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NITROGEN FERTILIZATION IN THE DEVELOPMENT OF Brassica oleracea L.

ADUBAÇÃO NITROGENADA NO DESENVOLVIMENTO DE Brassica oleracea L.

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Abstract: Leaf kale is a crop that is widely consumed today due to the new ways of using it in cooking and its nutritional properties. However, the crop has a high requirement for nitrogen fertilization, so the excessive application of mineral fertilizers causes environmental impacts. Considering the importance of kale and its high nutritional requirement, the objective of this work was to evaluate the effect of organomineral fertilization on the development of kale cv. Butter. The treatments were distributed in randomized blocks, in a 2x4 factorial scheme, referring to two sources of nitrogen (urea and cattle manure) and four doses of fertilizers (0, 50, 100 and 150% of the dose of 120 kg ha-1 of nitrogen) with three replications and during two growing seasons. The sources used were urea and bovine manure. Plant height, number of leaves, leaf area, stem diameter, fresh and dry mass of shoots were analyzed. The organomineral fertilization positively influenced the development of the aerial part. Cultivation season 1 favored the increase of the evaluated variables with a lower percentage of organomineral used. Greater number of leaves was achieved by using 150% (higher dose) of fertilizers in season 2.

Keywords: *Brassica oleracea* L. Nutrition. Bovine Manure. Urea.

Resumo: A couve de folhas é uma cultura muito consumida atualmente em função das novas maneiras de utilização na culinária e às suas propriedades nutricêuticas. Porém, a cultura possui alta exigência de adubação nitrogenada, com isso a aplicação excessiva de adubos minerais ocasiona impactos ambientais. Tendo em vista a importância da couve de

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folhas e sua alta exigência nutricional, o objetivo deste trabalho foi avaliar o efeito da adubação organomineral no desenvolvimento da couve de folhas cv. Manteiga. Os tratamentos foram distribuídos em blocos ao acaso, em esquema fatorial 2x4, referente a duas fontes de nitrogênio (ureia e esterco bovino) e quatro doses dos adubos (0, 50, 100 e 150% da dose de 120 kg ha^{-1} de nitrogênio) com três repetições e durante duas épocas de cultivo. As fontes utilizadas foram ureia e esterco bovino. Foram analisados altura de plantas, número de folhas, área foliar, diametro caulinar, massa fresca e seca da parte aérea. A adubação organomineral influenciou positivamente no desenvolvimento da parte aérea. A época 1 de cultivo favoreceu o aumento das variáveis avaliadas com menor percentual de organomineral utilizado. Maior número de folhas foi alcançado pelo o uso de 150% (maior dose) dos adubos na época 2.

Palavras-chave: *Brassica oleracea* L. Nutrição. Esterco Bovino. Ureia.

Introduction

The leaves kale (*Brassica oleracea* L., var. acephala) is an annual shrubby vegetable of the Brassicaceae family and stands out commercially in Brazil due to its use in cooking, nutraceutical properties, high productivity and rusticity (1). However, this vegetable has high nutritional requirements, which most of the time make necessary the application and replacement of fertilizers to promote its better development and yield (2).

Nitrogen (N) is one of the key macronutrients for rapid and vigorous crop growth and is directly related to the growth and yield increase of hardwoods. The use of mineral fertilizers is therefore one of the alternatives employed to make nutrients available in greater quantities and with rapid absorption by the plant, such as urea (3).

Organic fertilizers, be they of vegetable or animal source, have also represented great relevance in the cultivation of horticultural plants, considering that their composition is very varied and acts on the soil improving its physical and chemical characteristics in a gradual way. Their application to the soil favors the exchange of cations, a factor responsible for the retention of positively charged nutrients such as N(4;5).

Studies report the efficiency of the use of chemical and organic fertilizers in vegetable yields. Dartora *et al.* (3) studying the performance of Malaysian cabbage under N fertilization using urea as a source, stated greater growth and increase in production by the use of N, mainly by the use of the 195 kg ha^{-1} dose of N. At the time, Peixoto Filho *et al.*(6) verified maximum yield in lettuce, through the use of bovine manure as a source of N.

However, the efficient management of fertilizers for agricultural crops is important, avoiding their inappropriate use and rapid mineralization during periods of high or low

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demand. In view of the above, the purpose of this study was to evaluate the development of the leaves kale, cv. Manteiga, due to the use of organomineral fertilization during two seasons of cultivation.

Methodology

The work was developed under field conditions of the experimental area of the Federal University of Campina Grande, Center of Sciences and Agrifood Technology, in Pombal-PB. The geographical location corresponds to latitude 06º47'04.0" S, longitude 37º48'09.3" W and altitude 186 meters.

According to the Köppen classification, the region's climate is of the BSh type, characterized as hot and dry semiarid, with an average temperature of 28ºC, annual rainfall of around 750 mm year^{-1} and average evaporation of 2000 mm. The soil is classified as Typical Optic Chromic Luvissolo [7;8].

The design was in randomized blocks in a 2 x 4 factorial scheme, referring to two sources of nitrogen (urea and cattle manure) and four doses of fertilizers (0; 50; 100 and 150%) of the reference dose of 120 kg ha^{-1} of N [9]. Furtini Neto *et al.* [10] recommended the calculation of organic fertilization using the following expression:

$$X = \frac{A}{\frac{B}{100} x \frac{C}{100} x \frac{D}{100}}$$

Where:

X = dose of organic fertilizer to be applied (kg ha^{-1});

A = dose of N required by the crop (kg ha^{-1});

B = dry matter content of organic fertilizer (%);

C = N content in organic fertilizer dry matter (%);

D = N conversion index from organic to mineral form.

The research being carried out in two seasons of the year. The first experiment was carried out from April 26 to July 21, 2017 (rainy season) and the second during the period from August 21 to December 8 (dry season) of the same year.

30 days before the start of the experiment, the experimental area was mechanically prepared by plating and grating. During this period, chemical analyses of the soil and bovine manure were also performed in the two seasons of cultivation to prepare the recommended doses (Table 1 and 2). Bovine manure was only applied at the foundation 15 days before

transplantation and urea were applied 1/3 at the foundation and the rest divided into two coverage applications performed every 20 days.

Table 1. Soil chemical analysis

	pH	N	C	OM	P	K	Na
	$CaCl_2$	**-------------- g/kg-------------**			**-------------- mg.dm³ -----------**		
Season 1	6.82	0.73	7.29	12.57	18. 20	8.11	0.11
Season 2	7.00	0.72	7.40	12.79	19.00	8.30	0.13

Source: Prepared by the authors.

Table 2. Chemical analysis of manure

	pH	N	C	OM	DMC	P	K	Na
	$CaCl_2$	**------------- g/kg----------------**			**(%)**	**------- mg.dm³ ------**		
Season 1	6.48	2.48	22.79	39.3	70.00	20.01	10.37	0.25
Season 2	6.59	2.50	23.03	41.2	93.01	21.78	11.34	0.29

OM= Organic matter; DMC= Dry matter content.
Source: Prepared by the authors.

Seeds of the leaves kale, cv. Manteiga, from Feltrin® were used. They were sown in Styrofoam trays of 200 cells, filled with Basaplant® substrate for the production of seedlings, and when the majority obtained three definitive leaves, they were transplanted to the experimental area.

During the entire experimental period, the main climatic conditions of the region were monitored by means of a hygrometer and a pluviometer, the values found being expressed in Table 3.

Table 3. Climatic data during the conduct of the experiment, UFCG, Pombal-PB, 2017

Season 1	Climate data	
Air temperature (°C)	Minimum	20.06
	Average	27.34
	Maximum	31.09
Relative humidity (%)	Minimum	75.90
	Average	80.50
	Maximum	85.10
Rain index (mm)	April to July	225.02
Season 2	**Climate data**	
Air temperature (°C)	Minimum	23.77
	Average	29.04
	Maximum	35.67
Relative humidity (%)	Minimum	65.90
	Average	70.00
	Maximum	75.10
Rain index (mm)	August to December	20.07

Source: Prepared by the authors.

The dose factors of mineral and organic fertilizer were distributed in four plants per parcel, are considered useful for the data collection of the two central plants. Thus, the experimental area consisted of ten manually raised lines, where each block consisted of 16 parcels totaling 32 useful plants, adopting the spacing of 1 m x 0.5 m (2 m²).

For irrigation, drippers with an average flow rate of 1.8 L h^{-1} were used, with the daily slide being applied based on crop evapotranspiration, using the Blaney-Criddle method [11]. Manual weeding was also performed fortnightly, avoiding the establishment of weeds.

At 45 days after transplantation, when the plants were at harvest point, the following parameters were evaluated in both tests: number leaves (NL); leaf area (LA in m/m²) estimated by the equation: LA= 0.72087 LxW (Length x Width) according to Marcolini *et al.* [12]; plant height (PH) obtained in centimeters with the aid of a tape measure; stem diameter (SD) observed with the aid of a digital pachymeter (mm); the fresh mass of the aerial part (FMAP) obtained after weighing in a precision scale (g $plant^{-1}$) and to obtain the dry mass of the aerial part (DMAP) the plants were placed in a greenhouse at 65 °C for 72h until obtaining constant weight.

The data were submitted to analysis of variance (ANOVA) and based on significant results observed, means were tested for the time factor, and regression was applied to quantitative factors using the SISVAR program [13]. Graphs and equations of response surfaces were prepared using SigmaPlot® software and Tablecurve 3D®.

Results and Discussion

For the leaf area (Figure 1) it was verified during season 1, expansion of up to 24589.28 cm^2 with the estimated use of 110% urea associated with 110% manure, decreasing after the use of higher percentages. Excessive levels of N through the use of mineral or organic fertilizers may impair the biochemical and physiological processes of plants by nitrate accumulation [14; 15].

While, at the time 2 was observed a higher value of 26939.19 cm^2, with the use of the same organomineral association. By using 150% urea and 150% manure, a value even higher than 29546.55 cm^2 was reached. This increase leaves as a function of N increase occurs because N has a fundamental importance in the processes of ionic absorption, photosynthesis, respiration, multiplication, and cell differentiation [16].

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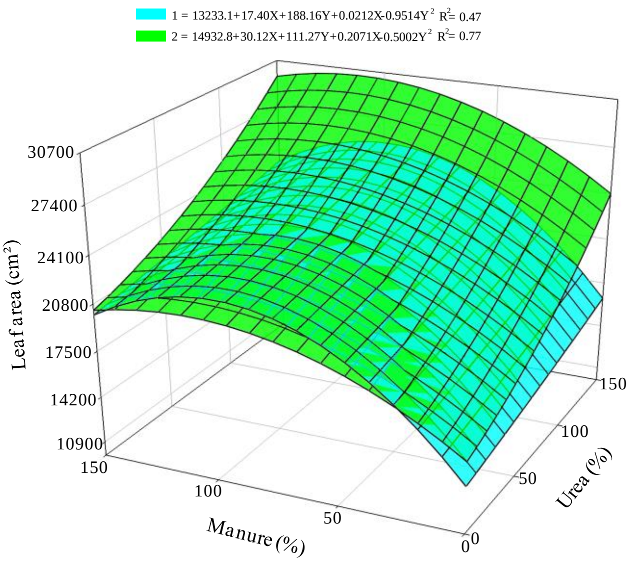

Figure 1. Leaf area of the leaves kale, depending on mineral and organic fertilizer during two growing seasons.

Regarding the number of leaves (Figure 2), it was found that in season 1 there was an increase in this parameter due to the association of mineral and organic fertilizer, the highest number being obtained by using the maximum percentage of organomineral.

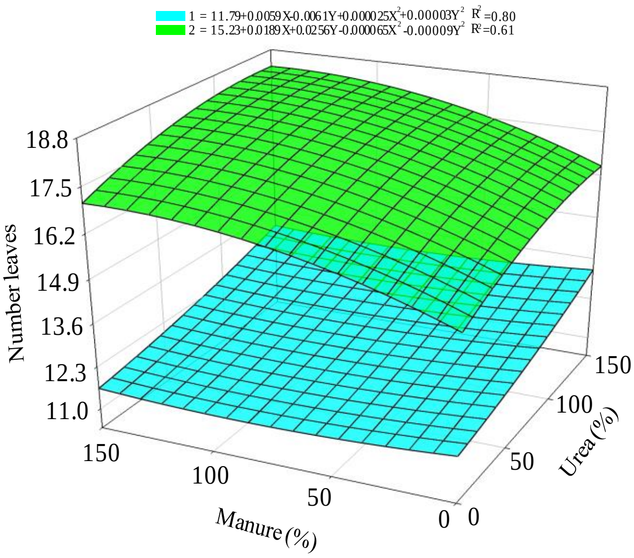

Figure 2. Number leaves of the leaves kale, depending on mineral and organic fertilizer during two growing seasons.

For season 2 a higher number of leaves was obtained with the association of 144% urea and 144% bovine manure. This fact can be explained by the increase in soil organic matter and total carbon (Table 1) in season 2, besides these factors, there was less rainfall

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and an increase in temperature (Table 3). The nitrogen applied to the soil, mainly that with manure source was mineralized in a slower way, promoting better use throughout the cycle.

According to Malavolta [17], the increase in soil organic matter provides an increase in cation exchange capacity, favoring greater retention of nutrients along with soil particles, thus reducing leaching losses. In addition, the process of mineralization of N from organic fertilizers based on bovine manure occurs mainly (0 or 5%) in the first 28 days after its addition to the soil, varying according to soil and climate conditions [18].

In height (Figure 3) the use of 82% organomineral promoted an increase of up to 9.91 cm, in season 1, with decreases from higher percentages. Contrary to what occurred in season 2, with the same percentage the height reached was 9.26 cm, gradually increasing until reaching 10.25 cm as a function of the higher percentages of both fertilizers used in this study.

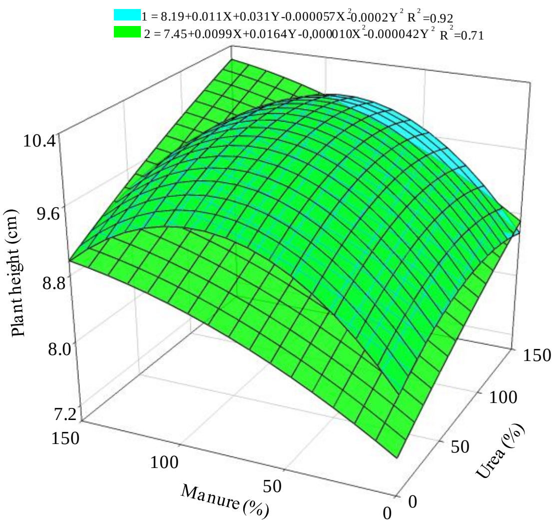

Figure 3. Plant height of the leaves kale, depending on mineral and organic fertilizer during two growing seasons.

Several authors show that the use of organomineral fertilization is more efficient than the use of only one of these materials, among them, Luz *et al.* [19] and Oliveira *et al.* [20] who found that when working with lettuce and arugula under organic and mineral fertilization they observed higher leaf yields for lettuce and the higher average height for the arugula, being the association of these a favoring of the development of these hardwoods, similarly to the present work.

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For stem diameter, in the interaction between the fertilizer sources (Figure 4A), it was verified that the percentage corresponding to 150% of urea associated with 75% of bovine manure promoted a maximum diameter of 9.13 mm. Andrade *et al.* (21) affirm that organomineral fertilization caused increases under the stem diameter in different lettuce cultivars, as well as in other growth characteristics, arguing that the absence of some essential nutrients for the plants in one of the types of fertilizer can be supplied by the combined use of another that contains, therefore the importance of the use of an organomineral is given.

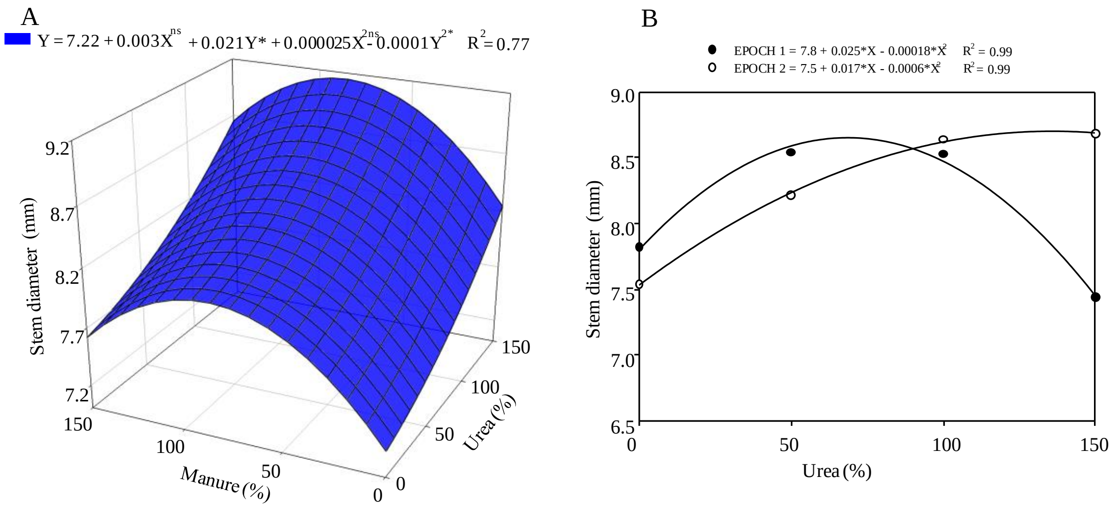

Figure 4. Stem diameter (A and B) of the leaves kale, depending on mineral and organic fertilizer during two growing seasons.

Regarding the response of the variable diameter to the interaction between the source of mineral fertilizer and the different seasons (Figure 4B), it was noticeable that during the season 1 percentage of urea above 70% caused sharp decreases. In season 2, higher the percentages favored stem diameter, with stability from 120% of mineral fertilizer.

Regarding the fresh mass of the aerial part (Figure 5) it was observed that both in season 1 and 2 the use of mineral and organic fertilizer in a higher percentage increased 130.615 and 106.47g for season 1 and 2, respectively.

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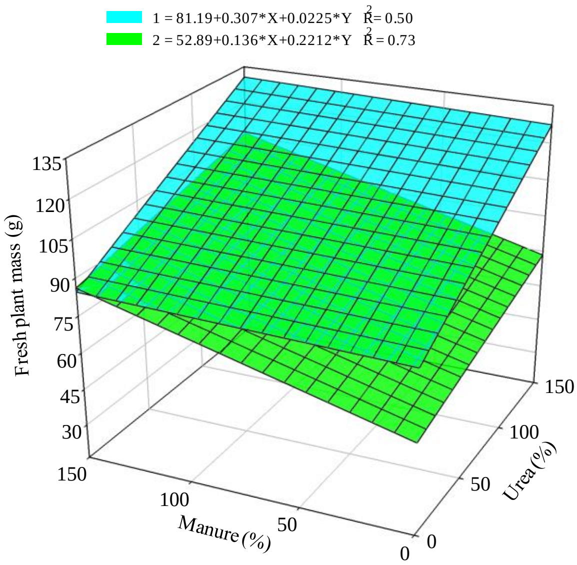

Figure 5. Fresh mass of the aerial part of the leaves kale, depending on mineral and organic fertilizer during two growing seasons.

In season 2 the crop cycle was relatively longer than in season 1, corresponding to 100 and 83 days respectively. Consequently, in the second growing season, there was a greater need for extraction and export of N by the plant. This effect may have occurred due to the different meteorological conditions during the experimental periods. Indicating that changes in temperature, humidity, and pluviometric index affect the development cycle of the plant, and these elements can act in an isolated or joint way. Santos *et al.* (22) state that climatic factors may directly interfere with the production of vegetables.

For the dry mass of the aerial part (Figure 6), during season 1 there was an increase in up to 17.04 g using the 87% dose of both fertilizers, with decreases to this parameter using higher doses. In season 2 the increase of the fertilizer doses up to 150% benefited the increase of the dry mass of the air part to 15.07 g.

When vegetables are conducted within an optimal range of conditions, photosynthesis tends to benefit and the amount of accumulated dry mass should, therefore, be favored.

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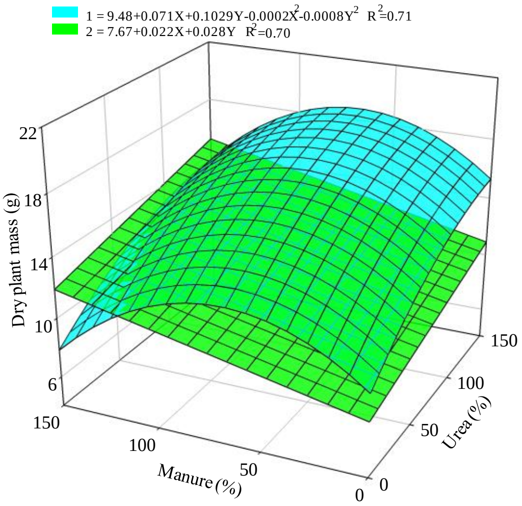

Figure 6. Dry mass of the aerial part of the leaves kale, depending on mineral and organic fertilizer during two growing seasons.

According to Silva *et al.* [23] analyzing the variable dry mass in lettuce plants, they stated that it is altered differently by the application of increasing doses of the different organic compounds evaluated, and it was found that the compounds with high concentrations of N provided significant increases in production.

Oliveira *et al.* [20], working with organic and mineral fertilization in different arrangements for the culture of the arugula, observed better performances of the aerial dry mass with organic fertilization. These factors lead us to assume that the association of bovine manure with urea is a more efficient method with respect to the production of the aerial part since the isolated use of them requires larger quantities to generate the same degree of efficiency compared to when they are applied associated.

Based on the results obtained, the growing seasons considering the edaphoclimatic factors may present impacts on the development leaves' kale, however, the use of organomineral fertilization is efficient for the improvement of practices in agricultural production.

Conclusions

The use of organomineral fertilization benefits the development of the leaves kale cv. Manteiga, var. acephala. The first season of cultivation contribut to a greater increase in the

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variables evaluated with a lower percentage of organomineral. The higher number of leaves was achieved by the use of 150% organomineral in season 2.

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