Effects of compost on lettuce (*Lactuca sativa)* yield and soil biochemical properties

Efectos de compost sobre el rendimiento de lechuga y propiedades bioquímicas del suelo

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A B S T R A C T

Amended soils with compost produced from livestock effluents can increase soil fertility and crop productivity. The aim of this work was to assess the effect of the fertilization with a compost on the soil enzymatic activity and yield of a lettuce crop. An experiment was carried out under field conditions with the following treatments: control without fertilization; mineral N fertilization with 85 kg N ha^{-1} (Ni85); fertilization with compost in pellets (CP170N) at N dose of 170 kg ha^{-1}; fertilization with CP at N dose of 85 kg ha^{-1} together with mineral N at 42.5 kg ha^{-1} (CP85N+Ni42.5). The fertilization increased the lettuce biomass compared with the control treatment; the pelletized compost showed similar yields ($P > 0.05$) than those obtained with the mineral N fertilization. The acid phosphatase and the total microbial biomass increased significantly in the soils fertilized with CP170N treatment. However, the alkaline phosphatase and β-glucosidase were similar between the treatments. The acidic pH of the soil may have decreased the alkaline phosphatase activity. The application of the pelletized compost at a dose of 170 kg N ha^{-1} showed the best agronomic behavior regarding the lettuce yield, the soil microbial biomass and the acid phosphatase activity.

Keywords: acid phosphatase; pelletized compost; soil enzimatic activities; vegetable crops.

R E S U M E N

Suelos enmendados con compost producido a partir de efluentes de ganado pueden aumentar la fertilidad del suelo y la productividad de los cultivos. El objetivo de este trabajo fue evaluar el efecto de la fertilización con compost sobre la actividad enzimática del suelo y el rendimiento de un cultivo de lechuga. Se realizó un experimento en condiciones de campo con los siguientes tratamientos: testigo sin fertilización; fertilización mineral N con 85 kg N ha^{-1} (Ni85); fertilización con compost en pellets (CP170N) a dosis de N de 170 kg ha^{-1}; fertilización con CP a una dosis de N de 85 kg ha^{-1} junto con N mineral a 42.5 kg ha^{-1} (CP85N+Ni42.5). La fertilización incrementó la biomasa de lechuga en comparación con el tratamiento testigo; el compost peletizado mostró rendimientos similares ($P > 0.05$) a los obtenidos con la fertilización con N mineral. La fosfatasa ácida y la biomasa microbiana total aumentaron significativamente en los suelos fertilizados con el tratamiento CP170N. Sin embargo, la fosfatasa alcalina y la β-glucosidasa fueron similares entre los tratamientos. El pH ácido del suelo puede haber disminuido la fosfatasa alcalina. La aplicación de compost peletizado a la dosis de 170 kg N ha^{-1} mostró el mejor comportamiento agronómico en cuanto al rendimiento de la lechuga, la biomasa microbiana del suelo y la actividad de la fosfatasa ácida.

Palabras claves: fosfatasa ácida, compost peletizado, actividades enzimáticas, hortalizas.

INTRODUCTION

Phosphorus (P) and nitrogen (N) are essential macronutrients for the correct development of plants. The deficiency of these elements in the soil is associated with a loss of yield and functionality of the plant. Under the current agricultural production system, nitrogen and phosphate fertilizers obtained from nonrenewable and finite resources such as fossil fuel energy and phosphate rock deposits. The manufacture of the phosphate fertilizers will reach a maximum in the coming decades, since they are essential to maintain and increase high crop yields (Dawson & Hiton, 2011). In addition, an inadequate use in the quantity and application time can lead to environmental problems such as contamination of waterbodies, and watertables as well as losses of N oxides to the atmosphere. In a scenario of world population growth, which entails an increase in food consumption, increasing crop yields in a context of climate change and reducing dependence on mineral fertilizers is essential. Composting organic residues is one method of recycling organic materials. Compost amendments have many beneficial effects on soil quality and function, improving soil structure stability (Yanardağ *et al*., 2017). Labile organic matter, which could improve nutrient availability, contributes to the growth of plants (Sánchez *et al*., 2017). Moreover, compost to soil provides abundant active microbes, further affecting the structure, activity, and metabolic function of the microbial community (Zhang *et al*., 2020). However, its powdery physical condition makes it expensive to transport and difficult to apply to the soil due to its large volume. An alternative is the pelletization of the composts. Besides, combining composts with inorganic fertilizers is therefore an appealing soil management practice. This strategy would make it possible to reduce the rate of inorganic fertilizers added to the soil, thus decreasing the risks of soil degradation and nutrient leaching, while also maintaining soil quality by the organic matter addition.

The aim of this work was to evaluate both the feasibility of using a pelletized compost obtained from a pig slurry effluent, either alone or in combination with inorganic fertilizers, as an alternative to inorganic fertilizers in lettuce cultivation as well as the effect of these treatments on soil microbiological properties.

MATERIAL AND METHODS

Completely randomized experiments were carried out under field conditions with lettuce *(Lactuca sativa)* were carried out in Castelo Branco (39.823655, -7.451606) with four treatments each one with four replicates. Each plot had (1.20 X 0.90 m) with 12 lettuces. The soil is a Cambisol with the following main physicohemical properties: sandy loam texture, pH 6.0, electrical conductivity (EC) (1:5) 0.10 dS m^{-1}, total organic carbon 5.4%, C/N 8.3, available-P 149 mg kg^{-1}, Nk 2.62 g kg^{-1}. The four treatments were: a control without any fertilisation (Control); mineral N fertilisation with a N application rate of 35 kg N ha^{-1} before seedling planting and with 25 kg N ha^{-1} in each top dressing with a total application of 85 kg of inorganic N (Ni85), this is the reference N fertilisation; Application of an amount of compost in pellets (Table 1) corresponding to 170 kg ha^{-1} of N from an organic source-No before seedling planting (CP170N); Application of an amount of compost in pellets corresponding to 85 kg ha^{-1} of N from an organic source (CP85N) plus 22.5 kg ha^{-1} of N from a mineral fertiliser (Ni22.5) before seedling planting and of 20 kg Ni ha^{-1} at the first N top-dressing (CP85N+Ni42.5). After harvest, fresh biomass was measured and the soil samples were immediately sieved to <4 ◦C for biochemical analyses, while the other fraction was air-dried. P bioavailable by the method of Olsen *et al*. (1954). Nitrogen (Nk) by the Kjeldahl procedure and the β-glucosidase activity was determined according to Eivazi and Tabatabai (1969). Acid and alkaline phosphatase were determined according to Tabatabai and Bremner (1969). Soil microbial

Tabla 1 - Chemical composition of the pelletized compost (CP) used in the field experiment

DM (g kg^{-1})	797
OM (g kg^{-1})	542
pH	7.3
EC (dS m^{-1})	1.01
Nk (g kg^{-1})	17.6
P (g kg^{-1})	6.1
K (g kg^{-1})	17.6
Ca (g kg^{-1})	99.4
Mg (g kg^{-1})	15.0
C:N	18

DM, dry matter; OM, organic matter

communities was detreminated by Ester Linked Fatty Acid (ELFAs) according Schutter & Dick (2000).

RESULTS AND DISCUSSION

The biomass production (fresh matter yield) of the lettuce crop showed significant differences between the treatments (Figure 1). The biomass of the lettuce ranged from 2730 g m^{-2} in treatment control to 4280 g m^{-2} in CP170N. The changes in biomass production observed in lectuca crops will be a consequence of the differences in N availability provided through different sources: mineral fertilization or compost application. This suggests that

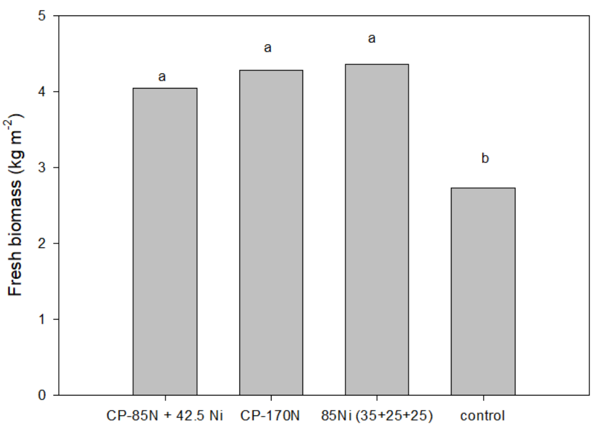

Figure 1 - Fresh biomass of lettuce grown in soil amendment with compost. Values represent the mean (±SE) of four replicates. Different letters represent significant differences between treatments according to the Tukey test (P<0.05).

composts provide lettuce plants with all the nutrients they need, particularly N, and other nutrients (Grassi *et al*., 2015; Hernandez *et al*., 2016).

Overall, compost and its management of fertilization integrated with inorganic fertilization altered the biogeochemical cycle of nutrients in the soil. The soil total N showed values similar to those of the mineral fertilizer with pelletized compost treatments at the highest rate of fertilization (3.05 g kg^{-1}), showing a significantly lower value for the compost applied together with mineral N (Figure 2). Olsen P measured in soil after crop showed a significant increase in the tendency for soil amended with compost at the highest rate of application, with the higher value for CP170N with a value of 96.12 mg kg^{-1} (Figure 3). Soils amended were more effective in increasing soil-available P than fertilized with mineral N fertilizer. These facts show that composts are a source of P and N available for the crop (Ciadamidaro *et al*., 2016; de Sosa *et al*., 2021).

The acticity of β-glucosidase, acid and alkaline phosphatase and the total microbial biomass are shown in Figure 3. The soil amended with compost significantly modified the acid phosphatase activity for CP170N. This treatment showed the higest value for acid phosphatase with an average value of 427 mg pnp kg^{-1} h^{-1} without showing significant differences compared with the mineral and control treatments. This fact could be attributed to an increase in energy expenditure to secrete enzymes by microorganisms and plants in soils with lower content of P available. Although severeal studies

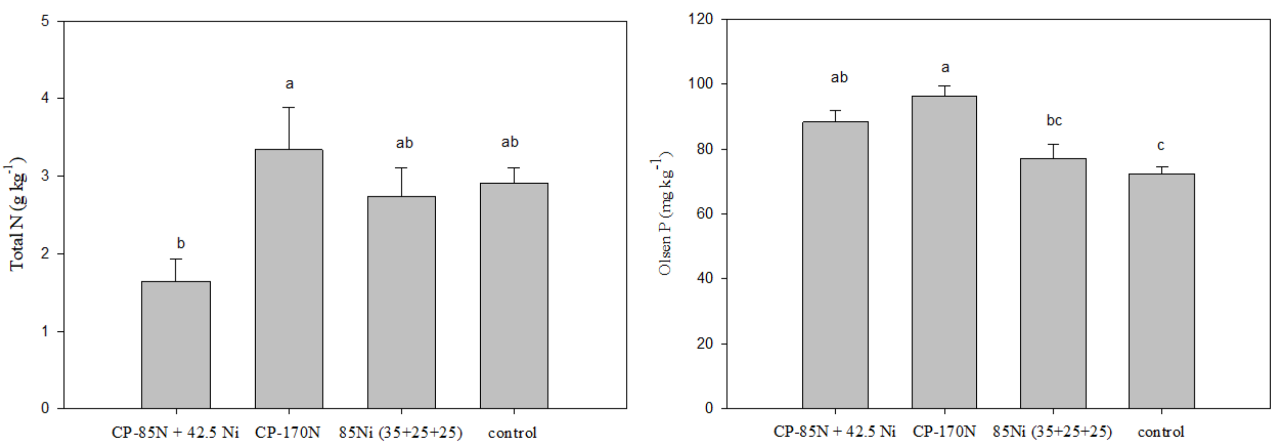

Figure 2 - Total N (a) and Olsen P (b) after crop in soil amendment with compost. Values represent the mean (±SE) of four replicates. Different letters represent significant differences between treatments according to the Tukey test (P <0.05).

have shown an increase in soil microbial activity as β-glucosidase (Hernandez *et al.*, 2016), this fact has occurred after several years of application of organic amendments, while our work only had a crop cycle of 3 months and with only one CP application. CP170N aplication to the soil induced significant changes in total microbial biomas measured by ELFAs although no significant changes were shown between the microbial communities.

CONCLUSIONS

The application of pelletized compost can help reduce the use of mineral fertilizers without affecting crop yield. In addition, it contributes to increasing the content of bioavailable P for the crop, also reduces the dependence on mineral fertilizers. Besides, enzymatic activities, and soil microbial communities were stimulated by organic matter and nutrients supplied by the compost differently depending on the application rate.

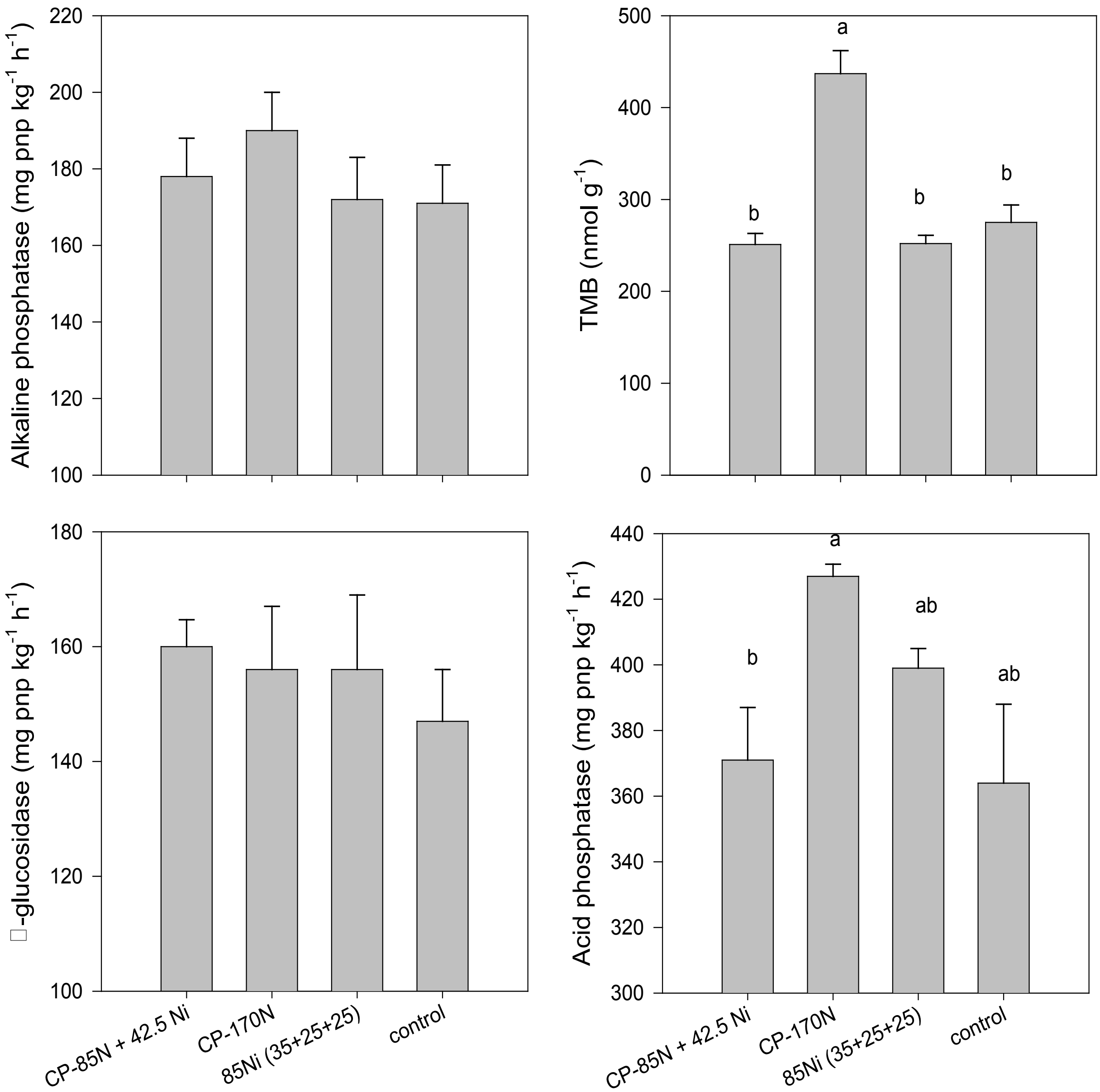

Figure 3 - Changes in enzyme activities and total microbial biomass (TMB) Values represent the mean (±SE) of four replicates. Different letters represent significant differences be- tween treatments according to the Tukey test (P<0.05).

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