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EFFECT OF STAND DENSITY AND INTRA-ROW SPACING ON GROWTH AND YIELD OF ROSELLE (*Hibiscus sabdariffa* L.)

ALIYU, L.[1], ADEKPE, D.I.[1] AND HARUNA, I.M.[2*]

[1]*department of Agronomy, Ahmadu Bello University, Zaria*
[2]**Department of Agronomy, Nasarawa State University, Keffi*
**Corresponding Author: Ibrahimmharuna@Nsuk.Edu.Ng*

Abstract
A field experiment was carried out during the wet seasons of 2019 to 2021 at the Institute for Agricultural Research farm Samaru, Zaria; in the Northern Guinea Savanna (110° 11' N; 70° 38' E and 686m above sea level). The treatments consisted of factorial combinations of three stand densities (1, 2 and 3 plants/stand) and three intra-row spacings (25,50 and 75cm). Randomized complete block design was used with four replications. Gross and net plot sizes of 9m^2 and 4.5m^2 respectively were adopted. The number of branches significantly increased with increase in number of plants per stand from 1 to 3 plants/stand. Intra-row spacing also affected number of branches significantly with each increase in spacing from 25cm to 75cm, resulting in significantly more branches. Taller plants were however, significantly produced with the use of 25cm compared with 75cm. The number of leaves was significantly increased with 50cm and 75cm compared with 25cm. Number of capsules per plant from 2 and 3 plants/stand were statistically comparable and significantly fewer than that produced from 1 plant/stand. Although the number of capsules per plant at 25cm and 50cm were statistically at par, they were significantly lower compared to those of 75cm spacing. Stand density of 3 plants per stand resulted in significantly the highest yield of capsules, calyces and seeds. The closest spacing of 25cm significantly out yielded others in total capsule yield per hectare.
Keywords: Plant population, spacing, growth characters, yield characters.

Introduction

Roselle (*Hibiscus sabdariffa* L.) is receiving increased attention due to the commercial and industrial use of the calyces. Roselle is widely cultivated in Nigeria where it has both domestic and commercial uses. The leaves, edible calyces, seeds and fibre are utilized in a variety of ways in the home and industry (Mohammed, 2021) Constraints to production of roselle includes lack of adequate information on the optimum spacing and stand density for the crop. Commercial producers often use close spacing which was recommended for fibre production (Aliyu, 1918). Wider spacing has been suggested for calyx production (Aliyu *et al*., 2005). One plant per stand was reported to improve the growth and performance of the crop (Daudawa, 2007). However, (Salau and Makinde, 2014); (Usman, 2021) reported that yield increased with increase in stand density. Considering the paucity of information on the agronomic practices for roselle cultivation and the increasing demand for it due to its numerous uses, this study was conceived to determine the appropriate stand density and intra-row spacing for roselle production to meet the demand of the world's teeming population.

Materials and Methods

A field experiment was carried out during the wet seasons of 2019 to 2021 at the Institute for Agricultural Research farm Samaru, Zaria. Samaru is located in the Norther Guinea Savanna (11^0 11'N; 7^0 38' E and 686m above sea level) (Keay, 1959). Annual rainfall ranges from 800-1300mm with a long term mean of 1054.8mm and lasts between late April/May to September/October. Mean maximum and minimum temperatures during the rainy seasons range from 29-38ºC and 18-24ºC respectively. The soil of the area is a loam described as well drained often leached (Klinkenberg and Higgins, 1968) ferruginous tropical soil (Higgins *et al.*, 1965). It is characterized by low pH, organic matter, nitrogen and available phosphorus. The treatments consisted of factorial combinations of three stand densities (1, 2 and 3 plants/stand) and three intra-row spacings (25, 50 and 75cm). Randomised complete block design was used with four replications. Gross and net plot sizes of 9m^2 and 4.5m^2 respectively were adopted. Fertilizer was applied at the rate of 400kg/ha using NPK (20-10-10) at 3and 6 weeks after sowing. Appropriate Agronomic and crop protection practices were carried out to ensure adequate crop growth and performance. Data were collected on growth parameters and yield components on plant and stand

basis, yield characters were recorded from the net plot and converted to hectare. These were analyzed statistically in accordance with Snedecor and Cochran (1967). Significantly different means were compared using Duncan's multiple range test (Duncan, 1955).

Results

The effect of stand density and intra-row spacing on the growth characters of roselle during the rainy seasons of 2019 to 2021 combined data is presented on Table 1.

Table 1: Effect of Stand Density and Intra-Row Spacing on the Growth Characters of Roselle during the wet seasons of 2019 to 2021 (combined) at 10 WAS at Samaru

Treatment	Plant height (cm)	Number of branches per stand	Number of leaves per plant
Stand Density			
1 plant	50.00	20.00^{c}	169.08
2 plants	55.67	23.42^{b}	164.50
3 plants	53.92	26.67^{a}	156.17
SE±	2.701	0.585	5.279
Intra-Row Spacing (cm)			
25	57.25^{a}	20.83^{c}	150.^{67b}
50	53.58^{ab}	23.00^{b}	166.17^{a}
75	48.75^{b}	26.25^{a}	172.92^{a}
SE±	2.701	0.585	5.279

Means in a column of treatment followed by different letter(s) are significantly different using DMRT (5%)

The number of branches significantly increase with increase in number of plants per stand from 1 to 3 plants/stand. However, the effect of stand density on plant height and number of leaves was not significant. Intra-row spacing also affected number of branches significantly with each increase in spacing from 25cm to 75cm, resulting in significantly more branches. Taller plants were however, significantly produced with the use of 25cm compared with 75cm. The number of leaves was significantly increased with 50cm and 75cm compared with 25cm.

Table 2 shows the effect of stand density and intra-row spacing on the yield components of roselle.

Table 2: Effect of Stand Density and Intra-Row Spacing on the Yield Component Characters of Roselle during the wet seasons of 2019 to 2021 (combined) at Samaru

Treatment	Number of capsules per plant	Number of seeds per capsules	Seed weight (g per capsule)
Stand Density			
1 plant	54.28^{a}	30.25	1.20
2 plant s	43.23^{b}	30.67	1.10
3 plants	39.12^{b}	28.83	1.41
SE±	3.537	1.741	0.183
Intra-Row Spacing (cm)			
25	35.20^{b}	29.67	1.04
50	45.22^{b}	30.83	1.36
75	56.20^{a}	29.25	1.30
SE±	3.537	1.741	0.183

Means in a column of treatment followed by different letter(s) are significantly different using DMRT (5%)

Number of capsules per plant from 2 and 3 plans/stand were statistically comparable and significantly fewer than that produced from 1 plant/stand. Number of seeds per capsule and seed weight per capsule were not significantly affected by stand density. There was no significant difference in number of

capsules per plant between 25cm and 50cm spacing but they were significantly lower than 75cm. Intra-row spacing did not significantly influence number of seeds per capsule and seed weight per capsule.
The response of yield characters to stand density and antra-row spacing is shown on Table 3. The planting of 3plants/stand resulted in significantly higher capsule yield, calyx yield and seed yield compared with planting only 1 plant/stand.

Table 3: Effect of Stand Density and Intra-Row Spacing on the Yield Characters of Roselle during the wet seasons of 2019 to 2021 (combined) at Samaru

Treatment	Capsule Yield (t/ha)	Calyx Yield (t/ha)	Seed Yield (t/ha)
Stand Density			
1 plant	5.88[b]	2.09[b]	3.69[b]
2 plants	7.45[ab]	2.94[ab]	3.93[ab]
3 plants	8.03[a]	3.66[a]	4.48[a]
SE±	0.713	0.422	0.422
Intra-Row Spacing (cm)			
25	8.88[a]	3.21	4.56
50	6.42[b]	2.76	3.73
75	6.04[b]	2.71	3.80
SE±	0.713	0.422	0.263

[a, b]: Means in a column of treatment followed by different letter(s) are significantly different using DMRT (5%)

The use of 2 plants/stand resulted in significantly comparable yields to the other treatments. Capsule yield was significantly increased by the use 25cm intra-row spacing compared to the other spacings which were at par statistically. Calyx yield and seed yield were not significantly affected by intra-row spacing.

Discussion

Effect of Stand Density on the Growth and Yield of Roselle

In this study the performance of roselle was affected by stand density with plants higher density being taller than single plants possibly due to etiolation because of competition for light and space. Number of leaves and capsules per plant were higher with single plants/stand compared with denser treatments probably due to more available nutrients, moisture and other growth factors; as there was less competition. This allowed such plants to express their full potential as was earlier reported by Daudawa (2007). Conversely, total yields of capsule, calyx and seed per hectare were higher at the highest stand density of 3plants/stand. This could be attributed to increase in number of plants per area which compensated for the poor performance of individual planta at such density. Salau and Makinde (2014) reported that pod yield/ha increased with increase in stand density from 1 to 3 plants/stand while number of pods/plant and pod weight /plant decreased. Usman (2021) also reported that the use of 2 plants/stand gave the best marketable yield per hectare compared with 1 plant/stand.

Effect of Intra-Row Spacing on the Growth and Yield of Roselle

There was a positive response of most growth and yield component characters to wider intra-row spacing in this study compared with the closest spacing. This could be due to the fact that plants widely spaced had more resources in terms of nutrients, light, moisture and space thus enabling such plants to develop and produce more than closely spaced plants. Similar observations were reported by Aliyu *et al*. (2018) and Abubakar *et al*. (2021). They explained that the increase in population at the close spacing exerted an adverse effect on the development of buds from which the leaves and branches develop owing to the vigorous competition among plants at such close spacing. The taller plants at the close spacing could be due to etiolation of plants as reported by Aaron *et al*. (2021). Total capsule yield per hectare was however, more at the closest spacing of 25cm compared with the wider spacings because the larger number of plants per area outweighs the low productivity of plants at the close spacing. Aliyu *et al*. (2014, 2018) and Aaron *et al*. (2021) made similar observations and added that plants at the closest spacing develop full canopy faster and much earlier thus enabling them to intercept more radiation and have greater photosynthetic production than the partial canopy of widely spaced plants. Although wider

spacing had more vigorous plants due to less competition, but these could not compensate for the reduced number of plants per area.

Conclusion

Stand density of 3 plants/stand resulted in significantly highest yield of capsules, calyces and seeds. The closest spacing of 25cm significantly out yielded others in total capsule yield per hectare and is therefore recommended

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