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Influence of spacing and application of biofertilizer on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench)

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The adequate spacing in okra (*Abelmoschus esculentus*) influences its growth and fruit production. The objective of this study was to evaluate the growth, the leaf composition and okra production in different spacing with and without biofertilizer. This research was carried out from October, 2012 to March, 2013, at the Federal University of Paraiba, Areia county, Paraiba State, Brazil. The experimental design was a randomized complete block design with three replications, using the 3 × 4 × 2 factorial scheme, referring to three spacing between rows (0.80, 1.00 and 1.20 m), four spacing between plants (0.30, 0.40, 0.50 and 0.60 m), with and without bovine biofertilizer. The leaf area, mean fruit mass, number of plant^{-1} fruits, plant^{-1} fruit yield and N, P and K contents were significantly influenced by the spacing × biofertilizer interaction. The commercial productivity of the okra was altered only by the spacing. The application of biofertilizer at spacing of 1.00 × 0.50 m and 1.20 × 0.50 m increased the leaf area of okra. The smaller spacing, associated with the presence of biofertilizer, increased the productive characteristics of okra.

Key words: Organic input, population density, yield.

INTRODUCTION

Okra (*Abelmoschus esculentus*) is an annual vegetable, of easy cultivation; it has erect, upright and semi-woody stem, being able to reach up to 3 m in height. The main producing regions of Brazil are the Northeast and Southeast (Oliveira et al., 2013). The crop is very suitable for family agriculture practiced in Brazil, because it has

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Table 1. Soil chemical characteristics in the 0-20 cm depth, biofertilizer and the of cattle of manure used in the experiment.

Soil characteristic	Value	Bovine biofertilizer	Value	Bovine manure	Value
OM (g kg^{-1})	17.4	N (g kg^{-1})	1.04	N (g kg^{-1})	10.96
pH em água (1:2.5)	5.8	P (g kg^{-1})	0.33	P (g kg^{-1})	3.44
P (mg dm^{-3})	87.6	K (g kg^{-1})	0.54	K (g kg^{-1})	11.33
K^+ (mg dm^{-3})	109.5	Ca^{+2} (mmol L^{-1})	0.29	OM (g kg^{-1})	72.14
Na^+ ($cmol_c dm^{-3}$)	0.18	Mg^{+2} (mmol L^{-1})	0.49		
Ca^{+2} ($cmol_c dm^{-3}$)	3.5	Na^+ (mmol L^{-1})	38.00		
Mg^{+2} ($cmol_c$ dm^{-3})	1.30	OM (g kg^{-1})	21.04		
Al^{+3} ($cmol_c dm^{-3}$)	0,00				

OM = organic matter.

good adaptability to the tropical climate, resistance to drought and provide employment in the harvest, classification and packing operations, besides the precocity in the production and relatively long period of harvest, being a good alternative of income for the small scale farmer (Oliveira et al., 2007; Kumar et al., 2015).

The ideal plant density to be used in a given crop is that sufficient to achieve the optimum leaf area index to intercept the maximum solar radiation useful for photosynthesis (Oliveira et al., 2010; Paranhos et al., 2016). In this sense, the plant population acts on the penetration of solar radiation and on the balance between growth of the vegetative parts and the fruits. Thus, changes in the plant population or increased availability of solar radiation indirectly affect the distribution of dry matter between plant organs (Kunz et al., 2007).

The spacing used for the cultivation of okra varies with the producer's system of conduction and interest, with recommendations of high and low population densities, such as: 90 × 30, 100 × 50 and 150 × 50 cm, the last one with two plants by pit (Sediyama et al., 2009). The use of adequate spacing is very important because it exerts influence on flowering, number of productive stems, yield per plant and crop productivity, which may exceed 15,000 kg ha^{-1} (Silva et al., 2007; Gaion et al., 2013). In the literature it is possible to find scientific information of works evaluating the effect of spacing on the okra culture in Nigeria (Makinde, 2014) and India (Brar and Singh, 2016). However, the scientific information for Brazil is still incipient. Philip et al. (2010) by evaluating the effect of NPK spacing and fertilization on okra in Nigeria, verified that planting density affects crop production components, and concluded that the spacing of 0.9 m × 0.3 m provides the higher yield for the crop.

The crop usually requires high doses of organic fertilization, which is of fundamental importance for adequate plant nutrition, fruit quality and productivity improvement with less or no use of nitrogen fertilizers (Sediyama et al., 2009). In view of these aspects, it is necessary to use organic fertilizers, solid or liquid, in adequate quantities, since the okra has a good vegetative and productive development in the organic system of production, reaching quality adequate to market demands (Cardoso and Berni, 2012).

Among the liquid organic fertilizers, the bovine biofertilizer stands out because it is an organic source of low cost, mainly due to the increasing demand for new production technologies that present cost reduction. These facts have stimulated researchers and farmers to experiment biofertilizer prepared from the aerobic or anaerobic digestion of organic materials as fertilizer to replace mineral fertilizers (Silva et al., 2012). In vegetables, the biofertilizer can be used by spraying weekly on soil or leaf, diluted in water in proportions ranging from 10 to 30% to allow a perfect development of the plants, since it has a short vegetative and reproductive cycle, requiring a faster and more efficient complementation (Oliveira et al., 2013). In this sense, this work aimed to evaluate the growth, the leaf composition and okra production in different spacing with and without biofertilizer.

MATERIALS AND METHODS

The work was carried out from October, 2012 to March, 2013, at the Federal University of Paraiba (UFPB), Areia, Paraiba States, Brazil. According to Köppen's classification, the climate of the research area is type As' (Alvares et al., 2014), which is characterized as hot and humid, with autumn-winter rains, and average annual temperature ranging between 23 and 24°C. Altitude of the research site is 574.5 m. The soil of the experimental area, according to the criteria of the Brazilian System of Soil Classification-SiBCS (Embrapa, 2013), is classified as a RegoliticNeosol. The chemical analyzes of the soil in the 0 to 20 cm layer, bovine biofertilizer and bovine manure (Table 1) were performed according to Embrapa (2011), by the Laboratory of Chemistry and Soil Fertility of the UFPB.

The experimental design was a randomized complete block design with three replications, in a 3 × 4 × 2 factorial scheme, referring to three spacing between rows (0.80, 1.00 and 1.20 m), four spacing between plants (0.30, 0.40, 0.50 and 0.60 m) and presence and absence of bovine biofertilizer. The number of plants of the experimental plot varied according to the spacing, and the two central rows were collected for evaluation purposes. The soil was prepared by means of plowing and harrowing, in order to provide favorable conditions for planting and development of the

Table 2. Summary of analysis of variance for leaf area (LA), average fruit mass (MMF), number of fruits per plant (NFP), nitrogen (N), phosphorus (P) and potassium (K) contents, and yield per plant (PP) and commercial yield (PC) of okra cultivated at different spacing with and without bovine biofertilizer.

FV	GL	LA	MMF	NFP	N	P	K	PP	PC
Block	2	147193.93*	1.73ns	26.33ns	22.74ns	1.81ns	29.68ns	1.28ns	52.58**
Spacing (S)	11	1074142.49**	2.47ns	315.18**	25.32**	3.66**	57.61**	0.28**	194.20**
Biofertilizer (B)	1	284457.84**	0.57ns	280.64**	26.69ns	11.42**	59.67**	0.34**	9.25ns
S × B	11	231307.25**	3.93**	57.12*	21.93**	2.01*	27.26*	0.10**	10.04ns
Residue	46	35735.51	1.25	27.02	8.14	1.02	9.51	0.03	9.31
Total	71								
CV (%)		16.00	5.77	17.17	7.75	19.98	12.81	23.84	15.82

FV, Source of variation; GL, Freedom degree; **significant at P<0.01 probability error; *significant at P< 0.05 probability error; ns, non-significant; CV, coefficient of variation.

plants, and then opening of pits. The planting of the crop was by means of direct sowing by placing five seeds per pit of the Xingó hybrid, with thinning at 15 days leaving only one plant per pit. The fertilization consisted of 100 kg ha^{-1} of P_2O_5 (single superphosphate), 70 kg ha^{-1} of K_2O (potassium chloride) and 15 t ha^{-1} of bovine manure in planting fertilization. The coverage was supplied 100 kg ha^{-1} de N (ammonium sulfate) in equal parts at 30 and 60 days after sowing (DAS). The biofertilizer was prepared according to Diniz et al. (2013), obtained by fermentation for 30 days in plastic recipient in the absence of air and mixture containing fresh bovine manure and water in the proportion of 50% (volume/volume). To obtain the anaerobic system, the mixture was placed in a 200 L plastic bottle, leaving a sealed space of 15 to 20 cm in its interior, hermetically sealed, and fitting a hose to the lid, plunging the other end into a recipient with water of 20 cm height, for the exit of gases. In the treatments that received biofertilizer (in the soil), six applications were performed at a concentration of 20% (1 L of biofertilizer and 4 L of water) every 15 days until 90 DAS, in the amount of 0.5 L $plant^{-1}$.

Manual weeding was performed with the help of hoes, aiming to keep the weed free area. In the periods of absence of rainfall, additional irrigations were carried out by the conventional sprinkler system, with an attempt to maintain the crop with sufficient moisture availability for its normal growth. There was no attack of pests and diseases that could cause economic damage to the crop. Flowering started 52 days after sowing with management of the plots as per the recommendation, leaf area of five plants in each treatment and repetition was determined using the LAI-model 2200 equipment. Twenty fresh leaves were collected on the same day from the middle part of the plants each treatment, as suggested by Malavolta et al. (1997), which were conditioned in Kraft paper bags to oven drying with forced air circulation at 65°C until it reached constant weight. The leaves were ground in a Willey mill and transferred to the Laboratory of Chemistry and Soil Fertility of the Federal University of Paraiba for the determination of the N, P and K contents, according to Embrapa (2011) methodology. Harvesting of the fruits, every two days, started at 52 days after sowing and lasted until 113 DAS, at which time the experiment was closed. In all harvests, the fruits were harvested before their full maturation. The average commercial fruit mass was recorded by weighing all the commercial fruits, divided by the number of fruits harvested. Fruits with length between 10 and 15 cm, straight, without deformations and with intense green coloration were considered commercial fruit (Filgueira, 2008). The number and production of commercial fruits $plant^{-1}$ corresponded to the number and production of commercial fruits divided by the number of plants harvested in each plot and repetition. Commercial fruit yield was determined by weighing all commercial fruits in each treatment, and the results were estimated for t ha^{-1}. The data were submitted for analysis of variance by F test, and then the means comparisons by Scott-Knott test, at 5% probability, using the statistical program SISVAR (Ferreira, 2011).

RESULTS AND DISCUSSION

The leaf area, average fruit kneading, the number of fruit per plant (fruit $plant^{-1}$), fruit production per plant (kg $plant^{-1}$), and the contents of N, P and K were significantly influenced by the interaction effect of spacing × bovine biofertilizer. The commercial productivity of okra only responded to the isolated effect of spacing (Table 2). The largest leaf areas in the treatments with bovine biofertilizer were obtained at spacing of 1.00 × 0.50 m and 1.20 × 0.50 m, with an area of 2246 and 1978.7 cm^2, respectively. In the treatments without the organic input, the largest leaf area was observed in the spacing 1.20 × 0.50 m, with a value of 1968.61 cm^2. When the leaf area values were compared in the treatments with and without biofertilizer in the spacing of 1.00 × 0.50 m, it was observed that the area in the treatments with biofertilizer was superior (103%) (Table 3). When considering the leaf area alone, it was observed that the plants in this spacing presented a larger area to intercept the incident solar radiation. According to Silva et al. (2010), the reduction of plant density increased the leaf area, however, it reflects in lower production per plant (Ramos et al., 2009), as observed in Table 5. In this sense, the plant population acts on the penetration of solar radiation and on the balance between vegetative growths (Kunz et al., 2007; Taiz and Zeiger, 2013).

At the spacing of 1.00 × 0.60 m, without biofertilizer, the maximum average mass of 20.3 g was obtained (Table 3). The average fruit mass is located within the range for commercial fruits in okra, defined by Filgueira (2008), between 20 and 25 g, which may indicate that it is not necessary for high population of plants in the okra to raise the average mass of fruits. It was expected that in this spacing the effect of the biofertilizer on the average

Table 3. Leaf area, average mass of commercial fruits and number of fruits plant^{-1} in okra cultivated in different spacing with and without bovine biofertilizer.

Spacing (m)	Leaf area (cm^2)		Average mass of fruit (g)		N° of fruit planta^{-1}	
	Biofertilizer		Biofertilizer		Biofertilizer	
	With	Without	With	Without	With	Without
0.80 × 0.30	702.80^{dA}	741.33^{dA}	19.5^{aA}	19.6^{cA}	22.7^{bA}	23.8^{cA}
0.80 × 0.40	830.53^{dA}	785.30^{dA}	20.3^{aA}	19.9^{bA}	38.8^{aA}	33.9^{bA}
0.80 × 0.50	1083.65^{cA}	781.63^{dA}	21.0^{aA}	19.2^{cA}	39.8^{aA}	42.5^{aA}
0.80 × 0.60	726.09^{dA}	682.53^{dA}	19.3^{aA}	18.6^{cA}	42.6^{aA}	42.4^{aA}
1.00 × 0.30	805.30^{dA}	781.06^{dA}	20.0^{aA}	18.2^{cA}	31.9^{aA}	23.7^{cB}
1.00 × 0.40	764.13^{dB}	1224.20^{cA}	22.2^{aA}	18.7^{cB}	26.7^{bA}	22.3^{cA}
1.00 × 0.50	2246.00^{aA}	1104.76^{cB}	19.4^{aA}	19.4^{cA}	28.5^{bA}	24.0^{cA}
1.00 × 0.60	1232.40^{cA}	1021.35^{cA}	18.3^{aB}	20.3^{aA}	35.0^{aA}	17.5^{cB}
1.20 × 0.30	1722.20^{bA}	1278.36^{cB}	19.4^{aA}	19.2^{cA}	19.0^{bA}	22.7^{cA}
1.20 × 0.40	1072.53^{cA}	1241.95^{cA}	19.1^{aA}	17.9^{cA}	29.3^{bA}	25.2^{cA}
1.20 × 0.50	1978.70^{aA}	1968.61^{aA}	20.2^{aA}	18.2^{cB}	37.0^{aA}	27.3^{cB}
1.20 × 0.60	1570.05^{bA}	1615.70^{bA}	18.0^{aA}	18.5^{cA}	35.4^{aA}	30.3^{cA}
Mean	1272.63	1102.23	19.47	19.29	32.26	28.31

Means followed by the same lowercase letter in the columns and upper case in the lines, do not differ by the Scott-Knott test, 5% probability.

fruit mass would be higher, because the okra responds positively to its use (Oliveira et al., 2013), due to its easy assimilation, providing an increase in infiltration velocity of water, due to the organic input contributing to improvement of soil conditions, especially the physical properties of the soil (Silva et al., 2012), taking into account the nutritional requirements of the crop, due to the balanced supply of macro and micronutrients, which allowed development of their genetic potential and results in higher yields. On the other hand, the highest average mass of fruits in the treatments without biofertilizer can be attributed to the initial soil characterization (Table 1), associated to organomineral fertilization with 100 kg ha^{-1} of N, 100 kg ha^{-1} of P_2O_5, 70 kg ha^{-1} of K_2O and 15 t ha^{-1} of bovine manure. In addition, although the fruits were harvested every two days, and fruits with a length between 12 and 18 cm (Filgueira, 2008) were adopted as the criterion for harvesting, possibly the fruits collected in the treatments without the biofertilizer presented a longer length, which may have contributed to increase the average mass of the fruits in the treatments without the organic input.

The highest numbers of okra plant^{-1} (42.6, 39.8, 38.8, 37.0, 35.4, 35.0, 31.9) fruits with biofertilizer were verified at the spacing 0.80 × 0.60 m, 0.80 × 0.50 m, 0.80 × 0.40 m, 1.20 × 0.50 m, 1.20 × 0.60 m, 1.00 × 0.60 m and 1.00 × 0.30 m, respectively. Without biofertilizer, the spacing 0.80 × 0.50 m and 0.80 × 0.60 m produced 42.5 fruits plant^{-1} (Table 3). The results obtained for fruit numbers are similar to those obtained by Sediyama et al. (2009) and Wu et al. (2003) evaluating the effect of spacing in the okra, where they found a number of fruits plant^{-1} of 45.09 and 42.76, respectively. Oliveira et al. (2013) working with the same crop registered a number of lower fruits plant^{-1}, with a value of 33 fruits plant^{-1}.

The maximum levels of leaf N in okra were 42.9, 42.6 and 40.2 g kg^{-1} obtained at the spacing 0.80 × 0.30 m (41666 plants ha^{-1}), 0.80 × 0.40 m (31250 plants ha^{-1}) and 1.00 × 0.60 m (16666 plants ha^{-1}) in the treatments without biofertilizer (Table 4). According to Malavolta (1987), these contents were within the species-specific range (35 to 50 g kg^{-1}) and were similar to the levels of 35.8 and 32.6 g kg^{-1} obtained by Sediyama et al. (2009) in the populations of 23809 and 35714 plants ha^{-1}. The highest leaf content of N in the 0.80 × 0.30 m and 0.80 × 0.40 m spacing in the treatments without biofertilizer is the response of chemical fertilization with 100 kg ha^{-1} of N and organic fertilization with bovine manure (10, 96 g kg^{-1}), associated to lower fruit yield per plant (Table 5), which may have contributed to increased leaf N content of okra plants even without the application of bovine biofertilizer.

The spacing 1.20 × 0.40 m, 1.20 × 0.50 m and 1.20 × 0.60 m, with biofertilizer, were responsible for the highest levels of P in okra at 6.69 g kg^{-1}, 6.32 g kg^{-1}and 6.39 g kg^{-1}. However, these levels were above the appropriate range (3.0 to 5.0 g kg^{-1}) for the species (Malavolta, 1987; Trani and Raij, 1996). The maximum K contents with biofertilizer use were verified at spacing 0.80 × 0.50 m, 29.4 g kg^{-1}, 0.80 × 0.60 m, 26.5 g kg^{-1}, 1.00 × 0.30 m, 27.3 g kg^{-1}, 1.20 × 0.50 m, 27.0 g kg^{-1} and 1.20 × 0.60 m27.6 g kg^{-1} (Table 4). Without the addition of the organic input, the highest K contents in the leaves were verified at spacing 0.80 × 0.60 m, 29.7 g kg^{-1}, 1.00 ×0.30 m, 27.6,

Table 4. Nitrogen, phosphorus and potassium contents in okra leaves in okra grown at different spacing with and without bovine biofertilizer.

Spacing (m)	Nitrogen (g kg^{-1})		Phosphorus (g kg^{-1})		Potassium (g kg^{-1})	
	Biofertilizer		Biofertilizer		Biofertilizer	
	With	Without	With	Without	With	Without
0.80 × 0.30	36.2^{aB}	42.9^{aA}	5.99^{aA}	5.38^{aA}	22.6^{bA}	25.3^{bA}
0.80 × 0.40	34.4^{aB}	40.2^{aA}	4.08^{bA}	4.07^{bA}	23.8^{bA}	21.5^{cA}
0.80 × 0.50	40.0^{aA}	35.9^{bA}	5.98^{aA}	4.00^{bB}	29.4^{aA}	24.1^{bB}
0.80 × 0.60	33.6^{aA}	37.6^{bA}	5.41^{aA}	5.54^{aA}	26.5^{aA}	29.7^{aA}
1.00 × 0.30	34.3^{aA}	38.5^{bA}	4.81^{bA}	5.39^{aA}	27.3^{aA}	27.6^{aA}
1.00 × 0.40	35.0^{aA}	32.1^{bA}	6.47^{aA}	4.95^{aA}	22.6^{bA}	21.1^{cA}
1.00 × 0.50	33.2^{aA}	34.6^{bA}	4.63^{bA}	4.73^{aA}	23.8^{bA}	23.5^{bA}
1.00 × 0.60	38.6^{aA}	42.6^{aA}	3.60^{bA}	3.98^{bA}	24.1^{bA}	14.0^{dB}
1.20 × 0.30	38.9^{aA}	35.4^{bA}	5.26^{aA}	2.85^{bB}	23.8^{bA}	17.0^{dB}
1.20 × 0.40	37.0^{aA}	34.0^{bA}	6.69^{aA}	4.23^{bB}	20.6^{bA}	22.0^{cA}
1.20 × 0.50	36.7^{aA}	37.1^{bA}	6.32^{aA}	6.41^{aA}	27.0^{aA}	29.4^{aA}
1.20 × 0.60	36.2^{aA}	37.8^{bA}	6.39^{aA}	4.49^{bB}	27.6^{aA}	22.0^{cB}
Mean	36.21	37.43	5.46	4.67	24.98	23.16

Means followed by the same lowercase letter in the columns and upper case in the lines do not differ by the Scott-Knott test, 5% probability.

Table 5. Production and commercial productivity of okra cultivated at different spacing with and without bovine biofertilizer.

Spacing (m)	Production of fruit $plant^{-1}$ (kg $plant^{-1}$)		Comercial productivity (t ha^{-1})
	Biofertilizer		
	With	Without	
0.80 × 0.30	0.44^{cA}	0.47^{bA}	20.48^{c}
0.80 × 0.40	1.35^{aA}	0.80^{bB}	29.31^{a}
0.80 × 0.50	1.03^{bA}	1.00^{aA}	28.88^{a}
0.80 × 0.60	0.99^{bA}	1.14^{aA}	25.37^{b}
1.00 × 0.30	0.74^{cA}	0.52^{bA}	19.97^{c}
1.00 × 0.40	0.54^{cA}	0.56^{bA}	16.75^{d}
1.00 × 0.50	0.67^{cA}	0.47^{bA}	15.76^{d}
1.00 × 0.60	1.01^{bA}	0.43^{bB}	17.33^{d}
1.20 × 0.30	0.42^{cB}	0.68^{bA}	14.73^{d}
1.20 × 0.40	0.65^{cA}	0.52^{bA}	13.56^{d}
1.20 × 0.50	0.93^{bA}	0.75^{bA}	16.25^{d}
1.20 × 0.60	0.76^{cA}	0.66^{bA}	13.03^{d}
Mean	0.80	0.66	19.28

Means followed by the same lowercase letter in the columns and upper case in the lines, do not differ by the Scott-Knott test, 5% probability.

g kg^{-1} and 1.20 × 0.50 m, 29.4 g kg^{-1} (Table 4). These contents were within the range suitable for okra (20.5 to 30 g kg^{-1}) according to Malavolta (1987). Values similar to the maximum K content obtained in this study were verified by Sedyama et al. (2009), which obtained K leaf content in okra of 25.14 kg^{-1}, in the population of 23,809 plants ha^{-1}.

In general, the presence of the biofertilizer increased P and K contents, possibly by improving soil properties (Mellek et al., 2010), providing better conditions for assimilation by the plants, together with the contents of these nutrients in their initial composition, of 0.33 and 0.54 g kg^{-1} respectively. The highest production of $plant^{-1}$ fruit was achieved in the 0.80 × 0.40 m s pacing in the presence of the biofertilizer and in its absence, the 0.80 × 0.50 m and 0.80 × 0.60 m spacing produced the highest production of plant^{-1} fruits, respectively, of 1.00 and 1.14 kg (Table 5). These results demonstrate that, regardless of the use of the biofertilizer to increase fruit production in okra, a population of over 31000 ha^{-1} plants is required. The efficiency of okra plant in harnessing higher soil volume and, consequently, higher amount of water and nutrients occurs in smaller spacing, consequently larger plant populations. Sediyama et al. (2009) and Ijoyah et al. (2010) reported that in this vegetable the highest yields of plant^{-1} fruits are obtained when it is cultivated with smaller spacing.

The maximum commercial fruit yields of 29.31 and 28.88 t ha^{-1} were obtained at the smallest spacing of 0.80 × 0.40 m and 0.80 × 0.50 m (Table 5). These productivities are considered good for the conditions of the present study, because according to Sediyama et al. (2009), it is within the range for maximum commercial productivity obtained with plant population of 23,809 and 35,714 plants ha^{-1}, which is 21.9 and 31.3 t ha^{-1}, respectively. The commercial fruit yield was reduced with the increase of the spacing, possibly due to the pressures exerted by the population of plants that markedly affected its development. According to Gebologlu and Sagllam (2002), when the density of plants per unit area increases, it is likely to reach a point at which plants compete for essential growth factors such as nutrients, light and water, reducing their productive capacity. Some authors have observed a reduction in fruit productivity with spacing elevation in some vegetables, such as tomato (Wamser et al., 2009), maxixe (Oliveira et al., 2010) and okra (Sediyama et al., 2009).

The increase in commercial fruit yield obtained in smaller spacing may be due to the greater interception of photosynthetically active light and photosynthesis in the canopy, which stimulates the growth of the crop and increases the total assimilates available for the fruits. Ibeawuchi et al. (2005) argue that one of the major aspects of ecology and management that often limits agricultural production is improper spacing in the field. Changes in the plant population or increased availability of solar radiation indirectly affect the distribution of dry mass between plant organs (Kunz et al., 2007).

Conclusion

The largest leaf areas of okra were obtained at spacing of 1.00 × 0.50 m and 1.20 × 0.50 m in the presence of biofertilizer. The plants were adequately supplied in nitrogen and phosphorus. The smaller spacing, associated to the presence of biofertilizer, increase the production characteristics of okra. To increase the productivity of commercial fruits in okra, management of the crop is more effective than the use of organic fertilizer.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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