THE BOOTS COMPANY LIMITED
RESEARCH DEPARTMENT

Lenton Research Station
Nottingham

EVALUATION OF MITAC ON COTTON, 1978

4. TRIALS IN SUDAN

October 18th - December 1st, 1978

by

B. Taylor and J. P. Burgess

Objectives

1. To monitor official large scale trials of MITAC and to discuss progress with Agricultural Research Corporation staff.

2. To evaluate effective dose rates and application methods for MITAC.

CONTENTS

SUMMARY

1. The official large scale trials of MITAC at 400 g a.i./feddan (952 g a.i./ha) which currently are underway in the first of two seasons, were monitored and the results obtained up to 24th November are analysed. The control of whitefly by MITAC was proving to be excellent and the majority of other products being tested were markedly inferior. The exigencies of the trial management did not favour the control of Heliothis by MITAC although excellent control was shown on the one occasion when, at the time of application, Heliothis egg levels were high but larval levels were very low.

2. A small scale trial was carried out to assess the efficacy of three dose rates of MITAC. All three dose rates, 500 g a.i./ha, 750g a.i./ha and 1000 g a.i./ha were highly effective against whitefly.

3. A large scale ULV application trial was initiated with the co-operation of the Shell Company. The first impressions were of a good performance by MITAC but formal results are still to come.

4. Appendices are provided dealing with

   (a) Cotton growing in the Sudan.

   (b) Agriculture in the Sudan.

INTRODUCTION

Cotton is the major export crop of the Sudan and the mainstay of the Sudanese economy. In 1977-8 a total of over 450,000 hectares of cotton were planted, most of it being of the highest quality long staple *Gossypium barbadense*. Insect pest problems have become increasingly severe over the past 15 years with yields decreasing while the number of insecticide sprays has risen. In 1975/6 it was estimated some 31 million U.S. dollars worth of insecticides were imported, with the bulk of these destined for the cotton field. The major pest is the whitefly, *Bemisia tabaci*, which not only causes a direct loss in yield by its debilitating effect on the plant but also a drop in quality of the cotton lint because of stickiness originating from the honey-dew exuded by the juvenile stages of the pest. Currently some 70% of the cost of pest control is directed against whitefly but this pest problem continues to increase in severity as the approved products such as dimethoate (Rogor) and monocrotophos, (Azodrin, Nuvacron) decline in their effectiveness. Other pests include jassids and bollworms but these are still relatively easily and cheaply controlled by products such as DDT and carbaryl (Sevin). All insecticide application is done aerially with some 35% being by the ULV (ultralow volume) method.

The potential of MITAC for whitefly control in cotton was first demonstrated in Turkey in 1975; with approval being granted by the Turkish Ministry of Agriculture in that year for use at 1.0 kg a.i./ha and in 1976 for use at 0.6 kg a.i./ha. Small scale trials were carried out in the 1976/77 season at the Gezira Research Station of the Sudanese Agricultural Research Corporation. As a result of these trials MITAC was deemed successful enough to be entered in the large scale trial programme. The current 1978/9 season is the first of the requisite two seasons of large scale trials in which MITAC is being tested at 400 g a.i./feddan (952 g a.i./ha).

OFFICIAL LARGE SCALE TRIAL

This trial, which is being held at the Guneid Extension Scheme, commenced on 14th October and will continue until late February or early March. The Guneid Extension is located some 95 km north-west of Wad Medani to the east of the Blue Nile (latitude 14°56', longitude 33°39'). It is an isolated flood irrigation scheme dependent on water pumped from the Blue Nile. The pest infestation usually includes the Spiny Bollworm, Earias insulana, in addition to whitefly and the American Bollworm, Heliothis armigera. Thus it is deemed a useful test area for candidate insecticides by the staff of the Agricultural Research Organisation.

This season severe flooding shortly after sowing in July caused crop damage and loss of seedlings. Some re-planting took place but establishment of late plantings is never wholly satisfactory. The total area of cotton available for the trial was much reduced and, instead of the planned allocation of four fields of 90 feddans each (1 feddan = 0.42 ha; 90 feddans = 37.0 ha), three fields were allocated to each product under test. Many of these fields were incompletely planted and thus, for example, the MITAC allocation was three fields with 61, 48 and 81 feddans of cotton respectively for Replicates 1, 2 and 3. Within these fields, moreover, the plantings were very variable and numerous patches of thin or non-existent cotton could be found.

In theory the timing of application is determined by the exceeding of economic threshold levels; viz., 200 whitefly adults/100 leaves, 10 Heliothis eggs or larvae/100 plants; but this is either liberally interpreted or ignored and spraying is more a matter of convenience i.e. when aircraft and staff are available, to avoid public holidays, and so on. Moreover, all plots are sprayed on the same day. Counting, in fact, takes place two/ three days after spraying then at weekly intervals. With two days notice of spraying the application intervals then fall into an 11 or 18-19 day pattern possibly longer in November when the great Moslem festival of Eid el Kabir takes place for five days.

The major criteria* used in assessing the performance of a product are (a) if the product, in the dose and formulation tested, is as effective as, or more effective than, the standard treatment, (this season Treatment Q in the Tables 1-4) dimethoate 0.4 lb a.i./feddan + DDT 1.0 lb a.i./feddan (432 g a.i./ha + 1080 g a.i./ha) and (b) if the product maintains an average level of infestation throughout the season which is below the economic threshold for the appropriate pest.

The Pests and Diseases Committee responsible for approval apparently also considers the cost of using the product at the dose rate and in the formulation tested. In its first appearance in trials the product performance is evaluated after one season of replicated small scale trials followed by two seasons of large scale. Thus, whatever the overall result of this season's trial MITAC will be eligible for entry into the 1979/80 large scale trial for conventional application as a 20% emulsifiable concentrate (e.c.) at a dose rate of 400 g a.i./feddan (952 g a.i./ha) and this would be the second season for the purposes of primary approval.

*Note these statements are based on verbal information and may not be wholly accurate.

If a change in dose rate, in formulation or in application method (e.g. from e.c. to U.L.V.) is contemplated then the product has to be entered into the small scale trial procedure for one season followed by, if successful, a single season of large scale trials at two different sites.

Following registration of a new product, the Agricultural Research Corporation will authorise the purchase of sufficient product to spray 15,000 feddans during a season's programme of application and this, in effect, is a very large scale user trial.

Tables 1-4 show the results of the official counts up to the time of the authors' departure from Wad Medani. The full results will be made known officially some time after the season ends (late February - early March). There is little that can or should be said at this time but it is significant that the products giving a reduction of 80% or over in the whitefly adult levels from the pre-third application counts (18-19 November) are Hostathion EC, dimethoate/DDT ULV, MITAC EC and Ekalux EC. Comparing the initial pre-spray level of 14-15 October with the post-spray level of 23-24 November shows those products with a post-spray level of 30% of the initial level or less to be Triazo/Endosulfan EC, Hostathion EC, dimethoate/DDT EC (Treatment E but not F or Q), dimethoate/DDT ULV, MITAC EC, and Ekalux EC. The worst products, in fact, those unsuccessful for whitefly control are Dursban ULV (Treatment C), Decis ULV, Sumicidin EC, Celathion/DDT EC and ULV, Hostathion/DDT ULV, Ripcord/Azodrin ULV and the standard dimethoate/DDT EC (Treatment Q).

For Heliothis control MITAC in this trial has not been over successful to date but the larval numbers have not exceeded the economic level of 10 larvae/100 plants and the third application, which was made to a high egg level but before any significant hatching, gave the good results our experiences elsewhere have led us to anticipate.

Chemicals in large scale trial (and developing companies/agents)

Celathion =	chlorthiophos	(Celamerck/Geo. Jerjian)
Decis	decamethrine	(Procida/Rhone-Poulenc/Bittar)
Dursban	chlorpyrifos	(Dow/Atlas Trading Co.)
Ekalux	quinalphos	(Sandoz/Comb. Harv. Eng.)
Hostathion	triazophos	(Hoechst/Bittar)
Ripcord	cypermethrin	(Shell)
Sumicidin	fenvalerate	(Sumitomo/ ?)
Thiodan	endosulfan	(Hoechst/Bittar)

The dose rates of the products other than MITAC were not available.

GUNEID EXTENSION LARGE SCALE TRIAL 1978-9 Whitefly adults/100 leaves (means of 3 replicates) TABLE 1

TREATMENT		14-15 Oct	18 Oct	20-21 Oct	26-27 Oct	30 Oct	1-2 Nov	6-7Nov	18-19 Nov	21 Nov	23-24 Nov
A. Triazo/Endosulfan	EC	103.8		29.2	143.4		42.3	83.1	115		29.1
B. Hostathion	EC	180.0		26.2	63.9		43.4	92.2	204		37.4
C. Dursban	ULV	138.5		96.1	130.9		41.6	266.4	550		142.5
D. Dursban	ULV	187.2		61.7	150.3		32.2	197.4	327		89.3
E. Dimethoate/DDT	EC	191.6		48.2	112.0		27.1	196.6	185		47.5
F. Standard Dimethoate/DDT	EC	133.6		82.4	94.0		66.8	194.6	214		56.3
G. Dimethoate/DDT	ULV	162.2		30.0	157.6		26.1	102.3	233		43.4
H. Decis	ULV	88.2		27.4	106.3		34.1	140.4	245		69.2
I. Celathion/DDT	EC	85.4	First Spray Application	50.8	126.7	Second Spray Application	32.2	135.7	126	Third Spray Application	57.2
J. Celathion/DDT	ULV	176.3		54.0	107.9		30.7	141.6	380		92.0
K. Sumicidin	EC	151.9		116.7	249.0		137.9	321.4	481		153.8
L. MITAC	EC	122.3		81.0	112.7		42.7	122.5	184		37.3
M. Ekalux	EC	71.9		14.6	66.1		23.4	71.5	119		21.3
N. Hostathion/DDT	ULV	159.3		50.2	93.4		29.9	121.3	186		85.6
O. Hostathion	EC	184.2		83.2	113.1		51.8	117.4	243		39.5
P. Ripcord/Azodrin	ULV	155.9		38.1	121.1		37.8	201.5	295		80.2
Q. Standard Dimethoate/DDT	EC	127.1		62.7	164.1		65.8	220.4	274		71.5

GUNEID EXTENSION TRIAL 1978-79 *Heliothis armigera* eggs/100 plants (means of 3 replicates) Table [illegible]

	TREATMENT		14-15 Oct	18 Oct	20-21 Oct	26-27 Oct	30 Oct	1-2 Nov	6-7 Nov	18-19 Nov	21 Nov	23-24 Nov
A.	Triazo/Endosulfan	EC	71.67		6.55	73.33		2.0	4.3			7.3
B.	Hostathion	EC	64.33		4.00	45.00		1.0	4.3			14.7
C.	Dursban	ULV	64.67		8.33	41.66		7.33	3.7			23.7
D.	Dursban	ULV	52.67		8.33	37.33		1.33	4.3			13.0
E.	Dimethoate/DDT	EC	60.00		8.33	38.33		4.00	5.7			12.3
F.	Standard Dimethoate/DDT	EC	70.33		4.00	33.66		0.0	5.0			2.7
G.	Dimethoate/DDT	ULV	57.67		16.33	104.00		4.33	1.3			20.7
H.	Decis	ULV	40.67		16.33	7.66		3.33	0.7			5.7
I.	Celathion/DDT	EC	68.0	First Spray Application	4.33	70.00	Second Spray Application	4.66	3.7	Results not available	Third Spray Application	15.7
J.	Celathion/DDT	ULV	90.33		14.33	76.33		5.00	5.7			13.7
K.	Sumicidin	EC	89.33		7.33	23.33		3.33	2.7			5.0
L.	MITAC	EC	76.67		6.00	51.33		1.33	10.0			11.3
M.	Ekalux	EC	23.33		6.00	33.66		2.33	1.0			9.7
N.	Hostathion/DDT	ULV	90.0		4.00	70.66		4.66	1.7			17.7
O.	Hostathion	EC	74.67		6.00	82.00		1.66	6.0			6
P.	Ripcord/Azodrin	ULV	77.67		8.66	28.33		3.00	1.7			22.7
Q.	Standard Dimethoate/DDT	EC	87.33		4.00	51.00		1.00	3.0			?

GUNEID EXTENSION TRIAL 1978-9 *Heliothis armigera* larvae/100 plants (areas of 3 replicates

	TREATMENT	14-15 Oct	18 Oct	20-21 Oct	26-27 Oct	30 Oct	1-2 Nov	6-7 Oct	18-19 Nov	21 Nov	23-24 Nov
A.	Triazo/Endosulfan EC	7.33		4.67	9.0		3.0	1.3			0.7
B.	Hostathion EC	17.67		3.67	4.0		3.33	2.3			1.3
C.	Dursban ULV	8.0		4.33	5.67		1.00	5.7			1.9
D.	Dursban ULV	12.0		5.0	8.0		4.33	5.7			2.3
E.	Dimethoate/DDT EC	13.0		8.33	12.67		2.0	2.7			1.3
F.	Standard Dimethoate/DDT EC	7.67		3.33	5.33		0	2.7			2.0
G.	Dimethoate/DDT ULV	7.33		12.67	8.67		0.67	0.7			1.7
H.	Decis ULV	2.0		3.67	0.33		0.33	1.0			0
I.	Celathion/DDT EC	8.33		2.33	1.67		1.67	2.7			0.7
J.	Celathion/DDT ULV	14.0	First Spray Application	6.33	2.00	Second Spray Application	2.67	4.3	Results not available	Third Spray Application	3.3
K.	Sumicidin EC	10.0		3.33	5.33		2.33	1.3			0
L.	MITAC EC	8.0		6.67	5.00		3.0	5.0			0.3
M.	Ekalux EC	0.33		0.33	3.33		1.0	2.3			0.7
N.	Hostathion/DDT ULV	11.33		8.33	4.00		1.67	2.0			2.6
O.	Hostathion EC	13.00		7.67	12.00		?	2.3			1.7
P.	Ripcord/Azodrin ULV	7.33		2.67	3.00		0	0.7			0.3
Q.	Standard Dimethoate/DDT EC	10.67		4.33	7.67		2.3	2.7			3.0

GUNEID EXTENSION TRIAL 1978-9 Damage to fruiting bodies % (means of 3 replicates)

TREATMENT		14-15 Oct	18 Oct	20-21 Oct	26-27 Oct	30 Oct	1-2 Nov	6-7 Nov	18-19 Nov	21 Nov	23-24 Nov
A. Triazo/Endosulfan	EC	12.0		14.3	16.7		8.0	11.0			6.3
B. Hostathion	EC	22.3		14.3	13.0		13.0	9.0			10.3
C. Dursban	ULV	12.7		18.7	16.3		8.7	16.7			10.0
D. Dursban	ULV	16.0		10.7	13.7		12.0	20.7			10.7
E. Dimethoate/DDT	EC	16.0		19.0	23.3		10.0	11.0			10.7
F. Standard Dimethoate/DDT	EC	10.0		13.0	14.7		5.0	13.7			7.0
G. Dimethoate/DDT	ULV	10.7		30.0	20.0		10.0	9.0			9.3
H. Decis	ULV	4.7	First Spray Application	11.0	4.0	Second Spray Application	2.0	7.3	Results not available	Third Spray Application	7.0
I. Celathion/DDT	EC	11.0		9.0	7.3		7.7	10.7			8.7
J. Celathion/DDT	ULV	13.7		17.0	10.7		16.3	11.7			16.7
K. Sumicidin	EC	15.3		12.0	16.0		10.0	10.0			5.7
L. MITAC	EC	10.3		20.3	14.3		5.0	18.7			8.3
M. Ekalux	EC	1.3		3.0	8.0		9.3	10.0			4.7
N. Hostathion/DDT	ULV	13.3		23.7	13.3		8.0	9.7			11.3
O. Hostathion	EC	16.7		18.3	21.7		11.7	10.0			9.3
P. Ripcord/Azodrin	ULV	16.0		14.0	15.0		5.7	9.3			4.7
Q. Standard Dimethoate/DDT	EC	15.7		19.7	17.0		10.7	13.3			14.3

SMALL SCALE TRIAL

The dose rate approved for use in Turkey against whitefly was between 600 and 1000 g a.i./ha. Thus it was suggested originally that dose rates of 1.0 l/feddan, 1.5 l/feddan and 2.0 l/feddan of the MITAC 20% e.c. be included in the small scale trials in the Sudan (i.e. 426 g a.i./ha, 714 g a.i./ha and 952 g a.i./ha). However, in the official trials in 1976 MITAC was tested at the single dose of 2.1 l/feddan (5 l/ha, 1000 g a.i./ha) in one trial and at 2.1 l/feddan and 1.68 l/feddan (800 g a.i./ha) in a second trial. The results of the second trial have not been seen by the authors. In a trial arranged by the Boots' Agent, The Atlas Trading Company Ltd., MITAC was tested at 2 l/feddan and 4 l/feddan.

In view of the possibility that even the 2.0 l/feddan might prove to be an uneconomic and/or an unnecessarily high dose rate, the authors requested the use of an area of cotton at the Gezira Research Station for a small scale trial of three dose rates, 1.0 l/feddan, 1.5 l/feddan and 2.0 l/feddan, of MITAC in comparison with a standard dimethoate treatment. Despite the lateness of the request, a one feddan area of late planted cotton, divided into quarter feddan irrigation plots, was made available for this trial. A simple sketch of the area is shown in Fig.1.

Each plot was planted with cotton at an inter-row distance of 80 cm (85 rows per plot). After thinning three plants per hill were left at an inter-hill distance of 50 cm. The plot dimensions were 15 x 70 m.

Agronomic details :

Variety	Barac
Date planted	September
Thinned	30-31 October
Ridged	1 November
Broadcast fertiliser (Urea)	2 November
Irrigated	9-12 November

Application details :

First spray on 4 November between 1630 and 1740; weather warm with light breeze.

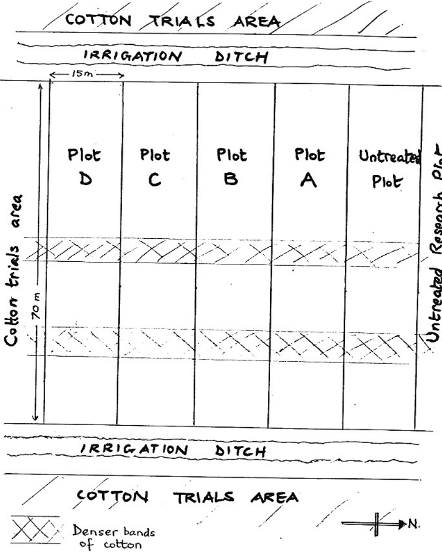
Second spray on 18 November between 1630 and 1730 weather warm with little or no wind.

Fontan motorised mist blower used with nozzle No.70, delivering approximately 80 l/ha, with operator walking between every fourth row. Minor problems occurred on both occasions during the spraying of Plot A.

Treatment details :

Plot A	MITAC 20% e.c. at 1000 g a.i./ha
Plot B	MITAC 20% e.c. at 750 g a.i./ha
Plot C	MITAC 20% e.c. at 500 g a.i./ha
Plot d	Rogor (dimethoate) 32% e.c. at 432 g a.i./ha

Fig. 1 Simple plan of small scale trials area at Gezira Research Station



The Rogor was obtained from the Gezira Research Station stock in use as the standard treatment for 1978-9.

Counting:

Counts were made of the number of whitefly adults on the underside of each of two lower leaves, one on the windward side and one on the leeward side, on 25 plants per plot. The first plant examined was in the fifth row and than a plant in every third row was examined. As far as possible leaves on vigorous plants were examined, with the checker moving in a zig-zag fashion up the central part of the plot.

Counting was at two-day intervals except when the field had been flood irrigated and thus was under water or deep mud, between 9 and 16 November. The trial was terminated on 27 November as the field was again flood irrigated. All counts were made in the early morning as later in the day the whitefly are more active and readily fly off when the leaves are touched.

Results and comments :

The results of the counts, expressed as numbers of whitefly adults per 100 leaves, are shown in Table 5. In addition to the counts on the four trial plots, the table includes counts on the untreated area immediately to the north of Plot A. The prevailing wind was from the north and re-invasion by adult whitefly from the untreated area was greatest in Plot A diminishing towards Plot D. What is clear from Table 5 is that following the first application MITAC at all three dose rates held the whitefly populations at a much lower level than did the standard Rogor. The counts following the second application show that Rogor had an effect on whitefly levels, albeit only a 35% reduction in adult numbers, but that this product did not affect the juvenile stages and the adult numbers rose within eight days to the same level as in the untreated area. MITAC had an extremely good effect on the levels with a 93% reduction in adult numbers some 38 hours after spraying in Plot C. The Plot A and Plot B levels dropped somewhat less but the reinfestation from the untreated areas could account for this. Even so MITAC clearly had a lethal effect on nymphal stages as the adult numbers remained low or declined until the trial ended. Direct observation in the field showed many dead nymphs on leaves in the MITAC plots.

Table 6 perhaps shows the effects of the MITAC treatments in comparison with the Rogor treatment even more dramatically as the whitefly adult levels expressed as % of the levels in the unsprayed area are very satisfactorily low.

One observation, that is not shown in the table and yet is of some significance, was that throughout the trial period, and in all four plots and the untreated area, higher whitefly numbers were recorded in two bands of vigorously growing and thus denser cotton which occurred between the 17th and 26th rows and the 41st and 47th rows. Although MITAC had a good control effect on the whitefly levels in these dense bands placement (penetration of dense foliage) of the chemical will have to be carefully observed in fields containing cotton of a greater maturity than that treated in this small scale trial.

SMALL PLOT TRIAL AT GEZIRA RESEARCH STATION — TABLE 5

NOS. OF WHITEFLY ADULTS/100 LEAVES

Date	Plot A	Plot B	Plot C	Plot D	Untreated
1 Nov	982	684	796	364	-
4 Nov	512	640	348	326	-
4 Nov	MITAC 2 l/fd	MITAC 1.5 l/fd	MITAC 1.0 l/fd	Rogor 0.4 lb a.i./fd	-
6 Nov	376	336	208	824	1112
8 Nov	294	702	744	1920	1672
16 Nov	848	558	576	1962	1810
18 Nov	1032	956	630	2142	2366
18 Nov	MITAC 2 l/fd	MITAC 1.5 l/fd	MITAC 1.0 l/fd	Rogor 0.4 lb a.i./fd	-
20 Nov	242	196	44	1390	2432
22 Nov	150	116	46	1536	2544
24 Nov	84	182	134	1210	2196
26 Nov	144	172	112	1724	1720

SMALL PLOT TRIAL - WHITEFLY ADULT LEVELS AS % OF UNSPRAYED LEVEL — TABLE 6

Date	Plot A	Plot B	Plot C	Plot D
4 Nov	MITAC 2 l/fd	MITAC 1.5 l/fd	MITAC 1.0 l/fd	Rogor 0.4 lb a.i./fd
6 Nov	33.8	30.2	18.7	74.1
8 Nov	17.6	42.0	44.5	114.8
16 Nov	46.9	30.8	31.8	108.4
18 Nov	43.6	40.4	26.6	90.5
18 Nov	MITAC 2 l/fd	MITAC 1.5 l/fd	MITAC 1.0 l/fd	Rogor 0.4 lb a.i./fd
20 Nov	10.0	8.1	1.8	57.2
22 Nov	5.9	4.6	1.8	60.4
24 Nov	3.8	8.3	6.1	55.1
26 Nov	8.4	10.0	6.5	100.2

ULTRA LOW VOLUME APPLICATION TRIAL

The reduction of overall area of cotton available for the official large scale trial meant that there was an excess of some 800 l of MITAC which was not required for the official trial. Following a chance meeting with Mr. R. Hood, the Technical Manager for Shell (East Africa) Ltd., and the expression of his company's interest in MITAC for whitefly control, contact was made with Mr. John Preston, Manager of the Shell Contract Spraying project based at Hassa Heisa. It transpired that Shell were having problems in controlling whitefly in their project area owing to a diminished effect of monocrotophos (Azodrin) against the pest. Thus, purely on an informal and ad hoc basis, the 800 l of MITAC was supplied to Mr. Preston for application by the ULV method at a dose rate of 4 l/ha. Mr. Preston is closely monitoring whitefly levels with a single 90 feddan field and will make at least three successive applications of MITAC (the first was on 9 November and the second on 23 November). He will inform Boots' of the results as soon as possible but his first impressions were favourable.

CONCLUSIONS AND RECOMMENDATIONS

The Sudanese cotton growing industry currently is facing a near crisis situation in which the established insecticides no longer give adequate control of the major pest, whitefly. Dimethoate, monocrotophos and Anthio* have all lost their effectiveness and the contract spraying companies, Ciba-Geigy, Rhône-Poulenc and Shell are all either rumoured as, or openly admit to, being in difficulties. The synthetic pyrethroids, of such promise in recent years, while typically highly effective against bollworms, have no effect on whitefly. Indeed they probably exacerbate the whitefly problem by killing the major predatory species, chalcids, whose decimation originally led to whitefly becoming a problem.

Of the new products, Hostathion EC and Dursban ULV formulations were approved for 1978 use but probably only the former is of real importance for whitefly control. In the large scale trials this season, at the time of this report, Hostathion EC was performing well but not a Hostathion/DDT ULV formulation. The Dursban ULV was doing badly. A product of major promise is Ekalux EC and this is performing well in its second year of large scale trials. A reliable report (from the local Sandoz agent) was that Shell are applying Ekalux on a single 90 feddan field, presumably under the same ad hoc arrangement as the MITAC trial. Triazo/Endosulfan EC also was giving good whitefly control in the large scale trial but no information on this product has been obtained.

All in all MITAC is in a situation of good promise. We are one year behind our competitors, unfortunately, and this may be compounded by the relatively high dose rate of 2.0 l/feddan that is under test. The results of the small scale trial carried out by the authors indicated that lower dose rates should be feasible with ultimate development of a treatment programme using dosages selected to suit the density of the foliage and the level of pests. The advice from Prof. O. I. Gameel, the Head of the A.R.C. Entomology Section and responsible for the trials procedure, is to include MITAC in the 1979-80 large scale trial for the second compulsory year of testing and this all being well should at least make MITAC eligible for registration. MITAC at a range of dose rates should be put forward for inclusion in the 1979-80 small scale trials both for EC and ULV application. The optimum dose rate can then be entered for the 1980-81 large scale trials for testing at two sites and this, if successful, would lead to registration for the dose rate and EC and ULV usage.

While the official procedures have to be followed, however slow and poorly run they may be, the opportunity must be taken for our own company trials to satisfactorily establish the best dosages, application techniques and timing strategy. These trials can be conducted in two ways: Firstly, cotton plots can be requested at the Gezira Research Station and small scale trials laid down. This presents no major problems other than the obvious ones of staffing but small scale ground application is really of limited value in a country where all insecticide application to cotton is by aerial spraying.

*formothion

Secondly, agreement can be reached with a contract spraying company to include MITAC in its scheme with a member of Boots' staff responsible for the management of the MITAC fields. This would have to be on a fairly informal basis as, strictly speaking, contract spraying companies are not supposed to utilise products other than those with official approval. However, one of the key factors in operating a contract spraying project is the capacity to utilise products which are under development or, if approved, at dosages etc. which are not officially recognised. Of the three companies operating such a project at present only Shell seems likely to be party to the development of MITAC. Rhône-Poulenc are already involved with Hoechst in the development of Decis and Hostathion. Ciba-Geigy are a law unto themselves and their vast organisation, some 70 expatriate staff this season, seems likely to swallow up a single Boots' staff member.

Thus, to summarise our recommendations:

1. The senior author should return to the Sudan in late-February or early March 1979 to finalise arrangements for the 1979-80 season.

2. By that time, the absolute latest for logistic reasons, decisions will have to have been made on; (a) the inclusion of MITAC at 2.0 l/feddan EC in the 1979-80 official large scale trial; (b) the inclusion of MITAC in the 1979-80 official small scale trials for testing at a range of doses both by EC and ULV application; (c) whether we carry out our own small scale trials in parallel to the official small scale trials or we place a staff member to work with a contract spraying company, probably Shell, in order to evaluate MITAC dosages and strategies utilising aerial application.

NOTES ON LOGISTICS

1. A Boots staff member will be required for the evaluation throughout the 1979-80 season, September-March (or two staff members on a split season basis). If we carry out our own small scale trials then two staff members will be necessary at all times.

2. Decent transport must be provided and the provision of a new Land Rover is most strongly urged. Distances are great and road conditions often appalling. Company prestige is also an important factor. Assuming further large scale trials are entered into in 1980-81, at least two seasons use will be got from the vehicle and re-sale of expatriate owned and driven vehicles is usually easy and an excellent price can be obtained.

3. If our staff members are carrying out independent trials then consideration should be given to renting a house for the season. This is fairly standard company practice and provides an element of privacy and comfort that the rather poor Sudanese hotels cannot supply. In the case of an agreement with a spraying company then accommodation probably would be available with them.

4. MITAC requirements will be, as in 1978-9, 6000 l for the large scale official trial. For official small scale trials 50 l will be more than sufficient.

If private aerial application is agreed to then discussions to date indicate 6 x 90 feddan fields at say 4 l/ha (1.68 l/fd) and 8 applications thus requiring 8000 l of MITAC. Total MITAC requirement, bfn 8051, (assuming private large scale trials) <u>14000 l</u>.

NOTES FOR CLARIFICATION

1. The Atlas Trading Company Ltd., in the person of Mr. I. M. Gabr el Dar, while competent at the multifarious tasks that smooth the passage of the trials and registration procedures does not, in our opinion, have an adequate technical knowledge to cope with the actual development work. There should be no expectation, therefore, of Mr. Gabr el Dar playing a competent role in the actual evaluation work.

2. It should be realised that even if the 1979-80 large scale trial of MITAC is successful then registration will not be before November 1980 (when the Pests & Diseases Committee have their annual registrations meeting). Entry into the tender for the limited purchase to treat up to 15000 feddans would then be in February 1981. However, again the advantage of the association with a contract spraying company is the opportunity to continue development and for the proper management of the 15000 feddan quantity in 1981-82.

3. The official small scale trials, of different dose rates and EC and ULV applications, while essential, are unlikely to yield any useful data for our development purposes. The management of all the official trials is notoriously inefficient and no provision can be made for unusual procedures, timing etc. The small scale trials in fact rarely lead to rejection of any product unless it is totally unsuitable or phytotoxic.

4. A meeting was held on 20 November, between Mr. D. Leate (Agricultural Manager, Shell, Sudan), Mr. J. Preston (Shell Project Manager), Mr. P. Coutts and one other (Shell, U.K.) and Messrs. A. Gibbins, B. Taylor and J. P. Burgess of Boots, at Hassa Heisa to discuss a potential arrangement for 1979-80. While we were given courteous attention a decision will have to await the results of Mr. Preston's applications of MITAC. However, Shell (E. Africa) clearly have the autonomy to decide on such an arrangement and assuming Boots' agreement Mr. Gibbins should be able to process matters directly in Nairobi.

Senior Author: B. Taylor
B.Tech, Ph.D, M.I.Biol., F.R.E.S.

APPENDIX 1

Temperature and Relative Humidity records during visit period

	Temp. °C		RH%			Temp °C		RH%	
Date	Max	Min	Max	Min	Date	Max	Min	Max	Min
18 Oct.	40.7	23.0	72	19	7 Nov.	34.9	19.3	44	21
19	40.5	23.6	56	15	8	35.1	17.2	49	17
20	39.3	21.3	67	12	9	34.7	17.2	43	16
21	39.0	21.4	68	25	10	34.5	15.1	46	17
22	40.7	20.2	65	21	11	32.8	14.0	49	16
23	38.5	23.0	68	28	12	31.7	13.8	52	17
24	38.5	22.2	77	27	13	31.5	12.4	50	14
25	39.9	23.5	69	23	14	32.8	12.7	53	16
26	39.3	24.2	40	18	15	34.0	13.9	50	18
27	38.6	19.6	59	23	16	32.9	13.8	48	16
28	40.2	24.1	59	21	17	31.8	12.8	51	14
29	39.5	24.7	56	25	18	32.4	11.8	53	16
30	38.0	20.8	56	22	19	34.6	13.2	51	18
31	37.8	24.3	47	27	20	35.0	14.0	58	21
I Nov.	38.3	20.0	60	30	21	34.7	15.2	51	19
2	37.8	22.7	59	19	22	34.2	14.0	47	21
3	38.2	22.8	49	20	23	33.7	13.8	57	19
4	34.9	24.0	45	21	24	33.5	13.7	54	22
5	?	19.3	56	29	25	34.3	15.5	55	26
6	34.9	?	43	22	26	34.0	14.3	46	26

(a) Records kindly supplied by the Meteorological Station, Gezira Research Station, Wad Medani.

(b) Temperature recordings are for screened thermometers.
The maximum recorded 40.7°C = 105.3°F
and the minimum recorded 11.8°C = 53.2°F

(c) The maximum humidity was usually at around 0300 h and the minimum at around 1500 h.

(d) Temperatures during October are probably the highest normally encountered during the cotton season.

APPENDIX 2

COTTON GROWING IN THE SUDAN

Cotton is the major export crop of the Sudan and the mainstay of the Sudanese economy. In 1977-8 a total of over 450,000 hectares of cotton were planted. The majority of cotton planted is of the highest quality long staple Gossypium barbadense, although planting of the medium staple upland cotton G. hirsutum has become necessary in areas with severe Fusarium wilt problems. Yields have been relatively high by African standards, in excess of 4 kantars/feddan (1480 kg/ha) in the fifties and sixties, but in recent years changes in farm practice and pest infestation have led to reduced yields for example 2.73 kantars/feddan (1010 kg/ha) in 1975-6 and 3.65 kantars/feddan (1350 kg/ha) in 1976-7. The problem has been compounded by the need to increase the number of insecticide sprays and thus a rise in production costs has occurred at the same time as a drop in yield.

In 1977-78 the area under cotton was 325,000 ha in the gravity-irrigation schemes, 85,000 ha in rain-fed regions and 44,500 ha in the flush-irrigation schemes. The long-staple cotton varieties Barakat, Huda and V.S.(A) were grown in the gravity-irrigation schemes; the medium staple Barac variety in gravity- and flush-irrigation schemes; and the medium staple Albar and Acrain varieties in rain-fed plantations.

Pre-planting urea fertiliser is applied to the field in June. Sowing then takes place in July/August. Timing is critical for sowing as earlier the seedlings can be subjected to attack by flea beatles, Podagrica puncticollis Weise and P. pallida Jacoby, and thrips, Caliothrips fumipennis Bagn and Cam and C. sudanensis Bagn and Cam. Later sowing exposes the crop to attack by the pink bollworm Pectinophora gossypiella (Sound). Thinning out of seedlings to three plants per hole or hill takes place in September and may be followed by more urea fertiliser. Irrigation where necessary takes place every 14 days or so.

Weeding is essential in the period 4-6 weeks after sowing if significant crop losses are not to occur. This is usually by hand although rising labour costs are leading to an adoption of herbicides, especially in the larger schemes. The major weeds, which can easily overwhelm the newly emergent crop, are perennials such as Cynodon dactylon. Cyperus rotundus and Ischaemum afrum. Unweeded cotton gives a yield 60-90% down on a clean crop and a delay of six weeks after sowing will give a yield loss of 35-40%.

Picking by hand starts in December and continues to the end of March depending on the variety. The season for long staple varieties is about 240 days and for medium and short staple varieties is about 180 days. A crop-free period is compulsory from the end of May to mid-July and alternative host (for pests) cultivation is prohibited until mid-September. Cotton is grown in a rotation system of which the cotton-wheat-ground nuts/sorghum-fallow programme utilised in the Gezira scheme is a typical example.

The Gezira scheme is worthy of special comment as it claims to be the largest single farm in the world with some 800,000 ha under the management of the Sudan Gezira Board. Crops in the Gezira are tenant crops with the exception of cotton and the Board is responsible only for technical supervision, especially of the irrigation scheme and its enormous network of canals, and the implementation of crop rotation. Each tenant is allocated 16.5 ha of which one quarter is planted with cotton. Nearly all fields are 90 feddan rectangular blocks sub-divided by irrigation ridges into 5 feddan plots, each of which is managed by a single tenant. In a cotton plot the tenant has to perform the manual tasks, primarily weeding, thinning out, fertiliser broadcasting and cotton picking. Ploughing and ridging is done by tractor; irrigation by centrally managed labourers; and pest control by the Gezira Board staff.

COTTON DISEASE PROBLEMS

The major disease of economic importance that affect cotton in the Sudan are bacterial blight, leaf curl virus and wilt.

1. Bacterial blight of cotton is caused by the bacterium, Xanthomonas malvacearum (E.F.Smith) Dowson. It was first reported in the Sudan in 1922. A number of different manifestations of the disease occurs; angular leaf spot, veinal blight, blackarm (of stems), bract spot and boll rot. The bacterium is usually seed-borne and causes primary infections in seedlings from which secondary infection spreads by rain storms. Further development of the disease is favoured by warm humid conditions. Control of the diseases is effected by the following measures:

   (a) Clean-up campaign; post-harvest to pull up cotton stalks, sweep and burn debris. This tends to be an ineffective process and unauthorised storage of cotton stalks for domestic fuel can be a problem.

   (b) Resistant varieties; plant breeding work has done much to improve the resistance of long staple varieties to bacterial blight and for some years the disease was no more than a minor problem. However, in 1973 a new race pathogenic to the widely used Barakat variety was detected and this has been spreading gradually since then.

   (c) Seed dressings; many types of seed dressing have been tested and organo-mercurials have been in use for many years. Currently Agrosan 5W/30% Heptachlor is the standard product, although in view of the widely reported long term hazards of mercury toxicity a number of non-mercurial compounds have been tried in the past few years. Bronopol mixtures have shown good promise and this will be commented on elsewhere in this report (Appendix 4).

2. Leaf curl virus is a whitefly-borne disease of cotton which was first observed in the Sudan in 1923. With the increase in cultivation of cotton the disease became widespread with heavy losses. Two manifestations of the disease, small vein thickening and main vein thickening, occur and these are thought to indicate two viruses or two strains of one virus. The disease is carried over from season to season in cotton ratoons, out of season cultivation of okra and other alternate hosts. At the present time control is effected primarily by the planting of resistant varieties but it is speculated that it may not be long before a mutation of the virus or some other factor leads to a resurgence of the disease.

3. Cotton wilt is caused by the fungus Fusarium oxysporum f. vasinfestum (Snyd and Hans) and can be confused with physiological wilt. However, fusarium wilt is always associated with vein clearing and mosaic-like symptons of leaves with the disease progressing from the lowest leaves upwards. Control is effected in various ways:

   (a) Crop rotation. This is probably the most important factor in reducing fusarium wilt but the present policy of intensification and reduction in fallow may lead to a build-up in the disease level.

   (b) Soil treatment. The fungicides Granosan and Lansatan were tested some years ago but gave only slight control and the economics of their use have been questioned.

   (c) Resistant varieties. Work is continuing to identify resistant varieties of the commercially grown barbadense cottons and to quantify the effect of nematodes, e.g. Pratylenchus, which are precursors to infection. Acala and other upland varieties are resistant to the disease but their use as alternative plantings to barbadense varieties is undesirable.

COTTON PEST PROBLEMS

In the 1950's cotton in the Gezira received a single annual application of DDT in mid-October to control jassids, Empoasca lybica de Berg. However, this application led to a rapid build-up of cotton whitefly populations, Bemisia tabaci (Genn); probably as a result of the elimination of natural enemies and the removal of competition by jassids. By the early 1960's, Bemisia had become so severe that the frequency of insecticide applications had to be stepped up and alternative insecticides sought out. Endrin , dimethoate, endosulfan and carbaryl came into use and, with the increase in applications, aerial spraying became common. This increase in insecticide use led to further problems and, around 1965, 4 to 5 chemical treatments were applied during the season. The American bollworm, Heliothis armigera (Hbn), previously regarded as a minor pest, assumed importance as, in some areas, did the spiny bollworm, Earias insulana (Boissed). Bemisia infestation, initially an early season problem ceasing by late November, continued into January and February with stickiness of the cotton lint, caused by the honey-dew excretion of the whitefly nymphs, reducing quality and causing complaints by the ginners. This was alleviated by two late sprays of dimethoate or monocrotophos; thus raising the number of sprays to 6 or 7. In some areas, such as the Suki scheme, spray applications have increased now to up to 14 mainly against Bemisia.

In the Gezira alone in 1976-77 seven million Sudanese pounds worth of insecticides, 24% of the total cotton production cost and about Sud. £16.482/feddan for 6-7 sprays, were used. The cost of whitefly control exceeds the combined cost of jassid and American bollworm and amounts to some 70% of the expenditure.

Jassid infestations are the first of the season with an onset in early August reaching an economic threshold of 200 nymphs/100 cotton leaves in early September. The American bollworm invades (some 93% originating from sources other than cotton) at the time of flower bud set in early September and rapidly reaches the economic threshold of 10 eggs or larvae/100 plants. Whitefly appears as early as jassids or American bollworm but its build-up is more gradual and the threshold of 200 adults/100 leaves may not be reached until mid-November. The spiny bollworm appears in some areas usually from November onwards and several sprays may be required to keep the pest level below 10 eggs or larvae/100 plants. Other late season pests but only in pockets of infestation are the Egyptian leafworm, Spodoptera littoralis (Boised) and the Sudan bollworm, Diparopsis watersi (Roth).

Finally, at the end of the season contamination of the cotton lint can take place because of honey-dew excreted by aphids, Aphis gossypinm (Glover) which feed on new growth. An economic level of 15-20 infested plants/100 plants is taken as the norm for the use of aphicides.

Whitefly, Bemisia tabaci

The cotton whitefly, which can cause serious crop losses in areas with high temperatures and low humidity such as the Sudan, causes debilitation of the cotton plant by both the motile adults and the more or less sessile nymphs sucking sap from the phloem of the leaf veins. The honey-dew excreted as a result of feeding can form a sticky layer on all parts of the plant. If this stickiness is unchecked it can cause a serious drop of lint quality because of resultant problems in ginning and spinning.

Prior to the first use of insecticides to control jassids in the mid 1950's whitefly was a pest only when it transmitted cotton leaf curl virus. This disease, however, had been countered by the selection of resistant varieties of cotton. The use of DDT for jassid control is believed now to have caused severe mortality of the insect predators, notably chalcid wasps (Eretmocerus and Encarsia), and predatory mites. Insecticides such as dimethoate, endrin, endosulfan and carbaryl initially gave good control but over the years whitefly populations have steadily increased and the number of applications of insecticide has also increased until today 6 or 7 applications per season are routine and as many as 14 are necessary in some areas. The whitefly which used to be an early season pest is now present almost throughout the season with as many as seven generations per season. Apart from the recommendation of an economic threshold of 200 adults/100 leaves (for which no published basis seems to be available) to date no alternative pest strategy has been suggested despite a fair amount of research work. It is estimated that 70% of all insecticide consumption is aimed at whitefly control and with the drop in performance of the older insecticides there is an urgent need for new products.

The American bollworm, Heliothis armigera (Hbn) first appeared as a pest in Sudan cotton in 1963 possibly because of the destruction of its natural enemies by parathion used for jassid and whitefly control. It has many alternative hosts, such as maize, dolichos beans and chickpea, and the first appearance on cotton in early September, when the flower buds or squares first set, is the result of migration from these hosts. There can be 2-3 complete generations of H. armigera in a season. The eggs hatch within 2-8 days, followed by five instars in 15-32 days and a pupal stage of around 15 days. In a hot climate the complete cycle can take no more than a month to complete. The very voracious larvae attack both squares and bolls at all stages of development and thus an economic level of 5-10 eggs and/or larvae per 100 plants is very critical.

COTTON PEST MANAGEMENT IN THE SUDAN GEZIRA

Aerial spraying of chemicals in the Gezira is accomplished in two ways :

1. The Sudan Gezira Board purchases chemicals by means of a tender system and these are then applied by aerial spraying companies or organisations. Both conventional (E.C.) and ULV applications are utilised. In 1978 the following spraying programme was adopted as the standard for the Gezira :

   Spray 1 (after first onset of pests) DDT + dimethoate

   Spray 2 Torbidan (toxaphene - DDT - methyl parathion)

   Spray 3 DDT + dimethoate

   Spray 4 Thimul + dimethoate or monocrotophos (Azodrin)

   Spray 5 Thimul + dimethoate or monocrotophos

   Spray 6 dimethoate or carbaryl (Sevin) + Anthio

   Spray 7 dimethoate or carbaryl + Anthio

   Four organisations; The Sudan Crop Protection Service (national but Ciba-Geigy managed?); Farmair (British); Pesetel (Polish); and a Bulgarian company; are engaged in the spraying in 1978-9.

2. The Sudan Gezira Board in recent years has adopted a system of pest management contracts whereby agrochemical companies have contracted to undertake spraying of the crop without a strict specification as to the chemical used or the number of sprays required. The chemicals used, however, do have to be from among those approved by the Pest and Diseases Committee. The contract requires the company to meet with a given crop yield as determined by the following formula :

$$\frac{T}{\bar{T}} = \frac{A}{\bar{A}} \quad \text{where}$$

T = Average yield of the area treated by the company in the season in question.

$\bar{T}$ = 10 years average yield of the same area treated by the company.

A = Average yield of the Gezira in the season in question.

$\bar{A}$ = 10 years average yield of the Gezira.

During 1978 some 25% of the total cotton area will be sprayed under this form of contract, or package deal. By far the biggest operator is Ciba-Geigy who have contracted for 185,000 feddans in the Gezira plus 10,000 feddans in the Rahad Scheme and 20,000 feddans in the Suki Scheme (a total of over 90,000 ha). Some 30 aircraft are used in this operation and 70 expatriate staff are involved.

Rhône-Poulenc, in their first season of the package deal, are spraying some 12,000 feddans in the Gezira, 10,000 feddans in Rahad and 10,000 feddans in Suki (a total of over 13,000 ha). Seven aircraft are being used. The third company operating this season are Shell, who regard it as a pilot year and have contracted for 15,000 feddans (6,300 ha) in the Gezira. Three aircraft are being used.

One advantage of the package deal, and a major factor to Shell and Rhône-Poulenc, is that it offers the opportunity to do development work. Although the chemicals used are supposed to be only those on the approved list in practice newer products are being used.

APPENDIX 3

AGRICULTURE IN THE SUDAN*

The Sudan is the largest country in Africa with an area of 2,500,000 km^2. The economy is based almost entirely on agriculture with some 7,140,000 ha (17 million feddans) under cultivation. This area represents some 3.3% of the total area and 9.3% of the cultivable land. The continuous expansion of the cultivable area, both in rain-fed and irrigated zones, faces serious labour shortages for many operations including the control of weeds.

The country can be divided into 3 major geographical areas:

(a) Northern Sudan

From the Egyptian border south to Khartoum.
This area has 200 mm of rain a year all falling in a single three month period. The average relative humidity is <40% and the mean temperature 29 °C. This area is of little agricultural importance.

(b) Central Sudan

From Khartoum southwards to latitude 9°N, 675 km.
The annual rainfall increases from 200 mm in the north to 900 mm in the south. In the wet season the daily mean RH is 75% but in the middle of the seven month dry season this drops to <30%. The annual mean temperature is 28°C.

The area includes the vast irrigated schemes, such as the Gezira, controlled by state organisations like the Sudan Gezira Board, the Agricultural Production Corporation, the Mechanised Farming Corporation and the Rahad Agricultural Corporation. The so-called organised sector is the main producer of Sudanese cotton, nearly all the wheat and 50% of both sesame and groundnuts. As much as 80% of the total agricultural produce of the Sudan comes from this sector. A semi-organised sector run on a private ownership and co-operative bases covers about 500,000 feddans most of which are under horticultural crops.

(c) Southern Sudan

From latitude 9°N to the border with Uganda, Kenya and Zaire. The annual rainfall increases from 900 mm in the north to 1500 mm in the far southwest. The mean annual RH is 70% and the mean temperature 27°C. The 4 million population is mostly involved in traditional agriculture on about 567,000 feddans but under a development plan the area and the use of mechanisation are planned to increase the area to 1,263,000 feddans by 1982/3. The major traditional crop is cassava but the expansion plan mainly concerns sorghum which is planned to occupy an area of over 1 million feddans.

*Based largely on papers presented to a Symposium on Crop Pest Management, Sudan. February 1978.

CROPS OTHER THAN COTTON

(i) Cereals These currently cover about 10 million feddans with yields as follows in tonnes.

	Sorghum (dura)	Millets (Dukhn)	Wheat
1975/6	2,025,000	403,145	264,310
1976/7	1,774,000	467,800	301,000
1977/8	1,773,000	503,500	373,000
Feddans in 1975/6	6,374,000	2,513,000	714,000

Several pests can be serious, e.g. stem-borers, midges, grasshoppers, aphids and pentatomid bugs, and smuts can cause problems. At present wheat is the only crop other than cotton to be sprayed with insecticide and one or two applications per season may be applied to control Schizaphis graminum. In the Southern region the weaver birds, Quelea quelea, can cause major economic losses, as can the armyworm, Spodoptera exempta. Serious losses are caused by the depredations of various species of rat.

(ii) Sesame is currently grown in over 2 million feddans but no research is underway on pests and diseases. The average yield is around 1,000 kg/feddan.

(iii) Groundnuts are grown in over 2 million feddans but, although several important pests are known, there is currently no research or pest control work. Yields average up to 900 kg/feddan with recent totals of 930,000 tonnes in 1975/6; 704,900 in 1976/7; and 918,500 in 1977/8.

(iv) Sugar-cane is at present grown in a limited area but schemes to increase production are underway. The crop suffers from termites, stemborers and smut diseases. 42,000 feddans were under sugar cane in 1975/6.

(v) Miscellaneous The following crop areas were recorded in 1975/6:

Maize 212,000 feddans; Fasulia 12,000 feddans

Chickpeas 7,000 feddans; Castor 46,000 feddans

Rice 17,000 feddans (increasing currently to 40,000 feddans in two organised schemes in the Southern region)

Onions 11,000 feddans; Ful Masri 36,000 feddans

Coffee 85,000 feddans and Tea 15,000 feddans

Other unquantified areas are under smallholder horticultural crops such as eggplant, okra, potatoes, tomatoes, water melon etc.

For all these crops further research into pests and diseases is required.

WEED PROBLEMS IN THE SUDAN

(a) Aquatic weeds

With the vast irrigation schemes and their concomitant canal systems from the two great rivers, the Blue Nile and the White Nile, the problem of aquatic weeds is a very serious one for the Sudan. About 1600 km of the White Nile above Jebel Aulia Dam, near Khartoum, are seriously infested with water hyacinth, Eichornia crassipes (Mart.) Solms. Still further to the south hundreds of kilometers of tributaries are also infected. Fortunately, at present the Blue Nile is believed to be free of this weed but an infestation could quickly spread to the network of canals fed from the Blue Nile, such as in the Gezira Scheme, and bring economic disaster to the country. Several species of submerged and semi-aquatic weeds already cause problems in the canals both by excessive water loss from transpiration and blockages in pumps etc. The weeds mats also harbour insects and snails which are vectors of human and animal diseases. Currently the Sudan spends close to £1 million annually on water hyacinth control mostly on application of the amine salt 2,4-D at about 4.5 kg a.i./ha; by spray launches in the flood season and, in the dry season, when conditions improve by aerial spraying.

(b) Terrestrial weeds

With the intensification of agriculture and the increase in the number of irrigated schemes, the problem of terrestrial weeds has become a major problem. Perennial weeds, e.g. Cynodon dactylon, Cyperus rotundus and Ischaemum afrum are causing particular concern. Severe crop losses usually occur if weeding is neglected or delayed; for example, unweeded cotton, sorghum and ground-nuts give 60-90% less yield than a clean-weeded crop. The critical weeding time for most crops is 4-6 weeks after germination but with a shortage of labour handweeding has become expensive and practically impossible in the large schemes.

To some extent mechanical control by discing is practical for Ischaemum, Sorghum spp. and some annual weeds but this is not possible in all crops. Other problems are encountered such as the parasitic weed Striga hermonthica which affects graminaceous crops, such as sorghum, maize, rice, sugar cane and millet, and is of particular importance in the Central Rainlands. A number of weeds are hosts for various pests and diseases, such as Levillula taurica (Lev) Arn (powdery mildew) which infects a wide range of crops. The smut, leafspot and rust fungi of sorghum have weed hosts among grasses related to sorghum. Rhyncosia memnonia (Del.) Cooke which is a dominant weed in most schemes is an alternate host for Xanthomonas phaseoli (Smith) Dowson which infects haricot bean, soya bean and bonavist bean. Nematode root-knot (Meloidogyne javanica) is associated with four common weed species thus negating some of the value of the fallow rotation for nematode control. Finally, a number of weeds are alternative hosts for a range of insect pests. For example, over 50 weed species are alternative hosts of Bemisia tabaci.

Weed control in all the irrigation schemes is still primarily by hand by the tenant farmers but many factors can combine to reduce the efficiency of handweeding and hired labour is in scarce supply during critical periods. Attention is thus being given to mechanical and chemical control of weeds but at present there are only three weed control specialists in the Agricultural Research Corporation and research is thus very limited.

In cotton, herbicide use on a commercial scale has started with examples of compounds in use being; Trifluralin as part of seed-bed preparation; pre-emergence treatment with oxadiazon, oxadiazon + diuron, penoxalin, nitrofen or norflurazon gave satisfactory control of annual grass weeds and some control of broadleaved weeds. Fluometuron applied pre-emergence gave good control of broadleaved weeds and mixtures of this compound with oxadiazon, penoxalin or nitrofen gave good control of both grasses and broadleaved weeds. More potent compounds under test include pre-emergence RP 20630 and EL 171.

Groundnuts benefited from use of benfluralin as a pre-planting treatment mainly for control of annual grasses. This is recommended in the Gezira as the crop is tolerant and residues are negligible. Oxadiazon, nitrofen, oxadiazon + prometryne and RP20630 also look promising.

Sorghum is very sensitive to weed competition during early development particularly where moisture is a limiting factor. Pre-emergence applications of atrazine and Sorgoprim have given adequate control of broadleaved weeds and some control of annual grasses. Propachlor + atrazine as a tank-mix has been found of preliminary promise. Post-emergence control of broadleaved weeds has been good with atrazine, 2,4-D and MCPA.

For sugar-cane pre-emergence applications of ametryne, chlorbromuron and diuron have been recommended, as has post-emergence use of Gramuron.

Specific weed measures include; cultivation to a depth of over 15 cm at the end of the rainy season for Cynodon dactylon as this dessicates the rhizomes; during the rainy season or following irrigation dalapon (2 applications of 3.0 kg/fd) or glyphosate (1 application at 1.0 kg/fd) are effective against C. dactylon; cutting through the tubers of Cyperus rotundus, for instance by horizontal blades 25-30 cm below the soil surface, leads to desiccation in the dry season.

0 km 20 40 60 80 100
SUDAN
Omdurman
Khartoum
(Al Khartum)
Abu Se'id
Umm Dawm
Abū Zullayq
KURDOFÁN
Khazzān Jabal
al Awliyā'
Al Lubeik
Wad Rāwah
Harāzah
Al Qurra'a
'Abd al Ghanī
Kasambar
Kamlin
Sharq
Abū Shām
Hammurab
Abū Qūtah
Al Quṭaynah
Artimeili
Sayyāl
Dakhākhīn
Guneid
Rufa'a
Shatawī
Aṭ Ṭulayb
Al 'Uqdah
Blue Nile
Rahad
Al 'Azāzī
AL
JAZIRAH
(Gezira)
Wad Medani
Arkez
Nile
Ad Dubasi
Shudaydah
Kudaybāt
Ad Duwaym
Umm Sunayṭah
Ḥājj 'Abd Allāh