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Production of tomato seedlings Santa Cruz cv. Kadain using different substrates

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Abstract

The tomato crop is considered of great socio-economic importance in the world, feeding millions of people daily. This crop is considered strategic because its production is diverse in the world, being produced by large agro-industries, moving a rich productive chain. This work aimed to evaluate the production of tomato seedlings as function of different substrates, and to comprehend the interrelation of characteristics through linear associations. The experimental design was randomized blocks, using one tomato cultivar, Santa Cruz Kada, in 32 repetitions for each treatment. The treatments consisted of several substrates such as carbonized rice husk, grape husk (S10), coconut fiber, and commercial substrate (Bioplant®). The experiment was carried out in a greenhouse using pots. The characters measured 25 days after sowing were: stem diameter, number of leaves, shoot length, root length, green mass of root, green mass of shoot, dry mass of shoot, and dry mass of root. The analysis of variance was performed and the characters that presented significance were compared by the Duncan test at 5% of probability. Subsequently, Pearson's linear correlation was individually performed for each substrate. The results showed that commercial (Bioplant®) and grape skin substrates were the most suitable for production of tomato seedlings cv. Santa Cruz Kada. The characters of stem diameter, number of leaves, shoot length, green mass of root and green mass of shoot revealed significant correlations; however they differently behaved in the substrates.

Keywords: *Solanum lycopersicum*L, grape skin, Bioplant®, linear correlation.
Abbreviations: SD_ stem diameter; NL_ number of leaves; RL_ root length; SL_ shoot length; GMR_ green mass of root; DMR_ dry mass of root; GMS_ green mass of shoot and DMS_dry mass of shoot.

Introduction

Tomato (*Solanum lycopersicum* L.) is considered one of the most widespread vegetables in the agricultural scenario, being cultivated under several field and protected environments (Pereira, 2010). In Brazil, tomato is the second economically most important among vegetables. It has consumption preference mainly due to its organoleptic qualities and its value as a functional food because of the antioxidant properties of lycopene (Ronchiet al., 2010).

One crucial step in tomato production is the development of high-quality seedlings, since vigorous seedlings result in good plant performance, which affects early production, satisfactory fruit size and high final yield (Oviedo, 2007). In this context, seedling production is closely related to the substrates, regarding the mineral, organic or synthetic raw material, mixtures and desirable chemical, physical and biological features of the substrate (Kanashiro, 1999). In addition, related characteristics such as precocity, reduction of contamination, higher seed/seedling ratio, and lower stress caused by transplant reveal that a suitable substrate may increase yield compared to traditional methods of seedlings production (Silveira et al., 2002).

Substrates of organic origin are widely used by nurseries, because they do not only meet plant nutritional needs at the beginning of development, but also they have lower cost and cause lower environmental contamination (Silva Júnioret al. 2014). In addition, they contribute to moisture retention, nutrient supply, increased oxygen diffusion to the roots due to greater porosity, cation exchange capacity, suitable pH regulation, aid in the physical support and plants development (Camargo et al., 2011; Pessoa et al., 2012; Costa et al., 2013).

Several organic materials are used for the commercial production of vegetable seedlings such as turf, wood residues, carbonized husk of pine and rice, lignite and vermiculite are used as substrate, either alone or in combination (Carrijo et al., 2002). The rice carbonized husk presents great potential for use due to the huge availability of raw material in rice fields and importance of its economical and ecological disposal to a correct destination. Also, coconut fiber and grape skin are considered materials of low cost and high availability.

After the seedlings establishment, it is important to verify the interrelations among several traits that determine the

crop potential, because they allow understanding linear associations and identifying which of them are indispensable and must be measured. In this way, the Pearson linear correlation analysis allows to identify tendencies between traits and to determine which should be considered and measured (Carvalhoet al., 2004).
The aim of this work was to evaluate de effect of different substrates in the production of tomato seedlings.

Results and discussion

The analysis of variance revealed significant differences at 5% of probability for the stem diameter (SD), number of leaves (NL), root length (RL), shoot length (SL), green mass of root (GMR), dry mass of root (DMR), green mass of shoot (GMS), and dry mass of shoot (DMS).
Stem diameter (SD) presented higher values, when the plants were grown in commercial substrates. The substrates such as rice husk and coconut fiber lower values to the others (Table 1). This behavior is due to rice husk and coconut fiber providing less nutrients. Silva et al. (2012) conducted a study with different combinations of substrates for the production of tomato seedlings and concluded that regardless of the level of rice husk used, the commercial substrate is superior. According to Campos (2002) and Silva et al. (2012), the stem diameter is an indicator of seedling quality, and may be associated with survival and growth after transplantation to the definitive site. Thus, it is possible to infer that plants produced in commercial substrates and grape skin may have a higher survival rate after transplantation.
The number of leaves (NL) was higher when we used commercial substrate and grape skin, and the substrate rice husk was inferior to the others. This character is strongly influenced by mineral nutrition, by which substrates with higher nutrient availability tend to increase the number of expanded leaves per plant. Silva Júnior et al. (2014), evaluated the production of tomato seedlings cv. Caline IPA 6 in different substrates and verified that the number of leaves varies with the type of substrate used. Therefore, the magnitude of leaves per plant is dependent on the techniques and management used for seedling production. Medeiros et al. (2013), evaluated the performance of cherry tomatoes seedlings cv. Fernon in organic and commercial substrates (Plantmax®). The authors found that the organic substrate promoted greater emission of leaves in the seedlings than the commercial substrate.
The root length (RL) was higher when the seedlings were cultivated in commercial substrate, grape skin and rice husk, whereas the smallest magnitude was verified in the coconut fiber (Table 1). No difference was evidenced among commercial substrate, grape skin and rice husk for this character. The formation of larger roots resulted in a better adaptation of the seedlings after transplantation, allowing a more efficient exploitation of the available substrate volume, thereby resulting in a greater aeration, water and nutrient uptake (Souza et al., 2013). In studies conducted by Dos Santos et al. (2015), there was an increase in root length of tomato seedlings, due to the increase of the rice husk proportion in the substrate. Silva Júnior et al. (2014), evaluated the production of tomato seedlings cv. Caline IPA 6 in different substrates and verified significant differences in the root length of seedlings, and proved the influence of the type of substrate in this character.
For the characters shoot length (SL) and green mass of rot (GMR), we revealed that commercial substrate and grape skin are more valuable substrates. This result is due to the satisfactory proportions of chemical and physical constituents, which allowed the formation of better quality seedlings. These results corroborate with Silva Júnior et al. (2014), who evaluated different substrates for production of tomato seedlings cv. Caline IPA 6 and obtained significant difference for shoot length as function of the substrates.
The dry mass of roots (DMR) presented the largest value in commercial substrate as well. Seedlings with higher root volume provided greater resistance to adverse conditions after transplanting, since they evidence a vigorous root system associated to a greater leaf development, stem diameter and plant height, which are characteristics that can favor the survival on field and avoid dumping off.
The characters green mass of shoot (GMS) and dry mass of shoot (DMS) revealed that grape skin is the best substrate. The smallest GMS and DMS were appeared in rice husk and coconut fiber, evidencing that the substrate quality positively or negatively influences the accumulation of phytomass. Silva Júnior et al. (2014), evaluated the production of tomato seedlings cv. Caline IPA 6 on different substrates and revealed that dry mass of shoot was significantly influenced by the type of substrate. Silva et al. (2012), evidenced that the addition of rice husk to different substrates reduced the mass of shoot for the production of tomato cv. Santa Clara. These results corroborate with this experiment, defining that addition of more rice husk produces seedlings with lower dry mass.
In order to discover substrates with appropriate properties for plant development, the physical, chemical and biological characteristics of these materials is essential. However, the physical characteristics are the most important because they control air and water relationships (Farias et al., 2012). According to Silva et al. (2006) the Bioplant® commercial substrate, similar to the one used in this study, is the most suitable for production of tomato seedlings, when compared to other commercial substrates.
The Pearson's linear correlation was performed for the eight morphological characters (Table 2) revealing 112 associations, being 18 significant at 5% of probability by the t-test. According to the classification by Carvalho et al. (2004), the correlations equal to 0 correspond to null; correlation from 0 to ≤ 0.30 are considered weak; correlation from 0.30 to ≤ 0.60 are intermediate; correlation from 0.60 to ≤ 0,90 are strong; correlation 0.90< 1 are very strong, and correlation equal to one are considered perfect correlation.
The character stem diameter (SD) was positively correlated with number of leaves (NL) in the substrates coconut fiber (r = 0.60*) and commercial (r = 0.38*), indicating that whatever the stem diameter is larger, the number of leaves will be higher. The number of leaves (NL) showed significant negative correlation coefficient with dry mass of the root (DMR r = -0.38*), indicating that the larger the number of leaves, the lower the dry mass of root. Root length (RL) did not reveal significant correlation for any character in this study.
Regarding shoot length (SL), significant negative correlation was verified with dry mass of root (DMR r = -0.51 *) in the

Table 1. Average of the characters: (SD) stem diameter (mm), (NL) number of leaves (unidades), (RL) root lenght (cm), (SL) shoot lenght (cm), (GMR) green mass of root (g), (DMR) dry mass of root (g), (GMS) green mass of shoot (g) and (DMS) dry mass of shoot (g), Pelotas – RS, 2017.

Substrates	SD	NL	RL	SL	GMR	DMR	GMS	DMS
Rice husk	1.30 c	2.13 c	2.79 a	4.86 b	0.003 b	0.0007 c	0.035 c	0.002 c
Coconut fiber	1.26 c	2.60 b	1.55 b	5.44b	0.003 b	0.0007 c	0.029 c	0.001 c
Grape skin	2.36 b	5.15 a	3.16 a	15.23 a	0.046 a	0.0025 b	0.679 a	0.034 a
Commercial	2.54 a	5.20 a	3.16 a	15.23 a	0.048 a	0.0053 a	0.470 b	0.029 b
CV (%)	9.88	17.35	41.17	10.65	37.62	57.9	30.5	33.3

*Means followed by the same letter in the column do not statistically differ from each other by the Duncan test, at 5% of probability.

Table 2. Estimates of Pearson's linear correlation for the characters: (SD) stem diameter (mm), (NL) number of leaves (unidades), (RL) root lenght (cm), (SL) shoot lenght (cm), (GMR) green mass of root (g), (DMR) dry mass of root (g), (GMS) green mass of shoot (g) and (DMS) dry mass of shoot (g), Pelotas – RS, 2017.

		NL	RL	SL	GMR	DMR	GMS	DMS
	Rice husk	-0.14	0.01	-0.31	-0.09	-0.21	-0.25	-0.04
SD	Coconut fiber	0.60*	0.07	0.06	0.48	-0.22	-0.22	-0.11
	Grape skin	-0.15	0.11	0.27	0.02	-0.12	0.30	0.24
	Commercial	0.38*	0.17	0.04	-0.09	-0.27	-0.23	-0.15
	Rice husk		0.06	-0.26	0.49	0.35	0.06	0.17
NL	Coconut fiber		0.02	0.14	-0.06	0.10	-0.38	-0.11
	Grape skin		-0.28	-0.08	-0.09	0.14	-0.13	-0.06
	Commercial		-0.02	-0.04	-0.01	-0.38*	0.00	0.05
	Rice husk			0.22	0.07	-0.18	0.38	0.30
	Coconut fiber			0.01	-0.22	-0.17	-0.19	0.08
RL	Grape skin			0.28	0.08	-0.10	0.28	0.24
	Commercial			0.28	0.25	0.04	0.24	0.25
	Rice husk				0.19	-0.51*	0.29	0.11
	Coconut fiber				-0.21	-0.02	0.47	0.08
SL	Grape skin				0.46*	0.19	0.80*	0.73*
	Commercial				0.36*	0.13	0.28	0.24
	Rice husk					0.13	0.39	0.51*
GMR	Coconut fiber					0.06	-0.15	-0.15
	Grape skin					0.39*	0.61*	0.52*
	Commercial					0.55*	0.50*	0.51*
	Rice husk						-0.12	0.13
DMR	Coconut fiber						0.00	0.36
	Grape skin						0.14	0.17
	Commercial						0.30	0.27
	Rice husk							0.75*
GMS	Coconut fiber							0.45
	Grape skin							0.80*
	Commercial							0.92*

*Pearson linear correlation coefficients (n = 32) significant at 5% of probability of error.

rice husk substrate. Significant positive correlation was observed for green mass of root (GMR r = 0.46 *), green and dry mass of shoot (GMS r = 0.80*; DMS r = 0.73*), in grape skin substrate and for the character green mass of root (GMR r = 0.36*) in the compost substrate.

The character green mass of root (GMR) presented significant positive correlation with green mass of shoot (GMS r = 0.51*) in rice husk substrate, indicating that the larger the magnitude of green mass of root, there will be an increment in shoot green mass. There was also correlation of this character with dry mass of root (DMR r = 0.39*), green and dry mass of shoot (GMS r = 0.61*DMS r = 0.52*) in grape skin. There were positive significant correlations for dry mass of root (DMR 0.55*) and with green and dry mass of shoot (GMS r=0.50* DMS r=0.51*) grown in the commercial substrate, indicating that an increment in the magnitude of root green mass is followed by an increment of root dry mass, green and dry mass of shoot. For the character dry mass of root (DMR), there was no significant correlation.

Regarding the character green mass of shoot (GMS), positive significant correlations were found with dry mass of shoot (DMS) in the rice husk (r=0.75*), grape skin (r=0.80*) and commercial (r=0.92*), indicating that the greater the green mass, larger the dry mass of shoots.

Materials and methods

The experiment was conducted in a greenhouse in the 2016 year, in the Department of Plant Science of the Eliseu Maciel Agronomy College - Federal University of Pelotas - RS. The experimental design was completely randomized blocks (CRBD), on one tomato cultivar, Santa Cruz Kada, planted in 32 repetitions for each substrate treatment. The treatments were established through the substrates (carbonized rice husk, grape husk (S10), coconut fiber and commercial substrate (Bioplant®). Seeding was carried out with seeds provided by *Isla sementes,* in pots of 200 cm^{-3}, with sowing depth standardized at 1.5 centimeters for planting. After the emergence, thinning was performed, remaining only one seedling per pot, which was considered as an experimental unit. The seedlings were kept in a greenhouse under constant light and temperature at 25°C, with daily irrigations.

Measured characters

The response of variables was measured 25 days after sowing (DAS). The stem diameter (SD), measured through a caliper ruler 1 cm above the substrate level in millimeters. Number of leaves (NL): verified by counting the number of expanded leaves per plant, with results in units; Shoot length (SL) and root length (RL), obtained with the aid of a ruler, where the distance between the neck and the aerial and radicular apex of the plant was measured, in millimeters. Green mass of root (GMR) and green mass of shoot (GMS) were obtained through a digital scale at the exact moment of evaluation, results in grams. For determining the dry mass of shoot (DMS) and dry mass of root (DMR), the tissues were placed in kraft bags and later placed into an oven with forced ventilation at 65°C until the samples reached constant weight, results expressed in grams.

Statistical analysis

The data were submitted to the normality test of residues by Shapiro Wilk (1965), and the homogeneity of variances by Bartlett (Steel et al., 1997). There was no need to perform transformation in the collected data. The analysis of variance was performed and the characters that presented significance were compared by Duncan at 5% of probability. Afterwards, Pearson's linear correlation was individually carried out for each substrate. The correlation coefficients were classified by Carvalho et al. (2004). The statistical analyzes were performed using the Genes software (Cruz, 2013).

Conclusion

Commercial and grape skin substrates are the most suitable for production of Tomato seedlings cultivar Santa Cruz Kada. The characters stem diameter, number of leaves, shoot length, green mass of root and green mass of shoot revealed significant correlations; however, they behaved differently in the substrates.

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