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Doffinger Ramos, Diovany; do Carmo Vieira, Maria; Heredia Zárate, Néstor Antonio; Takeo Yamamoto, Natanael; Oliveira Carnevali, Thiago; Hilgert Souza, Natália
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Spacings between plants with chicken manure in Roselle crop

Diovany Doffinger Ramos*, Maria do Carmo Vieira, Néstor Antonio Heredia Zárate, Natanael Takeo Yamamoto, Thiago Oliveira Carnevali and Natália Hilgert Souza

*Departamento de Ciências Agrárias, Universidade Federal da Grande Dourados, Rua João Rosa Góes, 1761, 79825-070, Dourados, Mato Grosso do Sul, Brazil. *Autor para correspondência. E-mail: diovany3@hotmail.com*

ABSTRACT. The purpose of this work was to analyze the effects of plant spacing within rows by means of applying or not applying chicken manure to the soil cover in the growth and yields of roselle biomass. The treatments consisted of five spacings between plants (0.30, 0.35, 0.40, 0.45 and 0.50 m) and the application or non application of chicken manure to the soil cover in a dose of 10 ton. ha^{-1}, arranged in randomized blocks of 5 x 2 with four replicates. The maximum plant height (282.92 cm) was achieved at 200 days after the transplant (DAT), with 0.35 m between plants and without the application of chicken manure. The leaf area was significantly influenced by the interaction of the spacings between plants and the application of chicken manure, presenting a linear growth of 32,009 cm^2 plants^{-1}. The biggest fresh and dry weight yields in leaves were 31,571 and 3,339 kg ha^{-1}, respectively, with a 0.30 m spacing between the plants. The biggest yields of both fresh and dry weights of the stems and fruits of roselle plants were obtained in the soil with chicken manure.

Keywords: *Hibiscus sabdariffa*, plant arrangement, organic residues.

RESUMO. Espaçamentos entre plantas e cama-de-frango na produção de Rosela. O objetivo deste trabalho foi avaliar o efeito de espaçamentos entre plantas dentro das fileiras e do uso ou não de cama-de-frango na cobertura do solo sobre o crescimento e a produção de biomassa de plantas de rosela. Os tratamentos consistiram de cinco espaçamentos entre plantas (0,30; 0,35; 0,40; 0,45 e 0,50 m) e do uso ou não de cama-de-frango em cobertura do solo, na dose de 10 t ha^{-1}, arranjados como fatorial 5 x 2, no delineamento de blocos casualizados, com quatro repetições. A altura máxima da planta (282,92 cm) foi alcançada aos 200 dias após o transplante (DAT) sob 0,35 m entre plantas e sem o uso de cama-de-frango. A área foliar foi influenciada significativamente pela interação espaçamentos e cama-de-frango e cresceu linearmente com os espaçamentos entre plantas, sendo de 32.009 cm^2 planta^{-1} com cama. As maiores produções de massas frescas e secas de folhas foram de 31.571 e 3.339 kg ha^{-1}, respectivamente, sob 0,30 m entre plantas. As maiores produções de massas frescas e secas de folhas, caules e frutos de plantas de rosela foram obtidas em solo com cama-de-frango.

Palavras-chave: *Hibiscus sabdariffa*, arranjo de plantas, resíduo orgânico.

Introduction

Roselle (*Hibiscus sabdariffa* L., Malvaceae) is a famous medicinal plant with several uses and benefits (OTTAI et al., 2006). The plant originated from India, Sudan and Malaysia and was later introduced to Oriental Africa and the Central American countries. In Brazil, it is adapted to several regions and can also be found in residential gardens (SILVA JÚNIOR, 2003). Owing to the interest in its leaves, calyxes, seeds and fibers, the roselle plant has been cultivated and widely used as human and animal food; its fibers also represent a great source for the textile and paper industry (FAGBENRO, 2005; MUKHTAR, 2007). The roselle plant is an important source for vitamins A, B and C, iron, phosphorus and proteins, which enables the replacement of animal protein. Its calyx is used in jelly, paste, sweets, syrup and wine preparation; its manufacturing residues can also produce vinegar of very good quality (CHANG et al., 2003). Its seeds contain 17% oil with properties similar to cotton oil (OOI; SALLEH, 1999).

Regarding medicine, the roselle plant has been considered an anti-septic, aphrodisiac, astringent, digestive, diuretic, emollient, purgative, sedative and a tonic (OLALEYE, 2007); its calyxes have also been used as an anti-hypertensive (FARAJI; HAJI TARKHANI, 1999). In addition, the polysaccharides of its flowers stimulate keratinocyte proliferation and differentiation (BRUNOLD et al., 2004).

The roselle extract (HSE) is known for its hypolipidemic and anti-atherosclerosis activities in rabbits with experimental atherosclerosis (CHANG et al., 2003). Hibiscus antocianine, a group of phenolic natural pigments present in the dry flowers of *Hibiscus sabdariffa* and *Hibiscus rosasinensis*, has a cardioprotective (OLALEYE, 2007) and anti-oxidant effect (AMIN; HAMZA, 2005) in animals.

Castro et al. (2004) evaluated the yield of roselle calyxes in four planting seasons (October 18, November 15 and December 18 of 2001, and January 15 of 2002) in the city of Lavras in the state of Minas Gerais and observed that the planting seasons were different. The best results were obtained in October, with a calyx yield of 2,522 kg ha^{-1}.

There is little available information on roselle crops in the literature. The purpose of this work was to evaluate the effects of spacing plants within rows and to determine the effects of applying semi decomposed chicken manure to the soil cover on the growth and yield of roselle plants.

Material and methods

The field experiment was carried out from September 2006 to March 2007 at the Medicinal Plant Nursery (HPM), Federal University of Grande Dourados (UFGD), in the city of Dourados, Mato Grosso do Sul State. This area is located in the southern part of Mato Grosso do Sul (452 m in altitude; 22°14'16" S latitude and 54°49'2" W longitude). The climate is Cwa, by the Köppen classification system. The total precipitation and highest and lowest temperatures (means per each ten days) were registered in the city of Dourados throughout the experiment cycle and are shown in Figure 1.

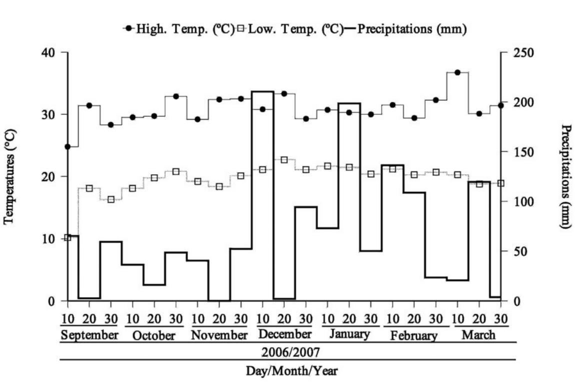

Figure 1. Total precipitation and highest and lowest temperatures (means per each ten days) throughout the roselle crop cycle. City of Dourados, State of Mato Grosso do Sul-UFGD, 2006/2007.

The soil, originally from Cerrado vegetation, is classified as distroferric Red Latosol, with a sandy texture and heavy and of flat topography. Its chemical characteristics before the transplant and after the harvest, with or without chicken manure, as well as the semi decomposed chicken manure, are shown in Table 1.

Table 1. Chemical analysis of the soil samples with and without semi decomposed chicken manure cover harvested from the field before the transplant, but after the harvest and analysis of the semi-decomposed chicken manure. City of Dourados, State of Mato Grosso do Sul - UFGD, 2006/2007.

Soil attributes[1]	Before the transplant		After the Harvest	
	without manure	with manure	without manure	with manure
pH in $CaCl_2$ (1:2.5)	4.90	5.20	5.00	5.00
pH in water (1:2.5)	5.90	6.10	5.80	5.70
Al^{+3} (mmol$_c$ dm^{-3})[4/]	0.00	0.60	0.60	0.60
P (mg dm^{-3})[3/]	38.00	72.00	33.00	45.00
K (mmol$_c$ dm^{-3})[3/]	8.20	13.30	4.90	5.50
Mg (mmol$_c$ dm^{-3})[4/]	17.00	16.30	13.00	14.00
Ca (mmol$_c$ dm^{-3})[4/]	51.30	59.30	32.00	35.00
Organic weight (g kg^{-1})[2/]	32.00	32.30	26.10	24.10
Pot. Acid. (mmol$_c$ dm^{-3})	65.00	53.00	58.00	55.00
Sum of bases (mmol$_c$ dm^{-3})	76.50	88.90	49.90	54.50
(CTC) (mmol$_c$ dm^{-3})	141.50	141.90	107.90	109.50
Bases saturation (V) %	54.00	62.00	46.00	49.00
Attributes of the semi decomposed chicken-manure[5]				
C organic %			18.20	
P total %			0.89	
K total %			0.58	
N total %			2.01	
Ca total %			6.56	
Mg total %			0.57	
Relation C/N			9/1	

[1]Analysis made at the Laboratory of Soil of FCA-UFDG; [2]Walkley & Black Methods (JACKSON, 1976); [3]Mehlich Extractor (BRAGA; DEFELIPO, 1974); [4]KCL [1]N Extractor (VETTOR, 1969); [5]Analysis made at the Laboratory of Organic weight and residues of UFV.

The roselle plants were studied by using five spacing treatments between the plants in a row (0.30, 0.35, 0.40, 0.45 and 0.50 m) in soil with or without semi decomposed chicken manure cover, in a dose of 10 ton. ha^{-1}. Treatments were arranged in randomized blocks of 5 x 2 with four replicates. The total area of the plots corresponded to 4.5 m^2 (1.5 m of width x 3.0 m of length) and a work area of 3.0 m^2 (1.0 m of width and 3.0 m of length), which included two rows of plants with a spacing of 0.50 m.

Scattering was done by indirect sowing on 24 September, 2007, with harvested seeds of cultivated plants from the Medical Plant Nursery of HPM, UFGD, Federal University of Grande Dourados. Plantlets were produced in polystyrene trays of 128 cells with Plantmax® substrate, which were kept in a protected environment with 50% sombrite® and were submitted to daily irrigation. When seedlings achieved approximately 10 cm of height, on 28 October, 2007, they were transplanted to their soil plots.

A week before the transplant, the soil was plowed and harrowed with a tractor, and the seed beds were raised with a rotative seed bed lifter. Immediately after the transplant, the semi decomposed chicken manure was scattered over the plots. Throughout the crop cycle, the field cultural practices consisted of irrigation by sprinkling every 2 days and manual hoeing. The heights of the plants were evaluated every 20 days, from the 20th day until the 200th day after the transplant (DAT). At the blooming stage, on the 88th DAT, four plants were selected from each plot and cut at soil level. The stems and leaves were then separated to obtain the fresh weight and leaf area. Leaf area was determined by integrating the leaf area model LI 3000. Five harvests of fruit from plants from each plot were made every 15 days, beginning on the 151st DAT, and they were measured; a size larger than 3.5 cm was an indication that the fruit was ready to be harvested. Hand harvesting with pruning shears was applied to cut the stems just below the fruit, which were then weighed to obtain the fresh weight. The total number was obtained after cutting all the fruit after the last harvest. A digital pachymeter was used to measure the length and diameter of samplings of six fruit per plot. To obtain the dry weight, the fresh weight of the stems, leaves and fruit were cut separately and put into paper bags. The bags were put in an oven with forced air circulation at a temperature of 60 ± 5°C until a constant weight was achieved.

Analysis of the proportions of N and P in the dry weight of leaves and calyxes was done for random samples from each plot. Extracts obtained by sulphuric digestion for N and perchloric-nitric for P were also used. After digestion, the determination of N was done by the micro-Kjedhal method, and the determination of P was done by using a coulometer with a mobilate vandalate (MALAVOLTA et al., 1997).

The data averages were submitted to analysis of variables, and when the F test showed meaningfulness at 5% of probability, regression equations were adjusted for the spacing between plants.

Results and discussion

The plants' heights showed similar tendencies of growth, independent of spacing and application of chicken manure (Figure 2). The maximum height average at 200 DAT was 261.88 cm. Such low variation despite the treatments demonstrates the predominance of the standard characteristics of shape in the species (ZHUKOVA et al., 1996).

The leaf area was significantly influenced by the interaction between the spacings and the application of chicken manure. The largest leaf areas (26.359 cm^2 plant^{-1} without chicken manure, and 32.009 cm^2 plant^{-1} with chicken manure) were obtained with 0.50-m spacings between the plants (Figure 3). The smallest leaf area, under a bigger population pressure, may have occurred because of the competition for light, nutrients and water throughout the process of growth (ZANINE; SANTOS, 2004). Considering the increase in leaf size induced by the dead cover, the chicken manure may have kept the soil slightly damper and allowed water infiltration to provide nutrients and maintain the soil structure (HEREDIA ZÁRATE et al., 2003).

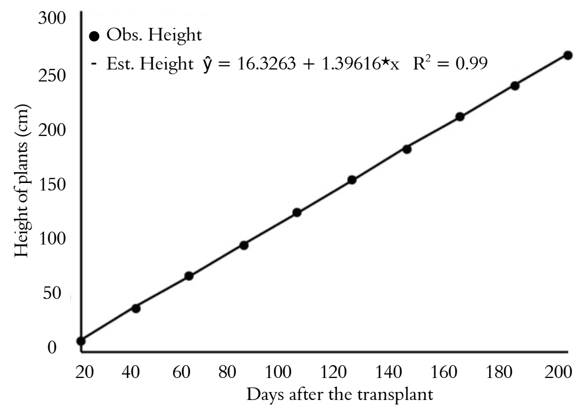

Figure 2. Height of the roselle plants throughout the crop cycle. City of Dourados, State of Mato Grosso do Sul - UFGD, 2006/2007. *Refers to 5% of probability.

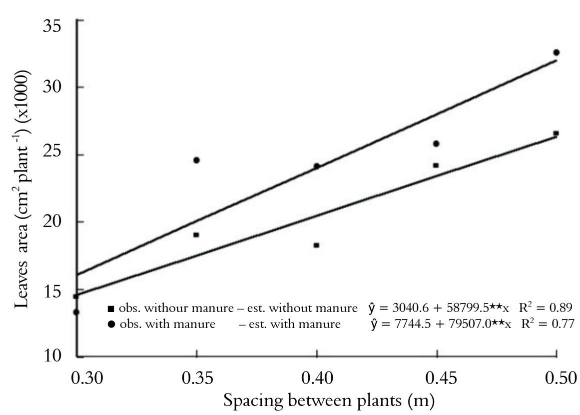

Figure 3. The area measurements of the leaves from the roselle plants cultivated in five spacings between plants within the rows and in soil with or without chicken manure. City of Dourados, State of Mato Grosso do Sul - UFGD, 2006/2007. **Refers to 1% of probability.

The fresh and dry weight yields of the roselle leaves were significantly influenced by the spacings between plants and the application of chicken manure, separately. Regarding the spacings between plants, the biggest fresh and dry weight yields were 31,571 and 3,339 kg ha^{-1}, respectively, at 0.30 m between plants, and the smallest were 24,272 and 2,301 kg ha^{-1}, respectively, at 0.50 m between plants (Figure 4). Such results demonstrate that, although the individual yield was reduced as the competition increased, the higher number of plants per area was worthwhile and resulted in a bigger yield.

In percentage terms, the fresh and dry weight yields in leaves showed a significant increase of 24.83 and 26.06%, respectively, with the treatment of chicken manure (Table 2). Such results demonstrate that the chicken manure cover must have provided mineral organic products, such as P and K, to the soil (Table 1). Owing to the increase in the microbial activity in the soil, it simultaneously promoted changes in the airing and capacity to retain water (HEREDIA ZÁRATE et al., 2002) in response to the organic decomposition, which occurred due to the long vegetative cycle of the roselle plant. Consequently, it helped in the growth and development of the plants. As the leaf area was not bigger with the application of chicken manure, the increase in the leaf weight may have resulted from the increased thickness of the leaves and the size of their stems.

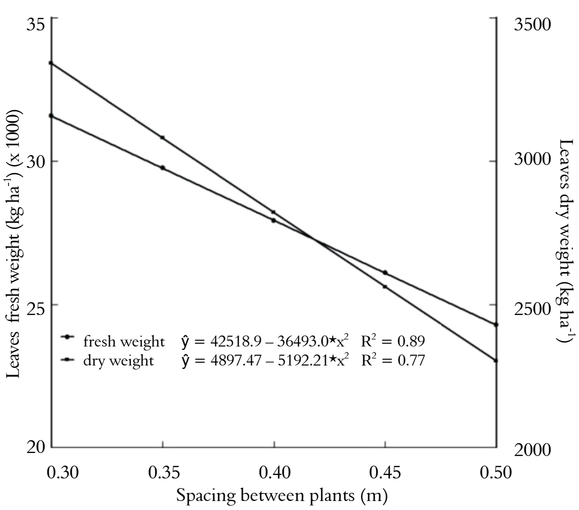

Figure 4. Fresh and dry weight of leaves from the roselle plants cultivated in five spacings between plants within the rows. City of Dourados, State of Mato Grosso do Sul - UFGD, 2006/2007. *Refers to 5% of probability.

Table 2. Fresh weight yields of leaves (LFW) and stems (SFW) and dry weight yields of leaves (LDW) and stems (SDW) from the roselle plants cultivated in soil with and without semi decomposed chicken manure in the covering. City of Dourados, State of Mato Grosso do Sul - UFGD, 2006/2007.

Chicken-manure	LFW	LDW	SFW	SDW
	kg ha^{-1}			
with	31,880 a	3,243 a	61,032 a	8,157 a
without	23,963 b	2,398 b	38,944 b	5,443 b
C.V. (%)	16.60	21.94	13.24	19.42

The means followed by the same letters in the columns do not differ among themselves by the F test at 1% of probability. The data of spacing were gathered.

The fresh and dry weight yields of the roselle stems were not significantly influenced by the spacings between plants and presented an average of 49,988 and 6,800 kg ha^{-1}, respectively. On the other hand, the fresh and dry weight yields were greater in plants that were cultivated in soil with chicken manure cover than without it, presenting an increase of 36.19 and 33.27%, respectively (Table 2). The soil covered with chicken manure may have improved water infiltration and retention, which consequently improved the distribution in the radicular system of the roselle plants, as Heredia Zárate et al. (2003) observed in scallions (*Allium fistulosum*) 'Todo ano'. The higher stem yields is an important finding for extracting fiber, which is used in the rope industry. In studying the effect of sowing periods (at the end of April with two breaks of 20 days) and the climatic factors (four experimental stations) over the fiber yield in the years 1979 and 1980, Sermsri et al. (1987) mentions that the cutting at the blossoming stage, approximately 165 days after the planting, resulted in greater yields of fiber 2,775 and 1,965 kg ha^{-1} in 1979 and 1980, respectively, which were the averages for both the three periods and the four places. The low yield presented by the author in relation to such work must have been due to the differences between the climatic and soil conditions.

The fresh and dry weights of the fruit were not significantly influenced by the spacings between plants, which presented average yields of 27,460 and 3,379 kg ha^{-1}, respectively. On the other hand, the fruit yields were significantly influenced by the application of chicken manure, being 38.28 and 32.62% larger with chicken manure, respectively (Table 3). The positive effect of applying chicken manure may have been caused not only by the increased nutrient supply but also by raising the soil humidity and capacity to exchange cations, which consequently improved the use of the nutrients already present in the soil (KIEHL, 2008). Thus, the benefits from adding organic residues may have enabled the roselle plant to improve its capacity to produce fruits. Vieira et al. (2009) studied the yield of 'Mandirituba' chamomile capitula as functions of N addition (3, 18, 30, 42 and 57 kg ha^{-1}) in the ammonia sulfate form combined with semi-decomposed chicken litter (1,000; 6,000; 10,000; 14,000 and 19,000 kg ha^{-1}) doses and obtained the highest fresh and dry mass yields of capitula from combinations of the greatest doses of chicken litter with N. The yields obtained in this study were larger than the ones obtained by Castro et al. (2004); however, the authors evaluated the calyxes (calyxes and small calyxes) and not the complete fruits and achieved a 2,522 kg ha^{-1} yield.

The number of fruit was not significantly influenced by the spacing between plants and presented an average of 5,404,874 fruit ha^{-1}. On the other hand, the use of chicken manure increased the number of fruit by 27.71% (Table 3). Castro et al.

(2004) studied the yield of calyxes in different periods and obtained a yield of 7,276,500 fruit ha^{-1} when sowing in October. The length and diameter of the fruits were not influenced by the spacing between plants regardless of the presence or absence of chicken manure (Table 3), with averages of 38.4 mm with chicken manure and 20.8 mm without.

Table 3. The fresh weight (FRFW) yields and dry weight (FRDW) yields of fruit, number (NUM), length (LENGTH) and diameter (DIAM) of the fruits from the roselle plants cultivated in soil with or without chicken manure covering. City of Dourados, State of Mato Grosso do Sul - UFGD, 2006/2007.

Chicken-manure	FRFW	FRDW	NUM	LENGTH	DIAM
	(kg ha^{-1})		(million ha^{-1})	(mm)	
with	33,960 a	4,037 a	6,273.987 a	38.6 a	20.9 a
without	20,960 b	2,720 b	4,535.762 b	38.2 a	20.7 a
C.V. (%)	18.74	16.59	23.82	3.24	3.05

The means followed by the same letters in the columns do not differ among themselves in the F test at 5% of probability.

The nitrogen (N) and phosphorus (P) levels in the leaves and calyxes were not influenced by the spacing between the plants or by the application of chicken manure. The average dry weights of the leaves and calyxes were 29.5 and 18.0 g kg^{-1} of N and 0.67 and 0.76 g kg^{-1} of P, respectively. The level of N in the leaves corresponded to the values established by Cantarella (2007), which ranged from 20 to 30 g kg^{-1} of N in dry weight. As established by Novais et al. (2007), when considering P, both in the leaves and calyxes, the values were below critical, ranging from 1 to 5 g kg^{-1} of P in dry weight; P is required for excellent plant growth in general. The values established by Novais et al. (2007) may be more appropriate for larger crops and improved species, which are recognizably efficient in absorption and translocation of such a nutrient. The opposite occurs with medicinal plants, which present a great genetic variability but are yet to be greatly studied.

Conclusion

Under the conditions of this experiment, the largest fresh and dry weight yields in the leaves, stems and fruits of roselle plants were achieved with chicken manure covering (10 ton. ha^{-1}) and spacings of 0.30 m between plant rows.

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