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Performance of agricultural substrates in the production of lettuce seedlings (*Lactuca sativa* L.)

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Abstract: The production of seedlings for transplanting is one of the most important stage to successful for lettuce cultivation. Among the techniques practiced to obtain seedlings of vegetables, stands out using agricultural substrates associated with the cultivation trays. The experimental setup design was carried out in completely randomized with 5 treatments and 6 repetitions. The experiment was carried out in a greenhouse, where were evaluated five commercial substrates (TropstratoHT®, Vivatto Slim Plus®, Tecnomax®, Holambra HS® and Bianchi Power) for the development of lettuce seedlings cv. Lucy Brown. Analyzes were performed to quantify the physical and chemical characteristics of the substrate. It was evaluated Fresh mass of shoots and roots, total fresh mass, dry mass of shoots and roots, total dry mass, stalk diameter, leaf area and leaf number. The results showed that among evaluated substrates, Bianchi Power® showed be more efficient to seedling lettuce production by influence on the growth and development.

Keywords: Banana Stalk, Organic Matter

Introduction

Lettuce (*Lactuca sativa* L.) is the most popular of leafy vegetables and your growth is distributed in almost every region of the globe (Gomes, 2001; Resende et al., 2003). Lettuce is considered a very important leafy vegetable in the diet of Brazilians and with significant economic importance by producers.

The cultivation of this species is concentrated largely in green belts, near the capitals and in typically warm regions, being planted through both family farming and large vegetable producers (Caetano, 2013).

The success to good quality for this culture is linked to seedling quality. Prior to the development of the crop in the field, the production of lettuce seedlings is an important step because influences the growth and development aspects during the production process.

In the chain production of quality vegetables, seedling formation is one of the most important phases for the crop cycle, directly influencing the final performance of the plant, both from the nutritional and productive point of view. Agricultural production is highly dependent on the addition of agricultural inputs and, in this context, substrates have stood out due to their wide use in the production of vegetable seedlings (Silveira et al.,

2002). The quality of a substrate for tray supply is dependent on its physical structure and chemical composition and on its quality depends on the plants produced (Miranda et al., 1998). The main function is providing support to the plant growth (Röber, 2000). Silva Jr. & Visconti (1991) described that a good substrate should have good nutrient and moisture retention capacity, good aeration, low root penetration resistance and good loss of structure resistance, since it is used at a developmental stage, where the plants are susceptible to attack by microorganisms and less tolerant to water deficit.

Despite the advantages of this seedling production system, some difficulties have been observed in relation to the substrate characteristics, such as moisture maintenance, aeration and nutrient availability, that directly affect the germination percentage and seedling development determining the quality of the plants produced (Silva et al. (2008). Brazil is a country with a strong agricultural and livestock tendency. However, Brazil suffers with them the large amounts of agricultural and industrial waste produced such as coconut husk, chicken manure, sugarcane bagasse, rice husk, sawdust, cattle manure, among others what makes the necessity of the transformation of these products. All the products show potencial to be used

in the agriculture and depends on the species to be cultivated. The use of organically based waste has shown economic, social and economic viability. From this information, nutrient recycling is an important technique available and with low cost when compared with inorganic supply to the agriculture. Pollutant waste material can be used with great purpose in activities related to agriculture and livestock.

Actually, the elaboration of substrates is currently based on the use of organic based sources and also the combination of inorganic sources. Organic sources include carbonized rice husk, earthworm humus, peat, poultry manure, cattle manure, among others, as well as inorganic sources such as rock dust, vermiculite and even the addition of mineral fertilizers. One of the concerns regarding these organic and mineral combinations is related to the physical and chemical characteristics and not compromise the balance between plant growth and development.

Based on the great importance of substrates for horticultural crop production and the possibility of disposal of agricultural residues, this study aimed to evaluate the agronomic performance of lettuce seedlings in relation to different types of commercial and local substrates in Sinop - MT

Methods

The experiment was carried out in a greenhouse located at Sitio das Videiras, Cirene Road, Lot 21, in Sinop - MT (11° 42'12"S and 55° 27' 36" O and altitude of 380 m).

Climatic characterization according to Köppen classification, is Aw (tropical climate), characterized by the presence of two well-defined seasons: a rainy season (from October to April) and a dry season (from May to September), with average annual temperature and precipitation of 24.7 ° C and 1974 mm year⁻¹, respectively (SOUZA et al. 2013).

The experimental design used was CRD with 5 treatments and 6 repetitions. The treatments consisted of using 5 substrates described as follows: a) TropstratoHT®; b) VivattoSlim Plus®; c) Tecnomax®; d) Holambra HS®; e) Bianchi Power®. The latter being a substrate produced by a local producer. The description of the substrate raw materials are mentioned in Table 1.

The substrates were analyzed to quantify their physico-chemical characteristics, such as: electrical conductivity (EC), humidity, pH and density, besides of macronutrients and micronutrients contents.

The commercial substrates characteristics were obtained by manufacturer's packaging, except for their macronutrient and micronutrient contents, which were determined by commercial laboratory analysis in the region. The method adopted was the same described by Embrapa (2011). In relation to local substrate, the moisture, pH, density, macronutrients and micronutrients characteristics were determined by the same laboratory in the region but the electrical conductivity and density determinations were performed in the laboratory of the Universidade Federal of Mato Grosso Campus Sinop. Electrical conductivity was carried out following Raj et al. (2001) by substrate saturation and the self-compaction method suggested for substrate density determination by Normative Instruction No. 31 (MAPA, 2008).

The results obtained by physicochemical substrate analysis are listed in Tables 2 and 3.

Lettuce pellets seeds cv. Lucy Brown were commercially purchased and sown on September 5, 2014 in expanded polystyrene trays consisting of 63 cells totaling 63 plants with the appropriate substrates studied as described in Table 1. For each repeat the tray center lines were used totaling 10 useful plants discarding borders.

Table 1. Raw materials present in the manufacture of different substrates used, pine bark (CP); vegetable peat (TV); vermiculite (VER); charcoal (CV); phenolic foam (EF); poultry manure (CA); charred rice husk (CAC); banana stalk (EB); paper fiber (FP) and coconut fiber (FC).

Substrate:	CP	TV	VER	CV	EF	CA	CAC	EB	FP	FC
TropstratoHT® ^a *	X	X	X							
Vivatto S. P.®*	X		X	X	X					
Tecnomax®*	X		X	X		X			X	X
Holambra HS® ^b *	X	X	X							X
Bianchi Power® ^c				X		X	X	X		

a. The TropstratoHT® Substrate also has in its formulation an unknown dosage of single superphosphate and potassium nitrate.

b. Holambra HS® substrate also has in its formulation corrective acidity and addition of various fertilizers, without dosage specification and elements.

c. The Bianchi Power® Substrate has in its composition 50% poultry manure, 30% banana stalk, 10% charcoal, 10% carbonized rice husk plus 5 kg m⁻³ of gypsum and addition of 5 kg m⁻³ of Basacote® Mini 3M fertilizer (N: 13%; P: 6%; K: 16%; Mg: 1.4%; S: 10%; Fe: 0.15%; B: 0.02%; Zn: 0.02%; Cu: 0.05%; Mn: 0.06%; Mo: 0.015%).

* Information mentioned by the manufacturer's packaging.

Table 2. Physical and chemical characteristics of evaluated substrates.

Substrate:	Moisture (%)	pH (water)	Density (kg m ⁻³)	E.C(mScm ⁻¹)
TropstratoHT®*	60	5,8	200	2,0
VivattoSlim Plus®*	48	5,6	260	1,2
Tecnomax®*	50	6,5	500	0,7
Holambra HS®*	55	5,7	500	1,0
Bianchi Power®	37	6,2	578	7,7

*Information according to the product labeling described on the packaging.

Table 3. Macro e Micronutrients content in different substrates evaluated.

Substrate:	N	P	K	Ca	Mg	S	Zn	Cu	Fe	Mn	B
	gkg ⁻¹						mgkg ⁻¹				
TropstratoHT®	5,2	2,3	6,7	11,5	23,4	3,8	256,0	45,7	3821,7	551,5	1,4
VivattoSlim Plus®	68,9	2,1	4,1	12,7	13,2	3,2	50,9	24,9	3728,1	173,0	2,8
Tecnomax®	5,3	2,3	4,3	16,8	6,6	5,9	162,7	124,5	4419,7	799,7	2,9
Holambra HS®	4,6	1,4	3,7	7,4	3,3	1,3	67,0	20,8	3443,5	223,8	2,4
Bianchi Power®	22,0	5,5	11,1	28,5	11,3	8,9	553,0	125,4	4191,9	680,0	29,0

After sowing, the trays were transferred to a greenhouse covered with transparent plastic of 120µm anti-UV-A and UV-B with a daily 5mm day-1 sprinkler system remaining for 24 days. After this period, the plants were harvest and conducted for growth and development evaluations as: a) Stem diameter: measured with a digital caliper. The results were expressed in mm plant⁻¹; b) Number of leaves per plant. the result were expressed by units plant⁻¹; c) Fresh shoot and fresh root: The seedlings were cut and separated into two parts, respectively: shoot and roots. After separation the aerial parts and roots were weighed separately with the help of a semi-analytical balance. The results were expressed in g plant⁻¹. d) Leaf area was measured with a leaf

area integrator (Li-Cor 3100), and the results expressed in cm² plant⁻¹; e) Shoot and Root dry mass: After weighing of fresh mass of shoot and root, the material were dried in a forced air oven at approximately 70 °C until constant weight. Results were expressed in g plant⁻¹.

To evaluate the effect of different substrate types on all evaluated variables, the data were subjected to analysis of variance by F-test and the means compared by Tukey test with (p < 0.05).

Results and discussion

The results of variance analysis and the means for all variables analyzed by the different substrates are presented in Table 4.

Table 4. Variance analysis and means to leaf area (AF), stalk diameter (DC), Shoot aerial fresh mass (MFPA), Root fresh mass (MFRA), Total fresh mass (MFT), Shoot dry mass(MSPA), Root dry mass (MSRA), Dry total mass (MST) and leaf number (NF) by different evaluated substrates.

Substrates:	Variable								
	AF (cm ²)	DC (mm)	MFPA (g)	MFRA (g)	MFT (g)	MSPA (g)	MSRA (g)	MST (g)	NF
Bianchi Power	794,00 A	1,91 A	30,53 A	4,61 A	35,14 A	1,45 A	0,39 BC	1,83 A	4,9 A
Vivatto SP®	430,00 B	2,05 A	10,93 BC	5,69 A	16,20 B	0,69 B	0,56 AB	1,25 B	4,3 B
Tecnomax®	308,33 BC	1,92 A	8,22 CD	4,87 A	13,09 C	0,57 B	0,48 ABC	1,06 B	4,0 BC
TropstratoHT®	290,00 C	1,85 A	12,64 B	4,74 A	12,64 C	0,53 B	0,61 A	1,14 B	3,9 BC
HolambraHS®	191,67 C	1,45 B	5,10 D	2,91 B	8,01 D	0,35 C	0,35 C	0,66 C	3,7 C
C.V (%)	12,69	5,89	9,32	9,49	5,57	9,39	14,24	8,27	4,44
F-Test.	63,2*	13,2*	188*	16,5*	368*	120*	9,90*	55,4*	19,4*

* Significative with p<(0,05).

In relation to leaf area (AF), Bianchi power was superior to all other substrates evaluated with an average of 794 cm² plant⁻¹ followed by Vivatto S.P., Tecnomax, Tropstrato HT and Holambra substrates with averages of 430; 308.33; 290.00 and 191.67 cm² plant⁻¹ and increments of 84.65; 257.51; 273.79 and 414.25% respectively.

Leaf area determination according to Bakker (1994), Caron et al. (2004) and Oliveira et al. (2008) is important because it reveals the photosynthetic capacity of the plant by intercepting luminosity and contribute to photoassimilates metabolism. This situation represent effects on growth and development parameters. If the leaf surface is known and the change in plant weight over a period of time, it becomes possible to evaluate the efficiency of the photosynthetic apparatus and its contribution to plant growth as a whole. Despite not having applied the effect of correlation between these factors, it can be observed according to table 4 that the Bianchi Power® substrate was superior to the others, showing that the increase in leaf area is directly related to the increase of MFPA. These result corroborates the nutrient content presented in table 3 and among them the very high N content which could have corroborated a larger increase in leaf area compared to other substrates.

As the leaf area parameter of the crop, especially in leafy crops, is fundamental for the production of photoassimilates and later distribution and accumulation of phytomass (CARON et al. 2004), it can be stated that the substrates that reached the largest leaf area were which obtained higher accumulation of dry shoots (MSPA), as shown in Table 4.

Another important variables in leafy crop is stem diameter (DC) and fresh root mass (MFRA). In this study was possible note that in stem diameter (DC) and root fresh mass (MFRA) parameters, Bianchi Power, VivattoSlim Plus®, Tecnomax® and TropstratoHT® substrates did not differ significantly from each other, but they were greater than commercial Holambra HS® substrate. In DC, VivattoSlim Plus® substrate stood out with an average of 2.05 mm plant⁻¹ followed by Tecnomax®, Bianchi Power, TropstratoHT® and Holambra HS® materials with values of 1.92; 1.91; 1.85 and 1.45 mm plant⁻¹, respectively. In leafy crops, especially in lettuce, DC is a important sink because its possible to storage photoassimilates principally carbohydrates that lately will be used to change to vegetative to reproductive phase. According to table 3 it's possible perceive that one of the macronutrients that influenced directly was potassium content. Holambra HS substrate presented the lesser content than another ones. Potassium is a important element and contribute directly to enhance photoassimilates and distribution in plants. Probably, the lesser content of potassium could explain this behaviour in relation to another ones. The MFRA results obtained were closely to those obtained for DC with VivattoSlimPlus® substrate showing 5.69 g plant⁻¹

followed by Tecnomax®, TropstratoHT® and Bianchi Power with values of 4.87; 4.74 and 4.61 gplanta⁻¹, respectively. The Holambra HS® substrate was the only one that differed statistically from the others, presenting the lowest performance with 2.91 g plant⁻¹. The lowest MFRA to Holambra HS® when compared to the others can be explained by the lowest nutrient index (Table 3) when compared to the others and this may have directly influenced their performance in the DC and MFRA requirements.

Another parameter, (MFPA) Bianchi Power® substrate was superior to all other substrates evaluated with an average of 30.53g plant⁻¹ followed by Vivatto S.P., Tropstrato HT, Tecnomax and Holambra HS treatments with values of 10.93; 12.63; 8.22 and 5.10 g plant⁻¹ respectively. The technical efficiency percentage of Bianchi Power substrate in relation to VIVATTO S.P., TROPSTRATO HT, TECNOMAX and HOLAMBRA HS was 279.32; 241.72; 371.41 and 598.62% respectively. One of the factors that contributed to this better performance is that the nutrient contents in this substrate were higher than the previous ones, which favored a better development of aerial structures (Table 3). Following the same behaviour of MFPA, the Bianchi power substrate was statistically superior to the others in the total fresh mass (MFT) variable with an average value of 35.14 g.planta⁻¹ followed by VivattoSlim Plus® material with an average of 16.20 g. plant⁻¹. Tecnomax® and TropstratoHT® had no significant differences with averages of 13.09 and 12.64 g plant⁻¹ respectively, but were superior to Holambra HS®, which obtained an average of 8.01 g plant⁻¹.

In relation to shoot dry mass (MSPA) the values obtained were between 0.35 g plant⁻¹ and 1.45 gplanta⁻¹. The Bianchi Power substrate was higher than others evaluated with means of 1.45 g plant⁻¹, followed by commercial products VivattoSlim Plus® (0.69 gplanta-comerciais), Tecnomax® (0.57 g plant⁻¹) and TropstratoHT®. (0.53 g plant⁻¹) that did not differ statistically between them. The worst performance among the evaluated substrates was Holambra HS® with 0.35 g plant⁻¹.

The superiority of a substrate is in the composition, that must harmonize the chemical, physical and biological characteristics so that there is a dynamic equilibrium which provides better development for seedlings. In the Bianchi power substrate, the chemical, physical and biological components provide a better harmonization which favored its better performance for this variable. In studies with different substrates with tomato, Campanharo et al. (2006) observed that substrates with organic wastes lead to increases of MSPA when compared with commercial substrates.

Total dry mass (MST), another parameter evaluated followed the same results as presented by MSPA. Bianchi Power substrate had the best performance among the others with 1.83 g plant⁻¹. Vivatto Slim Plus®, Tropstrato HT® and Tecnomax® materials did not present significant differences

among themselves, but were statistically superior to Holambra HS®, with an average of 0.66 g plant⁻¹.

For root dry mass (MSRA), the commercial substrate TropstratoHT® presented higher values than others ones but did not differ statistically from VivattoSlim Plus®, Tecnomax® and Bianchi Power. The MSRA values had a variation of 0.61 g plant⁻¹ and 0.35 g plant⁻¹, where Holambra HS® material again had the lowest result when compared to the others, and this parameter was the only one that the substrate Bianchi Power was poor, and the substrate TropropatoHT® that excelled in this parameter did not maintain a pattern in relation to the others, varying greatly between the parameters..

In relation to leaf number (NF), the values were between 4.9 and 3.7 units plant⁻¹. In this parameter the Bianchi Power substrate obtained the best result with 4.9 units plant⁻¹ followed by VivattoSlim Plus®, Tecnomax® and TropstratoHT® with 4.3; 4.0 and 3.9 units plant⁻¹, respectively. Holambra HS® substrate presented the lowest performance with 3.7 units plant⁻¹, however, not statistically different from Tecnomax® and TropstratoHT® materials. The best performance of bianchi power can be attributed to chemical and physical properties according to table 2 and 3.

Overall, local substrate "Bianchi power" showed best performance in almost totality for growth and development of lettuce seedling.

Araújo Neto (2002), Medeiros et al. (2001) and Neto et al. (2009), showed in yours studies that alternative organic substrates pointed out best performance to production of yellow passion fruit, lettuce and sweet pepper seedlings, respectively when compared with commercial substrates. Other interesting characteristics of organic substrates is related to economical, nutrients and besides of improving good development and provide a good structure for root system .

According to Lopes et al. (2007) commercial substrates provided producers with a number of advantages, such as: work rationalization , inputs and fertilizers, ensuring the formation of seedlings with better architecture, on the other hand The large variability of these substrates and the market prices associated with the lack of chemical and physical uniformity between the manufacturing batches can compromise the production planning, since the transplantation of the seedlings can be done with delays that lead to additional costs to the producer and in greater burden for the consumer.

From the evaluated parameters, it was noted that the only ones in which the alternative organic substrate did not presented good performance was related to root development (MFRA and MSRA). The explanation for this low development to the others can be explained by particule size or until fertilizer added to it. Particule size can contribute to reduce macropores and increase micropores leading to reduce oxygen around the roots and membrane permeability. Other purpose to explain could be the excess of mineral fertilizer. Excess of mineral

fertilizer could reduce Ca to the root and contributing to lower growth. In general, no deficiency symptoms was observed including shoot analysis.

Another factor that may also have corroborated the optimal development of plants in the local alternative substrate is the absence of pine bark. and also coconut fiber. This raw materials are rich in tannins (phenols) that can interfere with seedling development. The greater development of lettuce seedlings produced with Bianchi Power® substrate is probably due to the greater presence of nutrients in its composition, as observed in Table 3. The amount of nutrients superior to the other substrates is associated with the use in its composition. Basacote® Mini3M, controlled release fertilizer, suitable for seedling production and rich in macronutrients and micronutrients and also the addition of banana stalk (data not shown).

In contrast, Table 4 shows that lettuce seedlings produced with Holambra HS® substrate had the lowest development. The respective commercial substrate presented the lowest averages compared to the others. This is probably due to the low concentration of nutrients in its composition as described in Table 3.

Another interesting feature of the alternative organic substrate was the electrical conductivity. Ribeiro et al. (1999) indicate that the ideal electrical conductivity for lettuce production is 1.3 mScm⁻¹. Viana et al. (2001) mention that each unit increase in electrical conductivity (EC) above this value decreases by 13%.

In the Table 2, EC of Bianchi Power substrate is higher than others ones and the value is above the recommended by the literature, however, in fact, did not influence plant development until the moment of analysis. Possibly being a substrate of strictly organic origin it is believed that there was a buffering which allowed a better development of the seedlings. This buffering can be mediate by CAC e EB. More studies must be carried out to verify this information..

Similar results were also obtained by Liz (2006) who used alternative substrates based on green coconut for the production of vegetable seedlings. This same author found that the electrical conductivity was 5.0 mScm⁻¹, which is higher than commercial substrates that generally have an average of 2.4 mScm⁻¹. The author observed that the discrepancy in the values obtained for electrical conductivity may be linked to different determination methodologies or, due to a lower dilution of the saturation extract at the moment of obtaining the values, not impacting the final development of the seedling.

pH values (in water) observed of all substrates evaluated in the Table 2, showed varition between 5.6 and 6.5. These values according to Kämpf (2000) are improper and it is recommended to use substrates with pH between 5.2 and 5.5. However, Trani et al. (2007) stated that it is not

possible to justify discrepancies in seedling development with this factor alone.

Conclusion

The Bianchi Power® substrate presented the best performance of growth and development to commercial samples and can be used as an alternative to lettuce seedling production.

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