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Cultivation and physicochemical characterization of roselle under organic compost levels

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Abstract

Widely used in various countries, roselle (*Hibiscus sabdariffa*) is used for culinary, medicinal, and ornamental purposes. Due to the growing need for more nutritious foods free of toxic substances and aiming at the development of environmentally-correct alternatives, this study aimed to evaluate the growth, development, and physicochemical quality of roselle under organic compost levels. The experiment was conducted at the Horticulture Unit of the Federal University of Acre, consisting of the application of four levels of organic compost, corresponding to the following treatments: T1 - 0 (control), T2 - 200 mL, T3 - 400 mL, and T4 - 600 mL, deposited into planting holes spaced 0.5 m in three planting rows approximately 10 m long and spaced by 1 m. The experimental design was in randomized blocks, with five blocks. The data were subjected to regression analysis at 5% of probability. The growth, production, and physicochemical quality variables of the leaves were analyzed. Significant results were obtained for plant height and the number of branches, with the levels of 325 mL and 142 mL standing out as the best to provide the highest plant height (276 cm) and number of branches (14), respectively. There was no significant difference between the compost levels and the production parameters and physiochemical analyses of the leaves. The organic compost promoted the growth in height and the number of branches of *Hibiscus sabdariffa*.

Keywords: bromatology, composting, *Hibiscus sabdariffa*, organic fertilization

Introduction

Unconventional Food Plants (PANCs) constitute a healthy and sustainable alternative to achieving food security, reducing nutritional deficiency, diversifying the diet, and favoring health and quality of life. In this scenario, roselle (*Hibiscus sabdariffa*) is an unconventional vegetable of expressive use in several parts of the world, emerging as an important source of income for rural producers, especially in developing countries (Terra & Viera, 2019; Tuler et al., 2019).

Also known in Brazil as hibiscus, azedinha, and carurú-azedo, this species has been employed, over the years, for therapeutic, culinary, and ornamental purposes in various countries (Esteves et al., 2014).

The calyces of this species are widely used to prepare teas, liqueurs, flours, and preserves, standing out as the most used plant part due to their antimicrobial, diuretic, and anti-inflammatory bioactivity. However, the leaves, although less used, are outstanding sources of vitamins A and B1, mineral salts, organic acids, pectin, and amino acids. These structures are consumed as vegetables in various African countries, and their extract is rich in phenolic compounds, contributing to the reduction of chronic diseases (Al-Snafi, 2018; Zhen et al., 2016; Wu et al., 2018).

Moreover, although this crop is not considered of commercial importance in Brazil, it has favorable agronomic and biological characteristics for cultivation in the different Brazilian regions due to its high variability and rusticity (Kinupp & Lorenzi, 2014; Coelho & Amorim, 2019). The highest roselle consumption in Brazil occurs in the state of Maranhão, with the leaves of this species being used as the main ingredient of local traditional dishes, e.g., ‘cuxá’ and ‘cuxá rice’ (Cardoso, 1997).

Especially for family farming, horticulture represents an important alternative to obtaining rapid revenue since it relies

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on short-cycle crops. Roselle, for example, can be harvested after 90 days to obtain marketable leaves or after 180 days to obtain marketable calyces (Rezende, 2016).

In the current scenario, the main focus of the modern production of vegetable crops is carrying out ecological agriculture with a low supply of fertilizers or developing new manures and/or fertilization systems in order to increase the nutrient uptake, growth, and development of plants, thus improving their quality, yield, and reducing environmental impacts (Santos et al., 2014; Gomaa et al., 2018).

The supply of organic matter through organic composts is essential to maintain the balance of fertility in tropical soils by increasing the cation exchange capacity and the formation of soil aggregates, thus increasing aeration, drainage, and water retention through the formation of macro and micropores and allowing plants to reach higher production levels in the presence of nutrient supply (Araújo-Neto & Ferreira, 2019).

From this perspective, this study aimed to evaluate the growth, development, and physicochemical quality of roselle plants under levels of organic compost.

Material And Methods

The experiment was set up at the Horticulture Unit of the Federal University of Acre (UFAC), located at the following geographic coordinates: 9° 57' 35" S and 67° 52' 08" W, from October 2018 to June 2019. The data on the mean, maximum, and minimum temperatures inside the plant nursery were recorded using an Ht-500 datalogger, corresponding to 25 °C, 41 °C, and 17 °C, respectively.

The experimental design was arranged in complete randomized blocks. The treatments consisted of four levels of organic compost made of plant residues applied when the seedlings were transplanted to the field, as follows: T1 - 0 (control), T2 - 200 mL; T3 - 400 mL; and T4 - 600 mL, totaling 20 experimental units, each with three plants.

The organic compost used in the treatments was prepared at UFAC six months before the beginning of the experiment using a mixture of soil layers and Brachiaria grass (*Urochloa brizantha*) with alternate heights of 1.5 m and 10 m. Organic compost samples were taken out and sent for analysis, showing the following chemical composition: pH = 6.9; organic matter = 18 g.dm³; P = 130 g.dm³; K = 1.9 mmol.c/dm³; Ca = 50 mmol.c/dm³; Mg = 16 mmol.c/dm³; Al = 0 mmol.c/dm³; H = 18 mmol.c/dm³; SB = 67.9 mmol.c/dm³; CEC = 86 mmol.c/dm³; and V = 79%.

The seedlings were produced by direct sowing in 200-mL plastic containers containing a mixture of soil and Subras® substrate at a ratio of 1:1. The seedlings were then transplanted to their definitive location upon reaching 30 cm in height.

Soil preparation consisted of cleaning the area and opening plant holes 20 cm deep. The spacing used was 1 m between rows and 0.50 m between plants. Then, the seedlings were fertilized according to the treatments, with no subsequent topdressing fertilization.

Irrigation was performed with a watering can according to the crop requirements. Hoeing was performed manually. Preventive weed control was performed using a natural product based on 1% neem oil, whereas fungal control was performed using a biofertilizer based on topsoil, grass, and ash, diluted in water at a ratio of 1:1.

Roselle evaluation was performed by measuring the following variables: plant height 172 days after transplanting; the number of branches per plant, quantified after harvest; the number of fruits per plant; and the dry phytomass of the calyces, expressed as grams and determined after drying in a forced-air oven at 65° C until constant weight. The product between the planting density (20,000 plants/ha^{-1}) and the number of fruits per plant was used to obtain the mean number of calyces per hectare, whereas the product between the planting density and the dry phytomass of calyces provided the mean calyx yield, expressed as kg.ha^{-1} .

After 90 experimental days, roselle leaf samples corresponding to each treatment were collected and sent to the Food Technology Unit (UTAL) of UFAC. At the laboratory, the samples were analyzed to determine the content of ascorbic acid, lipids, moisture, ash, and protein by the Kjeldahl method. The contents of carbohydrates and total soluble solids were determined according to (Lutz, 2005).

The collected data were subjected to verification of assumptions by the (Shapiro & Wilk, 1965) test and homogeneity of variances by (Bartlett's, 1937) test. The variables of production, lipids, and carbohydrates underwent logarithmic transformation. The data were subjected to analysis of variance by the F-test at 5% of probability. Regression models were adjusted for the results that showed significant differences according to the determination coefficient up to 5% of significance.

Results And Discussion

The number of branches per plant and plant height showed a significant effect of the treatments employed in the experiment. According to the regression equation, these variables adjusted better to the quadratic model, expressing a height of 276 cm with 325 mL/hole of organic compost (**Figure 1**).

The same behavior was observed in the number of branches per plant, with the level of 142 mL/hole of organic compost corresponding to the formation of 14 branches per plant (**Figure 2**).

(Norhayati et al., 2019) studied the effect of organic fertilizers on the growth and yield of *Hibiscus sabdariffa* and observed similar performance, with a height of 102.27 cm for plants treated with organic fertilizer. (Amin & Kanimarani, 2020) and (Hewidy et al., 2018) studied the effects of organic compost application on the vegetative and reproductive growth of roselle and also observed positive effects on plant growth parameters.

Significant results for fertilizer application on growth parameters were obtained by (Akanbi et al., 2009). However, there was a negative correlation between plant growth and compost levels, demonstrating that the plants showed reduced performance as the compost levels increased.

The present study corroborates the explanation of the authors mentioned above since, from the maximum levels of 325 and 142 mL/hole, the variables of plant height and number of branches per plant showed a decreasing behavior. Therefore, adding organic residues at adequate levels can provide better conditions for roselle plants to express higher growth efficiency, induced by their genetic structure and cultivation conditions. The increase in these parameters shows that organic composts potentiate the physical conditions of the soil through organic matter incorporation, increasing the microbiota, which, in turn, produces organic acids, directly influencing growth (Baldotto & Baldotto, 2014).

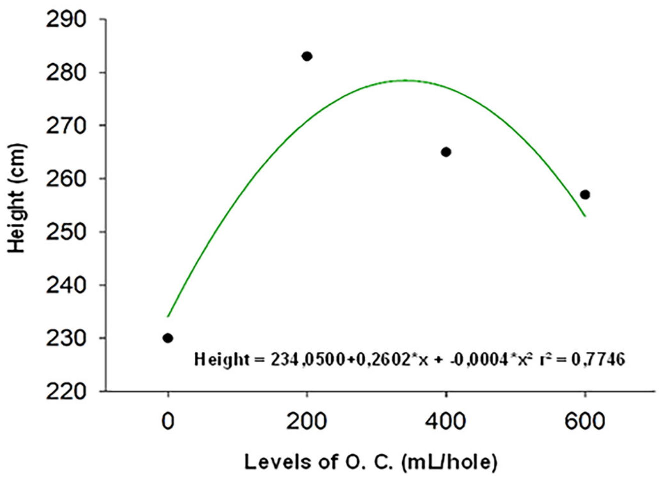

Figure 1. Levels of organic compost in roselle's height, in Rio Branco - AC, 2019.

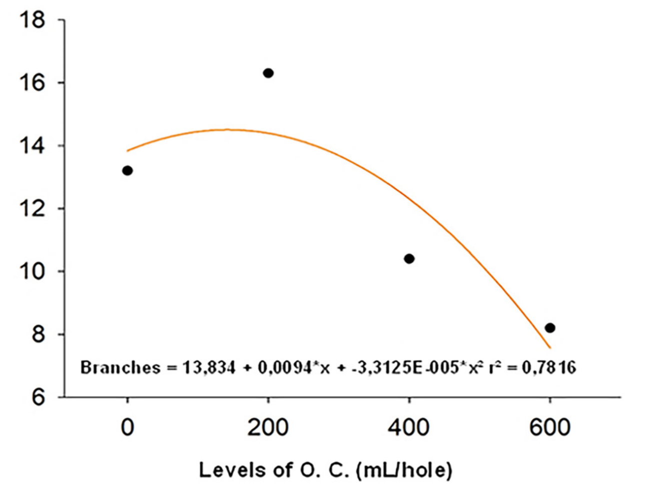

Figure 2. Levels of organic compost in the number of branches of roselle, in Rio Branco - AC, 2019.

Since roselle can be cultivated as a vegetable through the commercialization of its leaves for salads and traditional dishes, it is more favorable to produce plants with a more abundant architecture and a higher number of branches. Different organic compost levels did not influence the number of calyces per plant, the dry phytomass expressed as grams, the mean number of calyces per hectare, and the mean calyx yield expressed as kg/ha^{-1}.

In absolute terms, the highest dry calyx phytomass was observed in T3, corresponding to 400 mL/hole of organic compost and agreeing with the yield expressed as kg/ha^{-1}. However, this treatment also showed the lowest number of calyces per plant and hectare compared to the treatment with 200 mL/hole, showing that the highest calyx mass compensated for the reduction in the number of fruits (**Table 1**).

The literature contains other references that disagree from the results of the present study. (Shuhaimi et al., 2019) observed significant differences when evaluating the number of fruits per plant and the dry calyx mass, highlighting that the use of organic compost made of food plant residues contributed to forming heavier fruits, with 1.78 g per calyx, and the highest number of fruits, 11 per plant.

However, at the level of 400 mL/hole of organic compost, the present experiment obtained 627.04 kg/ha^{-1}, showing that, regardless of not showing any statistical difference in relation to the compost levels, the calyx yield as kg/ha^{-1} accompanied the production average observed in the literature.

The absence of roselle response in relation to the production parameters as a function of organic compost could be associated with the use of non-marketable seeds resulting from ripe fruits harvested from spontaneously-grown plants and a single harvest event 20 days after the beginning of flowering, with no time for complete maturation or gain of calyx mass.

According to (Castro et al., 2004), a single harvest

Table 1. Mean values of calyxes dry mass, yield in kg/ha^{-1}, number of calyxes per plant and calyxes per hectare in levels of organic compost, in Rio Branco - AC, 2019

Levels of O. C. (mL/hole)	Dry mass (g)	Yield (kg/ha^{-1})	Nº of calyx per plant	Calyx per hectare
0	22.29^{a}	445.88^{a}	82.6^{a}	1652^{a}
200	24.04^{a}	480.72^{a}	95.4^{a}	1908^{a}
400	31.35^{a}	627.04^{a}	84.9^{a}	1698^{a}
600	26.13^{a}	522.68^{a}	59.3^{a}	1186^{a}
Mean	25.95	519.08	80.55	1611

Means followed by distinct letters indicate a significant difference for the T test.

Table 2. Centesimal composition of roselle leaves, protein, fat, carbohydrate, ashes, humidity, content of vitamin C (Vit. C) and total soluble solids (TSS). Rio Branco - AC, 2019

Levels of O. C. (mL/hole)	Protein (g/100g)	Fat (g/100g)	Carbohydrate (g/100g)	Ashes (g/100g)	Humidity (%)	TSS (%)	Vit.C (mg)
0	4.66^{a}	1.82^{a}	10.11^{a}	1.77^{a}	81.62^{a}	18.37^{a}	15.68^{a}
200	5.36^{a}	5.42^{a}	5.97^{a}	1.69^{a}	81.54^{a}	18.45^{a}	16.37^{a}
400	4.91^{a}	4.76^{a}	6.04^{a}	1.71^{a}	82.58^{a}	17.42^{a}	15.35^{a}
600	5.91^{a}	6.31^{a}	6.66^{a}	1.59^{a}	81.24^{a}	18.76^{a}	16.09^{a}
Mean	5.21	4.58	7.20	1.69	81.75	18.25	15.87

Means followed by distinct letters indicate a significant difference for the T test

at the end of the reproductive cycle results in heavier calyces since these structures remain longer on the plant. However, many fruits reached senescence, generating quality losses and hindering commercialization, thus resulting in low yields.

Therefore, the alternate harvest performed every 15 days after the beginning of the reproductive period could be a viable alternative to increasing production indices. It should also be noted that organic fertilizers release nutrients slowly and for longer, unlike immediate inorganic fertilizers, which explains the similarity between treatments and suggests the need for higher compost levels (Lanna et al., 2017).

As stipulated by the nutritional composition table of food products consumed in Brazil (IBGE, 2011), roselle shows 2.11 g of protein, 0.36 g of fat, and 4.91 of carbohydrates. By evaluating the values found in this study and considering that the analyses showed no significant differences ($p>0.05$) between treatments, the results obtained for protein, fat, and carbohydrates were higher than the reference cited above (**Table 2**).

The (TACO food composition, 2011) table establishes an ideal ascorbic acid content of 10.3 mg for 'cuxá', a sauce prepared with roselle leaves. Compared to the lowest vitamin C content observed (15.35 mg), the equivalent to treatment 3 (400 mL of organic compost), it can be inferred that the ascorbic acid content present in the roselle leaves of the present study is 32% higher than the value determined in the literature.

As explained by (Rocha et al., 2014), the nutrient composition of roselle leaves shows variations between the studies present in the literature due to genetic, environmental, and ecological differences, the cultivation conditions, and the harvest differences to which plants are subjected.

These results demonstrate that the insertion into the diet of unconventional food plants such as roselle contributes to diversifying consumption and provide favorable levels of ascorbic acid, proteins, fat, carbohydrates, and minerals, acting as powerful complements for healthy nutrition and boosting the spread of ecological knowledge by the simplicity of management and lower use of fertilizers.

Conclusion

Organic compost promotes plant growth and height and increases the number of roselle stems (*Hibiscus sabdariffa)*.

The levels of organic compost did not increase the production and contents of physicochemical compounds in the leaves of roselle plants.

References

Akanbi, W.B., Olanyan, A.B., Togun, A.O., Ilupeju, A.E.O., Olaniran, A.O. 2009. The effect of organic and inorganic fertilizer on growth, calyx yield and quality of roselle (*Hibiscus sabdariffa* L.). *American-Eurasian Journal of Sustainable Agriculture* 3: 652-657.

Al-Snafi, A.E. 2018. Pharmacological and therapeutic importance of *Hibiscus sabdariffa* - A review. *International Journal of Pharmaceutical Research* 10: 451-475.

Amin, M.I.M., Kanimarani, S.M.S.A. 2020. Growth and productivity of roselle (*Hibiscus sabdariffa* L.) as affected by compost fertilizer. *Plant Archives* 20: 5980-5986.

Araújo Neto, S.E., Ferreira, R.L.F. 2019. *Agricultura ecológica tropical*. Clube de Autores, Rio Branco, Brasil. 169 p.

Baldotto, M.A., Baldotto, L.E.B. 2014. Ácidos húmicos. *Revista Ceres* 61: 856-881.

Bartlett, M.S. 1937. Properties of sufficiency and statistical test. *Procedings of the Royal Society of London* 160: 268-282.

Cardoso, M.O. 1997. *Hortaliças não convencionais da Amazônia.* Embrapa Ocidental, Brasília, Brasil. 152 p.

Castro, N.E.A., Pinto, J.E.B.P., Cardoso, M.G., Morais, A.R., Bertolucci, S.K.V., Silva, F.G., Delú-Filho, N. 2004. Planting time for maximization of yield of vinegar plant calyx (*Hibiscus sabdariffa* L.). *Ciência e Agrotecnologia* 28: 542-551.

Coelho, C.A., Amorim, S.B. 2019. Expandindo a distribuição geográfica de *Hibiscus sabdariffa* L. (Malvaceae): uma espécie naturalizada e negligenciada para a flora brasileira. *Hoehnea* 46: 2-7.

Esteves, G.L., Duarte, M.C, Takeuchi, C. 2014. Sinopse de *Hibiscus* L. (*Malvoideae, Malvaceae*) do Estado de São Paulo, Brasil: espécies nativas e cultivadas ornamentais. *Hoehnea* 41: 529-539.

Gomaa, A.O., Youssef, A.S.M., Mohamed, Y.F.Y., Abdallah M.S.A. 2018. Effect

of some fertilization treatments on Growth, Productivity and Chemical Constituents of Roselle (*Hibiscus sabdariffa* L.) plants. *Scientific Journal of Flowers and Ornamental Plants* 5: 172-193.

Hewidy, M., Elsayed, M., Sultan, E. 2018. Water Schedule of Roselle (*Hibiscus sabdariffa* L.) under organic fertilization. *Egyptian Journal of Horticulture* 45: 53-64.

Instituto Adolfo Lutz. 2005. *Métodos Físico-Químicos para a Análise de Alimentos*. Instituto Adolfo Lutz, Brasília, Brasil. 1018 p.

IBGE. 2011. *Pesquisa de Orçamentos Familiares 2008-2009: Tabela de composição nutricional para os alimentos consumidos no Brasil.* IBGE, Rio de Janeiro, Brasil. 351 p.

Kinupp, V.F., Lorenzi, H. 2014. *Plantas Alimentícias Não Convencionais (PANC) no Brasil: guia de identificação, aspectos nutricionais e receitas ilustradas.* Instituto Plantarum de Estudos da Flora, São Paulo, Brasil. 768 p.

Lanna, N.B.L., Silva, P.N.L., Colombari, L.F., Freitas-Nakada, P.G., Cardoso, A.I.I. 2017. Doses of organic compost on yield and accumulation of macronutrients on endive. *Horticultura Brasileira* 35: 621-627.

Norhayati, Y., Ng, W.H., Adzemi, M.A. 2019. Effects of organic fertilizers on growthand yield of roselle (*Hibiscus sabdariffa* L.) on bris soil. *Malaysian Applied Biology* 48: 177-184.

Rezende, A.L.P.S. 2016. *Caracterização e estudo da vida útil de vinagreira cultivada em Seropédica - RJ.* 60 f. (Dissertação de Mestrado) – Universidade Federal Rural do Rio de Janeiro, Seropédica, Brasil.

Rocha, I.C., Bonnlaender, B., Sievers, H., Pischel, I., Heinrich, M. 2014. *Hibiscus sabdariffa* L. A phytochemical and pharmacological review. *Food Chemistry* 165: 424-443.

Santos, C.F., Siqueira, E.S., Araújo, I.T., Guedes, Z.M. Agroecology as a means of sustainability for family-based agriculture. *Ambiente & Sociedade* 17: 34-49.

Shapiro, S.S., Wilk, M.B. 1965. An analysis of variance test for normality (complete samples). *Biometrika* 52: 591-611.

Shuhaimi, S.A.N.B., Kanakaraju, D., Nori, H. 2019. Growth performance of roselle (*Hibiscus sabdariffa*) under application of food waste compost and Fe_3O_4 nanoparticle treatment. *International Journal of Recycling of Organic Waste in Agriculture* 8: 299-309.

TACO. *Tabela brasileira de composição de alimentos.* 2011. NEPAUNICAMP, Campinas, Brasil. 161 p.

Terra, S.B., Viera, C.T.R. 2019. Plantas Alimentícias Não Convencionais (PANCs): levantamento em zonas urbanas de Santana do Livramento, RS. *Ambiência* 15: 112-130.

Tuler, A.C., Peixoto, A.L., Silva, N.C.B. 2019. Plantas alimentícias não convencionais (PANC) na comunidade rural de São José da Figueira, Durandé, Minas Gerais, Brasil. *Rodriguésia* 70: e01142018.

Wu, H.Y., Yang, K.M., Chiang, P.Y. 2018. Roselle Anthocyanins: Antioxidant Properties and Stability to Heat and pH. *Molecules* 23: 1357-1370.

Zhen, J., Villani, T.S., Guo, Y., Qi, Y., Chin, K., Pan, M.H., Ho, C.T., Simon, J.E., Wu, Q. 2016. Phytochemistry, antioxidant capacity, total phenolic content and antiinflammatory activity of *Hibiscus sabdariffa* leaves. *Food chemistry,* 190: 673-680.

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