EFFECT OF SPENT MUSHROOM COMPOST ON P AND K FERTILITY IN A VINEYARD SOIL OF THE LA RIOJA REGION (SPAIN)

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1 INTRODUCTION

At present, 306.000 Mg of Spent Mushroom Substrate (SMC) are yearly produced in La Rioja region (Spain), the production of mushroom represents the second major activity in this region after vineyard farming. These SMC have been accumulated at open cast dumping sites, where lixiviation becomes a serious contamination source for groundwaters. This organic waste, owing to its high organic matter (OM) content and appreciable amounts of essential plant nutrients as N, P, K, Ca and Mg, and could be exploited as a soil fertilizer and amendment to increase the OM content in vineyard soils which are generally low (< 1 %) in La Rioja region (Peregrina et al., 2010). However few information exits about the SMC utilization in vineyard with the agronomic conditions of the La Rioja region. For this we studied the effect of two different SMC (fresh and recomposted) with two different rates of dry matter (DM), as organic amendment (25 Mg ha⁻¹) and as fertilizer (8 Mg ha⁻¹), in the P and K soil fertility.

2 MATERIALS AND METHODS

2.1 Site description and experimental design

The experiment was established in 2006, at the experimental farm “La Grajera” property of La Rioja region government (northern Spain) (42°27’N, 2°31’E), in Logroño (La Rioja). The vineyard selected, was established in 1990 with Vitis vinifera L., cv. ‘Tempranillo’, grafted on 110-R rootstock, which had a planting density of 3135 vines per hectare.

The experimental design was a randomized complete block with five treatments and three replications per treatment with subplots of 35.09 m². The soil was classified as Typic Haploxerepts (Soil Survey Staff, 2006). The particle size distribution of surface horizon was 33.7 % sand, 43.3 % silt and 23.0 % clay. Respect the carbonates content it was 14.9 % and pH H₂O 8.62. The organic matter content was 0.93 %, similar to the OM content in vineyards of Rioja region (Peregrina et al., 2010).

In general the climate in the area is semiarid, with heavy winter rains and summer drought conditions. For the period 2005–2008, the average annual precipitation was 477 mm, average annual temperature was 12.9 °C, and average annual potential evapotranspiration (FAO-Penman) was 1123 mm.

2.2 Description of SMC

Two different SMC were used in the assay.

- Fresh SMC (F-SMC). It comes directly from the farms where the mushrooms are cultivated, and as only preparation process the plastics and the “gravillín” (little calcic stones) were eliminated. The SMC properties were OM (49-65%), relation C/N (13-17) and nutrient contents of 2-2.9 % N, 0.70-0.95 % P, 0.74-0.96 % Mg and 1.97-2.40 % K. (Table 1).

- Recomposted SMC (R-SMC). The F-SMC was recomposted under aerobic conditions during 90 days. In these 90 days, SMC structure is enhanced with the addition of wood pieces. The SMC is turned over under aerobic conditions and, after the elimination of the residual wood pieces (which have not been incorporated to the SMC during the recomposting process), SMC is finally sieved, crumbled, and homogenized. The properties of the resultant material were OM (41-52%), C/N ratio (13-16.2) and nutrient contents of 1.4-1.8 % N, 0.60-0.85 % P, 0.97-2.45 % Mg and 1.80-2.20 % K (Table 1).
TABLE 1  Physical and chemicals properties of the F-SMC and R-SMC

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<tr>
<td>Dry matter (%)</td>
<td>50.2</td>
<td>48.1</td>
<td>26.7</td>
<td>50.3</td>
<td>58.8</td>
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<tr>
<td>pH (1:5)</td>
<td>6.7</td>
<td>8.1</td>
<td>6.6</td>
<td>6.7</td>
<td>8.1</td>
</tr>
<tr>
<td>E.C. 1:5 (mS/cm)</td>
<td>6.0</td>
<td>5.4</td>
<td>5.6</td>
<td>7.1</td>
<td>5.8</td>
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<tr>
<td>O.M (%)</td>
<td>48.9</td>
<td>39.1</td>
<td>65.4</td>
<td>36.2</td>
<td>63.5</td>
</tr>
<tr>
<td>O. C. (%)</td>
<td>28.4</td>
<td>22.7</td>
<td>37.9</td>
<td>21.7</td>
<td>37.4</td>
</tr>
<tr>
<td>N total (%) d.m.)</td>
<td>2.0</td>
<td>1.4</td>
<td>2.9</td>
<td>1.6</td>
<td>2.2</td>
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<tr>
<td>C/N</td>
<td>14.2</td>
<td>16.2</td>
<td>13.1</td>
<td>13.1</td>
<td>17</td>
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<tr>
<td>P (%) d.m.)</td>
<td>0.85</td>
<td>0.6</td>
<td>0.94</td>
<td>0.64</td>
<td>0.73</td>
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<tr>
<td>K⁺ (%) d.m.)</td>
<td>2.05</td>
<td>1.91</td>
<td>2.46</td>
<td>1.8</td>
<td>2.7</td>
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<tr>
<td>Mg²⁺ (%) d.m.)</td>
<td>0.74</td>
<td>2.45</td>
<td>0.96</td>
<td>0.97</td>
<td>0.87</td>
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2.3  Treatments

Treatments were applied for three consecutive years. The first application was in May 2006, the second in April 2007 and the third in February 2008. The compost was distributed homogeneously on surface, and mixed with the soil (0-15 cm depth) by cultivator.

The rates of the annual application of DM were:
- C: Control, without SMC application.
- F08: F-SMC rate of 6630 kg ha⁻¹ in 2006; 7996 in 2007 and 8417 kg ha⁻¹ 2008.
- R08: R-SMC rate of 7975 kg ha⁻¹ in 2006; 8009 kg ha⁻¹ in 2007 and 8289 kg ha⁻¹ 2008
- F25: F-SMC rate of 9889 kg ha⁻¹ in 2006; 25228 in 2007 and 26288 kg ha⁻¹ 2008.
- R25: R-SMC rate of 23925 kg ha⁻¹ in 2006; 25010 kg ha⁻¹ in 2007 and 25890 kg ha⁻¹ in 2008.

In each application the SMC treatments as fertilizers (F08 and C08) supplied approximately 160 kg N ha⁻¹, 160 kg K ha⁻¹ and 60 kg P ha⁻¹ and the P and K amounts supplied are lightly higher than the N, P and K vine crop requirements, also the SMC treatments as organic amendments (F25 and C25) supplied approximately 500 kg N ha⁻¹, 500 kg N ha⁻¹ and 200 kg P ha⁻¹.

2.4  Soil sampling and analysis

In February 2009, soil samples were collected for each plot at three depths (0-15, 15-30 and 30-60 cm). Soil samples were air dried, and the soil ground and sieved to 2 mm. P and K were extracted by the Mehlich III method (Mehlich, 1984) and determined by ICP. Mg exchangeable was determined by cobaltihexamine method (Orsini and Remy, 1976).

2.5  Statistical Analysis

Soil properties were statistically analysed using a completely randomised block design. Treatment effects on measured variables were tested using ANOVA (univariate linear model), and comparisons among treatment means were made using the least significant difference (LSD) multiple range test calculated at p < 0.05. Statistical procedures were carried out with the software program SPSS 12.0.

3  RESULTS AND DISCUSSION

All SMC treatments increased significantly the P respect to the control in the 0-15 cm depth (Fig. 1). The F25 and R25 treatments tended to be higher respect to the F08 and R08 treatments. In the 15-30 cm depth, the P tended to increase respect to the control in all SMC treatments, this increments were significant in the R08, F25 and R25 treatments. In the 30-60 cm depth, the effects of the SMC treatments were few appreciable. Courtney and Mullen (2008) also reported P increments in the soil surface after the SMC application (25 Mg ha⁻¹).

Our results indicate that the P rate applied was greater than the P uptake by the vine. P was accumulated in the zone of application (in the 0-15 cm depth) due to the low mobility of the P in the soil. Therefore, at the soil
surface (0-15 cm) for all SMC treatments, the P reached a very high value for all kind of crops according to Sawyer et al. (2006).

The K content tended to increase respect to the control in all SMC treatments at 0-15 and 15-30 cm depth. In the case of the higher rate (F25 and R25) this increments were significant. Similar results were reported by Courtney and Mullen (2008). The SMC treatments at 0-15 cm depth, reached a K value very high for all kind of crops according to Sawyer et al. (2006).

Also in the F25 and R25 treatments the K:Mg ratio reached values higher than the desirable (0.7) for orchards crops (López and López, 1978) (Fig. 2), due to the K accumulation in the soil surface (0-15 cm depth) caused by the SMC application.

Different letter indicate significant differences between treatments with LSD (p < 0.05)

FIGURE 1  P and K content at three different depths of the soil after three SMC applications

Different letter indicate significant differences between treatments with LSD (p < 0.05)

FIGURE 2  K/Mg ratio at three different depths of the soil after three SMC applications
4 CONCLUSIONS

The two types of SMC (fresh and recomposted) have similar effects as P and K fertilizer in the two rates studied. After 3 years of applications, all SMC treatments can increase the P and K availability in soil, particularly in the 0-15 cm depth where the SMC was applied.

The higher rates of SMC (25 Mg ha\(^{-1}\)), cause an excessive K content in the soil surface (0-15 cm), and therefore increase the K:Mg ratio to undesirable level for the vine crop. The SMC utilization as organic amendment (with rate > 25 Mg ha\(^{-1}\) d.m.) must be avoid in soil with an adequate K soil content.

Finally the N amounts supplied with the SMC treatments were higher than the requirements of the vine crop and therefore is necessary evaluate the organic N mineralization for avoid the environmental risk due to nitrate soil accumulation and the leaching to groundwaters.

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REFERENCES


