academicJournals

Vol. 11(33), pp. 3090-3096, 18 August, 2016
DOI: 10.5897/AJAR2016.11305
Article Number: ADA3D4660036
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Use of alternative waste wood substrates in the production of seedlings zinnia

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Received 7 June, 2016; Accepted 26 July, 2016

Ornamental plants require a substrate that ensures the germination and healthy growth and vigor of the seedlings. Thus, this study aimed at studying the most suitable substrate for the production of zinnia seedlings from waste wood. The substrates evaluated in greenhouse were: Plantmax®; Sawdust (SM); SM + clay soil + sand (1: 2: 1); SM + clay soil + sand (2: 2: 1); SM + clay soil + sand (2: 1: 1); SM + clay soil (1: 1); SM + clay soil (1: 1) + Simple Superphosphate (SS); SM + clay soil (1: 1) + Sulphate Ammonium (SA); SM + clay soil (1: 1) SA + + SS; SM + SS; SM + SA; and SM + SS + SA. The sawdust in proportions 1: 1 (sawdust / clay soil) behaved like an excellent ingredient composition on the substrate to produce seedlings zinnia. The SM + SS provides higher percentages of plant emergence, reaching a rate 30% higher compared to the Plantmax®. The superphosphate associated with ammonium sulfate promoted increment in height of zinnias seedlings. The sawdust associated with superphosphate and ammonium sulfate provide excellent results in substrate composition for plant emergence and establishment of seedlings zinnias.

Key words: Ornamentals, propagation, sawdust.

INTRODUCTION

The species *Zinnia elegans* is an herbaceous plant, annual, of full sunlight, belonging to the Asteraceae family. It is popularly known as zínnia or Captain. It presents flowers of the type daisy simple, folded or frizzy, often used in parks and gardens of tropical and subtropical regions. It is an ornamental plant also cultivated for the production of cut flowers (Szopińska and Politycka, 2016) because of their long-term durability, being suitable, also, for the lawn hedge row and massive in full sun in regions of mild and tropical temperatures (Souza et al., 2011). Since a few years ago, the system for produce seedlings is getting modern and advanced on their technological level, because of the adaptation of new techniques, like protected cultivation, intermittent

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nebulization, climate control in the greenhouses and the use of modern inputs, such as re-usable containers, sterile and biodegradable substrates. The result is the production of seedlings of quality and on a commercial scale as already occurs in the cultures of coffee, citrus and in some forest and oil species (Oliveira et al., 2011).

The substrate is one of the most important factors on obtaining good quality seedlings. The term "substrate" applies to all solid material, which can be natural, synthetic or residual, mineral or organic, different of soil *in situ*, that when is replaced in a container - pure or mixed with other materials - enables the development of the radicular system (Abad et al., 2001). Planting on substrates demonstrate great advance to the cultivation systems on the soil. This system offers advantages such as the more appropriate management of water, the supply of good conditions for seed germination, adequate levels of nutrients. Moreover, it also improves reducing the occurrence of plant health problems that means direct benefits on the yield and the quality of products harvested (Duarte et al., 2011). With the need for sustainable actions and environmental preservation, it becomes necessary and important for the development of substrates with low cost, easy application, long durability and recyclable, or even the development of methods to be used in the conventional cultivation and proving better conditions of soil chemical and physical aspects. The use of discarded material in the environment, like the sapwoods in the formulation of substrates, contributes with reducing it costs and with the reutilization of materials which had no function until this time.

The quality of the sawdust which comes from lumberyards for the production of substrates depends on the species that were processed, time and condition of storage (Paes et al., 2013). The pure sawdust, if used as substrate, can present problems of excess of moisture, being recommended the mixture with other materials considered coarse, like sand, before the cultivation of the plants (Gonçalves et al., 2013). The use of sawdust with very small particles for the confection of substrates may increase the quantity of microspores that will reduce the level of oxygen available for the plants (Neto and Ramos, 2010) and develop anaerobic processes which starts fermentation that produce organic acids (Park et al., 2013). Junior et al. (2011), the chemical characteristics of the sawdust may vary according to the specie of wood, but in general, the sum of nutrients found in the amazon region sawdust is low and the pH varies between 4.0 to sawdust recently processed which was up to 6.0 for the older ones. The sawdust can be found in abundance in lumber regions as occurs with the straw of rice. Both can be used widely in horticulture. Its benefits range from the low cost of obtainment to the chemical, physical and biological characteristics found on it. Araújo et al. (2013) working with different types of substrates in melon plants, observed the same development of seedlings when sawdust is used. They notice also, that the same number of sheets when compared to a substrate was from soil + humus. The objective of this work was to evaluate the effect of substrates made of residues of sawmill or sawdust and fertilizers in the production of seedlings of Z. elegans.

MATERIALS AND METHODS

Location and design

The experiment was conducted in a greenhouse with nursery conditions with 70% of passage of light and approximate average temperature of 26°C and approximate relative humidity of 70%. A completely randomized design with 12 substrates and 5 repetitions in a total of 60 plots was used. Each plot was constituted by 10 polyethylene bags with diameter of 8.0 cm and height of 17.0 cm, totaling 850 cm^{-3} volume. These were placed the substrates and sown three seed of zinnia from plants present in ornamental flowerbeds, in a depth of 1.0 cm. Chapters were harvested when ripe (dry). Seeds were removed manually and stored at ambient temperature (approximately 25°C) for 15 days. Thereafter, the seeds were sown. Through the thinning, only one seedling per purse was left. The irrigation type micro sprinkling consisted of 6.0 mm daily divided into three shifts, being 1/3 at the beginning of the morning, 1/3 at the beginning of the afternoon and 1/3 at the beginning of the evening.

The raw material for the production of different substrates was: washed sand (0.25 to 2 mm), clayey subsoil the oxisol (60% kaolinite clay, type 1:1), bovine manure and sawdust originated from sawmills, which are very common in lumber regions. The sawdust was obtained in sawmills active or deactivated, and was found exposed to time and without use or function. The main specious that had originated the sawdust were: *Carapa guianensis*; *Goupia glabra*; *Jacaranda copaia*; *Dinizia excelsa; Ceiba pentranda*; *Parkia pendula.*

Substrates

The fertilizer dose in the subtrates in which had the addition of SS (Simple Superphosphate) and SA (Sulphate Ammonium) was 0.5 kg of both fertilizers by m³ of substrate. These, together with each substrate were manually homogenized with a hoe until it obtains uniform color. For the production of seedlings, substrates were used in the proportions described in the table footer 1, giving the treatments. Also, in the same table appears the description about the pH, levels of macronutrients and the chemical properties of the substrates after the cut of the seedlings. The Plantmax® characteristics were taken from the product label. The other substrates were analyzed in soil laboratory. These attributes were characterized according to Alvarez V. et al. (1999). It was observed that the levels of phosphorus present in substrates were relatively low. While the levels of potassium present in SM (Sawdust) + clay soil + sand (1:2:1); SM + clay soil + sand (2:2:1); SM + clay soil + sand (2:1:1); SM + clay soil (1:1) + SS; SM + clay soil (1:1) + SA; SM + clay soil (1:1) + SS + SA; SM + SS and SM + SA were low, the SM + SS + SA presented average concentration of "K", SM and SM + clay soil (1:1) which showed a good level of potassium and a commercial substrate was very good.

A very good content of calcium in the commercial substrate was found, medium in SM + clay soil + sand (1:2:1), SM + clay soil + sand (2:2:1), SM + clay soil (1:1), SM + clay soil (1:1) + SS, SM + clay soil (1:1) + SA, SM + clay soil (1:1) + SS + SA, SM + SS, SM + SA and SM + SS + SA was low in SM and SM + clay soil + sand (2:1:1). In the case of the magnesium, a very good content in the

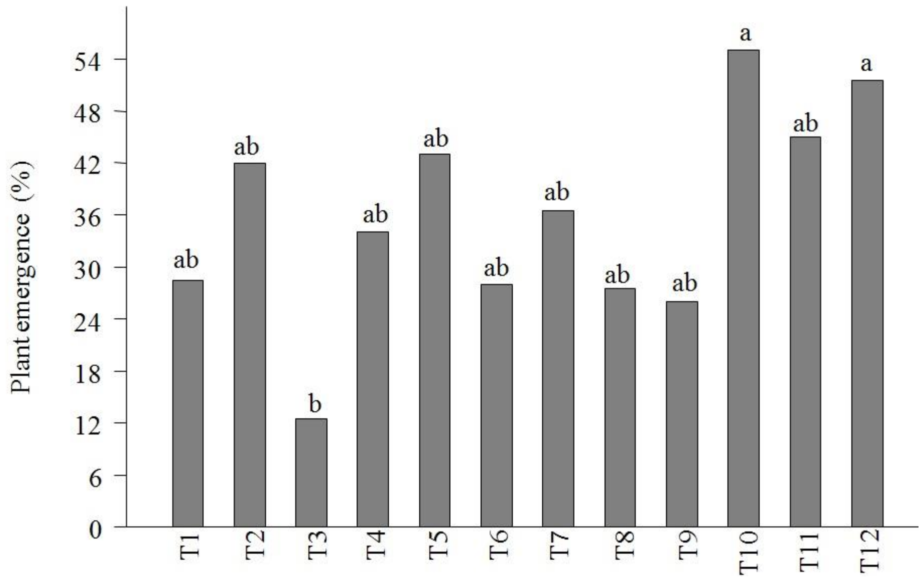

Figure 1. Values of percentage of plant emergence of *Z. elegans* submitted to different types of substrate. T1= commercial substrate; T2= wood sawdust (SM); T3= SM + clay soil + sand (1:2:1); T4= SM + clay soil + sand (2:2:1); T5= SM + clay soil + sand (2:1:1); T6 = SM + clay soil (1:1); T7 = SM + clay soil (1:1) + SS; T8 = SM + clay soil (1:1) + SA; T9 = SM + clay soil (1:1) + SS + SA; T10 = SM + SS; T11 = SM + SA; T12 = SM + SS + SA. Values followed by different letters differ statistically, by F test and Tukey test, at 5% probability. There was normality of the residue by Kolmogorov-Smirnov test and homogeneity of variances by Levene test at 1% probability.

commercial substrate was detected, medium in SM, SM + clay soil (1:1), SM + clay soil (1:1) + SS, SM + clay soil (1:1) + SA, SM + clay soil (1:1) + SS + SA, SM + SA, SM + SS + SA was low in SM + clay soil + sand (1:2:1), SM + clay soil + sand (2:2:1), SM + clay soil + sand (2:1:1) and SM + SS. According to Alvarez et al. (1999) the quantity of aluminum was changeable (Al3+) is low in SM + clay soil (1:1) + SS + SA and very low in the other treatments. The sum of the bases was considered very good in the commercial substrate, medium in SM + clay soil + sand (1:2:1), SM + clay soil + sand (2:2:1), SM + clay soil (1:1), SM + clay soil (1:1) + SS, SM + clay soil (1:1) + ammonium sulfate (SA), SM + clay soil (1:1) + SS + SA, SM + SS, SM + SA, SM + SS + SA was low on SM and SM + clay soil + sand (2:1:1). The potential of acidity (H + Al) was medium in the commercial substrate and low in the other treatments. The cation exchange capacity at pH 7 (T) was very good for commercial substrate Plantmax®, medium in SM + clay soil (1:1), SM + clay soil (1:1) + SS, SM + clay soil (1:1) + ammonium sulfate (SA), SM + clay soil (1:1) + SS + SA, SM + SS, SM + SA and low for SM, SM + clay soil + sand (1:2:1), SM + clay soil + sand (2:2:1), SM + clay soil + sand (2:1:1) and SM + SS + SA. The saturation per basis (V) was very good in the commercial substrate and medium in the rest, while the saturation of aluminum (m) was very low in all treatments. The variables analyzed were the plant emergence (%) for about ten days after the seeding (DAS) and the height of the seedlings at 40 DAS. The seedlings were measured with the aid of a escalímetro graduated (mm). The height of the base of the plant to the apex was measured. After 40 DAS, the seedlings were presented from two to six true leaves, depending on the substrate used, being suitable for transplantation.

Statistical analysis

The results were submitted to analysis of variance (ANOVA) conducted by F test at 5% probability, and the averages compared by Tukey test at 0.05 significance (Ferreira, 2011). ANOVA presuppositions of tests were made concerning the normality of the residuals and homogeneity of variances 1% probability. Principal components analysis (PCA) was performed for emergency and plant height and chemical constituents of the substrates.

RESULTS AND DISCUSSION

In figure 1 are the percentages of plant emergence of *Z. elegans* submitted to many different types of substrates. Observing the percentage of emergence at ten DAS, differences between the substrates was noticed. It can be observed that the substrate SM + SS and SM + SS + SA, were superior to the substrate SM + clay soil + sand (1:2:1). The highest percentage of emergence 51.5 and 55% of seeds in substrates containing SM + SS and SM + SS + SA can be attributed to favorable conditions to germination, such as the availability of water and oxygen in quantities and ideal proportions. According to Souza et al. (2011), there are some factors that interfere in the germination process of seeds in different substrates such as light, oxygen, temperature and water, beside of conditions inherent to the seed as numbness. Another considerable factor on the germination capacity is the genotypic inheritance. Species which are not improved, present high genetic variability in the expression of seed germination and seedling vigor (Martins et al., 2013). The seed treatment against fungi and bacteria also provide

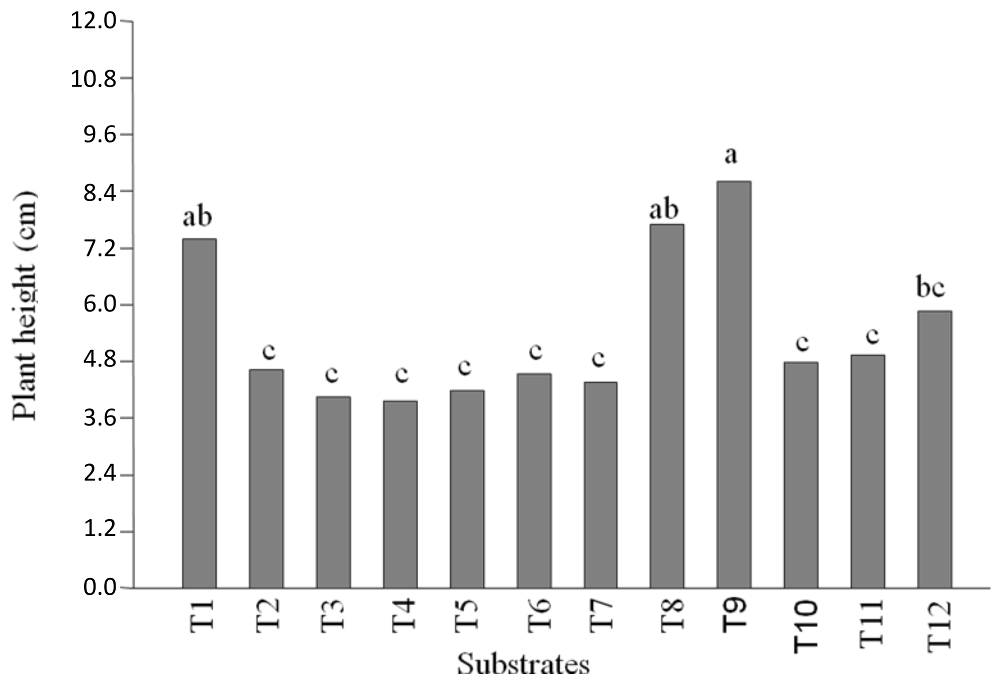

Figure 2. Medium values of plant height of *Z. elegans* submitted to different types of substrates. T1= commercial substrate; T2= wood sawdust (SM); T3= SM + clay soil + sand (1:2:1); T4= SM + clay soil + sand (2:2:1); T5= SM + clay soil + sand (2:1:1); T6 = SM + clay soil (1:1); T7 = SM + clay soil (1:1) + SS; T8 = SM + clay soil (1:1) + SA; T9 = SM + clay soil (1:1) + SS + SA; T10 = SM + SS; T11 = SM + SA; T12 = SM + SS + SA. Values followed by different letters differ statistically, by F test and Tukey test, at 5% probability. There was normality of residue by Kolmogorov-Smirnov test and homogeneity of variances by Levene test at 1% probability.

gains in germination and growth. Szopińska (2014) studied the effects of the treatment with hydrogen peroxide on germination, vigor and seed health of *Zinnia elegans*, observed significant increases in the germination of the seeds treated. Yet, according to the author, the presence of some pathogens influences in the germination of seeds of zinnias between the *Alternaria zinnia,* where, infected samples may present 39.5% of germination. This shows the importance in sanidades seeds to ensure seedlings of good quality.

The availability of water and oxygen is related with the texture of the substrate, which substrates with coarse texture and favor the presence of oxygen, because there are a greater number of macrospores (Gonçalves et al., 2013). In the other hand, substrates with fine texture favor the presence of water, because the number of macrospores is reduced and the number of microspores is increased, this last being responsible for the storage of water (Barreto et al., 2012). According to Ferreira et al. (2008), a good substrate must provide ideal conditions for a higher rate of emergence and favor the growth of the roots. The adequate substrate for germination and plant emergence must present a balance between macro and micro porosity, which promotes a good availability of water and oxygen. For the average height of seedlings (Figure 2) growth of seedlings is observed. In the substrate SM + clay soil (1:1) + SS + SA seedling were performed by plants with height of 8.6 cm higher in 2.8 cm compared to the substrate SM + SS + SA, this being higher than to the others. The height difference between the plants may be related to nutrition available by the substrate allied to its physical characteristics. The simple superphosphate and ammonium sulfate are fertilizers containing phosphorus (18%) and calcium (12%) in the first; and nitrogen (20%) and sulfur (22%) in the second. These fertilizers allied with the macro porosity present in sawdust and microspores present in clay soil, favored the best balance between nutrients, water and air present in the tested treatments. It is worth notice that the nitrogen present in the ammonium sulfate was sufficient to attend the demands of the seedlings, observed because of the good development.

In this experiment, the treatment with commercial substrate Plantmax® was indifferent when compared to treatments SM + clay soil (1:1) + SA, SM + clay soil (1:1) + SS + SA and SM + SS + SA. Frantz (2013) evaluating the efficiency of absorption of phosphorus in different environments by *Z. elegans* showed great growth and rate of flower development of the plants to apply 0.5 mm ($0.5 * 10^{-3}$ mol L^{-1}) which is equivalent to 15.5 mg dm-3 of element. The growth of the plants was reduced as the decrease of the phosphorus applied. The author noted

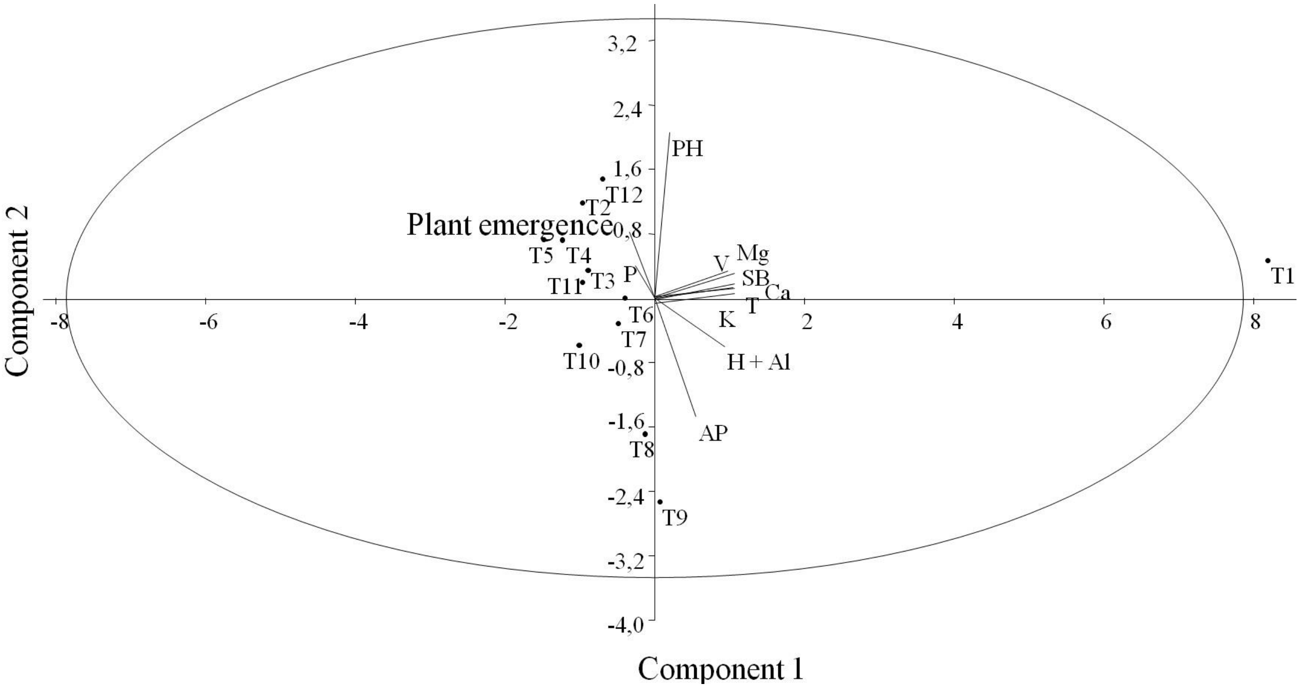

Figure 3. Dispersion of the graphical scores of the principal components one and two in *Z. elegans* evaluated in 11 characters.

that concentrations above 0.5 mm were not beneficial to growth and flowering of the plant. It was found in figure 3, an inverse relation between the variables, plant emergence and phosphorus content with plant height and potential acidity. Probably the different phosphorus contents were present in substrates, their porosity and consequently the balance between the remaining nutrients interfered in the germination and emergence of seedlings reflected at the height at the time of 40 DAPS. The macronutrients calcium, magnesium and potassium correlated among themselves, demonstrating that the development of plants may be degraded because of the detriment of any of these elements.

A correlation was observed between the treatments SM and SM +SS +SA with the plant emergence rate. These treatments had the best emergence rates of 68.7 and 56.0%, respectively, not presenting significant differences between themselves. The sawdust and the sand promoted higher porosity to the substrate by facilitating the germination and the emergence of seedlings. On the other side, substrates containing two parts of clay soil reduced the percentage of plant emergence, reaching only 16%. Hanim et al. (2014), usually, the seeds of annual crops have high germination percentage, reaching up to 95% in the sand when compared to other treatments. These authors obtained 20% of emergency of *Z. elegans* when using soil as substrate, 15% with sand, gravel 5% and 10% to the use of rock dust.

The treatment SM + SS + SA was correlated with the pH, being the substrate with higher pH (6.2) when compared with the other substrates. The treatments SM + clay soil (1:1) + SA and SM + clay soil (1:1) + SS + SA correlate with plant height; these are between the substrates that showed the highest height. Probably the greatest height has a relation with better nutritional balance present in the substrate, being applied sources of nitrogen and sulfur on the first treatment and phosphorus, calcium, nitrogen and sulfur on the second. The height of the plant provides information of their process of growth, being influenced by the nutritional level provided by the nutrient solution and the physical conditions of the substrate like porosity and aeration. The phosphorus is important in all metabolic processes that exist in plants (Schemidt et al. 2010). These authors had observed linear growth in the height of the plants which were submitted to different doses of phosphorus and high correlation of height with other physiological indices like the leaf area (R^2= 0.79), fresh mass of the aerial part (R^2= 0.80) and fresh mass of the root (R^2= 0.73).

No relationship was observed between the commercial substrate Plantmax® (T1) and the analyzed characters. The cultivation with this substrate showed 28.50% of plant emergence and plants with average height of 7.38 cm. This can be explained by better nutritional balance and physical properties presents in this substrate. This showed the highest levels of macronutrients, when compared to the others (Table 1). Castro et al. (2010) emphasize that for the same dose, the source of organic fertilizers used on composting plants can interfere on their growth and development. These authors had notified best results of average height on plants of chrysanthemum for cut when they used the bed of aviary

Table 1. Characterization of substrates about the pH, levels of macronutrients and the chemical properties after the cultivation of the seedlings.

Substrates	pH (H_2O)	Macronutrients						Chemical properties			
		P	K	Ca	Mg	Al	H + Al	SB	T	V	m
		--mg dm^3--		---------$cmol_c$ dm^3-------				------------ % -----------			
Plantmax®	5.9	19.1	290	10.3	6.8	0.0	3.7	17.80	21.50	83	0
T2	6.0	24.3	92	1.0	0.6	0.0	2.2	1.80	4.04	46	0
T3	5.8	17.5	65	1.5	0.4	0.0	1.6	2.07	3.67	56	0
T4	5.6	26.2	55	1.6	0.4	0.1	1.7	2.14	3.84	56	4
T5	5.7	18.9	60	1.1	0.4	0.1	1.6	1.65	3.25	51	6
T6	5.7	15.0	92	1.6	0.6	0.1	2.1	2.44	4.54	54	4
T7	5.5	15.2	63	2.0	0.5	0.1	2.3	2.66	4.96	54	4
T8	5.4	20.2	81	1.7	0.6	0.2	2.3	2.51	4.81	52	7
T9	5.2	19.5	73	2.0	0.5	0.4	2.5	2.69	5.19	52	12
T10	5.2	21.5	55	1.8	0.4	0.2	2.2	2.34	4.54	52	8
T11	5.7	22.9	65	1.3	0.5	0.2	2.5	1.97	4.47	44	7
T12	6.2	18.0	39	1.7	0.6	0.0	1.8	2.40	4.20	57	0

T2= wood sawdust (SM); T3= SM + clay soil + sand (1:2:1); T4= SM + clay soil + sand (2:2:1); T5= SM + clay soil + sand (2:1:1); T6 = SM + clay soil (1:1); T7 = SM + clay soil (1:1) + SS; T8 = SM + clay soil (1:1) + SA; T9 = SM + clay soil (1:1) + SS + SA; T10 = SM + SS; T11 = SM + SA; T12 = SM + SS + SA. SB = sum of bases; T = cation exchange capacity at pH 7.0; V = base saturation; m = saturation of aluminum.

when compared to other sources of organic fertilizer as the bovine and sheep manure. Kenyangi and Blok (2012) found higher efficiency on the length of the aerial part of lettuce using fertilizer, while the peat favored the root growth. The sawdust has promoted excellent physical environment as substrate showing itself similar to all the substrates studied for germination and plant emergence. This has supplied the requirements of porosity and water storage as reported by Silva and Ferreira (2015). As characterized in Table 1, the sawdust has low capacity in the supply of nutrients. So, this did not supply the nutritional demand of seedlings of *Z. elegans*. To assess the development of seedlings of *Eugenia involucrata* Souza et al. (2015) verified smaller development of plants when they use sawdust as substrate, in contrast, the plants showed greater development with the use of commercial substrate Plantmax®. This result is similar with what was found on this study in which the seedlings of *Z. elegans* showed lower plant height when it was used, only the sawdust.

Conclusion

The sawdust associated with simple superphosphate provides the greatest percentage of plant emergence of *Z. elegans*. The simple superphosphate associated with ammonium sulphate promotes an increase in the height of the seedlings of zinnias. The sawdust associated with simple superphosphate and ammonium sulfates are efficient in the composition of substrates, promoting better plant emergence and development of zinnias.

Conflict of interest

The authors have not declared any conflict of interest.

REFERENCES

Abad M, Noguera P, Bures S (2001). National inventory of organic waste for use as growing media for ornamental potted plant production: case study in Spain. Bioresour. Technol. Essex, 77(2):197-200.

Alvarez VVH, Novais RF, Barros NF, Cantarutti RB, Lopes AS (1999). Interpretação dos resultados das análises de solos. In: Ribeiro AC, Guimaraes PTG, Alvarez VVH. Comissão de fertilidade do solo do Estado de Minas Gerais. Recomendações para o uso de corretivos e fertilizantes em Minas Gerais – 5º Aproximação. Viçosa, MG, s.n, 322 p.

Araujo DL , Junior SOM, Silva SF, Andrade JR, Araujo DL (2013). Production of seedlings of melon cantaloupe in different types of substrates. Rev. Verde 8(3):15-20.

Barreto CVG, Testezlaf R, Salvador CA (2012). Dinamic of matricial potencial in substrates of pinus and coconut under action of capilarity. Horticul. Bras. Brasília 30(1):26-31.

Castro AMC, Sato O, Santos KH, Zaparolli RA, Sartori SB, Demetrio GB (2010). Fertilizing with mineral and organic on the development of crisântemo. Semina: Ciências Agrárias, Londrina, 31(1):93-100.

Duarte RF, Sampaio RA, Junior DSB, Silva HP, Parreiras NS, Neves JMG (2011). Inicial growth of seedling of *Acacia mangium* cultivated on fiber mats of coconut containing as substrate sewage sludge. Rev. Árvore, Viçosa 35(1):69-76.

Ferreira DF (2011). Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia, Lavras 35(6):1039-1042.

Ferreira EGBS, Matos VP, Sena LHM, Sales AGFA (2008). Germination of seeds and development of plântulas cockscomb on different substrates. Sci. Agrária, Curitiba 9(2):241-244.

Frantz JM (2013). Uptake efficiency of phosphorus in different light environments by zinnia (*Zinnia elegans*) and vinca (*Catharanthus roseus*). HortSci. Alex. 48(5):594-600.

Goncalves FG, Alexandre RS, Silva AG, Lemes EQ, Rocha AP, Ribeiro

MPA (2013). Emergence and quality of seedlings of *Enterolobium contortisiliquum* (Vell.) Morong (Fabaceae) on different substrates. Rev. Árvore, Viçosa 37(6):1125-1133.

Hanim A, Nazera AAB, Kahar S, Hamdan MN (2014). Effects of different inorganic mulches on seed germination, weed biomass and plant growth. J. Trop. Agric. Fd. Sci. 42(1)29-36.

Junior JOS, Carmello QAC, Sodre GA (2011). Substrate and fertilizing with phosphorus for the production of clone seedling of Cacau. Rev. Bras. de Ciênc. do Solo, Viçosa 35(1)151-159.

Kenyangi A, Blok W (2012). Vermicompost as a component in potting mixes for growth promotion in ornamental plants. Rwanda J. Agric. Sci. 28:53-63.

Martins CC, Bovi MLA, Oliveira SSCD, Vieira RD (2013). Emergência e crescimento inicial de plântulas de Archontophoenix cunninghamiana H. Wendl. & Drude provenientes de sementes de diferentes plantas matrizes. Ciênc. Rural 43(6).

Neto RMR, Ramos CB (2010). Avaliação das características físicas de substratos formulados com resíduos orgânicos para a produção de mudas florestais em tubetes. Pesqui. Aplicada Agrotecnol. Guarapuava 3(2)117-122.

Oliveira AB, Filho SM, Bezerra AME (2011). Tempo de cultivo e tamanho do recipiente na formação de mudas de *Copernicia hospita.* Acta Sci. Agron. Maringá 33(3):533-538.

Paes JB, Diniz CEF, Lima CR, Melo BP, Medeiros NPN (2013). Taninos condensados da casca de angico-vermelho (*Anadenanthera colubrina* var. cebil) extraídos com soluções de hidróxido e sulfito de sódio. Rev. Caatinga, Mossoró 26(3):22-27.

Park JH, Kim SH, Park HD, Lim DJ, Yoon JJ (2013). Feasibility of anaerobic digestion from bioethanol fermentation residue. Bioresour. Technol. 141:177-183.

Schemidt B, Domonkos M, Sumalan R, Biro B (2010). Suppression of arbuscular mycorrhiza's development by high concentration of phosphorus at *Tagetes patula* L. Res. J. Agric. Sci. Washington 42(4):156-162.

Silva LR, Ferreira LG (2015). Desenvolvimento de mudas de melancia sob efeitos de diferentes tipos de bandejas e substratos. Connection Line (12):97-105.

Souza HHF, Bezerra FC, Assis JRN, Ferreira FVM, Silva TC, Crisostomo LA (2011). Produção de mudas de *Zínnia elegans* em substratos a base de resíduos agroindustriais e agropecuários em diferentes tamanhos de recipientes. Revista Brasileira de Horticultura Ornamental, Campinas 17(2):115-120.

Souza PLT, Vieira LR, Boligon AA, Vestena S (2015). Produção e qualidade de mudas de *Eugenia involucrata* DC. em diferentes substratos. Rev. Biociênc., Taubaté 21(1):100-108.

Szopinska D (2014). Effects of hydrogen peroxide treatment on the germination, vigour and health of *Zinnia elegans* seeds. Folia Horticul. 26(1):19-29.

Szopinska D, Politycka B (2016). The effects of hydro- and osmopriming on the germination, vigour and hydrolytic enzymes activity of common zinnia (*Zinnia elegans* Jacq.) seeds. Folia Horticul. 28(1):3-11.