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Effective microorganisms on the development of green cabbage

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Abstract

The cabbage culture has economic importance for small farmers, being one of the most consumed vegetables in Brazil, which demands more sustainable and low-cost technologies for its cultivation. Thus, the objective of this work was to analyze the influence of fertilization with biofetilizer enriched with effective microorganisms (EM) on the development of green cabbage (*Brassica oleracea var. capitata.*) in agroecological production management. The experimental design was in randomized blocks with four treatments: (T1 – 0.0%; T2 – 5.0% (0.25 L of inoculated solution for 5 L of dechlorinated mineral water); T3 - 10% (0. 5 L of inoculated solution to 5 L of dechlorinated mineral water) and T4 – 20% (0.75 L of inoculated solution to 5 L of dechlorinated mineral water) and 5 replications. Traits of growth, development and production were evaluated. The data were submitted to analysis of variance and linear regression. The characteristics circumference, longitudinal diameter, transversal diameter, marketable fresh mass, total fresh mass, nitrogen content, protein and moisture showed significant effects in response to EM doses. In general, the regression model with the best fit was the quadratic, with the maximum points close to the 10% dose of effective microorganisms, which is recommend for cabbage crops under agroecological production management.

Keywords: agroecological management, *Brassica oleracea var. capitata.*, organic production, vegetables

Introduction

The cabbage is a vegetable of great importance in human consumption due to its high nutritional quality, and also because of the ease of acquisition and low cost to the consumer (Filgueira, 2013). It is the third most consumed vegetable in the Brazilian market, characterized by intensive production and involvement of family farmers (Perin *et al.,* 2015; Cassol *et al*., 2017).

The economic importance of cabbage is related to the high profitability of the crop due to the high volume of production and consumption. In Brazil, the commercial cultivation of two varieties of cabbage is more common, the green cabbage (*Brassica oleracea var. capitata.*) and red cabbage (*Brassica oleracea L. var. captain f. rubra*), both have rounded and waxy leaves, with the formation of a compact head in which they occupy a cultivated area of over 35,000 ha and a production of over 417,000 ton (Santos *et al.*, 2016; Melo *et al.*, 2019).

According to Silva (2021), among vegetables, cabbage has a high demand for nutrients because of the high productivity of dry matter in a short period of time, which must be considered to restore the export of nutrients and maintain fertility of the soil and, with that, the cultivation of cabbage rises mainly with the high prices of mineral fertilizers.

With trends of increased production and consumption, goals of constant research on the culture arise, mainly with regard to the morpho-agronomic and bromatological characteristics in which they are decisive for commercialization, mainly considering the new feeding pattern, in which there is concern, in addition to food security, with more sustainable production (Reis *et al.,* 2017).

Faced with this reality, sustainable alternatives that promote the increase of nutrients for the crop and that, at the same time, are ecologically correct,

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economically viable and socially safe from the food point of view, have been sought, as is the case of the use of effective microorganisms (EM) in partial or even total replacement of synthetic fertilization (Torres *et al.,* 2017).

Baldoto and Baldoto (2016) suggested the use of EM associated with organic waste to improve the physical, chemical and biological characteristics of the soil, significantly influencing the productivity and quality of the products generated. This biofertilizer, in addition to providing greater protection and resistance to plants against attack by pests and diseases, reduces the use of mineral fertilizers, making it possible to reduce production costs, associated with the ease of producing it inside the rural property (Lew *et al.*, 2021).

It is believed that, according to the innumerable benefits linked to effective microorganisms, with the increase in doses of biofertilizer enriched with microorganisms, there will be an increase in the characteristics of growth, development and production of cabbage. Thus, the objective of this work was to analyze the influence of fertilization with biofertilizer enriched with different concentrations of microorganisms effective on the development of green cabbage *(Brassica oleracea var. capitate.)*.

Material and Methods

Plant material and site preparation

The work was carried out at the Federal Institute of Espírito Santo (IFES), in the municipality of Alegre - ES, at coordinates 20°45'44''S and 41°27'43''W, 134 m altitude, in 2019. According to the KÖPPEN & GEIGER classification, the climate in the region is type Aw, with significant rainfall in the summer and dry winters, with annual precipitation around 1,200 mm and an average annual temperature of 23°C (Inmet, 2022).

To prepare the seedlings, seeds of the hybrid Esmeralda 235 (ISLA pro®) were used. Sowing was carried out in trays of 128 cells using Basaplant ® as commercial substrate. According to the manufacturer, the substrate is enriched with NPK and micronutrients, and composed of pine, charcoal, peat fibrous and vermiculite. In addition, it has 150% water holding capacity, electrical conductivity of 2.0 +/- 0.3 mS cm^{-1} and pH of 5.8 +/- 0.5.

The trays were arranged for germination in a greenhouse under cover in translucent polypropylene material followed by a shading screen with 50% brightness. Then, they were placed on a platform located 70 cm above the ground. When the seedlings reached 10 cm in height, they were transplanted at 80 cm x 30 cm spacing in beds of 1.2 m wide and 2 m long.

The soil used in the experiment had the following characteristics: M.O: 14 g/dm^3, pH: 5.8, P: 34.2 mg/dm^3, K: 72 mg/dm^3, Ca: 2.6 cmol/dm^3, Mg: 0.8, cmol/dm^3, Al: 0.18 cmol/dm^3, H+Al : 5.30 cmol/dm^3, SB: 4.58 cmol/dm^3, CTC: 8.88 cmol/dm^3, V: 50%, K in CTC: 2%, Ca in CTC: 29%, Mg in CTC: 9%, Al in CTC: 2.0%, H+Al in CTC: 60 % , P-rem : 32.7 mg/L, S. monoic : 20 mg/dm^3, B: 0.60 mg/dm^3, Zn: 1.2 mg/dm^3, Mn: 1.1 mg/dm^3, Cu: 0.3 mg/dm^3, Fe: 1.2 mg/dm^3.

For transplanting, the land was prepared with plowing, harrowing and raising the beds with a roadbed. Irrigation was carried out by sprinkling, with a daily watering shift to meet demand during the crop cycle. The control of spontaneous plants was with the aid of hoes between the rows and manual pulling within the rows. The biofertilizer was applied via the soil by means of manual costal spraying during transplanting. No complementary fertilization was carried out during the experiment.

Obtaining effective microorganisms

For obtaining and preparing the microorganisms, the recommendations of Siqueira & Siqueira (2013) were followed. Initially, the microorganisms were captured. For this, trays containing cooked rice free of oil and salt were used, coated with screens which were arranged in some points of the forest of the pole of environmental education of the IFES-Campus of Alegre, the place has an area of 70 ha of reserve forest with high plant diversity. The material remained for approximately 15 days on site for inoculation of effective microorganisms.

The formation of colonies of different shades of orange color was observed, discarding the parts with gray, brown and black color in which they are not representative of the group of microorganisms that make up the EM, which according to Siqueira & Siqueira (2013) yeasts of the genus *Saccharomyces*, *actnomycetes*, bacteria that produce lactic acid '*Lactobacillus*' and '*Pediococcus*' and photosynthetic bacteria can be mentioned.

To prepare the solution, four transparent PET® bottles with a two-liter capacity were used, where 200 g of orange-colored colonies were inserted, along with 200 mL of sugarcane molasses per bottle, completing the volume with dechlorinated water. This process was carried out with the aim of multiplying the microorganisms, using sugar from sugar cane molasses as a source of supply. To avoid possible breakage of the bottles, at intervals of 2 days, they were depressurized. This process occurred until the absence of fermentation could be verified, which lasted from 15 to 30 days. In the preparation of the final solution, the contents of the bottles were homogenized in a single container for subsequent preparation and dilution of the solutions.

Experimental design

It was used randomized blocks, with four treatments and five repetitions, in which each bed represented a repetition with 10 useful plants per experimental unit, that is, 20 beds were implemented, totaling an area of approximately 50 m².

The treatments consisted of the dilution of a highly concentrated standard solution of effective microorganisms. For the preparation of the four concentrations (treatments) of the biofertilizer solutions, a 500 mL beaker was used, proceeding with the determinations of each treatment according to its concentration, in which they were T1 - 0.0% (mineral water without chlorine only); T2 – 5.0% (0.25 L of inoculated solution to 5 L of dechlorinated mineral water); T3 - 10% (0.5 L of inoculated solution to 5 L of dechlorinated mineral water) and T4 – 20% (0.75 L of inoculated solution to 5 L of dechlorinated mineral water).

Evaluated variables and statistical analysis

It was determined as the harvest point, the 40 days after the transplanting (DAT) evaluating at this moment the following characteristics: ALT - Plant height (cm); CIR - head circumference (cm); DIAL - longitudinal diameter of the head (cm); DIAT - transversal diameter of the head (cm); DIAC – stem diameter (cm); MFC - commercial fresh mass (kg); PCF – total fresh mass (kg); PR – root fresh mass (g); PMSR - root dry mass (kg); NIT - head nitrogen content (%); PROT - head protein (%); LIPI - head lipid (%); UMI - moisture in the head (%) and CIN - ash content in the head (%). The inclusion of leaves that are not marketed was considered in the total fresh mass variable.

The data from the evaluations carried out were submitted to analysis of variance with the aid of the statistical software Rbio vs. 126 (Bhering, 2017) and the graphs in R vs. 4.0.1(R Core Team, 2020), with the help of the ggplot2 package.

Results and Discussion

The use of effective doses of microorganisms influenced the growth, development and production of cabbage under agroecological management. The 10% dose provided the best crop development, with an average production of 1.33 kg/plant.

There was no significant difference for the variables: plant height (ALT), stem diameter (DIAC), root fresh mass (PR), root dry mass (PMSR) and ash (CIN) (**Table 1**). Calero *et al.*, (2019) and Nuñez *et al.*, (2017) reported contrasting results in *Phaseolus vulgaris* L. and *Daucus carota* L., respectively, which showed an increase in the height and diameter of the stem of these plants after the application of effective microorganisms. Díaz *et al.*, (2019) found a stimulating effect on morphological, physiological and biochemical parameters in *Sorghum bicolor* L. after its seeds were submerged in a solution based on effective microorganisms.

For the other variables (CIR, DIAL, DIAT, MFC, PCF, NIT, PROT, OIL and UMI) there was a significant effect for doses of effective microorganisms. In addition, the use of this biofertilizer may be related to the decomposition of organic matter, favoring the release of nutrients to plants. With so much spending on chemical inputs, ensuring a way to attribute productivity gains through organic fertilizers allows the producer to lower production costs (Xavier *et al.*, 2019), *which* makes the biofertilizer enriched with effective microorganisms promising.

The characteristics CIR, DIAL, DIAT, MFC, PCF, NIT, PROT and UMI had a quadratic effect in response to fertilizer doses with ME $p \leq 0.05$. All traits had R2 ≥ 80%, a percentage considered good for the regression model to explain most of the variation of the trait evaluated in response to EM fertilization doses. The significant model for lipid was of the third degree (Table 1), however, we considered using the quadratic model since the cubic model does not follow a biological behavior.

For the characteristic fresh mass of the head (kg), the maximum extreme point was 1.33 kg/plant with the application of 10% EM (**Figure 1**A) higher than that obtained by Ferreira *et al.*, (2021) working with experiments of cabbage with different organic fertilizations where they obtained average results of fresh mass of "head" of 1.22 kg/plant. The total fresh mass had a maximum extreme point of 2.27 kg/plant with the application of 10.10% EM (Figure 1E).

Several publications present commercial characteristics of cabbage. Moreira *et al.*, (2011) reveal that there was quadratic effect ($p<0.01$) of nitrogen doses on cabbage yield. In addition, head fresh mass (MFC) responded markedly to the increase in nitrogen doses with an estimated maximum value of 1.13 kg with a dose of 277.8 kg N ha^{-1}, showing the importance of this element for the cabbage production. However, the result of fresh mass (kg) found in this experiment shows that the small farmer will have savings if he chooses to use effective microorganisms, in addition, he can reach a fresh mass of the head of 1.33 (kg) using the dose of 10% of EM (Figure 1A).

The characteristic Circumference (cm) had a maximum extreme point of 58.98 cm with the application of 10.60% EM (Figure 1B). It is evident that the use

Table 1 - Summary of analysis of variance with mean squares (MS) of the morphoagronomic and bromatological characters of cabbage in response to inoculation with effective microorganisms. ALT (cm); CIR - circumference (cm); DIAL - longitudinal diameter (cm); DIAT - transverse diameter (cm); DIAC – stem diameter (cm); MFC - commercial fresh mass (kg); PCF – total fresh mass (kg); PR – root fresh mass (g); PMSR - root dry mass (kg); NIT - nitrogen content (%); PROT - protein (%); LIPI - lipid (%); UMI - moisture (%) and CIN - ash content (%)

SV	DF	ALT	CIR	DIAL	DIAT	DIAC	MFC	PCF	PR	PMSR	NIT	PROT	LIPI	UMI	CIN
		------------(cm)----------					----------(kg)--------				--------------(%)------------				
Treatment	3	5.78ns	265.43*	46.34*	178.04*	0.009ns	0.68*	1.60*	0.17ns	1.17ns	0.29*	11.38*	8.37*	0.79*	0.001ns
Linear	1	-	5.14ns	0.85ns	8.14ns	-	0.006ns	0.03ns	-	-	0.01ns	0.44ns	4.21ns	0.81*	-
Quadratic	1	-	778.02*	131.74*	166.91*	-	1.95*	4.58*	-	-	0.73*	28.67*	7.31ns	1.43*	-
Cubic	1	-	13.13ns	6.43ns	2.98ns	-	0.09ns	0.20ns	-	-	0.12*	5.03*	13.58*	0.13*	-
Residue	16	1.82	17.15	2.91	95.40	0.032	0.05	0.11	0.22	0.71	0.004	0.17	1.73	0.008	0.002
CV%	-	7.88	8.15	8.46	12.44	9.14	24.94	20.58	16.76	10.6	4.66	4.57	16.28	0.1	9

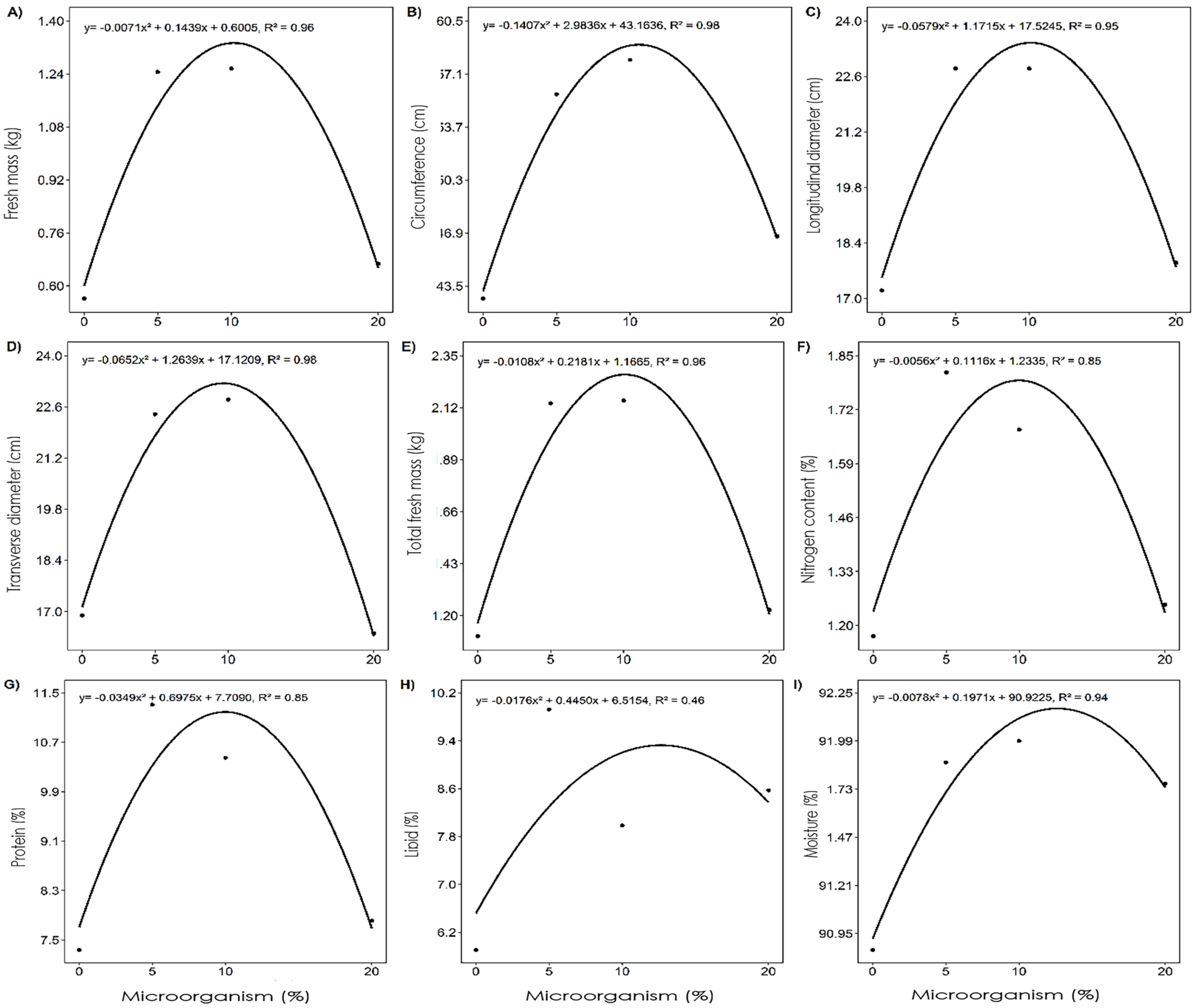

Figure 1 - Fresh mass (kg); circumference (cm); longitudinal diameter (cm); transverse diameter (cm); total fresh mass (kg); nitrogen content (%); protein (%); lipid (%) and moisture (%) in the head.

of effective microorganisms is promising since the aforementioned characteristic is too important because it has a direct relationship with the increase in cabbage productivity.

The maximum extreme point for the characteristic Longitudinal diameter (cm) was 23.45 cm with the application of 10% EM (Figure 1C), much higher than that found by Oliveira *et al.,* (2001) in which the longitudinal diameter of the cabbage heads reached 13.0 cm and 12.0 cm using 46.0 t/ha of bovine manure and 29.0 t/

ha of earthworm humus, respectively. Vargas *et al.,* (2011) obtained in their studies with green manuring with legumes the average value of the horizontal diameter of the head was 19.86 cm, which was also lower than that found in this study. As for the extreme maximum point for the Transverse diameter (cm) characteristic, it was 23 .25 cm with the application of 9.69% EM (Figure 1D).

Studies with cabbage culture should be carried out in order to analyze the existing associations between growth characteristics and the accumulation of essential nutrients in food. The leaf nitrogen content (%) reached the maximum extreme point of 1.79% cm with the application of 9.96% EM (Figure 1F). The percentage of protein found with the use of EM reached the maximum extreme point of 11.19% cm with the application of 9.99% of EM (Figure 1G).

According to Aquino *et al.,* (2005) in studies with chemical fertilizers of cabbage, observed that the contents of nitrogen and protein in the head, similarly to the growth characteristics, increased with the increase in N doses. It is important to show that this increase does not was linear in relation to the increments in the percentage of EM, however good results related to these parameters were found.

It is known that lipids are extremely important in human nutrition, especially for providing energy to the body, as well as for the synthesis of important hormones such as testosterone. In this sense, the use of only 12,642% of EM was able to supply 9,328% of lipid (Figure 1H) in only one cabbage plant, which tends to contribute to the improvement of texture and flavor. As for moisture, it is observed that the highest percentage was 92.2% using the dose of 12,967 of EM (Figure 1I). For a result like this, it is essential to use the water supply through daily irrigation, especially in hot regions such as the region where this study was carried out.

Conclusion

The use of doses of effective microorganisms (EM) affected the development and production of cabbage, with the maximum points close to the 10% dose, which is indicated for cabbage crops under agroecological production management.

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