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RESEARCH PAPER

Effect of different levels of row spacing and nitrogen on yield characters in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

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Abstract : Investigation was carried out to study the effect of different levels of nitrogen and spacing on the yield characters in roselle. A field trial was conducted in a Factorial Randomized Block Design with five levels of nitrogen (50, 100, 150, 200 and 250 kg ha^{-1}) and three levels of row spacing (60, 90 and 120 cm). The results of the present study revealed that the spacing of 120 × 75 cm and nitrogen application of 250 kg ha^{-1} was found to be superior in improving the yield characters like number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, yield of fresh and dry calyces $plant^{-1}$, yield of fresh and dry calyces yield $plot^{-1}$, yield of fresh and dry calyces ha^{-1}, seed yield and dry matter production.

Key Words : Nitrogen, Spacing, Roselle, Yield

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INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) a member of the Malvaceae family, is a tropical plant of considerable economic importance (Purseglove, 1968; Al-kahtani and Hassan, 1990). The plant is reported to be indigenous to tropical Africa. Its cultivation is fairly widespread in many countries *viz.*, Philiphines, Malaysia, Indonesia, Cuba, U.S.A, Egypt, Sudan, Nigeria, West Indies, Srilanka and India (Purseglove, 1968 and Morton, 1987). In India, it is reported to be cultivated in the hotter parts of Punjab, Uttar Pradesh, Bengal, Assam, Orissa, Maharastra, Karnataka and Andhra Pradesh. It is an important multipurpose annual under shrub preferred for its red, acid succulent calyces, young leaves, stems, fruits, seed and seed oil for food, beverages and in Unani and modern systems of medicine, an export oriented commodity throughout the tropics and subtropics. The swollen red calyces which are dried and brewed into teas and are also used in the processing of juices, jellies, jams, ice cream, sauces, chutneys, wines, preserves and natural food colourant (anthocyanin) (Al-kahtani and Hassan, 1990). The calyx is rich in citric acid, pectin and is so useful for making jam, jellies etc. (Chopra *et al*., 1986). It is also used to add a red colour and flavour to herbal teas (Bown, 1995) and can be roasted to be used as a coffee substitute in Africa (Facciola, 1990). A refreshing beverage can be made by boiling the calyx, sweetening it with sugars and adding ginger (Facciola, 1990). Tender young leaves and stems are used as either raw or cooked (Duke, 1983). The seed yields 20 per cent oil (Komarov, 1968), which is probably edible (Ken Fern, 2000). A fibre from the stem called Roselle hemp is used for making sackcloth, twine and cord (Komarov, 1968 and Hill, 1952). For appropriation of maximized yield, plant density is an important management requirement for the efficient utilization of applied inputs. Hence, due attention is

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to be paid to determine optimum spacing for higher calyx yield in *Hibiscus sabdariffa*. For normal crop growth, nitrogen, phosphorus and potassium supplements are of vital value to the crops, which are the major players in crop growth. But improper nutrition leading to nutrient imbalance in plants is one of the major factors contributing to low yields in many crops under normal agro climatic conditions. The deficiencies of major nutrients namely nitrogen, phosphorus and potassium are more common and pose serious problems in crop production. The major nutrients are known to exercise positive influence on the various growth and yield parameters and have brought about increased yield in various crops. Application of fertilizer has been documented to enhance plant growth and development. Many research activities have reported an increase in the vegetative development of crops with fertilizer application. However, there are contrary views on the role of fertilizer on the quality of crop produced. Improved soil nutrients could improve the quality of the minerals, vitamins and protein content of roselle. Although several workers (Mahran *et al*., 1979; El-Gamel *et al*., 1984 and El-Shafie, 1994) in other countries have studied the effect of application of fertilizers on the growth and productivity, the available information on the effects of nutrients and spacing on this crop in India is very limited. Hence, this present investigation was carried out to study the effect of different levels of nitrogen and spacing on the yield attributes of roselle.

MATERIAL AND METHODS

The present investigation was carried out in the Vegetable Unit, Department of Horticulture, Faculty of Agriculture, Annamalai University during 2009. Seeds were collected from University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bangalore. The experiment was laid out in Factorial Randomized Block Design with three replications. Regular cultural practices were adopted to raise the crop successfully. Observations were recorded on yield parameters *viz.*, number of flowers plant^{-1}, number of fruits plant^{-1}, yield of fresh and dry calyces plant^{-1}, yield of fresh and dry calyces yield plot^{-1}, yield of fresh and dry calyces ha^{-1}, seed yield and dry matter production. The treatment details are as follows :

Treatment No.	Details
Nitrogen levels (kg ha^{-1})	
N_1	50
N_2	100
N_3	150
N_4	200
N_5	250
Spacing	
S_1	60 cm between rows (22,222 plants ha^{-1})
S_2	90 cm between rows (14,814 plants ha^{-1})
S_3	120 cm between rows (11,111 plants ha^{-1})

RESULTS AND DISCUSSION

The ultimate goal to be achieved in any management system is increased yield. In the present study, it was observed that various levels of row spacing and nitrogen fertilizer exhibited significant variation on yield and yield parameters. Significant differences in flowering (earliness) and increase in number of flowers plant^{-1} was noticed with increase in spacing in the present study. The plants spaced at 60 × 75 cm showed early flowering while, the plants spaced at 120 × 75 cm produced greater number of flowers plant^{-1} (Table 1). Cumulative superiority in vegetative parameters *viz.*, number of branches, number of leaves, leaf area must have contributed to early flowering and higher production of flowers plant^{-1} in wider spacings as compared to closer spacings. Earliness and increased flower production were also reported by Subbi Reddy and Krishnan (1991) in *Solanum viarum*.

Application of N @ 250 kg ha^{-1} had remarkably advanced

Table 1 : Effect of different row spacing and nitrogen levels on number of flowers plant^{-1} and number of fruits plant^{-1} in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

Treatments	Number of flowers plant^{-1}				Number of fruits plant^{-1}			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	173.50	192.50	175.00	180.33	169.56	182.91	173.42	175.29
N_2	197.50	177.50	229.00	201.33	195.96	175.97	226.61	199.51
N_3	177.00	227.50	217.00	207.16	174.90	224.02	221.50	206.80
N_4	194.00	230.00	269.00	231.00	187.62	220.00	265.57	224.39
N_5	198.50	221.50	265.00	228.33	195.40	218.62	259.88	224.63
Mean	188.10	209.80	231.10		184.68	204.30	229.00	

	S	N	S×N	S	N	S×N
S.E.±	NS	NS	NS	17.18	NS	NS
C.D. (P=0.05)				34.39		

Nitrogen levels (kg ha^{-1})	Spacing
N_1 – 50, N_2 – 100, N_3 – 150, N_4 – 200, N_5 - 250	S_1 - 60 × 75 cm, S_2 - 90 × 75 cm, S_3 - 120 × 75 cm

NS=Non-significant

Table 2 : Effect of different row spacing and nitrogen levels on fresh calyces yield plant^{-1} and dry calyces yield plant^{-1} in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

Treatments	Fresh calyces yield plant^{-1} (g)				Dry calyces yield plant^{-1} (g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	612.55	699.72	808.57	706.94	173.50	192.50	175.00	180.33
N_2	684.17	799.55	866.50	783.40	197.50	177.50	229.00	201.33
N_3	789.15	883.90	1052.30	908.45	177.00	227.50	217.00	207.16
N_4	848.85	978.60	1198.92	1008.79	194.00	230.00	259.00	227.66
N_5	879.15	1009.45	1330.20	1072.93	198.50	221.50	265.00	228.33
Mean	762.77	874.24	1051.29		188.10	209.80	229.10	

	S	N	S×N	S	N	S×N
S.E. ±	73.11	94.42	NS	8.50	0.63	2.63
C.D. (P=0.05)	146.28	188.85		17.6	1.25	5.28

Nitrogen levels (kg ha^{-1})	Spacing
N_1 – 50, N_2 – 100, N_3 – 150, N_4 – 200, N_5 - 250	S_1 - 60 × 75 cm, S_2 - 90 × 75 cm, S_3 - 120 × 75 cm

NS=Non-significant

Table 3 : Effect of different row spacing and nitrogen levels on yield of fresh calyces plot^{-1} (kg) and yield of dry calyces yield plot^{-1} (kg) in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

Treatments	Fresh calyces yield plot^{-1} (kg)				Dry calyces yield plot^{-1} (kg)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	29.37	25.19	24.24	26.26	3.24	2.97	2.56	2.92
N_2	32.83	28.74	25.97	29.18	3.42	3.10	2.61	3.04
N_3	37.85	31.80	31.56	33.73	4.02	2.99	3.75	3.58
N_4	40.7	35.20	35.96	37.30	5.04	4.42	4.91	4.79
N_5	42.17	36.31	39.93	39.47	6.23	5.23	5.83	5.76
Mean	36.59	31.44	31.53	33.18	4.39	3.74	3.93	4.02

	S	N	S×N	S	N	S×N
S.E. ±	0.05	0.03	NS	0.05	0.03	NS
C.D. (P=0.05)	0.10	0.15		0.10	0.15	

Nitrogen levels (kg ha^{-1})	Spacing
N_1 – 50, N_2 – 100, N_3 – 150, N_4 – 200, N_5 - 250	S_1 - 60 × 75 cm, S_2 - 90 × 75 cm, S_3 - 120 × 75 cm

NS=Non-significant

Table 4 : Effect of different row spacing and nitrogen levels on yield of fresh calyces ha^{-1} and yield of dry calyces ha^{-1} (t) in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

Treatments	Fresh calyces yield ha^{-1} (t)				Dry calyces yield ha^{-1} (t)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	10.88	9.33	8.98	9.73	1.20	1.10	0.95	1.09
N_2	12.16	10.66	9.62	10.81	1.27	1.15	0.97	1.13
N_3	14.02	11.78	11.69	12.49	1.49	1.11	1.39	1.33
N_4	15.09	13.04	13.32	13.81	1.87	1.64	1.82	1.77
N_5	15.62	13.45	14.79	14.62	2.31	1.94	2.16	2.14
Mean	13.55	11.65	11.68		1.63	1.38	1.46	

	S	N	SxN	S	N	SxN
S.E. ±	NS	1.37	NS	NS	0.173	NS
C.D. (P=0.05)		2.76			0.347	

Nitrogen levels (kg ha^{-1})	Spacing
N_1 – 50, N_2 – 100, N_3 – 150, N_4 – 200, N_5 - 250	S_1 - 60 × 75 cm, S_2 - 90 × 75 cm, S_3 - 120 × 75 cm

NS=Non-significant

flowering and also resulted in more flower production when compared to other treatments (Table 1). This may be attributed to the fact that earlier plant vigour that could be stimulated by better absorption of abundant nutrients by growing plants results in advancing the flower production as suggested by Chauhan and Gupta (1973) and Mahabaleswar Hedge (1984). Further, delayed flowering with lower dose of fertilizers may be due to the non-physical maturity of the plants on account of poor vegetative growth as reported by Bharathipriyan (2007). The effect of N fertilizer on both earliness in flowering and number of flowers plant^{-1} clearly indicated the importance of a balanced nutrition for certain critical stages of plant growth and development. Similar findings were reported by Mahabaleshwar Hedge (1984) and Ilangovan *et al*. (1990) in senna and Bharathipriyan (2007) in ambrette. The results of the present study revealed that the calyces harvested from plants grown at wider spacing of 120×75 cm were bigger in size and it was found to decrease with increase in plant population. Bigger size of calyces in wider spacing could be attributed to the overall superiority of wider spacing in enhancing the vegetative parameters which was due to better utilization of light and soil moisture resulting in production of higher photosynthates and ultimately leading to increased calyx size. The decrease in the yield attributing parameters in closer spacing might be due to the higher inter-plant competition which limited the availability of nutrients and light. The fresh and dry calyx yield plant^{-1} (Table 2) was also influenced by various spacing treatments. Plants spaced at 120×75 cm recorded the highest calyx yield plant^{-1}. Increased calyx yield plant^{-1} at wider spacing could be attributed to the superiority of wider spacing on the vegetative parameters and yield attributing components. The cumulative effect of all these had resulted in the production of higher calyx yield plant^{-1} under wider spacing over closer spacing. Moreover, the yield of calyx plant^{-1} decreased under closer spacing which could be mainly due to less light interception by the crowded canopy and consequent reduction in photosynthesis (Reddy, 1982). Because of competition among the plants for water, solar radiation and other factors in thickly populated treatments, the production of photosynthates was reduced which in turn,

Table 5 : Effect of different row spacing and nitrogen levels on seed yield in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

Treatments	Seed yield											
	Seed yield plant^{-1} (g)				Seed yield plot^{-1} (kg)				Seed yield ha^{-1} (t)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
N_1	156.10	169.87	134.72	153.56	7.47	6.10	4.02	5.86	2.77	2.26	1.49	2.17
N_2	187.67	153.67	187.70	176.34	9.09	5.50	5.61	6.73	3.37	2.04	2.08	2.49
N_3	182.85	201.95	231.57	205.45	8.77	7.26	6.93	7.65	3.25	2.69	2.57	2.83
N_4	206.12	258.85	298.22	254.39	6.96	7.61	8.93	7.83	2.58	2.82	3.31	2.90
N_5	162.70	224.07	241.50	209.42	7.80	8.04	7.23	7.69	2.89	2.98	2.68	2.85
Mean	179.08	201.68	218.74		8.01	6.90	6.54	7.15	2.97	2.55	2.42	

	S	N	SxN	S	N	SxN	S	N	SxN
S.E. ±	NS	22.65	NS	0.22	0.29	NS	0.22	0.29	NS
C.D. (P=0.05)		45.38		0.45	0.59		0.45	0.59	

Nitrogen levels (kg ha^{-1})	Spacing
N_1 – 50, N_2 – 100, N_3 – 150, N_4 – 200, N_5 - 250	S_1 - 60 × 75 cm, S_2 - 90 x 75 cm, S_3 - 120 x 75 cm

NS=Non-significant

Table 6 : Effect of different row spacing and nitrogen levels on dry matter production (g plant^{-1}) in roselle (*Hibiscus sabdariffa* var. *sabdariffa*)

Treatments	Dry matter production (g plant^{-1})			
	S_1	S_2	S_3	Mean
N_1	329.82	373.30	343.04	348.72
N_2	362.21	406.50	383.92	384.21
N_3	382.25	444.98	426.24	417.82
N_4	407.75	533.52	446.50	462.59
N_5	597.07	491.60	688.57	592.41
Mean	415.82	449.98	457.65	

	S	N	S×N
S.E. ±	13.64	17.60	30.50
C.D. (P=0.05)	27.32	35.27	61.10

Nitrogen levels (kg ha^{-1})	Spacing
N_1 – 50, N_2 – 100, N_3 – 150, N_4 – 200, N_5 - 250	S_1 - 60 × 75 cm, S_2 - 90 × 75 cm, S_3 - 120 × 75 cm

caused reduction in the vegetative and yield components. The results are in confirmity with the findings of Rao *et al*. (1981) and Saxena and Dutta (1985) in *Dioscorea floribunda* and Subbi Reddy and Krishnan (1991) in *Solanum viarum*. The yield and yield components like number of flowers, number of fruits, yield of calyces (Table 3, 4 and 5) were significantly influenced by the application of N @ 250 kg ha^{-1}. Improved nutritional environment for growth and development of the crop resulted in enhancing the yield parameters. With the application of optimum doses of nitrogen, more leaves might have been produced, which in turn resulted in more photosynthesis, thereby increased the plant height, branching, leaf production, flower production and fruit production resulting in the production of more number of calyces and ultimately greater yield as opined by Amirthalingam (1988). The results are in conformity with the findings of Khan *et al*. (1995) in *Solanum nigrum*, Sundharaiya *et al*. (2000), Bhaskar *et al*. (2002) in *Solanum viarum* and Bharathipriyan (2007) in ambrette. With regard to the influence of spacing treatments on the dry matter production (Table 6), it was observed that the plants planted at wider spacing recorded higher dry matter production when compared to closer spacing. This may be due to the fact that at wider spacing, plants must have faced less competition for moisture and sunlight which was reflected in the production of higher number of branches, increased leaf production with maximum leaf area, which in turn led to increased dry matter production as suggested by Gangadharappa (2000).

In the present study, it was found that the dry matter production was significantly influenced by the application of optimum dose of nitrogen fertilizer. It was maximum with the application of N @ 250 kg ha^{-1}. The increase in dry matter accumulation may be due to the fact that nitrogen brings about luxuriant growth and the increased uptake of nitrogen, phosphorus and potassium by the crop resulted in increasing the vegetative growth characters such as plant height, number of branches, number of leaves, leaf area and greater accumulation of nutrients ultimately resulting in the higher yield, which in turn contributed to the higher plant dry weight. Similar results were obtained by Pareek *et al*. (1988) in Henbane and Prasad *et al*. (2002) in Gymnema.

The findings of this investigation clearly brought out that nitrogen at 250 kg per ha with 120×75 cm spacing was beneficial for obtaining highest yield of dry calyces while, nitrogen at 200 kg per ha with a spacing of 120 × 75 cm was suitable for getting higher seed yield ha^{-1}.

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