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Seedlings of cassava varieties are responsive to organic fertilization

Mudas de variedades de mandioca são responsivas à adubação orgânica

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Resumo

No Brasil, já existe recomendação para produção de manivas semente de mandioca indicadas para mudas produzidas a partir da micropropagação, podendo ser estendida para a produção de mudas obtidas de hastes derivadas de plantas sadias, para evitar a disseminação de doenças. Assim, há necessidade da determinação de substratos de cultivo de fácil aquisição e que estimulem o crescimento das mudas, tanto para redução do tempo em viveiro, como também para reduzir os custos de produção das mudas. O objetivo deste trabalho foi avaliar o efeito do adubo orgânico elaborado a partir de estercos bovinos e caprino, além de resíduos de podas de árvores para a produção de mudas de três variedades de mandioca. As parcelas foram dispostas em delineamento experimental inteiramente casualizado, com seis repetições. Os tratamentos constaram de três genótipos de mandioca (BRS Formosa, BRS Tapioqueira e BRS Kiriris) e cinco proporções de adubo orgânico: solo (0:100, 20:80, 40:60, 60:40 e 80:20). As avaliações foram realizadas aos 30 e 45 dias após o plantio (DAP). Houve efeitos isolados para massa seca da parte aérea, massa seca total, área foliar e número de folhas. Interação para comprimento de raiz, índice de clorofila a e total, massa seca da raiz e relação entre MSPA/MSR aos 45 DAP. O adubo orgânico estimulou o crescimento inicial das mudas de mandioca nas três variedades estudadas na proporção de 50% de adubo orgânico e 50% de Latossolo. As variedades BRS Formosa e BRS Kiriris apresentaram os maiores Índices de Qualidade de Dickson. Os genótipos respondem eficientemente a adubação orgânica e podem ser propagados nesses substratos de cultivo de fácil aquisição.
Palavras-chave: *Manihot esculenta* Crantz. Fertilizante orgânico. Substratos de cultivo.

Abstract

In Brazil, there is already a recommendation for the production of cassava seed-cuttings for the production of seedlings originated from micropropagation, which may be extended for the production of seedlings obtained from cuttings from healthy plant stems, in order to avoid the spread of diseases. Therefore, it is essential to establish adequate cultivation substrates of easy acquisition which may stimulate the growth of seedlings, both to reduce the nursery period, as well as the seedling's production costs. The objective of this work was to evaluate the effect of organic fertilizers made from bovine and

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goat manures, and tree pruning residues, to produce seedlings of three cassava varieties. The plots were set in a completely randomized design, with six replicates. The treatments consisted of three cassava genotypes (BRS Formosa, BRS Tapioqueira and BRS Kiriris) and five proportions of organic fertilizer: soil (0: 100, 20:80, 40:60, 60:40 and 80:20). The evaluations were performed 30 and 45 days after planting (DAP). There were isolated effects for shoot dry mass, total dry mass, leaf area and number of leaves. Interactions were verified for root length, chlorophyll a and total chlorophyll index, root dry mass and shoot dry mas/root dry mass ratio 45 DAP. The organic fertilizer stimulated the initial growth of cassava seedlings in the three varieties studied in the proportion of 50% of organic fertilizer and 50% of Latosol. Varieties BRS Formosa and BRS Kiriris showed the highest Dickson Quality Scores. Genotypes reacted efficiently to organic fertilization and can be propagated on these easily acquisition cultivation substrates.

Key words: *Manihot esculenta* Crantz. Organic fertilizer. Crop substrate.

Introduction

Cassava (*Manihot esculenta* Crantz) is widespread cultivated in Brazil, as in different countries in the Asian, African and American continents. This crop is cultivated in all Brazilian states, taking on a prominent role in human and animal food, as well as being used as raw material to produce many industrial products, generating many direct and indirect jobs.

Notwithstanding, the crop in most cases is growth without the use of fertilizers, using vegetative material multiplied by the farmer himself. Therefore, the crop can be affected by fungal, viral and bacterial diseases, due to the lack of proper nutrition for full development and by the lack of selected healthy material for plant propagation.

Drought tolerant varieties with resistance against root rot and bacterial plant pathogens are desired for the Brazilian Northeastern region. Varieties BRS Tapioqueira, BRS Kiriris and BRS Formosa have such characteristics, while BRS Formosa and BRS Tapioqueira varieties have strong tolerance against the common mosaic virus (VENTURINI et al., 2016), which highlights the agronomic potential of these varieties. The average yield of Tapioqueira, Kiriris and Formosa varieties can reach 56, 46 and 54 t ha^{-1} of roots/year, respectively, a value which is far above the national average.

In Brazil, there is already a recommendation for production of cassava seed-cuttings intended for micropropagated produced seedlings, which may be extended to the production of seedlings obtained from healthy plant stems, in order to avoid the spread of diseases (MENDONÇA et al., 1986). Therefore, it is necessary to establish cultivation substrates of easy acquisition which may stimulate seedling growth, both to reduce the period in the nursery and the production costs of the seedlings.

The use of alternative inputs to compose seedling cultivation substrates is a way to increase crop production which may promote the reutilization of organic wastes from agricultural activities. In forest crops there is some evidence showing growth stimuli of seedlings in the nursery phase, where substrates composed of organic residues can increase the growth variables in comparison with seedlings cultivated only with soil (LUSTOSA FILHO et al., 2005). This is due to the fact of organic fertilization promotes improvements of the physical and chemical attributes of the cultivation substrates (PAIVA et al., 2009; PRIMO et al., 2013, MOREIRA et al., 2018), which may allow an increase in the growth of cassava seedlings (NASCIMENTO et al., 2014) and cassava seed-cuttings in the nursery phase. Thus, it is necessary to establish organic substrates of easy acquisition which may stimulate the initial growth of cassava seedlings, reducing the nursery period, simplifying plant propagation and reducing production costs. The objective of this study was to evaluate the effect of organic fertilizer made from bovine and goat manures and pruning residues from trees, for the production of plantlets seeds of cassava varieties.

Material and Methods

The experiment was performed in greenhouse at the Federal University of Recôncavo da Bahia (UFRB), located in the municipality of Cruz das Almas - BA, geographical coordinates 12º40'24 "south latitude and 39º06'07" west longitude, at 220 m height. According to Köppen and Geiger the climate of Cruz das Almas fits into the type Af; tropical, hot and humid with average temperature of 23ºC and average annual rainfall of 1136 mm.

The substrates were made up of compost constituted by soil samples collected at more than 50 cm depth of a dystrophic cohesive Yellow Latosol (Oxisoil) medium texture, collected in the city of Cruz das Almas, Bahia, Brazil, added with organic compost produced at UFRB with residues of gardening pruning added with goat and cattle manure at a 3: 1 ratio.

Soil samples were collected from 20 to 40 cm depth .Samples were crushed and sieved in 5 mm mesh. The chemical analysis of the soil was carried out at the Soil Laboratory of the Escola Superior de Agricultura Luiz de Queiroz and showed pH (in water) of 5.2; organic matter content of 1.44 (dag kg^{-1}); P and K: 0.11 and 0.19 (mg dm^{-3}), respectively. Ca, Mg, Al and H + Al; 0.80; 0.40; 0.30; 2.60 $cmol_c$ dm^{-3}, respectively; potential CEC of 4.00 $cmol_c$ dm^{-3}. A batch sample of the organic compost produced at UFRB was used to carry out the present study and its chemical characterization is showed in table 1 to assist in the discussion of the present work, as well as the chemical characterization of the standard substrate used by EMBRAPA.

Table 1. Chemical characterization of the organic compost made from cattle and goat manure and tree pruning (COP) and the standard (control) substrate.

Chemical Attributes	COP *	Standard substrate
	Dry Basis (65%)	Dry Basis (65%)
pH (0.01 M $CaCl_2$)	6.4	5.0
Density (organic residue)	1.00 g cm^{-3}	0.83 g cm^{-3}
Humidity (organic waste) 60 - 65 ° C	12.03%	23.90%
Humidity (organic waste) 110 ° C	0.69%	5.02%
Total Organic Matter (combustion)	12.10%	85.82%
Organic carbon	5.99%	46.61%
Total Mineral residue (RMT)	87.12%	7.58%
Mineral residue (MR)	6.55%	6.77%
Insoluble Mineral residue (RMI)	80.57%	0.81%
Total nitrogen	0.70%	0.51%
Phosphorus (P_2O_5) Total	0.23%	1.73%
Potassium (K_2O) Total	0.25%	2.01%
Calcium (Ca) Total	0.57%	1.88%
Magnesium (Mg) Total	0.13%	0.13%
Sulfur (S) Total	0.02%	0.09%
C / N	8.56	91,39
Copper (Cu)	15 mg kg^{-1}	14 mg kg^{-1}
Manganese (Mn)	127 mg kg^{-1}	105 mg kg^{-1}

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Zinc (Zn)	35 mg kg^{-1}	39 mg kg^{-1}
Boron (B)	234 mg kg^{-1}	5 mg kg^{-1}
Sodium (Na)	824 mg kg^{-1}	2704 mg kg^{-1}

Methods 0.01 M $CaCl_2$ pH; Total organic matter and mineral residue on combustion in muffle; potassium (K_2O), calcium (Ca), magnesium (Mg) by an atomic absorption spectrophotometer, extracted with CH 1l + 1; total nitrogen, sulfuric digestion (Kjeldahl); carbon by dichromate oxidation followed by titration; phosphorus (P2O5): Extraction with HCl 1 + 1, determined by spectrophotometer (reading at a wavelength of 430 nm) by the method with vanadomolbidical solution; sulfur (S) Gravimetric barium sulfate; iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), sodium (Na) for an atomic absorption spectrophotometer extracted with HCl 1 + 1. Boron (B) with a spectrophotometer Azomethine H monosodium. (Ref.: Manual of official analytical methods for fertilizers and lime. MAPA, 2013).

The experiment was organized in a completely randomized design with six replicates and a factorial scheme (3 x 5) was adopted, consisting of three cassava genotypes: BRS Formosa, BRS Kiriris and BRS Tapioqueira (Table 2) combined with five proportions of pruning compost mixed to a sample of dystrophic cohesive Yellow Latosol (Oxisoil) with the following proportions of organic fertilizer:soil (0: 100, 20:80, 40:60, 60:40, 80:20) (v / v), each experimental unit consisted of a 5 cm long seedling with three buds.

Table 2. Botanical and agronomical characteristics of cassava genotypes.

Genotype	Color of adult leaf	Root	Root production (t ha^{-1})	Dry matter content (%)	Use	Cyanide Content	Note
BRS Formosa	Dark green	Taper-cylindrical	22-54	30.6 to 40.5	Industry of flour and starch	Medium	Resistance to bacte-rial blight
BRS Kiriris	Light green	Taper	26-46	22.8 to 30.1	Industry of flour and starch / human consumption	Low	Resistance to root rot
BRS Tapioqueira	Dark green	Taper-cylindrical	33-56	23.7 to 30.5	Industry of flour and starch	High	Drought tolerance

Source: Embrapa Cassava and Germplasm bank: management, conservation and characterization.

As a standard control we used the substrate routinely used to produce seedlings at EMBRAPA, consisting of one part of vermiculite (25%), two parts of coconut fiber (50%) and one part of washed sand (vegetable soil) (25%). The soil and the organic compost were air-dried, crushed, sieved in a 5 mm mesh sieve and distributed in 288 ml capacity tubes, according to the respective proportions mentioned.

The cuttings were slashed longitudinally, planted in plastic tubes in horizontal position with 1/3 of the cutting immersed in the soil + organic fertilizer and the buds oriented upwards to facilitate emergence. Humidity was sustained with daily irrigations simulating nursery conditions. The number of leaves

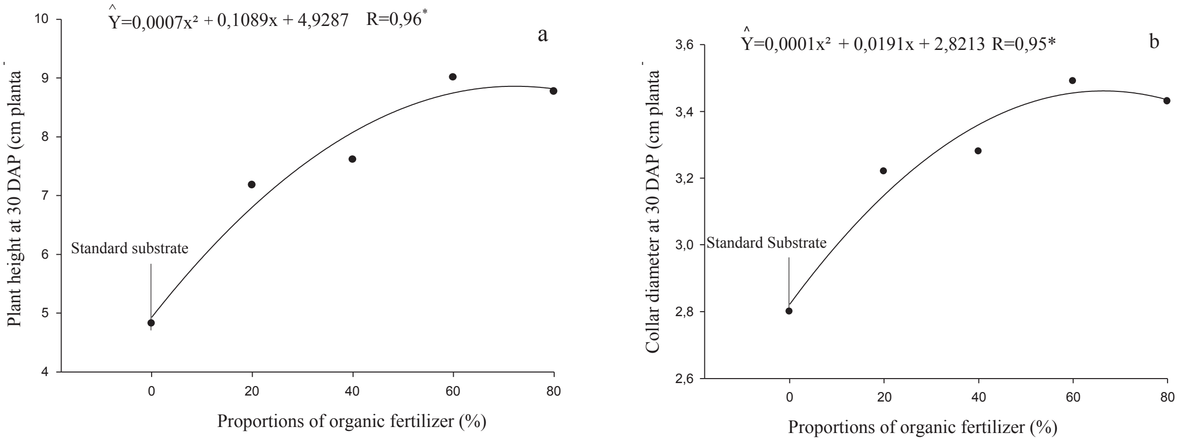
(NL), height of the aerial part of the plant (H), the average diameter of the stem (D) and height-per-diameter ratio (H / D) were evaluated 30 days after sprouting. At 45 days after sprouting the seedlings were collected to evaluate the NL, D, H and H / D and also the index of chlorophyll a, b and total chlorophyll, leaf area (LA) and root length (RL). Subsequently, the plants were washed and divided in aerial portion and roots which were dried in a forced air circulation oven at a temperature of 65ºC before quantifying the dry mass of the aerial portion (MAP), dry mass of roots (MR), total dry mass (TM) and the ratios H/DMAP and DMAP/DMR. The determination of the dry mass was performed in electronic balance and the height of the plant was measured with a graduated ruler (measured from the base of the stem, the neck, to the apex [emergence of the last leaf]). The diameter of the stem (D) was measured with a pachymeter (measured at the base and upper third of the stem) and the root length with the graduated ruler. The quantification of chlorophyll and LA were made using a FALKER CFL1030 electronic chlorophyllometer and WINDIAS image leaf area meter, respectively. The Dickson quality index was determined according to the weight of total dry matter (WTDM), height of the air portion (H, in plant^{-1}), steam diameter (D, mm plant-1), dry matter (DM g plant^{-1}), dry matter of roots (DMR, g plant^{-1}), using the formula: DQI = { WTDM / [(H / D) + (DMAP / DMR)} (DICKSON et al., 1960). The data were submitted to analysis of variance (ANOVA) by the F test, at 5% of probability and multiple comparisons of means by the Tukey test and polynomial regression analysis at 5% probability for the variables studied, as a function of the proportions of organic compost, using the statistical program (R Core Team, 2016), ExpDes.pt package (FERREIRA, 2013). The data were adjusted to the polynomial regression model when they were significant. For variables LN, H / DMAP and DMAP / DMR, the data were transformed to square root of Y - SQRT (Y), square root of Y + 0.5 - SQRT (Y + 0.5).

Results and Discussion

There was interaction between cassava varieties and proportions of organic fertilizer: soil for H / D ratio and individual effects of varieties and proportions of organic fertilizer: soil for H and D, evidenced in the evaluation performed 30 DAP (Table 3).

At 45 DAP, there was interaction between the treatments studied for H, D, H / D, RL, chlorophyll a and total chlorophyll, DMAP / DMR and DMR ratio. Individual effects also occurred for the following variables: LA, chlorophyll b, LN, DMAP and TDM, H / DMAP and DQI (Table 4). At 30 DAP, the maximum H and D of cassava varieties were obtained in the substrates consisting of 27.7: 72.3 and 33.0: 67.0 (soil: organic fertilizer), (Figures 1a, b), with an increase of 73.3 and 25.0%, respectively, in relation to plants grown with standard substrate (control). In seedlings having only soil as substrate (0: 100), this increase was of 86.9 and 25.0%, respectively.

Figure 1. Height (a) and diameter (b) of cassava plants 30 DAP, as a function of genotypes and proportions of organic fertilizer and control (standard substrate).



Considering the individual effect of the varieties, BRS Formosa showed the highest mean H and D of the stem, followed by BRS Tapioqueira and BRS Kiriris (Table 3). Seedlings that showed greater growth and vigor of the aerial portion tend to be more productive, as a result of the higher contents of reserves that provide greater sprouting force for plantlets. Moreover, plants with higher vegetative growth allow quicker soil cover and reduced weeding costs. At 45 DAP, the variety BRS Formosa also showed higher H (12.52 cm plant^{-1}) (Table 4).

Table 3. Evaluation of height (H) and diameter (D) of cassava genotypes grown on substrates made of organic fertilizer and dystrophic Yellow Latosol 30 DAP.

Genotype	H (cm^{-1} plant)	D (mm^{-1} plant)
BRS Formosa	9.98 a	3.41 a
BRS Kiriris	5.92 b	3.34 a
BRS Tapioqueira	6.35 b	2.99 b

Means followed by the same letter in the column did not differ at the 5% probability by Tukey test

Varieties BRS Kiriris and BRS Tapioqueira had an average of 10.11 cm and 8.93 cm, respectively, obtained with 60.8, 48.1 and 51.6% of the organic fertilizer, respectively (Figure 2a). These averages were higher than 66.7 and 81.4%, as observed in seedlings grown with the standard substrate and only soil: (0: 100), respectively, which shows their early growth responsiveness (Table 1). Some organic residues have already been tested for the crop, both at the initial stage for seedling formation and under field conditions. The seedlings of the variety "Fools Thief" showed better initial development when cultivated with 10% of enriched sugarcane bagasse (NASCIMENTO et al., 2014). In field conditions, the use of 10 t ha^{-1} of bovine and domestic manure, for a period of two years in a Plintic Luvissol promoted an increase in plant H (MAKINDE; AYOOLA, 2008).

Table 4. Evaluation of cassava genotypes grown on substrates made of organic fertilizer and dystrophic Yellow Latosol 45 DAP.

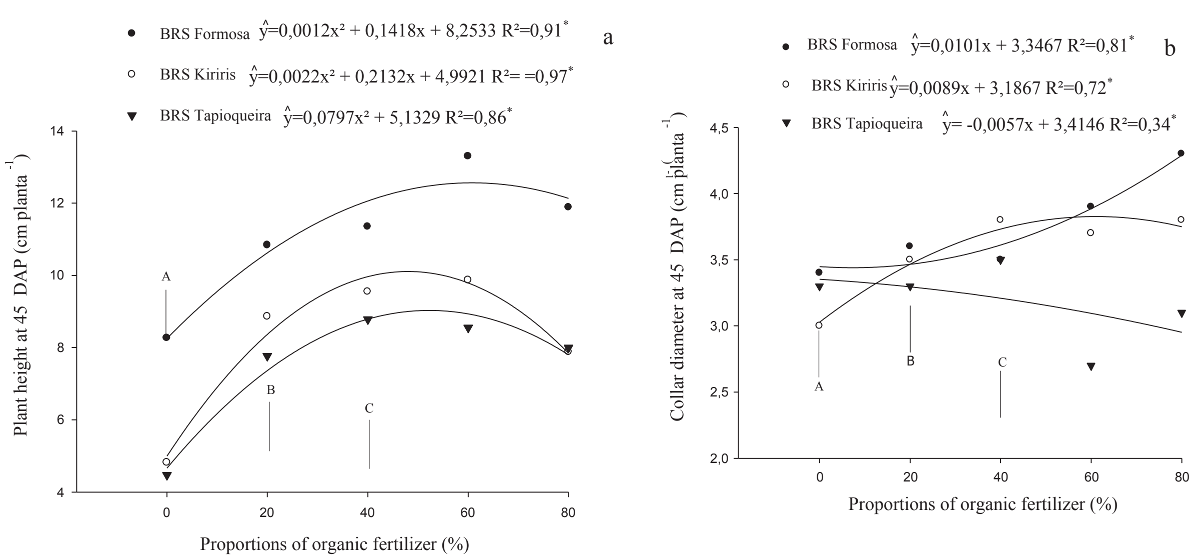
Genotype	LA[1]	NL[2]	CLOB[3]	DMAP[4]	TDM[5]	DQI[6]
	cm^2 $plant^{-1}$	Items. $Plant^{-1}$	-------g $plant^{-1}$------			
BRS Formosa	90.68 b *	6.43 b	6.57 a	1.02 a	2.15 a	0.55 a
BRS Kiriris	114.21 a	7.13 a	7.04 a	1.01 a	1.75 b	0.49 a
BRS Tapioqueira	86.55 b	6.43 b	5.91 b	0.79 b	1.14 c	0.26 b

[1]AF leaf area, [2]NF: number of leaves, [3]CLOB: chlorophyll b) [4]DMAP: Dry weight of shoots, [5]TDM: Total dry matter and [6]DQI Dickson Quality Index. * Means followed by the same letter in column , do not differ, the 5% probability by Tukey test

Considering the average D of the stem, the maximum means were of 4.31 and 3.81 mm with application of 67.8 and 61.2% of organic fertilizer, respectively (Figure 2b) and these were 32.1% at (0: 100), and 15.6% higher, respectively, in relation to the standard substrate (control). The difference between the average H and D between the varieties (Table 4) may be related to their genetic characteristics. The H of cassava plants is an important factor, both in the competition with spontaneous plants and in the choice of crops for use in a consortium (RÓS, 2013; PEREIRA et al., 2012).

In fact, the BRS Formosa variety is recommended for animal feed as an important nutritional source, mainly for its shoot production. The aerial portion of this variety is composed of upright stems, which facilitate the handling, transport of the stems and the mechanized planting, which results in greater uniformity of the crops. BRS Formosa is recommended for planting in the Mid-South Bahia mesoregion because it is resistant to bacterial diseases caused by *Xanthomonas axonopodis* pv. *manihotis*, being able to produce a dry biomass of around 30.6 to 40.5 kg ha^{-1}. Thus, in the growing phase, the variety BRS Formosa shows potential for the consortium with other species.

Figure 2. Height (a) and diameter (b) of cassava plants 45 DAP, as a function of genotypes and proportions of organic fertilizer and control (standard substrate). A, B and C percentage difference of the treatments in relation to the standard substrate.



There was interaction ($p < 0.05$) 30 DAP for H/D ratio with maximal averages of 3.26 and 2.13 for BRS Formosa and BRS Kiriris, while in BRS Tapioqueira the response increased linearly (Figure 3a). These results were obtained with the combination of 46.3 and 67.5% of organic compost in the soil. The increment resulting from organic fertilization was of 42.2% in relation to the control substrate and 52.0% in relation to the substrate 0: 100 (compost: soil). Organic fertilization may promote improvements in the chemical and physical attributes of substrates, not only by the addition and availability of nutrients, but also by the effect of organic matter (Table 1) on the physical attributes of the substrates, whose effects may occur on structure, density, hydraulic conductivity and porosity, besides promoting increments in the substrate fertility stimulating the initial growth of seedlings in small pots (PAIVA et al., 2009; PRIMO et al., 2013). This fact was verified since the increase was of 86.9% in relation to the seedlings cultivated in soil only (0: 100). With the application of the organic fertilizer, the variables H and D showed increments of 16.3 and 3.0%, respectively, from 30 to 45 DAP.

Similar results were obtained for the H/D ratio 45 DAP, although the BRS Kiriris variety did not differentiate ($p > 0.05$) from the BRS Tapioqueira. The indices obtained were of 3.48 and 2.74 for the BRS Formosa and BRS Kiriris varieties, respectively, with application of the maximum dose of 45.4 and 45.6% of organic fertilizer, which is not the case with BRS Tapioqueira, whose behavior is linearly increasing with increasing proportions of organic fertilizer (Figure 3b).

There was an increase in 37.6% and 74.0% in relation to the standard substrate and the control, respectively. LN per plant was also influenced by the application of organic fertilizer, with up to seven leaves with 50% of compost and 50% of soil. Regarding the individual effect of the genotype, BRS Kiriris produced more leaves at 45 DAP (Figure 4a). The increase of production was superior in 24.91% in relation to the control and 33.46% in relation to the standard substrate. This result is quite interesting, because the larger the number of leaves, the higher the photosynthetic rate, and consequently the greater the accumulation of photoassimilates in the plant. In addition, leaves are widely used in food composition in the North and Northeast regions of Brazil. Regarding the variables that showed individual effects, the maximum leaf area of the plants studied was of 119.43 cm^2 obtained by applying the maximum dose of 54.2% of organic fertilizer (Figure 4b).

Figure 3. Relation (ratio) height and diameter (HD) of cassava plants 30 DAP (a) and 45 DAP (b) according to the genotypes and proportions of organic fertilizer and control (standard substrate). A, B and C percentage difference of the treatments value in relation to the standard substrate.

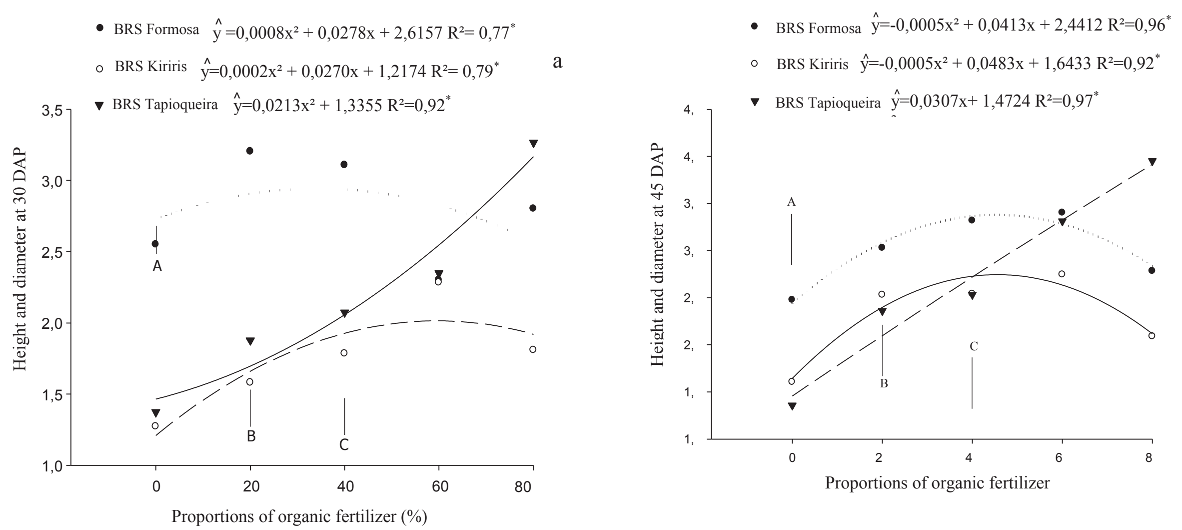
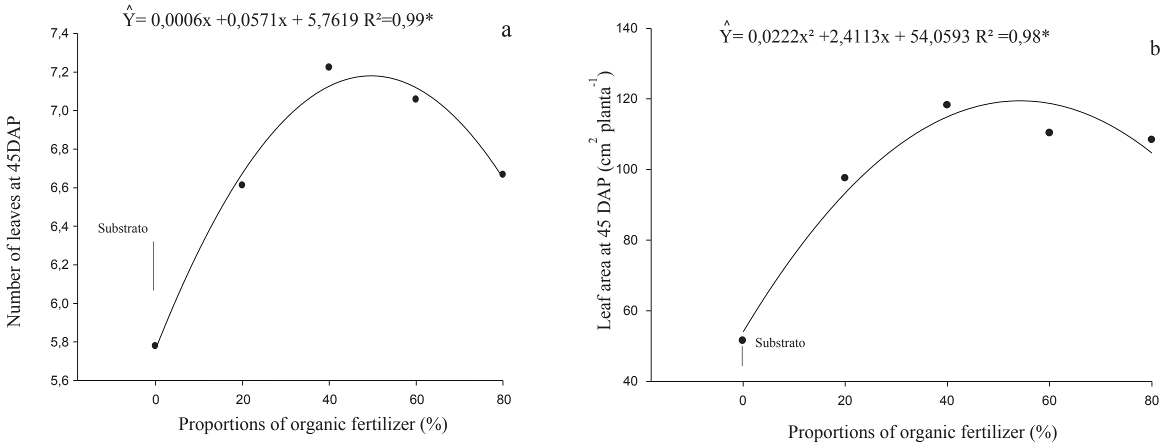


Figure 4. Regression of the number of leaves (a) and leaf area (b) of cassava 45 DAP cultivated in different proportions of organic fertilizer.



The variety that showed the largest leaf area was BRS Kiriris, with 114.21 cm^2 (Table 4). This variable is extremely important because it is related to the interception of solar luminosity in photosynthesis by the plant, which will result in higher productivity of the cassava plant, besides being an indicator of the growth rate of the crop. Makinde and Ayoola (2008) evaluated the effect of organic fertilization on cassava in a field experiment, evaluated nine months after planting, with a leaf area of 192 cm^2, using organic fertilization, demonstrating the responsiveness of fertilization in cassava. The use of organic substrate favors the physical-chemical and functional properties of cassava starch, increasing among other variables the total leaf area of cassava, as seen in an experiment evaluated between five and eight months after planting, by Hernández-Fernández et al. (2016), which obtained a total leaf area of 300 cm^2 in cassava plants. In this way it is verified that the organic substrate tends to favor a significant increase for this variable, still in the initial period of cassava seedlings production in the greenhouse.

Considering the DMR, there was a decreasing quadratic effect ($p < 0.05$) with the increase of proportions of the organic fertilizer, being the maximum yields per variety of 1.33 and 0.54 grams plant^{-1} for BRS Formosa and BRS Tapioqueira obtained with the addition of 56.88 and 50.13% of organic compound in the substrates, whereas for BRS Kiriris there was no response (Figure 5a). This effect can be attributed to the improvement of substrate fertility, which promoted the supply of nutrients and organic matter, stimulating the root mass production of the plants. The increase in DMR was of 64.29% and 35.29% in relation to the standard substrate, respectively. However, the average length of roots of the varieties tended to decrease with the increasing proportions of the organic fertilizer in the cultivation substrate. Therefore, the average root lengths ranged from 17.96, 16.27 to 17.62 cm plant^{-1} in the BRS Formosa, Kiriris and BRS Tapioqueira varieties, respectively, in the absence of the fertilizer, length ranged from 14.97, 14.75 to 14.08 cm with application of the maximum dose of 80% of organic fertilizer, respectively (Figure 5b). These differences represent a reduction of 15.7% in relation to the control and 10.2% in relation to the standard substrate.

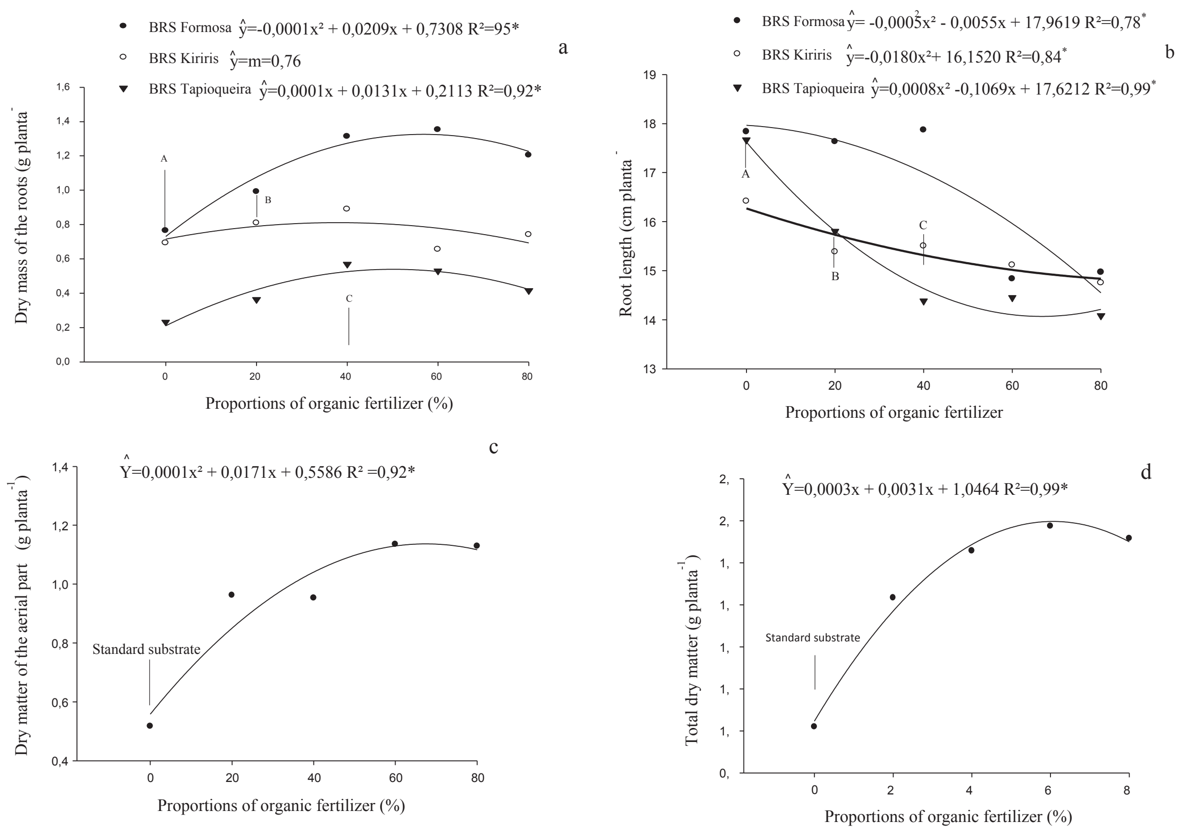
Also, with regards to the individual effects, for the dry mass of aerial portion, the highest yield was of 1.14 grams of plant^{-1} obtained with the application of 67.37% of organic fertilizer (Figure 5c) and the varieties BRS Formosa and BRS Kiriris were the ones that responded better to the organic fertilizer (1.02 and 0.99 g plant^{-1}, respectively).

The BRS Tapioqueira variety was the least responsive (Table 4). The use of organic fertilizer allowed an increase of 76.6% and 45.7% in relation to the standard substrate and substrate composed only of soil (0: 100), respectively. This information is relevant for the propagation of seed plantlets, since the quality of the cultivation substrate will directly influence the quality of seedlings produced and may reduce nursery time.

The total dry mass (TDM) showed a maximum of 2.0 g plant^{-1} with the application of 60.54% of organic fertilizer and the BRS Formosa variety was quite responsive (2.15 g plant^{-1}) in relation to the others, followed by the BRS Kiriris variety and BRS Tapioqueira, 1.75 and 1.14 g plant^{-1}, respectively (Figure 5d, Table 4). The use of the organic fertilizer provided an increase of 49.2 and 93.1%, relative to the standard substrate and the control, respectively.

Regarding DMAP/DMR ratio, there was interaction between the genotype treatments and the proportion of organic fertilizer, with increasing quadratic effect for the BRS Tapioqueira variety and decreasing quadratic effects for BRS Kiriris variety with maximum values of 2.28 and 1.78 for maximum doses of 80 and 57.3% of organic fertilizer, while for BRS Tapioqueira ($p < 0.05$) there was no significant effect (Figure 5e). The averages were higher than the seedlings cultivated with standard substrate in 53.7% and 43.1%. For the chlorophyll b index, a similar result was obtained in the BRS Kiriris variety with a mean value of 7.04 µg cm^{-2}, followed by the BRS Formosa and Tapioqueira varieties. The control group showed a lower yield of 129.6% for leaf area and 5.79% for chlorophyll b, while for leaf substrate it was of 146.3% for leaf area and 39.3% for chlorophyll b (Table 4).

Figure 5. Regressions of dry mass of root (DMR) (a), root length (b) dry matter of the aerial portion (DMAP) (c) Total dry weight (d) DMAP / DMR ratio (e) and H / DMAP ratio (f) from cassava 45 DAP cultivated in different proportions of organic fertilizer. A, B and C value of percentage difference from treatments versus standard substrate.



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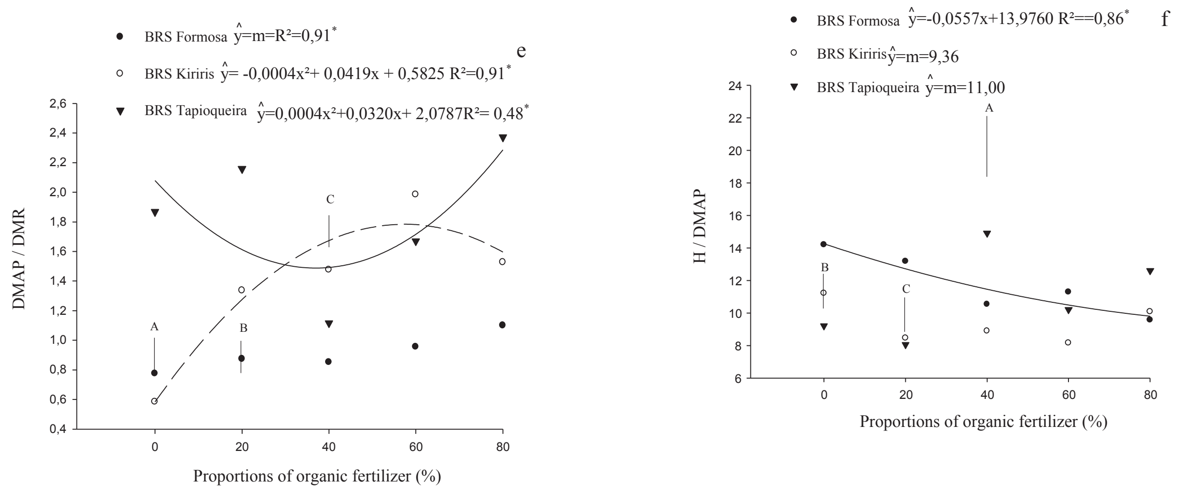
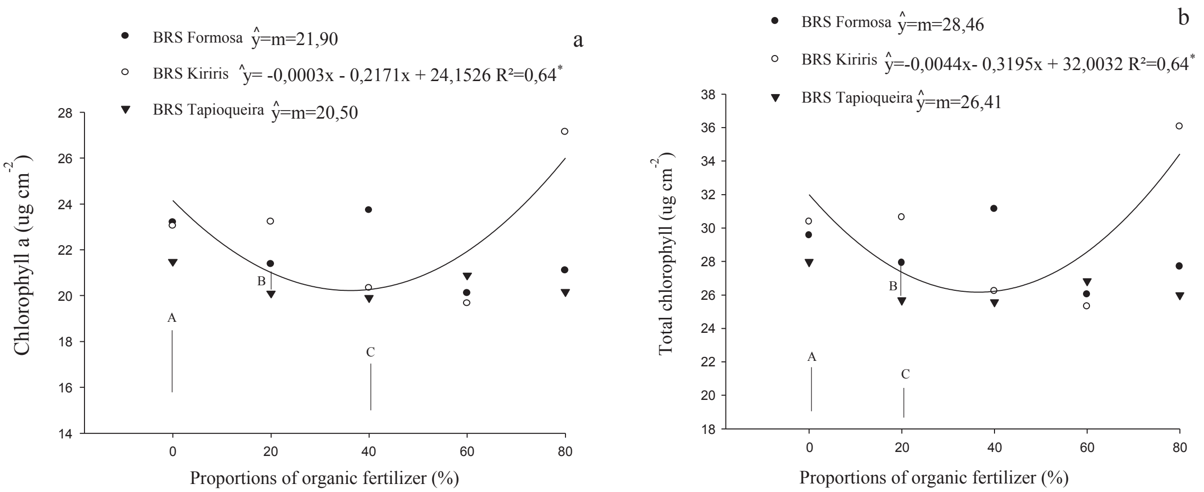


Concerning the H/ DMAP ratio, the varieties with the highest plant H (BRS Formosa and BRS Kiriris) also had higher DMAP (Figure 5f, Table 4). Otsubo et al. (2008) obtained similar results, with positive and significant genotypic correlations between plant H and DMAP.

The chlorophyll a indices of the BRS Formosa and BRS Tapioqueira varieties were lower than those of BRS Kiriris ($p < 0.05$) and showed a constant effect with the increase of organic fertilizer proportions, whereas BRS Kiriris showed a quadratic behavior, whose minimum index of 20.23 µg cm^{-2} was obtained with the application of 36.15% of organic fertilizer and a maximum of 26.00 µg cm^{-2} with the maximum proportion of 80% (Figure 6a).

Figure 6. Regressions of chlorophyll a (a) and total chlorophyll (b) of cassava genotypes cultivated in different proportions of organic fertilizer 45 DAP. A, B and C value of percentage difference from treatments versus standard substrate.



For the total chlorophyll index, similar results were obtained for all varieties (Figure 6b). The BRS Kiriris showed maximum value of total chlorophyll of 43.43 μg cm^{-2} in the proportion of 20:80 (soil: compound) (Figures 6a and 6b). These results were also higher than those obtained by the standard substrate at 25.4% and 28.5% difference in chlorophyll a and total chlorophyll, respectively. Thus, the use of organic fertilizers may lead to an increase of the photosynthetic rate in the initial stage of growth of cassava seed plantlets.

In order to evaluate the quality of seedlings, the evaluation of a single variable is not recommended, in this case DQI can be an interesting alternative, since it integrates important plant growth variables, also present in the production of seedlings of fruit and tree species (DIAS et al., 2012; AMARAL et al., 2016; LUSTOSA FILHO et al., 2015; SOUSA et al., 2015). Thus, the higher the DQI, the higher will be the standard quality of the seedlings. The BRS Formosa and BRS Kiriris varieties showed the highest DQI with 0.55 and 0.49, respectively (Table 4). Costa et al. (2011) report that the DQI is a good indicator for quality and vigor of eggplant seedlings. However, for the cassava crop, the ideal value of DQI has not yet been defined, requiring further studies.

Cassava crop is recognized as responsive to fertilization (PEREIRA et al., 2012), as well as is able to grow in low fertility soils. Analyzing the production of dry mass of seedlings the organic compost at a proportion of 50: 50 (organic compost: soil) promoted the highest mean values, with values even exceeding those obtained for plants cultivated with the control substrate used for the production of genotypes of cassava seedlings.

The level of organic matter in the soil of the substrates was low (Table 1). This justifies the expansion and use of organic fertilizers in cassava production systems. The ease decomposition of materials used in organic fertilization depends on the carbon: nitrogen ratio (C: N ratio). The ideal value is around 30: 1. The C: N ratio of 8.56 of the organic pruning compost is less than ideal, meaning that the fertilizer is mineralized. On the other hand, the standard substrate with a very high C: N ratio indicates immobilization of nutrients. The pH of the compost may be an indicative of the composting status of the organic residues, as well as the availability of nutrients to the plants, low pH values (<5) are indicative of lack of maturation due to the short duration of the process, or the occurrence of anaerobic processes inside the compost pile. Therefore, the organic pruning compost has a slightly neutral value (6.0), which, in a way, favors the availability of nutrients to cassava seedlings.

The need for a sustainable environment and lower cost of production is generally one of the reasons that motivate investments in the use of organic fertilizer in cassava. Organic compost composed of bovine-goat manure and tree pruning can be used to propagate seed plantlets of better quality, being an alternative fertilizer that can be easily produced by farmer.

Conclusions

The bovine-goat manure and tree pruning compost was able to stimulate the growth of seed plantlets of cassava genotypes, with the BRS Formosa and BRS Kiriris varieties having the highest Dickson Quality Index scores. The proportion of 50% compost and 50% of a dystrophic cohesive Yellow Latosol was the most suitable for the preparation of the substrate aiming the initial growth of seed plantlets of the different cassava varieties.

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