Original Research Article

APPLICATION OF BIOFERTILIZERS IN COVER OF AND ITS EFFECTS ON ORGANIC MAIZE

UNDER PEER REVIEW

ABSTRACT

The objective of the present study was to verify the effect of two doses of the biofertilizer 'Supermagro' applied in cover, in the presence and absence of cured bovine urine in the maize crop, and in the soil penetration resistance, as well as the effect in the application of biofertilizer 'Fert Bokashi'. The experimental design used was of randomized blocks with four replicates. The treatments constituted of cover application of 'Supermagro' in the dose of 6% (recommended dose) (T1); cover application of 'Supermagro' in the dose of 12% (T2); cover application of 'Supermagro' in the dose of 6% + cured bovine urine 3% (T3); cover application of 'Supermagro' in the dose of 12% + cured bovine urine 3% (T4); cover application of cured bovine urine 3% (T5); use of the biofertilizer 'Fert Bokashi' in the dose of 0,5% of dilution) (T6); and control (T7). The results obtained were tabulated and submitted to analysis of variance and the comparison of means by the Dunnett test at 5% of probability, with the aid of the statistical analysis software SAS. For the parameters: thousand grain mass, the treatment 'Fert Bokashi' alone presented the highest thousand grain mass (375,00 g) being it superior to the control ($p<0,05$) with 360,94 g. For the yield parameter, the treatments 'Supermagro' 12% + urine, bovine urine alone and 'Fert Bokashi' presented the highest averages, (5961 kg ha^{-1}, 5512 kg ha^{-1} and 5808 kg ha^{-1}, respectively) which differed statistically from the control (5500 kg ha^{-1}) ($p<0,05$) . The biofertilizers are an alternative to increase the yield of maize in the organic system with an average increase of 20% in the maize production in relation to the area without application. The biofertilizer 'Fer Bokashi' is an alternative to increase maize yield in the organic production system. The application of biofertilizers did not influence in the soil penetration resistance.

Keywords: Zea mays, alternative agriculture, cured bovine urine, stem height, yield, Supermagro.

1. INTRODUCTION

The organic agriculture concept may be easily defined as the adoption of agricultural practices which aim to reach the maximum as possible the natural conditions of the environment. The term organic is used to designate a non-conventional system of cultivation, based on ecologic principles, being a productive system that seeks the preservation of nature and life, preconizing the rational use of natural resources, using traditional methods of cultivation and ecologic technologies. The cultivation techniques

involve practices that favor the equilibrium between soil the climatic conditions and the plant [1].

Seeking for a more sustainable production an agricultural development, farmers have been using even more organic inputs, instead of using the synthetic ones. There are many byproducts that can be used in as biofertilizers in ecological agriculture. Such products still need some validation information to be used. The organic fertilizers are composed of materials derived from the decomposition of urban, rural, vegetable or animal raw materials, which may be produced in an aerobic or anaerobic environment or from a mixture of organic materials (fruits, milk, manure), minerals (macro and micronutrients) and water [2,3].

According to Barros et al. [4], the biofertilizer on its liquid form allows a better and faster absorption, being of great utility in crops that need of higher amounts of nutrients in a small period of time, considering that the flux of nutrients that are immobilized from the soil are essential in the maintenance of the fertility in organic cultivation systems.

Among the most used products in alternative agriculture, it can be highlighted the 'Supermagro' biofertilizer and the bovine urine, besides the materials from dust powder. These products are widely because they make available in an efficient way the nutrients for plants and for adding a higher biological resistance due to the equilibrated nutrition necessary according to the trophobiotic theory [5].

The 'Supermagro' is a biofertilizer that was developed by the agricultural technician Delfino Magro, with the collaboration of the Ecologic Agricultural Center of the Rio Grande do Sul state (CAE-RS) as a biofertilizer rich in mineral salts of secondary origin [6]. As a foliar fertilizer, it is generally recommended a concentration between 2% and 5% in the spraying volume (1 L of biofertilizer to each 20 liters of water). Considering that the biofertilizers prepared with the 'Supermagro' must not be applied in concentrations above 10% because it can harm the leaf tissue, also making them to fall [7]. For the maize crop, it is recommended a dose of 6% of 'Supermagro' being it defined by Burg and Mayer [8] as the most efficient dose. However, little is still known about its use in the maize crop.

The bovine urine is an agricultural input that helps farmers to reduce the need for industrialized products, especially in an agroecological production system. It might be used as a liquid biofertilizer, being possible to stimulate the plant growth and rooting, besides acting as a natural alternative technique in the control of pests and diseases. However, despite being a well indicate practice for the production system, it requires further research into its effects when applied to plants.

The 'Fert Bokashi' is another biofertilizer that shows good results when used in crops, such as zucchini, melons and medicinal plants [9, 10, 11], however, no experiments are found in the literature considering the effects of this product in maize. The 'Fert Bokashi' is a fermented fertilizer, generally obtained by a suspension of microorganisms, made of a mixture of many byproducts (rice husks, wheat, soybean, peanuts, as well as animal wastes, such as fish, meat and bone).

In addition, it is known that the application of biofertilizers may improve the soil physical properties, since its composition is based on the organic matter components, which cements the soil particles, forming soil aggregates, and increasing its cation exchange capacity making the nutrients more available to plants [12]. A direct and efficient way of measuring the effects of the biofertilizers on the soil physics is through the soil penetration resistance determination.

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In this context, the use of bovine urine, allied to other methods and products, can contribute to increasing the productivity of an agroecological and organic system, due to the necessity in the development and application of fertilizers capable of minimizing the use of industrialized inputs [13].

The objective of the present study was to verify the effect of two doses of the biofertilizer 'Supermagro' applied in cover, in the presence and absence of cured bovine urine in the maize crop, and in the soil penetration resistance, as well as the effect in the application of biofertilizer 'Fert Bokashi'.

2. MATERIAL AND METHODS

2.1 Place of experiment

The experiment was conducted in the Agroecological Experimental Station professor Alcibíades Luiz Orlando, located in Entre Rios do Oeste city, belonging to the 'Universidade Estadual do Oeste do Paraná.' The geographic coordinates of the area Were 54º01'45 " longitude and 24º 31 W '42' 'S latitude, with an average altitude of 420 m.

The weather in the region is classified, according to the Koppen classification, as Cfa subtropical with hot summers and tendency to concentration of rainfalls, and winters with low frequency of frosts. The soil from the experimental area is classified as an Oxisoil with clayey texture [14].

2.2 Experimental design

The experimental design used was of randomized blocks with four replicates. The treatments constituted of: cover application of 'Supermagro' in the dose of 6% (recommended dose) (T1); cover application of 'Supermagro' in the dose of 12% (T2); cover application of 'Supermagro' in the dose of 6% + cured bovine urine 3% (T3); cover application of 'Supermagro' in the dose of 12% + cured bovine urine 3% (T4); cover application of cured bovine urine 3% (T5); use of the biofertilizer 'Fert Bokashi' in the dose of 0,5% of dilution (T6); and control (T7). Each plot had an area of 50 m² (5 x 10 m).

2.3 Experiment conduction

2.3.1 Crop managements

Maize was sowed in October 11th, 2017, being used the hybrid IPR 164, which was mechanically sowed with a 13 row sower, in a row spacing of 50 cm, with a sowing depth of 4 cm and 2,75 seeds per linear meter (55.000 seeds ha^{-1}). The fertilization was made with an organic compound chicken bed-based, enhanced with sulfur, potassium sulfate and reactive natural phosphate (0-8,2-8).

Three mechanical harrows with a flail mower were made to remove weeds from the space between plots, plus three manual harrows in the space between rows.

2.3.2 Biofertilizers preparation

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The biofertilizer 'Supermagro' was previously produced, used for its composition: 1% volume of zinc sulfate; 1% calcium chloride; 1% magnesium sulfate; 0,15% manganese sulfate; 0,025% cobalt sulfate; 0,05% sodium molybdate; 0,5% boric acid; 0,7% hydrated lime; milk; brown sugar; 0,1% bone powder; 25% fresh bovine manure and water to complete the volume of the chosen recipient. The compound was made by gradually adding the ingredients, weekly, starting from the manure, milk, brown sugar and then added the macro and micronutrients. This production process took 60 days, and at its end, it was waited 30 days for full fermentation in a closed recipient, being it opened and homogenized five times along this process [15].

The bovine urine was collected from the experimental farm of the university, being immediately packed into a closed recipient (anaerobic medium), until it was used, following the recommendation from the [16]. The biofertilizer was made available by the company Korin, which works with resources and defense of natural agriculture.

2.3.3 Biofertilizers application

The biofertilizers were mechanically applied with a tractor and a sprayer. The 'Supermagro' and the bovine urine were applied twice in the crop cycle, in the vegetative stages V4 and V6 of maize plants. The applications were separately made, following the area division and their respective treatments. Adding both products, it was used around 200 liters of the mixture in all the area, in each application.

The 'Fert Bokashi' was applied three times in its respective treatment (T6), in the phenological stages, V4, V5, and V6 of maize plants, following the manufacturer's recommendations.

2.3.4 Evaluations made

The maize production components evaluated were: plants height, first ear insertion height, stem diameter, ear length, number of kernel rows and the number of kernels per row to estimate the number of grains per ear. The production component's evaluation was made by collecting 10 plants from the central rows of each treatment. Plants height and height of insertion of the first ear were made with a metric tape, from the soil surface up to the flag leaf or to the first ear (main ear).
Stem diameter was quantified with the aid of a digital caliper, being measured the same plants which the height was evaluated. The population density was verified through the counting of plants in random spots in the area, being counted in line the number of plants per linear meter and used the average to estimate the plants per unit of area.

The counting of the number of kernel rows and the number of kernels per row was manually made. The crop yield was made by weighing the grains from the area evaluated, which was posteriorly converted to kilograms per hectare.

Soil penetration resistance was determined with a penetrometer Falker ® PLG 1020 at the 5-40 cm depth, being collected 5 points per experimental plot.

2.3.5 Statistical analysis

The results obtained were tabulated and submitted to analysis of variance and the comparison of means by the Dunnett test at 5% of probability, with the aid of the statistical analysis software SAS (Statistical Analysis System).

3. RESULTS AND DISCUSSION

It was found that plant height, stem diameter, ear length, and a number of kernels per row did not differ statistically from the control (p>0,05). For the parameters: height insertion of the first ear, thousand-grain mass, and productivity, the treatments differed from the control (p<0,05). The application of biofertilizer 'Supermagro' in the dose of 6% + cured bovine urine favored the first ear insertion height. The number of kernels per ear and the productivity was higher when the 'Supermagro' at 12% + cured bovine urine was applied. The biofertilizer "Fert bokashi" showed a better result for thousand-grain mass and productivity when compared to the control (Table 1).

The application of the biofertilizer 'Supermagro' at 12% + cured bovine urine, as well as the application of cured bovine urine at a 3% dilution, and the biofertilizer 'Fert Bokashi', promoted an average increase of 20% in the yield when compared to the control. Such results corroborate with the ones found by Costa et al. [17], who also found positive results in the yield of maize consorted with beans when a 5% solution of cured bovine urine was applied to the crop.

Table 1. Plant height, first ear insertion height, stem diameter, ear length, number of kernels per ear, thousand-grain mass and yield for the application of different biofertilizers applied alone or in combination.

Treatments	Plant height	1st ear insertion height	Stem diameter	Ear length	Kernels per ear	1000 grain mass	Yield
	--------m--------		--dm--	---cm---		---g---	kg ha^{-1}
Sup. dose 1	2.07^{ns}	1.08b	27.33^{ns}	18.65^{ns}	464.75b	360.94b	5500b
Sup. dose 2	2.03^{ns}	1.12b	25.84^{ns}	18.35^{ns}	469.99b	362.50b	5225b
Sup. dose 1+Ur.	2.15^{ns}	1.25a	27.27^{ns}	18.07^{ns}	457.73b	351.56b	5361b
Sup. dose 2+Ur.	2.14^{ns}	1.18b	26.47^{ns}	18.37^{ns}	497.77a	368.75b	5961a
Bovine Urine	2.10^{ns}	1.16b	27.23^{ns}	18.31^{ns}	490.23a	362.50b	5812a
Fert Bokashi	2.14^{ns}	1.15b	26.90^{ns}	18.15^{ns}	449.22b	375.00a	5808a
Control	2.09^{ns}	1.13b	27.30^{ns}	17.56^{ns}	460.09b	346.87b	4859b

^{ns} Non-significant (p>0.05) * Means followed by different letters, lowercase in the column, differ from each other by Dunnett's test (P≤0.05). (Sup dose 1. - Supermagro at 6%; Sup dose 2 - Supermagro at 12%; Ur – cured bovine urine).

The better results found in in this study for when a higher dose of 'Supermagro' + bovine urine and of urine alone was applied might be related to the amount of nutrients being higher than the other treatments, since the bovine urine has some essential nutrients required for the better development of plants [18] this results are important because most researches are about small crops or vegetables and no researches explain about the effects of biofertilizers on maize.

Araújo et al. [19] found similar results in coffee with the application of crescent doses of the 'Supermagro' biofertilizer, where the maximum yield was obtained in the doses of 14,6 and 16,2% of dilution.

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Silva et al. [20] found that the use of bovine urine associated with other biofertilizers provided a better development to beans, result that corroborates with the ones found in this study. Its use improved the parameters: initial growth, dry mass, and in the chlorophyll pigments. Cesar et al. [21] also observed the benefits of bovine urine when it was sprayed in cucumbers, where its use improved the initial crop development.

When evaluating the application of the biofertilizer under different dilutions in maize, Pavinato et al. [22] found increases in the plants dry mass, in the dose of 3 and 6% of dilution. However, in the dose of 12% the dry mass production was reduced due to foliar toxicity, opposite results to the ones found in this study where the 12% dose was the best one for the yield parameter.

The family/specie that is used in the experiment may also present a different behavior when biofertilizers are applied on them, as observed by Verona et al. [23] that found no effects from the 'Supermagro' biofertilizer applied on leaves of strawberries. Also, in another experiment, these authors found that the 5% dilution of the biofertilizer reduced the plant's yield due to phytotoxicity.

Plucinski Filho and Godoy [24], testing the application of different biofertilizers in beans, also found no meaningful difference in the application of cured bovine urine and 'Supermagro' in the recommended dose when compared to the control for the yield parameter. In addition, no phytotoxic effect was observed when the applied doses were higher than the recommended ones, without affecting the yield.

Opposite to the results observed, Pereira et al. [13] noticed that crescent doses of bovine urine harmed the tomatoes development when compared to the control. The highest concentration (5%) caused the worst results for all productive characteristics evaluated for this crop, among them the germination, emergence, population of abnormal plants, non-germinated seeds, germination velocity rate, and dry and fresh mass.

The use of biofertilizers did not change the soil penetration resistance ($p>0,01$) (Figure 1) These results are in accordance to the ones found by Dias et al. [25], who found that independent of the application frequency the biofertilizers did not change the soil penetration resistance on the passion fruit crop. It is worth noting that from the 20 cm depth all treatments presented the soil penetration resistance values superior to the one considered ideal for crop conditions [26].

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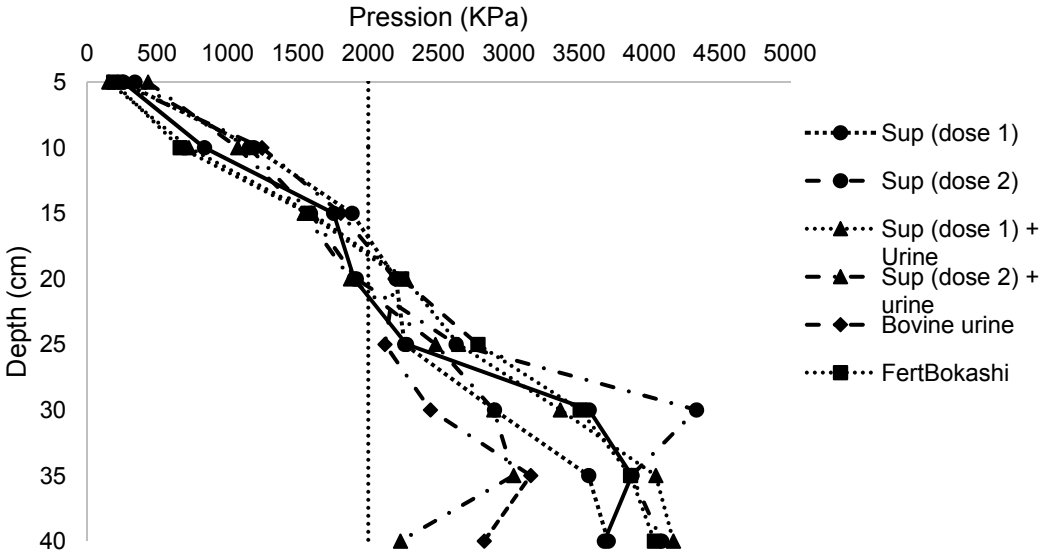

Figure 1. Effect of the treatments in the soil penetration resistance (KPa), in the depth of 5 to 40 centimeters.

No results were found in the literature for the influence of Bokashi on maize, however, Ferreira et al. [27] found that the higher the doses of Bokashi applied on broccoli the higher were the head dry mass obtained in the experiment, without a maximum limit being determined for the application.

4. CONCLUSION

The biofertilizers are an alternative to increase the yield of maize in the organic system with an average increase of 20% in the maize production in relation to the area without application.

The biofertilizer 'Fer Bokashi' is an alternative to increase maize yield in the organic production system.

The application of biofertilizers did not influence in the soil penetration resistance.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company; rather it was funded by personal efforts of the authors.

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