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Effect of Sowing Date and Planting Distance on Growth and Yield of Two Cultivars of Roselle (*Hibiscus sabdariffa var. sabdariffa*)

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Abstract: Two field experiments were conducted during 1998 and 1999 rainy seasons at Usmanu Danfodiyo University Sokoto Dry Land Farm, Sokoto, with a view to studying the effect of sowing date, planting distance, nitrogen and phosphorus fertilization and cultivar on growth, yield components and calyx/seed yields of roselle. The treatments consisted of three sowing dates (7th and 20th July and 3rd August in 1998; 14th and 28th July and 11th August in 1999), two cultivars (Sokoto Red and Sokoto White) and four planting distances (60x60, 60x45, 60x30 and 60x15 equivalent to 27,777, 37,037, 55,555 and 111, 111 plants ha^{-1}, respectively). Factorial combinations of the treatment were laid out in a randomized complete block design in a split-plot arrangement, replicated three times. Analysed data showed that the cultivar Sokoto Red was superior to Sokoto white in both growth attributes as well as calyx and seed yields. The results also revealed that early sown roselle was more vigorous in growth as expressed by plant height, leaf area index and crop growth rate than latter sowings. Early sown roselle also had significantly higher ($p<0.01$) calyx and seed yield ha^{-1}. Plant growth yield and their attributes were significantly influenced by plant population. Individual plants at wide intra-row spacings (60x60 and 60x45 cm) produced higher number of pods as well as calyx and seed, but on per unit land area basis, were out-yielded by those at close intra-row spacings (60x30 and 60x15 cm).

Key words: Planting time, intra-row spacing, growth, yield, roselle

Introduction

Edible roselle *(Hibiscus sabdariffa var sabdariffa* L.) is a member of the Malvacae family, it is a native to India and Malasia where it is commonly cultivated and must have been carried at an early date to Africa (Babajide *et al*., 2004), is grown mainly in the northern Guinea and Sudan savanna and to a limited extent, in the southern Guinea and Derived savanna zones of Nigeria. Traditionally, the tender leaves and shoots are eaten in salads and used as pot-herb (Duke, 1984). Preparations from various parts of the roselle plant such as flower (calyx and corolla) and leaves are used as remedy for various illnesses. According to Babajide *et al.* (2004) in India, Africa and Mexico, all the above-ground parts of the plant are valued in native medicine. Infusions of the leaves or calyces are regarded as diuretic, cholectic, fetrifugal and hypothesive. The calyx of the red type when partially boiled in hot water is strained and sweetened to taste. The later is taken as a soft drink commonly known as *soborodo* or simply *sobo*. Currently, it has good prospects for industrial purposes (Alegbejo, 2000).

Despite the promising prospects that roselle enjoys, there has been no proportionate effort in research on the crop in the study area. Work done so far on roselle is limited to northern Guinea savanna zone (Alegbejo, 1998; Lamido, 1998) excluding the Sudan savanna zone where roselle is predominantly being grown as a dividing hedge between farms and a lot of variants of roselle are found.

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Hence, the present study was conducted with the objective of determining the response of growth and yield characteristics of roselle cultivars (Sokoto red and Sokoto white) to varying population densities and sowing dates in the Sudan savanna zone of Nigeria.

Materials and Methods

Two field trials were conducted during the 1998 and 1999 rainy seasons at the Usmanu Danfodiyo University Dry Farm, Sokoto (Latitude 13°09[1]N and Longitude 5°18[1]E). Nigeria.

The treatments consisted of three sowing dates (7/7/98, 20/7/98 and 3/8/98 in 1998; 14/7/99, 28/7/99 and 11/8/99 in 1999), two roselle cultivars (Sokoto Red and Sokoto White) and four intra-row spacings (60x60 cm, 60x45 cm, 60x30 cm and 60x15 cm, equivalent to 27,777, 37,037, 55,555 and 111,111 plants ha^{-1}, respectively). The treatments were factorially combined with sowing date and cultivar in the main plot and the intra-row spacing in the subplot in a randomized complete block design which was replicated three times. Gross and net plot sizes were 6x4.8 and 4.8x3.6 m, respectively, consisting of eight and middle six rows.

The land was harrowed and prepared to give a fine soil tilth. Three to five seeds of either Sokoto Red or Sokoto white were planted per hill on flat. NPK fertilizer was applied at the rate of 150 kg ha^{-1} in two equal split doses at land preparation and 6 Weeks After Planting (WAP). The crop was thinned to one plant per stand at 2 WAP bringing the number of plants to 2, 4, 6 and 12 plants m^{-2} for the 60x60, 60x45, 60x30 and 60x15 cm, respectively. Weed control was carried out manually with the first weeding at 2 WAP which was later followed by two additional weedings at 4 and 6 WAP.

For the assessment of plant height, six separate plant samplings were carried out at fortnightly intervals starting from 4 WAP by measuring two plants from ground level to the apex of the last leaf from each net plot area. Number of pods and dry calyx were determined at 16 WAP from plants m^{-2} in the net plot area expressed on per plant basis. Total seed and calyx yields were also obtained by the same procedure but recorded on hectare basis.

Results

The texture of the soil is loamy sand and the soil is deep, loose and well drained, classified as Typic Psammants (USDA, 1988). Chemical analysis showed that the soil was slightly acidic, very low in organic-C and total-N content, moderate in exchangeable cations, low in cation exchange capacity and available-P but medium in K, Na, Ca and Mg contents. Meteorological data for the seasons during the periods of the trials.

Plant height was significantly influenced by sowing date at 4 and 14 WAP in 1998 and 1999 (except at 10 and 12 WAP) with plants in the first sowing dates (7/7/98 and 14/7/99) significantly taller than plants at later sowing dates (Table 1 and 2). There was no significant response to cultivar effect but planting distance was significant at 8 WAP in 1998 and 10, 12 and 14 WAP in 1999. Plant height increased significantly with decrease in intra-row spacing from 60 to 15 cm.

Calyx harvest index was highly significantly influenced by cultivar but planting distance was significant ($p<0.05$) in 1998 (Table 3). They both were highly significant ($p<0.01$) in 1999 season whereas sowing date response was only significant ($p<0.05$) (Table 4). Calyx harvest index at 60 cm intra-row spacing was at par with tat at 45 and 30 cm in 1998 and 1999, respectively but was significantly higher than that at the other intra-row spacings. Sokoto

Table 1: Mean plant height (cm) of roselle as affected by sowing date, cultivar and planting distance during 1998 rainy season

	Weeks after planting					
Treatment	4	6	8	10	12	14
Sowing date						
7/7/98	28.89a	46.18	71.37	115.83	159.47	174.54a
20/7/98	22.63b	42.50	71.79	116.81	156.52	167.81a
3/8/98	22.05b	44.98	76.33	120.33	149.25	141.73b
Sig.	**	ns	ns	ns	ns	**
SE±	0.918	1.246	2.685	3.488	4.448	4.248
Cultivar						
Sokoto red	25.04	44.07	74.07	116.68	162.39	162.40
Sokoto white	3.65	10.68	20.91	15.65	14.21	163.67
Sig.	ns	ns	ns	ns	ns	ns
SE±	0.750	1.017	2.191	2.848	2.632	3.468
Planting distance (cm)						
60×60	24.04	44.55	68.25c	111.69	147.79	161.197
60×45	24.73	43.72	70.64bc	117.78	153.94	164.40
60×30	24.24	44.03	75.24ab	120.83	157.31	159.94
60×15	25.07	45.90a	78.53a	120.33	161.09	165.78
Sig.	ns	ns	**	ns	ns	ns
SE±	0.775	1.284	1.713	2.885	3.099	2.218

ns and *, ** -not significant and significant at 5 and 1%, respectively. Means followed by the same letter within a treatment group are not different statistically by DMRT at 5%.

Table 2: Mean plant height (cm) of roselle as affected by sowing date, cultivar and planting distance during 1999 rainy season

	Weeks after planting					
Treatment	4	6	8	10	12	14
Sowing date						
14/7/99	28.46a	50.71a	68.92a	103.00a	135.21a	163.58a
28/7/99	21.21b	32.00c	53.88c	86.83b	121.21b	140.17b
11/8/99	20.21b	39.54b	61.42b	99.08a	123.54b	133.88b
Sig.	**	**	**	*	*	**
SE±	0.694	1.074	1.058	3.391	2.891	2.602
Cultivar						
Sokoto red	23.81	41.94	64.31	98.50	127.64	146.72
Sokoto white	22.78	39.56	58.50	94.11	125.67	145.03
Sig.	ns	ns	ns	ns	ns	ns
SE±	0.566	0.877	0.864	2.769	2.360	2.124
Planting distance (cm)						
60×60	23.78	41.44	64.44	92.94b	121.33b	141.11b
60×45	22.72	40.17	60.78	93.06b	127.83ab	144.22b
60×30	22.56	39.36	64.22	98.72a	124.39b	145.61ab
60×15	24.11	41.83	67.78	100.50a	133.06a	152.56a
Sig.	ns	ns	ns	*	*	*
SE±	0.618	0.879	1.462	1.951	2.799	2.557

ns and *, ** -not significant and significant at 5 and 1%, respectively. Means followed by the same letter within a treatment group are not different statistically by DMRT at 5%

red calyx harvest index was significantly better than Sokoto white calyx harvest index in 1998 but the reverse was the case in 1999 season. Calyx harvest index increased with delay in sowing date in 1999 although it was at par at 28th July and 11th August sowing dates.

Seed harvest index responded positively to sowing dates in both seasons but the responses to planting distance were not significant (Table 3). It however responded positively to cultivar only in 1999. The influence of sowing date on seed harvest index showed decrease with delay in sowing but it increased instead in 1999. In 1998 season, Sokoto red seed harvest index was significantly higher than Sokoto white seed harvest index.

Both sowing date and planting distance influenced significantly yield and yield components in the two seasons whereas the response of cultivar to these parameters were

Table 3: Mean calyx and seed harvest indices of roselle as affected by sowing date, cultivar and planting distance in 1998 season

Treatment	Calyx harvest index (%)	Seed harvest index (%)
Sowing date		
7/7/98	11.07	21.46a
20/7/98	9.64	20.49a
3/8//98	10.57	9.56b
Sig.	ns	**
SE±	0.450	1.642
Cultivar		
Sokoto red	11.33	18.11
Sokoto white	9.52	16.23
Sig.	**	ns
SE±	0.368	1.341
Planting distance (cm)		
60×60	10.34ab	17.67
60×45	11.97a	16.99
60×30	10.13b	17.70
60×15	9.27b	16.31
Sig.	*	ns
SE±	0.584	1.926

ns and *, ** - not significant and significant at 5 and 1%, respectively. Means followed by the same letter within a treatment group are not different statistically by DMRT at 5% level

Table 4: Mean calyx and seed harvest indices of roselle as affected by sowing date, cultivar and planting distance in 1999 season

Treatment	Calyx harvest index (%)	Seed harvest index (%)
Sowing date		
14/7/99	6.81b	6.56b
28/7/99	7.81a	7.80a
11/8/99	8.08a	8.31a
Sig.	*	**
SE±	0.248	0.318
Cultivar		
Sokoto red	7.19	8.48
Sokoto white	7.94	6.63
Sig.	**	**
SE±	0.203	0.260
Planting distance (cm)		
60×60	8.35a	7.96
60×45	7.17b	7.60
60×30	7.60ab	7.56
60×15	7.12b	7.12
Sig.	**	ns
SE±	0.265	0.364

ns and *, ** - not significant and significant at 5 and 1%, respectively. Means followed by the same letter within a treatment group are not differnt statistically by DMRT at 5% level

not significant except it responded positively to calyx yields per plant and hectare in 1999 season (Table 5 and 6). The number of pods at the initial sowing dates and at the intra-row spacing of 60 cm was significantly the highest. While the seed and calyx yields per hectare decreased with delay in sowing date, they increased with decrease in intra-row spacing from 60 to 15 cm. Calyx and seed yields ha^{-1} of Sokoto red was significantly higher than calyx and seed yields ha^{-1} of Sokoto white.

The result of the combined 1998-1999 seasons analysis (Table 7) showed that calyx and seed yields ha^{-1} responded positively to sowing date, cultivar and planting distance. Early sown roselle yields were significantly different from later sowing dates. Sokoto red cultivar significantly had higher calyx and seed yields ha^{-1} than Sokoto white. The 15 cm intra-row yields were significantly higher than the wider spaced roselle.

Table 5: Yield and yield components of roselle as affected by sowing date, cultivar and sowing date in 1998 season

Treatment	Pod plant^{-1}	Calyx plant^{-1}	Calyx ha^{-1} (kg)	Seed plant^{-1}	Seed ha^{-1} (kg)
Sowing date					
7/7/98	98.71a	26.24a	1267.46a	47.72a	2302.3a
20/7/98	49.67b	12.50c	604.96c	25.19b	1209.9b
3/8/98	34.46b	19.17b	921.45b	16.58c	795.8c
Sig.	**	**	**	**	**
SE±	6.178	1.278	68.389	2.620	130.182
Cultivar					
Sokoto red	59.72	17.97	871.24	31.51	1514.3
Sokoto white	62.17	20.64	991.33	28.15	1357.8
Sig.	ns	ns	ns	ns	ns
SE±	5.044	1.044	55.839	2.139	106.293
Planting distance (cm)					
60×60	79.86a	23.96a	479.49b	39.90a	796.2c
60×45	71.36ab	25.46a	1018.47a	34.65ab	1386.1b
60×30	60.33b	18.48b	1108.27a	30.19b	1811.2a
60×15	32.32c	9.31c	1118.93a	14.57c	1748.7a
Sig.	**	**	**	**	**
SE±	4.471	1.318	63.762	2.385	124.992

ns and *, ** - not significant and significant at 5 and 1%, respectively. Means followed by the same letter within a treatment group are not differnt statistically by DMRT at 5% level

Table 6: Yield and yield components of roselle as affected by sowing date, cultivar and sowing date in 1999 season

Treatment	Pod plant^{-1}	Calyx plant^{-1}	Calyx ha^{-1} (kg)	Seed plant^{-1}	Seed ha^{-1} (kg)
Sowing date					
14/7/99	64.06a	16.14a	764.83a	15.75a	766.50a
28/7/99	45.50b	12.73b	647.00b	12.44b	647.58a
11/8/99	33.78c	9.17c	478.33c	9.53b	478.50b
Sig.	**	**	**	**	**
SE±	3.641	0.710	21.555	1.002	38.935
Cultivar					
Sokoto red	44.88	13.78	691.28	13.39	664.94
Sokoto white	50.68	11.58	568.83	11.76	596.78
Sig.	ns	*	**	ns	ns
SE±	2.973	0.580	17.600	0.818	38.934
Planting distance (cm)					
60×60	65.28a	18.05a	361.00c	17.12a	342.33c
60×45	52.42b	14.32b	572.89b	14.74a	589.78b
60×30	39.94c	10.24c	614.33b	10.26b	615.33b
60×15	33.47c	8.10c	972.00a	8.18b	976.00a
Sig.	**	**	**	**	**
SE±	2.656	0.776	37.221	0.828	36.617

ns and *, ** - not significant and significant at 5 and 1%, respectively. Means followed by the same letter within a treatment group are not differnt statistically by DMRT at 5% level

Discussion

In terms of growth, roselle sown earlier in the season could be said to be more vigorous than roselle planted in mid- or- late season. Brown (1984) reported that plant height was the most obvious manifestation of growth in crop plants. This may be linked to the fact that early sown roselle plants had a longer period for vegetative growth which resulted in taller plants as indicated in the rainfall duration (Appendices A and B). The highest plant height at first sowing date in both seasons was 174 cm which compared favourably with the highest plant height of 196.5 cm of roselle in the second sowing date in May reported by Selim *et al.* (1993) but was higher than the plant height of 111.67 cm in the first sowing date reported by Lamido (1998).

The lack of response of roselle cultivar to plant height conformed with the report of Ariyo *et al.* (1991) of lack of response by cultivars of okra to plant height. Iremiren and Okiy (1986) also reported that the effects of okra cultivar on vegetative growth were not significant. On the other hand, Lamido (1998) reported significant response to plant height of roselle cultivars.

Table 7: Mean calyx and seed yield ha^{-1} of roselle as affected by sowing date, cultivar and planting distance in 1998-1999 seasons

Treatment	Calyx ha^{-1} (kg)	Seed ha^{-1} (kg)
Sowing date		
1st	810.82	1392.70
2nd	791.33	975.50
3rd	740.31	721.30
LSD	139.89	211.58
Cultivar		
Sokoto red	931.58	1438.10
Sokoto white	630.06	621.56
LSD	114.72	172.76
Planting distance (cm)		
60×60	487.68	478.80
60×45	822.14	1304.70
60×30	772.44	764.30
60×15	1041.03	1571.50
$LSD_{0.05}$	161.53	244.31

Appendix A: Meteorological data at the trial site during the rainy season of 1998

			Temperature (°C)		Relative humidity (%)	
Month	Days	Rainfall (mm)	Min	Max	Min	Max
July	1-10	21.8	25.43	37.14	37.43	84.00
	11-20	68.2	26.88	36.14	42.29	88.43
	21-31	32.8	26.27	36.50	35.73	84.00
August	1-10	8.6	24.20	33.90	45.60	89.10
	11-20	64.0	22.00	33.40	42.40	90.50
	21-31	63.5	23.36	35.55	37.45	87.00
September	1-10	79.6	24.30	34.80	41.30	89.60
	11-20	48.7	25.00	37.30	36.50	85.70
	21-30	0.0	23.55	34.18	28.73	85.90
October	1-10	0.0	22.90	33.70	23.70	83.60
	11-20	12.6	23.70	36.40	27.60	71.60
	21-31	0.0	23.88	35.30	22.30	80.60
November	1-10	0.0	18.00	34.40	18.70	53.78
	11-20	0.0	20.50	37.90	17.10	46.70
	21-31	0.0	18.00	34.80	19.50	52.30

Appendix B: Meteorological data at the trial site during the rainy season of 1999

			Temperature (°C)		Relative humidity (%)	
Month	Days	Rainfall (mm)	Min	Max	Min	Max
July	1-10	24.40	25.88	34.52	38.23	76.71
	11-20	50.10	24.70	31.24	48.50	78.71
	21-31	25.40	24.25	31.92	57.71	83.83
August	1-10	46.40	22.96	27.88	64.33	89.86
	11-20	55.90	24.54	30.16	52.42	87.25
	21-31	184.60	22.78	28.94	62.17	90.29
September	1-10	65.40	23.66	29.72	54.83	86.63
	11-20	75.20	25.22	32.13	46.00	83.67
	21-30	31.80	24.25	31.27	44.14	82.00
October	1-10	21.40	20.78	35.26	34.14	83.00
	11-20	6.86	21.74	34.50	27.36	79.00
	21-31	0.00	19.82	36.02	19.57	75.00
November	1-10	0.00	18.01	35.60	24.60	52.00
	11-20	0.00	17.79	35.90	32.60	60.60
	21-31	0.00	18.25	34.65	38.18	55.00

Roselle plants at the closest intra-row spacing were observed to be taller. Appendix (C,1) shows the soil analysis of the experimental site in sowing date, cultiver planting distance, N and P study in 1998

Appendix C: Soil analysis result from the expeimental site in sowing date, cultivar and planting distance study in 1998 and 1999 seasons

	1998	1999
% Sand	94.00	98.00
% Clay	4.00	1.00
% Silt	2.00	1.00
Soil pH	7.00	7.20
Total N (%)	0.006	0.004
Organic C (%)	0.08	0.06
CEC (cmol kg^{-1})	3.60	2.86
Exch. bases (cmol kg^{-1})		
Ca	2.50	2.10
Mg	1.30	1.60
Na	0.07	0.12
K	0.37	0.48
Available P (mg kg^{-1})	0.06	0.08

Appendix D: Soil analysis result from the experimental site in N and P study in 1998 and 1999 seasons

	1998	1999
% Sand	96.00	96.00
% Clay	3.00	3.00
% Silt	1.00	1.00
Soil pH	7.40	7.20
Total N (%)	0.006	0.005
Organic C (%)	0.06	0.05
CEC (cmol kg^{-1})	2.62	3.42
Exch. bases (cmol Kg^{-1})		
Ca	2.40	2.30
Mg	1.48	1.34
Na	0.20	0.08
K	0.42	0.52
Available P (mg kg^{-1})	0.06	0.07

and 1999 seasons. Donald and Hamblin (1976) held the view that denser stands had more rapid growth because they displayed more photosynthetic surface per unit area and thus synthesize more material. Brown (1984) reported that plant height may actually increase in competition for light because of the etiolation effect of shading. Shalaby and Razin (1989) reported that plant height of roselle tended to increase with closer spacings.

The calyx harvest index showed positive response to sowing date. Plants grown in the mid and late season were more efficient in converting dry matter into calyx while plants at the early sowing were the least efficient. It must be noted that early planting of roselle resulted in higher vegetative and consequently accumulated more dry matter than later sown plants. It may be inferred, therefore, that calyx harvest index may have an inverse relationship with dry matter in roselle. Arnon (1975) reported that increase in yield often associated with an increase in dry matter was not an absolute relationship. The greater vegetative growth at early sowing may have resulted in lower efficiency in photosynthetic process due to mutual shading of leaves which might have led to lesser accumulation of photosynthates and to low partitioning into calyx production. The disproportionately higher dry matter yield in relation to the calyx yield in the first sowing date might account for the lower harvest index.

Calyx harvest index of roselle also showed a positive response to cultivar. Sokoto red cultivar had a significantly higher calyx harvest index than Sokoto white, probably because the former generally had a higher vegetative growth. Calyx harvest index showed a positive response to intra-row spacing. The higher calyx harvest index at the wider intra-row spacing when compared with that at the close spacing may be due to competition at high plant population which resulted in drastic reduction in dry matter production per plant and the consequent low calyx yield. Also, in a similar response trend, Deloughery and Crooston (1979) reported that increasing population density resulted in significant decreases in harvest index of maize.

Seed harvest index responded positively to sowing date and cultivar in only one of the seasons. Early sown roselle was more efficient in partitioning dry matter into seed fraction, in contrast with calyx harvest index where it had the least percentage. Sokoto red, in terms of efficiency, again converted more dry matter into seed production than Sokoto white.

Number of pods of roselle showed a positive response to sowing date. The highest average number of pods was 98.71 in 1998 and 64.06 in 1999 season. Selim *et al.* (1993) reported the highest number of pods per plant of roselle of 41.8 in the second sowing date in May. However, Lamido (1998), as also observed in this study, reported that each successive delay in sowing significantly reduced roselle yield of fruit and flowers per plant, respectively. The higher pod number at the early season may be a reflection of its greater vigour in vegetative growth and higher growth rates.

Number of pods of roselle also showed a positive response to intra-row spacing. The highest number of pods of 79.86 was obtained with the widest intra-row spacing of 60 cm while the lowest number of pods of 32.22 was at 15 cm intra-row spacing in 1998 season. Shalaby and Razin (1989) reported the same in roselle with reduction of number of pods from 43.5 at the intra-row spacing of 70 cm to 21.5 at 30 cm intra-row spacing.

Calyx yield per plant of roselle responded positively to sowing date. The highest calyx yield plant^{-1} in the two seasons was 26.24 g at 1998 first sowing date which compared favourably with the average highest yield plant^{-1} of 31.5 g in the May second sowing date as reported by Selim *et al.* (1993). The high calyx yield plant^{-1} in the first sowing date may be as a result of its higher number of pods which might have been the cumulative effect of higher vegetative growth recorded in the first sowing date.

Calyx yield plant^{-1} responded positively to cultivar only in 1999 season. Calyx yield plant^{-1} in Sokoto red was higher than calyx yield plant^{-1} in Sokoto white and this may be associated with its high vegetative growth.

The response of calyx yield per plant of roselle to intra-row spacing was positive in both seasons. With the high calyx yield plant^{-1} at wide intra-row spacing when compared with that at the close intra-row spacing, it could be inferred that increasing roselle plant population will lead to reduced calyx yield per plant probably due to the stiff competition at high population density.

Calyx yield ha^{-1} of roselle responded positively to sowing date. Despite the fact that early sowing resulted in low calyx harvest, it had the highest calyx yield ha^{-1} while the second and third sowing dates alternated in the second position. Harvest index alone would not explain the difference in yield in the sowing dates. What may have accounted for the higher yield in the early sowing may be the significantly higher number of pods and calyx yield plant^{-1}. Since both the second and third sowing dates had similar calyx harvest index, the higher calyx yield ha^{-1} recorded at the second sowing might have been due to the significantly higher number of pods and calyx yield per plant when compared with the third sowing date. In 1998 season, although the late sowing had similar number of pods with the second sowing date, its calyx plant^{-1} was significantly higher than that at the mid season which may have resulted in the higher calyx yield ha^{-1}. Lamido (1998) also found significant reduction with delay in sowing in calyx yield ha^{-1}. The calyx yield ha^{-1} of 1267 kg in the first sowing date in 1998 compared favourably with the calyx yield ha^{-1} of 1477 kg ha^{-1} in the first sowing as reported by Lamido (1998).

Calyx yield ha^{-1} showed a positive response to cultivar in 1999 season only. The higher calyx yield ha^{-1} of Sokoto red when compared with Sokoto white might have been due mainly to its higher calyx yield plant^{-1}. However, Lamido (1998) reported that there was no significant differences in calyx yield ha^{-1} in roselle cultivars used in the present study.

Calyx yield ha^{-1} also showed a positive response to intra-row spacing. The low calyx yield plant of roselle at high plant population density may have been compensated for by more number of plants per unit area which might have contributed to the overall yield per hectare than under low plant population.

Seed yield plant showed a positive response to sowing date and the higher seed per plant in early sowing may be associated with the higher number of pods per plant at the first sowing date. Seed yield per plant responded positively to intra-row spacing. The highest seed yield per plant was at the wide intra-row spacing while it was lowest in the highest plant population density. The decrease in seed yield per plant at close intra-row spacing may be attributed to the competition between plants for light and nutrients.

Seed yield ha^{-1} responded positively to sowing date and the first sowing date recorded the highest yield of 2303 and 767 kg ha^{-1} in 1998 and 1999 seasons, respectively. Lamido (1998) also reported significant response of seed yield ha^{-1} in roselle to sowing date with highest yield of 254, respectively, which was lower than that reported in this study. The difference in yield may be due to differences in cultivar.

Seed yield ha^{-1} also responded to intra-row spacing. The high yield associated with the close intra-row spacing may be due to the higher number of plants per unit area which may have contributed to the overall yield per hectare than under low plant population.

Conclusions

Sokoto Red was significantly superior to Sokoto White in both growth and yield attributes. Roselle plants sown in close intra-row spacing of 15 cm were significantly taller and had higher calyx and seed yields ha^{-1} higher than those at 30, 45 and 60 cm but had the least calyx and seed yields $plant^{-1}$. Plant height, harvest index, yield and yield components in early sowing were significantly differently from later sown roselle.

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