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Tillage system effects upon productivity of *Menta* x *piperita* L.

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Abstract. The trial examined the cultivation of *Mentha x piperita* L. (variety Rubescens Camus). The experiment was carried out under Mediterranean climatic conditions. The experiment considered the adoption of three cultivation techniques: (P1) minimum tillage to a depth of 20 cm using a disk harrow, (P2) minimum tillage to a depth of 30 cm using a disk harrow, (P3) conventional tillage by mouldboard ploughing to a depth of 40 cm and then a tillage to a depth of 20 cm using a cutter. In 2006 and 2007 the following biometric parameters were determined: stalk length, number of leaves, total fresh weight, fresh weight of the root, fresh weight of the stalk, fresh weight of the leaves, total dry weight and LAI and weeding floristic mapping was performed. Considering the parameters most strictly linked to the economic results (total fresh weight, fresh weight of the leaves and total dry weight) for 2006 and 2007, we found that P2 treatment showed the best performance. P3 has higher values than P1, but in the case of the fresh weight of the leaves and the total dry weight these differences are minor. The results of this trial indicate that minimum tillage of 30 cm is more productive for M*enta x Piperita* L. Minimum tillage of 20 cm is less productive than conventional tillage.

Keywords. Mentha piperita - Minimum tillage – Yields - Mediterranean climatic conditions.

Les effets du labour sur la productivité de la Menta x piperita L.

Résumé. *L'étude examine la culture de la Mentha x piperita L.(Menthe poivrée variété Rubescens Camus) en milieu méditerranéen, conduite selon trois différentes techniques de labour du sol: (P1) tillage minumum à une profondeur de 20 cm., avec herse à disques, (P2) tillage minumum à une profondeur de 30 cm avec herse à disques, (P3) labour traditionnel avec charrue, suivi par un travail à la fraise à une profondeur de 20 cm. Pendant ces essais qui se sont poursuivis au cours de deux ans, on a examiné les paramètres suivants: longueur de la tige, nombre des feuilles, poids frais total, poids frais des racines, poids frais des tiges, poids frais des feuilles, poids sec total, LAI (Indice de surface foliaire) et présence de mauvaises herbes. En conclusion l'étude a mis en relief que, sur les deux ans, considérant les paramètres les plus importants pour le marché, la technique P2 est celle qui aboutit aux meilleurs résultats. P3 réalise des valeurs plus élevées que P1, sauf dans le cas du poids frais des feuilles et du poids sec total, paramètres pour lesquels la différence était moins sensible. Les résultats de l'étude mettent en évidence que le labour du sol à une profondeur de 30 cm. représente la solution la plus indiquée pour la culture de la Mentha x piperita L.*

Mots-clés. *Menthe poivrée – Tillage minimum – Productions – Milieu méditerranéen.*

I – Introduction

Soil water is the major limiting factor in dryland crop production in the Mediterranean region of Italy. Conservation tillage has been proposed as a promising strategy to improve soil and water conservation in these areas (Unger P.W., McCalla T.M., 1980; Lòpez M.V., Arrùe J.L., 1997; Hajabbasi M.A., Hemmat A,. 2000). Therefore, farmers need to manage crop residues and tillage to control soil erosion and effectively store and use the limited precipitation received for crop production (Hemmat A., Eskandari I., 2004; Hemmat A., Taki O., 2001). Tillage systems modify, in the short term, some of the physical properties of soil, such as soil porosity. Tillage has also an indirect effect on soil water content during the growth cycle of plants, particularly in areas with a Mediterranean climate. In several studies, minimum tillage has been reported to produce crop yields similar to (Carter M.R., Rennie D.A., 1984) or higher than (Tessier S. at all., 1990) conventional tillage.

II – Modeling approach

The trial examined the cultivation of *Mentha x piperita* L. (a variety of rubescens Camus) and was carried out in 2006 and 2007 in a field located near Segezia (FG) (41° 22' latitude N; 15° 18' longitude E). Table 1 presents physical and chemical properties of the soil.

Table 1. Physical and chemical properties of the soil.

	Depth 20 cm	Depth 30 cm	Depth 40 cm
pH	7.8	7.3	7.5
Total N (g kg^{-1})	1.6	1.5	1.4
Total C (g kg^{-1})	18	19	19
Available P (mg kg^{-1})	30	35	32
Sand (%)	57.9	59.5	61.7
Silt (%)	38	35.7	32.2
Clay (%)	4	4.8	6.1

The experiment was carried out under Mediterranean climatic conditions, characterized by rain mostly distributed in autumn and winter and a dry period in summer. Figure 1 presents the climatic conditions (precipitation and temperatures) from September 2005 to December 2007.

In 2006 a total rainfall depth of 739 mm occurred in late winter-early spring (from January to March). Usually spring crops can benefit from rain water stored in the soil.

In 2007 a total rainfall of 620 mm was recorded, but from January to March precipitation levels were half that of 2006. Temperatures for both years were similar.

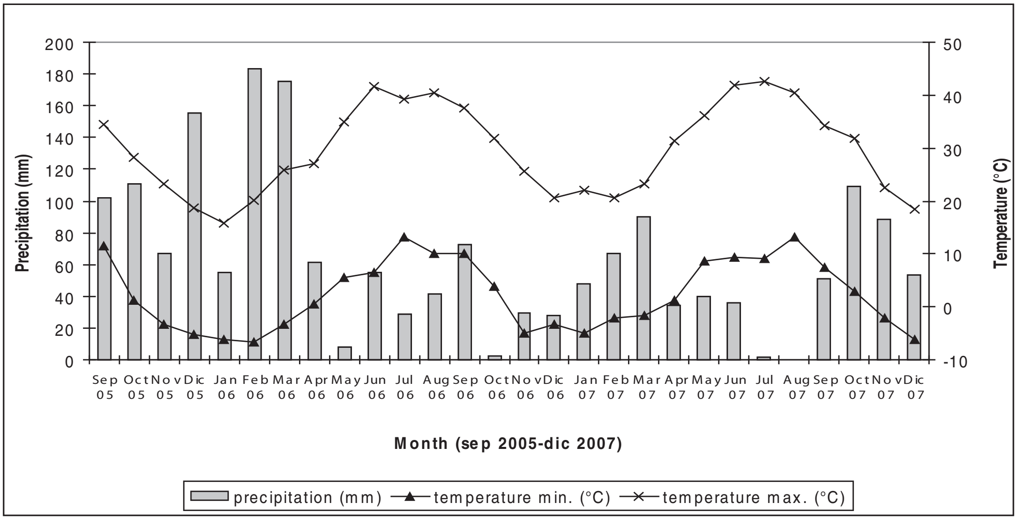

Figure 1. Climatic condition (precipitation and temperature).

The study was organized in a randomized complete block design with three replicates and each plot received the same treatment during the period of study. Plot size was 5 m by 2 m.

The experiment considered three cultivation techniques: (P1) minimum tillage to a depth of 20 cm using a disk harrow, (P2) minimum tillage to a depth of 30 cm using a disk harrow, (P3) conventional tillage by mouldboard ploughing to a depth of 40 cm followed by tillage to a depth of 20 cm using a cutter.

Tillage was carried out in January and a 100 units of ammonium nitrate were spread.

The stolons were manually replanted in rows 50 cm apart on 2/05/06 and a distance of 20 cm was left between each seedling. All the stolons were watered with a sprinkler immediately after replanting (about 400 m^3 of water/ha); the stolons were then watered a further four times, at 20 day intervals until the second harvest. In total, the plants were irrigated with 2000 m^3/ha/year of water.

Two manual weeding operations were carried out before each harvest. And before weeding floristic mapping was performed using the Bruan Blanquet method.

On 28/05/06, fertilization was performed using a mineral based leaf fertilizer containing NPK (40 40 20).

Two harvests were carried out per year: one before flowering (the third week of June) (D1) and one at the end of July (D2).

At each harvest some plants one meter long were harvested from each test group and the following biometric parameters were determined: stalk length, number of leaves, total fresh weight, fresh weight of the root, fresh weight of the stalk, fresh weight of the leaves, total dry weight and LAI. In order to calculate the dry weight, the product was kept in an oven at a temperature of 60°C.

All the data collected from the experiments were subjected to variance analysis using ANOVA statistical analysis.

III – Results and discussion

Tillage effected the biometric parameters significantly in both years (Table 2) but results were not significant for LAI.

The results shown in Table 2 indicate that all the biometric parameters examined were higher in P2, whereas only the root length was longer in P3 probably due to the fact that the soil was tilled to a lower depth of 40 cm which allowed the roots to grow longer.

In 2006, the highest precipitation levels were recorded in February and March and this rainfall was stored in the soil and was subsequently utilized by *Menta x Piperita* L. in the springtime during the taking of the root. The deeper tillage in P3 probably allowed the water to percolate deeper than in P1 and P2 and the seedlings were not able to utilise it. Then the biometric parameters examined in P3, apart from root length, were smaller than the parameters in P2.

It is possible that the minimum tillage depth of 20 cm (P1), compared to the deeper tillage depths (P2 and P3) permitted the growth of a greater number of weeds and so the biometric parameters of the seedlings in P1 were lower because they had to compete with more weeds (Figure 2), such as *Convolvulus arvensis* L. and *Chrysantemum segetum* L. in particular. In effect, the results of floristic mapping for 2006 indicate that the relative efficiency of weed containment (%) for *Convolvulus arvensis* L. was 50% in P1, 74% in P2 and 79% in P3 and in 2007 results showed an efficiency of 55%, 79% and 86% for P1, P2 and P3 respectively. The results of floristic mapping indicate that the relative efficiency of weed containment (%) for *Chrysantemum segetum* L. in 2006 was 67% in P1, 75% in P2 and 100% in P3 and in 2007 it was 78%, 77% and 96% for P1, P2 and P3 respectively.

In fact, all the biometric parameters in P1 were lower than or equal to those in P3, except for stalk length which was higher. The *Menta x Piperita* L. plants in P1 are probably higher because they had to compete with a greater number of weeds for the light.

Considering the parameters most strictly linked to the economic results, in particular total fresh weight, fresh weight of the leaves and total dry weight, higher values for 2006-2007 can always be found in P2 as shown in Figure 3. In effect, considering D1+D2 in 2006 the total fresh weight (g m^{-2}) in P1 is 442,3, in P2 it is 812 and in P3 it is 501,6 while in 2007 in P1 it is 347,2, in P2 it is 706,7 and in P3 it is 490,2. The fresh weight of the leaves (g m^{-2}) is 122,4 in P1, 348,8 in P2 and 160,8 in P3 in 2006 while in 2007 it is 116,8 in P1, 256,9 in P2 and 127,5 in P3. In 2006 the total dry weight (g m^{-2}) is 106,4 in P1, 170,8 in P2 and 112,24 in P3 and in 2007, 109,1 in P1, 179,3 in P2 and 145,4 in P3.

The results of this trial indicate that P3 has higher values than P1, but in the case of the fresh weight of leaves, a parameter of interest to the distilled essential oils industry, these differences are of minor importance.

In the case of the total dry weight, which is a parameter of interest to the herbalist industry, these differences also carry little importance.

Table 2. Influence of tillage depth on biometric parameters of *Menta x Piperita* L.

Tillage depth/ harvest/ year	Total fresh weight (g m^{-2})	Fresh weight of the root (g m^{-2})	Fresh weight of the leaves (g m^{-2})	Fresh weight of the stalk (g m^{-2})	Root length (cm plant)	Stalk length (cm plant)	Number of leaves (n m^{-2})	Total dry weight (g m^{-2})
P1xD1 06	160.3 E	72 E	51.2 F	32.72 E	15.3 D	17.3 D	179 E	33,6 DE
P2xD1 06	381.2 A	84.4 D	215.6 A	32.4 E	14.7 E	14.9 E	611 B	76.4 B
P3xD1 06	204.8 D	85.2 D	66.4 E	40.4 D	15.2 D	16.2 E	331 C	35.84 D
P1xD2 06	262 C	143.6 B	71.2 D	50 C	15.9 D	28.9 A	332 C	72,8 C
P2xD2 06	430.8 A	193.2 A	133.2 B	84.4 A	16.5 D	29.1 A	811 A	94.4 A
P3xD2 06	296.8 B	109.2 C	94.4 C	76 B	22.5 A	28.6 B	623 B	76.4 B
P1xD1 07	140.5 E	86.4 D	49.1 F	40.2 D	16.9 D	18.5 D	180 E	35,3 D
P2xD1 07	293.1 B	76.4 D	149.7 B	31.5 E	21.5 B	15.7 E	622 B	75.2 B
P3xD1 07	214.7 D	87.3 D	52.8 F	34.5 E	22.4 A	14.9 E	181 E	71.5 C
P1xD2 07	206.7 D	110.4 C	67.7 E	52.6 C	19.9 C	27.5 B	290 D	73.8 C
P2xD2 07	413.6 A	183.3 A	197.2 A	79.8 A	20.5 B	28.9 A	789 A	104.1 A
P3xD2 07	275.5 B	90.3 D	74.7 D	54.8 C	25.3 A	20.1 C	295 D	73.9 B

Values followed by the same letters in each column are not significantly different according to Tukey's ($p \leq 0.01$) test.

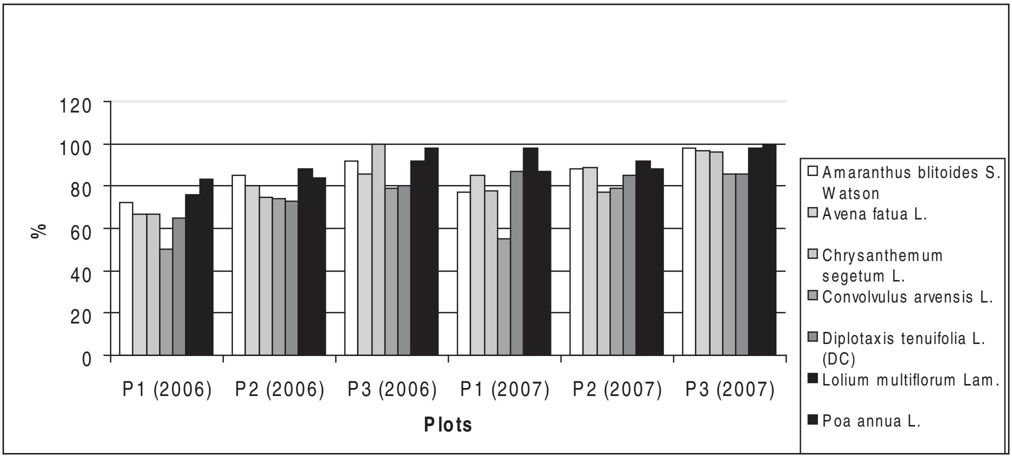

Figure 2. Relative efficiency of weed containment.

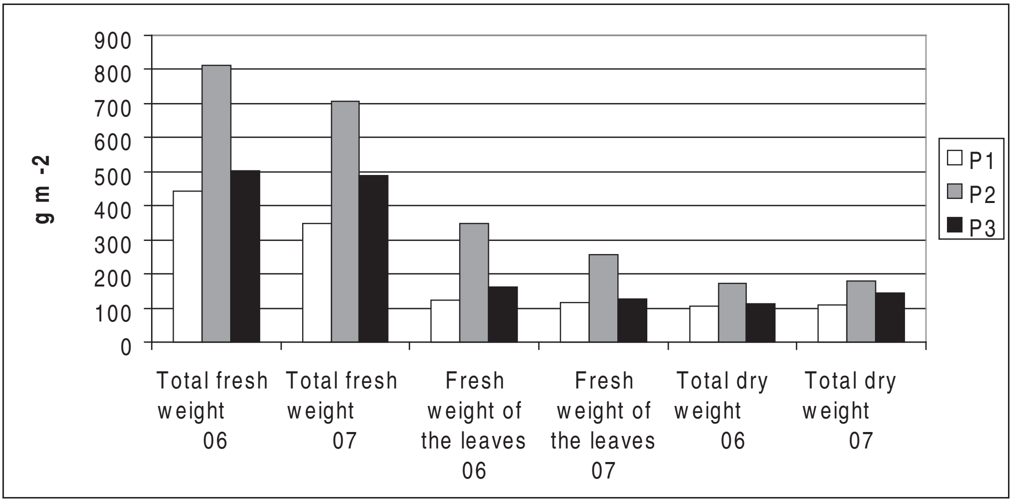

Figure 3. Total fresh weight, fresh weight of the leaves and total dry weight (06-07).

IV – Conclusions

In conclusion, the results of this trial indicate that the cultivation of *Mentha x piperita* L. (*Rubescens Camus* variety) in Mediterranean climatic conditions produces good results when minimum tillage to a depth of 30 cm using a disk harrow is adopted. Minimum tillage to 30 cm is probably more productive for *Menta x Piperita* L. because this technique makes it possible to simultaneously contain the growth of weeds and allow the soil to retain the water which is necessary for the plants.

Minimum tillage to a depth of 20 cm using a disk harrow is less productive than conventional tillage because it causes a greater number of weeds to grow.

Conventional tillage by mouldboard ploughing to a depth of 40 cm followed by tillage to a depth of 20 cm using a cutter is less productive than minimum tillage to a depth of 30 cm using a disk harrow, because the water percolates too deep and the seedlings are not able to utilise it.

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