Chapter 34

Nutrient contents in vegetables fertilized with phosphate rock and gliricidia

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Sandoval Menezes de Matos
ORCID:https://orcid.org/000-0002-3307-1775 Federal Institute of Education, Science and Technology of Roraima - IFRR, Brazil
E-mail:sandoval.matos@ifrr.edu.br

Romildo Nicolau Alves
ORCID: https://orcid.org/0000-0002-9182-6080 Federal Institute of Education, Science and Technology of Roraima - IFRR, Brazil
E-mail: romildo.alves@ifrr.edu.br

Josimar da Silva Chaves
ORCID: https://orcid.org/0000-0001-5871-5605 Federal University of Roraima - UFRR - Campus Murupu
E-mail: josimar.chaves@ufrr.br

Hipólito Ribas Pereira
ORCID: https://orcid.org/0000-0001-8773-6878
Federal Institute of Education, Science and Technology of Roraima - IFRR, Brazil
E-mail:hipolito.pereira@ifrr.edu.br

Manoel Raimundo Barreira Dias
ORCID:https://orcid.org/0000- 0003-4943-9199
Federal Institute of Education, Science and Technology of Amapá - IFAP, Brazil
E-mail:manoel.dias@ifap.edu.br

Marcelo Figueira Pontes
ORCID: https://orcid.org/0000-0003-1073-852X
Federal Institute of Education, Science and Technology of Roraima - IFRR, Brazil
E-mail:marcelo.pontes@ifrr.edu.br

Oziel Furquin Pinto
ORCID:https://orcid.org/0000- 0003-3448-0623
Universidade Federal de Roraima - UFRR - Campus Murupu
E-mail: ozielfurquin@hotmail.com

Juliano Jonas Sabio de Melo
ORCID: https://orcid.org/0000-0003-3337-1038
Federal Institute of Education, Science and Technology of Roraima - IFRR, Brazil
E-mail:julianosabio@ifrr.edu.br

André Ferreira Silva
ORCID: https://orcid.org/0000-0003-3343-9530
Federal Institute of Education, Science and Technology of Roraima-IFRR, Brazil
E-mail:andre.silva@ifrr.edu.br

Adnelson Jati Batista
ORCID: https://orcid.org/0000-0003-1389-0981
Federal Institute of Education, Science and Technology of Roraima - IFRR, Brazil
E-mail:adnelson.jati@ifrr.edu.br

Arnaldo Gonçalves de Matos
ORCID: https://orcid.org/000-0003-1822-7011 State Secretary of Education of the State of Pará - SEDUC, Brazil
E-mail:arn.goncalves@hotmail.com

ABSTRACT
The nutritional requirements of vegetables have caused losses to small and medium-sized family farmers in terms of reduced productivity and food security in society. In this sense, the objective was to evaluate the development of okra (Abelmoschus escurentes L.) and cucumber (Cucumis sativus L.) plants, using sheep manure associated with phosphate rock and gliricídia and the quantification of the levels of N, P and K in plant structures. The experiment was conducted at the Federal Institute of Science and Technology of Roraima - Campus Novo Paraíso, in a greenhouse, using pots with a capacity of 6 L^{-1}, filled with soil (Neosolo) collected from the 0-20 cm layer. The experimental design was a randomized block, with treatments arranged in a 2x2 factorial, composed of two levels of gliricídia (without gliricídia (S / G) and (with gliricídia (C / G) and two levels of phosphate rock (without rock) (S / R) and (with rock (C / R), with four repetitions, being distributed in the blocks in a completely randomized way. A dose of sheep manure, corresponding to 25 t ha-1, was added to the pots. The variables determined in the study were: plant height (cm), stem thickness (mm), number of leaves, fruit diameter (mm), fruit length (cm), fruit weight (g) and the contents of N, P and K in the plant and in the fruits The results found for the different treatments showed no differences It was observed that the standardization of the fertility of the pots directly interfered in the statistical results, this way, the farmers can renounce

the use of the leaf of the gliricídia and of the rock phosphate, as long as he has sheep manure available.

Keywords: Organic agriculture. Agroecology. Sustainability.

1 INTRODUCTION

Brazil has been characterized as one of the world's largest producers of vegetables. According to Cavalcante et al. (2010) and Paes et al. (2012), in Brazil, the largest vegetable producers are small and medium-sized family farmers. Since these family producers take advantage of all the spaces on small properties to work with organic agriculture. In this context, organic agriculture plays a prominent role in the production process of these crops. Currently, in the national scenario, the production of vegetables in an organic system has been presented as a growing activity. So that, as a result of the need to produce vegetables in the organic system, it became a reality, bringing quality of life to the consumers' table and preserving the environments, within the small cultivated spaces. According to Vidal (2011), organic cultivation appears not only as an alternative to the current agro-industrial system, but as a strong basis for a paradigm shift and the interrelationship between society and agriculture. In addition, it rescues social, ecological and environmental issues, placing agriculture within a sustainable level, causing a great differential in this production system, as it allows for equity and balance in social relations, as well as its sustainability. in time and space.

According to Galati et al. (2013), okra (Abelmoschus escurentes L.) and cucumber (Cucumis sativus L.), are vegetables that are part of the food production chain, due to their nutritional importance, since they are important sources of nutrients for humans. . Okra is a very popular vegetable in regions with a tropical climate, mainly due to its hardiness and heat tolerance (Santos et al., 2020). Cucumber, according to Amaro et al. (2014), is among the ten vegetables with the highest commercial value in Brazil, and among the cucurbits it is one of the most cultivated in a protected environment. These crops can be cultivated both in the conventional model and also in the organic system.

The cultivation of vegetables in the State of Roraima, especially in the southern region of the State, has been an income option for small and medium-sized farmers.

In the southern region of the State of Roraima, there are producers who work with vegetables grown in organic systems as well as those who adhere to the conventional model. The efficient and practical use of strategies and techniques, cultivation and management based on different crop management systems favors increased productivity of vegetables (Silva, 2016). In the region, producers can already count on the support of two Centers for Studies in Agroecology, a center at the Federal Institute of Education, Science and Technology of Roraima - Campus Novo Paraíso, called NEPEAGRO (Center for Research and Extension Studies in Agroecology) and , another at the State University of Roraima-UERR/Campus

Rorainópolis. The nuclei aim to develop research that will improve the production systems of family farmers.

The use of organic sources and minerals of low solubility, such as phosphate rocks, are recommended products for use in agroecological systems. In this sense, organic matter provides improvements in the chemical, physical and biological properties of soils. Among the physical properties, the improvement in soil density and porosity stands out, favoring the retention of moisture in the soil. Regarding the chemical properties, one can cite the increase in the availability of nutrients (macro and micronutrients) slowly (Novais et al., 2007). As for the biological properties, the effect is related to the increase in the biodiversity of the microbial population, favoring the availability of nutrients and contributing to the process of decomposition of organic matter (Machado et al., 2012).

Gliricidia sepium is a leguminous plant that has been planted in rural properties, due to its high capacity to produce biomass, in conditions of low water availability with high nitrogen (N) content, by virtue of carrying out the process of biological nitrogen fixation (BNF). According to Silva et al. (2020), legumes play a special role in the soil, such as reducing the environmental impact, working nutrient cycling, avoiding wind and rain erosion, improving macrofauna, increasing soil microorganisms.

Phosphate rocks in agroecological systems are the main source of phosphorus (P), since, in addition to tropical soils being poor in P, most organic sources contain intermediate values of P (Gomes, 2018, Pereira et al., 2020). In this context, research on the availability of nutrients from the combination of organic sources and mineral sources of low solubility are of great importance for small and medium farmers in the organic system.

Given the above, the objective of this work was to evaluate the vegetative development (plant height (cm), stem thickness (mm), number of leaves, fruit diameter (mm), fruit length (cm), fruit weight (g)) and nutrient levels (N, P and K) in okra and cucumber cultures, using sheep manure associated with phosphate rock and the leguminous gliricidia.

2 Methodology

This is an exploratory research of a quantitative nature (Pereira et al., 2018), carried out in the south of the state of Roraima, conducted at the Federal Institute of Education, Science and Technology of Roraima - IFRR/Campus Novo Paraíso, in a protected environment, located in the geographical coordinates: latitude 1o 15' 01.46 N", longitude 60º 29' 12.30 W" and at an altitude of 83.09 m, in the municipality of Caracaraí - Roraima. The experimental design was in randomized blocks, with treatments distributed completely at random, with four replications, in a 2 x 2 factorial scheme, with two levels of gliricidia (without gliricidia – S/G (0 t ha-1) and with gliricidia – C/G (20 t ha-1)) and two levels of phosphate rock: without rock – S/R (0 kg ha-1 P2O5) and with rock – C/R (120 kg ha-1 P2O5).

In the study, sheep manure, gliricidia (Gliricidia sepium (Jacq.) Steud.) (leaves + petiole) and rock were used.

phosphate. Sheep manure was collected from rural properties in the municipality of Caracaraí - RR. The leaves and petiole of gliricidia plants were collected at the Nucleus of Studies, Research and Extension in Agroecology – NEPEAGRO/IFRR/Campus Novo Paraíso and the phosphate rock in the local market, with the following specifications: 28% P2O5, according to the manufacturer. A sub-sample of the phosphate rock was collected and taken to the laboratory to determine its chemical composition. A sub-sample of manure and gliricidia was collected, and then taken to the Soil and Plant Laboratory of the IFRR/Campus Novo Paraíso; they were weighed to obtain the wet weight and then placed in a forced circulation oven at 65 ºC for 72 hours. After 72 hours, they were crushed and passed through a Willey-type mill, then passed through a 1 mm sieve and a 250 mg subsample was taken for digestion.

For the determination of total N, 250 mg samples were digested using H2SO4 + H2O2 according to Embrapa (2017). Total organic C was determined by wet method according to Carmo and Silva (2012), phosphorus (P) by Colorimetry and potassium (K) by flame photometry, according to Embrapa (2017).

Pots with a capacity of 6 L-1 filled with soil, classified as Neosoil, collected in the layer (0-20cm), with the following chemical characteristics were used: pH in water = 5.4; Al+3 = 0.3 cmolc/dm3; Ca+2 + Mg+2 = 0.3 cmolc/dm3; K+ = 0.04 cmolc/dm3 and available P 3.4 mg/dm3 of soil. A standard dose of sheep manure of 25 t ha-1 (Figueiredo et al. 2012) was applied to all pots. The pots were moistened and left to rest for 10 days. After this period, doses of phosphate rock (0 and 120 kg ha-1 P2O5) and gliricidia (0 and 20 t ha-1) were applied.

Three seeds were sown per pot of cucumber (var. Valencia) and okra (var. Aodai). After germination, the

plants were thinned, leaving one plant/pot. The pots were irrigated with distilled water daily according to field capacity, to avoid the salinity of the osmotic medium. The phytotechnical evaluations began on the 15th day after sowing, being carried out at intervals of 2 days until the end of the experiment, at 72 days. On the 35th day, the indicator leaves (IF) of the cultures were collected, placed in a paper bag, taken to the laboratory and placed in an oven at 65 °C for 72 hours, according to the recommendation of EMBRAPA (2017), in order to determine the fresh and dry mass of the leaves. After carrying out the quantification, they were crushed in the mill and then digestion was carried out for the quantification analysis of the nutrients in the material. The evaluated variables were: plant height (cm), stem thickness (mm), number of leaves, fruit diameter (mm), fruit length (cm), fruit weight (g) and N, P contents and K in the plant and fruit.

Statistical analyzes were performed using the statistical program SISVAR version 5.6 (Ferreira, 2014), applying the F test to assess differences between treatments. Splits were performed using Tukey's test at a 5% probability level.

3 RESULTS AND DISCUSSION

The results of the chemical analyzes of the nutrient content of the organic sources (leaves and petioles of gliricidia + sheep manure) and mineral (phosphate rock) used are shown in table 1. The C/N ratio is the important parameter when studying organic materials (Kiehl, 1995; Santos et al., 2008). It is observed that the organic sources (gliricidia (leaves

+ petioles) and sheep manure), presented good C/N ratios (Kiehl, 1995; Gomes, 2018; Pereira et al., 2020).

Table 1. C/N ratio, macro and micronutrient contents in sheep manure and gliricidia

SOURCES	C/N	C	N	P	K	Ca	Mg	S	Cu	Fe	Zn	Mn	B
	..... g/kg								..... mg/kg				
Gliricídia	12,79	430	33,60	2,10	20,50	11,00	5,55	2,50	4	144	14	34	57
Sheep manure	12,24	307	27,30	5,25	27,50	13,25	6,87	4,50	30	1380	160	385	-
Phosphate rock	-	-	-	23,00	2,42	287,50	9,25	8,50	710	6100	10800	380	-

Source: Laboratório Agrotécnico Piracicaba Ltda

Organic sources are a good option in the production of vegetables, as they have good levels of macro and micronutrients (Kiehl, 1995). The levels of N, P and K in sheep manure (Table 1) were higher than those obtained by Pereira et al. (2020), and equal to that obtained by Gomes (2018). These variations in the levels of N, P and K in sheep manure are related to the nutritional quality of the feed supplied, the time of collection of the manure and the management of the herd. Gliricidia showed values close to those quantified by Nascimento et al. (2021). A low C/N ratio due to its high N content. This high N content in gliricidia is due to the process of biological N fixation (Souza et al., 2020). Pereira et al., (2020), when analyzing gliricidia (Gliricidia sepium (Jacq.) Steud.) found values of 2.8% of N and 0.4% of P, respectively, results similar to those obtained in this work.

The development of a plant requires a sequence of events that must occur in a precise and orderly manner. Growth is a quantitative term, related to changes in size and/or mass (Taiz et al., 2017). Table 2 shows the variables of plant height (cm), stem diameter (mm), number of leaves, fruit length, fruit weight and number of fruit/plant for the okra crop, note that the treatments did not differ from each other by Tukey at 5%. Studies carried out by Neto and Tischer (2012), show that the lack of macronutrients in vegetables cause symptoms of deficiency in their plant physiology, and, implying in their growth.

When evaluating the results of the variable plant height (cm), (Table 2), a value of 54.50 cm was observed, this value was higher than the values obtained by Santos et al. (2010), who evaluated okra at the beginning of flowering, cultivated in the presence of different species of competing plants and found plant height values ranging from 12.42 to 21.87 cm; however, lower than that obtained by Costa (2014), who verified the okra height of 73.82 cm.

Regarding the number of leaves, the results ranged from 9 to 11 leaves/plant, corroborating the results obtained by Santos et al. (2010), who evaluated the number of okra leaves, when grown with competing plants, obtained values ranging from 8.67 to 10.92 leaves/plant.

Regarding the fruit length variable (mm), the observed values ranged from 140.3 mm to 169.3 mm (Table 2), with an average of 155.56 mm. Studies by Oliveira et al. (2003) verified mean values of 140.0 mm for the okra fruit, when 200 kg ha-1 of N was applied; lower value than those obtained in this study. On the other hand, Folini and Zanin (1993), report values from 111.0 to 150.0 mm of fruit length. Regarding fruit weight (g) in the present study, it ranged from 148.39g to 189.65g, with an average of 166.21 g (Table 2), similar to those obtained by Mota et al. (2005) verified values from 141.45g to 173.17g, working with different okra cultivars. Regarding the number of fruits/plant, the treatments presented an average fruit value of 10.50 fruits/plant (Table 2), which would correspond to a productivity of 17 t ha-¹, which according to Mota et al. (2000), okra productivity ranges from 15,000 to 22,000 kg ha-1. These results confirm that the use of an organic source, whether of vegetable and/or animal origin in the fertilization of the crop, is important to maintain its productivity. According to Tokeshi et al. (2013), the presence of macronutrients and micronutrients in the soil, okra plants will have a nutritional balance, increasing their productivity.

Table 2. Phytotechnical variables plant height (cm), stem diameter (mm), number of leaves, fruit length (cm), fruit weight (g) and number of fruit/plant of the okra crop

Tratamentos	Altura de planta		Diâmetro do caule		Número de folhas		Comprimento de fruto		Peso de fruto		Nº de fruto/planta	
	.....cm.....		.....mm.....		-		..... mm.....		..... g		-	
	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R
S/G	45,00aA	46,88aA	8,85aA	10,68aA	9aA	11aA	169,3Aa	160,8Aa	189,65Aa	169,7Aa	11,50Aa	16,08Aa
C/G	51,75aA	54,50aA	11,66aA	11,80aA	10aA	9aA	140,3Aa	152,1Aa	148,39Aa	157,1Aa	8,75Aa	15,21Aa
Média geral	49,53		10,75		12,68		155,56		166,21		10,50	
CV (%)	7,80		5,07		4,89		7,66		16,11		9,84	

Means with equal letters in the column and capital letters in the line are not differentiated by Tukey's test at 5%. S/G: without gliricidia; C/G: with gliricidia; S/R: without phosphate rock; S/R: with phosphate rock
Source: Prepared by the authors.
Subtitle: Treatments: Plant height / stem diameter / number of leaves / fruit length / fruit weight / number of fruit / plant

3.1 OVERALL AVERAGE

Regarding the cucumber crop, it appears that the plants reached an average of 243 cm in height, 9.19 mm in stem diameter and 41.26 leaves (Table 3), higher values than those obtained by Silva et al (2011) . The C/G and C/R treatment was superior to the C/G and S/R treatment for the plant height variable (Table 3). The superiority of this treatment is basically due to the joint effect of manure, gliricidia and phosphate rock.

Table 3. Phytotechnical variables plant height (cm), stem diameter (mm) and number of leaves in the cucumber crop

Tratamentos	Altura de planta		Diâmetro do caule		Número de folhas		Comprimento de fruto		Peso de fruto		Nº de fruto/planta	
	.....cm.....		.....mm.....		-		..... cm.....		..... g		-	
	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R
S/G	197,00aA	232,75aA	8,85aA	7,79aA	32aA	46aA	15,60Aa	14,69Aa	187,99Aa	178,82Aa	7,50Aa	4,75Aa
C/G	219,00aB	317,25aA	10,85aA	9,70aA	36aB	48aA	16,02Aa	11,28Aa	206,27Aa	145,87Ba	7,75Aa	3,00Aa
Média geral	243,00		9,19		41,26		14,40		179,74		5,75	
CV (%)	14,54		14,66		18,28		13,73		16,29		8,21	

Means with equal letters in the column and capital letters in the line are not differentiated by Tukey's test at 5%. S/G: without gliricidia; C/G: with gliricidia; S/R: without phosphate rock; S/R: with phosphate rock.
Source: Prepared by the authors.
Subtitle: Treatments: Plant height / stem diameter / number of leaves / fruit length / fruit weight / number of fruit / plant

3.2 OVERALL AVERAGE

The average weight of the cucumber fruit obtained in the work was 179.74g (Table 3), higher than those obtained by Cardoso and Silva (2003), in two seasons, summer and autumn-winter, ranging from 133.28 to 159 .55g and 131.38 to 159.52g, respectively. These authors also quantified the number of fruit/plant, which were higher than the average values found in the present study of 5.75. In summer cultivation, they found values from 18.40 to 25.42 fruit/plant and in autumn-winter values were from 24.49 to 38.00 fruit/plant. The average fruit length was 14.40 cm, lower than that obtained by Santi et al. (2013). These fruit variations are characteristics influenced, in addition to fertilization, by genetics and climate.

The table (Table 4) shows the levels of N, P and K in different parts of the okra, where it was observed that the treatments did not differ among themselves by Tukey at 5%, with the exception of N in the leaf. For this variable, treatments C/G-S/R and C/G-C/R were statistically different by Tukey at 5%. It is worth mentioning that the levels of N, P and K in the indicator leaf were determined at the time of okra flowering and in the other parts at the end of the experiment. This same behavior is observed for P and K. Considering the levels of N, P and K in the indicator leaf as a parameter for assessing the nutritional quality of okra, it is noted that these values were close to or within acceptable ranges for okra of according to the reference values indicated by Malavolta (1989); Pimentel (1985); Raij et al. (1997); Ribeiro et al. (1999), Zárate and Vieira (2018). N in the indicator leaf ranged from 23.07 to 29.15 g kg-1, P from 2.10 to 2.46 g kg-1 and K from 39.60 to 43.56 g kg-1 (Table 4). EMBRAPA (2017) recommends levels of 35 to 50 g kg-1 of N, 3 to 5 g kg-1 of P and 25 to 40 g kg-1 of K for okra cultivation.

Tabela 4. Teores dos nutrientes N, P e K na cultura do quiabo.

Tratamentos	N folha		N fruto		P folha		P fruto		K folha		K fruto	
	g kg¹											
	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R
S/G	23,07Aa	25,37Aa	28,97Aa	28,92Aa	2,20Aa	2,10Aa	4,74Aa	4,66Aa	40,93Aa	43,58Aa	28,58Aa	29,88Aa
C/G	24,25Ba	29,15Aa	30,47Aa	30,72Aa	2,37Aa	2,46Aa	3,68Aa	5,69Aa	41,48Aa	39,60Aa	25,65Aa	28,25Aa
Média	25,46		29,77		2,28		4,69		41,39		28,09	
CV (%)	19,37		9,84		9,40		13,61		16,48		8,83	

Means with equal letters in the column and capital letters in the line are not differentiated by Tukey's test at 5%. S/G: without gliricidia; C/G: with gliricidia; S/R: without phosphate rock; S/R: with phosphate rock.
Source: Prepared by the authors.
Subtitle: Treatments/ N leaf/ P fruit/ P leaf/ P fruit/ K leaf/ K fruit

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For the cucumber crop, the statistical results for the levels of N, P and K in leaves and fruits show that the treatments did not differ from each other (table 5). The average values of the contents on the indicator sheet were 13.58 g kg-1 for N, 1.84 g kg-1 for P and 24.00 g kg-1 for K. N, P and K quantified in the leaves were lower than the values recommended by Solis (1982); Moltay et al. (1999); Ribeiro et al. (1999), Zárate and Vieira (2018). Solis (1982), working with the Aodai cucumber cultivar grown in the open field, established adequate ranges of nutrients for the crop from 29 to 42; 2 to 4 and 16 to 27 kg-1 of dry leaf mass, for N, P and K, respectively. Moltay et al. (1999) proposed adequate levels of macronutrients in the crop, 41; 5.2 and 45 g kg-1 of leaf dry mass for N, P and K, respectively. The values of N and K did not differ from those recommended by Maynard and Hochmuth (2007), who established the appropriate ranges of macronutrients for cucumber grown in a greenhouse at concentrations, in g kg-1, from 25 to 50; 5 to 10; 30 to 60; respectively for N, P and K.

Table 5. Contents of nutrients N, P and K in cucumber culture.

Tratamentos	N folha		N fruto		P folha		P fruto		K folha		K fruto	
	g kg¹											
	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R	S/R	C/R
S/G	13,65 Ba	20,50 Aa	22,30Aa	18,30Aa	1,76Aa	1,81Aa	6,98Aa	5,63Aa	22,40Aa	33,90Aa	45,35Aa	38,23Aa
C/G	8,47 Aa	11,70 Ab	17,07Aa	15,10Aa	2,13Aa	1,66Aa	5,33Aa	4,15Aa	18,00Aa	21,71Aa	30,73Aa	26,61Aa
Média	13,58		15,10Aa		1,84		5,52		24,00		35,23	
CV (%)	30,93		34,35		44,08		44,34		28,81		31,10	

Means with equal letters in the column and capital letters in the line are not differentiated by Tukey's test at 5%. S/G: without gliricidia; C/G: with gliricidia; S/R: without phosphate rock; S/R: with phosphate rock.
Source: Prepared by the authors.
Subtitle: Treatments/ N leaf/ P fruit/ P leaf/ P fruit/ K leaf/ K fruit

The standardization of soil fertility, it was possible to verify that the application of manure directly influenced the results obtained and, it was observed that the dose of 25 t/ha-1 of sheep manure met the nutritional demand of plants in terms of N, P and K. However, the dose of gliricidia and phosphate rock used may have been below what the plant needed for high productivity.

4 FINAL CONSIDERATIONS

The application of sheep manure at a dose of 25 t ha-1 directly influenced the results of the work, supplying the nutritional demand of okra and cucumber.

With the use of 25 t ha-1 of sheep manure, there is no need, for the cultivation of okra and cucumber, to use gliricidia leaves and phosphate rock to meet the needs of the plant.

Other works involving the association of organic and mineral sources in the fertilization of vegetables for the Amazon must be developed, for better use of the resources available in rural properties in this region, given the scarcity of financial resources by family farmers. Perspectives such as other organic sources for fertilization and level of fertilization are attributes that can be analyzed and come to be added to this study.

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