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Plant growth and yield of butter kale (*Brassica oleracea* L. var. *acephala*), as influenced by the combined application of bovine manure and rock powder

Efecto de la aplicación combinada de estiércol bovino y polvo de roca en el crecimiento y producción de col rizada (*Brassica oleracea* L. var. *acephala*)

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Abstract

The supply of organic matter in soil of arid and semiarid in Brazilian regions is very import, as it allows to increase crop yields. However, there are few studies on alternative sources of fertilizer for vegetables. Therefore, the objective was to evaluate the effect of different doses of bovine manure and rock powder (RP) on growth characteristics, concentration of chlorophyll, and physiological indices and production of (*B. oleracea* L. var. *acephala*). The treatments were arranged in five randomized blocks in a factorial 4 x 4 reference doses of bovine manure (60, 120, 180 and 240 g pit⁻¹) combined with doses of rock powder (6, 12, 18 and 24 g pit⁻¹). Doses of bovine manure and rock powder of 180 and 18 g, respectively, increased the growth of *B. oleracea* by plant height, stem diameter, leaf number. The combination doses of bovine manure 120 g + 12 g rock powder and 120 g of bovine manure + 18 g rock powder, provided, in this order, larger leaf area results for the productivity of *B. oleracea*. The bovine manure promotes greater concentration of CO₂, net photosynthesis and stomatal conductance of *B. oleracea* plant, while rock powder limits these characteristics. Intermediate doses of bovine manure and RP promote higher growth and yield of *B. oleracea*.

Key words: *Brassica oleracea*, agricultural fertilizers, organic matter.

Resumen

El suministro de materia orgánica en suelos áridos y semiáridos en las regiones brasileñas permite aumentar los rendimientos de los cultivos. Sin embargo, hay pocos estudios sobre estas fuentes alternativas de fertilizantes para vegetales. Por tanto, el objetivo del trabajo fue evaluar el efecto de diferentes dosis de estiércol bovino y polvo de roca en el crecimiento, la concentración de clorofila, los índices fisiológicos y la producción de *B. oleracea* L. var. *acephala*. Los tratamientos fueron dispuestos en cinco bloques aleatorizados en dosis de referencia factoriales de 4 x 4 de estiércol bovino (60, 120, 180 y 240 g por pozo) combinados con dosis de polvo de roca (6, 12, 18 y 24 g por pozo). Las dosis de estiércol bovino y polvo de roca de 180 y 18 g, respectivamente, aumentaron el crecimiento de la *B. oleracea*, la altura de planta, el diámetro del tallo y el número de hojas. Las dosis combinadas de estiércol bovino 120 g + 12 g de polvo de roca y 120 g de estiércol bovino + 18 g de polvo de roca, proporcionan, en este orden, mayores resultados de área foliar para la productividad de la *B. oleracea*. El estiércol bovino promueve una mayor concentración de CO₂, la fotosíntesis neta y la conductancia estomática de la planta de *B. oleracea*, mientras que el polvo de roca limita estas características. Las dosis intermedias de estiércol bovino y polvo de roca promueven un mayor crecimiento y rendimiento de la *B. oleracea*.

Palabras clave: *Brassica oleracea*, fertilizantes agrícolas, materia orgánica.

Introduction

The cultivation of vegetables in Paraíba Agrest is mainly performed in soils with low content of organic matter. Moreover, they are characterized as acidic and poor in nutrients, caused in most cases by intensive agricultural use, which have the need for continued use of mineral fertilizers, mainly resulting limiting carbon content (C) over the years (Conceição et al., 2014).

Even in soils with nutrient levels considered adequate, a supply of organic material becomes necessary, it allows to enhance the chemical, physical and biological properties of the soil, resulting from the action of humic acids present and available by adding organic fertilizer. Associated to those situations soils in semiarid regions present naturally low levels of organic matter, due to weather conditions favorable to decomposition, compromising even more the viability of a successful farm, and there should have application of organic matter that can supply the nutrient requirements of crops indispensably, thus while increasing cation exchange capacity (CEC) decrease evaporation losses, and increase the water storage (Nascimento et al., 2015).

As an alternative in the supply of organic matter to the soil, has been used bovine manure (BM), due to greater availability and lower cost, because its consecutive use tends to increase soil fertility, especially nitrogen (N), phosphorus (P) and potassium (K) (Tejada et al., 2016). Studies using BM to fertilize vegetables in northeastern Brazil have been conducted and proved the beneficial effect on increasing crop productivity. For instance, in the culture of watermelon, Nascimento et al. (2015) and Nascimento et al. (2017) observed that 1.10 kg dose pit^{-1} of BM promoted higher productivity and the increase of BM dose reduced the need for potassium fertilizer to increase plant productivity.

In gherkin culture, Oliveira et al. (2014) observed that the doses of 26.3 and 27.7 t ha^{-1} of BM were responsible for the maximum

commercial productivity of gherkin fruits, wherein the authors indicate that the highest values obtained with BM must be due to the larger supply of macronutrients (N, P and K). Silva et al. (2012) also observed that the BM dose of 19.2 t ha^{-1} gave the highest yield of 20.3 t ha^{-1} in commercial yam tubers.

On the other hand, stonemeal technique, a practice that allows you to provide nutrients and increase the cation exchange capacity (CEC) due to the formation of new minerals of clay during the rock change, it is another common practice in the Northeast. The technique consists of rock powder (RP) application directly into the soil, providing nutrients to the soil, moreover, it is a low cost alternative, which provide nutrients for plants in the short, medium and long term (Manning and Theodoro, 2018), and can be used to increase the quality and amount of mineral organic fertilizer raising productivity in horticultural, ensuring economy, since the use of alternative sources may reduce the intake of chemical fertilizers and minimize the environmental impacts, turning essential to the organic production system. Therefore, the objective was to evaluate the effect of different doses of manure and rock powder on growth characteristics, chlorophyll content, and physiological indices and *B. oleracea* production.

Material and methods

The experiment was conducted in experimental, located in the city of Bananeiras-PB, in the geographical coordinates 6°45'4" 35°38'0". According to the Kopen the climate classification is considered the typ As' - Tropical rainy, dry summer, irregular annual rainfall distribution (1174.7 mm), with a maximum annual temperature of 27°C and a minimum of 18,8°C, averaging 22°C yearly. Meteorological data of the experimental period are shown in Figure 1.

The treatments were arranged in five randomized blocks in a factorial 4 x 4 refers to the different doses of bovine manure (BM) (60, 120,

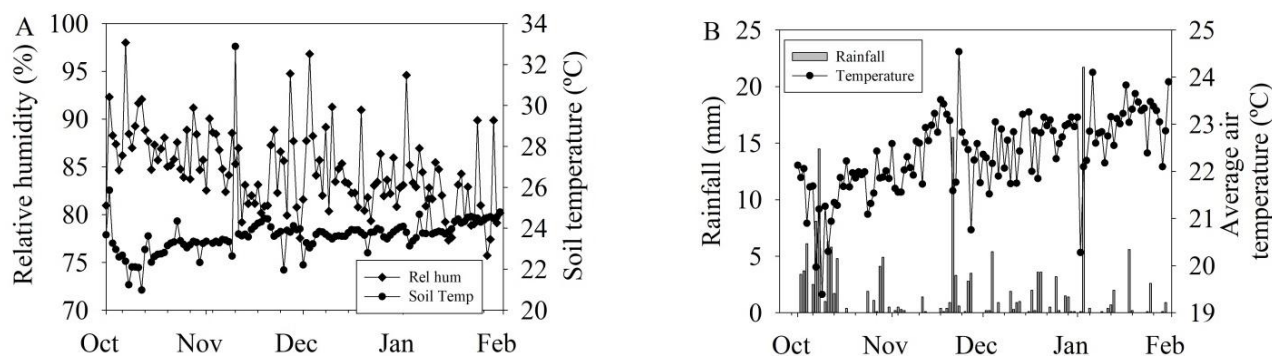


Figure 1. Graphical representation of relative humidity, soil temperature, rainfall and average air temperature in the period from October 2014 to February 2015. Data from the weather station, EFSA, PB, 2015.

180 and 240 g pit⁻¹) combined with rock powder (RP) doses (6, 12, 18 and 24 g pit⁻¹). Each block is composed of three plots of 18 m long and 1 m wide, the bed is composed of six portions and each experimental plot consisted of 14 plants spaced in 0.40 x 0.40 m making a total of 1190 plants, 85 portions and 15 beds in the studied area and 4 beds were used as surroundings.

The soil of the prevailing experimental area corresponds to Yellow Oxisol of medium texture, with gently curly relief, with deep profile, well drained, with moderate moisture retention capacity and Loam clay sandy textural class. Before conducting experiment soil simple samples were collected in the experimental area (0 - 20 cm), being homogenized and processed into composite samples, subsequently performing chemical and physical characterization (Table 1).

The seedlings of *B. oleracea* L. var. *acephala* cv. Georgia were produced in cups containing substrate composed of humus (60%), sand (30%) and bovine manure (10%). During the production of seedlings carried out a simple bio-fertilizer application at 15 days after sowing, the same being used as a natural defense.

Was used the conventional soil tillage preparation with plowing and harrowing with a subsequent lifting of the beds. Holes were made with 0.20 m depth in the transplanting seedling stage at the time when the fertilizer was also performed with the incorporation of BM and RP (MB-4®) according to the proposed treatments. The BM and RP were analyzed and showed the following characteristics, as can be seen in Table 2. The RP used was of origin of the mother rock (Neoproterozoica Brasileña s.l- Granitoids) (Santo et al., 2002) composed of 55% sand, 43% silt and 2% clay.

Table 1. Physical and chemical soil properties at the beginning of the experiment.

Physical attributes	Values	Chemical attributes	Values
Sand (g kg ⁻¹)	740	pH in H ₂ O (1.0:2.5)	6.50
Silt (g kg ⁻¹)	120	P (mg dm ⁻³)	69.5
Clay (g kg ⁻¹)	140	K ⁺ (cmol _c dm ⁻³)	0.20
CW (g kg ⁻¹)	78	Ca ²⁺ (cmol _c dm ⁻³)	3.50
DF (%)	30	Mg ²⁺ (cmol _c dm ⁻³)	2.20
DI (%)	56	Na ⁺ (cmol _c dm ⁻³)	0.20
Sd (kg dm ⁻³)	1.61	H ⁺ +Al ³⁺ (cmol _c dm ⁻³)	1.50
Pd (kg dm ⁻³)	2.60	Al ³⁺ (cmol _c dm ⁻³)	0.00
Pt (m ³ m ⁻³)	0.49	SB (cmol _c dm ⁻³)	6.1
M (m ³ m ⁻³)	0.049	CECpH7 (cmol _c dm ⁻³)	7.6
m (m ³ m ⁻³)	0.442	EC (%)	0.00
Fhc (m ³ m ⁻³)	0.209	V (%)	80.26
Wpt (m ³ m ⁻³)	0.134	O.M. (g dm ⁻³)	24.96
Aw (g kg ⁻¹)	0.074	-	-

After transplantation and fertilization, the beds were covered with straw *Brachiaria decumbens* in a layer of 2 cm thick, in order to enhance the development of biological activities, control weeds, and maintain soil moisture.

The irrigation was performed by the drip system, according to the water requirements of the *B. oleracea* crop, adopting the 9 h irrigation shift in the initial phase and establishing the cultivation field, continuing up to 1 day in the final stage, corresponding to the last 20 days of cultivation in the field, and use of self-cleaning emitters and self-compensation with a flow of 6.0 L h⁻¹, spaced apart 0.40 m, distributed along the line. The methodology used to calculate the irrigation was based on: $Etc = Kc \times ETo$ (crop evapotranspiration = crop coefficient x reference evapotranspiration (mm day⁻¹)).

The growth of kale was evaluated by plant height measurements, stem diameter, leaf number and leaf area at 8, 15, 22, 29, 36, 43, 50 and 57 days after transplanting (DAT), length root system and productivity at 57 days after transplanting.

Physiological parameters were assessed at 57 DAT by determining the carbon internal concentration (Ci), stomatal conductance (gs), transpiration (E), net photosynthetic rate (A), the instantaneous efficiency in the use of water, calculated by relating it to the net photosynthesis to transpiration and instantaneous carboxylation efficiency ($EiC - A/Ci$) from the net photosynthetic rate and the internal concentration of carbon, using infrared gas analyzer (IRGA) + LCpro system model.

Table 2. Chemical analysis of bovine manure and rock powder used in the planting fertilizer of *B. oleracea*.

Bovine manure	Values	Rock powder	Values
pH in H ₂ O (1.0:2.5)	8.25	pH	6.80
P (mg dm ⁻³)	5.06	P (mg dm ⁻³)	42.82
K ⁺ (cmol _c dm ⁻³)	0.0018	K ⁺ (cmol _c dm ⁻³)	0.12
Ca ²⁺ (cmol _c dm ⁻³)	4.00	Ca ²⁺ (cmol _c dm ⁻³)	5.65
Mg ²⁺ (cmol _c dm ⁻³)	3.90	Mg ²⁺ (cmol _c dm ⁻³)	1.95
Na ⁺ (cmol _c dm ⁻³)	1.08	Na ⁺ (cmol _c dm ⁻³)	0.30
H ⁺ + Al ³⁺ (cmol _c dm ⁻³)	0.495	H ⁺ +Al ³⁺ (cmol _c dm ⁻³)	1.70
Al ³⁺ (cmol _c dm ⁻³)	0.00	Al ³⁺ (cmol _c dm ⁻³)	0.00
Ca ²⁺ + Mg ²⁺	7.90	Ca ²⁺ + Mg ²⁺ (cmol _c dm ⁻³)	7.60
EC (dS m ⁻¹)	5.48	CEC (cmol _c dm ⁻³)	9.72
CEC (cmol _c dm ⁻³)	9.47	V (%)	97.77
V (%)	95.10	SB	74.56
SB	9.69	O.M. (g Kg ⁻¹)	43.85
O.M. (g kg ⁻¹)	100.82		

EC = electrical conductivity; CEC = cation exchange capacity; V = base saturation; SB = Sum of bases; O.M. = Organic Matter.

Also were evaluated the levels of leaf chlorophyll a, b and total through Clorofilog® chlorophyll (Falker), every 15 days after transplantation in the field. Readings were taken at intermediate leaves of four central plants from the experimental area between 08:00 and 10:00 hours, performing four readings by plants and was analyzed as average data.

The results were subjected to the variance analysis with 'F' test, evaluated by comparison of means by Tukey's test at up to 5% probability and by polynomial regression using the statistical software SAS® 9.2.

Results and discussion

The height of the plants was evaluated at different growth stages presenting significant effect for the interaction of bovine manure (BM) doses and RP to only at 8 (Figure 2A) and 15 (Figure 2B) days after transplanting (DAT) in the field. In others evaluations periods, the rock powder and BM did not differ one to another.

At 8 DAT the treatment that influenced initial development of *B. oleracea* interaction the most was 180 g of BM + 18 g of RP where plants obtained 12.4 cm height, the lowest values being observed in plants fertilized with BM 180 g + 6 g RP (Figure 2A). This limitation of the growth may be due to lower concentrations of RP present in the treatment used, which consequently may have been lower availability of nutrients to the plants, resulting in the commitment of its development in height.

At 15 DAT interaction of doses 240 g BM + 18 g of RP provided for taller plants of *B. oleracea* with maximum values of 16.85 cm statistically different of doses of BM 240 g + 24 g RP where lower values were observed in height, recording up to 14.26 cm (Figure 2B). The dose of 24 g of RP provided the greatest plant height, obtaining the maximum value of 16.91 cm (Figure 2B).

Possibly the largest doses of manure have provided greater levels of nutrients for plants of *B. oleracea* (Table 1), mainly nitrogen, which is the most important macronutrients for plants,

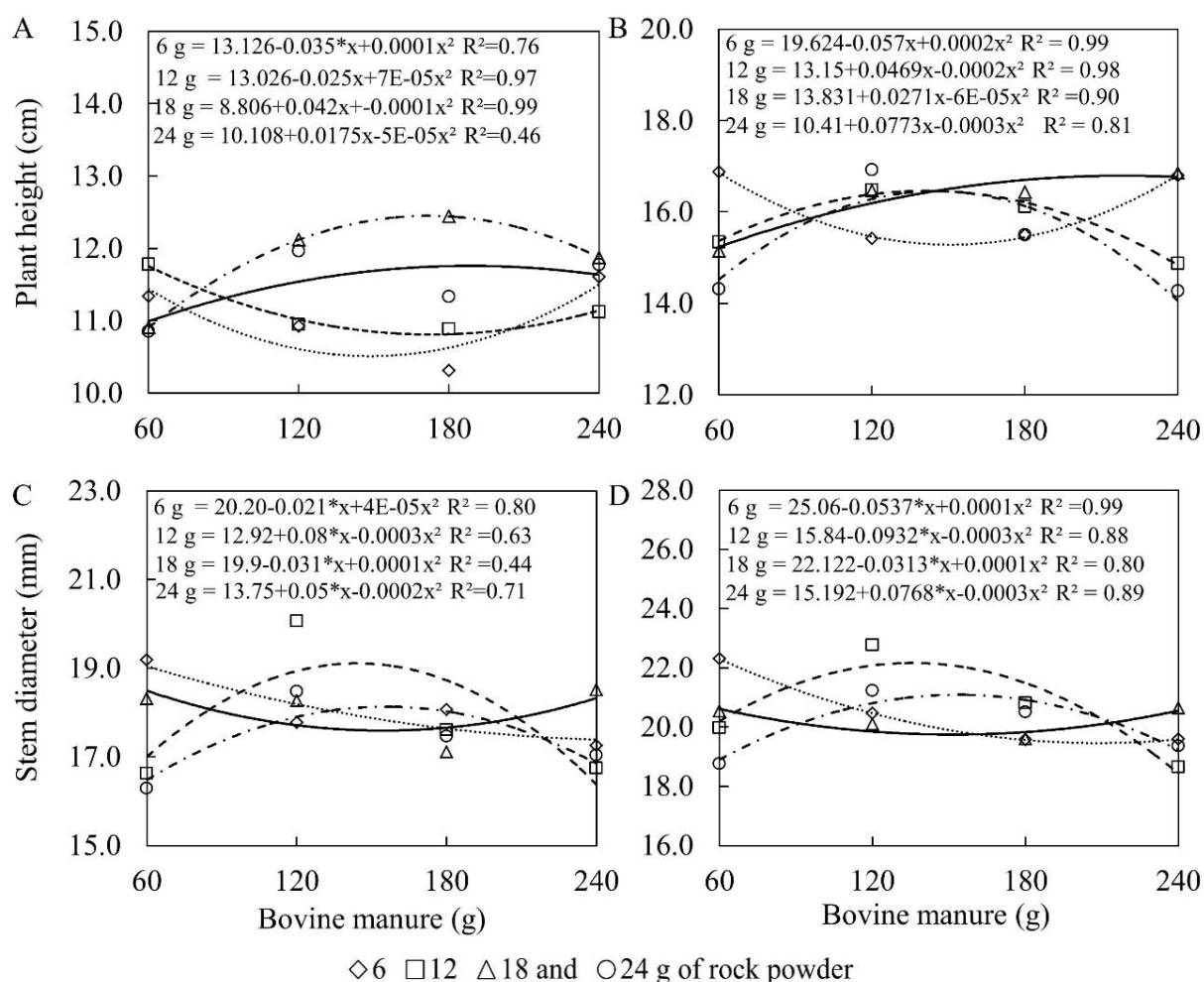


Figure 2. Height of *B. oleracea* at 8 DAT (A) and 15 DAT (B), stem diameter at 50 DAT (C) and 57 DAT (D) under the effect of bovine manure and rock powder

especialmente en la etapa inicial de crecimiento ya que las plantas absorben nitrógeno activamente cuando están en la fase inicial de crecimiento para la formación de células, generando más crecimiento en la fase inicial de desarrollo (Aguilar et al., 2015).

La planta de *B. oleracea* a 50 (Figura 2C) y 57 (Figura 2D) días presentó diámetro de tallo de respectivamente 20.1 y 22.7 mm planta⁻¹, registrando los valores más altos cuando se fertilizó con 120 g de BM + 12 g de RP. Con la reducción de orgánico fertilizante incluso asociado a la máxima dosis utilizada en RP, 60 g de BM + 24 g de RP, las *B. oleracea* plantas presentaron la mayor reducción en la expansión del diámetro del tallo, y observando 16.2 y 18.7 mm planta⁻¹, en este orden a 50 y 57 DAT. Las dosis intermedias de BM y RP pueden haber proporcionado un mejor equilibrio en la fertilidad del suelo y generado una mayor mineralización y solubilización de estos nutrientes, y por lo tanto una mayor disponibilidad de nutrientes, incluyendo nitrógeno, proporcionando un mayor crecimiento en el diámetro de los tallos de las plantas.

El número de hojas de *B. oleracea* fueron influenciadas por la interacción entre las dosis de BM y RP solo a 15 DAT (Figura 3A), en la

dosis de 60g de BM + 6 g de RP alcanzó 8.6 hojas planta⁻¹. En comparación hubo una restricción de hojas en las plantas fertilizadas con las máximas dosis de 240 g fertilizante BM + 24 g de RP, solo promoviendo el establecimiento de 7.2 hojas planta⁻¹.

Dosis intermedias de estiércol de vaca y polvo de roca pueden haber proporcionado un mejor equilibrio en la fertilidad del suelo y llevaron a una mayor mineralización y solubilización de estos nutrientes, y por lo tanto una mayor disponibilidad de nutrientes, incluyendo nitrógeno, proporcionando un mayor crecimiento en el diámetro de las plantas *B. oleracea*. Además, dosis más altas pueden haber causado un efecto fitotóxico en las plantas de brócoli (Moura et al., 2018).

El polvo de roca como un factor aislado influyó a 29 DAT (Figura 3B), y BM a 36 DAT (Figura 3C). En este primer período, las dosis de 6 y 12 g de RP mostraron un mayor número de hojas con 13.8 hojas planta⁻¹. En el segundo período, la dosis de BM proporcionó una reducción en el número de hojas, de esa manera, aumentando las dosis resultó en una restricción de crecimiento, resultando en el mayor número de hojas en las plantas *B. oleracea* fertilizadas con 60 g de BM (Figura 3D).

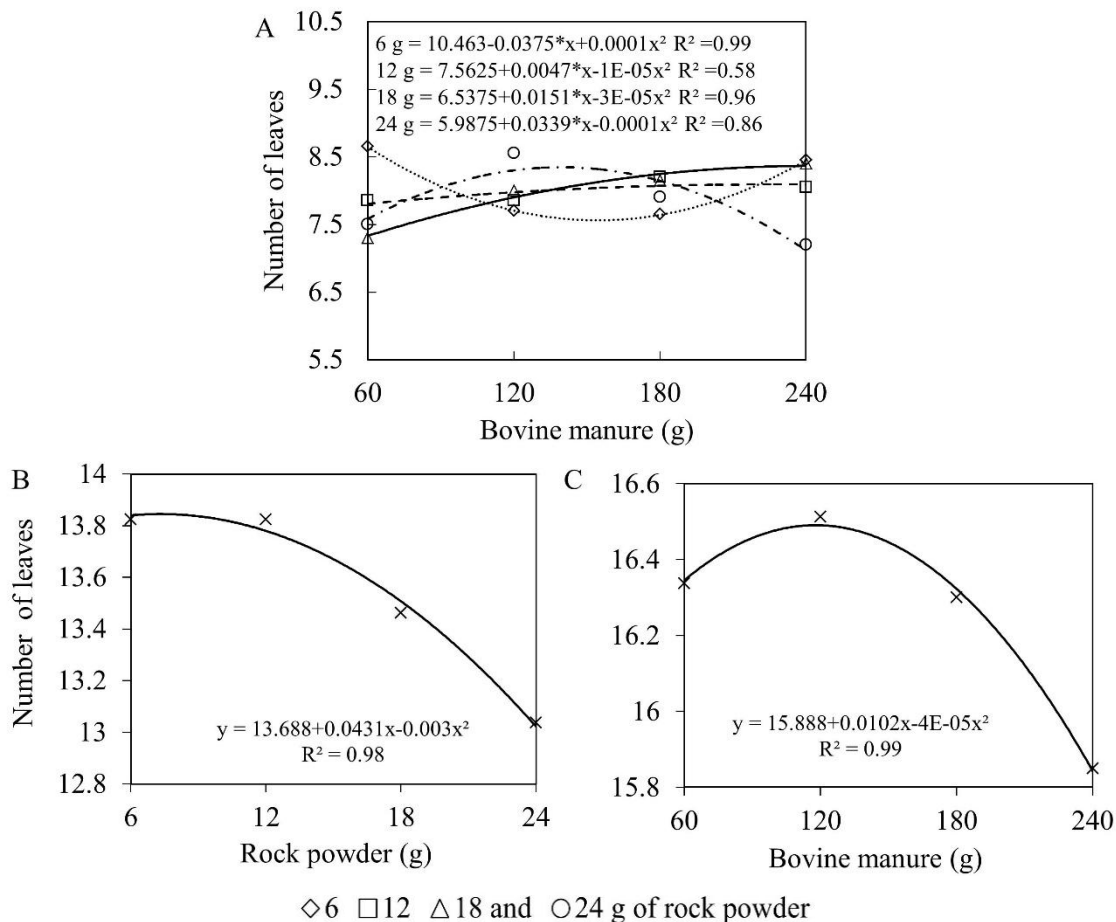


Figure 3. Number of leaves at 15 DAT (A), 29 DAT (B) and 36 DAT (C) of *B. oleracea* fertilized with bovine manure and doses of rock powder

In general, for growth variables (plant height, stem diameter, leaf number) which presented significant difference for the BM doses and RP or the interaction of these factors, the results obtained during the different growth stages can be justified in function of the mineralization process and the amount of these materials applied to the soil. The BM and RP are materials that tend to have a release of nutrients variable, affecting the availability to the plants and plant characteristics. In the case of BM, it has a higher relation C/N ratio when compared to other sources of fertilizer, which ends ultimately providing more slowly minerals for plants. The rock powders, the mineralization and release of the present ions are slow and gradual, they are not available in some cases in the initial phase of crop development (Tito et al., 2019).

However, when applied in appropriate associated form and in amount and particle sizes in a soil that has biological activity and chemical and physical characteristics favorable, the BM and RP can cause effects in a shorter period of time and thus to promote plant growth due to the fertilization (Osterroht, 2003). In this context, is realised that the effects on plants from the practice of fertilizing with these materials can be diverse, affecting them since the establishment phase of the field in culture to the production phase.

The results obtained for plant height, stem diameter, leaf number corroborate with those observed by Tessaro et al. (2012), analyzing agroecologic seedling production and development on field of Chinese kale using different percentages of compound (bovine manure + corn + soy+ wheat), sand and basalt powder, where the height plants obtained 46.7 to 53 cm, stem diameter 16.2 to 25.09 mm plant⁻¹ and for leaf number from 30.8 to 52.6 plant⁻¹.

Steiner et al. (2009) evaluated the effect of the organic compound on the production and accumulation of nutrients in the leaves of *B. oleracea*, also observed results for stem diameter variables in function of leaf number in function of alternative fertilizing used, where for these variables were influenced and obtained stem diameter of 16.2 mm to 22 mm and exhibiting 18.8 leaves plant⁻¹.

The leaf area was significantly affected by interactions of BM dosages and RP doses, where plants grown at doses 120 g of BM + 18 g of RP had greater leaf area up to 594 cm² plant⁻¹ (Figure 4A), the lowest leaf area of 403 cm² plant⁻¹ was observed in the plants fertilized with doses of BM 180 g + 24 g of RP. It is possible that the response of leaf area to fertilizer applied at intermediate doses is due to the effect of fertilization in a balanced way in the development of culture.

The interaction of doses of BM and RP also affect the productivity of *B. oleracea* plants, verifying expression between plants cultivated with doses 120 g of BM + 12 g of RP (70 t h⁻¹) and treatments with lower yields 120 g of BM + 6 g of RP (43.625 t h⁻¹), 180 g of BM + 6 g of RP (43.750 t h⁻¹) and 240 g of BM + 6 g RP (38.187 t h⁻¹).

The manure used as a source of organic fertilizer had C:N relation of 18/1 being considered optimal mineralization (Schröder et al., 2013). After incorporation of the BM into the soil, the mineralization process is activated by the microorganisms, allowing the release of these nutrients in its mineral form to the soil solution, being able to be absorbed by the plant root system and thus increase the productivity of *B. oleracea*. Thus, the gradual mineralization of bovine manure and solubilization of rock powder added to the soil may have allowed the supply of nutrients that were at low levels in the soil until appropriate levels, thereby generating an increase in productivity *B. oleracea* (Camargo et al., 2012).

Camargo et al. (2012) when took BM doses (0 to 100 t ha⁻¹) test and of basalt powder dose (0 to 6 t ha⁻¹) in the strawberry productivity, also achieved significant results. The evaluated fruits outperformed the association with higher doses of BM with intermediate doses of basalt powder. Even for the variable productivity,

Considering the behavior observed in Figure 4, can be attributed to the supply of BM has increased the absorption of macronutrients by *B. oleracea* plants, contributing to increased productivity since with the addition of organic matter there is increase of CEC, improvement of soil physical structure, factors that are crucial to keep the cationic nutrients such as K in the root absorption zone (Nascimento et al., 2015).

As observed in this study, use of organic sources such as BM and RP positively influence the *B. oleracea*. In semiarid regions, the use of alternative fertilizer is extremely important, since in these regions soil organic matter is oxidized rapidly due to high temperatures. Thus, in semi-arid regions, the cultivation of vegetables such as *B. oleracea* and other crops requires periodic replacement of the soil matters via manure (Medeiros et al., 2017).

Observing the Table 3 and can be verified that higher doses of BM promoted higher internal CO₂ concentration (Ci), net photosynthetic rate (A), stomatal conductance (gs), leaf transpiration (E) and instantaneous efficiency carboxylation (EIC), however, the higher water use efficiency (EiUA) was observed in *B. oleracea* plants fertilized with 60 g of BM.

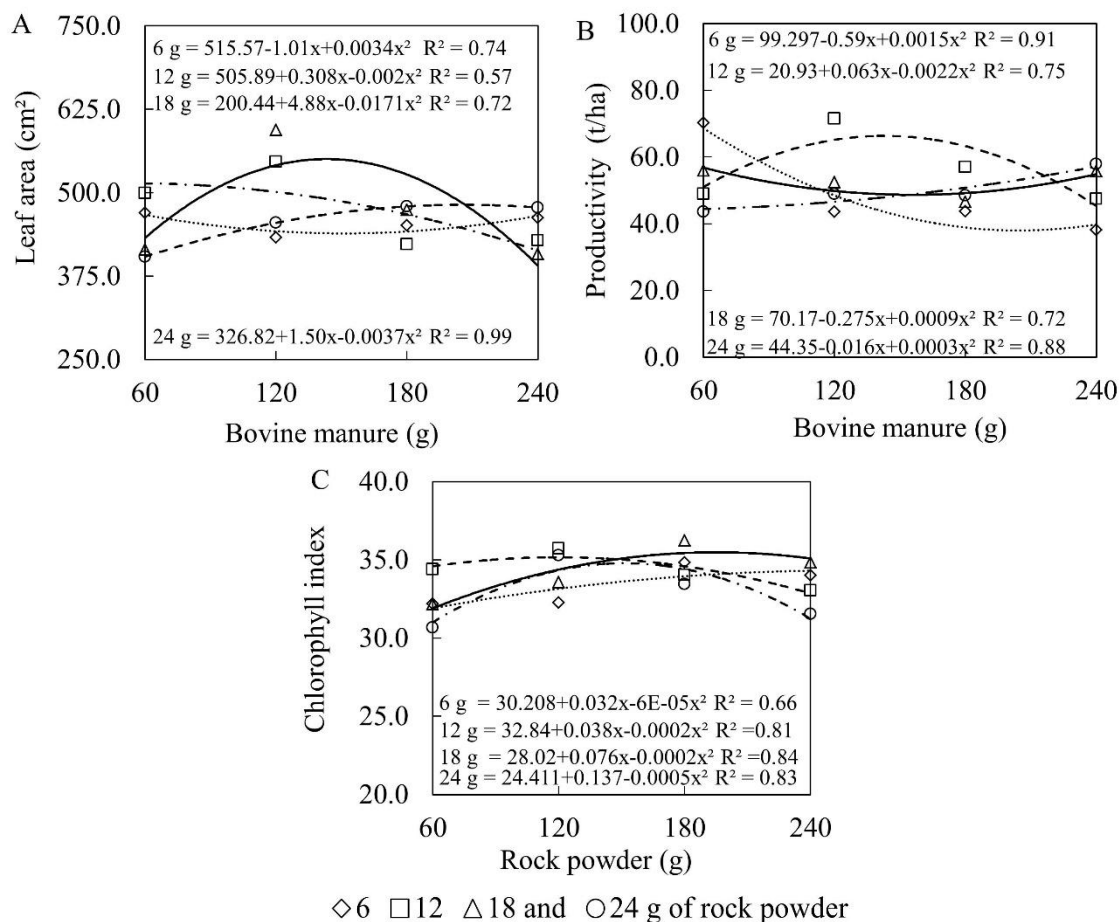


Figure 4. Leaf area (A), yield (B) and chlorophyll content (C) in the *B. oleracea*, depending on bovine manure and rock powder

These results indicate that the BM also positively influence the physiological characteristics of the *B. oleracea* concentrations of net photosynthesis and CO₂ indicate higher photosynthetic activity. The *B. oleracea* plant who received higher doses of BM presented the highest growth, proving that higher photosynthetic rates can be correlated with an increased stomatal opening, and thus greater absorption of CO₂, providing thus higher plant growth (Koyoro et al., 2013).

In beet crop, Gondim et al. (2015) observed that higher net photosynthesis rate (A), transpiration (E), stomatal conductance (Gs) and intercellular concentration CO₂ (Ci) was obtained in plants fertilized with the higher doses of BM, similar to that seen in Table 3 for *B. oleracea* culture. The authors note that these results are due to the abundant supply of essential nutrients for crops growth and development.

Variations referenced in Table 3, may be due to the improvement in the physical characteristics of the soil, since the BM has a high content of organic matter, allowing greater water retention, thereby plants absorb more water, a fact evidenced by the greater stomatal conductance.

Smaller doses of rock powder provided higher net photosynthesis rate, leaf transpiration, efficiency in water use and instantaneous efficiency of carboxylation. On the other hand, although not have shown a significant difference,

Table 3. Medium relating to internal concentration of carbon (Ci), net photosynthetic rate (A), stomatal conductance (gs), transpiration (E), instantaneous efficiency in the use of water (EiUA - A/E) and instantaneous carboxylation efficiency (EiC - A/Ci) *B. oleracea* plants depending on the dose of bovine manure and rock powder.

Sources dose (g)	Ci	A	gs	E	EiUA	EiC
Bovine manure						
60	286.31b	11.17a	0.307ab	2.51b	4.37a	0.040a
120	297.21ab	8.74b	0.268b	2.39b	3.72a	0.030b
180	370.83a	10.28ab	0.309ab	2.66ab	3.84a	0.035ab
240	280.73b	11.69a	0.370a	2.96a	3.93a	0.042a
ASD	163.88	2.20	0.06	0.32	0.83	0.009
Rock powder						
6	284.32a	12.57a	0.305a	2.76a	4.62a	0.044a
12	296.65a	11.99a	0.331a	2.90a	4.08ab	0.041ab
18	362.48a	9.58b	0.313a	2.59ab	3.68b	0.035bc
24	291.63a	7.74b	0.305a	2.28b	3.48b	0.026c
ASD	163.88	2.20	0.06	0.32	0.83	0.009

ASD = average significant difference. Means followed by the same letter in column are not different by Tukey test at 5% probability.

larger doses of rock powder tended to promote a higher concentration of CO₂, however, the higher concentration of carbon in the carboxylation site was not secured by the rubisco, since the highest concentration of CO₂ coincided with the reduced photosynthetic rate (Table 3).

Within the socio-economic context of agriculture in Brazil, where most low-income vegetable producers, the use of organic sources in agriculture with low purchasing value and high biological quality may be a further alternative for greater producer independence. and offering healthier foods. Thus, the fertilization of vegetables with organic sources becomes of great relevance.

Conclusion

Doses of bovine manure and rock powder 180 and 18 g, respectively, increased the growth of *B. oleracea* L. var. *acephala* by plant height, stem diameter, number of leaves;

The combination of doses bovine manure 120 g + 12 g rock powder and 120 g bovine manure + 18 g rock powder, provided, in this order, larger results for leaf area and productivity of *B. oleracea* L. var. *acephala*;

The bovine manure promotes greater concentration of CO₂, net photosynthesis rate and stomatal conductance of *B. oleracea* L. var. *acephala* plant, while rock powder limits these characteristics.

Intermediate doses of bovine manure and rock powder promote higher growth and yield of *B. oleracea* L. var. *acephala*.

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