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Substrate from vermiculite and cattle manure for ornamental pepper seedling production

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ABSTRACT

Substrates with a mixture of two or more materials have better conditions for root development of vegetables seedlings. This research aimed to evaluate the formation of ornamental pepper (cultivars Etna and Pyramid) seedlings in six different combinations between vermiculite (V) and cattle manure (M) (10%M + 90%V; 25%M + 75%V; 40%M + 60%V; 55%M + 45%V; 70%M + 30%V; 85%M + 15%V). The experiment was conducted at Universidade de Mato Grosso do Sul in a completely randomized design in a factorial scheme 6 x 2 (six substrates and two cultivars). The initial growth and emergence of ornamental pepper seedlings were evaluated. The highest amounts of vermiculite favored the emergence of pepper. The highest amounts of cattle manure in the substrate formed the best seedlings, especially the substrate with 30% vermiculite and 70% cattle manure. Cultivar Pirâmide showed more vigorous plants than Etna, being more suitable for the Cassilândia region. The most recommended substrate combination is composed of 30%V + 70%M for ornamental pepper, where the seedlings of the cultivar that best developed on the substrate was the Pirâmide.

Keywords: *Capsicum chinense*, ornamental plants, mixtures, seedlings.

RESUMO

Substrato à base de vermiculita e esterco bovino na formação de mudas de pimenta ornamental

Substratos contendo mistura de dois ou mais materiais apresentam melhores condições para o desenvolvimento radicular das mudas de hortaliças. Com este trabalho objetivou-se avaliar a formação de mudas de pimenteiras ornamentais, cultivares Etna e Pirâmide em diferentes misturas de vermiculita (V) e esterco bovino (B). Foram utilizados seis combinações de substratos: 10%B + 90%V; 25%B + 75%V; 40%B + 60%V; 55%B + 45%V; 70%B + 30%V; 85%B + 15%V. O experimento foi conduzido na Universidade Estadual do Mato Grosso do Sul, utilizando delineamento inteiramente casualizado em esquema fatorial 6 x 2 (seis substratos e duas cultivares). Foram avaliados a emergência e crescimento inicial das plântulas. As maiores quantidades de vermiculita favoreceram a emergência da pimenteira. A maior quantidade de esterco no substrato propiciou melhores mudas, com destaque para o substrato de 30%V + 70%B. A cultivar Pirâmide apresentou mudas mais vigorosas que a cultivar Etna, sendo a mais indicada para a região de Cassilândia. De acordo com este estudo, o substrato mais recomendado é o composto de 30%V + 70%B para pimenta ornamental, sendo que as mudas da cultivar que melhor se desenvolve nesse substrato é a Pirâmide.

Palavras-chave: *Capsicum chinense*, plantas ornamentais, misturas, mudas.

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Pepper is highly sensitive to cold temperatures, so in some regions it can be grown only in certain period of the year. However, it can be grown in protected environment, which presents several favorable conditions for seedling formation, through moisture, light and temperature management, among other factors (Bezerra, 2003).

According to Bezerra (2003), substrates are different types of materials, alone or in combination, which can offer all the requirements for root growth, in nutrient, moisture, aeration, that means, acting as soil and promoting support for the plant. Many raw materials have shown good results as substrate for pepper seedling production, as remains of fruit and vegetables or sugar cane bagasse mixed with cattle manure or broiler litter, containing residue of carnauba (Bezerra *et al.*, 2010), vermicompost of cattle manure + carbonized rice husk (Acosta *et al.*, 2011). Mixtures using only cattle manure and vermiculite for pepper seedling formation were not found in literature, thus the use of organic material (manure), obtained at the place of production, tend to decrease cost to growers.

To choose substrates, the characteristics of this substrate should be taken into account, as some materials used can delay seedling emergence and growth (Nascimento *et al.*, 2003). The use of substrates based on organic residues, from plant or animal origin, such as cattle manure, helps nourish the seedlings, and also on physical and chemical properties of the substrate. The use of these materials is a low cost option for growers, compared to commercial substrates, and they still recycle and reuse agricultural residues

(Rodrigues *et al*., 2010).

The use of vermiculite has been recommended in mixtures with other materials for substrate composition in seedling formation, due to its numerous characteristics such as high drainage capacity, nearly neutral pH, high porosity and low density (Minami, 1995; Pinto *et al*., 2004). Santos *et al.* (2010) recommend that, if the vermiculite is put into a mixture of humus, this mixture should not exceed 25%, because this can limit the seedling nutrients and thus affect the development.

Considering the above mentioned, the aim of this work was to evaluate seedling formation of ornamental pepper, cultivars Etna and Pirâmide, in different mixtures of vermiculite and cattle manure.

MATERIAL AND METHODS

This work was carried out at the experimental area at Universidade Estadual de Mato Grosso do Sul (UEMS), Unidade Universitária in Cassilândia, Mato Grosso do Sul state, Brazil, from March to June, 2013. A completely randomized design in a 6 x 2 factorial scheme (six substrate combinations and two cultivars) was used; two ornamental pepper cultivars (Etna and Pirâmide) and six substrate combinations with different concentrations of vermiculite (V) and cattle manure (M) (90%V + 10%M; 75%V + 25%M; 60%V + 40%M; 45%V + 55%M; 30%V + 70%M and 15%V + 85%M). Eight replications with five plants per replication were used.

Cultivar Etna, adapted for tropical climates, is ornamental, but can be consumed as other peppers. The plant is compact and has determined growth, dark green color and bright red when ripe. The plant shows high resistance to Tobaco Mosaic Virus (TMV) and moderate resistance to Nematode Virus (N) and Potato Vírus Y (PVY) (ISLA®). Cultivar Pirâmide is characterized by compact plants and with lots of colorful fruits (green, purple, yellow, orange and red), with spicy taste (ISLA®).

Cattle manure was composted in a covered place with water supply every two days and plowing. This procedure was performed for 30 days, from September 27, 2012 to October 27, 2012. For the vermiculite and cattle manure mixture, the manure was sieved through a sieve with diameter of 70 mesh 3.70 mm, to be better homogenized. Vermiculite super fine texture was used. The chemical characteristics of the manure were: N, P, K, Ca, Mg, S, C, Organic Matter, in g/kg (18.4; 1.71; 1; 15.05; 0.7; 1.95; 141; 244); pH in water = 5.4; Moisture = 38.91%, carbon/nitrogen ratio = 7.66; Cu, Zn, Fe, Mn, B, in mg/kg (18.5; 125; 6830; 214; 14). Analysis was performed by Solanalise company (Central of Analysis Ltda), which uses the organic fertilizer method, using extractor H_2SO_4 (P – N) and nitro-perchloric acid (K - Fe - Mn - Cu – Zn – S - Ca - Mg – Al).

The seedlings were sown in protected environment under agricultural greenhouse (8.00 x 18.00 x 3.50 m), in galvanized steel structure, closing at 45º inclination, with monofilament mesh all along the greenhouse, shading screen coverage with 50%. The treatments were performed in polystyrene trays of 72 cells (5.0 cm wide, 12.0 high and volume of 121.2 cm^3). For each treatment, one and a half trays were used, constituting 108 cells per treatment.

After mixing the materials and filling the trays, the irrigation was performed once a day, for seven days, before sowing. Sowing was performed on March 8, two seeds per cells were put at a depth of 0.5 cm, with seedling emergence on March 16, followed by a thinning on April 02. Irrigation was performed with a watering can, twice a day, in the morning and the afternoon, when necessary, until saturation of the substrate, as observed in the beginning of the water flow.

After sowing and beginning of seedling emergence, evaluations of emergency speed index (IVE) proposed by Maguire (1962) were performed, the percentage of emergence (PE), the mean emergence time (TME) proposed by Labouriau (1983) and the average speed emergency (VME) proposed by Labouriau (1970). Data were collected daily from March 16 to March 28, 2013, in 6 replications of 18 plants per plot.

When plants were ready for transplanting, at 44 days after sowing, aboveground height (AP) was evaluated with the aid of a ruler, graduated in centimeters, and stem diameter (DC), measured with a digital caliper. For these variables, five seedlings per replication samples were used, eight replicates being used per treatment.

Determination of aboveground dry phytomass (FSPA) and root system dry phytomass (FSSR) were performed using the seedling samples, which were divided into shoot and root with the aid of scissors. The root system was washed in running water, with the help of a sieve, being careful not to disrupt the root and prevent the loss of the study material.

The material was separately placed in paper bags, and dried in a forced air circulation oven, at temperature of 65ºC, for 72 hours. The material phytomass was determined in grams using an analytical balance.

Later, the authors measured the parameters: height/diameter ratio (RAD), total dry phytomass (FST), aboveground/root dry phytomass ratio (RMS), seedling height/aboveground dry phytomass ratio (RAM) and Dickson quality index (Dickson *et al*., 1960).

Dickson quality index (IQD) is a balanced formula, in which the morphologic characteristics ratios are included, described below:

$$IQD = \frac{FST}{RAD + RMS}$$

Data were subjected to variance analysis and average to Scott-Knott test, 5% probability (Ferreira, 2010).

RESULTS AND DISCUSSION

Interaction between cultivars and substrates was not significant for mean emergence time, plant height, plant height and aboveground dry phytomass ratio, aboveground dry phytomass and aboveground dry phytomass and root phytomass ratio. For other variables the interaction was significant. Interaction between the cultivar used and the characteristics of the substrate was noticed, and this factor shows that influence on the type of the substrate and

Table 1. Emergence average time (TME), plant height (AP), plant height and dry phytomass of shoots ratio (RAM), dry phytomass of shoots (FSPA), dry phytomass of shoots and dry phytomass of roots ratio (RMS) of ornamental pepper {tempo médio de emergência (TME), altura de plantas (AP), relação altura da planta e fitomassa seca da parte aérea (RAM), fitomassa seca da parte aérea (FSPA), relação fitomassa seca da parte aérea e radicular (RMS) da pimenteira ornamental}. Cassilândia, UEMS, 2013.

Cultivars	TME (days)	AP (cm)	RAM	FSPA (g)	RMS
Etna	16.63 a	3.13 a	261.53 a	0.016 a	2.73 a
Pirâmide	15.17 b	2.19 b	195.78 b	0.017 a	1.77 b
Substrates					
90%V + 10%M	15.63 B	1.81 D	366.94 A	0.005 C	1.39 D
75%V + 25%M	15.62 B	2.04 D	301.49 B	0.008 C	1.27 D
60%V + 40%M	16.09 A	2.54 C	218.99 C	0.012 C	2.70 B
45%V + 55%M	15.81 B	2.88 B	186.39 C	0.017 B	2.59 B
30%V + 70%M	16.05 A	3.78 A	129.67 D	0.037 A	3.40 A
15%V + 85%M	16.2 A	2.93 B	168.46 D	0.020 B	2.13 C
CV (%)	2.06	22.51	34.18	53.11	32.27

*Uppercase letters, equal in columns for substrates, as well as lowercase for pepper cultivars, for each variable, do not differ by the Scott-Knott test, 5% probability (letras iguais maiúsculas nas colunas para os substratos, assim como letras minúsculas para as cultivares de pimenteira, para cada variável, não diferem entre si pelo Teste de Scott-Knott a 5% de probabilidade); M= cattle manure (esterco bovino); V= vermiculite (vermiculita).

Table 2. Emergence speed index (IVE) and porcentage of emergernce (PE) of ornamental pepper {índice de velocidade de emergência (IVE) e porcentagem de emergência (PE) da pimenteira ornamental}. Cassilândia, UEMS, 2013.

	IVE (plants/day)		PE (%)	
Substrates	**Etna**	**Pirâmide**	**Etna**	**Pirâmide**
90%V + 10%M	8.87 Ab	13.07 Aa	98.15 Aa	93.52 Aa
75%V + 25%M	9.38 Aa	10.22 Ba	99.07 Aa	75.93 Ab
60%V + 40%M	4.83 Bb	9.46 Ba	68.52 Ca	75.00 Aa
45%V + 55%M	7.17 Aa	8.99 Ba	84.26 Ba	71.30 Aa
30%V + 70%M	6.07 Bb	9.55 Ba	80.56 Ba	81.48 Aa
15%V + 85%M	3.12 Cb	8.70 Ba	50.00 Db	75.00 Aa
CV (%)	22.14		17.54	

*Uppercase letters, equal in columns and lowercase in line, for each variable, do not differ by the Scott-Knott test, 5% probability {letras iguais maiúsculas nas colunas e minúsculas nas linhas, para cada variável, não diferem entre si pelo Teste de Scott-Knott a 5% de probabilidade; M= cattle manure (esterco bovino); V= vermiculite (vermiculita).

the characteristics of the cultivar itself was verified, which together act favorably on higher growth of seedlings. In other vegetables, significant interactions between cultivars and substrates were observed by Costa *et al.* (2010) for the formation of hybrid cucumber seedlings, Medeiros *et al.* (2008) for the formation of lettuce cultivar seedlings, Oliveira *et al.* (2011) for the formation of genotypes of "alecrim-de-tabuleiro" seedlings.

The mean emergence time of the seedlings in the substrate 30%V + 70%M was statistically the same comparing to the substrates 60%V + 40%M and 15%V + 85%M. However, the substrate 30%V + 70%M showed seedlings with higher height, lower plant height/aboveground dry phytomass ratio, higher aboveground dry phytomass and higher aboveground dry phytomass and root system phytomass ratio in this substrate (Table 1).

Plant height and aboveground dry phytomass increased as the amount of cattle manure increased, and formed seedlings in the substrate containing 70% of manure more vigorous expressed by Dickson quality index (Table 3). In substrate with 85% of manure, an excess of nutrients could be found, with a low capacity of absorption by the seedling, associated with a lower amount of vermiculite and an increased density of the substrate with the highest percentage of manure, which showed a lower growth of seedlings in substrate with 70% of manure. Acosta *et al* (2011) worked on ornamental pepper seedling production (*Capsicum annuum*) in organic substrate, and highlighted that in vermicompost of cattle manure 75% + carbonized rice husk 25% substrate the seedlings presented approximately 2.0 cm higher when compared to air-dried and sieved soil, due to the increase in the characteristics of the substrate with the use of vermicompost, making its structure better and increasing its cation exchange capacity (CEC). Batista *et al.* (2005), working with mixtures of vermiculite/manure using several proportions for hydroponic lettuce seedling production, observed that seedling substrate with 50% of each material showed greater fresh matter than plants of other substrates. Silva *et al.* (2008) verified that substrate with a mixture of manure and earthworm humus in a 2:1 proportion provided lettuce seedlings with greater accumulation of phytomass showing the importance of organic matter in the substrate.

Cultivar Etna showed higher mean emergence time, plant height, plant height and aboveground dry phytomass ratio and aboveground dry phytomass and root dry phytomass ratio than the cultivar Pirâmide. For aboveground dry phytomass, the two cultivar seedlings did not differ (Table 1). These characteristics showed are specific for each cultivar and no direct relationship between them was noticed.

For the two cultivars the highest amount of vermiculite in the substrate provided higher emergence speed, as the study showed for speed index (Table 2). High water retention capacity, high porosity, low density (Minami, 1995) provide the vermiculite properties

Table 3. Base diameter (DC), height and diameter ratio (RAD), Dickson quality index (IQD), dry phytomass of root system (FSSR) and total dry phytomass of ornamental pepper {diâmetro do colo (DC), relação altura e diâmetro (RAD), índice de qualidade de Dickson (IQD), fitomassa seca do sistema radicular (FSSR) e fitomassa seca total (FST) da pimenteira ornamental}. Cassilândia, UEMS, 2013.

Substrates	DC (mm)		RAD	
	Etna	Pirâmide	Etna	Pirâmide
90%V + 10%M	0.85 Ba	0.97 Ca	2.47 Aa	1.57 Ab
75%V + 25%M	0.74 Bb	1.07 Ca	3.01 Aa	1.80 Ab
60%V + 40%M	0.76 Bb	1.00 Ca	4.01 Ba	2.06 Ab
45%V + 55%M	0.88 Bb	1.12Ca	4.22 Ba	1.89 Ab
30%V + 70%M	1.18 Ab	1.73Aa	3.84 Ba	1.80 Ab
15%V + 85%M	0.94 Bb	1.36 Ba	3.66 Ba	1.85 Ab
CV (%)	15.14		23.28	
	IQD		FSSR (g)	
	Etna	Pirâmide	Etna	Pirâmide
90%V + 10%M	0.00243 Aa	0.00307 Ca	0.0039 Ba	0.0039 Ca
75%V + 25%M	0.00235 Ab	0.00683 Ba	0.0044 Bb	0.0094 Ba
60%V + 40%M	0.00259 Aa	0.00395 Ca	0.0045 Ba	0.0055 Ca
45%V + 55%M	0.00366 Aa	0.00478 Ca	0.0066 Aa	0.0063 Ca
30%V + 70%M	0.00532 Ab	0.01285 Aa	0.0081 Ab	0.0158 Aa
15%V + 85%M	0.00433 Ab	0.01055 Aa	0.0071 Ab	0.0141 Aa
CV (%)	45.11		43.04	
	FST (g)			
	Etna	Pirâmide		
90%V + 10%M	0.0096 Ca	0.0086 Ca		
75%V + 25%M	0.0106 Ca	0.0183 Ca		
60%V + 40%M	0.0187 Ca	0.0153 Ca		
45%V + 55%M	0.0256 Ba	0.0204 Ca		
30%V + 70%M	0.0398 Ab	0.0581 Aa		
15%V + 85%M	0.0268 Ba	0.0343 Ba		
CV (%)	48.39			

*Uppercase letters equal in columns and lowercase in line, for each variable, do not differ by the Scott-Knott test at 5% probability (letras iguais maiúsculas nas colunas e minúsculas nas linhas, para cada variável, não diferem entre si pelo Teste de Scott-Knott a 5% de probabilidade); E= cattle manure (esterco bovino); V= vermiculite (vermiculita).

that helped the emergence of pepper on substrates containing a higher percentage of this material.

For cultivar Etna, the seedlings emerged in substrates with 75 and 90% of vermiculite showed higher emergence percentage, with 99.07% and 98.15%, respectively. For cultivar Pirâmide, the substrates did not differ for this variable. In substrate with 75% of V and 25% of M, the percentage of emerged seedlings of cultivar Etna was higher than cultivar Pirâmide (Table 2). As previously explained, the properties of vermiculite provide the emergence of pepper in substrates with higher amounts of this mineral.

For the two cultivars evaluated substrate 30%V + 70%M showed higher stem diameter and higher total dry phytomass than other substrates (Table 3). In fertilized substrate, Costa *et al.* (2011) observed better eggplant seedlings from substrate containing 50% of vermiculite and 50% of crushed cassava branches. For sweet pepper and lettuce seedlings, Oliveira *et al.* (2008) obtained higher dry phytomass using pure vermiculite or 50% mixed to commercial substrate.

For height and diameter ratio, the lowest values for cultivar Etna were found in substrates with 90 and 75% of vermiculite and for cultivar Pirâmide the substrates did not differ statistically. Cultivar Pirâmide obtained the lowest averages for height and diameter ratio comparing with cultivar Etna, in all substrates (Table 3), as it is specific of this cultivar to be compact plants (ISLA®).

For Dickson quality index variable, the best values were observed on substrates 30%V + 70%M for cultivar Pirâmide as observed for diameter and total phytomass, since these substrates did not differ for this index in cultivar Etna. Cultivar Pirâmide showed better Dickson quality index than cultivar Etna in substrate which provided better seedling development, that means, in substrate 30%V + 70%M (Table 3).

For root system dry phytomass, in substrates 45%V + 55%M, 30%V + 70%M and 15%V + 85%M higher values for cultivar Etna were verified and for cultivar Pirâmide higher values were verified in substrates 30%V + 70%M and 15%V + 85%M. The authors observed that higher amount of manure provided better root growth of seedlings, as well as height and aboveground phytomass, due to a higher availability of nutrients.

Backes *et al.* (2007), evaluating ornamental pepper production related to substrate and fertilizer doses with slow-release and traditional fertilizers verified that the commercial substrate Tropstrato® + compost provided higher stem diameter when compared only with commercial substrate, when the slow-release fertilizer was used.

Silva *et al.* (2011), studying the emergence and initial growth of ornamental pepper seedlings in substrate based on tannery sludge compost and vermiculite, observed that for plant height and aboveground and root dry phytomass, the higher values were obtained when the substrate used was based on tannery sludge and 10% of vermiculite.

One substrate which provides emergence is not necessarily the best for the seedling, a direct relationship between these two phases of the plant related to the type of substrate used was not observed. Cultivar Pirâmide showed more vigorous seedlings than cultivar Etna, being more adapted for the region of Cassilândia. The proper range of aboveground and root system dry phytomass ratio varies from 2.5 to 3.5 g.

According to this study, the most recommended substrate is the compost of 30% vermiculite and 70% cattle manure for ornamental pepper, and the cultivar seedlings that best developed in this substrate are of the cv. Pirâmide.

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