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Production of eggplant from seedlings produced in different environments, containers and substrates

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ABSTRACT

The seedling quality affects the plant performance in the field and proper techniques can increase the productivity of vegetables. The objective of this study was to evaluate the production of eggplant seedlings, cultivar Embu, under protected environments, containers and substrates, and its development in the field at the State University of Mato Grosso do Sul, in Aquidauana, Brazil. For seedlings production, each environment was considered an experiment, which was carried out in a completely randomized design, in split-plot scheme (containers x substrates), with eight replications. Subsequently we realized joint analysis of the experiments to compare the environments. In the field, the design was in randomized blocks using four replications. The seedlings were grown in the protected environments: greenhouse covered with polyethylene film, light diffuser, 150 micron, and nursery monofilament screen with 50% of shading (Sombrite®). Inside environments, polystyrene trays with 72 cells and 128 cells were tested. The containers were filled with six substrates, from the combination of cattle manure and cassava stems. In the field were distributed 24 treatments generated from combinations of three factors. In both environments, the best seedlings are formed in trays with 72 cells. For two trays the best seedlings are formed in the greenhouse. In greenhouse, the substrate with 80% cattle manure and 20% of cassava stems promoted better growth of seedlings. In the screened, beyond this substrate, seedlings produced in the substrate with 100% manure showed higher vigor. For all substrates, the best seedlings are formed in tray with 72 cells inside the greenhouse. In the field the combination, “greenhouse + 72 cell tray + 80% manure and 20% cassava stems” was where the plants had better growth and productivity.

Keywords: *Solanum melongena*, protected cultivation, trays, cattle manure, cassava stems.

RESUMO

Produção de berinjela a partir de mudas produzidas em diferentes ambientes, recipientes e substratos

A qualidade da muda influencia o desempenho da planta a campo e técnicas apropriadas podem elevar a produtividade das hortaliças. Neste trabalho foi avaliada a produção de mudas de berinjela cultivar Embu, com o uso de ambientes protegidos, recipientes e substratos, e seu desenvolvimento a campo, na Universidade Estadual de Mato Grosso do Sul, Unidade de Aquidauana. Na formação das mudas, cada ambiente foi considerado um experimento, que foi conduzido no delineamento inteiramente casualizado em esquema de parcelas subdivididas (recipientes x substratos) com oito repetições. Posteriormente realizou-se análise conjunta dos experimentos para comparação dos ambientes. No campo, o delineamento foi em blocos ao acaso com quatro repetições. As mudas foram produzidas nos ambientes protegidos: estufa agrícola coberta com filme polietileno difusor de luz de 150 μm e viveiro agrícola telado com tela de monofilamento de 50% de sombreamento (Sombrite®). No interior dos ambientes utilizaram-se bandejas de poliestireno de 72 e 128 células, preenchidas com seis substratos, oriundos da combinação de porcentagens de ramas de mandioca triturada e esterco bovino. No campo foram distribuídos os 24 tratamentos gerados a partir das combinações dos três fatores. Em ambos os ambientes as melhores mudas são formadas na bandeja de 72 células. Para ambas as bandejas as melhores mudas são formadas na estufa agrícola. Na estufa agrícola o substrato com 80% de esterco bovino e 20% de ramas promove o melhor desenvolvimento das mudas e no telado, além desse substrato, as mudas produzidas no substrato com 100% de esterco apresentam elevado vigor. Para todos os substratos as melhores mudas são formadas na bandeja de 72 células, no interior da estufa agrícola. A combinação “estufa agrícola + bandeja de 72 células + 80% esterco bovino e 20% ramas de mandioca”, foi onde as plantas apresentam melhor desenvolvimento e produtividade.

Palavras-chave: *Solanum melongena*, cultivo protegido, bandejas, esterco bovino, manivas de mandioca.

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Eggplant (*Solanum melongena*) is a perennial plant, but it is considered annual. It has berry fruit type, variable format. This vegetable belongs to the Solanaceae family, like the tomatoes, potatoes, hot peppers, sweet peppers and garden eggs (Filgueira, 2008). Because of its nutritional value and medicinal properties, it is common to be part of the Brazilian diet (Oliveira *et al*., 2009) according to Gonçalves *et al*. (2006), it has the capacity to reduce cholesterol, associated with the reduction of fat in the human body and it is a therapeutic option for the prevention of cardiovascular diseases.

The state of São Paulo is the largest producer of eggplant in Brazil, with 42% of the total. However, in crop year 2009/2010, an acreage reduction of 19.6% was observed (1717 ha to 1380 ha) and a reduction of total production of 11.8% (50.7 mil t to 44.7 mil t). Nevertheless, it had a gain of 9.8% in productivity (29.5 t ha^{-1} to 32.4 t ha^{-1}) (IEA, 2011). In the State of Mato Grosso do Sul, the eggplant production, as well as the other grocery products, is not enough to supply the local markets. According to the Boletim Anual (2011), the State imports about 85% of these products. These data show the necessity of researches which help the horticrop developing in the state, producing high quality seedlings with productive capacity in the field. In the steps of the vegetable production chain, the stage of seedling production is an important issue for the production system, with quality and vigor of the seedlings as fundamental requisites for the performance of the future plant in the field. A malformed seedling compromises the whole development of the crop, increasing its cycle, leading to loss in production (Echer *et al*., 2007).

In the seedling production, factors like substrates, containers and crop environment, as well as irrigation and nutrition, are techniques which seek to maximize the productive potential and vigor of seedlings to be transplanted to the field. In the field, the quality seedlings have higher probability to overcome the stress conditions of the transplant and associated with the right crop management, promote high quality fruit production. Researches concerning to high quality vegetable seedling production are numerous. However, studies related to the productive capacity of these seedlings are scarce. Studies related to steps of seedling production and growth in the field are developed by Modolo & Tessarioli Neto (1999) and Modolo *et al*. (2001) with okra plant (*Abelmoschus esculentus*), as well as by Leal *et al*. (2011) with lettuce and beets. Based on the information above, this work aimed to evaluate the production of eggplant seedling under different protected environments, containers and substrates and its development in the field in the region of Aquidauana, Mato Grosso do Sul state.

MATERIAL AND METHODS

The experiments with eggplant cultivar Embu were carried out in the experimental area of the Universidade Estadual do Mato Grosso do Sul (UEMS) in Aquidauana (20°20'S, 55°48'O, altitude 174 m), from November 2009 to April 2010, involving seedling production and fruit production.

The climate of the Region, according to Köppen is classified as Aw, humid tropical climate with average annual temperature of 27 to 29°C, and annual rainfall ranging between 1200 and 1300 mm. The experiment was split in two parts: i) seedling production, evaluating the effects of protected environments, containers and substrates and ii) transplant and evaluation of fruit production.

Fruit production – This experiment involved protected environments, containers and substrates. Since the protected environments did not present any replications, these experiments were evaluated through joint analysis of the experiments (Banzatto & Kronka, 2006). In this kind of analysis, each growing environment is considered an experiment.

The experimental design in each growing environment was completely randomized in a split-plot scheme, where the main plot consisted of containers and the subplot consisted of substrates. For each treatment, eight replications were used, the replication being the average of two seedlings.

The growing environments were: A1) a greenhouse in an arc (8x18x4 m) structure in galvanized steel, with zenith opening in the ridge, covered with polyethylene film of 150 micron, light diffuser, with thermal reflect screen of 50% shading under the film, front and side locks with monofilament mesh screen of 50% shading and, A2) a nursery of galvanized steel structure (8x18x3.5 m), closing at 45°, with monofilament mesh screen with 50% shading (Sombrite®).

In each growing environment, the seedlings were tested in two containers, the polystyrene trays containing 72 cells (volume 121.2 cm^3 per cell) and 128 cells (volume 34.6 cm^3 per cell), designed for R1 and R2, respectively. The containers were filled with combination or not of cattle manure and triturated cassava stems, making the volumetric proportions of the substrates with the following characteristics: S1) 100% cattle manure; S2) 80% cattle manure and 20% stems; S3) 60% cattle manure and 40% stems; S4) 40% cattle manure and 60% stems; S5) 20% cattle manure and 80% stems and S6) 100% stems.

The cassava stems were ground in a hammer mill, using a 12 mm sieve. Later, these stems were dried in the sun for a week, being turned daily. The granulometry of the stems was performed. The characteristics were (sieve size ABNT/mm): 5/4.0= 2.82%; 10/2.0= 50.85%; 16/1.2= 15.45%; 30/0.6= 19.87%; 50/0.3= 7.52%; 100/0.15= 2.47% and bottom/0.0= 1.03%. The cattle manure was composted for 15 days, in full sun, with daily tickling and irrigation, and subsequently sieved (mesh sieve 2 mm) and stored until the substrate preparation.

The chemical analysis of the substrates was performed in the soil laboratory of Embrapa Agropecuária Oeste (CPAO) in Dourados Mato Grosso do Sul state. Respectively, for the substrates S1, S2, S3, S4, S5 and S6, the following characteristics were found: pH ($CaCl_2$)= 8.45; 8.65; 8.4; 8.8; 8.7 and 8.7; humidity (%)= 8.80; 31.36; 25.12; 24.56; 8.80 and 10.83; organic carbon (%)= 18.01; 16.95; 12.66; 12.95; 23.62 and 43.15; nitrogen (cmolc dm^{-3})= 65.71; 75.71; 60.71; 67.14; 64.29 e 69.29; phosphorus (mg dm^{-3})= 3400.0; 4100.0; 3000.0; 2600.0; 2800.0 and 2400.00; potassium (cmolc dm^{-3})= 28.46; 29.74; 24.62; 26.92; 27.69 and 36.92; calcium (cmolc dm^{-3})= 46.5; 52.5; 47.5; 50.0; 49.0 and 62.0; magnesium (cmolc dm^{-3})= 23.33; 29.17; 23.33; 25.83; 23.33 and 26.67; sodium (cmolc dm^{-3})= 4.78; 4.78; 3.04; 2.17; 2.61 and 0.87; copper (cmolc dm^{-3})= 0.026; 0.029; 0.021; 0.021; 0.023 and 0.006; iron (cmolc dm^{-3})= 42.71; 49.21; 33.39; 38.11; 40.32 and 7.95; manganese (cmolc dm^{-3})= 0.31; 0.37; 0.26; 0.28; 0.28 and 0.09, and zinc (cmolc dm^{-3})= 0.055; 0.065; 0.045; 0.055; 0.043 and 0.032.

Sowing was performed on November 15, 2009, with three seeds per cell. Emergence occurred five days after sowing. Thinning was performed two weeks after sowing (DAS). The irrigation was performed manually with a watering can, trying to keep the substrates moisturized and appropriate to the development of the seedlings. At 30 days after sowing were measured, during the transplant, seedling height (AP), stem base diameter (DC), aboveground part dry mass (MSPA), root dry mass (MSSR) and total dry mass (MST). In order to determine biomass, the material was taken to the greenhouse with forced air ventilation for 72 hours at 65^{0}C. It was also determined the stem base diameter and height ratios (RAD), aboveground and root dry masses (RMS) and the Dickson quality index (IQD), where IQD= [MST/(RAD + RMS)].

The dry bulb and wet bulb temperatures were collected, as well as the relative humidity at 9a.m., 12p.m. and 3p.m., in each growing environment. The Instituto Nacional de Meteorologia (INMET) informed about the rainfall data. These meteorological data were obtained from November 15 to December 14, 2009. The temperatures, respectively, of the external environment, in the greenhouse and in the screen nursery were: 28.9, 28.8 and 28.8ºC at 9a.m.; 32.0, 31.8 and 31.8 at 12p.m. and 33.1, 33.0 and 32.4 at 3p.m. The relative humidity, respectively, outdoors, in greenhouse and nursery were: 74.4, 71.8 and 73.9% at 9a.m.; 67.6, 64.6 and 66.1% at 12p.m. and 63.4, 61.9 and 64.3% at 3p.m. The accumulated rainfall was of 246.8 mm.

Transplant and fruit production – From the combination of two environments, two containers and six substrates, 24 treatments were obtained. These treatments were taken to the field on December 15, 2009. To evaluate the development and productivity in the field, experimental design in randomized blocks, with four replications was used. The useful plot, for each replication, was constituted by four plants.

Pits of 30x30x30 cm were prepared, with a spacing of 0.8x1.0 m, between plant and row respectively. The soil is classified as Ultisol (Embrapa, 2006). The soil chemical properties, the layers from 0 to 20 cm and from 20 to 40 cm, were: texture 2 (15 to 34% clay); pH (H_2O)= 6.1 and 6.3; organic matter = 3.3 and 2.6%; P= 56.6 and 38.8 mg dm^{-3}; K= 0.48 and 0.47 cmol$_c$ dm^{-3}; Ca= 5.4 and 5.7 cmol$_c$ dm^{-3}; Mg= 2.3 and 2.5 cmol$_c$ dm^{-3}; Al= 0.0 and 0.0 cmol$_c$ dm^{-3} and Al+H= 3.3 and 3.0 cmol$_c$ dm^{-3}.

Fertilization with 80 kg ha^{-1} P_2O_5, 50 kg ha^{-1} K_2O was performed, fifteen days before planting, and 100 kg ha^{-1} N fractionated into four parts, applied every 15 days in top-dressing and in canopy projection. Cultural treatments were performed when necessary. Irrigation was done by the use of a sprinkler. Staking was performed. Metamidophos was applied every fifteen days, dose of 1.0 mL L^{-1} on the first application and 2.0 mL L^{-1} on the following applications until the appearance of fruits. Hoeing was held manually during the cycle of the crop.

Flowering time (FLO) was evaluated when it presented 50% of the plot with at least one open flower and fruiting time (FRU) when it presented 50% of the plot with one fruit of 1 cm in diameter. Larger diameter (DMA); fruit length (CF); number of fruits per plant (NFP); weight per fruit (PF); plant production (PP) and production per hectare (PPA) were evaluated.

The Instituto Nacional de Meteorologia (INMET) informed about the temperature (^{0}C) minimum and maximum, and the rainfall (mm) in Aquidauana, during the experiment in the field, the average maximum being of 27.8^{0}C, the average minimum of 26.6^{0}C and accumulated rainfall of 617 mm.

Statistical analysis – Because there were no replications of environmental conditions, the results were subjected to analysis of variance of individual containers and substrates, in each growth environment, for further evaluation of the mean squares of the residues (Banzatto & Kronka, 2006), and the joint analysis of the environments. The fruit variables were subjected to analysis of variance, using F test.

Means were compared by Tukey test at 5% of probability, using the software SISVAR 5.3.

RESULTS AND DISCUSSION

Seedling production – For all traits evaluated, the ratio of the mean square of the residues (RQMR) of the analysis of individual variance of the experiments did not exceed the ratio of 7:1, allowing, therefore, the performance of joint analysis of the experiments (Banzatto & Kronka, 2006) and the comparison of the environments in seedling production. In the interaction between environments and containers, for all the traits evaluated, it was observed that the greenhouse and the tray with 72 cells provided the best seedlings, larger seedlings with more vigor, expressed by IQD (Table 1). For dry mass/root and height/diameter ratios, no difference was noticed between the interactions of environments and containers, so they were not included in Table 1.

The higher cell volume container provided better growth of the root (Table 1) and seedlings with more vigor because of its greater availability of nutrients and more space for the growth of the root. These results are according to those obtained for lettuce (Trani *et al*., 2004), chicory (Reghin *et al*., 2007), pumpkin (Piovesan & Cardoso, 2009) and eggplant seedlings (Costa *et al*., 2011).

Comparing both environments, the greenhouse provided better growth conditions than the nursery, where the plants accumulated greater biomass and they were higher (Table 1). Costa *et al*. (2009) observed that the greenhouse provided greater accumulation of biomass, for production of cucumber seedling in the same region. Little variation was observed related to temperature and relative humidity in times of harvesting. However, the rainfall was of 246.8 mm. The very structure of the shade mesh screen, which allowed the entry of the rainwater, different from the polyethylene film of the greenhouse, may have allowed the loss of nutrients, through leaching, in the trays, with greater damage to the tray of 128 cells, with lower volume, promoting the best development of the seedlings in trays of 72 cells (R1). In winter time, Costa *et al*. (2011) observed better eggplant seedlings in screen environment with Sombrite® when grown in trays of 72 cells and, when grown in trays of 128 cells, the greenhouse provided better conditions.

Table 1. Interactions between environments and containers for plant height, stem diameter, shoot dry mass, root dry mass, total dry mass and Dickson quality index for eggplant seedlings (interações entre ambientes e recipientes para a altura de plantas, diâmetro do colo, massa seca da parte aérea, massa seca do sistema radicular, massa seca total e índice de qualidade de Dickson para as mudas de berinjela). Aquidauana, UEMS, 2009-2010.

	Plant height (cm)		Stem diameter (mm)	
	Greenhouse	Screened nursery	Greenhouse	Screened nursery
72 cells	8.1 Aa*	5.9 Ab	2.6 Aa	2.0 Ab
128 cells	5.7 Ba	4.4 Bb	1.9 Ba	1.6 Bb
	Dry mass of roots (g)		**Dry mass of aboveground part (g)**	
72 cells	0.04 Aa	0.03 Ab	0.17 Aa	0.11 Ab
128 cells	0.02 Ba	0.02 Bb	0.08 Ba	0.06 Bb
	Total dry mass (g)		**Dickson quality index**	
72 cells	0.21 Aa	0.14 Ab	0.03 Aa	0.02 Ab
128 cells	0.10 Ba	0.08 Bb	0.01 Ba	0.01 Bb

*Means followed by same uppercase letters at columns, and same lowercase letters at lines do not differ by Tukey test at 5% (letras iguais maiúsculas nas colunas e minúsculas nas linhas não diferem entre si pelo Teste de Tukey a 5% de probabilidade).

In environment and substrate interactions, as well as container and substrate interactions, the substrate that provided best seedlings, with greater height, stem diameter and dry biomasses, was 80% manure (S2), for both containers (R1 and R2) and environments (A1 and A2) (Table 2). In the nursery, for aboveground dry mass, the substrate 100% manure (S1) was the best for root dry mass and for the height of the plant were the substrates S1 and S2. In this study, high percentages of manure provided the best seedlings, different from what Dias *et al.* (2009a) stated. They verified that the use of cattle manure above 10% in substrates reduced the growth of the root and leaf expansion of mango seedlings grown in greenhouse, relating this event to the action of pathogenic organisms (fungi) in root system. For coffee seedlings, Dias *et al*. (2009b) found that doses above 30% of cattle manure decreased the dry mass accumulation. Probably, manure composted by these authors was not enough, since in their methodology composting time is not related.

In an inefficient or insufficient composting, the continuity of reactions in the composted material (fermentation) can occur and the temperature of the material can be in inadequate levels to the growth of the root, besides not decreasing the quantity of pathogenic organisms, factors that affect the growth of the seedlings. This fact was not verified in the present work, which obtained high quality seedlings in substrate with high percentage of cattle manure.

In interactions between environments and substrates, for each type of substrate, for height, stem diameter, shoot and total dry biomasses, the greenhouse and tray with 72 cells provided best results, where the seedlings were larger, with higher biomasses (Table 2).

For the substrate with 100% manure (S1), the results for growing environments and for containers were similar to the results obtained for all the other substrates, where the greenhouse and the container with 72 cells showed the best results; however, the shoot and root dry biomasses did not differ between the growing environments (Table 2).

In nursery, a better development of the seedlings was noticed in the substrates with 80 and 100% of manure (S1 and S2, respectively) and in greenhouse, better development was observed in substrate S2. These seedlings presented smaller C/N ratio, and greater available quantities of micronutrients. The amount of organic matter aids the physical structure of the substrate, it also helps absorb water, improve retention, allowing the availability of the nutrients in solution for growing, developing and biomass accumulation. In substrate S6, besides the lower amount of nutrients, 86.17% of the particles showed a diameter between 0.6 and 2.0 mm (high porosity) and high C/N ratio, traits that do not provide the appropriate development of the seedlings.

The results of the environments and containers for each substrate, evaluating the total dry mass (MST) and the Dickson quality index (Table 2), was the same observed for dry biomasses. According to Gomes (2001), the formula that determines the Dickson quality index is balanced, because it includes morphological traits of height, diameter and biomasses. The higher value of DQI, the higher the seedling quality and they are more vigorous when they are transplanted in the field, because robustness and balance in the distribution of biomass is considered. Through this index, it is noticed that the greenhouse and the tray with 72 cells provided the most vigorous seedlings.

The height/diameter ratio (RAD) can be used as slenderness factor, mainly for morphological traits, which division expresses the balance of the growth of the seedling. According to Rodrigues *et al.* (2010), the higher RAD the higher is the possibility of seedling bending; this was not verified in this work since estiolation was not observed, where higher seedlings also presented greater diameters.

The shoot/root ratio (RMS) ranged from 2.24 to 5.01, and the average of 3.86 for the treatments, similar values to those found by Rodrigues *et al*. (2010) with tomato seedlings. The shoot/root dry mass ratio increased with the increasing of the cattle manure up to 80% in the composition of the substrate, for greenhouse and containers with 128 cells, and up to 100% of cattle manure for the nursery and the container of 72 cells, which can be caused by the decrease of C/N ratio, providing nitrogen in the substrate, promoting greater growth of the root (Table 2), and so better absorption of water and nutrients (Braun *et al*., 2010).

These high ratios between the dry biomasses are justified according to the period of time that the seedlings stayed in the environment (30 days), reaching maximum height of 9.7 and probably inhibiting the growth of root system depending on the container size.

Simply put, in both environments, the best seedlings are grown in trays with 72 cells. For both trays, the best seedlings are grown in greenhouse. In greenhouse the substrate with 80% manure and 20% of stems promoted the best growth of seedlings. In screen, besides this substrate, the seedlings grown in substrate with 100% manure showed high vigor. For all the substrates, the best seedlings were grown in trays of 72 cells, inside the greenhouse.

Transplant and fruit production – The beginning of flowering (FLO) and fruiting (FRU) occurred about 38 and 51 days after the transplant (DAT), respectively (Table 3). The beginning of flowering occurred earlier than observed by Carvalho *et al.* (2004) at 49 days after the transplant for the same cultivar.

Table 2. Interactions between environments and substrates, and between containers and substrates for plant height, stem diameter, aerial part dry mass, root dry mass, total dry mass, height and diameter relation, aerial part dry mass and root system dry mass relation and Dickson quality index for eggplant seedlings (interações entre ambientes e substratos, entre recipientes e substratos para a altura de plantas, diâmetro do colo, massa seca da parte aérea, massa seca do sistema radicular, massa seca total, relação altura da muda e diâmetro do colo, relação entre a massa seca da parte aérea e do sistema radicular e índice de qualidade de Dickson para as mudas de berinjela). Aquidauana, UEMS, 2009-2010.

	Plant height (cm)				Stem diameter (mm)			
	A1	A2	R1	R2	A1	A2	R1	R2
S1	7.5Ca*	6.6Ab	9.1Ba	5.0Db	2.5Ca	2.1Bb	2.8Ba	1.9Cb
S2	9.7Aa	6.6Ab	9.3Aa	7.0Ab	2.7Aa	2.2Ab	2.8Aa	2.1Ab
S3	8.6Ba	6.2Bb	9.0Ba	5.8Bb	2.7Ba	2.0Cb	2.8Ba	1.9Bb
S4	6.7Da	5.4Cb	6.6Ca	5.4Cb	2.3Da	1.9Db	2.4Ca	1.9Cb
S5	4.8Ea	3.2Db	4.4Da	3.6Eb	1.6Ea	1.3Eb	1.5Da	1.4Db
S6	3.8Fa	3.0Eb	3.5Ea	3.3Fb	1.5Fa	1.2Fb	1.3Ea	1.4Da
	Dry mass of roots (mg)				Dry mass of aboveground part (mg)			
S1	0.035Ba	33Aa	45Ba	24Bb	159Ca	153Aa	218Ba	94Bb
S2	0.044Aa	32Ab	50Aa	27Ab	226Aa	136Bb	240Aa	121Ab
S3	0.034BCa	30Bb	41Ca	23Bb	170Ba	113Cb	192Ca	92Bb
S4	0.032Ca	22Cb	34Da	20Cb	133Da	83Db	139Da	76Cb
S5	0.015Da	7Db	14Ea	9Db	57Ea	22Eb	49Ea	31Db
S6	0.008Ea	6Db	9Fa	5Eb	21Fa	13Eb	20Fa	14Ea
	Height:diameter ratio				Dry mass of aboveground part:root ratio			
S1	2.97Cb	3.06Aa	3.31Aa	2.73Cb	4.29Bb	4.56Aa	4.87Aa	3.98Bb
S2	3.56Aa	2.95Bb	3.27Aa	3.24Ab	5.01Aa	4.27Bb	4.76Aa	4.52Ab
S3	3.20Ba	3.00ABb	3.25Aa	2.95Bb	5.00Aa	3.66Cb	4.73Aa	3.93Bb
S4	2.91Ca	2.81Cb	2.81Bb	2.91Ba	4.16Ba	3.77Cb	4.07Ba	3.85Bb
S5	2.95Ca	2.55Db	2.88Ba	2.62Cb	3.74Ca	3.05Db	3.51Ca	3.28Cb
S6	2.51Da	2.55Da	2.59Ca	2.47Db	2.53Da	2.29Eb	2.24Db	2.58Da
	Total dry mass (mg)				Dickson quality index			
S1	0.194Ba	187Aa	263Ba	118Bb	0.025Ba	0.024Ab	0.032Ba	0.017Bb
S2	0.270Aa	168Bb	290Aa	148Ab	0.031Aa	0.023Ab	0.036Aa	0.019Ab
S3	0.204Ba	143Cb	232Ca	115Bb	0.025BCa	0.021Bb	0.029Ca	0.016Bb
S4	0.165Ca	104Db	173Da	96Cb	0.024Ba	0.016Cb	0.025Da	0.014Cb
S5	0.072Da	29Eb	62Ea	39Db	0.011Ca	0.005Db	0.010Ea	0.006Db
S6	0.029Ea	19Eb	29Fa	19Eb	0.006Da	0.004Db	0.006Fa	0.004Eb

**Means followed by same uppercase letters at columns, and same lowercase letters at lines do not differ by Tukey test at 5%; Substrates: S1= 100% cattle manure; S2= 80% cattle manure and 20% cassava stem; S3= 60% cattle manure and 40% cassava stem; S4= 40% cattle manure and 60% cassava stem; S5= 20% cattle manure and 80% cassava stem; S6= 100% cassava stem; A1= greenhouse; A2= screened nursery; R1= tray of 72 cells; R2= tray of 128 cells (letras iguais maiúsculas nas colunas e minúsculas nas linhas não diferem entre si pelo Teste de Tukey a 5% de probabilidade; Substratos: S1= 100% esterco bovino; S2= 80% esterco bovino e 20% ramas de mandioca; S3= 60% esterco bovino e 40% ramas de mandioca; S4= 40% esterco bovino e 60% ramas de mandioca; S5= 20% esterco bovino e 80% ramas de mandioca; S6= 100% ramas de mandioca; A1= estufa; A2= viveiro telado; R1= bandeja de 72 células; R2= bandeja de 128 células).

Table 3. Agronomic evaluations of eggplant crop in the field: flowering (FLO), fructification (FRU), fruit higher diameter (DMA), fruit length (FL), number of fruits per plant (NFP), weight per fruit (PF), plant production (PP) and yield per hectare (PPA) [avaliações agronômicas na cultura da berinjela a campo: florescimento (FLO), frutificação (FRU), diâmetro maior do fruto (DMA), comprimento de fruto (CF), números de frutos por planta (NFP), peso por fruto (PF), produção por planta (PP) e produtividade por hectare (PPA)]. Aquidauana, UEMS, 2009-2010.

Treatment	FLO	FRU	DMA (cm)	CF (cm)	NFP	PF (g)	PP (kg/plant)	PPA (t/ha)
A1R1S1	35E	47F[1]	6.0A	16.8A	11.9A	232.4A	2.7ABC	34.2ABC
A1R1S2	33E	47F	6.3A	16.3A	11.5AB	246.1A	2.9A	36.7A
A1R1S3	33E	47F	6.1A	16.0A	11.3AB	222.5A	2.6ABCD	32.0ABCD
A1R1S4	35E	47F	6.3A	16.7A	11.4AB	247.6A	2.9AB	35.7AB
A1R1S5	37E	49F	6.1A	16.7A	8.8AB	250.1A	2.2ABCD	27.7ABCD
A1R1S6	47AB	58ABCDE	6.1A	16.3A	5.2AB	223.1A	1.2CD	14.6CD
A1R2S1	38DE	50DEF	6.1A	16.4A	9.6AB	225.4A	2.1ABCD	26.8ABCD
A1R2S2	35E	47F	6.2A	16.8A	9.4AB	232.5A	2.2ABCD	26.9ABCD
A1R2S3	37DE	51BCDEF	6.2A	15.8A	7.4AB	234.0A	1.7ABCD	21.6ABCD
A1R2S4	36E	50EF	6.1A	16.1A	7.8AB	220.5A	1.8ABCD	21.9ABCD
A1R2S5	39CDE	51CDEF	6.3A	16.2A	7.8AB	243.4A	1.9ABCD	24.3ABCD
A1R2S6	50A	59ABC	6.1A	16.0A	6.0AB	215.8A	1.3BCD	15.9BCD
A2R1S1	35E	47F	6.3A	16.4A	9.7AB	244.9A	2.3ABCD	29.0ABCD
A2R1S2	35E	47F	6.1A	16.6A	10.1AB	225.0A	2.3ABCD	28.3ABCD
A2R1S3	36E	48F	6.2A	16.6A	10.5AB	237.7A	2.5ABCD	31.1ABCD
A2R1S4	37DE	50DEF	6.1A	16.0A	10.7AB	218.6A	2.4ABCD	29.6ABCD
A2R1S5	40BCDE	53ABC-DEF	6.7A	15.4A	8.2AB	265.8A	2.2ABCD	27.3ABCD
A2R1S6	44ABCD	60AB	6.1A	15.7A	6.0AB	217.8A	1.3ABCD	16.4ABC
A2R2S1	36E	49F	6.1A	17.0A	9.7AB	234.2A	2.3ABCD	28.5ABCD
A2R2S2	37DE	48F	6.3A	16.7A	10.2AB	235.9A	2.3ABCD	29.3ABCD
A2R2S3	36E	47F	6.1A	16.4A	8.7AB	235.7A	2.1ABCD	26.3ABCD
A2R2S4	38CDE	52BCDEF	6.3A	15.7A	7.0AB	233.0A	1.6ABCD	20.3ABCD
A2R2S5	46ABC	59ABCD	6.5A	15.9A	6.6AB	241.4A	1.6ABCD	19.8ABCD
A2R2S6	47AB	61A	5.8A	16.9A	4.8B	211.4A	1.0D	12.8D
CV(%)	7.37	6.41	6.87	5.57	28.99	10.78	29.83	29.83
$F_{Trat.}$	11.42**	8.38**	0.72^{ns}	0.96^{ns}	2.70**	1.05^{ns}	2.94**	2.94**
Average	38	51	6.19	16.3	9	233.11	2.057	25.707

[1]Means followed by the same letter at columns do not differ by the Tukey test at 5%;^{NS}not significant; *;**significant at 5% and 1% probability respectively; A1= greenhouse; A2= screened nursery; R1= tray of 72 cells; R2= tray of 128 cells; S1= 100% cattle manure; S2= 80% cattle manure and 20% cassava stem; S3= 60% cattle manure and 40% cassava stem; S4= 40% cattle manure and 60% cassava stem; S5= 20% cattle manure and 80% cassava stem; S6= 100% cassava stem (médias seguidas de mesma letra, na coluna, não diferem entre si pelo teste de Tukey, a 5% de probabilidade; ^{NS}não significativo; *;**significativo a 5% e a 1% de probabilidade, respectivamente; A1= estufa; A2= viveiro telado; R1= bandeja de 72 células; R2= bandeja de 128 células; S1= 100% esterco bovino; S2= 80% esterco bovino e 20% ramas de mandioca; S3= 60% esterco bovino e 40% ramas de mandioca; S4= 40% esterco bovino e 60% ramas de mandioca; S5= 20% esterco bovino e 80% ramas de mandioca; S6= 100% ramas de mandioca).

The experiment in the greenhouse with pots of 13 L showed higher precocity in Aquidauana, because of the climatic conditions over that period of time. However, the fall of temperature and rainfall, in the 3rd and 5th weeks after transplantation (SAT), delayed fruiting in relation to flowering.

Higher diameter (DMA), fruit length (CF) and fruit weight (PF) were not significant according to F test for any treatment (Table 3). The average value for higher diameter, 6.2 cm, was smaller than the value found by Polverente *et al.* (2005), 10.5 cm, for the same cultivar. The result found by the author may have happened due to the conduction type of the plants, which remained only two fruits (thinning), contributing to the increase in diameter.

The average fruit length (CF), 16.3 cm (Table 3) was smaller than the value found by Polverente *et al.* (2005), which was 25.0, and close to the values verified by Maldaner *et al.* (2009), with total average of 15.8 cm, for 'Napoli', 'Ciça' and 'Comprida Roxa' genotypes, conducted in greenhouse.

For number of fruits per plant (NFP), the treatments A1R1S1 (greenhouse + container with 72 cells + substrate "100% cattle manure), A1R1S2 (greenhouse + container with 72 cells + substrate "80% cattle manure and 20% stems") obtained 12 fruits per plant, in the treatment A2R2S6 (nursery + container with 128 cells + substrate "100% cattle manure") and A1R1S6 (greenhouse + container with 72 cells + substrate "100% stems") showed lower values with 5 fruits per plant (Table 3); for the other treatments, no difference among them was observed. Antonini *et al*. (2002), working with hybrids and eggplant cultivars, obtained averages from 20 to 25 fruits per plant, values two times higher than the ones verified in the present experiment.

The average fruit weight (PF) (233.1 g) was close to the values found by Brandão Filho *et al.* (2003) (326.3 and 246.8 g) for Napoli and Kokuyo cultivars, respectively and it is in accordance with the total average obtained by Aramendiz-Tatis *et al*. (2011), of 233.7 g, with 24 eggplant genotypes, conducted under the conditions of Colombian Caribbean, with annual average temperature and rainfall of 28^0C and 1600 mm, respectively, climatic conditions that are similar to the Aquidauana region (29ºC and 1200-1300 mm).

The treatments which contained substrate S6 (100% of cassava stems) showed deficiencies in the quantity of fruit and fruit weight of eggplant, showing that lower quality seedlings compromise the field performance. These deficiencies influenced in production per plant (PP) and production per hectare (PPA), where the treatment greenhouse + container with 72 cells + substrate with 80% of cattle manure (A1R1S2), obtained 2.9 kg plant^{-1} and 36.7 t ha^{-1}, being higher than treatments greenhouse + container with 72 cells + substrate with 100% of stems (A1R1S6), greenhouse + containers with 128 cells + substrate with 100% of stems (A1R2S6) and nursery + container with 72 cells + substrate with 100% of stems (A2R2S6), 1.2 kg plant^{-1} and 14.6 t ha^{-1}, 1.3 kg plant^{-1} and 15.9 t ha^{-1}, 1.0 kg plant^{-1} and 12.8 t ha^{-1}, respectively (Table 3). The lowest field production presented by plants from the substrate 100% stems, related to the plants from the substrate 80% of manure, is related to the quality of seedling production, because these seedlings showed less vigor. Echer *et al*. (2007) report that malformed seedlings undertake production, as it was observed in this study.

The average production per plant, 2.1 kg plant^{-1}, in seven harvests, approached the values found by Medeiros Junior (2007), 2.2 kg plant^{-1} (control treatment), for Ciça hybrid. The average production per hectare, 25.7 t ha^{-1}, is similar to the result obtained by Castro *et al.* (2005), 21.5 t ha^{-1}, for the overall average in no-tillage system and cultivar sole with F-100 hybrid, and higher than the results obtained by Aramendiz-Tatis *et al.* (2011), 11.9 t ha^{-1}, conducted with 24 genotypes of eggplant, spaced at 1 x 1 m, under the conditions of Colombian Caribbean. Maldaner *et al*. (2009) obtained overall average of 49.4 t ha^{-1}, with genotypes of eggplant 'Napoli', 'Ciça' and 'Comprida Roxa' conducting with one or two rods, in greenhouse, these values are higher than the ones found in this work.

Simply put, the lowest availability of micronutrients in substrate with 100% cassava stems (S6), may explain the low quality seedlings and the eggplant productivity. The early flowering with fructification show higher productivity per hectare. The combination "greenhouse + trays with 72 cells + 80% cattle manure and 20% cassava stems", was where the plants show best development and productivity.

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