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Use of compost from a compost barn installation as organic fertilizer

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Abstract. Organic fertilization is a profitable option and an environmentally correct alternative. The compost barn confinement system generates an organic material that can be applied to fertilize crops used to produce food for dairy cattle. This work objective is to evaluate the use of this material as an organic fertilizer. For the tests, sunflowers were planted in 15 L pots made up of ¾ soil and ¼ sand, kept in a greenhouse and four doses of fertilizer were tested (0, 5, 25 and 125 g/pot), using organic compost generated by a compost barn with Holstein dairy cows. The tests showed positive results for plant growth and development and for grain production for all doses, with a significant difference only for the 125 g dose, which presented an average number of leaves of 15.96, stem diameter of 12.5 mm and thousand seed weight of 28.63 g. It was found that there was greater plant growth and greater grain filling with an increase in the fertilizer dose, proving the positive effects on the plant of using organic compost from a compost barn.

Key words: composting, dairy herd, fertilizer dosage, grain, sunflower.

INTRODUCTION

The agricultural sector in Brazil has been leveraging the country's economy and gaining prominence at a global level, as it is responsible for a considerable contribution to the Brazilian economy, representing 27.4% of GDP (CEPEA, 2021). Brazil is one of the largest producers of bovine milk in the world, having produced 23.81 billion litres of milk in 2022 (EMBRAPA, 2023).

Data from the Brazilian Agricultural Research Corporation (Embrapa - Portuguese: Empresa Brasileira de Pesquisa Agropecuária) (2023), show that farms in Brazil in 2021 produced an average of 6.63 L per cow day^{-1}, far from the average of 28.5 L per cow day^{-1} in the United States (USDA, 2021). This fact demonstrates that despite having one of the largest milk production in the world, Brazil needs to improve the productivity of its herd, so that it can have high production with efficiency and profitability. For high milk production, good management practices and new confinement methods are being developed and improved, seeking greater comfort for the animals and better health conditions for the dairy herd, in order to reflect on quality and increased production.

One of the confinement methods that present good results is the compost barn system. This system is made up of a cycle in which the producer plants the forage that will be fed to the animals, which in turn provide the crop with organic fertilizer from the composting of the bedding material for these cattle, thus providing savings and sustainability for dairy farming (Guesine et al., 2023). Milk producers in Brazil have been adopting compost confinement with the intention of increasing productivity, sanitary conditions, and nutritional quality of milk, due to the better conditions offered to the animals (Andrade et al., 2023; Nepomuceno et al., 2023). The environmental conditions, associated with a good management of the genetics nutrition and sanity are the key of a good confinement (Damasceno et al., 2019).

In a compost barn confinement, the feeding area is separated from the bedding area, but with free access so that the animal can eat and drink water, without the bedding suffering from excess humidity from the drinking fountains, this way the bedding remains drier and with low compaction for a longer period, facilitating management and increasing animal well-being (Silva, 2018).

The intensive compost barn confinement system, recently introduced in Brazil, has been widespread in the country and many producers are adopting the method. According to Silva (2018), compost barn was created in the mid-1980s in the United States, with its use beginning in Brazil just 32 years later, in 2012 (Brito, 2016). The compost barn structure differs from the free stall confinement system, as it does not consist of individual beds, but rather a single bed made up of organic and absorptive material such as wood shavings. It is also characteristic that waste is not removed, being kept for the formation of organic compost.

The prices of chemical fertilizers, coming from mineral deposits with subsequent industrial processing, generate a large drain on financial resources from rural properties. Pereira (2017) demonstrated with the results of his research that the cost of chemical fertilizer was 32.1% higher than organic fertilizer. Therefore, alternative sources of fertilizer, mainly organic, have aroused the interest of both producers and researchers (Pereira, 2017). The Russian invasion of Ukraine in 2022 brought negative results for Brazilian agriculture, as part of the fertilizers used in Brazil come from Russia, such as urea, ammonium nitrate, potassium nitrate and monoammonium phosphate. Therefore, organic fertilizers are increasingly important for Brazilian agriculture, as they can replace partially or totally chemical fertilizers. Organic fertilizer, applied for several consecutive years, provides a residual effect for a long time, which causes stability in the availability of nutrients for crops, compared to mineral fertilizer (Santos, 2010).

Organic residues can nourish plants in a balanced way, also providing better soil conditioning, making it, in the long term, less prone to the depleting effects of intensive cultivation (Skoufogianni et al., 2019). Being a system of increasing use today, some points must be tested, such as the effect of this fertilization, providing data for better development of dairy producers, making them more efficient and technological.

The sunflower (*Helianthus annuus*) is an annual dicotyledonous plant, belonging to the order Asterales and family Asteraceae. The gender derives from the Greek helios, which means sun. It is a complex genus, comprising 49 species and 19 subspecies, of which 12 are annual and 37 are perennial (Cavasin Junior, 2001). The sunflower industrialization sector in Brazil is mainly formed by a small number of medium and large agro-industries, located mainly in the States of Goiás, Paraná, Rio Grande do Sul and São Paulo. These agro-industries process sunflower in order to meet demands of the Brazilian population, mostly demands for oil for cooking (Hiolanda, 2018).

The research problem is that the use of organic compost generated by compost barn is informally recommended in farming, however there is a deficiency in data and scientific tests that demonstrate the use of this fertilizer and its benefit for plants.Given the facts presented so far, this work aims to test different dosages of organic fertilizer obtained from the bed of a compost barn installation and their effects on the biophysical characteristics and productivity of sunflower.

MATERIALS AND METHODS

The compost used as organic fertilizer was obtained from a compost barn type dairy farm with one and a half years of bedding use and came from eucalyptus shavings. The place values animal well-being, using appropriate management to combine animal well-being with high productivity.The collection was carried out after the bed turning and aeration operation, in alternating points (zigzag), in a total of 10 points of 100 g each to ensure better representation of the material to be evaluated. The compound, when subjected to practical field tests, as recommended and described by Kiehl (2002), did not have an ammonia smell and, when touched, the temperature was not felt to be high, when squeezing the material in the palm of the hand there was no flow of water, demonstrating that the compound was suitable for use as organic fertilizer. After collection, it was dried in the shade with subsequent grinding to standardize the particles.

The compost was collected at Fazenda Custodinho in the municipality of Perdões, Minas Gerais, Brazil, which is located at 21° 6' 25" S latitude and 45° 2' 9" W longitude. The climate classification is Cwa according to Köppen (Ometto, 1981; Alvares, 2013), with 20.4 °C being the mean temperature and average yearly precipitation of 1,455 mm, with 85% of this total concentrated from October to March according to the climatological normals of 1991–2020 (INMET, 2020).

The shed has a total bed area of 800m², with an average population of 65 lactating cows, which ingest a total of 45.5 kg of feed per day: 29 kg of corn silage, 13 kg of protein concentrate and 3.5 kg of alfalfa. They make an average daily productivity of 32 litres of milk and an average daily production of 2,200 L.

The compost obtained was subjected to chemical analysis in the soil fertility laboratory of the Federal University of Lavras, with the following elements being analysed: N, P, K, Ca, Mg, S, Mn, Zn, B, Cu and Fe. In the vegetation house on the UFLA Energy and Waste Platform (PLAER) next to the Centre for Studies on Oil Plants, Oils, Fats and Biodiesel (G-Óleo), sunflowers were planted in pots. This greenhouse is located at the Federal University of Lavras, Minas Gerais, Brazil, at an altitude of 919 m, 21° 00' 14" S latitude and 45° 00' 00" W longitude and with a Cwa climate, with a cold and dry season from April to September and hot and humid season from October to March, according to the Köppen classification (Alvares, 2013; Ometo, 1981).

The experiment was conducted from May to August 2020, in a greenhouse under irrigation, in soil classified as a typical Dystroferric Red Latosol (EMBRAPA, 1999).

The results of the chemical analysis of the soil used in the experimental pots are presented in Table 1 with the following analyses: pH in water, P (Mehlich I phosphorus), K (Mehlich I potassium), Ca (calcium), Mg (magnesium), Al (aluminum), H + AL (potential acidity), S.B. (sum of bases), t (effective CEC), T (CEC at pH 7.0), m (aluminum saturation), V (base saturation).

The soil used in the experiment was mixed with sand in a proportion of ¾ soil and ¼ sand and then the doses of fertilizer were added and mixed, placed in pots with a volumetric capacity of 8 litres, equivalent to 9.06 kg of soil and 2.96 kg of sand and a total of 12.02 kg per pot. Four fertilizer dosage treatments were used, as follows:

1. Control (no fertilization)
2. 5 g organic compost per pot (equivalent to 1 t ha^{-1})
3. 25 g organic compost per pot (equivalent to 5 t ha^{-1})
4. 125 g organic compost per pot (equivalent to 25 t ha^{-1})

Table 1. Chemical analysis of the soil used in the experiment implementation

Attribute	Measurement unit	Value
pH in water	ph	6.5
P (Mehlich I phosphorus)	mg per dm^3	8.99
K (Mehlich I potassium)	mg per dm^3	180.72
Ca (calcium)	Cmolc per dm^3	5.50
Mg (magnesium)	Cmolc per dm^3	0.53
Al (aluminum)	Cmolc per dm^3	0.10
H + AL (potential acidity)	Cmolc per dm^3	1.82
S.B. (sum of bases)	Cmolc per dm^3	6.54
t (effective CEC)	Cmolc per dm^3	6.64
T (CEC at ph 7,0)	Cmolc per dm^3	8.36
m (aluminum saturation)	%	1.51
V (base saturation)	%	78.27

The genetic material used for sowing the test plant were BRS 324 cultivar sunflower seeds. 10 evaluations were carried out on days 21, 28, 35, 42, 49, 56, 63, 70, 77 and 84 after sowing, being the last evaluation one day before grain harvest, always at the same time, at 7am.

In the experiment, the characteristics evaluated were: plant height throughout the crop cycle, number of leaves, stem diameter and, at the crop cycle end, the weight of a thousand seeds was measured. The plant height and stem diameter parameters were determined using a tape measure and a digital calliper, respectively, while the number of leaves was measured by visual counting. The thousand-seed weight (TSW) was also measured, to carry out this evaluation the harvest was carried out on day 84 after sowing, considering that the plants were already in a condition to be harvested. TSW measurement was performed by visual counting, an important parameter in seed evaluation. The methodology used for the TSW was the same as that described in the Agrodefesa seed analysis manual (2021).

The experimental design employed was the Completely Randomized Design (CRD) with four treatments (doses) and six replications, with each plot consisting of one plant per pot. Statistical analyses were carried out using the SISVAR® software (Ferreira, 2011).

RESULTS AND DISCUSSION

The results of the chemical analysis of the compost used in the experimental pots can be seen in Table 2.

Analysing the chemical composition of the compost, there is a greater amount of nitrogen in relation to the other nutrients evaluated, possibly coming from the animals' urine, while it is poor in other elements. Commercial chemical fertilizers have higher percentages of nitrogen than the compost, as cited by Reetz (2017) ammonium sulphate and urea have respectively 21% and 46% nitrogen in their chemical compositions. Considering that the bed is changed every 12 to 18 months, it may be recommended adding other components to the bed-forming material, such as rock dust rich in phosphorus, potassium, calcium, magnesium and sulphur, which can be degraded together to the rest of the material, improving the composition of the compost.

Table 2. Chemical Analysis of the compost used in the implementation of the experiment

Attribute	Mass/Mass	Percentage
N	41.7 g kg^{-1}	4.170
P	8.7 g kg^{-1}	0.870
K	16.7 g kg^{-1}	1.670
Ca	11.7 g kg^{-1}	1.170
Mg	2.1 g kg^{-1}	0.210
S	1.6 g kg^{-1}	0.160
Mn	109.2 mg kg^{-1}	0.011
Zn	147.4 mg kg^{-1}	0.014
B	31.5 mg kg^{-1}	0.003
Cu	21.4 mg kg^{-1}	0.002
Fe	185.0 mg kg^{-1}	0.018

An analysis of variance was carried out for the response variables: plant height, number of leaves, stem diameter and thousand-seed weight (TSW) (Table 3). However, the plant height variable did not present statistical significance in the data, and therefore was not represented in tables and graphs. The 0.5 and 25 g treatments showed no statistical difference, while the 125 g treatment showed better results and statistical difference compared to the other fertilizer doses. In an experiment using corn as a test plant, Reina et al. (2010) obtained significant growth and productivity results with the use of cattle manure, up to a dose of 20 t ha^{-1}, unlike the present study in which there was no significance in the doses used with values below 25 t ha^{-1}.

Table 3. Average values for the variables number of leaves, stem diameter and thousand-seed weight (TSW)

Variable	of organic compost			
	0 g	5 g	25 g	125 g
Number of leaves	13.89b	13.49b	14.23b	15.96a
Stem diameter	9.52b	9.59b	10.85b	12.15a
TSW	19.46b	20.16b	23.07b	28.63a

Values followed by the same lowercase letter in the line do not differ from each other according to the Tukey test at 5% probability.

It is possible to observe the evaluation of the number of leaves depending on the different doses of organic fertilizer in relation to the days after sowing. It is noted from the summary of the linear regression analysis (Fig. 1), that for the variable number of leaves, the pots that used the highest concentration of organic fertilizer (125 g) obtained a greater number of leaves. The behaviour of the number of leaves presented an increasing and linear pattern as the days passed after sowing, similar to the results found in research by de Freitas et al. (2021), which despite obtaining an average value of 16.83, higher than the present study, also obtained a linear increase in the number of leaves when applying organic fertilizer.

It is possible to observe from the summary of the linear regression analysis (Fig. 2), that for the variable stem diameter, linear growth occurred despite the significant difference being only in the dose of 125 g of organic fertilizer, also obtaining a greater stem diameter. The growth in stem diameter had an increasing and continuous pattern until the last day of analysis. In their studies, de Freitas et al. (2021) and Medeiros et al. (2020) observed, in a similar way to the present work, the linear growth of the diameter of the sunflower stem until 70 days after sowing, as the availability of nitrogen through organic sources increased. As for the average value of stem diameter obtained in the last data collection, at 84 days, the highest value obtained was 12.16 mm, corresponding to a dose of 125 g of fertilizer. This value did not present a large numerical difference when compared to the value found by Bezerra et al. (2014), which was 12.33 mm.

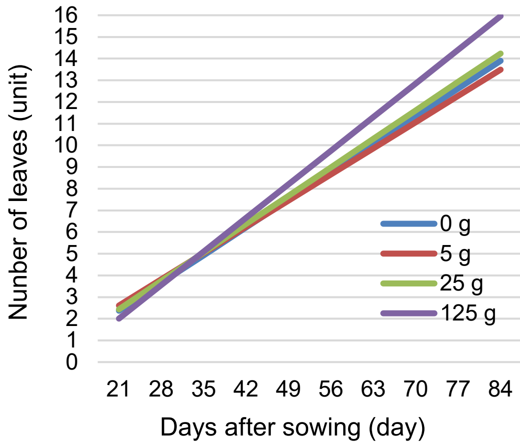

Figure 1. Evaluation of the number of leaves according to different doses of organic fertilizer.

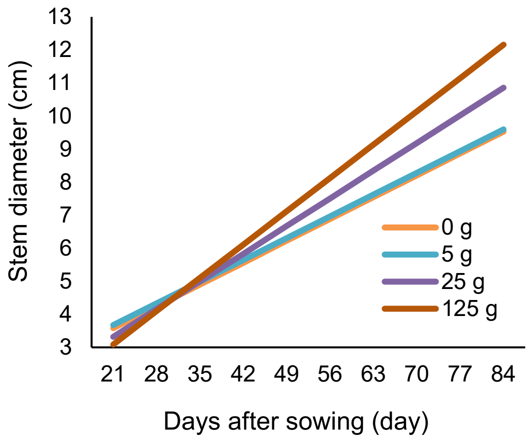

Figure 2. Evaluation of the stem diameter according to different doses of organic fertilizer.

It can be seen from the summary of the linear regression analysis (Fig. 3) for the thousand-seed weight variable, that the pots that received the highest concentration of fertilizer (125 g) obtained a higher TSW. The filling of the grains behaved in an exponentially increasing manner, with the highest value presented at the dose of 125 g. In terms of numbers, it is observed that the average thousand-seed weight on day 84, which was 28.64 g, is lower than the average found for the same cultivar by Carvalho et al. (2011) in their work, which was 53 g. This difference may have occurred due to the planting method, which was in pots, which generates a smaller root volume and, consequently, a tendency towards lower plant production. In the research by Wanderley et al. (2018) the authors concluded that, when applying organic fertilizer to sunflower cultivation, seed production is favoured by the increased amounts of organic fertilizer in the soil.

Among the four treatments, the doses of 0.1 and 5 t ha^{-1} did not show a significant difference between them. The dosage of 25 t ha^{-1} presented a difference from the others and obtained better results, indicating that the use of this organic compound is advantageous for the crop, as seen in Barros et al. (2019), in which there was the conclusion that the application of Organic fertilizer in the soil is beneficial for early sunflower growth. However, when calculating the nutrients individually for the dose of 25 t ha^{-1}, the quantities of nutrients suggest that it is necessary to reduce the amount applied, as in the case of nitrogen, which would be added at this dose, 1,042.5 kg ha^{-1}, an excessively high dose.

Ricardo (2016), in his research, mentions that a lactating cow with an average weight of 400 kg can produce 38 to 50 kg of faeces per day, of which between 28 and 32 kg are equivalent to faeces and the rest is made up of urine. Research by Campos (1997) shows that 87.3% of cattle manure corresponds to water, whereas Perissinotto (2005) mentions that he found in his research a water consumption of 37.3 L day^{-1} on cool days and 63.8 L day^{-1} on hotter days. Considering the data above and also the results of this work, the property from which the material for this work was collected, having a herd with an average of 65 cows, had the capacity to produce approximately 1,223.2 tons of dry organic compost over the course of 18 months. Following the best research result, the property would have the capacity to fertilize an approximate area of 48.9 ha with a dose of 25 t ha^{-1}.

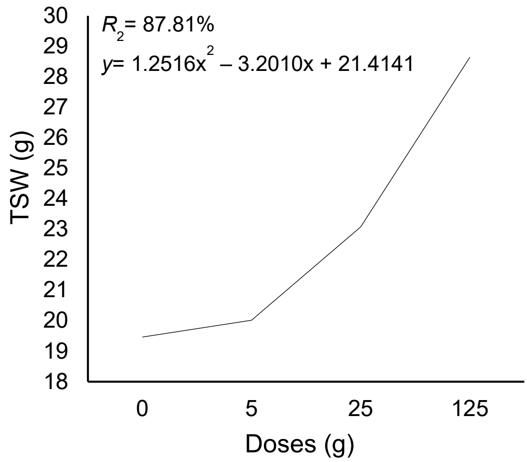

Figure 3. Thousand-seed weight according to different doses of organic fertilizer.

With the application of the best dose evaluated in the present work (25 t ha^{-1}), the producer would be adding approximately 1,040 kg of nitrogen, 218 kg of phosphorus and 418 kg of potassium per hectare to the soil. If fertilization were carried out with commercial fertilizers, these values would be equivalent to 5.2 tons of ammonium sulphate, 3.8 tons of potassium chloride and 20.9 tons of simple super phosphate per hectare, doses that are economically unviable and agronomically excessive. Therefore, there is a need to carry out field tests with dosages lower than the best performance in this work, to define the most appropriate dose or range for application in the crop.

CONCLUSIONS

Organic fertilization using compost from compost barn confinement proved to be efficient, with best results at a dose equivalent to 25 t ha^{-1}. This dose provided higher average values for number of leaves, stem diameter and thousand seed weight, respectively 15.9 leaves, 12.15 mm and 28.63 g. It was found, upon analysis of the data, that there was greater plant growth and greater grain filling with the increase in the fertilizer dose, proving the positive effects of using organic compost from a compost barn on the plant.

Organic fertilization was effective, however, the dose to be applied to the crop needs to be calculated according to the need to avoid causing excess nutrients.

The results of this research can provide great monetary savings for the producer as it generates a reduction in the purchase of chemical fertilizers, from an environmental point of view it generates fewer impacts due to the use of waste and improves soil biodiversity due to the addition of organic matter.

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