Scientia Agraria Paranaensis – Sci. Agrar. Parana.
ISSN: 1983-1471 – Online

GROWTH OF SEEDLINGS IN BANANA PLANT CV. PRATA CATARINA MICROPROPAGATED IN ORGANIC SUBSTRATES

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SAP 22283 Received: 03/05/2019 Accepted: 23/07/2019
Sci. Agrar. Parana., Marechal Cândido Rondon, v. 18, n. 4, oct./dec., p. 401-406, 2019

ABSTRACT - In commercial bananas there is an increasing increase for seedlings of high genetic quality and free of pathogens; thus, the use of micropropagation has been increasingly encouraged for the production of seedlings. However, the success of establishing these seedlings in the environment depends on several factors, in which, the substrate has a relevant role. The objective of this study was to evaluate the growth of micropropagated banana seedlings under the influence of different formulations of substrates based on soil, bovine manure and vegetable ash for organic production system. The experiment was carried out on a certified rural property under an organic production system in the municipality of Palmácia (CE). The experimental design used was completely randomized, with four replications. The substrates were used in a ratio of 2:1, always two parts of soil for one of substrate, which was used: soil (ravine soil), organic compost (bovine manure + vegeta1 remains), bovine manure and vegetable ash (from sugar cane mill). The test was conducted in full sun and without the aid of irrigation, as the experiment coincided with the rainy season in the region. At 68 days after planting (DAP), growth analyzes were carried out: plant height, diameter of the pseudostem, number of leaves, length of roots, fresh and dry mass of aerial part and roots. The best substrates for the growth of micropropagated banana seedlings cv. Prata Catarina were mixtures of soil + organic compost and soil + manure.
Keywords: *Musa* sp., organic matter, seedlings, micropropagated, organic system.

CRESCIMENTO DE MUDAS MICROPROPAGADAS DE BANANEIRA CV. PRATA CATARINA EM SUBSTRATOS ORGÂNICOS

RESUMO - Em bananais comerciais há um crescente aumento por mudas de alta qualidade genética e livres de patógenos; dessa forma, o uso da micropropagação tem sido cada vez mais estimulado para a produção de mudas. Porém, o sucesso do estabelecimento dessas mudas no ambiente depende de diversos fatores, nos quais, o substrato tem papel relevante. Objetivou-se com o presente trabalho avaliar o crescimento de mudas micropropagadas de bananeira sob a influência de diferentes formulações de substratos a base de solo, esterco bovino e cinza vegetal para sistema de produção orgânica. O experimento foi conduzido em uma propriedade rural certificada sob sistema de produção orgânica no município de Palmácia (CE). O delineamento experimental utilizado foi inteiramente casualizado, com quatro repetições. Os substratos foram utilizados na proporção de 2:1, sempre duas partes de solo para uma de substrato, ao qual foi utilizado: solo (terra de barranco), composto orgânico (esterco bovino + restos vegetais), esterco bovino e cinza vegetal (proveniente de engenho de cana-de-açúcar). O ensaio foi conduzido a pleno sol e sem auxílio de irrigação, pois o experimento coincidiu com o período chuvoso da região. Aos 68 dias após plantio (DAP) foram efetuadas as análises de crescimento: altura da planta, diâmetro do pseudocaule, número de folhas, comprimento de raízes, massa fresca e seca da parte aérea e de raízes. Os melhores substratos para o crescimento de mudas micropropagadas de bananeira cv. Prata Catarina foram às misturas de solo + composto orgânico e solo + esterco.
Palavras-chave: *Musa* sp., matéria orgânica, mudas, micropropagação, sistema orgânico.

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INTRODUCTION

Banana production in Brazil is predominant in the Northeast region, with a 33.74% share of national production in 2017 (EMBRAPA, 2017). In the State of Ceará, banana production stands out both for family farmers, as well as for large and medium-sized producers (EMBRAPA, 2014). One of the priority factors for the implantation of a banana orchard is the production of seedlings and their propagation in both organic and conventional systems. The quality of the seedling is of fundamental importance, as it directly influences the phytosanitary quality of the banana plantation (CORDEIRO, 2003).

Commercial banana trees are propagated vegetatively, and seedlings are obtained from the natural development of young, by rhizome fractionation techniques, accelerated propagation in vivo or *in vitro* methods (SALOMÃO et al., 2016). However, because of the increasing demand for high-quality, pathogen-free banana seedlings, the use of micropropagation techniques has been increasingly encouraged (OLIVEIRA et al., 2008).

Micropropagated seedlings show more uniform growth and fruit development. However, they also require a period of acclimatization before transplantation (SINGH et al., 2011). The use of substrate at the final location is also a requirement that directly influences the final quality of the seedling (OLIVEIRA et al., 2014; SANTOS et al., 2017), with the substrate used in seedling production one of the essential inputs for success of cultivation, as it provides support for the plant, in addition to providing nutrients, water and oxygen for its development (PAIVA et al., 2011).

The substrate is one of the most complex factors in the production of seedlings (ARAÚJO and SOBRINHO, 2011), which is considered a sensitive component in the production system, as any variation in its composition or property can alter the final process of seedling production (MINAMI, 2010). There are preponderant factors in the quality of a good substrate, such as having good physical, chemical and biological characteristics that enable the rapid growth of seedlings and the good dry matter content in the aerial and root parts (YAMANISHI et al., 2004; NOMURA et al., 2009). The substrate must also be easy to acquire and have low cost and low density (RODRIGUES et al., 2016).

The substrates can be of synthetic, mineral, organic origin, compound or not (YAMANISHI et al., 2004). In the market it is possible to find a variety of commercial substrates, which produce quality seedlings, but their cost is high (NOMURA et al., 2011). According to Almeida et al. (2012) it is necessary to determine the most suitable substrate for each species, seeking to meet mainly the nutritional demand of the plants. In some cases, it is necessary to mix two or more materials for the composition of the substrate, due to the difficulty in finding a material that meets all the necessary characteristics for the growth of certain species (GOMES and SILVA, 2004).

The most used materials in the formulation of substrates for micropropagated banana seedlings are carbonized straw or rice husk, tanned bark of eucalyptus or pine, vermiculite, sand, peat, coal, tanned manure from corral or chicken and terraces (NOMURA et al., 2009). In organic production systems, the most recommended is the use of organic substrates, as in these systems the use of synthetic fertilizers with high solubility is prohibited. In this case, organic substrates of vegetable and animal origin are used in mixture with the soil. Organic compounds that form substrates rich in mineralized organic matter and essential nutrients for plant development should be prioritized.

Therefore, the objective of this study was to evaluate the growth of micropropagated banana seedlings under the influence of different formulations of substrates based on soil, bovine manure and vegetable ash for the organic production system.

MATERIAL AND METHODS

The experiment was carried out on a certified rural property under an organic production system in the municipality of Palmácia (CE). The property is located in the mountainous region of the state of Ceará, Microregion of Maciço de Baturité and Mesoregion of Norte Cearense, geographically located 74 km from the state capital, under the geographical coordinates: 4°15'S and 38°87'W and 510 m altitude. According to the classification by Köppen and Geiger (1928), the region's climate is classified by *Aw*, with average temperatures ranging around 24 to 26°C and rainfall above 1300 mm (VIANA et al., 2016).

Micropropagated banana seedlings cv. Prata Catarina, approximately 8 cm tall, from the Biotechnology Laboratory of Ceará Ltda (BIOTEC®), in Fortaleza (CE). For the implementation of the experiment, the seedlings were removed from the flasks, washed in running water and planted on March 10, 2017, remaining in the field until May 18 of the same year in polyethylene bags with a capacity of 0.5 kg. The test was conducted in full sun and without the aid of irrigation, as the experiment coincided with the rainy season in the region.

The experiment was installed in a completely randomized design, containing four replications. The substrates were used in a proportion of 2:1 (v:v), always two parts of soil for one part of substrate, to which it was used: soil (barren soil), organic compost (bovine manure + vegetal remains), manure beef and vegetable ash (from sugar cane mill). All substrates underwent chemical analysis at the Soil Fertility Laboratory of the Soil Science Department of the Federal University of Ceará (UFC) (Table 1).

TABLE 1 - Chemical analysis of the substrates used in the study of micropropagated seedlings of banana cv. Prata Catarina.

Substrates	pH H_2O	N g kg^{-1}	Ca cmolc dm^{-3}	Mg	Na	K	P	CE $dS.m^{-1}$
				---------- mg dm^{-3} ----------				
soil	8.4	0.87	4.00	2.40	104.0	1,814	305.0	1.04
soil + ash	8.1	1.74	5.80	3.70	146.0	3,385	513.0	0.96
soil + manure	8.5	0.34	4.20	3.50	162.0	1,823	203.0	1.13
soil + compost	7.8	0.67	6.60	2.90	258.0	1,901	284.0	1.44

N = nitrogen, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, P = phosphorus, CE = electrical conductivity.

At 68 days after planting (DAP), growth analyzes were carried out: plant height, pseudostem diameter, number of leaves, length of roots, fresh and dry mass of aerial part and roots. The plant height was measured by measuring the neck of the plant until the insertion of the newest fully expanded leaf, while the diameter of the pseudostem was made with the aid of a digital caliper. The fully opened and expanded leaves of each plant were counted, and the root length was measured using a ruler, taking as reference the largest root.

To determine the fresh and dry mass of roots and shoots, four seedlings from each treatment were randomly selected, consisting of a repetition, which were removed from the substrate and separated into shoots (leaves and pseudostem) and roots. Then they were subjected to drying in an oven with forced air circulation at 65°C for 72 h, until reaching constant mass. The mass was determined by weighing on a semi-precision scale, considering two decimal places.

The data obtained were subjected to analysis of variance (ANOVA) by the F test and when found significant results, the means of each treatment were compared using the Tukey test at 5% probability, with the help of the statistical software SISVAR (FERREIRA, 2011).

RESULTS AND DISCUSSION

The highest values observed in most of the variables studied were for the substrate + organic compost, which was rich in calcium (Table 1). Although the substrate combined with the organic compost showed better behavior in the growth of seedlings, it did not differ significantly from the substrate prepared with bovine manure in the variables of pseudostem diameter, fresh and dry root mass, number of leaves and length of the largest root. It is observed in general that the substrates that involve some source of organic matter provided better conditions for the development of seedlings in relation to the isolated use of the soil (Figures 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B).

The substrate with organic compost provided a larger diameter of the pseudostem (16.99 mm, Figure 1A) and plant height (34.75 cm, Figure 1B), however, without differing as to the pseudostem diameter of the substrate that contained bovine manure (16,075 mm, Figure 1A). According to Santos et al. (2017), the pseudostem diameter of banana seedlings is an important characteristic, as it demonstrates their vigor.

Nomura et al. (2008), using subsoil earth substrate, carbonized rice husk and organic compound fertilizer, found an average seedling height of 28.4 cm, lower than this work for soil and compost and soil and manure. On the other hand, they observed a higher value in relation to the diameter of the pseudostem (24.4 mm). Moreira et al. (2006) found a higher plant height when they used organic compost and soil + manure as substrate in pineapple micropropagated plants.

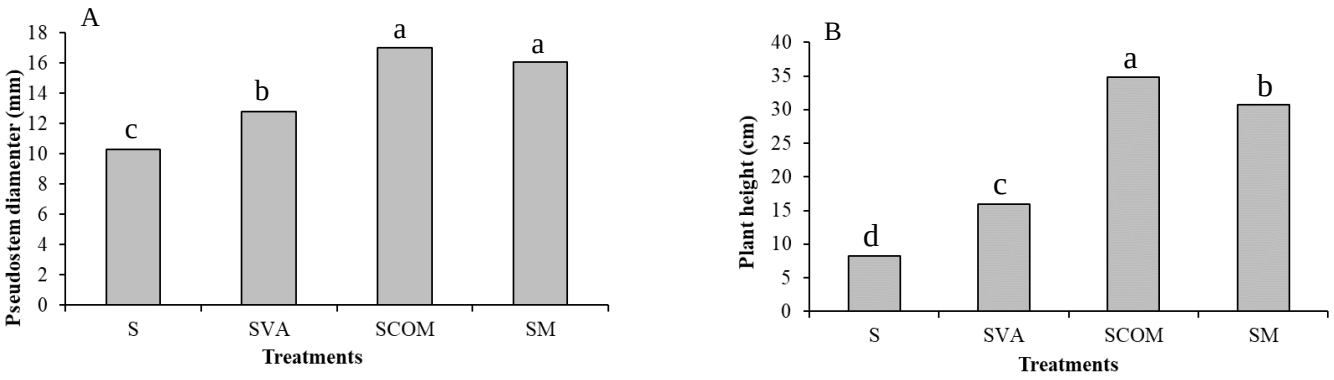

FIGURE 1 - Pseudostem diameter (A) and plant height (B) of micropropagated banana seedlings cv. Prata Catarina on substrates. SCOM: soil + compost, SM: soil + manure, SVA: soil + vegetable ash, S: soil.

These results highlight the importance of organic matter in providing better characteristics to the substrate, such as moisture, fertility and aeration. Martins et al. (2011) used cattle manure as a source of nutrients for the substrate for banana seedlings cv. Nanicão Williams and observed a higher pseudostem diameter (29 mm). However, in relation to the plant height (20.3 cm), the result was lower than that found in the present study

(30.68 cm) using soil and manure. Behavior like the diameter occurred in the characteristics of fresh and dry root mass in relation to the substrates soil + compost and soil + manure (Figures 2A and 2B). The fresh root mass was 42.405 g (soil + compost) and 41.202 g (soil + manure). Dry root weight was 3.4225 g (soil + compost) and 3.8800 g (soil + manure).

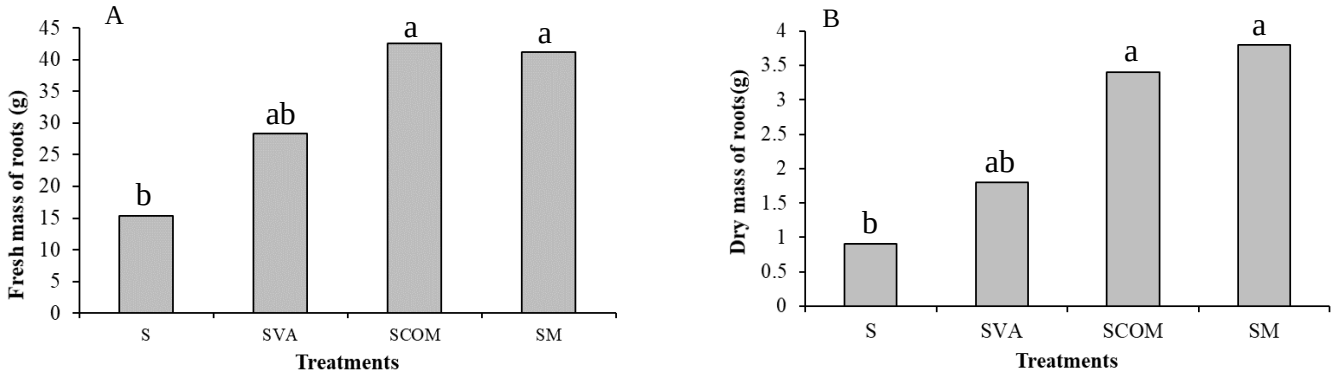

FIGURE 2 - Fresh root weight (A) and dry weight of root (B) of micropropagated banana seedlings cv. Prata Catarina on different substrates. SCOM: soil + compost, SM: soil + manure, SVA: soil + vegetal ash, S = soil.

The greatest results for number of leaves (Figure 3A) were provided by substrates with sources of organic matter, such as soil + compost and soil + manure (5.70 and 5.75, respectively). These values did not differ significantly from the soil + gray substrate. On the other hand, the lowest result was found for the soil substrate.

According to Santos et al. (2004), seedlings with a larger number of leaves, possibly, will present a higher index of setting, initial growth and development due to the higher production of photoassimilates. In practical terms, the number of leaves and the height of the seedlings are characteristics widely used by the biofactories that produce banana seedlings, since these characteristics are considered the main indicators in the decision to remove the seedlings from the greenhouse for sale (OLIVEIRA et al., 2014).

For the length of roots (Figure 3B), the soil provided the greatest root growth (30.38 cm). However, this value did not differ significantly from the soil + compost (21.75 cm) and soil + manure (24.65 cm) substrates. This result can be explained by the availability of water and nutrients in the substrate that directly affect root proliferation.

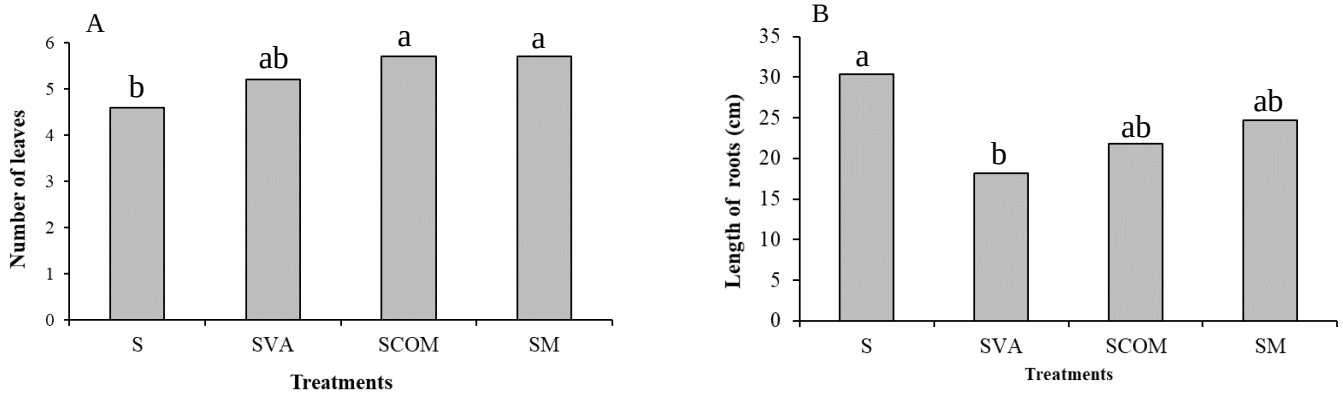

FIGURE 3 - Number of leaves (A) and root length (B) of micropropagated banana seedlings cv. Prata Catarina on different substrates. SCOM: soil + compost, SM: soil + manure, SVA: soil + vegetable ash, S: soil.

Thus, in the soil-based substrate there is a greater need for the root to grow to absorb water and nutrients. This result may have influenced the other variables, except for the root length, which was shorter. As in this substrate the plant allocated its reserves in the growth of the root for absorption of nutrients and water, therefore, there was restriction in the growth of the aerial part. Moreira et al. (2006), working with different substrates in the acclimatization of pineapple micropropagated seedlings, observed that the soil substrate, that is, the substrate without any organic component, presented a lower result when compared to seedlings that used other substrates. The best results for fresh (80.71 g) and dry (4.595 g) aerial parts were provided by the soil + compost substrate (Figures 4A and 4B).

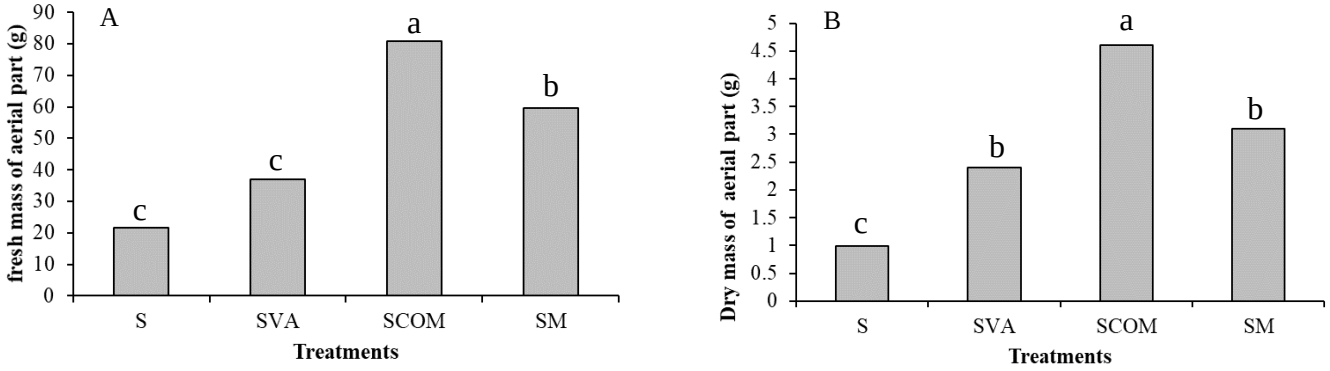

FIGURE 4 - Fresh (A) and dry shoot (B) mass of micropropagated banana seedlings cv. Prata Catarina in different substrates. SCOM: soil + compost, SM: soil + manure, SVA: soil + vegetable ash, S: soil.

The substrates soil + compost and soil + manure provided the best results, which can be suggested to the producer as an alternative in reducing costs when purchasing commercial substrates. The substrate prepared with vegetable ash did not show good results (Figures 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B and 5), despite the high nutrient content present in it (Table 1). Possibly, in this treatment, there was a loss in plant nutrition caused by a very high pH (8.1) and a strong imbalance in the potassium, calcium and magnesium relationships.

FIGURE 5 - Micropropagated banana seedlings cv. Prata Catarina in substrates based on soil, manure, vegetable ash and organic compost, respectively.

For all variables analyzed, the substrate that showed the worst results was the soil substrate (Figures 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B and 5), with the exception of the root length, which highlights the need incorporation of substrates containing organic matter.

Organic substrates allow plants to grow better, providing adequate conditions for good development. From the results, it is possible to identify that further research is needed with different proportions of organic matter, as well as other options for substrates of organic origin that may be incorporated into the soil, allowing for a higher quality in the production of seedlings.

CONCLUSION

The best substrates for the growth of micropropagated banana seedlings cv. Prata Catarina were mixtures of soil + organic compost and soil + manure.

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