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Agronomic Analysis of Pepper Seedling Submitted to Different Organic Substrates and Trays

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Authors' contributions

This work was carried out in collaboration between all authors. Authors ABSJ and JS participated in the idea and management of the experiment, besides writing the article. Authors IDEC and JST were responsible for collecting, tabulating and analyzing data. Authors MTS and DFS participated in the management of the experiment from the implementation to data collection. Author KDSC participated in the management and data collection of the experiment, as well as in the bibliographic review. All authors read and approved the final manuscript.

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ABSTRACT

Demand for organic products has been increasing due to great acceptance by consumers. However, there are obstacles that make it difficult for the population to access this food. Among them are the inadequate system of cultivation, mainly in relation to the type of substrate and tray.

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But the most appropriate management will lead to the attainment of better quality organic products. Thus, the objective of this work was to perform an agronomic analysis of pepper seedlings submitted to different organic substrates and trays. The experiment was conducted in a completely randomized design, in a 5 x 2 factorial scheme, where the five substrates evaluated were S_1: Bioplant® commercial substrate (control treatment), S_2: earthworm humus, S_3: soil, S_4: 50% soil + 50% earthworm humus and S_5: 75% soil + 25% earthworm humus; and the two types of trays were B_1: tray with 98 cells and B_2: tray with 200 cells. The results show that for the pepper emergence have not presented significant difference among the different substrates used in the experiments. The average mean value was 81.29%. The vegetative growth characteristics of the pepper seedlings studied provide good physical structure of fixation, good porosity, and excellent sources of nutrients. When trays was compared B_1 with B_2, the following variables diameter of the lap; plant height; root length; dry mass of aerial part; fresh root mass, with tray of 98 cells, the results showed the best results. In addition with trays 200 cells showed lesser pepper seedling production. Substrates based on humus presented good physical and nutritional characteristics, besides being cheaper.

Keywords: Capsicum annuum; yolo wonder; sustainability; cell volume; substrate fertilization.

1. INTRODUCTION

Global demand for food from the organic production system has increased by about 50 percent a year, even with a higher final cost compared to the conventional system [1]. Thus, it is clear that the organic production system is an interesting economical alternative, in view of value aggregation, not to mention the issue of ecological sustainability and social benefits [2,3].

The first step in obtaining quality organic products is the production of quality organic seedlings, in which their performance is strongly influenced by the cultivation substrate and the type of tray used.

In the substrate design, various organic and inorganic materials have been used to determine the most appropriate for each species, in order to meet both their demands for nutrient supply and physical properties such as water retention, aeration, ease of root penetration, without favoring the emergence of diseases, and the requirements to be an abundant material of low economic value in the region [4].

Another issue to mention about the seedling quality is the effect of the substrate volume in the tray, since it is the most widely used vegetable seedling production system. This system affects growth, photosynthesis, nutrient and water absorption, respiration and plant flowering, in which the adequate space available for root development, coupled with the nutritional quality of the substrate, can allow the seedling to express all its quality. In addition, it can culminate in an interesting economic return without damaging seedling quality [5].

Despite the importance of the best combination between the substrate and the tray type, there are few works that address these two aspects to cultivate Yolo Wonder pepper, so this knowledge can result in higher quality seedlings and more efficient resource management.

In view of the above, the objective of the present work was to analyze the responses of pepper (*Capsicum annuum*) seedlings submitted to different organic substrates and trays.

2. MATERIALS AND METHODS

2.1 Site Location

The present work was conducted in a shaded area at the Agricultural Sciences Center of the Federal University of Alagoas (CECA/UFAL), located in the municipality of Rio Largo-AL (09º28'02"S; 35º49'43"W; 127 m), in August, 2016.

2.2 Experimental Design and Treatments

The treatments consisted of the combination of five substrates with two types of trays. The five substrates evaluated were S_1: Bioplant® commercial substrate (control treatment), S_2: earthworm humus, S_3: soil, S_4: 50% soil + 50% earthworm humus and S_5: 75% soil + 25% earthworm humus (chemical compositions indicated in Table 1). The two types of trays were B_1: tray with 98 cells, and B_2: tray with 200 cells, because their use is more frequent in the management of this crop.

Table 1. Chemical composition of the five substrates. Rio Largo-AL, 2016

Parameters	Substrates*				
	S_1	S_2	S_3	S_4	S_5
pH (CaCl)	5.00	7.40	5.10	6.30	5.70
H+Al (cmol.dm^{-3})	3.70	1.70	4.00	2.90	3.40
Al (cmol.dm^{-3})	0.01	0.01	0.04	0.02	0.03
M.O. (g.dm^{-3})	21.80	30.10	16.70	23.40	20.10
Ca (mmol.dm^{-3})	22.00	56.00	26.00	41.00	33.50
Mg (mmol.dm^{-3})	12.00	46.00	18.00	32.00	25.00
K (mmol.dm^{-3})	16.30	6.50	2.10	4.30	3.20
P (mmol.dm^{-3})	5.90	8,00	0.30	4.20	2.20
SB (mmol.dm^{-3})	50.00	108.50	48.00	78.30	63.10
CTC (mmol.dm^{-3})	87.00	125.50	88.00	106.80	97.40
V (%)	58.00	86.50	54.40	70.40	62.40
Mn (mg.dm^{-3})	4.70	140.20	11.40	75.80	43.60
Fe (mg.dm^{-3})	113.10	76.10	236.00	156.10	196.00
Cu (mg.dm^{-3})	21.20	1.00	0.40	0.70	0.50
Zn (mg.dm^{-3})	28.20	71.00	1.80	36.40	19.10

** S1: Bioplant® commercial substrate (control treatment); S2: earthworm humus; S3: Solo; S4: 50% soil + 50% earthworm humus and S5: 75% soil + 25% earthworm humus.*

The research was implemented in a completely randomized design, in a 5 x 2 factorial scheme (five substrates and two types of trays), with four replications. Sowing was done in trays, being the plot considered as a tray, in which sample consisted of 60 central seedlings of the tray, regardless of the type of tray used. Before sowing, tray cells were filled with substrates corresponding to the treatments, then a space of 1 cm depth was made to deposit the pepper seed of the Yolo Wonder variety.

2.3 Evaluated Parameters

Irrigations were carried out once a day until 20 days after sowing (DAS). After that, the procedure was carried out twice a day until 33 DAS. This period deemed suitable for transplanting the seedlings with a consequent procedure for the evaluation of the following characteristics: emergence (E) in %; emergence velocity index (IVE), dimensionless; number of leaves (NF), in units; base diameter (DC), in mm; plant height (AP), in cm; root length (CR), in cm; fresh mass of aerial part (MFPA), in g; dry mass of aerial part (MSPA), in g; fresh root mass (MFSR) in g; and dry mass of roots (MSSR) in g.

The variable E was calculated by the formula E = $\frac{N}{A} x\, 100$, where N is the total number of emerged seeds and A is the total number of seeds sown. The IVE was measured by the formula IVE = $\frac{E1}{N1} + \frac{E2}{N2} + \cdots + \frac{En}{Nn}$, where E1, E2,..., and En are the number of seedlings emerged in the first, second to last count, and N1, N2,..., and Nn are the number of days of sowing the first, second to last count.

The NL was counted per unit of true leaves (non-cotyledonal leaves), whereas the BD was measured with the aid of a digital pachymeter, at the height of the base of the seedlings. For PH, a millimeter ruler was used, where it was measured from the surface of the substrate up to the insertion of the last leaf. Then, the largest root was used to measure CR. For MFPA and MFR, seedlings were cut and then the two variables were weighed on an analytical scale. Then, the two parts of the seedlings were placed in paper bags and subject to a forced ventilation oven at 65ºC for 72 hours and then weighed to evaluate MSPA and MSR.

2.4 Statistical Analysis

Analyzes of variance were performed, and in case the F test was significant, the Tukey test was applied at 5% probability using the Assistat 7.7 computational software [6].

3. RESULTS AND DISCUSSION

According to the F test at 1% probability, there was a significant difference for the substrates, at

1% probability for the number of leaves (NF), base diameter (DC), plant height (AP), mass fresh of the aerial part (MFPA) and dry mass of the aerial part (MSPA). For root length (CR) and dry mass of roots (MFR) there was a significant difference at 5% of probability and the others did not present difference by the same significance. For trays, there was a significant difference at 1% probability for NF, DC, AP, CR, MFPA, MSPA and MFR. For emergence (E) and MSR there was a significant difference at 5% probability and for E and MSR there was no significant difference by the same significance. For S x T interaction there was a significant difference at 1% probability only for NF, MFPA and MSR. For the emergency velocity index (IVE) there was a significant difference at 5% probability, indicating that there was influence of the trays in the substrates. For the other variables, there was no significant difference at 5% probability for the F test.

The production of plant seedlings is influenced by several factors, from the seed to the inputs for production as containers that will keep the seedlings, the nature of the substrate, as well as other factors of the environment. The influence of these various factors changes according to the species of seedling that are produced, depending on the type of seed, seedling requirements, among other factors [7,8].

According to Table 3, the Tukey's test at 5% probability can make some considerations.

For E, substrates did not present significant difference among the substrates, with an average of 81.29%. In order for seed germination to occur, it is necessary that the seed present a viable embryo and have minimum reserve and humidity so that the cellular processes can occur. In this way, the substrate does not influence the emergence, since among the main functions of the substrate there is the fixation of the seedling, maintenance of available water and the supply of nutrient. Consequently, emergence is a characteristic which is more influenced by the physiological condition of the seed when its water requirements are met [9].

The highest humus mean (1.93 mm) was presented by DC, and did not differ statistically from substrates 50% soil + 50% humus and 75% soil + 25% humus with respective averages of 1.90 and 1.84 mm. For PH, the substrate 50% soil + 50% humus (8.48 cm) presented higher average, and did not differ statistically from humus, Bioplant, and 75% soil + 25% humus, with respective mean of 8.32; 7.10 and 7.90 cm. CR had the substrate 50% soil + 50% humus (8.58 cm) with higher average, but did not differ statistically from Bioplant, 75% soil + 25% and humus, with respective averages of 8.25; 7.88 and 7.55 cm. The MSPA was higher for humus (0.0713 g) and did not differ statistically from the substrate 50% soil + 50% humus and 75% soil + 25% humus, with respective averages of 0.0643 and 0.0510g. For the dry mass of roots, the substrate 50% soil + 50% humus (0.1510 g) presented higher mass and did not differ statistically from humus, Bioplant, and 75% soil + 25% humus.

For plant growth characteristics such as DC, AP, CR, MSPA and MFR, the substrates humus, 50% soil + 50% humus and 75% soil + 25% humus showed the best results, because they provide a good physical structure of fixation presenting good proportion of porosity, besides being excellent sources of nutrients [10].

In the comparison between the trays, for the variables DC, AP, CR, MSPA and MFR the tray with 98 cells presented the best results, with respective averages of 1.89 mm, 8.21 cm, 8.57 cm, 0.0575 g and 0.1596 g. Trays with larger cells provide greater storage capacity of water, nutrients, besides providing more space for the roots of the seedlings to develop. Besides these advantages, the larger cells provide the seedlings with greater safety, because it is possible to keep them in the trays for longer periods if necessary [11].

The IVE showed variation regarding the use of substrates in different trays, In the trays with 98 cells there was no significant difference. In the tray with 200 cells the 50% soil + 50% humus presented higher index and did not differ statistically from Bioplant and 50% soil + 50% humus and 75% soil + 25% humus, all of them differing only from humus (Table 4). The speed of emergence depends on the vigor of the seed and the characteristics of the substrate surrounding the seed. In this way the physical structure of the substrate can form a barrier hampering emergence like the substrate humus, because its composition is rich in cementing minerals, which after moistening are added and with the decrease of moisture, forms a thin crust. Then the best alternative is to be mixed with the soil to increase the porosity of the substrate [12].

Table 2. Analysis of variance of the characteristics of pepper seedlings submitted to different substrates and tray types

Sources of variation	QM									
	E	**IVE**	**NF**	**DC**	**AP**	**CR**	**MFPA**	**MSPA**	**MFR**	**MSR**
Substrates (S)	2.2925 ns	34.3599 ns	0.1459 **	0.2551 **	7.5238 **	3.7537 *	0.1309 **	0.0030 **	0.0081 *	0.0001 ns
Trays (B)	9.0380 ns	61.3184 *	0.3300 **	0.5333 **	14.5603 **	19.7640 **	0.3682 **	0.0025 **	0.0501 **	0.0001 ns
Interaction S x B	2.1936 ns	38.8857 *	0.0442 **	0.0304 ns	0.5661 ns	0.8299 ns	0.0172 **	0.0001 ns	0.0052 ns	0.0001 **
Residue	2.9996	13.1148	0.0099	0.0242	0.6833	1.3370	0.0028	0.0001	0.0020	0.0001
CV (%)	19.56	28.66	4.54	8.86	11.01	14.90	12.17	25.74	38.53	25.39

*** Significant at 1% probability by F test; * Significant at 5% probability by F test; ns not significant at 5% probability by F test*

Table 3. Average of the substrates and trays of the characteristics of chili seedlings

Substrates	**E**	**DC**	**AP**	**CR**	**MSPA**	**MFR**
Bioplant	82.59 a	1.70 a	7.10 ab	8.25 ab	0.0407 b	0.1237 ab
Humus	72.78 a	1.93 a	8.32 a	7.55 ab	0.0713 a	0.1467 a
Soil	87.70 a	1.43 b	5.75 b	6.53 b	0.0143 c	0.0590 b
50% soil + 50% humus	81.43 a	1.90 a	8.48 a	8.58 a	0.0643 a	0.1510 a
75% soil + 25% humus	81.98 a	1.84 a	7.90 a	7.88 ab	0.0510 ab	0.1133 ab
Average general	81.29	-	-	-	-	-
$\Delta_{5\%}$	29.81	0.27	1.43	1.99	0.0215	0.0791
Trays	**E**	**DC**	**AP**	**CR**	**MSPA**	**MFR**
98 cells	88.57 a	1.89 a	8.21 a	8.57 a	0.0575 a	0.1596 a
200 cells	74.00 a	1.63 b	6.81 b	6.95 b	0.0392 b	0.0779 b
Average general	81.29	-	-	-	-	-
$\Delta_{5\%}$	13.13	0.12	0.63	0.88	0.0094	0.0348

Means followed by the same letter in the column do not differ from each other by the Tukey test at 5% probability.

Table 4. Averages of the substrate breakdown within the types of trays to characteristic of pepper seedlings

Substrates	IVE		NF		MFPA		MSR	
	98 cells	**200 cells**	**98 cells**	**200 cells**	**98 cells**	**200 cells**	**98 cells**	**200 cells**
Bioplant	11.55 a	17.49 a	5.00 ab	4.00 b	0.5087 c	0.2453 bc	0.0153 ab	0.0110 ab
Humus	11.90 a	5.88 b	6.00 a	5.67 a	0.6780 ab	0.5360 a	0.0123 ab	0.0180 a
Soil	13.18 a	17.66 a	4.00 b	4.00 b	0.2727 d	0.1787 c	0.0093 b	0.0113 ab
50% Soil + 50% Humus	9.16 a	15.49 a	6.00 a	4.33 b	0.7213 a	0.3540 b	0.0173 ab	0.0143 ab
75% Soil + 25% Humus	10.25 a	14.82 a	5.67 a	4.00 b	0.5567 bc	0.3153 b	0.0200 a	0.0080 b
$\Delta_{5\%}$	**8.85**	**8.85**	**1.09**	**1.09**	**0.13**	**0.13**	**0.0085**	**0.0085**

Means followed by the same letter in the column do not differ from each other by the Tukey test at 5% probability

For NF in trays with 98 cells, the humus and 50% soil + 50% humus presented larger amounts and did not differ statistically from 75% soil + 25% humus. For the trays with 200 cells, the humus presented higher NF, differing statistically from the other substrates. Humus presents great amount of nutrients, both macro and micronutrients. Thus, in trays with 98 cells, because they are larger and contain more mineral nutrients, all substrates were similar. In trays with 200 cells, where the volume of nutrients is lower, humus, for being richer, enabled the seedlings with a greater production of leaves [13].

For MFPA, in the trays with 98 cells, the substrate 50% soil + 50% humus presented higher mass and did not differ statistically from humus. In the tray with 200 cells, the humus presented greater mass, differing from the other substrates.

For the MSR in the trays with 98 cells, the substrate 75% soil + 25% humus presented greater mass, and did not differ statistically from the substrates Bioplant, humus, 50% soil + 50% humus and 75% soil + 25% humus. In the tray with 200 cells, the substrate humus presented greater mass and did not differ statistically from Bioplant, soil and 50% soil + 50% humus.

Substrates humus, 50% soil + 50% humus and 75% soil + 25% humus stood out for most of the evaluated variables, and any of these may be used for the production of pepper seedlings, considering that the substrate 50% soil + 50% humus presents technically the favorite, because it presents the good physical characteristics of the soil and the optimal nutritional proportion of the humus, being even cheaper in terms of cost-benefit [12].

4. CONCLUSION

The substrates humus, 50% soil + 50% humus and 75% soil + 25% humus stood out for most of the variables evaluated in the production of pepper seedlings.

The trays with 98 cells presented the best conditions for production of pepper seedlings.

COMPETING INTERESTS

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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