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Vegetative Development of Radish Seedlings in Different Organic Substrates

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MEPCJ, RSR, IMP, SAC, ECM and RRR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GAG, WLL and DPC managed the analyses of the study. Authors COB, SFS and MCP managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this work was to evaluate the vegetative development of radish seedlings in different organic substrates with seeds from two types of commercial packing. The completely randomized design was used in a 4 x 2 factorial scheme, consisting of four substrates (commercial, tanned bovine manure, mixed organic compound and vermicompost) and two seed packings (aluminized envelope and can), with eight replications, totalizing 64 seedlings. The biometric evaluations of the seedlings were carried out on the 14th day after sowing, and the following phytotechnical parameters were evaluated: leaf number, total fresh mass; fresh mass from aerial part and fresh mass from the root. According to the results, the commercial, vermicompost and mixed organic substrates provided the best results for the variables evaluated when the can was used.

Keywords: Raphanus sativus L.; organic residue; seedlings production.

1. INTRODUCTION

Raphanus sativus L. (radish) is an important species regarding economical and nutritional aspects [1,2]. This plant is mainly cultivated in relatively small properties, and because it has a short cycle, the planning and rational use of the land is allowed. Therefore, for the success of the productive process, the quality of the seedlings is an important factor in the implementation of vegetable gardens, once it directly influences the survival percentage of the plants in the field, and consequently, their production, concerning the nutritional value and the productive cycle of the crop [3].

Radish has its production many times associated to seedlings production, as what happens with many other vegetables, what guarantees a higher economic return to the producer, due to the productivity security and lower implementation costs the techniques for the radish production promotes. Currently, the use of plastic or polystyrene trays is the most implemented method for seedlings production [4].

Nevertheless, in the process of seedlings production, the substrate directly interferes on the plants quality due to the variations in its physical, chemical and biological properties [5], related to lower or higher production.

The use of cattle manure in farmland, for example, consists of an economical and environmentally sustainable alternative that has been increasing crop production throughout the world [6,7]. Agricultural Systems, which rely on low incomes destined to production, are favoured with the use of organic materials, such as some organic compounds and vermicomposts because they minimize the use of synthetic fertilizers and also contribute with the improvement of productivity ensuring ecosystem sustainability [8].

Although the importance of the substrate, seeds quality may also be affected by the type of material which restrains the seeds, which will influence the seedlings development [9]. A combination of factors may induce losses during storage, which can be caused by biotic, genetic and abiotic factors [10,11].

Seed storage is widely practised for the preservation of genetic resources especially for medium to long term conservation and it is popular amongst conservationists because of the easy handling, economical and to the capability to maintain genetic stability on conservation. However, the process of seed deterioration reduces under suitable storage conditions [12,13].

New forms of analysis must be developed for mixtures that in general present high percentages of organic compounds, what already differentiates them from mineral soils, which present the content of not more than 5% of organic matter [14].

Several species have been showing good results with the use of alternative substrates for the seedlings production [15,16,17]. Nevertheless, works relating the types of packing with seedlings development are scarce in the literature.

Thus, this work aimed to evaluate the vegetative development of radish seedlings in different organic substrates, with seeds proceeding from aluminized envelopes and cans.

2. MATERIALS AND METHODS

The experiment was carried out in a greenhouse, located in the Agroecology Section of the Federal Institute of Education, Science and Technology of Espírito Santo (IFES) in the municipality of Alegre, Espírito Santo State, at 20º45'44,53" South latitude, at 41º27'43,08" West longitude and altitude of approximately 134 m.a.s.l.

The greenhouse presents treated wooded support by its sides and is protected with white shading material to make the air circulation easier. The greenhouse is covered by plastic and cloth material (50% of coverage) to promote acclimatization, to control insolation and to maintain room temperature.

Regarding the irrigation management, a micro aspersion localized irrigation was used to irrigate seedlings twice a day (morning and afternoon), aiming to maintain the humidity of the substrate.

Three pure organic compounds (without voluminous addition) and one commercial substrate (control) were used for the radish seedlings production. These compounds were characterized by the ease of production in the fields and/or by the local market obtention. In this study the compounds were characterized by S1) commercial substrate (the most used substrate in the studied region); S2) cattle manure in its composition; S3) mixed organic compound, obtained by the composting process described by Souza et al. [18], in the agroecology sector of IFES; and S4) Vermicompost, mainly produced by earthworms (*Eisenia foetida*) after the composting process.

The entirely randomized experimental design was used with a factorial scheme 4 x 2, compounded by 4 substrates (S1- commercial, S2 - cattle manure in its composition, S3 - mixed organic compound and S4 vermicompost) and two seeds packing (Pack1 - can and Pack2 - aluminized envelope), with eight repetitions, totalizing 64 seedlings.

The substrates were characterized by chemical analysis, performed in the Soil Fertility Laboratory of the Soils Department of the Federal Rural University of Rio de Janeiro UFRRJ (Table 1).

The evaluated radish cultivar used in the study was "Crimson", which was obtained from two commercial types of packing, an aluminized envelope and a can. The radish seedlings were sowed in polypropylene trays (200 cells). The different types of substrates for each packing were added in each tray, totalizing eight trays. The biometric evaluations of the seedlings were carried out on the fourteenth day after sowing (DAS), where the following pyrotechnical parameters were evaluated: the number of leaves, total fresh mass (g seedlings^{-1}); fresh mass from the aerial part (g seedlings^{-1}) and fresh mass from the root (g seedlings^{-1}). Data were submitted to analysis of variance and the averages were compared by the Scott-Knott test at 1 and 5% probability using the [19].

3. RESULTS AND DISCUSSION

There was interaction regarding the type of packing x substrate used in the experiment for the variables fresh mass from the aerial part ($P \leq 0.01$), fresh mass from the root ($P \leq 0.05$) and total fresh mass ($P \leq 0.01$) according to the summary of variance analysis (Table 2).

For the fresh mass from the aerial part x root and number of leaves relation, there was no significant interaction among the treatments. However, there was a significant effect on isolated treatments.

Table 1. Chemical characterization of the commercial and organic substrates used in radish seedlings production. S1 - commercial; S2 - cattle manure in its composition; S3 - mixed organic compound; S4 – vermicompost

Substrates	N	P_2O_5	K_2O	Mg	Ca	C	pH in water
		(mg.dm^{-3})		(Cmolc.dm^{-3})		(g/kg^{-1})	
S1	18	213	18.07	5.0	26.0	40.7	6.2
S2	33	43.9	15.36	9.0	35.4	265	8.0
S3	11	12.5	11.16	6.8	26.7	62	7.4
S4	11	36.3	36.72	27.9	5.3	113	6.7

Source: Research data

Table 2. Summary of the variance analysis, decomposition of the double interaction (Sub*Pack), indicating the variation coefficient (CV), degrees of freedom (DF) and the mean squares of the response variables. FMAP - fresh mass from the aerial part; FMR - fresh mass from the root; TFM - total fresh mass; FMAP / FMR - fresh mass from the aerial part and fresh mass from the root ratio; NL - number of leaves

Source of variation	DF	Mean square (g seedling^{-1})				
		FMAP	FMR	MFT	FMAP / FMR	NL
Substrate (Sub)	3	0.78**	0.02**	0.98**	116.33^{ns}	3.47**
Error 1	28	0.01	0.00	0.02	154.08	0.68
Packing (Pack)	1	1.75**	0.12**	2.78**	835.84*	11.39**
Sub*Pack	3	0.26**	0.02*	0.35**	360.40^{ns}	1.26^{ns}
Error2	28	0.02	0.00	0.03	120.70	1.08
Total	63					
Total average		0.44	0.10	0.53	9.53	3.98
VC 1 (%)		25.20	60.15	25.93	130.21	20.71
VC 2 (%)		28.90	72.71	31.36	133.49	26.11

** e * significant by the F test at 1% and 5% of probability, respectively; ^{ns} - non-significant

An average test for the interaction between the substrate x packing was carried out, with the unfolding of the treatments for the variables fresh mass from the aerial part, fresh mass from the root and total fresh mass (Table 3).

The highest fresh mass from the aerial part was obtained when substrate S4 (vermicompost) was used, regarding packing 1 (can), with an average of 0.96 g seedling^{-1}. The lowest result was obtained for substrate S2 (Cattle manure in its composition), with an average of 0.15 g seedling^{-1} (Table 3).

When packing 2 (aluminized envelope) was evaluated, for the same variable, the lowest result was also obtained for S2 (0.13 g seedling^{-1}), which statistically differed from the other substrates.

The best seedlings formation has already been observed in alternative substrates when in comparison with commercial substrates, with greater accumulation of dry mass from the aerial part and dry mass from the root [20,17]. Higher efficiency was observed for vermicompost mixtures, carbonized rice bark, and powdered rocks as substrates, providing higher growth [21,22]. Silva Júnior and Visconti [23,24] describe how a good substrate should have the ability to retain nutrients and water, good aeration, low resistance to root penetration and good resistance to loss of the structure of the root ball, which is essential for success when transplanting.

Nevertheless, the use of different substrates in the seedlings production still needs studies, as observed by Oliveira et al. [25], who did not find significant results for the use of an organomineral fertilizer plus soil as the substrate in the production of radish seedlings. Linhares et al. [26] studied doses of jitirana (5.4; 8.8; 12.2 and 15.6 t ha-1 on dry basis) and decomposition times (0, 10, 20 and 30 days before sowing), concluding that the residual effect of the higher dose (15.6 t ha-1) at the longest period (30 days) was the one that provided the greatest number of leaves (7.5 leaves) and root diameter (4.38 cm) on radish [27].

Table 3. Fresh mass from the aerial part (FMAP), Fresh mass from the root (FMR) and total fresh mass (TFM) from radish seedlings cultivated in different substrates. S1 - commercial; S2 - cattle manure in its composition; S3 - mixed organic compound; S4 - vermicompost. Pack. 1 - can packing; Pack. 2 -aluminized envelope packing

Substrate	FMAP (g seedling^{-1})		FMR (g seedling^{-1})		TFM (g seedling^{-1})	
	Pack. 1	Pack. 2	Pack. 1	Pack. 2	Pack. 1	Pack. 2
S1	0.56 Ac	0.32 Ba	0.14 Aa	0.11 Aa	0.70 Ab	0.44 Ba
S2	0.15 Ad	0.13 Ab	0.08 Ab	0.02 Ab	0.23 Ac	0.15 Ab
S3	0.75 Ab	0.27 Ba	0.20 Aa	0.01 Bb	0.95 Aa	0.28 Bb
S4	0.96 Aa	0.37 Ba	0.14 Aa	0.07 Ba	1.10 Aa	0.44 Ba

Means followed by the same capital letter in the lines and lower case letters in the columns belong to the same group by the Scott-Knott test (P≤0.05)

Regarding the influence of the packing type in the fresh mass of radish aerial part, packing 1 provided the highest averages for substrates S1, S4 and S3 (0.56, 0.96 and 0.75 g seedling^{-1}, respectively), differing from S2 (0.15 g seedling^{-1}). However, for substrate S2, the type of packing did not influence plant development.

When packing 1 was evaluated, the lowest result was obtained by the fresh mass of the root, when substrate S2 was used (0.08 g seedling^{-1}), differing from the other, which presented approximately double of the value (0.16 g seedling^{-1}). For packing 2, the highest averages were obtained by substrates S1 and S4 (0.11 and 0.07 g seedling^{-1}, respectively), differing from the others.

Positive results were reported in the production of sweet pepper seedlings when two organic compounds were used in comparison to the commercial substrate (plantmax®), this improvement may be attributed to the higher nutrient levels these compounds may contain, and even to the higher moisture retention, they present [28].

Regarding the influence of packing in the fresh mass of the root, packing 1 presented the best averages for substrates S4 and S3, with averages of 0.14 and 0.20 g seedling^{-1}, respectively.

For the total fresh mass, substrates S4 and S3 presented the higher averages when packing 1 was used (1.10 and 0.95 g seedling^{-1}, respectively). The lowest result was obtained for substrate S2 with (0.23 g seedling^{-1}).

When packing 2 was evaluated, Substrates S3 and S4 presented the best answers with an average of 0.44 g seedling^{-1} for both variables, differing from the other substrates.

Therefore, the substrate S4 (vermicompost) and S3 (mixed organic compound) were excellent alternatives to the conventional substrate, and they may be used in the production of radish, as already observed by Pereira et al. [29], adding that the organic compound promotes the development of seedlings with higher vigour and resistance [30].

The influence of the type of packing in the production of total fresh mass is evidenced (Table 3). Substrates S1, S4 and S3 were statistically superior when packing 1 was used, with an average of 0.7, 1.1 and 0.95 g seedling^{-1}, respectively. Substrate S2 did not differ among the types of packing. These results suggest economic viability in the production of radish seedlings using alternative substrates based on earthworm humus, corroborating Mota et al. [31] and Lana et al. [32].

These results may be associated with the origin and composition of the substrates, also known for being considered organic material that possesses favourable characteristics, as the elevated water retention capability at low tensions [33].

The type of packing significantly influences the germination and consequently the seedling development, as observed by Kuhn et al. [34], noting that seeds proceeding from cans are superior to seeds from another hermetically sealed packing. Some types of packing can lead to fast deterioration of the seed sand loss of vigour, while proper storage conditions can preserve germination well because it allows the seeds to perform slow gas exchange between the bags and the surrounding environment [35]. There is a close relationship between the loss of seed viability during storage and the accumulation of genetic damage in the surviving seeds [27,36,37]. Seed moisture content, temperature, and storage periods are among the main factors affecting above relationship [38,39].

Irrespective of the type of packaging, there was no significant effect on the fresh mass from the aerial part / fresh mass of the root ratio, regarding the different substrates (Table 3). Nevertheless, substrate S2 presented the lowest results for the number of leaves, with averages of 4.19, 4.37 and 4.06 g seedling^{-1}.

Substrate S2 (Cattle manure in its composition) presented in general, the lowest results for the development of radish seedlings. However, this substrate associated to another may favour the plant development, as observed by Silva et al. [40] that when mixed cattle manure with humus, observed a greater accumulation of dry mass in the radish seedlings (Crimson variety).

This fact was related to the nutrients high values, mainly phosphorus, present in the substrate cattle manure with hummus, once phosphorus is a macronutrient of great importance for the culture.

4. CONCLUSION

As the influence of the packing is evaluated, independent from the used substrate, it has been observed that for the fresh mass from the aerial part / fresh mass from the root ratio, packing 2 was superior to packing 1, with an average of 13.15. The type of packing significantly influences the germination and consequently the seedling development. For the number of leaves, packing 1 was superior to packing 2, presenting an average of 4.40 and 3.56 leaves plant^{-1}, respectively. Thus, the higher influence of the type of packing is observed upon the fresh mass of the aerial part of the radish seedling about the fresh mass of the root.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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