ISSN 0104-7760

CERNE

Clenilso Sehnen Mota[1], Fabiano Guimarães Silva[2], Paulo Dornelles[2], Mariângela Brito Freiberger[2+], Giselle Camargo Mendes[2]

GROWTH, NUTRITION AND QUALITY OF *POUTERIA GARDERIANA* (A. DC.) RADLK. SEEDLINGS PRODUCED IN ORGANIC SUBSTRATES

Keywords:
Guapeva
Dickson quality index
organic matter sources

ABSTRACT: This work was conducted to investigate the using different organics substrate in the production of native seedlings fruits from Brazilian Savanna. The aim of this study was to evaluate the biometric parameters, nutrition and quality of *Pouteria gardneriana* seedlings produced in substrates containing different sources of organic matter. The following components were used to formulate the substrates: subsoil material (SB), rice husk (RH), cattle-manure compost [CC (corn silage+cattle manure)], cattle manure (CM), sugarcane bagasse (CB), sugar-mill filter cake (FC) and BioPlant® (BP). Five substrates were formulated using proportions on a volume basis, as follows: SB+RH (1:1, v/v), SB+CC (1:1, v/v), SB+CM (3:1, v/v), CB+FC (3:2, v/v) and BP. Was evaluated stem length, root collar diameter, root dry weight, shoot dry weight and the Dickson quality index. The use of CM as a source of organic matter provided, in general, the best results for the biometric characteristics and dry matter production. The increase of organic matter in the substrate like SB+CM (3:1, v/v) and SB+CC (1:1, v/v) improved the soil quality and favored the growth and quality of seedlings guapeva, and can be more indicate for guapeva seedlings production as an alternative substrate.

Histórico:
Recebido 21/09/2016
Aceito 18/11/2016

CRESCIMENTO, NUTRIÇÃO E QUALIDADE DE MUDAS DE *Pouteria garderiana* (A. DC.) RADLK. PRODUZIDAS EM SUBSTRATOS ORGÂNICOS

Palavras chave:
Guapeva
Índice de qualidade de Dickson
Fontes de matéria orgânica

RESUMO: Este estudo foi conduzido para averiguar o uso de substratos orgânicos na produção de mudas nativas do Cerrado brasileiro. O objetivo foi avaliar os parâmetros biométricos, nutrição e qualidade de mudas de guapeva (Pouteria gardneriana) produzidas em substratos contendo diferentes fontes de matéria orgânica. Utilizaram-se os seguintes componentes para a formulação dos substratos: subsolo (SB), casca de arroz (RH), composto de esterco bovino [CC (silagem de milho + esterco bovino)], esterco bovino (CM), bagaço de cana (CB), torta de filtro de cana (FC) e BioPlant® (BP). Cinco substratos foram formulados utilizando proporções em base de volume, como segue: SB+RH (1:1, v/v), SB+CC (1:1, v/v), SB+CM (3:1, v/v), CB+FC (3:2, v/v) e BP. Avaliou-se o comprimento do caule, o diâmetro do colo radicular, o peso seco da raiz, o peso seco da parte aérea, a nutrição e o índice de qualidade Dickson. A utilização do CM como fonte de matéria orgânica proporcionou, em geral, os melhores resultados para as características biométricas e a produção de matéria seca. O uso de matéria orgânica nos substratos SB+CM (3:1, v/v) e SB+CC (1:1, v/v) melhorou a qualidade do solo e favoreceu o crescimento e qualidade das mudas de guapeva, e podem ser indicados como substratos alternativos.

+Correspondência:
maia_bf@yahoo.com.br

DOI:
10.1590/01047760201622042234

[1] Catarinense Federal Institute - Rio do Sul, Santa Catarina, Brasil
[2] Goiano Federal Institute - Rio Verde, Goiás, Brasil

INTRODUCTION

The Brazilian Savanna (Cerrado) is the second largest Brazilian biome. Numerous fruit species of the Cerrado have fruits with unique flavors, food potential, pharmacological potential and nutraceutical properties (BOLETI et al., 2008; SILVA et al., 2009; LIMA et al., 2010). Many species of native fruit are known and used by the traditional population living in the Cerrado. Native fruits species are mainly exploited an extractive form. In general, Cerrado soils are originally acid and saturated by Al (HARIDASAN, 2000), which may have promoted evolution of native species, adapting to the low pH. However, these characteristics may not result in high-quality seedlings (SOUSA et al., 2007).

The genus *Pouteria* belongs to the family Sapotaceae and can be found on several continents. It has molecules with biological activities, such as antifungal, antibacterial, antioxidant and anti-inflammatory effects (SILVA et al., 2009a). Boleti et al. (2008) reports cytotoxicity of the pouterin protein on mammal tumor cells, protein, this, that is found in species of the genus *Pouteria*. *Pouteria gardneriana* (A.DC.) Radlk., popularly known as guapeva, usually occurs in the "Cerrado-Vereda" (valley-side marshes) interface, and is an example of specie of the genus *Pouteria* which few studies exist on fruit tree seedlings. The production of healthy, robust, well-nourished and high-quality seedlings is required for the propagation of woody plant species after transplantation in the field, resulting in successful establishment of fruit orchards and even reforested areas (GOMES et al., 2003). The quality of the substrate used is a major factor that influencing the quality of seedlings, and must display adequate physical and chemical characteristics (FERRAZ et al., 2005). For a good substrate to favor germination and emergence, it must exhibit a degree of porosity that allows the hydration and aeration, because to germinate and emerge seeds needs water and oxygen for their metabolism (NOGUEIRA et al., 2003).

The substrate should exhibit a appropriate accommodation in the container, so that pores can be formed in adequate amounts and sizes; to exhibit slow decomposition; have a high cation-exchange capacity; be free from pathogens and seeds of undesired plants; and must be available on the market at affordable prices (DANTAS et al., 2009). To obtain these characteristics, surely it is necessary to mix two or more components, which together will form a suitable substrate for the formation of seedlings (ARAÚJO NETO et al., 2009). The carbonized rice husk is widely used as a substrate component because it is a lightweight material (increases porosity and drainage), easy to handle with alkaline pH, the are high in calcium and potassium and pathogens free by carbonization process (MINAMI 1995). Studies using sugarcane bagasse are conducted to verify the quality of forest seedlings. However, this material can be used in the production of organic compounds (SILVA et al, 2002). Studies using manures are the most common organic fertilizers being sources of nutrients and is important to the improvement of physical, chemical and biological conditions, cattle manure being the most used and providing satisfactory results in the cultivation of seedlings of species (CARVALHO FILHO et al., 2004, MOTA et al., 2015).

The need to eliminate amounts of agro-industrial residues that are not recycled has encouraged studies on alternative materials (GRIGATTI et al., 2007) such as sugarcane bagasse and filter cake from sugarcane mills (CATUNDA et al., 2008; SANTANA et al., 2012) as well as carbonized rice husks (SAIDELLES et al., 2009; TERRA et al., 2011) to substrates for seedling production. The use of raw materials that are easily found near seedling nurseries is also preferred. Therefore, studies on substrates are necessary to discover new possible formulations, can use agro industrial, forestry, and urban wastes (MARTINS et al., 2011).

The use of rice husks is common in the production of seedlings of forest species (SILVA et al., 2012; DELAMERLINA et al., 2014). The use of cattle manure as a component of substrate for seedlings is also appropriate and yields good results, as observed in *Acacia* sp. (CUNHA et al., 2006), *Enterolobium contortisiliquum* (ARAÚJO; PAIVA SOBRINHO, 2011), *Harconia speciosa* (SILVA et al., 2009b), *Eugenia dysenterica* DC. (MOTA et al., 2016). However, the use of these components in substrates for seedling production of Cerrado native species is still incipient.

Several characteristics of the seedlings can be evaluated for their performance. The stem length/root collar diameter (SL/RCD) ratio is responsible for the robustness of the seedlings or the level of etiolation of these seedlings (MARANA et al., 2008). For being easy to measure and there isn´t need to sacrifice the plant, the SL/RCD ratio is widely used to measure the quality of seedlings. The root/shoot ratio is indicative of nutrient availability in the substrate, and in nutrient-deficient situations, the plants allocate photoassimilates to the root system to promote its growth and thus improve the area of substrate use (SILVA; DELATORRE, 2009). An increase in proportion of carbonized rice husk in substrates increased the R/S ratio due to a reduction of nutrient availability (SAIDELLES et al., 2009).

The Dickson Quality Index (DQI) is considered as important tool to measure morphological traits and thought to be a good indicator of seedling quality as its calculation computes robustness and biomass distribution (FONSECA et al., 2002). In addition to the growth characteristics, nutritional assessment of seedlings is also an important parameter to determine the needs of the species. Therefore, the objective of this work was to evaluate the initial development and nutrition production of *Pouteria gardneriana* seedlings in composts derived from agroindustrial wastes.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse located at the Goiano Federal Institute (Instituto Federal Goiano) in Rio Verde, GO, Brazil (Latitude 17°48'S, longitude 50°54'W and altitude of 753 m). The maximum, minimum, and mean daily temperature values during the experimental period were 35.2, 19.8, and 25.4°C, respectively; the corresponding relative humidity values were 95.6, 43.7, and 77%, respectively. Spray irrigation was performed twice daily (8:30 am and 4:30 pm), with a volume of 6 mm at each application, totalizing 12 mm per day.

The substrates that were evaluated included subsoil material (SB), rice husk (RH), manure compost [CC, (corn silage+cattle manure)], cattle manure (CM), sugarcane bagasse (CB), sugar mill filter cake (FC) and BioPlant (BP). Five substrates were formulated using proportions on a volume basis, as follows: SB+RH (1:1, v/v), SB+CC (1:1, v/v), SB+CM (3:1, v/v), CB+FC (3:2, v/v) and BP. After mixing the components according to the above-described substrate formulations, samples were collected chemical analyses. The results of the substrate chemical analyses are listed in Table 1. No fertilization was made.

Conical tubes with a 288 cm^3 capacity were used as cultivation containers. Fruits of *P. gardneriana* (A. DC.) Radlk were collected from healthy, mature plants in full production, originating from the municipality of Montes Claros de Goiás, GO, Brazil (latitude 19°53'S, longitude 44°25'W and altitude of 749 m). Seeds were removed from the fruit and placed in a 1 molar sodium hydroxide solution for five minutes under manual stirring to facilitate the removal of the mucilage surrounding. The seeds were washed under water, manually rubbed to remove the mucilage and then manually sowed, one seed per tube. The experiment design was arranged in a randomized block with five replicates. Each replicate was composed by 20 experimental units (tubes with seedling and substrate). Each treatment (substrate) was used 100 plants, there were about 500 plants in whole experiment. To biometric parameters evaluated (SL, RCD, NL, LA, SDW, LDW, RDW, TDW, SL/RCD, R/S e DQI) were select 25 plants per substrate.

TABLE 1 Chemical analysis of the substrates used in the study.

Substrate	pH^k	OM^s	K	Ca	Mg	EC^r	V^q
		$g \cdot dm^{-3}$	mg·dm	---- $cmol_c \cdot dm^{-3}$ ---			%
BPz	5.0	43.0	1207	10.4	4.04	18.7	55.7
SB^y+RH^x(1:1, v/v)	6.4	2.2	3.3	1.1	0.37	2.6	54.8
$SB+CC^w$(1:1, v/v)	6.7	10.3	950	4.9	5.30	12.6	87.1
SB^y+CM^v(3:1, v/v)	6.8	6.9	542.9	5.9	5.30	12.6	82.9
CB^u+FC^t(3:2, v/v)	7.0	60.0	667	2.3	0.61	5.3	69.7
Substrate	**P**	**Zn**	**Mn**	**Cu**	**Fe**	**B**	
	---------------------- $mg \cdot dm^{-3}$ ----------------------						
BPz	3.7	24.5	51.5	1.66	132	2.10	
SB^y+RH^x(1:1, v/v)	20.8	3.8	23.7	1.76	39.3	0.17	
$SB+CC^w$(1:1, v/v)	197.0	23.5	73.6	4.22	69.9	43.60	
SB^y+CM^v(3:1, v/v)	98.5	16.7	96.7	5.42	44.4	0.53	
CB^u+FC^t(3:2, v/v)	21.9	30.8	80.9	2.32	153	2.30	

[z]Bioplant®;[y]Subsoil; [x]Rice husk; [w]Cattle manure compost (corn silage+cattle manure); [v]Cattle manure; [u]Sugarcane bagasse; [t]Sugar-mill filter cake; [k]pH in H_2O; [s]Organic matter; [r]Electric conductivity;[q]Base saturation.

The percentage of emerged seedlings (PES) was assessed every two days within the period between the emergence of the first seedling and the end of that process; the emergence rate index (ERI) was calculated according to Maguire (1962). The biometric parameters evaluated at the harvest of the plants (at 175 days after emergency) were the stem length (SL), root-collar diameter (RCD) and the number of leaves (NL) and leaf area (LA), after separation of the plant into root, stem and leaves, the dry weight of which part was obtained separately. This material was dried in a forced-air oven at 65°C until it reached constant weight. The quality of the seedlings was evaluated based on the SL and RCD ratio (SL/RCD), the ratio between the dry weight of the root system and of the shoots of plants (R/S) and the Dickson quality index (DQI). The Dickson quality index (DQI) is a tool to evaluate seedling quality as a function of total dry matter (TDM) (g), shoot height (SH) (cm), stem base diameter (SBD) (mm), shoot dry matter (SDM) (g) – sum of stem base dry matter and leaf dry matter – and root dry matter (RDM) (g), and is given by the expression: DQI = TDM g / [(SH cm/ SBD mm + (SDMg/RDM g)] (DICKSON et al., 1960).

To assess macro and micronutrients in the leaf tissues, the dried material of 5 leaf tissue plants per substrate was ground in a Willey mill. The concentrations of N, P, K, Ca, Mg, S, Fe, B, Cu, Zn and Mn elements were measured according to the method described by Malavolta et al. (1997).

The normality and homogeneity of the variances were checked using the Shapiro-Wilk test ($p>0.05$)

before ANOVA. The data were submitted to analysis of variance (ANOVA). When a significant effect was found by the F test ($p < 0.05$), the Tukey test ($p < 0.05$) was performed to determine differences among means. The analysis of variance and tests of means were performed using SAEG 9.1 (SAEG, 2007) statistical software.

RESULTS AND DISCUSSION

The emergence of guapeva seedlings was higher in the BP (BioPlant) substrate than in the SB+CC (subsoil material and corn silage+cattle manure) substrate, with values of 89 and 59%, respectively (Table 2). The emergences in the substrates SB+RH (subsoil material and rice husk) and CB+FC (sugarcane bagasse and sugar mill filter cake) did not differ from those in the other formulations but gave percentages above 85%, which can be considered satisfactory because this species is not yet domesticated. The mean number of days for emergence (DFE) of guapeva seedlings was lower when grown on the substrates BP, SB+CM (subsoil material and cattle manure) and CB+FC, varying from 36.7 to 39.2 days, compared to the substrate SB+CC with a DFE of 49.9 days. The higher number of DFE resulted in a smaller emergence rate index (ERI) promoted by the SB+CC substrate than by the substrates BP and CB+FC.

Silva et al. (2009b) associate higher ERI with luminosity and with good drainage capacity substrate, which facilitates its oxygenation. A good substrate, to favor germination and emergence, it must exhibit a degree of porosity that allows the hydration and aeration, because to germinate and emerge seeds needs water and oxygen for their metabolism (NOGUEIRA et al., 2003).

Growth of guapeva plants was favored regarding all of the analyzed biometric variables by the substrate SB+CM, containing cattle manure, compared to the SB+CC substrate (Table 2). The substrates BP, SB+RH and SB+CC showed lower values for SL, LA, NL and root collar diameter (RCD) (Table 2), stem dry weight (SDW), leaf dry weight (LDW), root dry weight (RDW) and total dry weight (TDW) (Table 3) in comparison to the SB+CM substrate, that showed respectively 24 cm; 503 cm^2; 9.0 and 4.0 mm (Table 2), and 0.86 g, 2.66 g 1.44 g and 4.66 g (Table 3).

Several studies have shown that the use of cattle manure as a component of substrate for seedlings is appropriate and yields good results, as observed in *Acacia* sp. (CUNHA et al., 2006), *Enterolobium contortisiliquum* (ARAÚJO; PAIVA SOBRINHO, 2011), *Harconia speciosa* (SILVA et al., 2009b), *Eugenia dysenterica* DC. (MOTA et al., 2016). The increased performance of guapeva plants on substrate containing cattle manure can be related to the fact that manure exhibits fast mineralization and thus nutrient availability.

TABLE 2 Percentage of emerged seedlings (PES), emergence rate index (ERI), days for emergence (DFE), stem length (SL), root collar diameter (RCD), number of leaves (NL), leaf area (LA) in Pouteria gardneriana Radlk seedlings grown in different substrates 175 days after emergency.

Substrate	PES	ERI	DFE	SL	RCD	NL	LA
	%		days	cm	mm		cm^2
BPz	89 a	0.52 a	36.7 b	21 bc	3.7 ab	6.2 bc	191 c
SBy+RHx (1:1, v/v)	85 ab	0.45 ab	40.6 ab	19 c	3.6 ab	5.7 c	188 c
SB+CCw (1:1,v/v)	59 b	0.29 b	49.9 a	18 c	3.3 b	7.1 b	240 bc
SB+CMv (3:1, v/v)	75 ab	0.43 ab	39.2 b	24 a	4.0 a	9.0 a	503 a
CBu+FCt (3:2, v/v)	87 ab	0.51 a	37.8 b	24 ab	3.7 ab	8.6 a	328 b
F Blocks	0.80^{ns}	1.46^{ns}	1.61^{ns}	2.20^{ns}	0.78^{ns}	0.95^{ns}	2.28^{ns}
F Substrate	3.23^{*}	5.26^{**}	5.16^{**}	11.3^{**}	3.15^{*}	19.0^{**}	30.4^{**}

^{z}Bioplant®; ^{y}Subsoil; ^{x}Rice husk; ^{w}Cattle manure compost (corn silage+cattle manure); ^{v}Cattle manure; ^{u}Sugarcane bagasse; ^{t}Sugar-mill filter cake.
Means followed by the same letter in the column do not differ based on Tukey's test ($p<0.05$). ns not significant; * $p<0.05$; ** $p<0.01$ by F test.

TABLE 3 Stem dry weight (SDW) leaf dry weight (LDW), root dry weight (RDW) total dry weight (TDW), ratio between the stem length and root collar diameter (SL/RCD), ratio between the root and shoot dry weights (R/S) and Dickson quality index (DQI) in guapeva (*Pouteria gardneriana* Radlk) seedlings grown in different substrates 175 days after emergency .

Substrate	SDW	LDW	RDW	TDW	SL/RCD	R/S	DQI
	------------- g	-----------------			$cm \cdot mm^{-1}$	$g \cdot g^{-1}$	
BP^{z}	0.53 b	1.15 c	1.07 a	2.74 bc	5.61 bc	0.654 a	0.39 ab
$SB^{y}+RH^{x}$ (1:1, v/v)	0.52 b	1.11 c	1.12 a	2.76 bc	5.26 c	0.695 a	0.42 ab
$SB+CC^{w}$ (1:1,v/v)	0.56 b	1.32 bc	0.70 b	2.58 c	5.62 bc	0.405 bc	0.31 b
$SB+CM^{v}$ (3:1, v/v)	0.86 a	2.66 a	1.14 a	4.66 a	6.12 ab	0.354 c	0.50 a
$CB^{u}+FC^{t}$ (3:2, v/v)	0.65 ab	1.76 b	1.15 a	3.56 b	6.53 a	0.483 b	0.42 ab
F Blocks	0.35^{ns}	1.61^{ns}	0.82^{ns}	0.98^{ns}	3.16^{ns}	1.71^{ns}	0.74^{ns}
F Substrate	5.31^{**}	21.2^{**}	5.15^{**}	12.2^{**}	6.18^{**}	26.6^{**}	3.90^{**}

^{z}Bioplant®;ySubsoil; ^{x}Rice husk; ^{w}Cattle manure compost (corn silage+cattle manure); ^{v}Cattle manure; ^{u}Sugarcane bagasse; ^{t}Sugar-mill filter cake.
Means followed by the same letter in the column do not differ based on Tukey's test ($p<0.05$). ns not significant; * $p<0.05$; ** $p<0.01$ by F test.

The CB+FC substrate provided conditions for the guapeva plants to exhibit the largest SL/RCD in comparison to the substrates BP, SB+RH and SB+CC (Table 3). The SL/RCD ratio is responsible for the robustness of the seedlings or the level of etiolation of these seedlings (MARANA et al., 2008). For being easy to measure and there isn´t need to sacrifice the plant, the SL/RCD ratio is widely used to measure the quality of seedlings. The values obtained in this study for *Pouteria gardneriana* seem reasonable and do not refer of the etiolation.

The balance of the distribution of photoassimilates between roots and the shoot, provided by the ratio between the root and shoot dry weights (R/S), shows that the substrates BP and SB+RH favored the allocation of photoassimilates to the root system compared to other substrates, especially SB+CM. Saidelles et al. (2009) observed that an increase in proportion of carbonized rice husk in substrates increased the R/S ratio, which according to the authors was due to a reduction of nutrient availability. This because the R/S ratio is indicative of nutrient availability in the substrate, and in nutrient-deficient situations, the plants allocate photoassimilates to the root system to promote its growth and thus improve the area of substrate use (SILVA; DELATORRE, 2009). The R/S values vary according to the species and environmental factors (HODGE, 2004). The seams results was observed by Mota (2016) which *Eugenia Dysentherica* seedlings showed increased of root dry weight growth in different substrate. The seedlings of those study showed that the use of organic residues can produce better PSE and ESI, high macronutrients content in the leaves, resulting to more efficient photosynthesis to improve the native plants seedling development (MOTA et al., 2015; MOTA et al., 2016). However, Paiva Sobrinho; (2010) showed that the native species of the Midwest, such as the mangaba (*H. speciosa*) and baru (*Dipteryx alata* Vog.) were developed better when the substrate was devoid of any source of organic matter.

Regarding the DQI, the higher the value, the better the quality of the seedlings produced (GOMES et al., 2003). In this study, the highest value (0.50) was obtained by SB+CM substrate, which however differed just of the SB+CC (0.31). Studying the development of Cerrado cashew tree seedlings in substrates with different proportions of fine-grained vermiculite + carbonized rice husk, sugarcane bagasse + sugarcane mill filter cake and substrates commercials, it was found an IQD between 0.34 and 0.48 (DORNELLES et al., 2014), values similar to verified this study. The DQI is considered a promising integrated measure of morphological traits and thought to be a good indicator of seedling quality as its calculation computes robustness and biomass distribution while considering several important parameters (FONSECA et al., 2002).

The N leaf content in guapeva seedlings ranged from 10.6 to 12.0 mg·kg^{-1} and did not differ between the substrates (Table 4). One would expect, however, that the BP substrates and especially CB+FC, which have respectively 43.0 and 60.0 cmol$_c$·dm^{-3} OM, provide more N for guapeva seedlings. However, more important than the OM content in the substrate for the availability of N to plants is the degree of humification of OM, because the more recalcitrant, the lower its C/N rate, which increases the availability of nitrogen to plants. This information was evidenced by Lima et al. (2006) who studied the development of *Malpighia emarginata* seedlings on substrates with different degrees of humification.

TABLE 4 Content of nitrogen (N), phosphorus (P), potassium (K),calcium (Ca), Magnesium (Mg) and sulfur (S) in leaves of guapeva (Pouteria gardneriana Radlk) seedlings grown in different substrates 175 days after emergency.

Substrate	N	P	K	Ca	Mg	S
	g·kg^{-1}					
BP^{z}	10.6 a	1.40 ab	8.6 a	7.2 c	1.9 cd	1.34 b
SB^{y}+RH^{x}(1:1, v/v)	11.4 a	0.76 c	7.8 a	5.7 c	1.6 d	0.48 c
SB+CC^{w}(1:1, v/v)	11.2 a	1.04 bc	7.7 a	6.0 c	2.5 c	1.40 b
SB+CM^{v}(3:1, v/v)	11.0 a	1.08 bc	8.2 a	11.3 b	4.1 a	1.98 a
CB^{u}+FC^{t}(3:2, v/v)	12.0 a	1.92 a	5.3 b	13.9 a	3.1 b	0.92 bc
F Blocks	0.75^{ns}	1.29^{ns}	1.13^{ns}	0.62^{ns}	1.05^{ns}	0.43^{ns}
F Substrate	2.27^{ns}	11.3**	8.87**	61.6**	51.1**	24.6**

^{z}Bioplant®; ^{y}Subsoil; ^{x}Rice husk; ^{w}Cattle manure compost (corn silage+cattle manure); ^{v}Cattle manure; ^{u}Sugarcane bagasse; ^{t}Sugar-mill filter cake.
Means followed by the same letter do not differ based on Tukey's test ($p<0.05$).
^{ns} not significant; * $p<0.05$; ** $p<0.01$ by F test.

Guapeva seedlings grown in the substrate SB+CM showed higher Mg levels (4.1 mg kg^{-1}) and S (1.98 mg kg^{-1}). In their chemicals compositions among the substrate, the BP, SB+CC and SB+CM have the highest content of Mg (both with 5.30 cmol$_c$ dm^{-3}). However, the seedlings grown in SB+CC showed Mg leaf content 64% higher compared to SB+CM (Table 4). With respect to P, the larger element leaf content (1.92 mg kg^{-1}) was showed in the seedlings grown in CB+CF and did not differ to BP, which was not expected, since these substrates had low content of element (Table 1). This happened possibly because these substrates showed the highest OM content, which has an important contribution in providing P (GUPPY et al., 2005). Cavalcante et al. (2012) also found that increasing the OM content in organic substrates increased P content on the dry matter leaves of *Annona squamosa* L seedling.

For K and Ca it was observed that the CB+CF substrate resulted in the lowest (5.3 mg·kg^{-1}) and higher (13.9 mg·kg^{-1}) foliar content respectively. This result may have occurred because the availability of nutrients is not only related to the concentration of cations in the substrate, but also with the relationship between the ionic species. Such relationships are called ionic interactions and may occur in substrate or in plant and affect the availability of the elements (TISDALE et al., 1985). Thus, as the ratio K:Ca:Mg interferes in the availability of these elements, may occur induced deficiency of nutrients as a result of antagonism in absorption, defined by

Mengel and Kirkby (1987) as competition between ion type antagonism cations. Therefore, guapeva seedlings produced in CB+FC, per absorb more Ca, may have reduced the K uptake. Neves et al. (2008) also found that the increase in Ca absorption by seedlings *Spondia stuberosa* Arr. Cam reduced the K content in the leaves of the species.

It is widely accepted that the use of cattle manure increases the availability of nutrients within the substrate, in addition to being a conditioning factor of substrates (CUNHA et al., 2006; ARAÚJO; PAIVA SOBRINHO, 2011; SILVA et al., 2012). Similar results of the macronutrients foliar contents also were obtained from swine manure (NADDAF et al., 2011). The use of sugarcane bagasse and filter cake also showed good availability of nutrients, and studies have corroborated the effective use of these components (FREITAS et al., 2008). In the case of micronutrient guapeva leaves content, there was a significant difference only for B, Fe and Mn (Table 5).

TABLE 5 Content of boron (B), iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) in leaves of guapeva (*Pouteria gardneriana* Radlk) seedlings grown in different substrates 175 days after emergency.

Substrate	B	Fe	Cu	Mn	Zn
	---------------------- $mg\cdot g^{-1}$	----------------------			
BP[z]	91.6 a	202 ab	7.0 a	84.6 a	3.2 a
SBy+RHx(1:1, v/v)	27.6 c	185 b	7.6 a	59.4 b	1.8 a
SB+CCw(1:1, v/v)	34.0 b	205 ab	8.2 a	29.0 cd	1.4 a
SB+CMv(3:1, v/v)	17.6 d	247 a	5.8 a	20.6 d	2.4 a
CBu+FCt(3:2, v/v)	13.4 d	222 ab	7.6 a	44.8 cb	1.4 a
F Blocks	0.91[ns]	1.44[ns]	0.78[ns]	2.63[ns]	1.78[ns]
F Substrate	475.8**	4.73*	0.86[ns]	38.0**	2.70[ns]

[z]Bioplant®; [y]Subsoil; [x]Rice husk; [w]Cattle manure compost (corn silage+cattle manure); [v]Cattle manure; [u]Sugarcane bagasse; [t]Sugar-mill filter cake.
Means followed by the same letter do not differ based on Tukey's test ($p<0.05$).
[ns] not significant; * $p<0.05$; ** $p<0.01$ by F test.

The leaf content of B (91.6 $mg\cdot g^{-1}$) and Mn (84.6 $mg\cdot g^{-1}$) were higher for plants grown in substrate BP. Commonly, increasing the pH of substrates becomes micronutrients such as Cu, Fe, Mn and Zn least available throughout the crop cycle, which may affect the absorption of these elements.This observation was confirmed by Ludwig et al. (2014) that evaluated the development of *Gerbera jamesonii* in organic substrates. However, in this study, it was observed that foliar Cu (average of 7.24 $mg\cdot g^{-1}$) and Zn (mean 2.04 $mg\cdot g^{-1}$) showed no difference between the substrates, and the foliar Fe was higher for the substrate SB+CM (247 mg $\cdot g^{-1}$), which had 1.8 pH units higher than the substrate BP (pH 5.0). The leaf content of Mn was similar to SB+HR (59.4 $mg\cdot g^{-1}$) and CB+CF (44.8 $mg\cdot g^{-1}$) substrates, which had pH 6.4 and 7.0 respectively, and lower to SB+CM substrate (20.6 $mg\cdot g^{-1}$) whose pH was 6.8. This can happen because the Cerrado soils are originally acid and saturated by Al (HARIDASAN, 2000), which may have promoted evolution of native species, adapting to the low pH. Besides that, the availability of nutrients for organic substrates depends not only on the composition and pH of the substrate, but also of the adsorption capacity, of the biological stability and of presence of dissolved organic compounds (CABALLERO et al., 2007), which can change the dynamics of absorption of nutrients by plants.

CONCLUSIONS

From the results, it can be concluded that the use of cattle manure and cattle manure+corn silage with subsoil promoted a good supply of nutrients to the plants, but the subsoil+cattle manure (3:1, v/v) substrate was that more favored the growth and quality of seedlings guapeva. The use of agroindustrial composts can be more indicate for production of native seedlings fruits from Brazilian Savanna.

ACKNOWLEDGEMENTS

This work was funded by the Higher Education Personnel Improvement Coordination (CAPES), the Goias Research Foundation (*FAPEG)* for the financial support and fellowships granted, and Mr. Arlindo Thomáz da Silva and family for providing the plant material.

REFERENCES

ARAÚJO NETO, S. E.; AZEVEDO, J. M. A.; GALVÃO, R. O.; OLIVEIRA, E. B. L.; FERREIRA, R. L. F. Produção de muda orgânica de pimentão com diferentes substratos. **Ciência Rural**, v. 39, n. 5, p. 1408-1413, 2009.

ARAÚJO, A. P.; PAIVA SOBRINHO, S. Germinação e produção de mudas de tamboril (*Enterolobium contostisiliquum* (Vell.) Morong) em diferentes substratos. **Revista Árvore**, v. 35, n. 3, p. 581-588, 2011.

BOLETI, A. P. A.; VENTURA, C. A.; JUSTO, G. Z.; SILVA, R. A.; SOUSA, A. C.; FERREIRA, C. V.; YANO, T.; MACEDO, M. L. Pouterin, a novel potential cytotoxic lectin-like protein with apoptosis-inducing activity in tumorigenic mammalian cells. **Toxicon**, v. 51, n. 8, p. 1321-1330, 2008.

CABALLERO, R.; ORDOVÁS, J.; PAJUELO, P.; CARMONA, E.; DELGADO, A. Iron chlorosis in gerbera as related to properties of various types of compost used as growing media. **Communications in Soil Science and Plant Analysis**, v.1, n. 38, p. 2357-2369, 2007.

CARVALHO FILHO, J. L. S.; ARRIGONI-BLANK, M. F.; BLANK, A. F. Produção de mudas de angelim (*Andira fraxinifolia* Benth.) em diferentes ambientes, recipientes e substratos. **Revista Ciência Agronômica**, v.3 5, p. 61-67, 2004.

CATUNDA, P. H. A.; MARINHO, C. S.; GOMES, M. M. A.; CARVALHO, A. J. C. Brassinosteroide e substratos na aclimatação do abacaxizeiro 'Imperial'. **Acta Scientiarum Agronomy**, v.3 0, n. 3, p. 345-352, 2008.

CAVALCANTE, L. F.; PEREIRA, W. E.; CURVÊLO, C. R. S.; NASCIMENTO, J. A. M.; CAVALCANTE, I. H. L. Estado nutricional de pinheira sob adubação orgânica do solo. **Revista Ciência Agronômica**, v. 43, n. 3, p. 579-588, 2012.

CUNHA, A. M.; CUNHA, G. M.; SARMENTO, R. A.; CUNHA, G. M.; AMARAL, J. F. T. Efeito de diferentes substratos sobre o desenvolvimento de mudas de *Acacia* sp. **Revista Árvore**, v. 30, n. 2, p. 207-214, 2006.

DANTAS, B. F.; LOPES, A. P.; SILVA, F. F. S.; LÚCIO, A. L.; BATISTA, P. F.; PIRES, M. M. M. L.; ARAGÃO, C. A. Taxas de crescimento de mudas de catingueira submetidas a diferentes substratos e sombreamentos. **Revista Árvore**, v. 33, n. 3, p. 413-423, 2009.

DELARMELINA, W. M.; CALDEIRA, M. V. W.; FARIA, J. C. T.; GONÇALVES, E. O.; ROCHA, R. L. F. Diferentes substratos para a produção de mudas de *Sesbaniavirgata*. **Floresta e Ambiente**, v. 21, n. 2, p. 224-233, 2014.

DORNELLES, P.; SILVA, F. G.; MOTA, C. S.; SANTANA, J. G. Production and quality of *Anacardium othonianum* Rizz. seedlings grown in different substrates. **Revista Brasileira de Fruticultura**, v. 36, n. 1, p. 195-202, 2014.

DICKSON, A.; LEAF, A. L.; HOSNER, J. F. Quality appraisal of white spruce and white pine seedling stock in nurseries. **Forest Chronicle**, v. 36, n.1, p. 10-13, 1960.

FERRAZ, M. V.; CENTURION, J. F.; BEUTLER, A. N. Caracterização física e química de alguns substratos comerciais. **Acta ScientiarumAgronomy**, v. 27, n. 2, p. 209-214, 2005.

FONSECA, E. P.; VALÉRI, S. V.; MIGLIORANZA, E.; FONSECA, N. A. N.; COUTO, L. Padrão de qualidade de mudas de *Trema micrantha* (L.) Blume, produzidas sob diferentes períodos de sombreamento. **Revista Árvore**, v. 26, n. 4, p. 515-523, 2002.

FREITAS, T. A. S.; BARROSO, D. G.; CARNEIRO, J. G. A.; PENCHEL, R. M.; COUTINHO, M. P. Out planting performance of eucalyptus clonal cuttings produced in different containers and substrates. **Revista Árvore**, v. 32, n. 6, p. 1019-1028, 2008.

GOMES, J. M.; COUTO, L.; LEITE, H. G.; XAVIER, A.; GARCIA, S. L. R. Crescimento de mudas de *Eucalyptus grandis* em diferentes tamanhos de tubetes e fertilização NPK. **Revista Árvore**, v. 27, n. 2, p. 113-127, 2003.

GRIGATTI, M.; GIORGIONI, M. E.; CIAVATTA, C. Compost-based growing media: influence on growth and nutrient use of bedding plants. **Bioresource Technology**, v. 98, n. 18, p. 3526-3534, 2007.

GUPPY, C. N.; MENZIES, N. W.; MOODY, P. W.; BLAMEY, F. P. C. Competitive sorption reactions between phosphorus and organic matter in soil: a review. **Australian Journal of Soil Research**, v. 43, n. 2, p. 189-202, 2005.

HARIDASAN, M. Nutrição mineral de plantas nativas do cerrado. **Revista Brasileira de Fisiologia Vegetal**, v.12, n.1, p.54-64, 2000.

HODGE, A. The plastic plant: Root responses to heterogeneous supplies of nutrients. **New Phytologist**, v. 162, n. 1, p. 9-24, 2004.

LIMA, R. L. S.; SIQUEIRA, D. L.; WEBER, O. B.; CECON, P. R. Teores de macronutrientes em mudas de aceroleira (*Malpighia emarginata* DC.) em função da composição do substrato. **Ciência Agrotecnologia**, v. 30, n. 6, p. 1110-1115, 2006.

LIMA, T. B.; SILVA, O. N.; OLIVEIRA, J. T. A.; VASCANCELOS, I. M.; SCALABRIN F. B.; ROCHA, T. L.; GROSSI-DE-AS, M. F.; SILVA, L. P.; GUADAGNIN, R. V.; QUIRINO, B. F.; CASTRO, C. F. S.; LEONARDECZ, E.; FRANCO, O. L. Identification of *E. dysenterica* laxative peptide: A novel strategy in the treatment of chronic constipation and irritable bowel syndrome. **Peptides**, v. 31, n.1, p. 1426-1433, 2010.

LUDWIG, F.; FERNANDES, D. M; GUERRERO, C. G. A.; VILLAS BOAS, R. L. Characteristics of substrates for nutrient absorption and production of gérbera. **Horticultura Brasileira**, v. 32, n. 2, p. 184-189, 2014.

MAGUIRE, J. D. Speed of germination aid in selection and evaluation for seedling and vigour. **Crop Science**, v. 2, n. 2, p. 176-177, 1962.

MALAVOLTA, E. **Avaliação do estado nutricional das plantas princípios e aplicações**. 2. ed. Piracicaba: Associação Brasileira para Pesquisa da Potássio e do Fosfato, 1997. 319 p.

MARANA, J. P.; MIGLIORANZA, E.; FONSECA, E. P.; KAINUMA, R. H. Índices de qualidade e crescimento de mudas de café produzidas em tubetes. **Ciência Rural**, v. 38, n. 1, p. 39-45, 2008.

MARTINS, C. C.; MACHADO, C. G.; CALDAS, I. G. R.; VIEIRA, I. G. Vermiculita como substrato para o teste de germinação de sementes de barbatimão. **Ciência Florestal**, v. 21, n. 3, p. 421-427, 2011.

MENGEL, K.; KIRKBY, E. A. **Principles of plant nutrition.** Bern: International Potash Institute, 1987. 687p.

MINAMI, K. **Produção de mudas de alta qualidade em horticultura**. São Paulo: Fundação Salim Farah Maluf, 1995. 128p.

MOTA, C. S.; DORNELLES, P.; SILVA, F. G.; SOUSA, SILVA, J.; SANTANA, J. G.; SEVERIANO, E. C. Production of *Pouteria gardneriana* (A.DC) Radlk. seedlings on different substrates. **African Journal of agriculture Research**, v. 10, n. 30, p. 2961-2967, 2015.

MOTA, C. S.; SILVA, F. G.; DORNELLES, P.; COSTA, A. C.; ARAÚJO, E. L.; MENDES, G. C. Use of physiological parameters to assess seedlings quality of *Eugenia dysenterica* DC. grown in different substrates. **Australian Journal of Crop Science**, v. 10, n. 6, p. 842-851, 2016.

NADDAF, O. A.; LIVIERATOS, I.; STAMATAKIS, A.; TSIROGIANNIS, I.; GIZAS, G.; SAVVAS, D. Hydraulic characteristics of composted pig manure, perlite, and mixtures of them, and their impact on cucumber grown on bags. **Scientia Horticulturae**, v. 129, n. 1, p. 135-141, 2011.

NEVES, O. S. C.; CARVALHO, J. G.; FERREIRA, E. V. O.; ASSIS, R. P. Nutrição mineral, crescimento e níveis críticos foliares de cálcio e magnésio em mudas de umbuzeiro, em função da calagem. **Revista Ceres**, v. 55, n. 6, p. 575-583, 2008.

NOGUEIRA, R. J. M. C.; ALBUQUERQUE, M. B.; SILVA JÚNIOR, J. F. Efeito do substrato na emergência, crescimento e comportamento estomático em plantas de mangabeira. **Revista Brasileira de Fruticultura**, v. 25, n. 1, p. 15-18, 2003.

PAIVA SOBRINHO, S.; LUZ, P. B.; SILVEIRA, T. L. S.; RAMOS, D.; NEVES, L. G.; BARELLI, M. A. A. Substratos na produção de mudas de três espécies arbóreas do cerrado. **Revista Brasileira de Ciências Agrárias**, v. 5, n. 2, p. 238-243, 2010.

SAEG **Sistema para Análises Estatísticas**, Versão 9.1: Fundação Arthur Bernardes - UFV - Viçosa, 2007.

SAIDELLES, F. L. F.; CALDEIRA, M. V. W.; SCHIRMER, W. N.; SPERANDIO, H. V. Casca de arroz carbonizada como substrato para produção de mudas de tamboril-da-mata e garapeira. **Semina**, v. 30, n. 1, p. 1173-1186, 2009.

SANTANA, C. T. C.; SANTI, A.; DALLA CORT, R.; SANTO, S. M. L.; MENEZES, C. B. Desempenho de cultivares de alface-americana em resposta a diferentes doses de torta de filtro. **Revista Ciência Agronômica**, v. 43, n. 1, p. 22-29, 2012.

SILVA, C. D.; COSTA, L. M.; MATOS, A. T.; CECON, P. R.; SILVA, D. D. Vermicompostagem de lodo de esgoto urbano e bagaço de cana-de-açúcar. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 6, n. 3, p. 487-491, 2002.

SILVA, A. A.; DELATORRE, C. C. Alterações na arquitetura de raiz em resposta à disponibilidade de fósforo e nitrogênio. **Revista de Ciências Agroveterinárias**, v. 8, n. 2, p. 152-163, 2009.

SILVA, C. A. M.; SIMEONI, L. A.; SILVEIRA, D. Genus *Pouteria*: chemistry and biologicalactivity. **Revista Brasileira de Farmacognosia**, v. 19, n. 2a, p. 501-509, 2009a.

SILVA, E. A.; OLIVEIRA, A. C.; MENDONÇA, V.; SOARES, F. M. Efeito de diferentes substratos na produção de mudas de mangabeira (*Hancorniaspeciosa*). **Revista Brasileira de Fruticultura**, v. 31, n. 3, p. 925-929, 2009b.

SILVA, R. B. G.; SIMÕES, D.; SILVA, M. R. Qualidade de mudas clonais de *Eucalyptus urophylla* x *E. grandis* em função do substrato. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 16, n. 3, p. 297-302, 2012.

SOUZA, E. C.; VILAS-BOAS E. V.; VILLAS-BOAS B. M.; RODRIGUES L. J.; PAULA N. R. F. Qualidade e vida útil de pequi minimamente processado armazenado sob atmosfera modificada. **Revista Ciência e Agrotecnologia,** v. 31, n.1, p.1811-1817, 2007.

TERRA, S. B.; FERREIRA, A. A. F.; PEIL, R. M. N.; STUMPF, E. R. T.; BECKMANN-CAVALCANTE, M. Z.; CAVALCANTE, I. H. L. Alternative substrates for growth production of potted chrysanthemum (cv.Funny). **Acta Scientiarum Agronomy**, v. 33, n. 3, p. 465-471, 2011.

TISDALE, S. L.; NELSON, W. L.; BEATON, J. D. **Soil fertility and fertilizers**. 4. ed. New York: MacMilan Publishers, 1985. 754p.