Vol. 14(10), pp. 576-581, 7 March, 2019
DOI: 10.5897/AJAR2018.13426
Article Number: 43578A660425
ISSN: 1991-637X
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African Journal of Agricultural Research

Full Length Research Paper

Pig compost for the formation of coffee seedlings in the substrate composition

Felipe Santinato[1*], Carlos Diego da Silva[2], Renato de Mello Prado[3], Caio Fernando Eckhardt Souza[2], Victor Afonso Reis Gonçalves[2] and Roberto Santinato[4]

[1]Agronomic Institute of Campinas, IAC, Avenida Barão de Itapura, 1,481 Botafogo, Campinas, São Paulo, Brazil.
[2]Federal University of Viçosa, UFV, Campus Rio Paranaíba, Highway MG-230, km 7, 38810-000, Rio Paranaíba, Minas Gerais, Brazil.
[3]Department of Soils and Fertilizers, UNESP State University of São Paulo "Júlio de Mesquita Filho", Jaboticabal Campus, Path of Access Prof. Paulo Donato Castellane, s / n, 14884-900, Jaboticabal, São Paulo, Brazil.
[4]MAPA/Procafé, Street of Margaridas, 783 - Chácara Primavera - CEP: 13087-450 Campinas, São Paulo, Brazil.

Received 30 July, 2018; Accepted 13 September, 2018

Pigs can be used in the formation of coffee seedlings; it gradually provides essential nutrients for the development of plants, in addition to promoting the improvement of the substrate and water retention. It was decided, with this work, to evaluate the use of pig compost in the formation of coffee seedlings. The topics studied were: T1 - Witness (absence of organic compound); T2-30% concentration of cattle compost; T3-15% concentration of pig compost; T4 - 30% concentration of pig compost; T5 - 45% concentration of pig compost. The five treatments were arranged in a randomized block design, with five replications. The best treatment for plant height and collection diameter was 45% of pig compost. The best results for the total dry matter were obtained with treatments with 30 and 45% of pig compost. The compost based on pig manure at 30% stood out in comparison to the standard cattle manure at 30%, providing higher levels of M, O, P, Mg and micronutrients (B, Cu, Mn, Zn). The use of 30 or 45% of manure-based compost produces coffee seedlings similar to the 30% of cattle manure composting.

Key words: Dejects, organic matter, *Coffea arabica.*

INTRODUCTION

The use of organic matter in the substrate composition for the formation of coffee seedlings is essential for its proper development (Dias et al., 2009; Almeida et al., 2011). The organic matter improves the physical, chemical and biological characteristics of the soil (Malavolta, 2006). According to Araujo et al. (2007) the use of organic matter promotes an increase in the N, K and Mg leaf contents. In plantations already implanted the organic compound must also be supplied, because it improves the physical conditions of the soil, retains more water and provides nutrients gradually, when appropriate doses of the organic compound are used, the levels of post-planting chemical fertilizers can be reduced by 30 to 50%, this recommendation should take into account not

*Corresponding author. E-mail: fpsantinato@hotmail.com.

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only the soil characteristics, but also the nutrient demand of the plant (Matiello et al., 2010).

According to Clemente et al. (2008) coffee plantations with one year post-planting the critical ranges of macronutrients are: nitrogen 19.24 to 23.16 $g.kg^{-1}$; phosphorus 1.14 to 1.21 $g.kg^{-1}$; potassium 17.39 to 19.02 $g.kg^{-1}$; calcium 12.70 to 14.11 $g.kg^{-1}$; magnesium 8.26 to 8.97 $g.kg^{-1}$; and sulfur 1.49 to 1.77 $g.kg^{-1}$. The critical ranges of micronutrient concentrations in coffee leaves are: copper 11 to 14 mg kg^{-1}; iron 100 to 130 mg kg^{-1}; zinc 15 to 20 mg kg^{-1}; manganese 80 to 100 mg kg^{-1} and Boron 50 to 60 mg kg^{-1} (Malavolta et al., 1997). According to the nutritional demand of the coffee tree, it is advisable to associate organic compounds and fertilizers to obtain a balance that generates good productivity, but which maintains adequate soil physical and chemical characteristics (Fernandes et al., 2013a).

Among the available sources, the most common is the cattle compost, with 30% of the substrate being used. Cattle compost provides substrate aeration, adequate nutrients supply and satisfactory water retention, being superior to sources such as poultry compost (Fernandes et al., 2013a) and coffee straw (Fernandes et al., 2013b). Poultry compost does not provide the same aeration and the coffee straw, in addition to the higher C/N ratio, does not have adequate nutrient ratios (Matiello et al., 2010).

An alternative source to cattle compost would be the one originated by pigs, available in many Brazilian regions. When associated with other materials, they form a rich in nutrients compost and can meet the coffee seedlings nutritional requirements. However, no studies were found evaluating the agronomic potential of pig compost in the production of coffee seedlings. The hypothesis that emerges would be that by improving the chemical properties of the soil and the nutritional status of the plants with the pig compost, it favors the growth and quality of the seedlings in a similar way to the cattle compost. Therefore, the aim here was to study the proportion of pig compost compared to the cattle compost in the soil, nutritional status, growth and quality of coffee seedlings.

MATERIALS AND METHODS

The experiment was installed in a coffee nursery located in Campo Experimental Francisco Pinheiro Campos, located in the municipality of Patos de Minas, Minas Gerais, Brazil; with a 50% shading polypropylene mesh cover. The coffee seedlings were produced in polyethylene bags, with a volume of 1.693 cm^3. For the preparation of the substrate, the fertilization used in all treatments corresponded to: 1.0 kg m^{-3} of P_2O_5 and 0.6 kg m^{-3} of K_2O, using as sources single superphosphate (24% of P_2O_5) and potassium chloride (60% K_2O) respectively, as indicated by Matiello et al. (2010). The interior of each bag at 2 cm depth was seeded with two coffee seeds from Catuaí Vermelho IAC 144 on September 06, 2014.

The treatments studied refer to different substrate compositions of the seedlings: T1 - Witness (absence of organic compound); T2 - 30% concentration of cattle compost, considered Standard MAPA/Procafé; T3-15% concentration of pig compost; T4 - 30% concentration of pig compost; T5- 45% concentration of pig compost. The five treatments were arranged in a randomized block design, with five replications, totaling 20 plots. Each plot was composed of 20 plants, with the main eight being useful for evaluations. Between each plot there were plants to compose the double borders. The organic sources used were analyzed as organic fertilizer according to the Normative Instruction 27 (MAPA).

The organic sources were mixed with samples of a dystroferric Red Latosol (EMBRAPA, 2006) with a layer of 0.1 to 0.2 m depth where it was sieved (5 mm mesh) and employed according to the proportions equivalent to each treatment. The seedlings were irrigated by sprinklers with a 70.0 L h^{-1} flow rate, maintaining the containers with 80% field capacity throughout the entire production period (180 days). The following evaluations were carried out 180 days after sowing: biometry (plant height and collection diameter) and it determined the contents of: N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, Zn and Na in the 3rd, 4th and 5th pairs of leaves and the shoot, root and whole plant (total) of the dry matter production. Samples of properly homogenized substrate were collected and the pH values and the contents of O.M., P, K, Ca, Mg, S, B, Cu, Fe, Mn, Zn and Na were determined according to the methodology described by Raij et al. (2001). The quality indexes of seedlings evaluated were between plant height and collection diameter (RAD) and the Dickson quality index (IQD), calculated according to the Equations 1 and 2, respectively (Dickson et al., 1960).

$$RHD = \frac{H}{CD} \quad (1)$$

$$DQS = \frac{TDM}{RHD + \frac{DMA}{DMR}} \quad (2)$$

On what:
RHD = Ratio between plant height and collection diameter;
H = Plant height (cm);
CD = Collection diameter (mm);
DQS = Dickson Quality Score;
TDM = Total Dry Matter (g $plant^{-1}$);
DMA = Dry Matter of the Aerial Part (g $plant^{-1}$);
DMR = Dry matter of the Root System (g $plant^{-1}$).

The data were submitted to analysis of variance and, when appropriate, to the Tukey test, both with 5% of significance. The statistical program SISVAR (Ferreira, 2011) was used for that.

RESULTS AND DISCUSSION

The application of 45% pig compound promoted a higher M.O. of the soil in relation to the other treatments, followed by the pig and cattle composts with 30% each, and the pig compost with 15%, all higher than the control (Table 1). It was observed that the use of organic compost increased the soil pH value in relation to the control, highlighting the pig compost in the ratio of 45 and 30% and the bovine compost (Table 1). There are reports in literature showing a decrease in the pH due to the increase in M.O. (Fernandes et al., 2013a, b). The use of the pig compost independently of the concentration in the substrate promoted a higher P content in relation to the other treatments (Table 1). It

Table 1. Results of the chemical properties of the soil as a function of the organic compound treatments in the formation of the substrate for the production of coffee seedlings.

Treatments	dag kg^{1}	$CaCl_2$	mg dm^{3}		mmol$_c$ dm^{3}			%
	MO	pH	P	K	Ca	Mg	H + Al	V
T1 – C	14.5^{d}	5.4^{c}	538.5^{b}	4.4^{b}	33.0^{b}	2.7e	30.2^{a}	57.2^{c}
T2 – E30	43.5^{b}	5.9^{b}	585.7^{b}	10.6^{a}	70.0^{a}	23.2^{d}	19.2^{b}	84.5^{b}
T3 – S15	36.0^{c}	6.6^{a}	1121.7^{a}	10.9^{a}	62.2^{a}	32.2^{c}	14.2^{c}	88.2^{a}
T4 – S30	49.2^{b}	6.8^{a}	1490.0^{a}	10.0^{a}	69.2^{a}	51.7^{b}	13.7^{c}	90.5^{a}
T5 – S45	63.3^{a}	6.1^{b}	1385.3^{a}	6.3^{ab}	62.6^{a}	81.3^{a}	19.0^{b}	89.0^{a}
CV (%)	7.14	2.87	22.1	28.03	6.05	9.7	10.3	1.9

* Means followed by the same lowercase letters, compared in the columns, do not differ from each other, by the Tukey test at 5% significance.

was observed that the P content of the soil with the use of the pig compost was of 137 to 155% higher than the cattle compost, a fact that is explained by the high nutrient content in the pig compost.

An increase of the calcium contents in all the treatments fertilized with organic sources was observed in relation to the control (Table 1). The increase of the pig compost concentration reflected in the increase of the Mg content in the soil, showing a lower nutrient content with the use of cattle compost; and all of them differed from the control. The higher content of Mg in the soil due to the use of pig-based organic compost could be explained by the higher content of this nutrient in the compost. The exchangeable acidity was higher in the control and lower in the fertilized treatments. The proportions of 15 and 30% of pig compost obtained the lowest levels. The content of Ca present in the treatments fertilized with organic composts was practically double from the control (Table 1) given the presence of the element in the composts. The relation between the increase in Ca content and the reduction of exchangeable acidity had already been studied in other coffee seedlings production papers (Dias et al., 2009; Almeida et al., 2011). Regarding the V%, all the treatments that used the pig compost were superior to the standard, which in turn was superior to the control. For S the best treatments were 45 and 30% of pig compost, respectively, and all were superior to the control (Table 1).

Concerning the B content, there was no difference between the treatments with 30% of cattle compost and 15 and 30% of pig compost. It was observed that in all the treatments, the B contents were greater than control, and there was a reduction of the content in the greater dosage of the pig compost (Table 2). The Cu content was higher in the treatments fertilized with pig compost, which increased with the content. There was no difference between the cattle compost treatment and the control. The highest dose of the pig compost had a Cu content of 1636.25 and 1118.42% higher than the control and the cattle compost, respectively (Table 2). For the Fe content, the cattle compost and pig compost in the 45% ratio were the best treatments. The smaller proportions obtained lower levels. However, they were superior to the control. For the Mn content, there was an increase in the content due to the increase in the proportion of pig compost. All treatments fertilized with it were higher than the cattle compost and the witness (Table 2). For the Zn content, all the treatments fertilized with the pig compost were superior to the control and to the standard, with an emphasis on the treatment with the use of 30% of pig compost. As for the B content, the higher proportion of the pig compost reduced the Zn content in relation to the 30% ratio. It is possible that this has occurred because the high proportion of compost induced high O.M. content, which could compress the zinc and decrease its availability in the soil (Table 2).

The contents obtained with the fertilized treatments are within the appropriate ranges for the coffee, both for macro (Gonçalves et al., 2009) and for micronutrients (Gontijo et al., 2007). The control treatment, on the other hand, obtained contents less than adequate for N (Table 2). For the N content, all fertilized treatments were superior to the control. For P, the highest content was 15% of the compost. For the Ca content, the best treatment was 30% of the cattle compost. The best treatments for the Mg content were 30 and 45% of the pig compost. There were no differences between treatments for K, S, B, Cu, Fe, Mn, Zn and Na (Table 3). All the treatments fertilized with organic sources obtained plant height and diameter superior to the control. The best treatment for plant height was 45% of pig compost. The best results for collecting diameter were obtained with the pig compost. A great increase was observed in the collection diameter when 45% of pig compost was used, with a 50 to 19% value higher than the control and the standard, respectively (Table 4). The additions obtained in the treatments are the reflection of the higher nutrient levels in the soil provided by the tested fertilizers. The most important difference in the collection diameter was due to the Mg, Mn and Cu contents, which were highlighted with the use of 45% of the pig compost (Prado, 2008).

The use of organic sources in the substrate

Table 2. Micronutrient results as a function of the organic compound treatments in the substrate formation for coffee seedlings production.

Treatments	mg dm^{3}					
	S	B	Cu	Fe	Mn	Zn
T1	13.2^{b}	0.5^{c}	2.4^{c}	19.0^{c}	5.7^{d}	5.3^{d}
T2	18.5^{ab}	1.6^{a}	3.4^{c}	84.5^{a}	7.1^{cd}	10.1^{d}
T3	24.0^{ab}	1.6^{a}	19.7^{b}	47.0^{b}	13.9^{bc}	99.0^{c}
T4	28.5^{a}	1.7^{a}	34.4^{a}	55.5^{b}	16.1^{b}	158.0^{a}
T5	24.3^{ab}	1.0^{b}	41.6^{a}	76.0^{a}	26.4^{a}	130.6^{b}
CV (%)	22.6	14.9	17.6	12.8	22.7	14.5

* Means followed by the same lowercase letters, compared in the columns, do not differ from each other, by the Tukey test at 5% significance.

Table 3. Nutrient and sodium leaf content as a function of the treatments in the substrate formation for the production of coffee seedlings.

Treatmets	Leaf content (g kg^{-1})											
	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	Na
T1	16.1^{b}	2.7^{ab}	36.2^{a}	8.1^{b}	2.1^{c}	2.2^{a}	55.8^{a}	290.5^{a}	1420.0^{a}	41.2^{ab}	49.2^{a}	264.0^{a}
T2	27.0^{a}	2.9^{ab}	41.2^{a}	10^{a}	3.3^{bc}	1.7^{a}	53.7^{a}	265.5^{a}	1072.5^{a}	28.7^{b}	39.5^{a}	246.2^{a}
T3	23.5^{a}	3.0^{a}	40.6^{a}	8.1^{b}	3.4^{b}	1.7^{a}	53.2^{a}	282.6^{a}	868.7^{a}	41.2^{ab}	50.0^{a}	217.5^{a}
T4	24.7^{a}	2.3^{bc}	46.8^{a}	7.9^{b}	4.8^{a}	1.8^{a}	47.4^{a}	304.1^{a}	1086.2^{a}	38.7^{ab}	52.2^{a}	278.7^{a}
T5	25.3^{a}	1.9^{c}	38.1^{a}	8.2^{b}	5,2^{a}	1.5^{a}	39.9^{a}	296.0^{a}	1176.2^{a}	56.2^{a}	42.3^{a}	245.0^{a}
CV (%)	15.63	12.67	15.29	10.9	14.2	21.25	14.37	21.42	34.13	21.57	25.85	19.98

*Means followed by the same lowercase letters, compared in the columns, do not differ from each other, by the Tukey test at 5% significance.

Table 4. Height, collection diameter, and dry matter of coffee seedlings as a function of the treatments used in the formation of the substrate.

Treatments	Height of plants (cm)	Collection diameter (mm)	Dry matter (g plant^{-1})		
			Aerial part	Root system	Total
T1	8.82^{c}	2.1^{b}	0.41^{c}	0.60^{a}	1.01^{c}
T2	14.35^{b}	2.6^{ab}	1.06^{b}	0.67^{a}	1.76^{b}
T3	14.86^{ab}	2.7^{a}	1.03^{b}	0.70^{a}	1.70^{b}
T4	16.04^{ab}	2.7^{a}	1.11^{b}	0.75^{a}	1.86^{ab}
T5	16.51^{a}	3.15^{a}	1.27^{a}	0.90^{a}	2.17^{a}
CV (%)	6.01	9.29	14.91	18.84	10.13

* Means followed by the same lowercase letters, compared in the columns, do not differ from each other, by the Tukey test at 5% significance.

composition of seedlings promoted an increase in dry matter of the aerial and total part, although it did not have statistically effect on the dry matter of the root system. The best results for the total dry matter were obtained with treatments with 30 and 45% of pig compost. This fact is probably justified by the higher levels of P and Ca in substrates fertilized with pig compost, since these nutrients act in the formation of the constituent parts of the plant, notably the P content in the root (Silva and Delatorre, 2009) (Table 3). The supply of P is essential for seedlings with a satisfactory quality index (Santinato et al., 2014), since this is the most important nutrient for the coffee-growing phase (Matiello et al., 2010; Silva et al., 2010) (Table 4). The quality indexes of seedlings have the purpose of making associations between the biometric variables studied in order to propose a definitive and determinant variable. Tall seedlings can present a small amount of root system and vice versa, not being adequate in the same way for the diameter of the stem. The best index value means the plant with the best balance between its constituent parts. These rates are widely used in quality papers about forest species seedlings (Marana et al., 2008; Caione et al., 2012).

For the RAD, which relates only to plant height and collection diameter, all treatments fertilized with organic sources were superior to the control, with no differences

Table 5. Quality indexes of coffee seedlings as a function of the treatments in the substrate formation.

Treatments	Seed quality indexes	
	DQS	RHD
T1	4.24[b]	1.21[b]
T2	5.44[a]	1.25[ab]
T3	5.52[a]	1.24[b]
T4	5.95[a]	1.25[ab]
T5	5.25[a]	1.33[a]
CV (%)	8.81	15.04

* Means followed by the same lowercase letters, compared in the columns, do not differ from each other, by the Tukey test at 5% significance.

Table 6. Pearson correlation between biometrics, dry matter and leaf content parameters, soil fertility parameters with IQD.

Biometry	Pearson
Height of plants	0.46*
Stem diameter	0.76**
Mg content foliar	0.61**
Dry matter of the aerial part	0.52*
Dry matter of the root system	0.89**
Total dry matter	0.77**
M.O content in soil	0.66**
Mg content in soil	0.71**
V%	0.45*
Cu content not alone	0.61**
Fe content in soil	0.56*
Mn content in soil	0.61**

* ns = not significant; * = significant at 5%; ** = significant at 1%.

amongst them. For the IQD, a more complete index, since the biometric parameters were related to dry matters, the best treatment was 45% of pig compost, with the corral compost and the pig compost in the background, both with a 30% level. There was no difference between the witness and 15% of pig compost, so this proportion cannot be recommended. Santinato et al. (2014), in the experiment of P doses in the formation of coffee seedlings obtained similar indexes for the best treatments studied. Ribeiro et al. (2007) and Caldeira et al. (2008) pointed out that when using 100% of the compost in the production of seedlings there was a decrease in the quality of the indexes (Table 5). There was a positive correlation between the height of the plants and the diameter of the stem with the IQD, whether they weak and strong, respectively. Thus, the diameter of the stem is the most appropriate to evaluate coffee seedlings of the biometric parameters (Table 5). Of all leaf contents, only the Mg showed correlation with the IQD, being classified as moderate, that is, leaf contents are not good indicators of seedling quality (Table 5).

The dry matter of the aerial part from the total and root system presented correlations with the IQD, weak, strong and strong, respectively. The main one was the dry matter of the root system, with a correlation coefficient of 0.89, being the parameter of the greatest correlation of all the evaluated in the present study (Table 6). The high correlation of root dry matter and IQD was already pointed out by Marana et al. (2008). The fertility chemical attributes that most influenced the quality of the seedlings were organic matter, Mg, base saturation index, Cu, Fe, Mn, Ca in CTC and Mg in CTC. Of these, the ones who showed most correlation were the Mg, in the same way as in the leaf content, except in this case with a strong correlation. The organic matter content was the one that obtained the biggest correlation in the background, and was also strong. The remainder had a weak correlation (Table 6).

The correlations showed the superiority of the treatments fertilized with pig compost, especially in its greater composition (45%), emphasizing that mainly the content of Mg contained therein (200.0 vs 85.68 mg kg^{-1}) and its constitution with high CTC were fundamental to the quality of seedlings. This huge amount of nutrients that compose the compound can even replace much of the supplemental mineral fertilizer used in the production of seedlings. Santos et al., (2010) they studied the feasibility of partial and total substitution of mineral fertilizers by the use of organic compounds and green manure in the field. In the same direction Fernandes et al. (2013) did the same using chicken manure. Both have come to the conclusion that it is necessary to associate the organic with the mineral for the best results.

The use of pig compost in the formation of the substrate for the production of coffee seedlings is an interesting alternative for those producers that are in pig producing regions, since it is a source of organic matter cheaper and superior in relation to other compounds such as bovine. The use of pig compost in the production of coffee plants, as well as in adult crops, arises from the need to minimize the negative effects that this compound could bring to the environment if it were discarded without any care (Navia et al., 2011). The pig compost can be improved when associated with higher C / N ratio materials, such as coffee straw, which is always available in coffee farms (Nolan et al., 2011).

Conclusions

1). The compost based on 30% pig manure was highlighted in comparison to the standard with 30% cattle manure, providing higher levels of OM, P, Mg and the micronutrients (B, Cu, Mn, Zn) of compost and it reflected in the increase of Mg contents in the aerial part of the coffee tree.
2). The use of 30 or 45% pig manure compost produces coffee seedling similar to the 30% cattle manure compost.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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