Assessment of the effects of plant population and sowing date on growth and yield of cotton

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ABSTRACT

A field experiment was conducted during 1999/ 2000 season at the Gezira Research Station Farm (GRSF) to evaluate the response of two newly released cotton cultivars (Acala (93) H-a hirsutum, and Barakat S-a barabdense) to two plant populations (75600 and 151200 plants/ha and five spring dates (23 and 31 July and 7, 14 and 21 August) as reflected by lint yield and growth parameters. A factorial experiment in a randomized block design with three replications was laid out. Lint yield of both cultivars was significantly reduced as sowing was extended beyond July, and yield reduction of 40% or more was observed as sowing was delayed to 21 August. A significantly fewer number of bolls per plant was noticed in August planted cotton (nine bolls vs. six bolls for the earliest and the latest sowing dates, respectively), but boll size was not influenced by sowing date treatment. Days to flowering showed no response to sowing date treatment, but days to first boll opening and boll maturation period were significantly delayed as the date of sowing was delayed. Plant height and number of nodes per plant were clearly affected and early sown plants were taller and produced a significantly greater number of nodes (28 vs. 22 nodes per plant for the earliest and the latest sowing dates, respectively). Leaf area index (LAI), total dry weight (TDW) at 100 days after sowing (DAS) responded significantly to sowing date treatment and the trends were the earlier the date of sowing the greater the value of the above mentioned parameters. The tested sowing dates gave no significant effect on the number of nodes to first flowering sympodia, vertical flowering interval (VFI), ginning percent, seed index and lint index. Plant population treatment significantly affected the leaf area index (LAI) and the higher population gave a greater LAI measured 100 DAS.

Introduction

Results obtained at the Gezira Research Station by Gregory *et al.* (1932) indicated that long stable cotton (*Gossypium barbadense* L.) yields were higher when the crop was sown during late August. The authors also reported that early sown cotton was not affected by spacing (intra-row spacing). Findings by Jackson and Faulkner (1961) showed that the age at which cotton plants began to flower and the node at which the first flower appeared were directly affected by sowing date. The response of Upland type plants (*G. hirsutum* L.) to management practices was similar to that of the Egyptian types (*G. barbadense* L.), where July sowing was superior (Fadda, 1962). Taha (1964) and Taha (1965) obtained significantly higher seed cotton yields when two hirsutum types and two barbadense types were sown during July as compared to August sowing.

Studies made by Jackson (1967) and Jackson *et al.* (1967) related the variation in cotton in cotton yield to pest attack, differences in soil nitrogen level and the length of the sowing season. Burhan and Taha (1974) supported the view that the optimum sowing for cotton in the Gezira is during July and early August.

Results reported by Omer (1979, 1980 and 1981) showed that cotton sown in July gave significantly higher yields than those, which were sown during August and early September. The author indicated that early sown cotton was highly infected by the bacterial blight disease (blackarm) which is caused by *Xanthomonas campestris* pv. *malvacearum*, but they were able to compensate, benefiting from the longer growing season as compared to August and early September sown cotton.

El Hassan (1999) reported that differences between cultivars in crop phenology were reflected by differences in plant height, number of nodes per main stem, leaf area index (LAI) and total dry weight. The author also reported that July sowing resulted in taller plants with greater number of main stem nodes, greater LAI and greater total dry weight than later sowing dates (August and September). The superiority of July sown cotton was clearly reflected in lint yield.

Taha (1969) reported that in the GRS yield obtained from cotton sown at 50 cm spacings between plant holes was significantly different than that from 30 cm between plant holes. The report by Saleem (1977) showed that when cotton plants were sown at three different spacings (30 cm, 50 cm and 75 cm), a significantly higher yield was obtained from the wider spacing, although no significant differences in yield were noticed when 30 cm and 50 cm and 50 cm and 75 cm spacings were compared.

The objectives of this investigation were to determine the performance of two cotton cultivars under different planting dates and plant populations as reflected by their growth characters and cotton yield and yield components.

Experimental procedure

The experiment was conducted during 1999/ 2000 season in the Gezira Research Station Farm (GRSF) at Wad Medani (Lat.14^0 24′ N, Long. 33° 30′ E). The soil of the site was described as vertisols of the Central Clay Plain of Sudan. These soils are characterized by having alkaline reaction (pH 7.8-8.5), with very low content of organic matter and nitrogen (0.2%

and 0.03%, respectively). These soils are classified as moderately suitable for agriculture, with vertisolic limitation due to high clay content - Reimeitab Series (Hassan, 1983).

Two cultivars (C) of cotton, namely Acala (93)H (*G. hirsutum* L.) a medium staple variety, and Barakat S (*G. barbadense* L.) a long stable variety were evaluated at two plant populations (P) (75600 and 151200 plant. ha^{-1}). These populations were obtained by using 50 cm and 25 cm intra-row distances and three plants per hole, and 80 cm inter-row distance. Sowing dates tested were 23rd and 31st July and 7th, 14th and 21st of August. A randomized complete block design with three replications was used. The total number of treatments was 20 treatments (two cultivars x two plant populations x five sowing dates). Plot size was 56 m^2 (10 m row length x 0.8 m inter-row distance x 7 rows).

Plants were thinned to three plants per hole four weeks after sowing. Nitrogen fertilizer in the form of urea was applied at the rate of 86 kg N. ha^{-1} immediately after thinning. Irrigation water was applied every 14-10 days. Weeds were adequately controlled by a combination of hand weeding and application of herbicides. Insect pests were controlled when necessary using pesticides. Generally, cultural practices were applied as recommended by the Gezira Research Station Practices.

Samples for growth analysis were collected at 20 days interval starting from 60 days after sowing (DAS). In each sampling date plants from one meter long, selected at random from the first two inside rows of each plot of the required treatment (s) were pulled out and taken to the laboratory, where they were washed, cut into parts and oven-dried for 48 hours at 90 °C, for total dry weight determination. Leaf area index (LAI) was calculated as total leaf area over ground area. Number of nodes per plant was determined by counting the number of nodes starting from the one just above the cotyledonary nodes. Plant height (cm) was measured as the potion of the stem above the cotyledonary nodes.

At anthesis, flowers on five plants per plot were randomly selected and tagged shortly after the appearance of the first flowers to determine the number of days to first flowering and number of days to first boll opening. The mean boll maturation period was calculated as the difference between the date of anthesis and the date dehiscence. Flower tagging was also used to calculate the vertical flowering interval (VFI) between successive flowering branches on the main stem.

Number of bolls per plant was recorded from a five plants sample, randomly selected from each plot just before picking. Boll attributes such as boll size, lint index, and ginning out turn were determined from a randomly taken 30-boll sample for each plot prior to harvesting. Lint yield (kg. ha^{-1}) was also determined.

Data were analyzed statistically and levels of significance for 0.05 and 0.01 probabilities for main factor and interaction responses were calculated. Means which differed significantly were separated by the Duncan Multiple Range Test (DMRT) at the 0.05 level of probability.

Results and Discussion

Results of the main effects means and statistical significance are shown in Tables, 1, 2 and 3, and lint yield interactions are presented in Table 4, 5 and 6.

Growth observations

Growth observations were made on five dates at 20 days interval starting from 60 DAS, but only one date (100 DAS) has been presented in this paper (Table 1). The interaction between sowing date and cultivar was only significant for plant height and LAI. The cultivars interacted significantly with the plant population only in the LAI character. Plant height was significantly affected by cultivar and sowing date treatments. Plants of Barakat S tended to be taller than those of Acala 93(H). The effect of sowing date on plant height was clearly reflected, and early sown plants were taller than later sown ones and a reduction of 14% in plant height was observed when the first and the last two sowing dates were compared. Similar results were reported by El Hassan (1999). Other growth characters measured (nodes per plant main stem, LAI, and total dry matter) were negatively affected when sowing was extended beyond July and reductions of 21%, 32% and 27% were observed when July sown plants were compared to 7, 14 and 21 August planted ones, respectively. Similar results were reported by Burhan and Taha (1974) and El Hassan (1999). The authors related these reductions as being results of a direct effect of climate (shorter season and lower temperature). Acala (93)H cultivar is known to be leafy, and this was clearly expressed in its significantly greater leaf area index and greater total dry matter content.

Development observations

The main effects of development observations are presented in Table 2. Days to first flower appearance was significantly extended as planting was delayed. These results are in general agreement with previous results obtained in the Gezira (Lambert and Crowther, 1953; Burhan and Taha 1974; and El Hassan 1999). Number of nodes to first fruiting branch and vertical flowering interval (VFI) were not affected by sowing date treatment, although an early report by Jackson and Faulkner, (1961) indicated that these characters were directly affected by sowing date. On the other hand days to first boll opening and boll maturation were significantly extended as sowing was delayed to mid August or later. El Hassan (1999) reported different results and observed that late sown cotton tended to flower and mature earlier than early sown cotton. It should be mentioned that in his study sowing was ex-

tended to almost mid September, and hence the overall effect of the climatic conditions were more pronounced as compared to the conditions reported in our study. Results presented in Table 3 show the main effects, means and statistical significance for yield components of cotton cultivars, sowing dates and plant population of cotton cultivars, sowing date and plant population. Number of boll per plant was clearly affected ($P< 0.01$) by sowing date, and delaying the date of planting from July to 14 August caused a 33% reduction in number of bolls per plant. It is worth mentioning that 21 August sown plants gave greater number of bolls than sown 14 August sown ones, but this difference was not significant. Boll size was not affected by sowing date, and the same was true for ginning percent, seed index and lint index. Previous reports by Jackson (1967), Burhan and Taha (1974), and El Hassan (1999) are in agreement with our results.

Lint yield

Lint yield of both cultivars was clearly affected by sowing date (Table 4). Reductions in yield amounting to 29% and 40% were recorded for Acala (93) H and Barakat (S), respectively, as planting was delayed to late August, 21st. The greater value of lint yield reduction expressed by Barakat S as compared to that of Acala (93) H may be explained by the later maturation period of the former, so it was greatly affected by adverse conditions occurring late in the season. These conditions were mainly related to climatic condition. Early sown cotton plants were able to better compensate for the shedding of yield forming components (squares, flowers, and bolls) than late sown ones (Jackson, 1967; Jackson *et al.*, 1967, Omer, 1979; Omer, 1980; Omer, 1981 and El Hassan, 1999). Reports by Jackson (1967) and El Hassan (1999) indicated that if a cultivar matured under favorable growing conditions, the less adversely its performance was affected by delaying the planting date. Low yields expressed by late sown cotton plants were explained by the small number of bolls retained, since no differences were noticed for the other yield components (boll size, ginning percent, seed index and lint index). Differences in lint yield due to plant population were not noticed, and these results are in agreement with the results obtained by Burhan and Taha (1974) and Saleem (1977). Generally, our findings were supported by earlier results obtained at the Gezira Research Station (Goegory *et al.*, 1932; Taha, 1964; Taha, 1965, Jackson, 1967; Jackson *et al.*, 1967; Burhan and Taha, 1974; Omer, 1981; El Hassan, 1999).

Summary

The findings of the present study may be summarized as follows:

1. The tested plant populations gave no effect on cotton lint yield and other characters measured except LAI.
2. The cultivars showed similar responses to sowing date and plant population
3. Extending the sowing date beyond July significantly increased, the number of days to flowering, days to first boll opening and boll maturation period.
4. Earlier sown plants were taller, and had a greater number of nodes in their stems. LAI and total dry matter content were significantly reduced as sowing was delayed to August.
5. Cotton lint yield was substantially reduced as sowing was extended beyond July due to the significant reduction in number of bolls retained by the late season plants.

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Table 1. *Main effects and statistical significance for plant growth characters of cotton cultivars, sowing date and plant population[a].*

	Plant height (cm)	Nodes per plant	Leaf area index (L.A.I)	Total dry matter ($g.m^{-2}$)
Cultivar (c)				
Acala (93) H	105 a	25	2.8 a	519 a
Barakat S	112 b	25	2.0 b	375 b
S.E	1.3	0.3	0.1	15
L.S.D	2.4	-	0.6	45
Sowing (S)				
23 July	106 a	28 a	2.6 a	476 a
31 July	103 b	26 b	2.8 a	467 a
7 August	97 c	25 b	2.7 a	450 a
14 August	93 d	24 bc	2.6 b	373 b
21 August	93 d	22 c	1.9 c	344 b
S.E.I	1.4	0.4	0.2	25
L.S.D	1.5	1.2	0.4	41
Population (P)				
31500	108	25	2.1 A	443
635003	110	25	2.7 B	450
S.E±	1.8	0.3	0.1	15.8
L.S.D	-	-	0.4	26
c.v.	10.9	5.9	10	15
		F-ratios		
C	*	n.s.	**	**
S	*	**	*	*
CxP	*	n.s.	**	n.s.
P	n.s.	n.s.	*	n.s
CxP	n.s.	n.s.	*	n.s.
SxP	n.s,	n.s.	n.s.	n.s.
CxSxP	n.s,	n.s.	n.s.	n.s.

[a]Means within the same column followed by the same letter (s) are not significantly different according to D.M.R.T

Table 2. *Main effects, means and statistical significance for earliness components, of cotton cultivar, sowing date and plant population*[a].

Factor	Days to 1st flowering	Node to 1st fruiting branch	VFI (days)	Days to 1st boll opening	BMP (days)
Cultivar (C)					
Acala (93)H	56	5.8	2.1	99	49
Barakat S	64	6.9	2.5	109	51
SE± sowing (S)					
23 July	0.53	0.11	0.08	0.43	0.52
	57 b	6.3 a	2.4 a	100 c	48 c
31 July	57 b	6.6 a	2.4 a	102 bc	50 bc
7 Aug.	60 a	6.5 a	2.2 a	104 b	50 bc
14 Aug.	61 a	6.0 a	20.3 a	106 a	51 ab
23 Aug.	61 a	6.5 a	2.4 a	106 a	53 a
SE±	0.84	0.18	0.17	0.68	0.82
LSD	2.4	-	-	1.95	2.36
Pop. (P)					
31500	60	6.2	2.3	104	50
63000	60	6.5	2.4	104	50
SE±	0.53	0.11	0.08	0.43	0.52
C.V%	4.9	9.7	17.7	2.3	5.7
Fractions					
C	130.7***	44.0***	14.9***	288.6***	10.3***
S	3.2**	n.s.	n.s	14.6***	5.1***
CxS	15.1***	n.s.	n.s.	3.6**	n.s.
P	n.s.	3.6*	n.s.	n.s.	n.s.
CxP	n.s.	n.s.	n.s.	n.s.	n.s.
SxP	n.s.	n.s.	n.s.	n.s.	2.8**
CxSxP	n.s.	2.6**	n.s.	n.s.	n.s.

[a] Means within the same column followed by the same letter (s) are not significantly differences at 0.05 level according to D.M.R.T.

Table 3. *Main effects, means and statistical significance for yield components of cotton cultivar, sowing date and plant population*[a].

Factor	No of bolls per plant	Boll size (g)	Gin %	Seed index (g)	Lint index (g)
Cultivar (C)					
Acala (93) H	5.9	5.4	34.7	12.9	6.5
Barakat S.	9.5	2.3	31.8	10.4	4.8
SE±	0.29	0.08	0.28	0.18	0.17
Sowing date (S)					
23 July	9.2 a	3.7 a	33.2 a	11.4 a	5.8 a
31 July	8.3 a	3.8 a	33.5 a	11.6 a	5.5 a
7 August	8.0 ab	3.9 a	33.5 a	11.5 a	5.6 a
14 August	6.1 c	3.7 a	33.4 a	11.6 a	5.8 a
21 August	6.8 bc	4.0 a	32.7 a	12.0 a	5.5 a
SE±	0.46	0.12	0.44	0.28	0.22
LSD	1.32	-	-	-	-
Plant pop. (P)					
31500p/fed	7.7	3.9	32.9	11.8	5.7
63000 p/fed	7.6	3.8	33.7	11.4	5.6
SE±	0.29	0.08	0.28	0.18	0.14
CV%	28.8	11.0	4.6	8.4	13.9
F ratio C	72.8***	805.9***	51.7***	98.7***	71.4***
S	7.0***	n.s.	n.s.	n.s.	n.s.
CxS	n.s.	n.s.	n.s.	n.s.	n.s.
P	n.s.	n.s.	4.1**	n.s.	n.s.
Cxp	n.s.	5.9**	n.s.	5.1**	n.s.
SxP	n.s.	n.s.	n.s.	n.s.	n.s.
CxSxP	n.s.	n.s.	n.s.	n.s.	n.s.

[a]Means within the same column followed by the same letter(s) are not significantly differences at 0.05 level according to D.M.R.T.

Table 4. *Interaction effects of cultivar (C) X sowing date (S) on lint yield (kg. ha^{-1})^{a}.*

Factor	23rd July	31st July	7th August	14th August	21st August
Acala (93) H	1402 a	1402 a	1154 b	1140 b	988 bc
Barakat (S)	978 c	846 cd	748 de	648 de	560 e
CXS					
S.E ±	65.2				
F- ratio	2.0*				
LSD	159.4				

[a] Means within the two rows followed by the same letter (s) are significantly different at 0.05 level according to D.M.RT.

Table 5. *Interaction effects of cultivar (C) X plant population (P) on lint yield (kg. ha^{-1})^{a}.*

Factor	75600 plants.ha^{-1}	151200 plants.ha. $^{-1}$
Acala (93) H	1306 a	1192 a
Barakat (S)	690 b	802 b
C X P		
S.E ±	41.2	
F ratio	3.9 *	
LSD	118.0	

[a] Means within the two rows followed by the same letter (s) are significantly different at 0.05 level according to D.M.R.T .

Table 6. *Interaction effects of sowing date (S) X plant population (P) on lint yield (kg. ha^{-1})^{a}.*

Factor	23rd July	31st July	7th August	14th August	21st August
7500 plant. Ha^{-1}	1260	1120	940	922	754
151200 plant ha^{-1}	1280	938	989	798	686
S x P					
SE±	65.2				
F-ratio	n.s.				

[a] Means within the two rows followed by the same letter (s) are not significantly different at 0.05 level according to D.M.R.T.