Effects of inter-row and intra-row spacing on growth, yield and fiber quality of rain-fed cotton in the Blue Nile State

Osama M. A. Elhassan[1] and Abdelrahman H. Abdelatif[2]

Abstract

Field experiments were conducted during 2000-01, 2001-02, 2002-03 and 2003-04 cropping seasons, at Damazin Agricultural Research Farm, under rainfed conditions, to study the effects of inter-row (70, 90 and 110 cm), intra-row spacing (15, 30, 45 and 60 cm) and their interactions on growth, yield and lint quality of two cotton varieties differing in growth habit [Barac(67)B and Albar A(57)12]. Data for each season and the combined data were statistically analyzed. In general, wider spacing enhanced earliness in both cotton varieties. The closer spacing produced the shortest plants and gave the highest number of branches/m². Seed cotton yield significantly increased due to narrowing the inter-row spacing. The intra-row spacing had no significant effect on yield. On average, the difference in seed cotton yield between the two varieties was not significant. The closer spacing showed the highest number of bolls/m², while the wider one gave the largest boll weight. The intra-row spacing of 15 cm resulted in the lowest seed index and lint index compared with others. The difference in seed index and lint index due to inter-row spacing was not significant. Also, ginning out turn (G.O.T) was not significantly affected by both inter-row and intra row-spacing. The effects of different inter-row and intra-row spacing on yield, yield components and fiber quality suggested the use of 70 cm inter-row spacing for both cultivars, with intra-row spacing of 15-60 cm for Barac (67)B and 30-60 cm for Albar A(57)12.

Introduction

Cotton (*Gossypium sp*) is the major cash crop in the tropics and sub-tropics. In the Sudan cotton is one of the most important cash crops. The Sudan produces a wide range of cotton fiber length, ranging from the extra-long to short staple cotton. Long and medium staple types are produced under irrigation, whereas short staple cotton is produced exclusively under rain-fed conditions. In the last ten year (1988- 1997) the area under cotton production in the Sudan ranged between 110 and 282 thousands ha, with average yields ranging from 364 to 476 kg/ha of lint (cotton world statistics, 1997). In the Blue Nile State the area under cotton is small and varies from one season to another (about 4-7 thousand feddans) with an average yield of 140-250 kg/fed for the ten last years.

High levels of production require favorable combinations of climate, soil and cultural practices. Cotton requires four to five months of warm temperature (about 32ºC) during the growing season. Although cotton is grown under a wide range of annual precipitations, the amount and distribution of rainfall is a limiting factor in production of cotton. The crop can be produced on a wide variety of soils. The attainment of the yield potential of this crop is often limited by poor cultural practices (sowing date, plant spacing, plant population and mineral nutrition).

Plant spacing is a factor that influence cotton production, and it has been studied for many years under irrigated areas. Studies indicated that cotton yield increased with

[1] Damazin Research Station, Agricultural Research Corporation
[2] Cotton Research Program, Agricultural Research Corporation

the decrease in inter-row spacings (Fadda, 1961; Burhan, 1967; Babiker, 1987 and 1988). Taha (1962, 1963) reported that yield increased with the increase in plant population from 22500 to 52500 plants/fed. Some reports showed no significant difference between 30, 40, 50 and 60 cm intra-row spacings (Babiker, 1986; Lazim, 1986, 1987, 1988 and 1990). Babiker (2004) showed that the optimum plant density at Rahad area was achieved by planting 3 plants/hill spaced at 80x30 cm (52500 plants/fed).

The objectives of this study are to evaluate the effects of inter-row and intra-row spacing on cotton yield and quality to determine the optimum plant population of cotton under rainfed conditions, at Damazin.

Materials and methods

a. Site characterization

The field experiment was conducted for four consecutive seasons (2000-01, 2001-02, 2002-03 and 2003-04), at the Agricultural Research Farm, Damazin (lat. 11º 47́ N, long. 34º 21 É; 492 m asl), in a cracking heavy clay soil. Chemical analysis of the top soil (0- 20 cm) and the sub-soil (20-40 cm) sampled from the site in 2002 revealed the following data: pH (1:5 H_2O) 7.0 and 7.3; total N (%), 0.042 and 0.044; available P, 3.9 and 3.9 mg/kg; exchangeable K, 0.63 and 0.59 c mol/kg; O.C, 0.593 and 0.598; C/N ratio, 14 and 13, respectively.

b. Growing conditions

Average monthly rainfall, during the growing periods are presented in Table 1. Generally, most of rainfall was received in June, July, August and September (Fig. 1). The total was 464, 660, 480 and 670 mm for the years 2000, 2001, 2002 and 2003, respectively.

c. Treatments and design

Treatments were factorial combinations of two varieties [(Barac (67)B and Albar A(57)12], three levels of inter-row spacing (70, 90 and 110 cm) and four levels of intra-row spacing (15, 30, 45 and 60 cm). These treatments were replicated three times and laid out in randomized complete block design. Plot area was four rows x 7.2 m. Table 2 shows the theoretical and actual plant populations.

d. Cultural practices

Each season the experimental area was ploughed twice with wide level disc. Cotton seed was sown in rows (on flat), in mid July for the first, second and fourth seasons, and late July for the third season. The seedlings were thinned to three plants/hole three weeks after emergence. Fertilizer was applied after thinning in the form of urea at the rate of 18 kg N/fed. Experimental plots were hand-weeded three times, during the growing season. Other cultural practices followed ARTC recommendations.

e. Collection of data

Number of nodes to the first fruiting branch and plant height (at maturity) were recorded from a five-plants sample, taken randomly from each plot. Number of sympodial branch/m², number of monopodial branch/m² and number of bolls/m² were taken from 1 m² area. Days to first flowering and days to first boll opening were recorded. Yield components (boll weigh, seed index, lint index and ginning outturn)

were determined from a ten-bolls sample, taken randomly prior to harvest. Seed cotton yields were taken from the two central rows in each plot. The harvested cotton was weighed to obtain seed cotton yield (kg/fed). Fiber quality tests were carried in Fiber Testing and Spinning Laboratory, at Gezira Research Station, Wad medani.

f. Statistical analysis

Data for each season and the combined data for the four seasons (2000 to 2003) were subjected to statistical analysis. Level of significance for 0.05, 0.01 and 0.001 probabilities for the factors and their interactions responses were calculated. Duncan's Multiple Range Test, at 0.05 level for mean separation was used.

Results and discussion

a. Combined analysis

Combined analysis for the data on growth, yield and yield attributes of the four seasons showed highly significant differences among seasons for all parameters. Significant differences among intra-row spacings and between varieties were also detected for all parameters except that for seed cotton yield. However the effect of inter-row spacing was significant for the days to first flowering, plant height, number of sympodial branch/m², seed cotton yield, number of bolls/m² and boll weight. Some interaction effects were significant for some observations.

b. Earliness

Table 3 showed the main effects of variety, inter-row and intra-row spacing on days to first flowering, days to first boll opening and number of nodes to first fruiting branch (average over four seasons), which are indications of the earliness. In general, the closer the spacing, the longer it took to give the first flower, first boll opening and the lower number of nodes to first fruiting branch. Barac (67)B showed significantly shorter period to first boll opening (109 DAP) and lower number of nodes to first fruiting branch (6 nodes), while Albar A(57)12 showed shorter period to first flowering (64 DAP).

c. Plant height and number of branches/m²

Plant height significantly increased with the decrease of plant population (wider inter-row and intra-row spacing), while an increase of plant population (closer spacing), irrespective of variety, significantly increased the number of sympodia/m² and number of monopodia/m² (Table 4). Albar A(57)12 produced taller plants and higher number of branches/m², compared to Barac (67)B.

d. Yield and yield components

Main effects of variety, inter-row and intra-row spacing on some yield components (number of bolls/m², boll weight, seed index, lint index and G.O.T.) are presented in Table 5. The closest inter-row and intra-row spacings gave significantly the highest number of bolls/m², while the widest spacing gave the largest boll weight. The results showed no significant differences between 30, 45 and 60 cm intra-row spacing, all gave higher values of seed index and lint index, compared to the 15 cm. The inter-row spacings 70, 90 and 110 cm showed significantly similar values of seed index and lint index. Also, the difference in G.O.T. due to the inter-row and intra-row spacing was not significant. Barac (67)B showed higher values of yield components than Albar A(57)12, except number of bolls/m².

Table 6 showed the main effects of variety, inter-row and intra-row spacing on seed cotton yield, for the four individual seasons and for all seasons combined. The seed cotton yield was the highest in the second season (669 kg/fed.) followed by the fourth season (608 kg/fed.) and this was probably due to the high amount of rainfall during the growing season (see Table 1). The seed cotton yields from the separate and the combined data of the four seasons exhibited similar trends for the inter-row spacing. Hence, seed cotton yield increased with a decrease in the inter-row spacing. The difference between intra-row spacing (15, 30, 45 and 60 cm) was significant only in the 2000-01 and 2003-04 seasons where the closest intra row spacing (15 cm) produced the lowest yield in season 2003-04. In 2000-01 the 15 cm spacing produced significantly higher yield than 45 cm spacing. The two varieties produced similar seed cotton yield (average over four seasons).

The inter-row spacing x intra-row spacing x cultivar interaction was significant (Table 7a). Barac (67)B produced its highest seed cotton yield at 70x30 cm spacing, while Albar A(57)12 produced its highest seed cotton yield at 70x60 cm. The cultivar x season interaction was also significant (Table 7b). Albar A(57)12 out yielded Barac(67)B in season 2001-02. The data in Table 7c show that the effect of inter-row spacing varies with seasons. In wet season (2003-04) the closest inter-row spacing produced the lowest seed cotton yield.

Fig. 2 and 3 showed the relationship between plant population and seed cotton yield of Barac(67)B and Albar A(57)12, respectively. The seed cotton yield of Barac (67)B increased with the increasing plant population up to 99680 plants/fed, with no significant difference in the range of 22146- 99672 plants/fed (70x15-60 cm), while for Albar A(57)12 the seed cotton yield declined after 54450 plants/fed (70x 30 cm).

e. Fiber quality tests

Fiber characteristics of the two varieties under study as influenced by different inter-row and intra-row spacing (2000-01, 2001-02 and 2002-03 seasons) were shown in Table 7 Generally 2.5% span length was reduced by closer intra-row spacing in 2000-01 season. This effect was more pronounced in Albar A(57)12 than Barac (67)B, while in the 2002-03, Barac (67)B was more affected by the intra row (due to shortage of rainfall). Also, the difference between treatments in the 2001-02 season was little (Table 8). Fiber fineness (micronaire) was slightly affected by plant spacing in the three seasons. The influence of intra-row spacing on fiber strength (stelometer) of the two cotton varieties was more pronounced in the 2002-03 season due to the shortage of rainfall.

Conclusions

As expected cotton seed yield followed closely the variation in seasonal rainfall. Higher cotton yields (> 600 kg/fed) were obtained when seasonal rainfall exceeded 600 mm. Under rain-fed conditions the inter-row spacing was more important and had more pronounced effect on cotton yield than intra-row spacing. There were indications that in dry seasons closer intra-row plant spacing (15 and 30 cm) had greater positive effects on cotton yield than wider spacings (45 and 60 cm), while the reverse was true in wet seasons.

Recommendations

Based on the results above, the following plant spacing is recommended for growing cotton in the Blue Nile rainfed areas:

1. 70 cm as inter- row spacing for both Barac (67)B and Albar A(57)12.
2. 15-60 cm as intra-row spacing for Barac(67)B, i.e. 22145-99680 plants/fed; and 30- 60 cm intra row spacing for Albar A(57)12, i.e. 26900-54450 plants/fed.

References

Babiker, E. A. (1986). Annual Report of the Rahad Research Station, ARC, Sudan.

Babiker, E. A. (1987). Annual Report of the Rahad Research Station, ARC, Sudan.

Babiker, E. A. (1988). Annual Report of the Rahad Research Station, ARC, Sudan.

Babiker, E. A. (2004). Effect of plant density and spatial arrangement on growth, quality and yield of morphologically varying cotton varieties. Gezira j. agric. Sci. 2(1): 16- 25.

Burhan, H. O. (1967). Annual Report of the Gezira Research Station, ARC, Sudan.

Fadda, N. R. (1961). Annual Report of the Research Division, Ministry of Agriculture, Sudan.

Lazim, M. E. (1986). Annual Report of the Gezira Research Station, ARC, Sudan.

Lazim, M. E. (1987). Annual Report of the Gezira Research Station, ARC, Sudan.

Lazim, M. E. (1988). Annual Report of the Gezira Research Station, ARC, Sudan.

Lazim, M. E. (1989). Annual Report of the Gezira Research Station, ARC, Sudan.

Taha. M. A. (1962). Annual Report of the Research Division, Ministry of Agriculture, Sudan.

Taha. M. A. (1963). Annual Report of the Research Division, Ministry of Agriculture, Sudan.

Table 1. Rainfall data at Damazin Research Farm, during 2000- 2003 seasons.

	Rainfall (mm)			
Month	2000	2001	2002	2003
1. June	82.8	46	19	Trace
2. July	169.1	205	163	301
3. August	143.2	243	197	189
4. September	40.5	107	76	149
5. October	28.3	36	24	17
6. November	Trace	22	Traces	Traces
Total	464	660	479	671

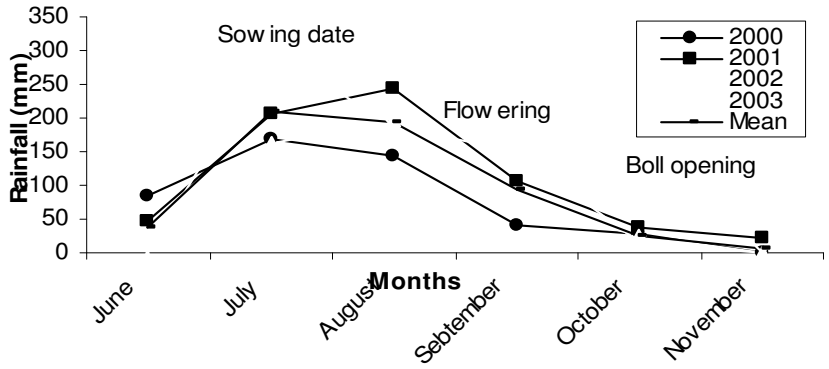

Fig. 1 rainfall data at Damazin Research Farm, during 2000- 2003 seasons.

Table 2. Theoretical and actual plant populations.

Inter row x intra row spacing (cm)	Theoretical Plants/fed.	Actual (plants/fed)	
		Barac (67)B	Albar (57)12
1. 110 x 60	19090	13780	16440
2. 90 x 60	23330	17820	19120
3. 70 x 60	30000	22140	26300
4. 110 x 45	25450	20150	24390
5. 90 x 45	31110	25920	26890
6. 70 x 45	40000	29830	34910
7. 110 x 30	38180	27840	35530
8. 90 x 30	46660	39210	41800
9. 70 x 30	60000	46600	54450
10. 110 x 15	76360	68410	69200
11. 90 x 15	93330	78750	83930
12. 70 x 15	120000	99670	112140

Table 3. Main effect means of variety, inter row and intra row spacing on some earliness components of cotton during 2000- 2003 seasons.

Factors	Days to first flowerir	Days to first boll opening	Number of nodes to first sympodia
Variety			
Barac (67)B	65	109	6
Albar (57)12	64	110	7
SE±	0.11	0.15	0.04
Inter row (cm)			
70	65a	109a	7a
90	65a	109a	6b
110	64b	109a	6b
SE±	0.13	0.19	0.05
Intra row (cm)			
15	66a	111a	7a
30	65b	109b	6b
45	64c	108c	6b
60	64c	108c	6b
SE±	0.15	0.22	0.06
C.V.%	2.0	1.7	8.4

Means of each factor followed by the same letter(s) are not significantly difference at P= 0.05, according to DMRT.

Table 4. main effect means of variety, inter-row and intra-row spacing on plant height and number of branches of cotton during 2000- 2003 seasons.

Factors	Plant height cm	Number of sympodia/m²	Number of monopodia/m²
Variety:			
Barac (67)B	63	81	4.0
Albar (57)12	86	93	5.0
SE±	0.67	1.20	0.25
Inter row (cm):			
70	71c	103a	5.0a
90	74b	83b	4.0b
110	79a	75c	4.0b
SE±	0.82	1.50	0.30
Intra row (cm):			
15	68c	134a	6.0a
30	73b	91b	5.0b
45	78a	68c	4.0c
60	79a	55d	4.0c
SE±	0.94	1.70	0.35
C.V.%	10.8	16.4	36.2

Means of each factor followed by the same letter(s) are not significantly difference at p= 0.05, according to DMRT.

Table 5. Main effect means of variety, inter-row and intra-row spacing on yield components during 2000- 2003 seasons.

Factors	Number of bolls/m	Boll wt (g)	Seed index	Lint index	G.O.T. %
Variety:					
Barac (67)B	38	5.3	10.7	6.5	37
Albar (57)12	43	3.8	9.5	4.6	33
SE±	0.71	0.03	0.05	0.04	-
Inter-row (cm)					
70	46a	4.4c	10.1a	5.5a	36
90	40b	4.5b	10.1a	5.6a	36
110	36c	4.7a	10.2a	5.6a	36
SE±	0.87	0.03	0.07	0.05	-
Intra-row (cm)					
15	56a	4.1c	9.7b	5.4b	36
30	41b	4.6b	10.1a	5.6a	36
45	35c	4.7ab	10.3a	5.6a	36
60	30d	4.8a	10.2a	5.7a	36
SE±	1.00	0.04	0.08	0.06	-
C.V.%	20.9	7.0	6.5	8.6	-

Means of each factor followed by the same letter(s) are not significantly difference at p= 0.05, according to DMRT.

Table 6. Main effect of variety, inter row and intra row spacing on seed cotton yield (kg/fed.) during 2000-01, 2001-02, 2002-03, 2003-04 seasons and combined.

Factors	Seed cotton yield (kg/fed.)				
	2000-01	2001-02	2002-03	2003-04	Combined
Variety					
Barac (67)B	495	626	383	609	528
Albar (57)12	440	712	328	608	522
SE±	9.5	18.0	9.5	15.3	7.2
Inter row (cm)					
70	524a	726a	380a	635a	566a
90	459b	663ab	362a	616ab	525b
110	421c	619b	325b	584b	486c
SE±	11.6	22.0	11.6	18.7	8.8
Intra row (cm)					
15	491a	641a	366a	546b	511a
30	494a	665a	378a	630a	541a
45	432b	669a	350a	618a	517a
60	456ab	704a	330a	641a	532a
Mean	468	669	356	608	525
SE±	13.4	25.4	13.4	21.6	10.1

Means of each factor followed by the same letter(s) are not significantly difference at p= 0.05, according to DMRT.

Table 7. some of interaction effects on seed cotton yield (kg/fed.), during 2000-2003 seasons.

a. Variety x inter-row x intra-row spacing

	Inter-row spacing (cm)											
	70				90				110			
	Intra row spacing (cm)											
Var	15	30	45	60	15	30	45	60	15	30	45	60
V1	607	586	529	582	537	562	522	502	431	481	463	539
V2	506	558	554	603	500	553	524	498	484	507	509	471
	SE± 24.8											

V1= Barac (67)B, V2 = Albar (57)12

b. Variety x season

	Seasons			
Varieties	**2000-01**	**2001-02**	**2002-03**	**2003-04**
Barac (67)B	495	626	383	609
Albar (57)12	440	712	328	608
	SE± 14.3			

c. Intra-row spacing x season

	Seasons			
Intra-row Spacing (cm)	**2000-01**	**2001-02**	**2002-03**	**2003-04**
15	491	641	366	546
30	493	664	378	630
45	431	669	350	618
60	456	703	330	640
	SE± 20.2			

Means of interaction effect followed by the same letter(s) are not significantly difference, at p= 0.05 level, according to DMRT.

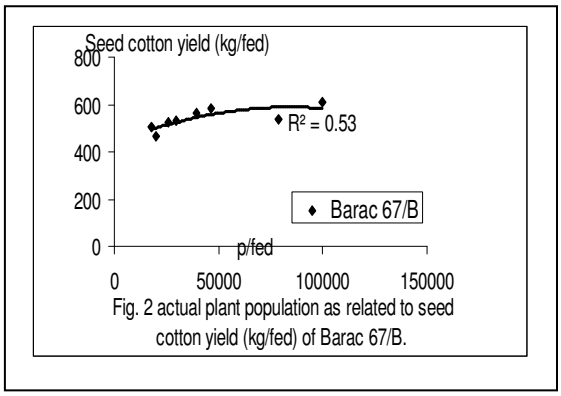

Fig. 2 actual plant population as related to seed cotton yield (kg/fed) of Barac 67/B.

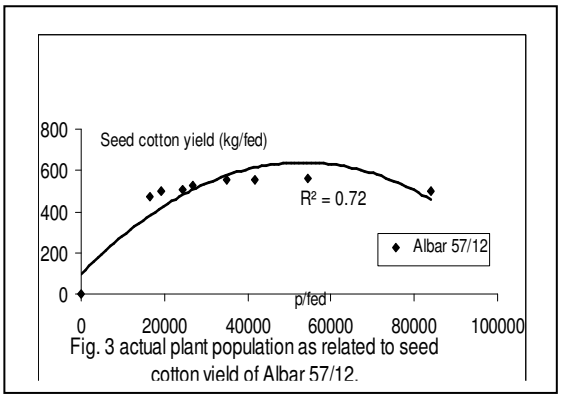

Fig. 3 actual plant population as related to seed cotton yield of Albar 57/12.

Table 8. Fiber quality parameters as influenced by cultivar, inter-row spacing and intra-row spacing during 2000 –2002 seasons.

Variety	Inter-ro (cm)	Intra- ro (cm)	Fiber length (2.5% SL)			Fiber fineness (micronaire)			Fiber strength (stelometer)	
			2000-0	2001-02	2002-03	2000-01	2001-02	2002-03	2000-01	2002-03
Barac (67)B	110	60	26.9	27.6	29.5	3.8	4.0	3.5	22.0	22.8
	90	60	27.1	27.6	28.0	3.6	4.1	3.7	23.0	23.0
	70	60	27.7	27.3	27.8	3.4	3.9	3.5	23.4	22.5
	110	45	26.5	29.1	29.5	3.4	3.6	3.4	21.1	21.9
	90	45	27.1	29.4	27.6	3.4	3.9	3.7	22.5	20.0
	70	45	27.4	29.3	29.1	3.4	3.9	3.4	21.6	22.0
	110	30	27.5	27.5	27.3	3.7	3.7	3.7	21.6	21.2
	90	30	27.6	27.8	25.9	3.6	3.9	3.4	23.6	22.0
	70	30	27.5	28.2	26.4	3.2	3.7	3.4	23.1	19.6
	110	15	26.7	28.2	26.5	3.4	3.9	3.4	21.9	20.9
	90	15	27.6	28.1	25.9	3.1	3.8	3.6	21.8	19.8
	70	15	27.5	27.8	27.2	3.5	3.9	3.4	20.9	20.6
Albar A(57)12	110	60	28.4	29.3	27.3	3.6	4.5	4.4	21.5	21.3
	90	60	28.4	29.5	27.5	3.8	4.1	3.9	20.8	21.7
	70	60	29.4	28.3	28.0	3.6	4.5	3.7	20.8	21.0
	110	45	27.6	29.6	29.1	3.8	4.2	4.0	22.3	22.6
	90	45	26.9	28.9	27.6	4.1	4.1	3.9	21.7	22.2
	70	45	27.2	29.9	27.6	4.1	4.2	3.9	20.4	21.6
	110	30	27.7	28.2	30.0	3.7	4.5	4.1	20.3	20.9
	90	30	27.4	30.0	27.6	3.6	4.3	3.5	21.3	19.8
	70	30	27.4	29.3	29.3	4.0	4.2	4.1	19.8	20.6
	110	15	27.5	29.4	27.3	3.6	4.3	4.1	19.2	21.3
	90	15	27.5	29.0	27.6	4.1	4.3	3.6	19.9	21.7
	70	15	25.7	29.6	28.3	3.8	4.4	3.8	19.3	21.0