Sudan Cotton Research and Production Scenarios: Challenges, Achievements and Prospects

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Introduction

The introduction of cotton in the central Sudan (Gezira,1925) was preceded by the establishment of the cotton based Agricultural Research (Shambat,1904 and Medani,1918) where basic scientific information had been availed on agricultural environment, varieties, cultural practices and crop protection. Up to the 1980th cotton had been the predominant research area of ARC, due to the government priority and full support for commercial cotton production at that time.

These achievements were, however, not up to the new challenges facing the agricultural system such as: soil deterioration, insect unbalance due to irrational use of insecticides, crop diversification and intensification under dilapidated infrastructures and emergency crop rotations. Moreover, insects like bollworm is threatening productivity whereas whitefly induced stickiness is the main bottleneck for quality marketing of cotton, coupled with the rank growth phenomenon which is a reflection of how inputs are inefficiently utilized and resources being wasted. Crop production practices are traditional and depend on hand labour which is not enough for the recommended precise cultural practices. The present pattern of escalating cost of production and stagnating low yields, despite variation in finance and agricultural polices may question the economic feasibility of growing cotton.

The framework of the cotton research is pillared upon the following especialties:

1. Variety improvement.
2. Cotton stickiness and testing technology
3. Agronomy and crop physiology
4. Plant protection (in co-operation with the plant Protection Center)
5. Soil and Water Management. (in co-operation with Soil and Water Center).
6. Mechanization(in co-operation with Agriculture Eng. Program**.**

The objectives of the program are:

1. Varietal improvement for higher yields, earliness, disease and insect resistance.
2. Diversification of intrinsic quality by breeding new styles and variants having different balances of fiber characteristics, measuring up to the progress in the textile and spinning technology.
3. Vertical upgrading of productivity via generation of multidisciplinary technological packages that fit into the integrated crop management (ICM) strategy and with concomitant reduction in production cost.

Challenges facing the Sudanese cotton production

- Implementation of the basic cultural practices in the field is not up to the level of inputs applied. This will not lead to the yield maximization using the high input varieties bred before 1990th.
- The long time average yield is in the range of 4-5 kantar/fed (400-450 kg/ha) for the last 80 years, despite variation in financial and agricultural polices adopted throughout the years(Table.1).

Table1. Number of sprays and seed cotton yield (kantar/fed) for 1925-2005 (Gezira, sudan).

Periods	Seed cotton(kantar/fed)	No. of Sprays
1950-1925	3.8	0
50-51/60-61	4.2	1
71/70- 62/61	3.9	5.9-2.0
81/80-72/71	3.8	9.3-5
91/90-82/81	4.4	3.1- 8.5
2001/2000-92/91	4.1	5.05-2.68
2001/02-05/6	4.4	3.5-2.5

- High cost of production coupled by the low world prices especially for Upland cotton.
- Yield variability between farmers in the same number being attributed to the financial ability of the farmers in timely execution of cultural practice.
- Cultivated area of cotton is fluctuating and is on sharp decline (Table 2).

Table 2. Fluctuation in cropping area

Season	Cotton acreage (feddans)*
96/97	663.000
97/98	421.000
98/99	278.000
99/2000	387.000
2000/2001	380.000
2001/2002	294.000
2002/2003	391.000
2003/2004	408.000
2004/2005	491.000
2005/2006	403.000

- ***(one feddan= 1.038 acres***

- Grain crops are competing with cotton.
- Inputs like fertilizers and pesticides are imported (No local industry).
- More than 90% of the cotton is exported as raw material (No added value).
- Decayance and obselecy of production infra-structures (mainly irrigation networks, agricultural machinery, ginneries and other supported equipments).
- Sharp increases in the cost of agricultural operations(mainly land preparation and labour cost).
- Increase in fixed (overhead) cost per unit due to acreage reduction.
- High cost of finance.
- Stickiness as a bottleneck for marketability.

Impact of cotton plant morphophsiology on agronomic management

Cotton is a perennial woody plant and of indeterminate growth habit. Being a perennial crop and through indeterminate growth habit cotton is always had the habit of stay a life as along as it can. Its priority is therefore to grow vegetatively at the expense of production wherever stress occurred. Therefore cotton is very sensitive to management of cultural practices and inputs and the other environmental factors i.e failure to properly control the bollworm will result in shedding of flower buds and small bolls, thus diverting assimilates to vegetative parts (rank growth). On the other hand crops like sorghum (determinate growth) is easy to mange, hence, assimilates will be diverted only to the head.

Achievements and Prospects in integrating crop management for cotton

1. Compliance with the recommended crop rotation:

Crop rotations were designed on agricultural, economical and social studies that were scientifically based on the integrated crop management. Non compliance with crop

rotation will lead to improper crop sequence and hence, deterioration in cultural practices. Consequently, the efficiency of crop protection will be lessen.

2. Land Preparation:

- In the 1980th and 1990th no differences were found between the varying methods of land preparation except for soils that has especial problems.
- Tamboul Pilot Farm studies recommended the pre-watering followed by disc harrowing to 6 inches and subsoiling every 4 years and emphasized land leveling before ridging.

3. Sowing date:

- July sowing for the Upland cotton.
- Third week of July to 10th of August for the Egyptian cotton.

4. Varieties:

The objective of variety improvement program is to develop varieties that are resistant to diseases and pest, of higher yield and better quality Table.3.

Table 3. Fiber characteristics

Fibre characteristics	Strength g/tex	Length (2.5%)S.L
Extra Fine Count Cotton	27-30	33-35
Fine count Cotton	23-24	29-32
High A Count Cotton	20-23	28-31
Medium Count Cotton	20-21	27-28
Coarse Count Cotton	16-19	24-26

More than 50 varieties and registered lines had been released. However, only 7 varieties are currently grown either commercially or in limited propagation plots. These are: Barakat 90(EFC), Barakat(EFC),Shambat-B(FC),Nour(HCA),Barac(67)B(MC),Albar(57)12(CC)and Acrain(CC). More recently (2004/05 and 2005/06), nine varieties were released as listed hereunder:

A- Abdin: (BB-80)

The fine-count cotton variety Abdin, derived from the cross (Barac(67)B× BLCA B PD8S-1-90) F_1 × (Shambat collection 19-95-1 × CAHUGARPIH-1-88) F_1, was evaluated across ten environments in the Sudan in 2003-2005. Abdin gave average lint yield advantage over Shambat-B of 61%. It had a ginning out turn percentage of 36.0 compared to 29.0 for Shambat-B. It has 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 higher degree of tolerance to jassids.

B-Wagar :

Wagar gave average seed cotton and lint yield advantage over Shambat-B, Barac (67) B and Nour, of 36%, 25% and 15%; and 73%, 21% and 16%, respectively and gave comparable seed cotton and lint yield to Hamid. Moreover, Wager exhibited higher ginning out turn surpassing that of Hamid.

C- Burhan: (BB-65):

Burhan gave average lint yield advantage over Albar A (57) 12, Almac (80) 15 and Acrain of 37%, 29% and 21 %, respectively. Stability measures found Burhan to be most stable, and widely adaptable to rain-fed cotton growing areas of the Sudan.

D- Khalifa: (Damazin):

Khalifa excelled Albar (57) 12, Almac (80) 15 and Acrain by 32%, 30% and 30 % and 50%, 41% and 32 % for seed cotton and lint yield, respectively. Khalifa was found adaptable to cotton growing areas of the tested environments and had stable seed cotton and lint yield. Khalifa was found earlier than other genotypes tested as demonstrated by its shorter days to first flowering. Khalifa was resistant to both old and new races of *Xanthomonas compestris* pv *malvacearum*.

E- Hamid : (BB-82):

This a medium count, high yielding, early maturing genotype that showed resistance to bacterial blight, jassid, low preference to whitefly and harboring less population of ABW, emerged as a suitable choice for short duration low management system. Hence it can be recommended for Integrated Crop Management (ICM) due to its open canopy, low leaf area, medium hairiness and earliness. It can also be fitted into short-season production system in rain-fed areas, where problems of late drought are anticipated.

F- Knight :(BB-90)

This a medium count cultivar .Because of its additional improvements in yield, resistance to bacterial blight, and yarn strength, BB90 is recommended for irrigated areas, to cater for bacterial blight in areas more prone to high disease incidence (B2B3B6B7B9) and to enhance the deteriorating fiber bundle strength of medium staple cotton .

G-Kheiralla: (CRP-12):

This is a high count Acala (HCA), jassid resistance , excelling Nour(93) in yield and fineness. It is a bacterial blight resistance and harboring less whiteflies (lower (lower stickiness) .

H-Siddig (Sudan Pima) :

It is a selection from a cross between Barakat –90 and Pima. This is a Fusarium Wilt resistance variety. It is an extra – fine count cultivar excelling Barakat-90 , in length strength and fineness.

I- Hadi: (Okra-leaf Barakat):

It is a selection from a cross between Barakat-90 and Pima Okra. It is a fine count cultivar , early maturing, high yielding and has better (GOT) as compared to Barakat 90.

5. Plant density

The recommended seed rate of non–delinted seeds is about 9-10 kg/fed (plant density thinned to 32000 plants/fed) for the recommended sowing date. With the late sowing date the plant density is 52000 plants/fed to cater for the reduced growth with the onset of low temperature. Studies at Tamboul Pilot Farm recommended seed rate of 5-6 kg/fed for acid delinted seeds and 6-8 kg/fed for the mechanically delinted seeds to give 52000 plants/fed with intra-raw spacing of 10cm into 80 cm ridges.

6. Seed Production:

Varieties do not deteriorate by time if well maintained and properly propagated . For examples in Egypt some varieties like Meitafifi ,Sakel and Ashmouni had been in commercial production for 32,31 and 117 years, respectively Seed deterioration happens as the result of seed mixtures due to cross pollination where isolation distances are not practiced and or mechanical mixtures that usually take place in the ginneries. Therefore seed production should be practiced as recommended, hence, the crop will never be better than the planted seeds. Steps for the scientific seed propagation should be as follow:

- **Breeder seeds:**
  This is the responsibility of the breeder, being true to type and with morphological differences and colour markers.
- **Foundation seed(1):**
  Produced from the breeder seed under the responsibility of ARC .
- **Foundation seed(2):**
  Produced from foundation seed (1) in the field of production schemes and supervises by ARC staff in-cooperation with the production schemes.

- **Registered seed:**

Propagated from foundation seed(2) by the production schemes and ginned by the schemes. However the follow up by the breeders and roughing staff is recommended.

7. Efficient water use:

This requires proper application to avoid water logging which promotes lateral roots that lack the ability of providing the plant with the required water and nutritional materials. The critical period for water requirement is from October to November where water stress can cause up to 40% yield losses, Water stoppage should be done by the end of December for the Upland cotton and by the end of March for Egyptian cotton. Drainage is very important particularly in Mid August where water logging can cause yield losses of 50-60% if not drained within 48 hours.

8.Fertilizers:

Fertilization of cotton in Gezira started in the middle of 1950th with one dos(1N) of nitrogen(18kgN/fed) and in the 1960th it increased to 36kgN/fed(2N). The(2N) has remained as the recommended rate till today, even though, in 1981-82 it increased to 3N but then abandoned due to the low world cotton prices. Also(3N) had been practiced in the 1980th in Northern Section of the Rahad Scheme but the outcome had not been up to the cost and it was then decided to go back to (2N).

9. Protection:

A- Insect:

The chemical insecticides has been the main method of control but it is highly costive (30-40% of the total cost), polluting to the environment and damaging to the quality of life. The major insects pests are: Bollworms, Jassids, Thirips, Fleabeatles, Whiteflies and Aphids. Insects pattern differs from season to season due to variation in rainfall and intensity of host plants with the late season pest (Aphid) appears early in the season and the early season pests(Jassid and Bolloworm) being long season pests. When applying insecticides, the following practices should be considered:

- Intensify and increase the samples of insects counts.
- Use of efficient insecticides of varying chemical categories.
- Avoid use of pyretheroids at the beginning of the season as not to flare Aphid at the end of the seasons.

B- Diseases:

The variety development in the Sudan is highly affected by disease infection. Many varieties (D.S,X1530 and X1730) were replaced due to their susceptibility to disease such as leafcurl and bacterial blight .Later the gene combination B_2B_6 was isolated as the source of resistance for the pre-Barakat race of bacterial blight. More recently (2004/05 and 2005/06) new gene combinations (B2B3B7) and (B2B3B6B7) were isolated as sources of resistance to both pre and post Barakat races and fitted into the newly released varieties (Hamid, Abdin, Knight, Khalifa and Burhan). Despite of the varietal resistance ,sanitary measures such as cleaning and burning of the crop remains, seed dressing, acid delinting and enforcement of the crop protection and seed laws, should be in place.

10. Integrated Pest Management (IPM) Project:

This was executed in area of 5.000-33000 fed. where the new Economic Threshold Levels (ETL) were used. Yield attained were equaled to the neighboring farmers despite difference of 2 sprays(4 vs. 6 spray). The cost of 2 sprays/fed is US$25. Another experiment was the cotton production without the use of insecticides(1987/86) in Nediana, Messalamia in 793 feddan. The seed cotton yield for the non sprayed was 3.79 kantar/fed whereas the sprayed was 4.8 kantar/fed with 6 sprays. The cost of the 6 sprays was found to be equal one kantar/fed.

Table 4. Economic Threshold Levels (ETL) for spraying of cotton insects

Insect	Old ETL	New ETL
Whitefly	200 adults/100 leaves	600 adults/100 leaves
Jassid	50 nymphs/100 leaves	70 nymphs/100 leaves(Upland) 100 nymphs/100 leaves*(Barbadense)*
Aphids	15-20 infested plants	40% infested plants
boll worm	10 eggs or small larvae/ 100 plants	30 eggs or 10 small larvae/100 plants * insecticide not to be sprayed unless flowering is advanced.

11. Cotton picking:

Programming of early cotton picking with irrigation is the ideal way but most of the farmers do not adhere to, due to their anticipated low profits. The policy of purchasing seed cotton at the farm gate may enhance picking. Machine picking had to be adopted due to the shortage and high cost of labour. The technical and socioeconomic reasons that aborted machine picking in 1984 (Rahad) need to be reassessed.

12. Crop remains:

Cleaning and burning of crop remains have to be well enforced and all sanitary measures have to be applied to avoid carrying over of pest infestation and disease infection.