1611 Development of Fine-Count Cotton in the Sudan

Mr. Ahmed M. Mustafa , Agricultural Research Corporation -ARC-, Wad Medani, Sudan

The fine-count cotton variety Abdin, derived from the cross (Barac (67) B × BLCABPD8S-1-90) F_1 × (Shambat collection 19-95-1 × CAHUGARPIH-1-88) F_1, was evaluated across ten environments in the Sudan for two seasons (2003/04 and 2004/05). Abdin gave lint yield advantage over Shambat-B of 61%, and had a ginning out-turn percentage of 36.0 compared to 29.0 for Shambat-B. It had a growth period of 150-160 days, 15-25 days earlier than Shambat-B. Abdin possesses ($B_2B_3B_6B_7$) gene combination that confers resistance to both bacterial blight disease races prevalent in the Sudan and had a high degree of tolerance to jassids. The fibre testing data revealed that Abdin had a sizeable increase in fibre strength and count spinning product over Shambat-B. Therefore, it measures up to the progress in spinning and textile industry. It can be concluded that Abdin is a suitable variety for bridging the fine-count cotton quality gap that has been created via the commercial withdrawal of Shambat-B because of its ginning problems.

Introduction

With the changes that have and are occurring in marketing of cotton, it is essential that breeders improve both lint yield and fibre quality. Modernization of spinning and textile manufacturing technologies necessitates fibre property improvement, particularly fibre strength, for the new technology to function efficiently. Recently, textile processing has undergone tremendous changes. The trend has been towards automatic and high speed processing at all stages in spinning, weaving, knitting and wet finishing (Niles 1980). Stronger cotton fibre is important to industry because new, high-speed machinery used to produce cotton yarn requires stronger fibre to work most effectively. This new technology has been driven by global competition that has forced manufacturers to produce more cotton yarn and fabric at less cost (Patil and Singh 1994).

Sudan produces five types of cotton; namely, Extra-fine, Fine, HA-count, Medium and Course-count cotton represented, respectively, by Barakat-90, Shambat-B, Nour, Barac 67 B and Albar A (57) 12 cotton varieties. All these types of cotton are now being grown in the Sudan, except the fine-cotton type represented by Shambat-B. This variety has been withdrawn from production because of ginning problems and low ginning-out-turn (Mursal 1994). Accordingly, the development of fine-count cotton varieties has been sought as the top priority in the breeding programme.

Bacterial blight of cotton caused by *Xanthomonas compestris* pv *malvacearum* (Smith) Dye is an economically important disease. The B_2B_6 gene combination which was incorporated into Barakat cotton variety (Siddig 1973) and Barac (67) B (Kheiralla 1970) proved to be effective against the old race of the pathogen. However, its resistance has been broken down after the appearance of a new race (Post-Barakat) rendering all Sudan cotton varieties susceptible (Ahmed *et al*. 1997). Abdalla *et al*. (2004) reported resistance improvement to the old and the new races prevailing in the Sudan when B_4, B_6, or B_9 were added to $B_2B_3B_7$ genetic background. Recently, two new cotton varieties resistant to races of the pathogen, Hamid with $B_2B_3B_6B_7$ and Knight with $B_2B_3B_6B_7B_9$ gene combinations were released (Mustafa *et al*. 2004). The seriousness of the disease in the Sudan, therefore, makes bacterial blight resistance an important prerequisite for new cotton varieties release. In this paper, research work done in the Sudan to develop a new fine-count cotton variety is discussed.

Materials and Methods

Abdin cotton genotype originated as an F_6 plant selection from the cross (Barac (67) B × BLCABPD8S-1-90) F_1 × (Shambat collection 19-95-1 × CAHUGARPIH-1-88) F_1. The parental lines BLCABPD8S-1-90 and CAHUGARPIH-1-88 were introduced from the Multi-Adversity Resistance Program of Texas A&M University. These parents were chosen on the basis of their potential for bacterial blight resistance, yield and fibre quality. Hybridization, selection and development of Abdin were done at the Agricultural Research Corporation, Wad Medani, Sudan.

Yield and fibre data were derived from the national variety trials conducted at five locations: Gezira Research Station, Hag Abdalla, Suki, Rahad and New Halfa. At each environment, seven varieties: Abdin, Barac (67) B, Shambat-B, Nour, Kheiralla, Knight and Hamid were grown for two seasons (2003/04 and 2004/05) in a randomized complete block design with five replications. The plot size was 5 ridges 6 m long spaced 0.8 m apart. Seeds were sown in hills 0.5 m apart and thinned to three plants per hill, six weeks after planting. Inorganic fertilizers were applied at the recommended rates for each location and chemical pest control and hand weed-control were carried out. The trials were sown between first and mid-July. Agronomic characters, earliness of maturity and bacterial blight disease assessment were evaluated at Gezira Research Station during 2003/04 and 2004/05 seasons. Abdin was also tested in variety and demonstration tests in farmers' fields at the Gezira Scheme in seasons 2003/04 and 2004/05, Rahad Scheme in season 2004/05 and at Suki Scheme in 2005/06 season.

Fibre tests were carried out at the Fibre Testing and Spinning Laboratory of the Cotton Research Programme, Agricultural Research Corporation (ARC), Sudan, according to fibre testing standards under standard testing conditions.

Field inoculation and scoring of the disease severity as described by Knight (1946) were used. Disease severity was recorded 21 days after inoculation using a scale of 0-10, where zero represents immunity and 10 represents full susceptibility. Regular counts of insect pests, predators and parasites were performed according to the standard ARC procedures: 2 upper, 1 middle and 2 lower leaves for whitefly and jassids, percentage of infested plants for aphids and number of eggs and larvae of African bollworm (ABM)/100 plants.

Combined analysis of variance of the data was carried out using the Gensat 3.2 (version 5) computer package. Duncan's multiple range test was used to differentiate significant differences between varieties.

Results and discussion

Mean seed cotton yield ranged between 3104 kg ha^{-1} for Hamid and 2271 kg ha^{-1} for Shambat-B and mean lint yield ranged between 1120 kg ha^{-1} for Hamid and 655 kg ha^{-1} for Shambat-B (Table 1). Abdin produced 2943 kg ha^{-1} seed cotton yield and 1056 kg ha^{-1} lint yield. However, yield differences in seed cotton and lint between Abdin and Hamid, the latest released cotton variety, were not significant. Abdin gave significantly better seed cotton and lint yields than Shambat-B, Barac (67) B and Nour. The higher lint advantage of Abdin over Shambat-B could be attributed to ginning out-turn (GOT). Abdin had significantly better GOT (35.6) than Shambat-B (29.5).

Average seed cotton and lint yields of Abdin grown in farmers' fields at Gezira Rahad, and Suki schemes are shown in Table 2. Because of unavailability of planting seeds in season

2003/04, the on-farm trial was grown only at Gezira Scheme. Although the variety was grown in unsprayed fields at Rahad and Suki Schemes, average lint yield at Gezira for the two seasons and that at Rahad was comparable. However, average lint yield at Suki was lower. This could be due to the late sowing date (August; 16^{th}) compared to early July in both Gezira and Rahad Schemes and could be due to higher insect pests, especially bollworm infestation. However, the results of the on-farm trials showed that the average lint yield advantage for Abdin over the other commercial cotton varieties, which have an average lint yield of 400.0 kg ha^{-1}, was 86.0%, 97.0% and 40% at Gezira, Rahad and Suki Schemes, respectively.

Average disease grade of the tested varieties inoculated (sprayed) with *Xanthomonas campestris* pv *malvacearum* is shown in Table 3. Disease grades ranged from 3.0 to 6.3 for Post-Barakat race; Abdin showed a high level of resistance (3.0) for this race, likewise Hamid (3.6). High level of resistance to Post-Barakat race was reported for the recently released cotton variety Hamid with a gene combination $B_2B_3B_6B_7$ (Mustafa *et al.* 2004). Abdin has the same gene combination, as Hamid, which might be responsible for the high level of resistance observed for Post-Barakat race and the immune reaction for Pre-Barakat race. The early sowing causes severe build-up of bacterial blight; on contrary, late sowing date adversely affects yield and quality (Jackson *et al.* 1967). Hence, the high resistance of Abdin to bacterial blight would widen the sowing date margin for better yield and quality.

Agronomic data collected over two seasons for the tested varieties are presented in Table 4. Abdin was earlier in maturity; it gave 59% of its total lint yield from the first pick compared to 54% for Barac (67) B and 56% for Nour. Moreover, Abdin reached harvest maturity within 165 days compared to 185 days for Nour and 170 days for Barac (67) B. Hamid, Knight and Abdin had the lowest first fruiting node compared to other varieties, indicating that they were early maturing varieties (Table 4). Hamid, Abdin and Knight had the highest number (33, 33 and 32) of bolls, respectively, compared to the other varieties. Number of sympodial branches ranged from 9 for Knight to 7 for Barac (67) B and Nour; however, Abdin had comparable number of sympodial branches to the other tested varieties.

Season 2003/04 was characterized by a heavy jassid and whitefly infestations but lower incidence of bollworm and aphid (Table 5). Abdin exhibited a consistent performance to the bollworm and whitefly population during 2003/04 and 2004/05 seasons. Though jassid infestation was high in 2003/04 season, yet no significant differences were obtained between Abdin, Hamid and Knight. Generally, Abdin showed good performance against the pest complex during both seasons.

Table 6 shows that. the mean fibre length of Abdin (30.5 mm) was similar to that of Shambat-B (30.8 mm) and Nour (29.5 mm) and significantly longer than that of Barac (67) B (27.5 mm). Abdin had fibre strength (34.3 g/tex) significantly stronger than Shambat-B (30.4 g/tex), Nour (30.9 g/tex) and Barac (67) B (28.9 g/tex). It had significantly higher (2123) count strength product (CSP) than Nour (1994) and Barac (67) B (1984) and a comparable CSP (2084) to Shambat-B. Abdin had fibre fineness of (4.4) similar to Nour (4.5), Mursal (1993) reported similar and parallel fibre characteristic of Barac (69) 2 and mid grades of Shambat-B, respectively, to Nour. In this study, Abdin had similar fibre length to Shambat–B and Nour, but had stronger fibre. Table2 shows results of fibre quality in variety and demonstration test in farmer fields. Abdin gave consistently strong bundle strength for the top grades (36.0-39.0 g/tex) which appear near or as the middle grade of Barakat-90. According to shift in cotton quality demand by industry, cotton breeders have succeeded in developing cotton varieties with desirable fibre strength. For instance, in California the variety Prema has been released with fibre strength of 33g/tex (Gannaway

1989) and in India Pusa lines have been released with fibre strength of 33-36 g/tex (Patil and Singh 1994). May and Jividen (1999) reported that higher machine output and rotor and air-jet yarn manufacture require improved cotton fibre properties, particularly fibre strength. Stronger fibre can withstand the forces associated with higher manufacturing speeds (Faerber 1995). The newly released cotton variety Abdin with 34.4 g/tex would certainly represent a significant genetic improvement in fibre strength, that will contribute to productivity gains in the textile industry and make a significant change in cotton quality parameters. Likewise, this will significantly enhance the marketing position of Sudan cotton.

According to the international fibre classification, Abdin fits well in the fine-count (long staple) cotton category. Since the high HA-count cotton Barac (69) 2 and the fine-count cotton Shambat-B were withdrawn from commercial production, Abdin will fill this gap of fibre quality and widen its spectrum, strengthening Sudan cotton marketability.

Yield and fibre quality advantages empirical for this variety qualify it as a potential variety. Most of the farmers, especially in Gezira Scheme, prefer to grow Barakat-90 because of its price advantage. Sukumar *et al*. (2003) stated that the exceptional fibre length, strength and fineness of Pima and Sea Island give it a 30% to 50% price advantage over the upland cotton. Abdin, as a fine-count cotton, will have a price advantage over Sudan cotton Acala. Since it combines both yield and quality, it appears as a good compromise between farmers on one hand interesting in increasing benefits and overall national income, and spinners on the other hand demanding high textile quality.

References

Abdalla, K.M; Mustafa, A.M. and Ibrahim, A.S. (2004). New gene combinations conferring resistance to the bacterial blight disease of cotton. *Gezira Journal of Agricultural Science* 2, 1-14.

Ahmed, N.E; Mavridis, A. and Rudolph, K. (1997). Isolation of new races of *Xanthomonas compestris* pv *malvacearum* (Smith) Dye from continuous cotton plot at the Gezira Research Farm, Sudan. *University of Khartoum Journal of Agricultural Sciences* 5, 32-38.

Faerber, C. (1995). Future demands on cotton fibre quality in the textile industry, technology-quality-cost. pp. 1449-1454. In; D.A. Richter and J. Armour (eds.) *Proceeding Beltwide Cotton Research Conference, San Antonio, TX, U.S.A.. 4-7 Jan. 1995*. National Cotton Council, Memphis, TN., U.S.A.

Gannaway, J (1989). Registration of germplasm lines of cotton. *Crop Science* 29, 833-834.

Jackson, J.E; Faulkner, R.C. and Razoux Schulz, L. (1967). Studies on the sowing dates of cotton in the Sudan Gezira. III the effect of sowing date on yield and quality under different fertilizer and spraying treatments. *Journal of Agricultural Science, Cambridge* 69, 329-339.

Kheiralla, A.I. (1970). Varieties in the Gezira Environment. pp 173-178. In: *Cotton Growth in the Gezira Environment*. Siddig, M.A. and L.C. Hughes (eds). The Agricultural Research Corporation, Wad Medani, Sudan.

Knight, R.L. (1946). Breeding cotton resistant to blackarm disease (*Bacterium malvacearum*). *Empire Journal of Experimental Agriculture* 14, 153-74.

May, L. O. and Jividen, G.M. (1999). Genetic modification of cotton fibre properties as measured by single and High Volume Instruments. *Crop Science* 39, 328-333.

Mursal, I.E. (1993). Cotton varieties for IPM and rain fed areas. ARC, Variety Release Committee, Khartoum, Sudan.

Mursal, I.E. (1994). New cotton varieties for integrated management. pp. 373-375. In: *Challenge the Future* Proceedings of the World Cotton Research Conference 1, Brisbane Astralia Constable, G.A. and N.W. Forrester, (eds), CSIRO, Melbourne.

Mustafa, A. M; Babiker, E. A; Ahmed, N. E; Kannan, H. O; Abd Ellatif, A. H. and Abd Elmagid, G. E. (2004). Proposal for the release of new cotton genotypes (BB82 and BB90) resistant to bacterial blight. ARC, Variety Release Committee, Wad Medani, Sudan.

Niles, G. A. (1980). Breeding cotton for resistance to insect pests. pp. 337-369 In: *Breeding Plants Resistant to Insects.* F. G. Maxwell, and P. R. Jenning (eds.). John Wiley and Sons Inc., New York.

Patil, N. B., and Singh, M. (1994). Development of medium-staple high-strength cotton suitable for rotor spinning systems. pp 264-267. In: *Challenge the Future* Proceedings of the World Cotton Research Conference 1, Brisbane Astralia Constable, G.A. and N.W. Forrester, (eds), CSIRO, Melbourne.

Siddig, M. A. (1973). Barakat, a new long-staple cotton variety in the Sudan. *Cotton Growing Review* 50, 307-315.

Sukumar, S. D.A.; Raska, N.; Jenkins, J. C.; Jack, C.; McCarty, J.; Osman, A.; Gutierrez, R.G.; Percy. R.G.; Contrell, J.; Wu. and Stelly, D. M. (2003). Effect of chromosome on important quantitative traits of agronomic and fibre traits using *Gossypium barbadense* chromosome-specific recombinant lines of *Gossypium hirsutum*. pp 169-174. In: *Cotton Production for the New Millennium*. Proceedings of the World Cotton Research Conference-3., Cape Town, South Africa.

Table 1. Mean seed cotton and lint yields and ginning out-turn (GOT) of seven varieties at five locations in seasons 2003/04 and 2004/05.

Variety	Seed cotton yield (k ha^{-1})	Lint yield (kg ha^{-1})		GOT
Abdin	2943 ab	1056 abc		35.9 b
Shambat-B	2271 e	655 e		28.9 c
Nour	2695 c	976 d		36.4 b
Barac (67) B	2481 d	939 d		37.7 a
Knight	2827 bc	1031 bc		36.3 b
Kheiralla	2751 bc	1001 bcd		36.5 b
Hamid	3104 a	1120 a		36.2 b
SE±	63.3	27.2		0.14

Means followed by the same letter (s) are not significantly different at P = 0.01% (Duncan's Multiple Range Test)

Table 2. Seed cotton and lint yields kg/ha and fibre characteristics of Abdin at Gezira, Rahad and Suki Schemes (on farm trials) in 2003/04, 2004/05 and 2005/06 seasons

Location	Season	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Fibre length (mm)	Micronaire	Fibre strength g/tex
Gezira	2003/04	2083	750	31.3 - 32.8	4.1 - 4.3	36.4 - 39.2
Gezira	2004/05	2056	740	31.5 - 32.9	4.0 - 4.3	35.5 - 38.6
Rahad	2004/05	2194	790	31.2 - 32.7	4.1 - 4.4	35.5 - 38.5
Suki	2005/06	1550	558	31.4 - 32.8	4.0 - 4.2	35.6 - 38.7

Table 3. Average disease grade of seven cotton varieties carrying different bacterial blight resistance genes inoculated (spraying) with *Xanthomonas compestris* pv *malvacearum* at GRS in 2003/04 and 2004/05 seasons

Variety	Disease grade (old race)	Disease grade (new race)	Resistance genes
Abdin	0 Im	3.0 HR	($B_2B_3B_6B_7$)
Shambat-B	0 Im	5.0 MR	(B_2B_6)
Nour	0 Im	6.2 S	(B_2B_6)
Barac (67) B	0 Im	6.3 S	(B_2B_6)
Knight	0 Im	3.6 HR	($B_2B_3B_6B_7B_9$)
Kheiralla	0 Im	6.2 S	(B_2B_6)
Hamid	0 Im	4.0 R	($B_2B_3B_6B_7$)

GRS = Gezira Research Station, Sudan

Im = immune (no visible symptoms), HR = highly resistant, IR moderately resistant, S = susceptible

Disease assessments were made 3 weeks after inoculation.

Table 4. Average number of bolls, sympodial branches, monopodial branches, first fruiting node, earliness percent and days to last pick measured for seven varieties at GRS in 2003/04 and 2004/05 seasons

Variety	No. of bolls	No. of sympodial branches	No. of monopodial branches	First fruiting node	Days to last pick	Earliness (%)
Abdin	33	8	4	5	150-160	61
Shambat-B	26	8	5	6	175-185	56
Nour	31	7	5	6	175-185	56
Barac (67) B	22	7	4	6	160-170	54
Knight	32	9	4	5	150-160	61
Kheiralla	24	8	4	6	175-185	56
Hamid	33	8	3	5	130-140	69
SE±	1.2	0.37	0.26	0.11		

Earliness (%) = Expressed as the percentage of the first harvest from total yield

GRS = Gezira Research Station, Sudan

Table 5. Mean number of major insect pests, parasitized whitefly and predator population, on some cotton genotypes at GRS (2003/2004 and 2004/2005) *

			Major insect pests and predators						
Season	Genotype		Jassid nymphs/ 50 leaves	% Aphid infested plant	ABW (larvae + eggs) / 50 plants	Whitefly Adult/ 50 leaves	% Parasitized whitefly	Mean number of Chrysoid larvae	
2003/04	Abdin		37	4.0	3.2	87	23	2.4	
	Hamid		35	0.0	2.6	18	41	2.9	
	Knight		34	0.0	0.0	128	40	2.5	
	SE ±		2.3	0.2	0.4	7.1	2.7	0.3	
2004/05	Abdin		0.8	1.4	6	31	26	2.3	
	Hamid		0.7	1.3	7	28	44	3.1	
	Knight		0.7	4.0	10	55	45	2.6	
	SE ±		0.02	0.4	1.7	8.3	3.9	0.2	

* Average of 8 counts

GRS = Gezira Research Station, Sudan

Table 6. Fibre properties and yarn strength in seven cotton varieties grown at five locations in 2003/04 and 2004/05 seasons

Variety	Fibre length (mm)	Micronaire value	Fibre strength (g/tex) HVI*	Yarn strength CSP **
Abdin	30.5	4.4	34.3	2123
Shambat-B	30.8	3.9	30.4	2084
Nour	29.5	4.5	30.9	1994
Barac (67) B	27.5	4.1	28.9	1984
Knight	28.4	4.6	31.2	2010
Kheiralla	29.4	4.2	32.0	2062
Hamid	28.0	5.0	30.5	1857
SE (±)	0.4	0.7	0.1	22

* HVI = High volume instrument

** CSP = Count Strength Product