USDA (Gee *et al.*, 1986). The climate is defined as “accentuated thermomediterranean” on the FAO-UNESCO Bioclimatic Maps. It is hot and dry in the summer and cool in the winter. The moderate rainfall is concentrated in autumn and spring. During 1995 and 1997, the rainfall levels recorded for the period from November to May were 315.8 and 262.8 mm for the first and second years, respectively. During the first year of the study, temperatures fell below 0°C at the beginning of flowering. In the second year, between the end of flowering and the beginning of pod formation the temperatures fell below 0°C several times.

Experimental design and treatments

The broad beans were grown in rotation with durum wheat and a randomized block design with three replicates of 1120 m² size plots, was chosen for the trial. The soil was subjected to four different tillage systems: CT - conventional tillage (double-share ploughing at 35-40 cm depth, rotary tillage operations at 20 cm with disc plough, 5 cm rotary tillage); TT - two-layer tillage (combined equipment – 50 cm sub-soiling and 5 cm rotary tillage); ST -

surface tillage (25 cm five-share ploughing, 5 cm rotary tillage); MT - minimum tillage (5 cm rotary tillage). The broad beans were sown in a parcel, which had been fertilized with 50 kg/ha of Nitrogen during the previous year's wheat cultivation. In 1995, the parcels were sown with the cultivar *Aguadulce*. In 1997, this cultivar was substituted with the cultivar *Aguadulce supersimonia* because the latter is more suitable for mechanical harvesting. Between sowing and harvest, the moisture levels in the soil were measured with the gravimetric method. During pod development, the mechanical impedance of the soil was measured with a penetrometer. At harvest, the yield and the main biometric parameters were recorded. The experimental data were then analysed statistically with a SAS/STAT package and graphically with SAS/GRAPH.

Results

In both years, the sprouting was uniform with no variations among the different soil-tilling techniques. The moisture content of the soil varied during the two years depending on the rainfall levels. During the autumn of the first year of the trial, there was low precipitation and, hence, the moisture level in the soil was very low at sowing, as shown in Figure 1.

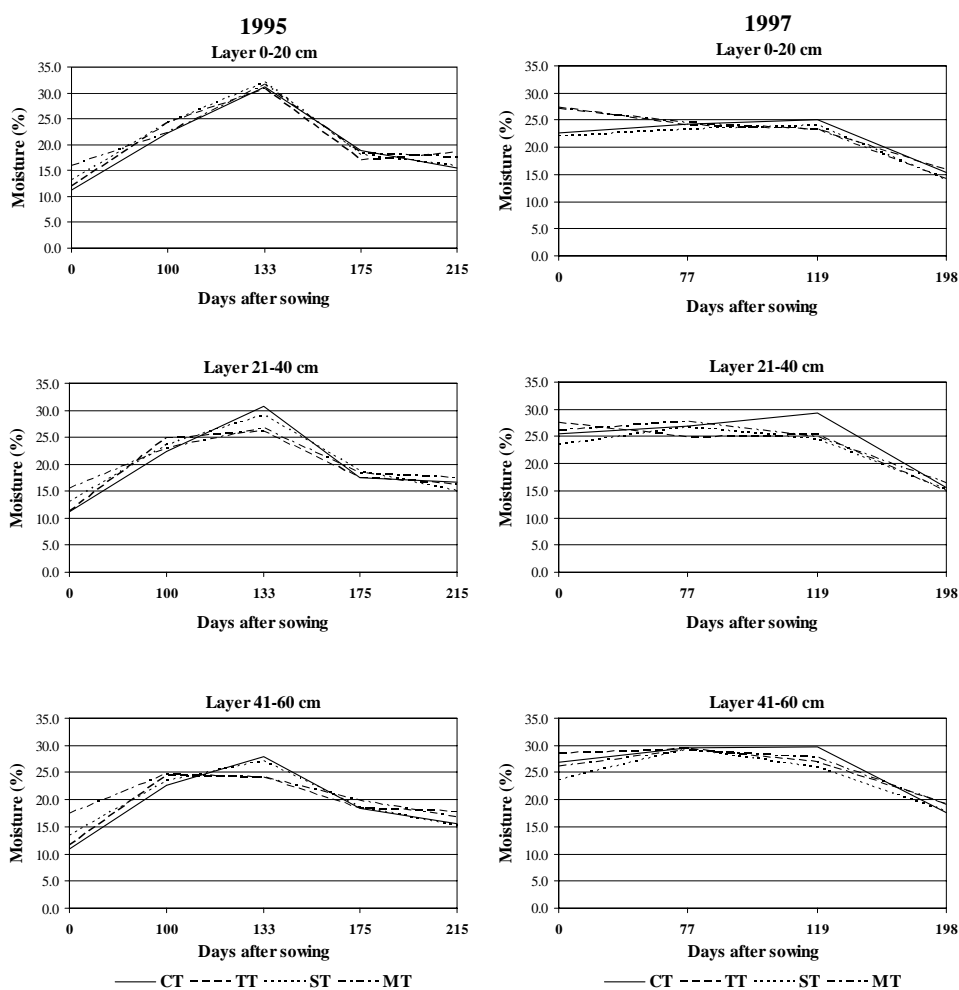


Figure 1. Variations in the soil moisture content of for the different tillage systems measured from sowing to harvest at three depths (0-20, 21-40, 41-60 cm). (CT = Conventional Tillage; TT = Two-Layer Tillage; ST = Surface Tillage; MT = Minimum Tillage)

During the crops main stages of development, precipitation was fair and the moisture levels increased, reaching their highest level on the 110th day after sowing (DAS). By bean maturation, the moisture levels decreased notably. In the second year, there was abundant precipitation in autumn, which produced good moisture levels at sowing and continued for most of the growth cycle. However, after the 119th DAS, which corresponded with flowering, these levels decreased.

The different tillage systems produced slight differences in the moisture levels in the soil. In periods with low

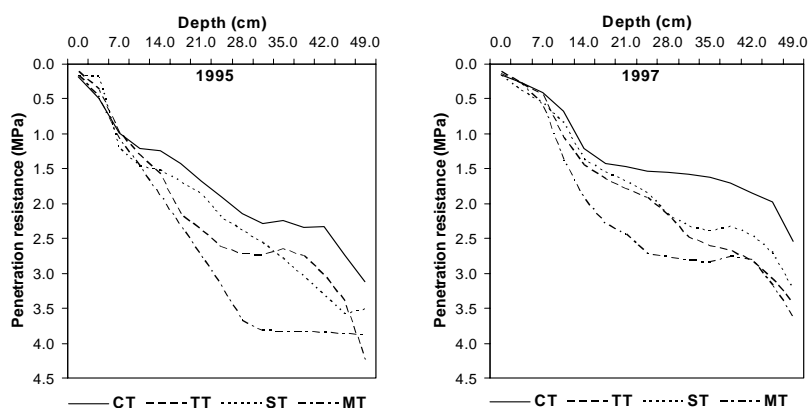


Figure 2. The effects of the tillage methods on the soil resistance to penetration measured at pod formation. (CT = Conventional Tillage; TT = Two-Layer Tillage; ST = Surface Tillage; MT = Minimum Tillage)

precipitation, the moisture levels tended to be higher with minimum tillage, especially in the lower layers of the soil. Instead, during periods with greater rainfall, the values tended to be higher with conventional tillage. This difference is of great importance in semiarid environments such as southern Italy where drought is common. Under these conditions, minimum tillage can better preserve the limited availability of water in the soil. Among the tillage systems, differences in resistance to penetration (Figure 2) were noted below 10 cm in depth. In both years, the greatest resistance was found in the soil worked with minimum tillage. In the 20-40 cm layer, the variation in resistance between minimum and conventional tillage were even more evident, causing a difference of about 2 MPa in both years. The other two techniques, two-layer and surface tillage, produced an intermediate situation up to 40 cm in depth. At deeper levels, their trend became more like that of minimum tillage. The minimum and two-layer tillage do not involve turning the soil. In the plots where these methods were used, a greater presence of weeds was found with an increase in the coverage index between 2 and 2.5% (Figure3).

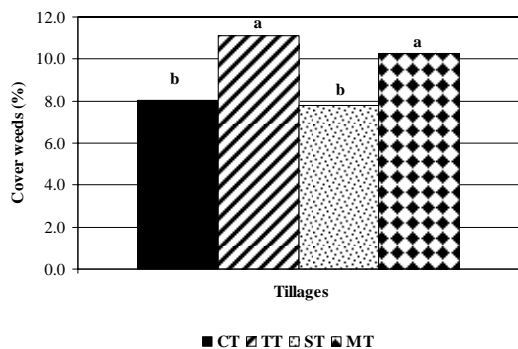


Figure 3. The effects of the soil tillage on the percentage of weed coverage. Values averaged over the two-year trial period. (CT = Conventional Tillage; TT = Two-Layer Tillage; ST = Surface Tillage; MT = Minimum Tillage)

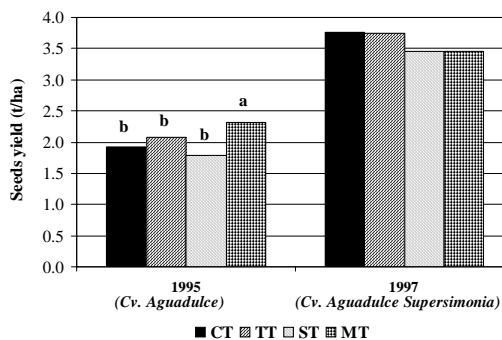


Figure 4. The effects of the soil tillage on the broad bean yields during the two-year study. (CT = Conventional Tillage; TT = Two-Layer Tillage; ST = Surface Tillage; MT = Minimum Tillage)

Single degree of freedom contrast analysis between minimum tillage vs. conventional, two-layer and surface tillage was carried out using the data collected at harvest. From this analysis, the only differences found were in the grain yield the first year and the height of the first pod on the main stem the second year (Table 1). In the first year there was a rapid fall in temperature during full flowering, which had a negative effect on the general levels of productions. The average yield for the whole trial was 1.95 t/ha. Under these conditions, minimum tillage produced a yield of a little more than 1 t/ha. This level was higher than those produced by the other tillage techniques, which were similar to each other (Figure 4).

In the second year, using the cv *Aguadulce supersimonia*, the average level of productivity was 3.4 t/ha. There weren't significant differences between minimum tillage and other tillage systems. Conventional and two-layer tillages demonstrated a slight increase, but they weren't significant in comparison with the other methods. In this same year, the height of the first pod on the main stem was 2.4 cm greater with conventional tillage. In conclusion, the four tillage systems did not significantly influence the main parameters at harvest.

Table 1. Single degree of freedom contrast analysis between minimum tillage (MT) vs. conventional tillage (CT), two-Layer tillage (TT) and surface tillage (ST) for the yield and the main biometric parameters

Parameters	Tillage (MT vs. CT, TT, ST)			
	1995		1997	
	F	Pr>F	F	Pr>F
Seed yield (t ha ⁻¹)	5.78	*	2.39	n.s.
Weight of 1000 seeds (g)	0.55	n.s.	3.13	n.s.
Total dry matter (TDM)	2.50	n.s.	0.02	n.s.
% of roots dry matter vs TDM	2.44	n.s.	0.43	n.s.
Seeds (n./plant)	4.08	n.s.	0.26	n.s.
Pod (n./plant)	0.24	n.s.	3.34	n.s.
Fertile node of first stem (n.)	1.02	n.s.	0.91	n.s.
Height of first pod of principal stem (cm)	0.03	n.s.	9.14	*

* = significant P≤0.05; n.s. = not significant.

Conclusions

The results of this two-year study demonstrate that in conditions of limited water availability, such as those present in semiarid areas, a greater quantity of moisture can be conserved in the soil if minimum tillage is used. The greater resistance that the broad bean root system encounters because of the minimum tillage will not have a negative influence on the development of the plant or the crop yield. In conclusion, the results of this study indicate that, in semiarid environments, broad bean can give satisfactory results with minimum tillage. As a result, the production of broad beans can be managed with minimum tillage, while maintaining good production levels and reducing costs. In addition, it can help to protect the environment by allowing the nitrogen accumulated in the soil to be available for uptake by subsequent crops and by reducing the consumption of non renewable resources.

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