Full Length Research Paper

Effects of piggery waste doses and modes of application in the early development of maize plants


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The objective of this work was to evaluate the effect of different doses and modes of application of piggery waste in the early development of maize plants. The experiment was carried out in a greenhouse using a randomized block experimental design, with treatments arranged in a 6x2 experimental scheme. Factors consisted of six doses of piggery waste (0, 20, 30, 40, 50 and 60 m³ ha⁻¹) and two modes of application (incorporated into the soil and placed on the surface), with four replications. The following characteristics were evaluated during the experiment: plant height, stalk diameter, fresh and dry weight of shoots and roots, and root volume. Piggery waste doses led to increases in all analyzed variables, but no statistical difference was found between the modes of application, which indicates that applying the waste on the surface or incorporating it into soil did not result in significant agronomic changes.

Key words: Organic fertilizing, Zea mays, animal waste.

INTRODUCTION

Maize is a monocotyledon plant, belonging to the family Poaceae, genus Zea, and scientifically named Zea mays L. (Fancelli and Lima, 1982). Due to their high nutritional value, its grains are used in human and animal diets, and serve as raw material for industry (Buzetti et al., 2009). It is an essential crop for poultry, pork and beef farming activities (Cieslik et al., 2009), and is regarded as one of the main source of food worldwide.

In Brazil, the average grain yield of maize crops is considered low when compared to those of other producing countries. In most cases, this loss may be linked to fertility factors (lack of nutrient replacement) and soil density (Rizzardi et al., 1994). This is often due to the high cost of industrialized mineral fertilizers and the incorrect use of organic waste generated in rural properties. The increasing costs of commercial fertilizers and growing environmental pollution make the use of organic waste a viable option from an economic standpoint. To Costa et al. (2000) the use of piggery waste in agriculture can result in savings and financial

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gains by increasing crop yields, reducing application of chemical fertilizers and water use, and improving the physical, chemical and biological conditions of the soil.

However, more information is still needed to evaluate the technical and economic viability of applying these types of organic waste on soils for agriculture (Santos et al., 2011), as they must be properly used to minimize their environmental impact (Selbach and Sá, 2004). Most grain producers acknowledge the need for a proper program to manage nutrients applied onto the soil in order to meet yield goals. Even today, little is known about when foliar fertilizers can complement soil-applied fertilizers, in order to increase the use efficiency of the nutrient, yield and profitability (Carvalho et al., 2001).

According to Konzen (2003) incorporating organic waste into soil saves fertilizer, contributing to improve its chemical, physical and mineral properties, thus increasing crop yields. Furthermore, it has a suppressive effect on nematodes, and serves as a solution for disposal problems, avoiding environmental pollution (Ehteshamul-Haque et al., 1996; Zambolim et al., 1996). In that context, the objective of this work was to evaluate possible effects of doses of piggery waste applied on the surface and incorporated into the soil, on the early development of maize crops.

MATERIALS AND METHODS

The study was conducted in a greenhouse located in the Professor Mario César Lopes Horticulture and Biological Control Station, NEE/UNIOESTE, Marechal Cândido Rondon campus – Paraná, Brazil. The soil used in the experiment was collected from the A horizon of an eutroferric Red Latosol (Lv), with very clayish texture (Embrapa, 2013).

Prior to the experiment, soil samples were collected and placed to dry in the shade, then sieved in 2 mm mesh for chemical characterization according to the methodology described by Raji (2001) and particle size measurement using the Bouyoucos densimeter method, as per Embrapa (1997). The results of the chemical characterization were: pH (CaCl$_2$) = 5.5; O.M.= 17.5 g dm$^{-2}$; 33.67 mg dm$^{-3}$ of P; 2.35; 1.1; 0.65; 0.1; 2.54 cmol. dm$^{-3}$, respectively, Ca$^{2+}$, Mg$^{2+}$, K$,\text{Al}^{3+}$ and $\text{H}^+$ + $\text{Al}^{3+}$. Particle size results were: clay, 830 g kg$^{-1}$; silt, 122 g kg$^{-1}$; and sand, 48 g kg$^{-1}$.

The experimental design adopted was randomized blocks in a 6 x 2 factorial scheme, with four replications. The first factor consisted of six piggery waste doses: 0, 20, 30, 40, 50 and 60 m$^3$ ha$^{-1}$, and the second factor comprised the different modes of application: incorporated into the soil; and placed on the surface, according to the corresponding amount. The piggery waste used in the experiment was acquired from a nearby pig farm, from a lot of finishing pigs. Chemical analysis was carried out to determine the composition of the waste, as shown in Table 1.

The crop was implanted in 5 kg vases filled with previously sieved soil to separate any clods. The maize utilized was the Pioneer 30F53 hybrid, which was sown manually by placing seven seeds per vase. Plants were thinned seven days after emergence, leaving four plants in each vase. Waste was applied at sowing time, as it has already gone through a fermentation phase in a collection and storage tank (manure tank), and was applied according to each type of treatment (incorporated or surface).

To provide water for plant growth and development, irrigation was carried out in order to preserve the moisture level near field capacity. There was no need for pest control, nor was nitrogen fertilization supplemented. Weed control was done manually. At 45 days after plant emergence, the study evaluated height, shoot fresh weight and stalk diameter. To obtain dry matter weight, the plants were cut and placed in paper bags. They were then taken to a forced air oven at 65°C, for 72 h, as per the methodology described by Benincasa (2003). To determine the fresh and dry weight of the root system, the vases were unmade and the roots were washed in running water to remove excess soil. Next, fresh weight was measured, followed by drying in a forced air oven and measurement of dry weight. After the data were collected, they were subjected to analysis of variance to determine their significance. Whenever there was a significant effect, the means of the evaluated variables were studied using regression analysis with Sisvar software (Ferreira, 2011).

RESULTS AND DISCUSSION

There was a linear increase in plant height and stalk diameter from the growing doses of piggery waste applied on the crop; however, the mode of application did not interfere in that variable, nor was there any interaction between the factors, as shown in Figure 1. Similar results were also found by Freitas et al. (2004), Prior (2008) and Mondardo (2010), in which the tallest plant heights were observed at the highest doses of piggery wastewater applied. Stalk diameter also showed linear growth, as according to Niklas (1994) the variables are correlated, so that plants can withstand the weight of an organ – in this case the leaves in the upper canopy. Normally, stalk diameter is correlated with yield because it a reserve organ of the plant, acting as a storage structure for soluble solids that will be used later in grain formation (Fancelli and Dourado-Neto, 2000).

The different piggery waste doses also showed statistically significant differences at 5% probability for variables fresh and dry shoot weight and fresh root weight, in a growing linear manner. The modes of application did not interfere in early crop development, nor was there any interaction between the factors. For dry root weight, growth was quadratic, with low point at the dose of 19.18 m$^3$ ha$^{-1}$ of piggery waste, and with yield of 13.79 g of dry root weight, as shown in Figure 2.

To Mondardo (2010), the piggery wastewater in maize crops lead to increased shoot dry matter, which is higher for very clayish soils. Similar results were obtained by Seidel et al. (2009) in which soil organic matter levels changed dry matter production in the shoots of maize crops. With regard to root volume (Figure 3), a growing linear effect was observed from the applied doses, but there was no significant effect at 5% probability according to mode of application. Adding N to maize plants stimulates the proliferation of the root system, resulting in shoot development (Fancelli, 1997).

The response of maize crops to liquid swine waste, according to Giacomini and Aita (2008), can vary according to climate and soil conditions and waste
Table 1. Chemical composition of the piggery waste used in the experiment.

<table>
<thead>
<tr>
<th>Dry weight</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Mn</th>
<th>Cu</th>
<th>Zn</th>
<th>Fe</th>
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<tr>
<td></td>
<td>g dm$^{-3}$</td>
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<td>8.7</td>
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<td>55</td>
<td>3.78</td>
<td>209</td>
<td>774</td>
<td>1856</td>
</tr>
</tbody>
</table>

Figure 1. (A) Height of maize plants under the effect of doses of piggery waste. (B) Maize stalk diameter under the effect of doses of piggery waste.

Figure 2. (A) Shoot fresh weight under doses of piggery waste (B) Dry shoot weight under doses of piggery waste (C) Fresh root mass in doses of piggery waste (D) Dry root weight under doses of piggery waste.
composition, with regard to N and other nutrients. According to Lemaire and Gastal (1997), N is the element required in greatest amount by maize and is the most limiting nutrient for grain yield. The absence of effect of the modes of application of piggery wastewater (on surface or incorporated), may be linked to the fact that organic waste applied is liquid, which easily percolates through the soil profile, becoming equally available for plants.

Conclusions

The growing piggery waste doses led to greater plant height and diameter, fresh weight yield and dry shoot and root weight, and root volume. In this study there was no statistical difference between modes of application, which indicates that waste application in incorporated or surface form did not result in significant agronomic changes.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES


Drainage Program, University of São Paulo, São Paulo.