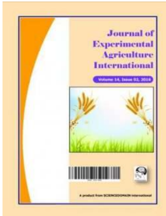

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Pepper Seedlings Quality Submitted to Different Substrates and Types of Trays

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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 JST and MTS were responsible for collecting, tabulating and analyzing the data. Authors DFS and JLXLC participated in the management of the experiment from the implantation to the 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

In the chili crop, substrates are used that provide a high quality of the seedling, which directly reflects the productivity of the plant. To maximize the use of this input is usually used the system of production of seedlings in trays, in this system, the volume of the substrate and its quality are determinants in the quality of the seedling. Thus, the present research had as objective to evaluate pepper seedlings quality submitted to different substrates and types of trays. Five substrates and two types of trays were evaluated, the substrates were S1: Bioplant® commercial substrate (control treatment); S2: Earthworm humus; S3: Solo; S4: 1/2 Soil + 1/2 Húmus of earthworm and S5: 3/4 Soil + 1/4 Humus of earthworm, and the types of trays B1: with 98 cells and B2: with 200 cells, in a

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completely randomized design, in the 5 x 2 factorial scheme, with four replicates. Regarding the emergence and the emergence speed index, all the alternative substrates (S2, S3, S4 and S5) confer quality and homogeneity of seedlings similar to the control treatment. Regarding the Dickson quality index, the alternative substrates S1, S2, S4 and S5 conditioned the best qualities of seedlings, and the seedlings improved vigor and resistance to adverse factors. Analyzing the characteristics of dry shoot mass and total dry mass, both substrates S2 and S4 presented the best results for tray B1. Thus, the alternative substrates S2, S4 and S5, allied to tray type B1, provided better red pepper quality.

Keywords: Initial development; seedling; organic compounds; volumes of substrates; Capsicum annuum L.

1. INTRODUCTION

The pepper (*Capsicum annuum L.*) belongs to the Solanaceae family, having its origin in Central America, being one of the main vegetables in the Brazilian market. The most economical part of this crop is the fruit, where its quality is based on the texture, the visual and nutritional aspects of these fruits, and can be commercialized *in natura*l or powder form, giving it flavor, aroma and color to the processed or consumed fresh food, besides having important medicinal properties [1,2].

However, this horticultural crop is very demanding in terms of nutrient uptake, thus making the substrate an important factor for seedling quality, which directly reflects plant productivity, and commercial substrates are usually used to remedy this problem, however, the adoption of this material makes the cost of the seedling higher [3]. It is known that the replacement of the commercial substrate by alternative substrates is a relevant option to reduce the cost of production of the seedling.

The alternative substrate should be economically advantageous, besides having physical and chemical characteristics at least similar to the commercial substrate. A good substrate should adequately supply the plants with respect to nutrients, water and oxygen, giving them good conditions for the formation of the root system of the seedlings and, also, should contain materials of easy availability in the region [4]. These substrates may be formed from materials of organic or synthetic mineral sources of only one material or of the mixture of two or more materials, however only one material may not guarantee the proper development of the seedling, and the use of various materials [5].

The most used system in the production of horticultural seedlings is in trays, which presents several advantages, through the reduction of the substrate used, greater viability in the control of pests and diseases, increase of the quality of the seedling produced and the index of glue of the seedling after transplanting, reflecting on better agronomic quality [6]. In this system, the volume of the substrate is determinant in the quality of the seedling, in which the substrate volume reduction contributes negatively to growth, photosynthesis rate, leaf chlorophyll content, nutrient and water absorption, seedlings [7]. Thus, the adequate volume of substrate in the cells of the trays can bring interesting economic returns and without impairing the quality of the seedlings.

In the literature several authors report that the type of substrate and tray type interfere in the quality of the seedlings, the example of [7,8,9,10] reviewed the developments of basil seedlings (*Ocimum basilicum* L.), eggplant (*Solanum melongena* L.), Cabbage (*Brassica oleracea* var. Capitata L.) and lettuce (*Lactuca sativa* L.), respectively. However, there is a few work that relates the quality of the All Big chili peppers to alternative substrates combined with tray types, so the adequate knowledge of the use of these two factors can result in seedlings of superior quality and a more efficient management, resulting in less use of environmental resources.

In view of the above, the present research had the objective of evaluating the quality of pepper seedlings submitted to different substrates and types of trays.

2. MATERIALS AND METHODS

2.1 Site Location

The experiment was carried out in a greenhouse at the Agricultural Sciences Center of the Federal University of Alagoas (CECA/UFAL), located in the municipality of Rio Largo-AL (09° 28 '02 "S; 35 ° 49'43" W; 127 m), in March 2016.

2.2 Experimental Design and Treatments

The design was completely randomized, in the 5 x 2 factorial scheme (five substrates and two types of trays) with four replications. In that the five substrates were S1: Bioplant® commercial substrate (control treatment); S2: earthworm humus; S3: solo; S4: 1/2 soil + 1/2 earthworm humus and S5: 3/4 soil + 1/4 earthworm humus, whose chemical compositions are presented in Table 1, and two types of trays B1: with 98 cells (30.0 cm³) and B2: with 200 cells (18.0 cm³).

The sowing was done in the respective trays, the useful area is the 20 central seedlings of the tray, for both types of trays. Before sowing the cells of the trays were filled with the substrates corresponding to the treatments, the chili seeds of the All Big cultivar were planted at a depth of 1 cm and then covered with the same substrate.

2.3 Evaluated Parameters

Irrigations were carried out daily by the sprinkler system up to 33 days after sowing (DAS). For the variables emergency (E), in%, and emergency speed index (IVE), plantas.dia^{-1}, were calculated according to the emergence count of the seedlings daily until 14 DAS, in which the variables E and IVE were calculated by the following formulas:

$$E = \frac{N}{A} \text{ x } 100,$$

on what:

N - Total number of seeds emerged;
A - total number of seeds sown.

$$IVE = \frac{E1}{N1} + \frac{E2}{N2} + \cdots + \frac{En}{Nn},$$

on what:

E1, E2, ..., Em = number of normal seedlings emerged in the first, second to the last count,
N1, N2, ..., Nn = number of days of sowing to first, second to last count.

In the 33 DAS, considered appropriate for the transplanting of the seedlings, the following characteristics were evaluated: number of leaves (NF), in unit; diameter of the collar (DC), in mm; plant height (AP), in cm; root length (CR), in cm; dry shoot mass (MSPA), in g; root dry mass (MSR), in g; total dry mass (MST), in g; and Dickson quality index (IQD), dimensionless.

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

Parameters	Substrates*				
	S1	**S2**	**S3**	**S4**	**S5**
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
MO (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: 1/2 soil + 1/2 earthworm humus and S5: 3/4 soil + 1/4 earthworm humus*

For the variable NF was counted the number of true leaves in unit, in relation to the measurement of the DC was used a digital caliper, being the measurements were taken at the height of the lap of the seedling. To define the AP, a millimetre ruler was used, where it was measured from the base of the plant until insertion of the last leaf, then the CR was determined through the length of the root of greater length. To determine the MSPA and MSR variables, the seedlings were sectioned at the height of the colon where the root system was separated from the substrate in running water, later both the aerial part and the root system were placed in paper bags separately and then taken to a forced circulation oven at 65℃ during 72 hours, after that period were weighed in analytical balance. The MST was obtained by the sum of MSPA and MSR, whereas the IQD was calculated by the formula [11]:

$$IQD = \frac{MST\ (g)}{\left(\frac{AP\ (cm)}{DC\ (mm)}\right) + \left(\frac{MSPA\ (g)}{MSR\ (g)}\right)}$$

2.4 Statistical Analysis

Analysis of variance was performed and, where differences were detected by the F test, the Tukey test (P = 0.05) was applied using the Assistat 7.7 computational software [12].

3. RESULTS AND DISCUSSION

Through the analysis of variance, the significance of the substrate factor was determined in relation to the number of leaves, neck diameter, plant height, dry shoot mass, total dry mass and Dickson quality index at the level of 1% of probability by test F. In relation to the tray factor, a statistical difference was observed, at 1% probability by the F test, for the rate of emergence, number of leaves, neck diameter, plant height, root length, shoot dry mass, total dry mass and Dickson quality index, in addition to the significance, at the 5% probability level by the F test, for emergency character. considering the substrate x tray interaction, it was identified that the dry mass of the shoot and dry mass was significant at 5% probability by the f test (Table 2).

For the emergence and the emergence velocity index, none of the substrates showed a difference for these characteristics (Table 3), indicating that all the alternative substrates (S2, S3, S4 and S5) presented similar performance to the commercial substrate (S1). In other words, the alternative substrates confer quality and homogeneity of seedlings similar to the control treatment, culminating in the same time of permanence of the seedlings in the nursery and resistance to biotic and abiotic factors (Costa et al., 2015). By showing that the substrates evaluated have similar porosity and fertility, which promote water retention and air movement, in which the adequate combination of these two factors allows an ideal condition for the development of the seedlings.

It is worth noting that these results of the substrates were similar to the best substrate studied by [13], which evaluates the seed germination and the development of seedlings of chili cultivars on different substrates, in the All Big cultivar (the same as in the present study), obtained maximum values of 93.75% and 11.21 plants.day^{-1} for emergence and the rate of emergence, respectively, being able to measure the quality of the alternative substrates (S2, S3, S4 and S5).

With regard to the tray factor, it can be seen that the emergence of seedlings was favored in the tray of 98 cells, in which the largest volume of cells for this type of tray should have influenced this result, since it had, in the highest amount of water available to the seed, facilitating its emergence [14]. However, in relation to the rate of emergency, there was an inversion, where the tray with 200 cells holds the highest value, which can be attributed to the smaller amount of emerged plants in this type of tray.

In relation to the number of leaves, it is verified that the substrates S1, S2 and S4 presented the highest values, differing from the others. These results can be elucidated taking into account the chemical constitutions of these substrates (Table 1), in which S1, S2 and S4 hold the highest values of organic matter, where nitrogen is present, which is a fundamental element for the development of seedlings [15]. This argument is supported by the study of [1], who evaluated different substrates in the production of pepper seedlings, realized that the substrate that presented the highest number of leaves also had the highest nitrogen value.

Table 2. Summary of analysis of variance and coefficients of variation in quality evaluations of pepper seedlings submitted to different substrates and tray types. Rio Largo-AL, 2016

Sources of variation	QM										
	GL	E[1]	IVE	NF	DC	AP	CR	MSPA	MSR	MST	IQD
Substrate (S)	4	168.06 ns	2.21 ns	2.88 **	0.28 **	9.87 **	2.63 ns	0.0029 **	0.0001 ns	0.0033 **	0.00001 **
Tray (B)	1	331.67 *	97.99 **	4.03 **	0.53 **	5.25 **	18.25 **	0.0065 **	0.0001 ns	0.0074 **	0.00003 **
Interaction S x B	4	167.63 ns	4.51 ns	0.28 ns	0.01 ns	0.34 ns	0.74 ns	0.0002 *	0.0001 ns	0.0002 *	0.00002 ns
Residue	20	70.28	2.63	0.33	0.03	0.59	1.23	0.0001	0.0001	0.0001	0.00001
TOTAL	29	-	-	-	-	-	-	-	-	-	-
CV (%)		9.63	16.34	11.03	8.95	9.66	15.07	15.19	21.69	12.85	18.79

*ns, * and **: No significant, significant at 5% probability by F test and significant at 1% probability by F test, respectively. [1/] emergency (E), emergency speed index (IVE), number of leaves (NF), stem diameter (DC), plant height (AP), root length (CR), dry mass of the aerial part (MSPA), root dry mass (MSR), total dry mass (MST) and Dickson quality index (IQD).*

Table 3. Mean values for eight characteristics evaluated in pepper seedlings submitted to different substrates and tray types. Rio Largo-AL, 2016

Substrates[3]	E[2]	IVE	NF	DC	AP	CR	MSR	IQD
S1	91.79 a[1]	10.89 a	5.50 ab	1.77 bc	7.90 b	8.27 a	0.0131 a	0.0073ab
S2	79.36 a	10.09 a	6.17 a	2.12 a	9.71 a	7.33 a	0.0133 a	0.0089 a
S3	84.29 a	9.63 a	4.33 c	1.55 c	6.10 c	6.88 a	0.0115 a	0.0060b
S4	87.74 a	9.30 a	5.33 ab	1.99 ab	8.20 b	7.72 a	0.0155 a	0.0093a
S5	91.79 a	9.72 a	4.83 bc	1.84 bc	7.87 b	6.60 a	0.0125 a	0.0079ab
Average	86.99	9.92	-	-	-	7.36	0.0132	0.0697
DMS	14.49	2.80	0.99	0.29	1.33	1.92	0.0049	0.0004
Trays[4]	E	IVE	NF	DC	AP	CR	MSR	IQD
B1	90.32 a	8.12 b	5.60 a	1.99 a	8.37 a	8.14 a	0.0140 a	0.0089 a
B2	83.67 b	11.73 a	4.87 b	1.72 b	7.54 b	6.58 b	0.0123 a	0.0068 b
Average	-	-	-	-	-	-	0.0132	
DMS	6.38	1.23	0.44	0.13	0.58	0.84	0.0022	0.0011

[1/]Means with the same letter in the column do not differ by Tukey test, at 5% probability. [2/]emergency (E), in %; emergency speed index (IVE), plantas.dia^{-1}; number of leaves (NF), in uni; stem diameter (DC), in mm; plant height (AP), in cm; root length (CR), in cm; dry mass root (MSR), in g; and Dickson quality index (IQD), adi. [3/]S1: Bioplant® commercial substrate (control treatment); S2: earthworm humus; S3: Solo; S4: 1/2 soil + 1/2 earthworm humus and S5: 3/4 soil + 1/4 earthworm humus. [4/]B1: with 98 cells (30.0 cm³) and B2: with 200 cells (18,0 cm³)

In relation to the trays, type B1 (98 cells) provided the highest number of leaves, neck diameter, plant height, root length and Dickson quality index, being this result conveyed to the largest volume of substrate of this treatment [16]. Other authors also found unequal results in the comparative analysis of the tray types, in which they identified the highest values of several characteristics for trays of smaller numbers of cells, that is, in trays with larger cell volumes [9, 17].

Regarding the substrate factor for the diameter of the cervix, it can be seen that the substrates S2 and S4 presented the best means. For [18], this superiority of the substrates S2 and S4 can be determined by the greater availability of nitrogen, which has great contribution in the quality of the seedlings. Coincidentally, the chemical composition of these substrates (Table 1), presents S2 and S4 as having the highest levels of organic matter. however, other parameters such as base sum (SB), cation exchange capacity (CTC) and base saturation (V) had the same behavior of organic matter, these parameters being important indicators of the nutritional status of the substrates. Thus, as the majority of cultures showed good productivity with V between 50 and 80% and pH between 6.0 and 6.5, the quality of the substrates S2 and S4 can be verified, since they had V of 86 and 70 % and pH of 7.4 and 6.3, respectively [19].

Regarding the height of plants, it was verified that the substrate S2 obtained the highest average, differing from all others. This characteristic can be conditioned to the pH of the substrate, where S2 had a value close to neutrality (Table 1), which increases the availability for seedlings essential elements for development [20].

In order to plant seedlings in the field, root length is a decisive factor for the reduction of dead plants after transplanting, and also a reflection of aeration of the substrate, so that plants with higher root lengths point to low resistance to root penetration, which will culminate in more vigorous seedlings [21]. In this way, all the alternative substrates (S2, S3, S4 and S5) presented good results for the resistance to root penetration, equivalent to the commercial substrate performance, demonstrating the potential of these substrates.

The root dry mass did not differ between the substrates, so the alternative substrates (S2, S3, S4 and S5) had similar performance to the commercial substratum, so that they provided better conditions for the development of the seedlings, leaving categorically that it is agronomically acceptable to change the use of the commercial substrate for another alternative. We can support this assertion by analyzing the studies developed by [2 and 5], in which contrasting results are observed for root length and root dry mass, respectively, in relation to the type of substrate used.

In relation to the Dickson quality index, which is a good indicator of the quality of seedlings due to the fact of considering in its calculation the robustness (height and diameter) and the balance of biomass distribution (shoot dry matter and dry mass of root), that the higher the value of the index the better quality of the seedling [22]. In this way, the alternative substrates S2, S4 and S5 conditioned the best qualities of seedlings, not differing from the commercial substratum S1, with these seedlings from these substrates had better vigor and standardization of the relation of the biomass of the aerial part to that of the root system, resulting in seedlings with higher conditions of resistance to adverse factors [1]. The quality of the substrates S1, S2, S4 and S5 is confirmed when comparing the indexes of the studies by [1], in which the results of the present research present higher indexes.

Analyzing the characteristics of dry shoot mass and total dry mass, it was observed that they had similar behaviors for both substrates and trays (Table 4), with substrates S2 and S4 presented the best results for tray B1 (98 cells), results superior to commercial substrate S1 (control), indicating that there are alternative substrates capable of providing seedlings with superior quality to the commercial substratum, and may also be economically more interesting. However, when visualizing the substrate results for tray B2 (200 cells), it is noticed that only the substrate S2 was superior to the others, the decrease of two best substrates of B1 (S2 and S4) to only one in B2 (S2), In the present study, the use of S4 as the best substratum in B2, should be related to the smaller space available for seedlings, resulting in a possible restriction of water and nutrients fundamental to seedling development [7].

In general terms, one can observe interesting results, such as up to the productivity superiority of some alternative substrates in relation to the control for some characteristics, culminating in more vigorous seedlings.

Table 4. Mean values for two traits evaluated on pepper seedlings submitted to different substrates and tray types. Rio Largo-AL, 2016

Substrates	MSPA[2]			MST		
	B1	B2	DMS	B1	B2	DMS
S1	0.0586 c A[1]	0.0340 bc B	0,0146	0.0713 cd A	0.0476 b B	0,0153
S2	0.0973 a A	0.0760 a B		0.1100 a A	0.0900 a B	
S3	0.0373 d A	0.0173 c B		0.0523 d A	0.0253 c B	
S4	0.0893 ab A	0.0386 b B		0.1053 ab A	0.0536 b B	
S5	0.0740 bc A	0.0426 b B		0.0880 bc A	0.0536 b B	
DMS	0.0210			0.0219		

[1/]Means followed by the same lowercase letter in the column and upper case in the row, do not differ by Tukey test at 5% probability. [2/]dry mass of the aerial part (MSPA), in g; and total dry mass (MST) in g.

4. CONCLUSION

1. The chemical characteristics of the substrates are parameters that strongly interfere with the final quality of the seedlings.
2. The substrates S2 and S4 are the most suitable for the proper development of the seedlings.
3. The best responses regarding seedling quality were obtained with tray type B1 (98 cells).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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