

Use of bovine biofertilizer in cabbage production in alley system

Uso de biofertilizante bovino na produção de repolho em sistemas de aleias

Uso de biofertilizante bovino en la producción de repollo en sistemas de callejones

Received: 03/01/2022 | Reviewed: 03/09/2022 | Accept: 03/21/2022 | Published: 03/27/2022

Dayanne Beatriz Silva Rodrigues

ORCID: <https://orcid.org/0000-0002-8680-7248>
Universidade Federal de Roraima, Brasil
E-mail: dadayrodrigues13@gmail.com

Jandiê Araújo da Silva

ORCID: <https://orcid.org/0000-0003-3760-3959>
Universidade Federal de Roraima, Brasil
E-mail: jandie.araujo@ufr.br

Járisson Cavalcante Nunes

ORCID: <https://orcid.org/0000-0002-5129-2934>
Universidade Estadual da Região Tocantina do Maranhão, Brasil
E-mail: jarisson.nunes@uemasul.edu.br

Marcelo Barbosa Gomes Neto

ORCID: <https://orcid.org/0000-0002-1506-0060>
Universidade Federal de Roraima, Brasil
E-mail: netomarcelo11@gmail.com

Maria Aparecida de Moura Araújo

ORCID: <https://orcid.org/0000-0001-9531-5176>
Universidade Federal de Roraima, Brasil
E-mail: maria.moura@ufr.br

Fernando Gomes de Souza

ORCID: <https://orcid.org/0000-0001-5653-3939>
Universidade Federal de Roraima, Brasil
E-mail: fernando.souza@ufr.br

Juliete Araújo da Silva Nunes

ORCID: <https://orcid.org/0000-0002-8649-7569>
Doutora em Agronomia, Brasil
E-mail: juliyetearaujo@hotmail.com

Josimar da Silva Chaves

ORCID: <https://orcid.org/0000-0001-5871-5605>
Universidade Federal de Roraima, Brasil
E-mail: josimar.chaves@ufr.br

Abstract

Cabbage cultivation with organic inputs in agroforestry systems may be an alternative for cultivation in the state of Roraima. In this context, the objective of this study was to evaluate the effects of bovine biofertilizer and alley system on the production components of Sooshu hybrid cabbage. The experiment was conducted from August 2019 to July 2020 at the Agrotechnical School of the Federal University of Roraima. The treatments were arranged in randomized blocks, in split plots, with three replicates. The factorial scheme used was 2×5 , referring to production in systems without and with alleys and five concentrations of bovine biofertilizer (0, 25, 50, 75 and 100% of the 8 L m^{-2} dose). After 113 days of application of the bovine biofertilizer, the following were evaluated: i) mass of the leaves that form the head; ii) number of outer leaves; iii) mass of outer leaves; iv) transverse and longitudinal diameters and v) yield. The agroforestry system had no influence on cabbage production components. Bovine biofertilizer at concentration of 63.13% promoted higher mass of leaves that form the head and yield of Sooshu hybrid cabbage.

Keywords: Agroforestry; *Brassica oleracea* var. *capitata* L.; Fermented liquid manure.

Resumo

O cultivo de repolho com insumos orgânicos em sistemas agroflorestais pode ser uma alternativa para o cultivo no estado de Roraima. Nesse sentido, o objetivo desta pesquisa foi avaliar o efeito do biofertilizante bovino e do sistema de aleias nos componentes de produção do repolho Híbrido Manteiga Sooshu. A pesquisa foi realizada no período de agosto de 2019 a julho de 2020 na Escola Agrotécnica da Universidade Federal de Roraima. Os tratamentos foram dispostos em blocos casualizados, em parcelas subdivididas, com três repetições. O esquema fatorial utilizado foi 2×5 , referente a produção em sistemas sem e com aleias e cinco concentrações de biofertilizante bovino (0, 25, 50, 75 e 100% da dose de 8 L m^{-2}). Decorridos 113 dias da aplicação do biofertilizante bovino, foram avaliados: i) massa das folhas que compõe a cabeça; ii) número de folhas externas a cabeça; iii) massa de folhas externas a cabeça; iv) diâmetro

transversal e longitudinal e v) produtividade. O sistema agroflorestal não exerceu influência sobre os componentes de produção do repolho. A concentração do biofertilizante bovino no valor de 63,13% proporcionou maior massa das folhas que compõe a cabeça e produtividade do repolho Híbrido Manteiga Sooshu.

Palavras-chave: Agrofloresta; *Brassica oleracea* var. *capitata* L.; Esterco líquido fermentado.

Resumen

El cultivo de repollo con insumos orgánicos en sistemas agroforestales puede ser una alternativa para el cultivo en el estado de Roraima. Así pues, el objetivo de esta investigación fue evaluar el efecto del biofertilizante bovino y del sistema de callejones en los componentes de producción de repollo Híbrido Manteiga Sooshu. La investigación se realizó el en período de agosto de 2019 a julio de 2020 en la Escuela Agrotécnica de la Universidad Federal de Roraima. Los tratamientos fueron organizados en bloques al azar, en parcelas subdivididas, con tres repeticiones. El arreglo factorial utilizado fue 2×5 , referente a la producción en sistemas sin y con callejones y cinco concentraciones de biofertilizante bovino (0, 25, 50, 75 y el 100% de la dosis de 8 L m⁻²). Después de 113 días de aplicación del biofertilizante bovino se evaluó lo siguiente: i) la masa de las hojas que componen la cabeza; ii) número de hojas externas a la cabeza; iii) masa de hojas externas a la cabeza; iv) diámetro transversal y longitudinal y v) productividad. El sistema agroforestal no influyó sobre los componentes de producción del repollo. La concentración del biofertilizante bovino en la cantidad de 63,13% proporcionó mayor masa de las hojas que componen la cabeza y productividad del repollo Híbrido Manteiga Sooshu.

Palabras clave: Agroforestería; *Brassica oleracea* var. *capitata* L.; Estiércol líquido fermentado.

1. Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) production is an agricultural activity of great importance for Brazil. For this agricultural activity to be economically viable, it needs to be practiced in appropriate times and in places with good edaphoclimatic and market conditions for its commercialization. Cabbage is native to regions of temperate climate, and in the state of Roraima its production is incipient, mainly due to temperature and rainfall intensity during the rainy season. In Roraima, temperatures exceed 32 °C accompanied by radiation levels higher than 25 MJ m⁻² day⁻¹, which can impair the growth, yield and quality of vegetables that require mild temperatures (Castilla & Baeza, 2013).

In the agroforestry system, soil cover is one of the most important factors for its protection, so legume species are planted, due to their importance to the biome when the soil is poor and there is indiscriminate use of fire; in addition, they improve the physical, chemical and biological properties of the soil, control weeds and prevent erosion (Silva et al., 2018). As a component of the agroforestry system, one of the species used is *Gliricidia sepium*, for being an arboreal, leguminous and perennial plant, with an average height of 12 to 15 meters and with a diameter of up to 30 cm.

This type of management is part of the strategies that can contribute to increasing agricultural production and can be an alternative for cabbage (*Brassica oleracea* var. *capitata*) production in the municipality of Boa Vista, Roraima, considering that the system may be able to mitigate the negative effects of the high variability of rainfall and temperature (Santos et al., 2018).

Brassicaceae species, cabbage family, demand high levels of nutrients due to the high conversion rate in a short period of time, so fertilization needs to be supplied frequently and in adequate quantities (Filgueira, 2008). Replacing mineral fertilizers, of high prices, with products of animal origin, available in the field, can be an alternative to improve the chemical, physical and biological attributes of the soil (Pires et al., 2008) and meet the demand of the crop.

Bovine manure fertilizer is a source of bioactive compounds formed by bacteria, yeasts, algae and fungi (Marrocos et al., 2012) and, when applied to the soil, improves its physical (Benbouali et al., 2013), chemical and biological attributes, stimulating plant growth and production (Boraste et al., 2009; Patil, 2010), so it can contribute positively to the nutrition and production of cabbage in a savanna area.

In a study conducted by Silva (2018), evaluating the use of bovine biofertilizer in the cultivation of lettuce (*Lactuca sativa* L.), foliar application of biofertilizer led to superior results when compared to treatment with conventional fertilization. Saraiva (2020) also observed increments in the production components of common bean (*Phaseolus vulgaris*) with the application of 125% of bovine biofertilizer.

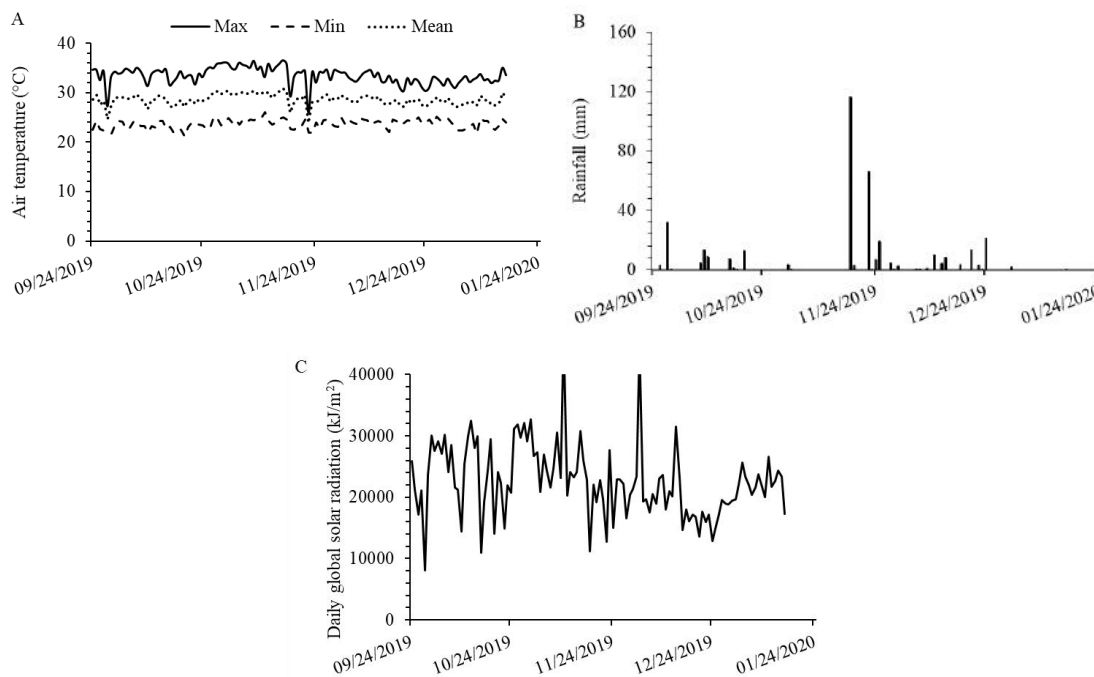
Considering the relevance of biofertilizers for sustainability, reducing the environmental impacts generated and reducing costs, it is essential to study them as to their real contribution to vegetable yield. Thus, the objective was to evaluate the effects of bovine biofertilizer and alley system on the production of Sooshu hybrid cabbage in the savanna (*lavrado*) of Roraima, Brazil.

2. Methodology

The experiment was carried out from August 2019 to July 2020, in the municipality of Boa Vista - RR. According to Köppen's classification, the climate of the municipality is Aw, characterized as Rainy Tropical, hot and humid, with a clear rainy season, after alternating dry and humid periods (Alvares et al., 2013).

In the period of 113 days, daily air temperature (Figure 1A), rainfall (Figure 1B) and daily global solar radiation (Figure 1C) data were recorded at the automatic station of the National Institute of Meteorology (INMET, 2022). The mean temperature was 28.5 °C, with accumulated rainfall of 369.6 mm and solar radiation of 2,575.37 MJ m⁻² (Figure 1).

Figure 1. Air temperature (A), rainfall (B) and global solar radiation (C) of the municipality of Boa Vista - RR along the experimental period (September 24, 2019, to January 15, 2020).



Source: Authors.

The experimental design was in randomized blocks, with split plots, in a 2 × 5 factorial scheme, that is, production systems - without and with alleys, and five huge bovine biofertilizers (0, 25, 50, 75 and 100% of the 8 L m⁻²) all with three replicates. Each treatment consisted of two rows, each with five plants of Sooshu hybrid cabbage, totaling 10 plants per plot (2 m²), at spacing of 0.8 m between rows and 0.4 m between plants in the row. The useful plot (0.32 m²) consisted of the four central plants of each treatment. The plants used as borders in each plot were subjected to the same conditions as those within the usable plot.

The soil of the experimental area of the system without and with alleys was classified as Argissolo Amarelo distrófico (Ultisol) (Embrapa, 2013). The system of alleys with *G. sepium* trees was implemented in 2013, using cuttings from the Experimental Unit of EMBRAPA-RR in the municipality of Mucajaí, Roraima. In the same year, green manuring was carried

out with rattlepod (*Crotalaria* spp.), dwarf pigeon pea (*Cajanus cajan*), jack bean (*Canavalia ensiformis*) and velvet bean (*Mucuna pruriens*). *G. sepium* plants were planted at spacing of 7.0 m between rows and 4.0 m between plants of each row. The management of the system consisted in pruning operations and deposition of plant biomass on soil surface. The soil attributes in the system with and without alleys were, respectively: pH = 6.3 and 5.4; P = 18.6 and 3.5 mg dm⁻³; K = 40 and 17 mg dm⁻³; Ca²⁺ = 1.12 and 0.52 cmol_c dm⁻³; Mg²⁺ = 0.35 and 0.13 cmol_c dm⁻³; Al³⁺ = 0.0 and 0.1 cmol_c dm⁻³; H + Al = 0.7 and 0.3 cmol_c dm⁻³; base saturation: 69.2 and 69.7%; sulfur = 4.52 and 19.27 mg dm⁻³; and organic matter = 1.21 and 0.94%. The soil of both areas was classified as sandy loam. The analysis of the biofertilizer was not performed, however, the cattle manure used to produce the input had the following attributes: N = 1.94%; P = 0.22%; K = 1.68%; Mg = 0.32%; S = 0.25%; Zn = 78 mg dm⁻³; Fe = 11344 mg dm⁻³; Mn = 729 mg dm⁻³; Cu = 11 mg dm⁻³; B = 14.2 mg dm⁻³; and organic carbon = 27.14%.

The seedlings of Sooshu hybrid cabbage were prepared in polystyrene trays of 128 cells and were transplanted 21 days after sowing, when they had four true leaves. It was used Tropstrato HA Hortaliças[®], composed of pine bark, peat, expanded vermiculite, enriched with macro and micronutrients. Fertilization was performed according to the results of soil analyses, following the recommendation proposed by Filgueira (2008), applying 200 kg ha⁻¹ of P₂O₅ and 110 kg ha⁻¹ of K₂O, using single superphosphate and potassium chloride as sources of phosphorus and potassium, respectively. Water was supplied by localized drip irrigation with flow rate of 7.5 L h⁻¹ m⁻¹. During the field activities, irrigation, weed control and alternative phytosanitary control using garlic (*Allium sativum*) and onion (*Allium cepa*) extract were performed according to Freitas et al. (2006) at the concentration of 10%.

Bovine biofertilizer was produced according to the recommendation of Diniz et al. (2013). To produce the biofertilizer, equal parts of water and fresh cattle manure were added in a container that does not undergo oxidation, leaving 20% of its volume to be occupied by methane gas produced during fermentation. To release the gas produced by bacteria, one end of a thin hose is connected to the top of the biodigester while the other is kept submerged in a container with water. Biofertilizer at the respective concentrations [0, 25, 50, 75 and 100% of the recommended dose, 8 liters m⁻²] was applied 48 hours after transplanting and reapplied every 16 days until harvest.

Harvest of the usable plots was carried out at 113 days after transplantation, when the heads were compact and well developed. A cut was made at the base of the head and the material was transported to the Laboratory of Technology of Agricultural Products (LTPA) of the Federal University of Roraima, to evaluate the following variables: i) number of outer leaves (leaves plant⁻¹); ii) number of inner leaves (leaves plant⁻¹); iii) fresh mass of outer leaves (g plant⁻¹); iv) fresh mass of leaves that form the head (kg plant⁻¹); v) longitudinal diameter (measured from the base to the apex of the head) and vi) transverse diameter, determined with a millimeter ruler; and vii) yield (kg ha⁻¹), obtained by estimating the product of the fresh mass of the leaves that form the head by the number of plants per hectare (Silva et al., 2012).

The results were subjected to analysis of variance by the F test; means referring to the system without and with alleys were compared by Tukey test at 5% probability level and means referring to the doses were compared by polynomial regression (Banzatto & Kronka, 2006), using the statistical program Sisvar (Ferreira, 2019).

3. Results and Discussion

According to the summary of the analysis of variance, it is noted that none of the variables evaluated were influenced by the interaction between the alley system and the application of biofertilizer. The number of leaves outside the head (NOL), the mass of leaves outside the head (MOL) and the number of leaves that make up the head (NLH) were not influenced by any of the sources of variation studied. The longitudinal (DL) and transversal (DT) diameter, the mass of the leaves (MOL) that compose the head and the cabbage productivity (PT) were influenced by the isolated biofertilizer factor (Table 1).

Table 1. Summary of analysis of variance, by the mean square, for the number of leaves outside the head (NLO), mass of leaves outside the head (MLO), number of leaves that make up the head (NLH), longitudinal diameter (DL) and transversal of the head (DT), mass of the leaves that compose the head (MLO) and productivity (PT) of hybrid cabbage plants Butter Sooshu fertilized with bovine biofertilizer in the absence and presence of alley system.

F.V.	G.L	NLO	MLO	NLH	DL	DT	MLO	PT
Block	2	2.72 ^{ns}	62.80 ^{ns}	10.57 ^{ns}	2.52 ^{ns}	2.74 ^{ns}	10.59 ^{ns}	4767.44 ^{ns}
Alley system (A)	1	2.90 ^{ns}	22.98 ^{ns}	1.04 ^{ns}	0.34 ^{ns}	0.22 ^{ns}	1.04 ^{ns}	3081.11 ^{ns}
Residue a	2	0.46	39.29	8.47	2.35	1.67	8.47	4834.93
Biofertilizer (B)	4	1.78 ^{ns}	68.60 ^{ns}	11.98 ^{ns}	4.10*	3.53*	11.98*	8405.17*
A × B	4	0.36 ^{ns}	4.53 ^{ns}	0.60 ^{ns}	0.28 ^{ns}	0.30 ^{ns}	0.60 ^{ns}	606.13 ^{ns}
Residue B	16	0.66	28.69	3.37	1.04	0.95	3.37	2053.57
Total	29							
C.V.a.		26.7	57.9	62.7	53.1	46.5	62.7	71.3
C.V.b.		31.7	49.5	39.6	35.3	35.2	39.6	46.7

F.V. = Source of variation; G.L = Degree of freedom; ns = Not significant; * = Significant by F test at 5% probability; C.V.a = Coefficient of variation of residue a; C.V.b = Coefficient of variation of residue b. The values shown were transformed to: $(x + 0.5)^{0.5}$. Source: Authors.

Plants grown in the alley system had NOL of 5.5 leaves plant⁻¹, while those cultivated in the system without alleys had a higher NOL, on average 3 leaves plant⁻¹. The numerical superiority of the data in the system without alleys was also observed for the mass of the leaves that form the head, with averages of 130.5 and 167.4 g plant⁻¹ for treatments with and without alley system, respectively (Table 2). The absence of a significant effect for the number of leaves per plant was also observed by Nomura et al. (2019), when they found that the application of doses of biofertilizer not increased the number of leaves of arugula plants (*Eruca vesicaria* ssp. sativa).

Table 2. Number of outer leaves (NOL) and mass of outer leaves (MOL) of Sooshu hybrid cabbage plants fertilized with bovine biofertilizer in the absence and presence of alley system.

Biofertilizer concentrations	NOL – leaves plant ⁻¹		MOL – g plant ⁻¹	
	Alley system		Alley system	
	With	Without	With	Without
0%	3.4	4.1	78.4	70.8
25%	4.0	9.7	112.8	171.6
50%	6.4	9.1	169.0	224.5
75%	7.2	8.8	167.2	183.0
100%	6.4	10.8	125.3	187.3
Mean	5.5	8.5	130.5	167.4

Source: Authors.

The number of outer leaves is lower than the average value of 9.37 leaves plant⁻¹ recorded by Leão and Alves (2019) when evaluating the yield of cabbage under application of boron sources and doses. Castro (2015), when studying the yield and quality of cabbage fertilized with nitrogen and boron in a protected environment, recorded higher values of mass of outer leaves,

with a maximum of 518.68 g of fresh matter under fertilization with 291.55 kg N ha⁻¹. The highest means occurred in treatments without alleys (Table 2), influenced by the lower shading compared to the treatments with alleys.

Similar to the number of outer leaves, the production of leaves that form the head was not influenced by the studied sources of variations, with mean values of 24.5 leaves head⁻¹ in treatments with alleys and 30.9 leaves head⁻¹ in treatments without the alley system. The mean values for treatments without and with alley system and 25, 50, 75 and 100% of bovine biofertilizer were 20.7, 23.4, 33.6, 32.9 and 27.9 leaves head⁻¹, respectively (Table 3).

Table 3. Number of leaves that form the head (NLH) of Sooshu hybrid cabbage plants fertilized with bovine biofertilizer in the presence and absence of alley system.

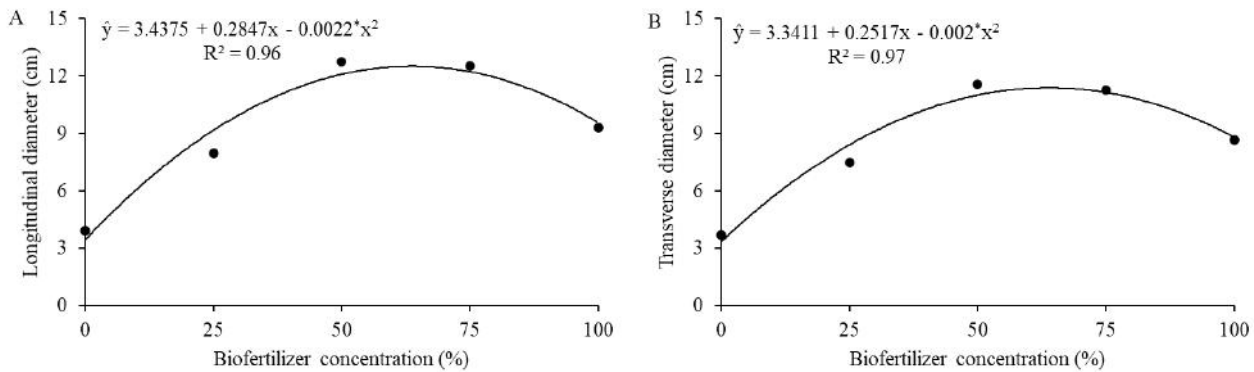
Biofertilizer concentrations	NLH – leaves head ⁻¹		
	Alley system		
	With	Without	Mean
0%	12.7	28.6	20.7
25%	22.7	24.2	23.4
50%	30.3	36.9	33.6
75%	32.4	33.3	32.9
100%	24.3	31.6	27.9
Mean	24.5	30.9	27.7

Source: Authors.

The average number of inner leaves is lower than the average value of 40.9 leaves head⁻¹ recorded by Silva et al. (2012) when studying the yield and development of cabbage cultivars as a function of boron doses. The average NLH of 27.7 does not corroborate the number presented by Silva et al. (2014), who worked with boric acid applications in cabbage at different times and recorded an average of 37.40 leaves head⁻¹ in the treatment with boron application (6.1 kg ha⁻¹) at 25 days after transplantation.

The data of longitudinal and transverse diameters of the head were described by a quadratic model as a function of bovine biofertilizer, with maximum values of 12.65 cm and 11.26 cm at concentrations equivalent to 64.70% and 62.93%, respectively (Figure 2 AB). Therefore, it can be observed that the increments in diameters (Figures 2AB) and fresh mass of leaves (Figure 3) caused by the application of the biofertilizer were essential for the increase in yield observed in Figure 4, especially when concentrations around 63% were applied. Castro (2015) observed that the data of transverse diameter of the head were described by quadratic model as a function of nitrogen doses, with a maximum value of 15.33 cm with the dose equivalent to 265 kg of N ha⁻¹. The beneficial effect of bovine biofertilizer was also reported by Lima et al. (2018) who observed that the supply of doses of bovine biofertilizer from 125 to 500 mL plant⁻¹ week⁻¹ increased the diameter of strawberry fruits (*Fragaria x ananassa* Duch.) by 7.5%.

Figure 2. Longitudinal (A) and transverse (B) diameters of Sooshu hybrid cabbage fertilized with bovine biofertilizer.

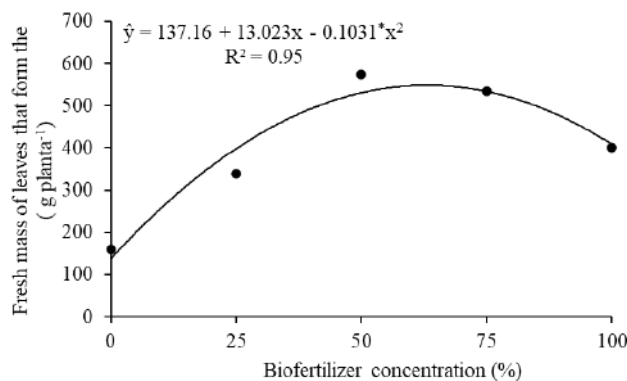


Source: Authors.

The results obtained agree with those found by Guerra et al. (2013), who reported that organic fertilization can totally replace mineral fertilization, and this practice should be recommended. The positive increment in the agronomic characteristics of cabbage may be related to the rapid availability of nutrients by the biofertilizer, which provides the essential elements for plants and contributes to the improvement of soil attributes.

There was no significant effect of the interaction between biofertilizer concentrations and alley systems for fresh mass of leaves that form the cabbage head, however, there was a significant effect for the biofertilizer factor individually. The application of increasing doses of the input increased the mass of leaves that form the head of cabbage plants up to the maximum estimated concentration of 63.15%, with a maximum head mass of 548.4 g plant⁻¹ (Figure 3). The beneficial effects of biofertilizer application on the growth of cabbage plants is related to its nutritional composition, which when applied to soil, improves its physical (Benbouali et al., 2013), chemical and biological properties, stimulating plant growth and production (Patil, 2010).

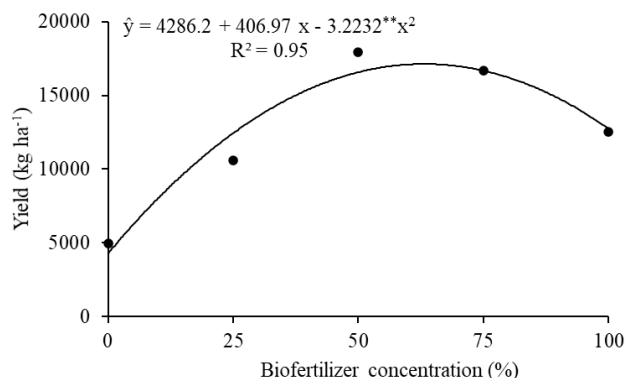
Figure 3. Fresh mass of leaves that form the head of Sooshu hybrid cabbage plants fertilized with bovine biofertilizer.



Source: Authors.

The application of bovine biofertilizer to the soil increased cabbage yield. The quadratic regression model data show that plant yield was increased from 4,286.2 kg ha⁻¹ in treatments without biofertilizer application to 17,132.1 kg ha⁻¹ with the application of biofertilizer at concentration of 63.13%. Such increase represents a superiority of 299.7% between treatments without and with the adequate application of the input (Figure 4).

Figure 4. Yield of Sooshu hybrid cabbage plants fertilized with bovine biofertilizer.



Source: Authors.

According to Zandonadi et al. (2014), the supply of nutrients through organic fertilizers such as bovine biofertilizer improves soil conditions, causing stimulating effects on plants, with a positive result in the increment of yield. The average cabbage production in Brazil is between 20 and 35 t ha⁻¹, higher than the values obtained in the present experiment. In Roraima, according to Luz et al. (2002), Sooshu hybrid cabbage in dry season reaches up to 21 t ha⁻¹, which is similar to the yield found in the treatments with application of bovine biofertilizer at concentration of 63.13%.

4. Conclusion

Under the experimental conditions, application of bovine biofertilizer at dose of 63.13% increases the mass of leaves that form the head and the yield of Sooshu hybrid cabbage.

Addition of bovine biofertilizer to the soil increases the quality attributes of Sooshu hybrid cabbage.

There is no effect of the connecting rod system on the production components of cabbage produced in the savanna of Roraima.

References

- Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M., & Sparovek, G. (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22 (6), 711-728.
- Banzatto, D. A. & Kronka, S. N. (2006). *Experimentação agrícola*. Jaboticabal: FUNEP, 247 p.
- Benbouali, E. H., Hamoudi, S. A. A., & Larich, A. (2013). Short-term effect of organic residue incorporation on soil aggregate stability along gradient in salinity in the lower chelif plain (Algeria). *African Journal of Agricultural Research*, 8 (19), 2141-2152.
- Boraste, A., Vamsi, K. K., Jhadav, A., Khairmar, Y., Gupta, N., Trivedi, S., Patil, P., Gupta, G., Gupta, M., Mujapara, A. K., & Joshi, B. (2009). Biofertilizers: A novel tool for agriculture. *International Journal of Microbiology*, 1 (2), 23-31.
- Castilla, N., & Baeza, E. (2013). Greenhouse site selection. In: Food and Agriculture Organization of the United Nations (Eds.). Good agricultural practices for greenhouse vegetable crops: Principles for Mediterranean climate areas. FAO, Rome, 21-34 p.
- Castro, T. J. (2015). *Produtividade e qualidade do repolho adubado com nitrogênio e boro em ambiente protegido no Amazonas*. 61 f. Dissertação (Mestrado em Agronomia Tropical) - Universidade Federal do Amazonas, Manaus.
- Diniz, B. L. M. T., Cavalcante, L. F., Mesquita, F. O., Lima Neto, A. J., Nunes, J. C., & Diniz Neto, M. A. (2013). Crescimento inicial e consumo hídrico de nim submetido ao estresse salino e biofertilizante bovino. *Revista Brasileira de Ciências Agrárias*, 8 (3), 470-475.
- Embrapa. Empresa Brasileira de Pesquisa Agropecuária. (2013). Sistema Brasileiro de Classificação de Solos. 3.ed. Brasília, 353 p.
- Ferreira, F. D. (2019). Sisvar: a computer analysis system to fixed effects split plot type designs. *Revista Brasileira de Biometria*, 37 (4), 529-535.
- Filgueira, F. A. R. (2008). *Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças*. 3. ed. Viçosa: UFV, 402 p.

Freitas, G. B., Barrella, T. P., Siqueira, R. G., Trivelatto, M. D., & Santos, R. H. S. (2006). (Ed). Aplique o extrato de alho e cebola. In: *Preparo e aplicação de biofertilizantes e extratos de plantas*. Brasília: SENAR, 84 p.

Guerra, J. G. M., Leal, M. A. A., & Ferreira, M. B. C. (2013). *Recomendações de adubos, corretivos e de manejo da matéria orgânica para as principais culturas do Estado do Rio de Janeiro: Brócolos, couve, couve-flor e repolho*. In: Freire L.R. (Org.). Manual de calagem e adubação do Estado do Rio de Janeiro. Editora Universidade Rural, Seropédica, 107-128.

Inmet. Instituto Nacional de Meteorologia. < <https://portal.inmet.gov.br/>>.

Leão, J., & Alves, L. (2019). *Produtividade do repolho irrigado submetido a diferentes fontes e doses de boro*. Trabalho de Conclusão de Curso, Instituto Federal Goiano. Brasil.

Lima, F. A., Viana, T. V. A., Sousa, G. G., Correia, L. F. M., & Azevedo, B. M. (2018). Yield of strawberry crops under different irrigation levels and biofertilizer doses. *Revista Ciência Agronômica*, 49 (3), 381-388.

Luz, F. J., Saboya, R. C. C., & Pereira, P. R. V. S. (2002). Cultivo do repolho em Roraima. Circular Técnica, 7. Boa Vista: Embrapa-CPAF/RORAIMA, 01 p.

Marrocos, S. T. P., Novo Júnior, J., Granjeiro, L. C., Anbrósio, M. M. Q., & Cunha, A. P. A. (2012). Composição química e microbiológica de biofertilizantes em diferentes tempos de decomposição. *Revista Caatinga*, 25 (4), 34-43.

Nomura, M., Barbosa, G. G. F., Silva, C. H. L., Costa, E. M., Abadia, M. V., Vilarinho, M. S., & Pereira, L. E. (2019). Biofertilizante na produção de rúcula. *Ipê Agronomic Journal*, 3 (1), 116-121.

Patil, N. M. (2010). Biofertilizer effect on growth, protein and carbohydrate content in *Stevia rebaudiana* var Bertoni. *Recent Research in Science and Technology*, 2 (10), 42-44.

Pires, A. A., Monnerat, H. P., Marciano, C. R., Pinho, L. G. R., Zampiroli, P. D., Rosa, R. C., & Muniz, R. A. (2008). Efeito da adubação alternativa do maracujazeiro amarelo nas características químicas e físicas do solo. *Revista Brasileira de Ciência do Solo*, 32 (5), 1997-2005.

Santos, A. F., Pérez-Marin, A. M., & Sarmento, M. I. A. (2018). Produtividade da palma forrageira em aleias com *Gliricidia sepium* sob adubação orgânica em diferentes espaçamentos no Semiárido. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, 13 (3), 276-281.

Saraiva, K. R., Oliveira, J. R., Marques F., F., Sousa Silva, F., & Silva S. J. R. (2020). Aspectos produtivos e biomassa do feijão caupi (*Vigna unguiculata*) sob doses de biofertilizante bovino em cultivo agroecológico. *Agricultura Familiar: Pesquisa, Formação e Desenvolvimento*, 14 (1), 184-198.

Silva, J. C. S. (2018) *Utilização de biofertilizante bovino líquido em cultivo de alface crespa* (vc. Vanda): *concentrações de doses de biofertilizante em cultivo de alface*. Dissertação (Mestrado em Agroecologia e Desenvolvimento Rural) – Universidade Federal de São Carlos.

Silva, K. S., Santos, E. C. M., Benett, C. G. S., Laranjeira, L. T., Eberhardt Neto, E., & Costa, E. (2012). Produtividade e desenvolvimento de cultivares de repolho em função de doses de boro. *Horticultura Brasileira*, 30 (3), 520-525.

Silva, L. M., Basílio S. A., Silva Júnior, R. L., Nascimento, M. V., Benett, C. G. S., & Benett, K. S. S. (2014). Aplicação de ácido bórico sobre as características produtivas do repolho em diferentes épocas. *Revista de Agricultura Neotropical*, 1 (2), 26-34.

Silva, P. M. P., Costa, F. K. J., & Silva, A. T. (2018). O uso de sistema agroflorestal como técnica de recuperação de áreas degradadas no bioma amazônico. *Inovae-Journal of Engineering, Architecture and Technology Innovation*, 6 (1), 279-299.

Zandonadi, B. D., Santos P. M., Medici O. L., & Silva J. (2014). Ação da matéria orgânica e suas frações sobre a fisiologia de hortaliças. *Horticultura Brasileira*, 32 (1), 14-20.