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Vol. 12(33), pp. 2608-2613, 17 August, 2017
DOI: 10.5897/AJAR2017.12451
Article Number: 010654065614
ISSN 1991-637X
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African Journal of Agricultural Research

Full Length Research Paper

Growth and yield responses of sesame to organic fertilizer under tropical conditions

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Received 15 May, 2017; Accepted 27 June, 2017

The use of cattle manure and other organic compounds can be a profitable and efficient alternative in sustainable agriculture. The aim of this work was to evaluate the development and production of sesame 'BRS Seda' for organic fertilization at different doses, under the conditions of soil and climate found in Catolé do Rocha, in the State of Paraíba, Brazil. The following characteristics were evaluated: number of leaves and pods; plant height; stem diameter; number of flowers; dry weight of the leaves, stems, roots, pods and seeds; number and length of secondary branches; height of the first fruit; seeds per pod; pod length; and emergence percentage and speed of the produced seedlings. The different doses of cattle manure influenced pod length, number of seeds per pod, and emergence percentage and speed of the produced seedlings, with better results for the dose of 40 t ha^{-1}.

Key words: *Sesamum indicum* L., fertilization, morpho-agronomic characterization, organic production.

INTRODUCTION

Sesame (*Sesamum indicum* L.) shows great adaptation to the conditions of soil and climate of the northeastern region of Brazil, which generally presents good yield even under irregular and scarce rainfall observed in this region (Pereira et al., 2017). This crop develops well when there is an adequate supply of nutrients in the soil; it is therefore essential to provide the correct fertilizer for each planting situation. Under the conditions of soil and climate found in the semi-arid region of the Northeast, sesame is easy to grow and offers excellent yield and oil quality at low cost. In addition, facing the relevant increase of this oil crop, a high demand for quality seeds

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has been required as well (Arruda et al., 2015; Silva et al., 2017).

The addition of manure to the soil to improve the organic matter content is a long-standing practice. Filho et al. (2010), in a study on the cultivar CNPA G3 in the Seridó region of Paraíba using amounts of corral manure ranging from 0 to 40 t ha^{-1} under a rainfed regime, found an effect on the number of fruits and on plant height, with responses at the lowest level of available soil water. Silva et al. (2017) also observed benefits provided by organic fertilization in sesame. These authors studied the effects of cattle manure (0 to 60 t ha^{-1}) fertilization in sesame 'BRS Seda' cultivar under rainfed conditions and reported that seed vigor was positively influenced by cattle manure application in the soil.

Because it is a species which is often recommended as an alternative for generating income in the Brazilian semi-arid region (Silva et al., 2016), it is extremely important to know the response to organic fertilization. Therefore, the use of cattle manure and other organic compounds may be a cheaper alternative for improving the physics and chemical properties of the soils in semiarid regions.

The aim of this work was to evaluate development and production in the sesame cultivar BRS Seda for different doses of organic fertilizer, under the conditions of soil and climate in Catolé do Rocha, PB.

MATERIALS AND METHODS

The work was carried out in the experimental area of Campus IV of the State University of Paraíba (UEPB), in the city of Catolé do Rocha, Paraíba State, Brazil (PB). The region is at an altitude of 272 m above sea level, at coordinates 6°20'38" S and 37°44'48" W. According to the Köppen classification, the climate in the region is of type BSw'h', with an average annual precipitation of 870 mm, and an average temperature of 27°C.

The chemical properties of the soil and manure used in this study are shown in Table 1, and were determined in the Soil and Plant Nutrition Laboratory of Brazilian Agricultural Research Corporation. The manure used for fertilization was collected from crossbred cows fed on forage (elephant grass) in the UEPB at the same campus. Chemical analysis (macro- and micronutrients) of the cattle manure used in the experiment was carried out at the Soil and Plant Tissue Analysis Laboratory, Centre for Agrarian Science of the UEPB (Table 1).

For this study, the BRS Seda cultivar was used, which was grown under field conditions, carried out in 60 L plastic pots with a height of 57 cm, upper diameter of 40 cm and lower diameter of 26.5 cm. Four seeds were planted per pot, which were later thinned at 15 days after emergence, leaving one plant per pot.

Irrigation was carried out daily, using graduated containers to leave the soil at field capacity. In the initial phase, in addition to the daily irrigation, the pots were cleaned manually to avoid the accumulation of invasive plants.

Partial data were collected 120 days after planting the sesame, when the following variables were analysed: a) number of pods/plant – by counting the pods on each plant manually to determine the total; b) plant height (cm) - measured from the stem collar to the apex of the plant, with the aid a millimetre rule; c) stem diameter (mm) - determined by measuring 1 cm above the stem collar using a manual calliper; d) number of leaves/plant - also determined individually for each plant; e) number of flowers/plant - determined by counting the sesame flowers in each treatment.

Evaluations such as the dry-matter weight of the roots, shoots, pods and seeds, were carried out during harvesting. An electronic weigh with an accuracy of 0.001 g was used to weigh the material. The height of the first fruit (cm), length of the secondary branches (cm), the number of secondary branches, seed yield and pod length was also evaluated. Shoot dry matter (stem, branches and leaves) and root-system dry matter were determined after drying at 65°C for 48 h in an air circulation oven. Yield was determined by collecting the fruits when they were completely dry, with the mean value for the replications extrapolated to kg ha^{-1}. After harvesting, the seeds were analysed to determine germination and vigour, through the variables first count germination and germination speed index (Silva et al., 2017.

For the germination test, plastic trays with a length of 40 cm, a width of 25 cm and a depth of 6.5 cm were used, where four replications of 50 seeds were sown in each tray. Irrigation was divided into two applications of 250 ml per tray. To obtain emergence percentage, the following equation was used:

$$PE = \frac{NGSx100}{Ns}$$

Where: PE = percentage emergence (%); NGS = number of germinated seeds; Ns = number of seeds sown. The experimental design was of randomised blocks, with the treatments represented by five doses of cattle manure (0, 10, 20, 30 and 40 t ha^{-1}) with 4 replications, giving a total of 20 lots, represented by the pots containing 40 kg of air-dried soil.

Data for the variables were submitted to analysis of variance by F-Test, and the mean values evaluated by regression analysis at 5% probability. Where necessary, the data as percentages were transformed into arcsine $\sqrt{X}$ /100. Statistical analysis was carried out using the SISVAR 5.0 software.

RESULTS AND DISCUSSION

According to the results of the statistical analysis, represented by a summary of the analysis of variance (Table 2), the various levels of cattle manure did not differ when analysed for number of leaves, number of pods, stem diameter, plant height or number of flowers in the sesame.

There were statistical differences between doses for the number of leaves; however, Lima (2006) found a statistically significant difference when the mean values were analysed. The author obtained a mean value for number of leaves of 14.25 leaves per plant when evaluating growth and production in the G3 cultivar as a function of zinc and boron.

The number of pods, although not influenced by the doses of cattle manure, showed higher values than those found by Maia Filho et al. (2010) in the Seridó region of Paraiba, who obtained a maximum value of 55 fruits/plant at a dose of 28 t ha^{-1} cattle manure. Perin et al. (2010), evaluating the performance of sesame as a function of NPK fertilization and soil fertility, found a mean value of 31.64 fruits/plant. The author explained that the behaviour displayed by the sesame is similar to results obtained by other authors (Ávila and Graterol, 2005), and

Table 1. Chemical characterisation of the manure used in the experiments.

Soil											
pH	**Ca^{+2}**	**Mg^{+2}**	**Na^{+}**	**K^{+}**	**S**	**H+Al**	**T**	**Al^{+3}**	**V**	**MO**	**P**
(H_2O)	**---------- mmolc/ dm^3 ----------**									**-- g/kg --**	**mg/dm^3**
8.4	78.3	22.2	5.2	9.5	115.2	0.00	115.2	100	0.0	14.1	100.2
Manure											
N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Cu**	**Mn**	**Zn**	**Na**	**B**
	---------- g kg^{-1}----------						**---------- mg kg^{-1}----------**				
8.93	1.85	1.95	4.39	2.50	13.29	4213	5.94	698	203	262.6	23.29

Soil and plant tissue analysis laboratory. Federal University of Paraiba, Areia, Brazil.

Table 2. Summary of the variance analysis and mean values of number of leaves (NL), number of pods (NP), stem diameter (SD), plant height (PH) and number of flowers (NF).

Source of variation	DF	Mean square				
		NL	**NP**	**SD**	**PH**	**NF**
Treatment	4	11913.87^{NS}	5342.87^{NS}	3.57^{NS}	142.17^{NS}	17.92^{NS}
Block	3	33784.20	4619.93	9.93	238.58	33.91
CV (%)		10.30	15.09	11.69	7.50	22.95
Dose (t ha^{-1})		**Observed mean values**				
				mm	**cm**	
0		795.50	407.50	24.75	149.75	19.00
10		696.50	358.25	27.00	143.25	17.75
20		703.25	347.00	25.50	156.25	15.50
30		798.00	415.50	26.50	141.00	19.25
40		804.25	429.25	26.75	147.00	21.25

DF, Degrees of freedom. ^{NS}**,** not significant by F-test.

no significant effect was found from the mineral or organic fertilizers on the number of pods per plant.

As regards stem diameter, the results found here agree with those seen by Silva et al. (2016), when studying the effect of organic and mineral fertilizers on sesame crop; the author found that the treatments employed had no effect on this variable. Similarly, there were no statistical differences found among the doses used in this study for plant height. According to the summary table of the analysis of variance (Table 3), there were no differences between the various doses of cattle manure when analysed for leaf, stem, root, pod and seed dry weight.

Although, no effect was seen from the doses of manure on leaf dry weight or stem dry weight, the mean values found were higher than those found by Severino (2002), when analysing the phenology of the sesame cultivar GNPA G4, the author explained that the biomass of the stems plus the leaves also continued to increase until day 75, from when it tended to decrease, possibly due to the translocation of reserves for filling out the fruit and loss of the older leaves.

The result for pod dry weight was satisfactory as compared to that obtained by Severino (2002), when he analysed this variable as a function of the phenology of sesame, and obtained a mean value of 36 g. Fruit biomass displayed significant growth from 60 to 100 days, increasing at a rate of 0.78 g day^{-1}. From day 100, the fruit showed no further tendency towards an increase in dry matter, despite only reaching maturation around 120 days.

The seed weight (Table 3) showed satisfactory yield when the results were compared with those obtained by Drumond et al. (2006), who explained the low productivity (61g) as due to the low rainfall that occurred during the growing period. Jan et al. (2014), on the other hand, observed that sesame plots treated with 100 kg P ha^{-1} produced maximum 1000 seeds weight of 3.64 g.

Satisfactory values for root dry weight, as compared to Santos and Silva (2009) studying dry-weight production in soybean fertilised with pig slurry, demonstrated that the application of organic fertilizer had a significant effect on this crop. The authors obtained the highest yields for root dry weight when two different treatments were used (mineral fertilizer and 50 m^3 ha^{-1} pig slurry + N residue). The results of the statistical analysis (Table 4) show that the various doses of cattle manure did not differ

Table 3. Summary of the analysis of variance and mean values of leaf biomass (LB), stem biomass (SB), root biomass (RB), pod biomass (PB) and seed weight (SW).

Source of variation	DF	Mean square				
		LB	SB	RB	PB	SW
Treatment	4	113.279^{NS}	799.344^{NS}	52.4120^{NS}	504.710^{NS}	134.600^{NS}
Block	3	205.7727	1176.802	17.98183	142.0333	98.48317
CV (%)		46.263	24.541	57.487	28.900	20.61
Dose (t ha^{-1})		**Observed mean values (g)**				
0		46.7750	121.2500	27.0750	74.8500	49.4250
10		43.2250	118.3750	23.1000	63.4750	37.6000
20		37.9250	109.9000	22.9500	54.0000	37.5000
30		34.9750	108.0000	19.4500	53.3750	36.2000
40		34.6500	85.3250	17.7500	45.6000	35.250

DF, Degrees of freedom. ^{NS}, not significant by F-Test.

Table 4. Summary of the variance analysis for the number of secondary branches (NSB), secondary branch length (LSB) and height of the first fruit (HFF).

Source of variation	DF	Mean square		
		LB	SB	RB
Treatment	4	2.325000^{NS}	0.902138^{NS}	87.700^{NS}
Block	3	3.333333	0.213360	136.317
CV (%)		19.181	19.054	10.56
Dose (t ha^{-1})		**Observed mean values**		
0		8.7500	0.9183	55.50
10		8.0000	0.9083	52.00
20		7.2500	0.8546	48.00
30		7.0000	0.8308	50.75
40		7.0000	0.8100	43.00

DF, Degrees of freedom. ^{NS}, not significant by F-test.

when analysed for the number of secondary branches, length of the secondary branches or height of the first fruit.

Values found for the number of secondary branches were greater than those observed by Lima (2006), who obtained an average of approximately three branches in the G3 cultivar of sesame at 45 days after emergence for concentrations of zinc in solution. Further, in relation to the number of secondary branches, satisfactory results were also found as compared to the mean values obtained by Severino (2004) at 80 days after emergence when analysing the phenology of the sesame cultivar CNPA G4 (*Sesamum indicum* L.).

As to the length of the secondary branches, values were found that were also greater than those found by Severino (2002), who obtained an average of 38 cm per plant. According to the author, the growth of the secondary branch accompanies that of the main stem of the plant, initiating elongation at about 30 days and maintaining the same pattern until about 80 days of age. The production of secondary branches is of great importance, and even the tertiary branches contribute to production in the sesame crop.

In the present work, values for the height of the first fruit stand out from values found by Silva (2006) when analysing the residual effect of organic and mineral fertilizers on a second-year crop of sesame. However, they did not differ from the results found by Lima (2006) when studying growth and production in the sesame cultivar G3 as a function of zinc- and boron-based fertilizers. On the other hand, the number of seeds per pod showed a statistical difference between treatments, with a tendency to increase as the doses of cattle manure increased, its greatest value is seen at the dose of 40 t ha^{-1} (Figure 1A). Similar results were found by Jan et al. (2014). The values for pod length displayed differences when the sesame plants were submitted to the treatments. Positive linear behaviour was seen as the

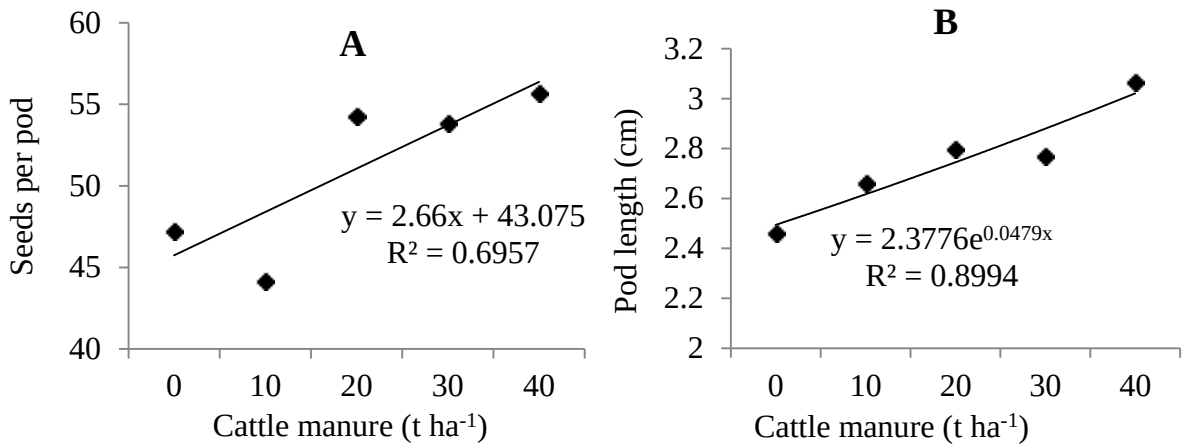

Figure 1. Number of seeds per pod (A) and pod length (B) in sesame for doses of cattle manure.

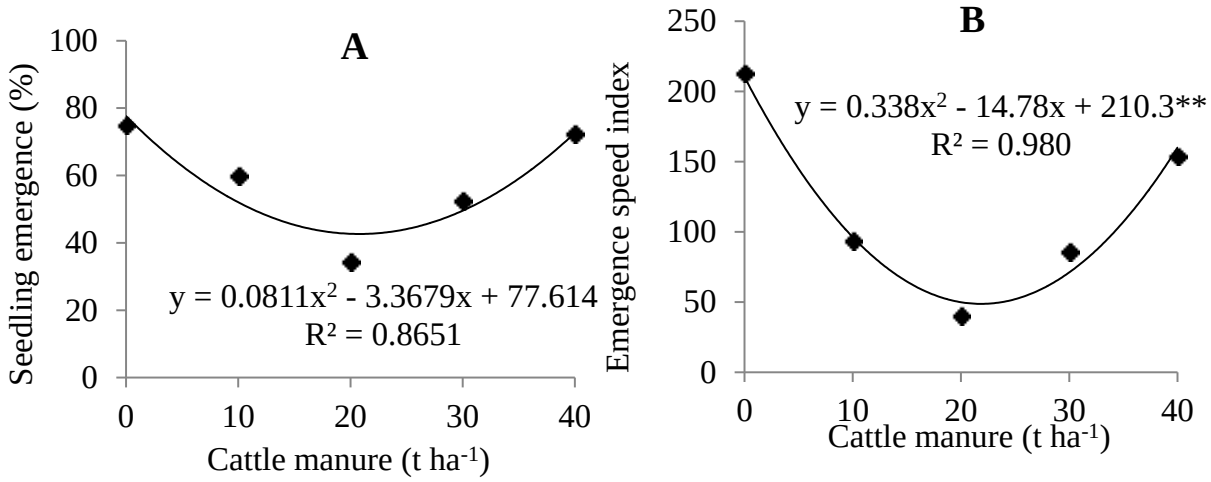

Figure 2. Seedling emergence (A) and emergence speed index (B) in sesame for doses of cattle manure.

doses were increased, reaching maximum length at the dose of 40 t ha^{-1} cattle manure (Figure 2B).

With the germination and speed of emergence index of the sesame, a quadratic effect was seen, showing a decrease in the values of these variables up to the dose of 20 t ha^{-1}, after which there was an increase up to the dose of 40 t ha^{-1} (Figure 2).

Regarding germination of the sesame seeds as a function of the doses of cattle manure, the results corroborate those found by Dornelas et al. (2005) when evaluating the production and seed quality of lima beans as a function of the use of cattle manure in the presence and absence of NPK, as the same authors found germination responses for the doses of cattle manure. The authors reported highest rates for seed germination at 40 t ha^{-1}, in the presence and absence of NPK, with high germination percentages of 93 and 95%, respectively.

Conclusion

The different doses of cattle manure had an influence on pod length, number of seeds, percentage emergence and emergence of produced seedlings, with better results at the dose of 40 t ha^{-1}.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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