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Use of organic waste and bokashi-type fermented compost in the development of cauliflower seedlings

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Abstract

The formation of seedlings reflects the culture's performance, and the substrate may influence the obtainment of seedlings. Bokashi compost and organic residues can change substrate characteristics and influence seedling development. The present study aimed to analyze the development of cauliflower seedlings by adding bokashi-type fermented compost and agricultural residues to the substrate. The experiment was performed in a completely randomized design in a 5x2 factorial scheme, with five conditions of agricultural residues (control (no residues), coffee residue, yerba mate residue, corn residue, and residue mixture (coffee, yerba mate, and corn)) two conditions of bokashi addition (with (5%) and without) and 18 repetitions. The sowing of cauliflower was performed in polyethylene trays and kept in a protected environment for 30 days. Fresh and dry mass of shoots (stem and leaves), number of leaves per seedling, relative water content (RWC) in leaves, and leaf pigments were evaluated. Data analysis of variance and comparison of means done by the Tukey test, multivariate analysis, and linear correlation. The bokashi compost favored the development of cauliflower seedlings. However, the addition of agricultural residues demonstrated efficiency only when incorporated with bokashi. The use of the residue mixture rendered the best performance of the cauliflower seedlings by adding organic residues to the substrate.

Keywords: *Brassica oleracea var. botrytis, Organic Compost, Waste*

Introduction

Cauliflower (*Brassica oleracea var. botrytis*), belonging to the Brassicaceae family, is a horticultural species of economic importance. However, the yield depends on environmental and management factors, with influence from the development of seedlings (Oliveira et al., 2019; Hassan et al., 2021).

In the production of seedlings, characteristics related to the cultivation medium and substrate directly interfere with the availability of water and nutrients, impacting morphological development, health, standardization, and commercial quality (Kumi et al., 2020; Antunes et al., 2021; Wenneck et al., 2021).

Practices involving the use of organic residues in the production of the substrate are beneficial for the sustainable production system, increasing the efficiency of the use of resources, materials that are usually discarded or incorporated into the soil, also favoring the reduction of costs for the horticulturist (Cordeiro et al., 2020). In addition, the incorporation of compounds into the substrate, such as bokashi, can favor plant development since it is rich in nitrogen, phosphorus, and potassium, benefiting the biological conditions of plants (Quiroz & Céspedes, 2019; Olle, 2021).

The addition of residues and organic compounds can change the composition of the substrate and reflect on the development of seedlings (Oliveira et al., 2019; Antunes et al., 2021). Thus, the study aimed to analyze the development of cauliflower seedlings by adding bokashi-like fermented compost and agricultural residues to the substrate.

Materials and Methods

The study was conducted at the Technical Irrigation Center (CTI) of the State University of Maringá (UEM), Maringá-PR. During conduction, the greenhouses'

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temperature ranged from 17.9 to 38.2° C and relative humidity from 52.7 to 97%, determined with a GSP-6 datalogger equipment (Elitech™).

The experiment was held in a completely randomized design in a 5x2 factorial scheme, with five substrate mixtures (control, coffee residue, yerba mate, corn, and mixture of the three residues) and application of bokashi fermented compost (with and without application) with 18 repetitions. The substrate for each treatment is composed of the bokashi compound and the waste mixtures.

Seeds of the cultivar Piracicaba were used, considered spring-summer season, where the formation of the head occurs at temperatures above 20°C, being a cultivar resistant to heat and when they need mild temperatures, being them only mild cold (Teixeira, 2018).

The seedlings were produced in flexible polyethylene trays (128 cells), kept in a protected environment, with substrate humidity maintained with water replacement at three periods (8, 12, and 17 hours), operating a manual watering can. Commercial substrate (MecPlant™) was used, and the residues were previously mixed, in the proportion of 20%, according to the respective treatment. Bokashi was produced on a rural property in the municipality of Ubiratã-PR, using efficient microorganisms collected in a permanent preservation area, according to the methodology described by Siqueira & Siqueira (2013), later incorporated into the substrate at a 5% proportion of the mass. Each repetition was characterized as a cell, disregarding the peripheral cells (border).

Thirty days after sowing (DAS) evaluated the development, analyzing the fresh and dry mass of the aerial part (stem and leaves), the number of leaves per seedling, and relative water content (RWC) in the leaves and foliar pigments.

The fresh mass determination used an analytical balance (±0.001 g). Then, the samples were kept in an oven with forced air circulation (65°C) until reaching constant mass, determining execution on an analytical balance to analyze the dry mass. Finally, the RWC was calculated according to equation 1, considering leaf tissue samples' fresh, turgid, and dry mass.

$$RWC = \left(\frac{(Fm - Dm)}{(Tm - Dm)}\right) x100 \ (Equation\ 1)$$

Where,

RWC = relative water content (%);

Fm = fresh mass (g);

Dm = dry mass (g);

Tm = turgid mass (g).

The analysis of leaf pigments was conducted using 150 mg of the fresh mass of leaf tissue extracted with pure acetone (2 mL) and determination of chlorophyll a, chlorophyll b, total chlorophyll (a+b), and carotenoids by spectrometry according to Lichthenthaler (1987).

Analysis of variance performed on data and averages compared by Tukey's test (0.05) using the SISVAR software (Ferreira, 2019). In addition, the linear correlation of the variables found with the Microsoft Excell ™ software and the morphological components multivariate analysis (dendrogram and principal component analysis (PCA)) with the Past 4.06 software 4.06™.

Results and Discussion

The use of residues and bokashi fermented compost in the substrate was significantly influenced ($p<0.05$). The adoption of residues to the substrate reduced the accumulation of mass (fresh and dry) of the aerial part, while the use of bokashi favored the development of seedlings (Table 1).

Table 1. Development of cauliflower seedlings as a function of the addition of organic residues and bokashi in the substrate.

Treatament [1]	*Bokashi* (%)	Stalk		Leaf		Leafs seeding	RWC
		Fresh Mass	Dry Mass	Fresh Mass	Dry Mass		
Control	0	63.2 bA	9.55 aA	167.9 bA	38.6 aA	3.5 aA	97.09 aA
	5	152.6 aA	8.17 aA	368.4 aA	37.4 aA	4.0 aA	82.70 bB
RC	0	17.4 bC	2.0 bB	48.3 bB	7.4 bB	2.2 bB	67.49 bC
	5	93.8 aB	7.1 aB	340.5 aA	32.4 aB	3.7 aA	96.53 aA
RM	0	11.7 bC	1.8 bB	43.4 bB	6.3 bB	2.0 bB	74.18 aC
	5	44.1 aC	3.6 aC	160.2 aB	18.0 aC	3.7 aA	73.22 aC
RE	0	13.9 bC	2.0 bB	44.2 bB	7.1 bB	2.0 bB	77.71 aB
	5	85.3 aB	6.6 aB	357.1 aA	31.2 aB	3.5 aA	80.61 aB
MR	0	41.4 bB	1.7 bB	38.9 bB	5.6 bB	3.0 aA	82.98 bB
	5	100.2 aB	9.4 aA	294.6 aB	36.4 aA	3.7 aA	90.99 aA
CV (%)		53.61	55.23	48.48	54.86	15.33	12.84

[1] Control-commercial substitution; RC- commercial substrate with 20% coffee flour; RM- commercial substrate with 20% corn milk; RE- commercial substrate with 20% yerba mate yeast; MR-commercial substrate with 20% of different residues (coffee, corn, and yerba mate); RWC- relative water content.

*Different, lowercase for bokashi dose and significant letters for substrate composition, mean Tukey difference at 5% significance.

According to Oliveira et al. (2019), high concentrations of coffee residues can present toxicity to plants, reducing mass accumulation due to caffeine and phenols that have allelopathic effects. Although the use of residues and alternative sources in the development of seedlings presents environmental and economic benefits, the efficiency in the performance of seedlings is associated with chemical, physical and biological changes caused (Antunes et al., 2021).

Regarding the number of leaves per seedling, in the condition without the use of bokashi (0%), there was no significant difference from the control, only using a mixture of residues to the substrate (MR). Comparatively, in the condition of application of bokashi (5%), there was no significant difference (Table 1). Xavier (et al., 2019) obtained similar results regarding the positive influence of the use of bokashi on the number of leaves in cabbage seedlings.

The increase in seedling development through the use of bokashi is associated with an improvement in the quality of the substrate, considering that the bokashi compound improves fertility and biological activity parameters, enhancing plant production (Quiroz & Céspedes, 2019; Olle, 2021).

Although univariate analysis (Table 1) allows the comparison of results considering each source of variation, the adoption of multivariate analysis allows a joint comparison of sources of variation (Kemsley et al., 2019). In the averages grouping using a dendrogram, regarding fresh mass, the smallest Euclidean distance concerning the control group used a mixture of residues with the application of bokashi (RM (B5)), and dry mass results were similar (Figure 1).

According to the principal component analysis (PCA), the adoption of bokashi in the control treatment affected fresh mass, the substrate with yerba mate residues, and the substrate with coffee residues (Figure 2).

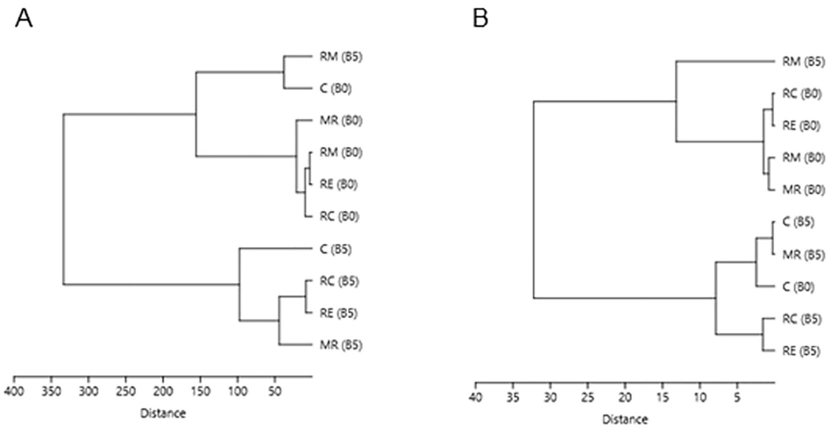

Figure 1. Dendrogram of fresh (A) and dry (B) shoots of cauliflower seedlings

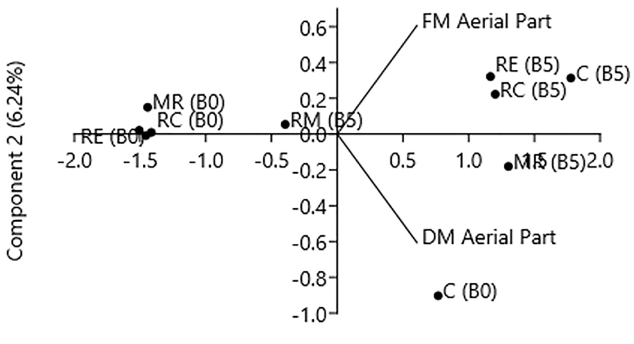

Figure 2. Principal component analysis (PCA) as a function of fresh (FM) and dry (DM) mass of the aerial part of cauliflower seedlings.

The accumulation of dry mass in the shoot presented better results (Figure 2) for control without the application of bokashi (C(B0)) and the mixture of residues with bokashi (MR(B5) corroborating the results presented in Table 1.

The accumulation of stem fresh mass and height exhibited a high correlation (0.95) during the global analysis of the data, while the dry mass of the seedlings presented a high correlation (0.99) with the dry mass of the leaves (Table 3), demonstrating that the developmental condition affects all plant components.

The substrate condition and the use of bokashi also influenced the content of leaf pigments, with the control treatment showing higher values for chlorophylls and carotenoids (Table 4).

Table 3. Linear correlation of morphological variables of cauliflower seedlings

	FM stalk	DM stalk	FM leaf	DM leaf	Leaves/seedling	Height
FM stalk	1.00	-	-	-	-	-
DM stalk	0.81	1.00	-	-	-	-
FM leaf	0.91	0.81	1.00	-	-	-
DM leaf	0.85	0.99	0.88	1.00	-	-
Leaves / seedling	0.85	0.79	0.83	0.84	1.00	-
Height	0.95	0.87	0.87	0.88	0.82	1.00

***FM- fresh** mass; MS - dry mass.

Table 4. Chlorophyll and carotenoid content in cauliflower leaves.

Treatment	Chlorophyll a	Chlorophyll b	Chlorophyll a+b	Carotenoids
Control (B0)	20.89 a	24.95 a	45.84 a	11.56 a
Control (B5)	20.49 b	23.13 a	43.62 a	11.56 a
RC	20.19 b	20.85 b	41.04 ab	10.81 ab
RM	19.26 c	15.01 c	34.27 b	10.58 b
RE	20.75 a	19.81 b	40.56 ab	10.99 a
MR	20.25 b	23.31 a	43.56 a	10.89 ab
CV (%)	4.85	31.09	17.02	4.95

RC- the commercial substrate with 20% coffee residue; RM- commercial substrate with 20% corn residue; RE- commercial substrate with 20% yerba mate residue; MR- commercial substrate with 20% of different residues (coffee, corn, and yerba mate).

According to Nasser (2018), the use of bokashi in soil preparation for kale seedlings indicated that the organic compost did not positively affect the leaf pigments, being similar to the study where seedlings obtained from the substrate with bokashi presented the content of chlorophyll lower than the bokashi-free condition (Table 4).

The proportion of chlorophyll a, chlorophyll b, and carotenoids is associated with the environment and crop management (Moura Neto et al., 2021). There is an increase in carotenoid levels during the development of cauliflower under stress conditions (Wenneck et al., 2021). However, in the study, the carotenoid content was lower only for substrate with corn residues.

Lower values were also obtained for chlorophyll a, chlorophyll b, and total using corn residues in the substrate, concerning the control, indicating damage to the accumulation of foliar pigments with possible reflections on photosynthetic activity and morphological development.

In general, the use of residues with the substrate negatively affected the development of seedlings. Furthermore, the addition of compounds to the substrate can change the physical and chemical characteristics of the material, requiring material processing before mixing with the substrate, as observed by Bustamante et al. (2021) when using compost from livestock waste (animal origin) as a substrate.

However, further studies are necessary to define adequate proportions of materials and cover new plant species.

Conclusions

The bokashi compost favored the development of cauliflower seedlings.

The addition of agricultural residues presented efficiency only when incorporated with bokashi.

The residue mixture performed best on the cauliflower seedlings by adding organic residues to the substrate.

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