THE REPUBLIC OF THE SUDAN
THE SUDAN GEZIRA BOARD
AND
KREDITANSTALT FUR WIEDERAUFBAU

Monitoring the Agricultural Inputs Programme 1985 - 1986

The Main Report
April 1986

HUNTING TECHNICAL SERVICES LIMITED
ENGLAND
in association with
TROPICAL DEVELOPMENT AND
RESEARCH INSTITUTE
ENGLAND

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Consultants in Agricultural Development

Our ref: Sudan/MAI 5/HP/MS 29th April 1986

The Director General,
Gezira Cotton Production Board,
P.O. Box 884,
Khartoum,
Sudan.

Dear Sir,

Monitoring Agricultural Input Programme 1985-86

In accordance with our contract with yourselves and Kreditanstalt für Weideraufbau (KfW) dated 2nd July 1985, we have pleasure in submitting our final report on the project. The report comprises two volumes:

Vol. I Main Report

Vol. II Technical Annexures

A separate Addendum dealing with environmental pollution aspects will be presented in June when all laboratory analyses are completed and available.

The report has been printed in 35 copies. Of these seventeen (17) have been sent to SGB Barakat for retention and local distribution in Sudan; three (3) copies have been despatched to KfW in Frankfurt; and fifteen (15) copies have been retained here or are being distributed according to your instructions.

We should like to express our appreciation for the assistance so willingly given by the staff of the Gezira Board, the other Agricultural Corporations and the other organisations who collaborated on the project. We trust we have the opportunity of renewing our associations in the future.

Yours faithfully,
HUNTING TECHNICAL SERVICES LIMITED

H. Piper
Director

Monitoring the Agricultural Inputs Programme 1985 - 1986

The Main Report

April 1986

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CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Feddan (fd)	-	4,200 m² (0.42 ha) or 1.038 acres
Hawasha (= hosha)	-	A traditional unit of 10 feddans, part of a field. Term now equates with a tenant holding, usually 5 fd.
Number	-	In SGB usually 80 - 90 feddans and comprising 8 or 9 hosha, but may be smaller. It is an irrigation unit from a canal. Referred to, for example, as Number 8 Barakat Canal W = 8th number from beginning of Darwish Canal feeding from it on W. side. Part of a block.
Block	-	An administrative agricultural unit - part of a group = 5,000 fd.
Group	-	Unit reporting direct to HQ (but in case of SGB spraying may be part of a Spray Unit) = 35 - 40,000 fd.
Scheme	-	Used on White and Blue Niles as unit, plantation, farm, roughly equivalent of a block.
Kantar (K)	-	141.5 kg (approx. 143 kg) = 312 lbs (approx. 315 lbs).
Bale	-	Cotton-lint pack. In Sudan 400 lbs approx.

SUMMARY

The use of agricultural inputs by the irrigated cotton producing corporations of Sudan in 1985/86 mainly financed by the West German government through Kreditanstalt fur Wiederaufbau, was monitored by consultants. The aim of the project was to attain effective and efficient use of inputs, mainly insecticides with the minimum of hazard to operators, farmers, the general public and the environment.

Supply, delivery and storage of products was reviewed. Their ground and aerial application was monitored, with particular attention being paid to hazards from the use of Temik applied mechanically to the soil. The impact of staffing and transport on use of the inputs was assessed and the degree of hazard to all categories of personnel involved was monitored through season-long blood cholinesterase determinations using the Lovibond field kit. Spray decisions through pest scouting were assessed and the scouting system and recommended action thresholds were reviewed. Some of the factors influencing the economics of the present pest control strategy and systems were analysed.

The impact of pesticide useage on non-target organisms and the environment was assessed as far as was possible through determination of insecticide drift downwind by soil, water and foodstuff residue analyses and assessment of effect on beneficial insects and on fish in canals.

Problems in the financing and tendering procedures resulting in holdups and delayed delivery are identified. The SGB tender document was revised. Recommendations on 16 different points are made (Section 2.5.10), which include advancing committee meetings, extending tendering periods, removal of taxes, simplification of documentation and insurance procedures and establishment of exchange rates. A major recommendation is that tenders be called on a C and F Site Warehouse basis, in Sudanese pounds, reducing bureaucratic involvement to the minimum necessary, such as import licencing and finance allocation by reversal to traditional commercial practices. Engagement of a Consultant to resolve the procedural problems is also suggested.

With constraints imposed on an airspray pest control strategy by the preferred habitat of whitefly (the lower part of the cotton crop) and the inherant resistance of the nymphal stage to insecticides, the pest control programme was successful. The limitations of these constraints means that aerial application must be considered, and is shown to be, unsuited for whitefly control. Poor cultural practises are seen to increase crop protection problems.

Factors affecting airsprayed pesticide application and performance were reviewed. Meteorological data was accumulated for the project areas and a simplified method of determining climatic limitation of air spraying through an Evaporative Index related to desired droplet sizes is demonstrated for both ULV and CLV application. This is in turn related to calibration of aircraft spray equipment and recommendations are given whereby operators would be required to set up aircraft equipment to give specified droplet VMDs and to spray to a 70 per cent coefficient of variation which would be monitored over the season by the contracting Corporation. Climatic and time of day limitations are given.

Airstrip operations were found not to meet reasonable operational safety standards particularly for aircraft loaders and cleaners, who showed substantial, and in a few cases serious, blood acetyl cholinesterase inhibition. Recommendations for improved loading equipment procedures, safety facilities and staff training are made to reduce hazard and pollution. Monitoring of airstrip workers for blood cholinesterase inhibition is recommended and SGB are already planning its implementation.

The main constraint to accurate in-field application was seen to be the lack of markers. Their use - either moving or, preferably, automatic flagmen - is recommended. If flagmen are used they should be monitored regularly for blood cholinesterase inhibition.

These recommendations would involve spray contractors in additional expense and to encourage greater commitment on their part it is recommended to introduce three season spray contracts and to make payments on schedule. It is also recommended to link finance of aerial application to donor finance of insecticide inputs. Engagement of a consultant in application technology and operations management for one or two seasons to assist in the implementation of recommendations is suggested.

The shortcomings in the system for notifying farmers and field workers of impending crop spraying are noted, as is the need for educating farmers on the hazards of insecticides.

The hazards associated with use of Temik are seen to be primarily related to mechanical spillage at field ends and roadsides, or canal banks, with subsequent irrigation and uptake by grasses which are grazed by livestock. Hazard to persons involved in application appears to be minimal. There is however an unquantifiable hazard to persons who might consume vegetables illicitly treated with Temik. While the manufacturers were seen to have mounted an effective campaign to publicise the hazards of improper use of Temik the effect of this was reduced by the inadequate storage and inventory control at Temik stores. The efficiency of Temik against whitefly has been well documented in earlier seasons but results in 1985/86 were found to be somewhat less satisfactory, and in this high whitefly season the cost/benefit picture may prove less than in earlier seasons. No yield data were available to clarify the position within this reports time frame. In summary however it is recommended that use of Temik may continue providing stores, safety measures and store control are upgraded; that irrigation scheduling be tightened; that an automatic disengagement mechanism be developed for the Temik applicator; and that grazing livestock are more strictly controlled. It is also recommended that an independant assessment of the economics of Temik be undertaken, and that the Veterinary Department carry out a full scale assessment of all livestock deaths to elucidate the true position with regard to Temik poisoning.

Deficiencies in stores, their safety facilities and storage management are identified and recommendations are given. It is noted that the construction of 16 new stores is scheduled shortly.

Problems of safe disposal of pesticide containers and old pesticide stocks were reviewed. Disposal of the substantial quantities of chemical by alternative use or incineration are proposed and recommendations for urgent incineration of the insecticides are made.

The availability of staff and transport for the crop protection department was reviewed and suggestions are made for increases or reallocation in accordance with areas of cotton cultivated, roads, group layout and homogenity.

The scouting system used in Sudan was reviewed against the policy requirement of scouting to assess pesticide performance rather than simply to determine a yes/no spray decision. While transport was generally not limiting this season the state of vehicles was not satisfactory and greater numbers of better standard will be needed next year. Scouting staff numbers were adequate but distribution needs revision. The present scouting system was seen to need modification so that greater accuracy and standardisation is obtained. The objective should be a scheme-wide system providing comparative counts of pest infestation on a 'per unit-area' basis. This is indispensible where plant populations vary greatly due to the poor and variable thinning seen on all schemes. Recommendations to attain this objective are given. In the long-term a sequential sampling system should be developed.

The policy of scouting to assess pesticide performance is questioned and should be reviewed. If it is still found necessary then scheme-wide, randomly selected field checks, with specially trained teams using more sophisticated methodology is recommended.

The basis for spray action threshold populations on the Gezira and their implementation in 1985/86 was reviewed, and problems in applying the whitefly action threshold and economic network on spraying are considered. It is argued that the *Heliothis* action threshold is too low and proposals for review are made. For whitefly an action threshold based on counts of nymphs is postulated.

A number of factors affecting cost of pest control are discussed and suggestions are made on changes in policy to effect savings. Regional variation in costs of pest control within the White Nile area are analysed in order to demonstrate the need for careful assessment of costs and return. Cultural practises affecting crop protection and climatological, soil and cultural practises resulting in variation in yield are briefly discussed.

Insecticide drift downwind was sampled quantitatively and amounts collected related to that applied to the fields. The hazard to man, livestock and environment from drift is considered to be minimal. Very high mortality of fish in canals is recorded after air-spraying and effects on other aquatic fauna are reported severe. However fish populations recover rapidly and are high by the following season. Long-term effects are not reported. Fish mortality is considered due mainly to overspraying canals.

Dramatic reduction in numbers of beneficial insects after spraying is documented, and the range of species collected in 1985 is compared with records from early collections held at the Agricultural Research Station, Wad Medani. The potential of beneficial insects for cotton pest control within an integrated pest management system is discussed, and the potential value from predatory species developing on untreated sorghum is emphasised. Recommendations to allocate a substantial area of cotton for production under unsprayed conditions are made as a basic step in developing the integrated pest management system of control. It is also recommended that the ARC insect collection be rehabilitated as a matter of urgency and outlined requirements are noted.

Cases of air-spraying villages for mosquito control were noted and are condemned, although this practise is already forbidden within the Gezira.

It is noted that possible pollution of soil, water and grain or vegetables will receive attention in an Addendum to the report when residue analyses are completed.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

Problems in financing imported inputs for the irrigated agricultural sector for 1985-86 led the Government of Sudan to approach the overseas aid department of the Federal German Government, Kreditanstalt fur Wiederaufbau, for assistance. Finance was required for fertiliser, herbicides, insecticides, baling hoop and jute material, and seed-dressings, rat poison, avicides, and other minor items. After carrying out a project study in early 1985 KfW accepted, in principle, to provide assistance through an aid grant of DM 130 million. An agreement was negotiated and signed on 14th June 1985. This agreement included provision for an external, fully independent consultancy to undertake monitoring the use of the inputs provided under aid funding, particularly of insecticides.

Hunting Technical Services were approached in May 1985 to take the lead role on the project, and an association was formed with the Tropical Development and Research Institute of the UK for provision of specialist scientific back-up and in-field expertise. This was specially in the areas of environmental polution by pesticide residues, the study of application parameters relating to drift pollution, analysis of pesticide residues, and safety aspects of insecticide storage and application.

A proposal for the project was prepared together with the outlined methodology for carrying out the work involved. Following discussions with the KfW and Sudanese delegates the basis for this was agreed and Terms of Reference set (Appendix A) in mid-June 1985.

The Terms of Reference combined a precise definition of objectives set by KfW, notably regarding efficient use of inputs with minimal hazard, together with a looser and wider responsibility to assess limiting factors and make appropriate recommendations to the Sudan Gezira Board. At the same time it was clearly established that the Consultants would have no responsibility for the performance of any product or for the application methodology, and nor would they intervene in the execution of any aspect of the commercial crop protection programme. The aim of the project was thus to monitor on-going commercial crop protection activities in the major irrigated agricultural production organisations of the Sudan, and at the close to make recommendations to them. It is considered that the scope for these recommendations extends to potential donor organisations, in so far as facilitating the provision of inputs in the future is concerned.

1.2 COTTON PRODUCTION SCHEMES INVOLVED

The planned area for irrigated cotton on the six major production schemes for 1985/86 was 892,000 fd. Details are shown in Table 1.1 together with some area reductions during the season. Cotton proposed for the northern Zeidab scheme, or in the eastern Tokar and Gash deltas is excluded (est. 30,000 fd). In view of the great areas involved it was decided at the outset to limit monitoring to four schemes. It was also planned to visit the Blue Nile Pump scheme and Suki scheme to obtain limited data. The major schemes are briefly described in the following sections.

The cotton areas are, characteristically, flat land sloping toward the north. Climate is semi-arid with mean annual rainfall from 200 mm in the north to over 500 mm south of Renk. On the Gezira the range is from about 50 - 190 mm in the north, 145 - 440 mm at Wad Medani, 80 - 470 mm in the south (Appendix E). Rain mainly falls in July - September. Temperatures range between mean minima of 15°C in January to mean maxima of 42°C in May. The soils over most of the area are deep, heavy, cracking, self-mulching vertisols with over 40 per cent montmorillonitic clays which are low in nitrogen. Rapid initial uptake of water occurs but with wetting the soil swells and seals, becoming almost impermeable. Heavy rain results in waterlogging with water standing for many days. Salinity problems would be expected but, probably due to the excellent quality of Nile waters, have not materialised on the Gezira after 60 years of irrigation.

TABLE 1.1 COTTON AREAS 1985-86 SEASON, APPROXIMATE FEDDANS

Scheme	Planned (Early 1985)	Sown	Type	Reduction through Season 1st Spray	Mid-Season	Late Season
Gezira	500,000	387,000	LS	414,440	411,220	411,110
		33,000	MS			
Rahad	135,000	132,200	MS			129,000
New Halfa	75,000	72,500	MS			72,500[1]
White Nile	79,000[2]	33,100	MS	64,340	59,400	59,400
		34,750	LS			
Blue Nile	65,000	62,000	MS	62,000	-	62,000
Suki	38,000	35,000[3]		-	-	-
Totals	**892,000**	**789,550**				

Notes: [1] No contraction of area reported to Consultants.

[2] A White Nile planned figure of 100,000 was quoted. This was never realistic and is ignored.

[3] Extremely severe losses due to wilt were reported, as high as 60% in some areas. Final true area could not be reliably ascertained.

1.2.1 Gezira/Managil Scheme

The scheme, situated in the triangle formed by the confluence of the White and Blue Niles has an irrigable area of 2,178,500 feddans stated to be 12 per cent of the total area cultivated in Sudan, and extends south from Lat. 15° 20' for 210 kilometres to Lat. 13° 30', immediately north of Senar. It is irrigated by gravity from the Sennar dam, opened in 1925, through two main canals channelling water to the Gezira and Managil zones (Ref. Figure J.1). It is administered by the Sudan Gezira Board with headquarters at Barakat near Wad Medani, 190 km by road south of Khartoum. The scheme is divided into 14 Groups, each sub-divided into Blocks, of which there are 107 on the scheme.

The scheme is farmed by tenants whose main crops are sorghum, cotton, and wheat with substantial areas of groundnuts and vegetables. There are approximately 102,200 tenants having average holdings of 20 fd each. For the Gezira a basically 4-course crop rotation system over 4 years is designed as cotton - wheat - sorghum (+ groundnuts/ vegetables) - fallow. For the Managil extension the fallow year is excluded. The area of groundnuts has fallen during the recent past for economic reasons. Most tenant farmers now cultivate five feddan of cotton. Earlier 10 fd (1 hawasha) were cultivated, with 9 of these units forming a field or 'number' of 90 feddan.

In 1985/86 a total of 420,000 fd cotton was planted, falling to 411,225 fd by mid-November due to flooding, poor growth and various other causes.

1.2.2 Rahad Scheme

The scheme lies to the east of the Rahad river about 160 km southeast of Khartoum. Development of the area which is now farmed under the management of the Rahad Agricultural Corporation became possible following the Nile Water Agreement in 1959 and the construction of the Roseires Dam, completed in 1966. The scheme was inaugurated in 1977, with a total area of 820,000 fd and has an irrigated area of 300,000 fd under cultivation. Irrigation is provided from two sources, the main one being from the Blue Nile. Water is pumped via 84 km of main canal to an outfall into the Rahad river, six kms above a river barrage and the offtake into the scheme's irrigation system. Flood water from the Rahad river is also an important secondary source in the early part of the season.

Hospitals, clinics and health centres have been developed along with about fifty villages to provide facilities for the new population. Facilities have recently been made available adjoining the southern part of the scheme to be used as reception centres and refugee camps. These facilities have without doubt alleviated much suffering and have aided the work of the various relief agencies. Road facilities are excellent. An asphalt road passes through the length of the cultivated area, which is bisected at Fau by the Port Sudan-Khartoum trunk road which crosses the Blue Nile at Wad Medani.

The scheme provides 17,000 tenant holdings. Approximately 20 fd of field crops and five fd of winter horticultural crops are grown by each tenant annually. Many of the farmers are former pastoralists who, while depending on livestock, cultivated substantial areas of raingrown sorghum. They had no traditional experience of irrigated agriculture but have acquired this either by experience or from the nearby Gezira scheme.

The main crop is cotton but substantial areas of sorghum and groundnuts are grown (Table 3.2) within the two course intensive rotation, in which there is no fallow period. Cotton is ginned by modern saw gins situated at Fau. The transport of cotton to the ginnery is aided by the asphalt road which runs through the scheme.

This present season has seen some labour unrest mainly regarding salary scales of management staff, which resulted in two short strikes. Administration of the scheme follows the general pattern of the Gezira, although responsibilities are more clearly defined.

1.2.3 New Halfa Scheme

The scheme, which covers 447,000 feddans in Kassala Province, was developed between 1962 and 1969 with Egyptian grant funds - primarily to resettle people (the Halfawyeen) displaced when the town of Wadi Halfa was flooded by Lake Nasser. It is designed to use 1.62 milliard m^3 of water each year which is drawn from the Kasham el Girba reservoir on the seasonal Atbara river (Ref. Figure J.2).

The scheme area is divided as follows:

22,000 tenancies	330,000 feddans
Halfawyeen freehold land	24,000 feddans
Reserved areas	19,000 feddans
Research sub-station	1,000 feddans
Afforestation	2,500 feddans
Sugar Estate	41,000 feddans
Infrastructure and waste	29,500 feddans
Total	**447,000 feddans**

After resettlement of 7,000 halfawyeen families the remaining tenancies were allocated to local pastoralists, making a total of 22,000 tenants. The population in the area is about 300,000 of whom 68,000 are halfawyeen, 148,000 nomads, 50,000 migrant labourers and 34,000 inhabitants of New Halfa town. The rural population is distributed over 25 planned villages and many spontaneous settlements. There is little integration between halfawyeen and nomads. They have different origins and customs and, because of this, were settled separately.

Administration of the scheme is by the New Halfa Agricultural Production Corporation with a board representing the tenants, Government and the Production Corporation. It is responsible for supplying goods and services to the tenant, such as agricultural inputs, tractor services, pest control including procuration of aircraft, the control of their operations, insect surveys, the maintenance of scheme facilities like water supplies and cash advances for labour. The tenants cultivate farms in accordance with prescribed cropping patterns using family and hired labour. They repay the Corporation for the goods and services it supplies out of crop proceeds and have their own organisation in the form of a Tenant's Union (Ref. 1).

Cotton is planted later in the year than in other areas. This is based on research which indicates that better yields result from this practice. The crop was sown this year between August 5th and September 15th. Sorghum now accounts for the major portion of the cereal part of the crop rotation since it is more acceptable to the 'nomadic' settlers tastes and experience than wheat.

1.2.4 White Nile

The area known as White Nile, (in the agricultural context) is that covering both banks of the White Nile river between Renk to the south in Upper Nile province, and Duiem to the north (Ref. Figure J.3). It is an area some 380 km long and was allocated to private landowners for irrigated agriculture by the British Administration in the 1920's and 1930's. Many of the farms (called 'schemes') were owned by rich and influencial families, and by 1968 there were some 200 similar schemes, varying in size from over 20,000 feddans to as little as 100 feddans. Tenant farmers leased land under agreements with the private landowners, a few of whom also farmed themselves.

In 1969, all these schemes were nationalised, and Government took over management, retaining former tenant farmers. The Agricultural Reform Corporation was formed to provide the necessary services to the schemes within the socialist concepts prevailing at that time. This was soon superceded by the Public Agricultural Production Corporation (PAPC) whose responsibilities covered all Government cotton projects, outside the SGB and Rahad.

The PAPC proved to be too unwieldy and was re-established as several Corporations, separating New Halfa, Blue Nile and White Nile regions. The White Nile was run as two Corporations initially covering the north and south of the area, but these were amalgamated into the White Nile Agricultural Corporation (WNAC).

The WNAC now operates some 170 schemes within a cultivatable area of some 370,000 feddans, farmed by 27,070 tenants. A three year rotational cycle of cotton, dura and fallow is followed, but wheat has become popular in the past five years in the northern areas and has surpassed the cotton acreages.

Cotton is now concentrated south of Kosti where the annual rainfall is over 500 mm per year and the warmer winter season is less suited to wheat production. Long staple

Barakat variety is grown. The new, fine, medium staple Shambat B is grown in the northern areas. Although Shambat yields are potentially higher than Barakat, records show that the southern schemes consistently outyield the northern areas.

WNAC is an extremely difficult corporation to manage. The geographic spread, the difficult communications, the many and varied schemes and systems, the antiquated pumps and equipment, the three separate tenant unions and shortage of finance provide a matrix of interrelated problems that require well planned and long-term solutions. The IDA financed rehabilitation project which is currently under implementation has addressed itself to some of these problems, and hopefully will begin to take effect by the 1986/87 season, particularly with providing more reliable water supplies at an earlier date to enable planting to begin on time, (early August) and preventing the abandonment of crops already planted because of lack of water later in the season. The supply of adequate transport and telecommunication links should also have a considerable impact in improving productivity.

To cope with such a complex project, WNAC has to have a larger than normal administration and has an establishment list of approximately 600 classified and some 3,700 unclassified staff. The Corporation sees its role as supportive to the benefit and welfare of the people of the region and the nationalised schemes, many of which would have collapsed without the Corporation's support. In return, the Corporation endeavours to improve the productivity of the tenants, inter extension services, advice, and credit loans, as well to carry out all the essential inputs necessary such as ploughing, irrigation, spraying and chemical inputs. This is not an easy task given the constraints already mentioned, and the more complicated social situation of dealing with three tenants unions instead of one, as in the other schemes. Because of these problems, WNAC losses over the past three years have mounted from LS 11.6 million in 82/83; LS 15 million in 83/84, and LS 19 million in 84/85. In 1985/86 data are not available but similar losses can be expected However it is hoped that, with new policies and the rehabilitation programme, the situation will reverse itself in 1986.

1.3 GENERAL METHODOLOGY AND STAFFING OF THE PROJECT

1.3.1 The Proposed Methodology

The monitoring programme was planned as two sectors. These were:

(a) Basic Monitoring studies to be carried out on Gezira, Rahad, New Halfa and White Nile to provide the minimum of data required by the client. These studies would be season-long, August to February.

(b) A Limited Assessment of Environmental Hazards in an area of two selected cotton blocks on the Gezira, over a two month period from mid-October to mid-December.

Details of the proposed assessment methodology, sampling procedures and sample numbers were presented in Annex A of the Consultancy contract and are not repeated here. In summary, however, Basic Monitoring would concentrate on safety and hazard in storage, handling and application, from delivery to the producing board through to spraying in the field, i.e. would include an assessment of hazard to field staff, labourers and farmers. It would also include assessment of the airspray contractors general efficiency, their compliance with contractual obligations and of physical aspects of the field application operation. It would not include assessment of environmental pollution (livestock, soil, water contamination) and hence excluded residue analysis. It would, however, include assessment of down-wind drift hazard by analysis of chemical deposited.

The Limited Assessment of Environmental Hazard was planned to include, in addition to (a), examination of environmental pollution on two selected cotton blocks over a limited period of time. The area selected (in the Gezira) should include a village with livestock. Environmental pollution parameters would include:

(i)	Drift hazard	-	vegetation and soil sampling, and analysis (additional to (a) above)
(ii)	Hazard to village inhabitants and farmers	-	blood sampling
(iii)	Residue hazard	-	soil sampling in sprayed fields
(iv)	Water pollution	-	pre-season, pre-spray, and post-spray sampling and analysis
(v)	Effect on beneficial insect populations	-	one block only
(vi)	Assessment of scouting procedures and spray decisions		

The two blocks were to be situated at north and south extremities of Gezira to sample under different climate and pest situations.

Responsibility for carrying out the in-depth assessment of environmental pollution and of application factors contributing to this was primarily that of the TDRI specialists, but was strongly supported by the full-time field staff on the Gezira.

1.3.2 Staffing

Staffing was under two operational headings:

(a) Field Monitoring and Sampling, for which five full-time and two shorter-term field staff were recruited.

(b) Laboratory analysis and technical back-up.

Operations in Sudan commenced with assignment of the Applications Specialist to make pre-mobilisation contacts and the arrival of the Team Leader soon after. Overseas input periods for staff over the season were:

Team Leader	August 13th	-	February 28th
Application Specialist	July 23rd	-	February 15th
Crop Protection Specialists	September 3rd	-	February 2nd
	September 19th	-	February 22nd
Entomologist	September 6th	-	February 9th
Pesticide Safety Specialist	September 20th	-	October 19th
Application Specialist	October 11th	-	December 7th

Technical back-up and advice was called upon as required during the fieldwork and the TDRI specialists carried out preparatory work in UK before arrival and incorporated analytical results into their reports in the UK after returning from field operations.

Over thirty-one man-months were spent in Sudan covering almost the whole of the cotton season. This enabled staff to carry through a wide range of study as is reported in Chapters 2 to 8.

1.4 AMENDMENT TO THE PROPOSED METHODOLOGY

It was stated in the proposal that methodology would have to be reviewed and amended in the light of conditions in the field and facilities available, particularly for residue analysis. It had been hoped that amendments would be minimal but in the event there had to be substantial changes. This is discussed in relation to the proposals in Annex A Appendix 1 of the Agreement.

The programme planned for White Nile was seriously disrupted due to political unrest and the security situation in the southern zone. In fact for over three weeks the Consultant delegate was not permitted to move south of Kosti. This unfortunately was in November at the height of the air-spray season, and as a result some aspects of the work could not be completed.

1.4.1 Basic Monitoring

(a) The surveys on storage were carried out as proposed. Additional studies were made of disposal of empty drums and of old pesticide stocks. Early in the project serious problems of delayed delivery were noted. A major effort to identify areas of hold-up was made, culminating in the redrafting of the pesticide tender document with recommendations for procedures.

(b) The monitoring of airstrip operations was carried out as planned. Chemical analysis of blood was not made since specialist advice was that this was valueless since results cannot be related to degree of contamination.

(c) The survey of use of Temik was expanded substantially at clients request to assess effect on whitefly, hazard to man by illicit use, to livestock, and residues in the environment. This survey took considerable time and effort. It more properly falls into the in-depth studies sector.

(d) The planned programme to monitor airspray operations was successfully carried out in full. In addition to chemical drift sampling 10 fields were sampled to assess uniformity of application. Weekly blood cholinesterase analyses were carried out as planned except in White Nile, where distances and irregular spray scheduling, and security restrictions, prevented a full survey.

The proposed drift sampling system was modified slightly to that used in the in-depth studies, whereby a reduced number of sampling stations (six as against eleven) was used and a reduction in number of samples to be analysed was achieved.

At the end of the season the Airspray Contractor Tender document was revised for the client.

(e) Monitoring of pest scouting was carried out satisfactorily. Detailed data on pest numbers and spray decisions, and on the pesticides sprayed, was acquired. These have been reviewed against the spray action thresholds currently in use. Again this study was additional to the planned programme.

1.4.2 Assessment of Environmental Hazard

Details of the original methodology were altered by the specialists involved to be more appropriate to the conditions, the equipment available and the constraints imposed on carrying out application assessment studies within a commercial airspray operation. It proved impractical to limit work to within two cotton blocks but most in-depth studies were carried out in either the South or the North Groups. Partly for reasons of distance and communication the Block 7 Wad-al-Shanaan village area of South Group proved most satisfactory and it was possible to coordinate Application studies and Soil and Drift pollution studies with safety hazard assessment work within this village area. The village was particularly appropriately situated across a long cotton number so that aircraft overflew the village during a spray operation.

A major constraint to the whole environmental hazard assessment programme developed when it became clear that the Pesticide Residue Laboratory of Wad Medani was unable to carry out the proposed analysis programme. While management welcomed the opportunity and offered all assistance possible it soon became apparent that the laboratory might be unable to reliably undertake the work. There were several reasons for this, the major one being the failure of their overseas consulting back-up laboratory to repair vital parts of the Gas Liquid Chromatograph equipment which effectively precluded analysis of organo-phosphorous pesticides. To resolve the problems a specialist was engaged by the Consultants to review the whole laboratory operation. His report to the Consultants and the client recommended that analytical work should be transferred to an overseas laboratory. This presented not only great problems in transportation of frozen samples but also in completion of analysis within the project time-frame, as well as a substantial rise in costs. The only way to overcome these problems was by drastically reducing the scope of work on soil and water contamination. While this was undesirable there was no alternative. (Ref. 25). Three recent studies on environmental contamination in the Gezira have, however, been published recently and these have been drawn upon to back the project studies (Refs. 2, 3, 4 and 5).

The problems experienced by the Pesticide Residues and Formulation Quality Control Laboratory of the Plant Protection Department have serious repercussions. These are noted in other sections of the report with recommendations where appropriate.

(a) The drift hazard assessment had to be substantially modified due to the analytical problems.

The original 'pesticide budget' concept to account quantitatively for distribution of emitted insecticide between infield, on-soil, and drift outside the field could not be implemented. It was impossible to prepare washed plant extracts for transmission to UK and this aspect of the programme had regrettably to be cancelled. The plant-extract analyses were replaced by colorimetric assessment but this was also not successful. It involved admixture of dye to the insecticide and thus interference with the commercial operations, and this was unsuccessful on the three occasions attempted.

Soil samples were taken in three fields as planned, but were bulked, as two replicates, from sites across the fields.

The programme to assess down-wind drift with aerial samplers was not affected and 120 samples for 211 determinations were taken. When the problems of chemical analysis were realised a qualitative assessment based on droplet distribution counts with sensitive papers and rotary samplers was introduced instead. Details are given in Annex A.1.

(b) Blood cholinesterase surveys were successfully carried out involving all groups of persons.

(c) Food sampling was carried out on the planned limited scale as 10 samples for 72 pesticide determinations.

(d) For the revised soil residue analysis programme, combined with (a) above, a total of 55 samples (reduced from 180) for 270 pesticide determinations were analysed.

(e) The water pollution programme had to be reduced to only 8 samples with 80 determinations from the 240 originally conceived. This was because of the great problems in transporting frozen water to UK since plastic containers could not be used.

(f) The studies on effect of spraying on beneficial insects were completed successfully. Screening of effect of different chemicals was impossible due to the Sudan policy that no one chemical mixture may be applied more than once in a block during the season.

CHAPTER 2

SUPPLY AND DELIVERY OF AGRICULTURAL INPUTS

2.1 BACKGROUND

A resume of the growth of insecticide use in irrigated cotton in Sudan is given in Appendix B. This provides a background to the situation regarding supply and financing of the 1985 - 1986 inputs.

KfW participation in the 1985 programme began with a consultant survey in January/February that year, which established the range and scope of donor assistance required. The subsequent agreement was integrated with formal tenders called earlier in 1985 for pesticides and urea fertiliser, and for baling hoops in 1984. The tender procedures for pesticides are discussed under Section 2.5 in detail, together with the problems during the past few seasons. It is considered essential that everything possible should be done to simplify the present cumbersome and involved procedures in order to expedite delivery of urgently needed inputs. The consultants therefore reviewed and revised the SGB Pesticide Tender Document early in 1986. This has been submitted as a Draft Document to the Purchasing and Supplies Department of SGB. No copy is attached to this report however, since it has not been formally approved.

2.2 PESTICIDES

2.2.1 1985 Purchase and Carry-Over Stocks.

All products provided under KfW finance were received on time for application, including the ULV formulations used at Rahad in the first application of the year on September 5th. This was possible because the commercial suppliers and their agents were prepared to ship and clear goods through customs in good faith against their own bank guarantees, and before Letters of Credit were formally issued.

In the case of British financed goods clearance was seriously delayed, apparently due to non-commercial British involvement in the procedures. In the case of the Italian funded input there was serious delay in authorisation to ship complicated by its being funded under a famine relief programme and not as agricultural assistance. One Dutch aided product was delayed due to it inadvertent omission from the list of L/C to be issued.

Details of delivery of all inputs were notified to the donor routinely and are not repeated here.

Details of insecticide ordered by the six main Producing Corporations for 1985/1986 season are given in Appendix B. Carry over stock from 1984, quantities sprayed in 1985/1986, and amounts to be carried over to 1986/1987 are also given (Tables B.2 to B.5). The technical basis for ordering is discussed in Chapter 3, where the biological reasons for the types of chemicals selected for application during the past season are also discussed for the four major schemes.

The fact that substantial stocks are carried forward from one season to the next is regrettable but unavoidable. Corporations must budget insecticides annually in advance and cannot forecast whether the year to come will pose early season **Heliothis**/**Jassid** problems (ULV products) or late season Whitefly/Aphid problems (CIV products). They have to budget for both eventualities and since both pest situations seldom occur in the same season, for pest ecology reasons, it is inevitable that one or the other of the insecticide classes will be carried over. The corporations, through experience, also feel compelled to carry over at least one spray round of ULV product for use at the beginning of the next season.

The quality of carry over stock is supposed to be checked by analysis for active ingredient and physical characteristics before the season begins and preferably before the meeting of the Joint Committee (Section 2.5.1). This cannot be done effectively at present pending reconstruction of the laboratory.

2.2.2 Pesticide Selection

It is accepted by all that a donor has the right to request preference for products of that country's manufacture; the German Governments flexibility for the 1985/1986 project has been noted with acclaim in the Sudan. It must however, be emphasised that donor finance may seriously limit the purchasers flexibility in ordering, as instanced last year by

- The embargo on Temik
- The purchase of much larger quantities of Facron (regrettably delivered in January) than was planned
- The purchase of greater stocks of Decis/dimethoate than planned.

These limitations could cause side-effects on the crop protection programme results. These have not been quantified this season since yields are not yet available.

2.3 UREA FERTILISER

KfW funded the supply of 30,000 cwt of urea fertiliser for use on Gezira 1985/1986 crops. The supplier's Messrs AMH Chemie, bid was accepted formally on July 21st 1985, but terms of the award failed to meet certain of the supplier and donor requirements, namely

Currency was stated in L.S not D.M (typing error).
Delivery date to be as 3 weeks from date of L/C.
Shipment terms were applicable to insecticides.
Packing stipulating 500 hrs shelf life was unacceptable.

Only the last presented problems and it was resolved. The revised award letter was mailed on August 12th, but a delay of 3 weeks had resulted.

By that date it was obvious delivery could not be in time for use on cotton or sorghum, but the fertiliser would be available for use on wheat, provided shipment was before the September 20th, to allow a generous 40 days delivery. These points were communicated in course of routine reporting to the donor.

In the event shipment from Germany was delayed due to a failure of communication between the three parties involved, thought to result from one or other of the parties thinking formal confirmation to ship had already been made when in fact this was not done. The first consignment of urea was received by SGB on December 17th and was available for post-emergent application to late planted wheat. For a number of reasons most wheat (75%) received urea at planting and the 25 per cent that was treated post emergent received urea from other donor sources. The KfW urea will however, be even more valuable an input for next season when it is understood little donor aid is yet confirmed.

The delivery of spare sacks for repacking gives cause for concern. None have been received at Gorashi Warehouse. It is stated they were held for repacking at Port Sudan but, if this is correct, it is not understood why those unused have not been forwarded. Tighter administration by SGB purchasing department is indicated.

2.4 COTTON LINT BALING INPUTS

2.4.1 Baling Hoops

The consultants were briefed to review the evaluation procedure applied to the tender for Baling Hoops that was issued July 1984, closing date August 30th, and to advise whether these procedures were acceptable within the KfW Guidelines for Procurement. This review was carried out with the full cooperation of Sudan Gezira Board, the Commodity Aid Committee and the Central Purchasing Department of the Ministry of Finance.

The Consultants reported on the 19th August that the procedures failed to meet KfW regulations because:

(a) The original tender specifications were amended to include black-painted hoop after date of closure (thus favouring Company A).

(b) The total tender price offer from Company A at Tender close date was the lowest by DM 26600. But the tender offer from Company B for the Gezira portion of the tender was lower by DM 45,600.

Thus the most advantageous, and the correct award procedure was to split the tender between the two companies.

(c) A discount price reduction offered on November 6th 1984 by Company A was improperly accepted by the Central Purchasing Department. This resulted in Company A total offer becoming DM 146,600 less than that of B, and A offer for Gezira portion becoming DM 74,400 below that of B.

Consultants however pointed out that rejection of the tender, carried out under procedures acceptable to Government of Sudan whereby bids are negotiable, would result in

- An increase in prices under a new tender
- Delays in delivery which could be prejudicial
- The necessity to stipulate on site delivery for Rahad, New Halfa, and White Nile by November 30th 1985.

It should be added that the Ministry of Finance did not concur with the Consultants opinion on the evaluation procedures and tender award.

Following negotiations between all parties involved KfW recommended the award be split according to the tender evaluation of 2.4.1 (b) above but this was not accepted by the Purchasing Department and Company A award stood. This was on the grounds that a legal and binding award agreement had been entered into.

Delivery of Baling hoops commenced about February 6th with 1,200 t to SGB and the balance being due by the end of February. Carry over stocks at Gezira of 235 t and at Rahad of 180 t were sufficient for ginning through to the end of February.The consultants request for priority to be given to Rahad requirements appear to have been misdirected within Ministry of Finance.

2.4.2 Jute Bale Material

In October it became apparent that funds would be available for further assistance in supply of inputs and negotiations were opened to finance supply of jute material for bales, to the approximate amount of US$6.8 million. By the end of November agreement had been reached and issue of Letters of Credit was in hand. Arrangements over performance bonds and SGB certificate of quality caused delays but these were resolved and the first shipments arrived at Port Sudan in late February 1986.

2.5 SGB TENDER

2.5.1 Sequence of Events and Committees Involved

A formal series of committee meetings precede the issue of the pesticide tender and delays in the meetings can cause consequential delays in the tender. Up to 1980 the tender was almost always issued by December 20th and closed 45 days later, circa 5th February. The award was made by mid March with on site deliveries requested not later than mid-May for herbicides and mid July for insecticides. The 1986/1987 tender will not be issued before February 20th, two months later.

The key committee meeting is the **Pest and Disease Committee** meeting, which traditionally was held in November but now is delayed until December and is chaired by the Director General of the Agricultural Research Corporation. The secretary of the meeting is the National Coordinator for cotton pest research at the ARC. The meeting is attended by SGB Managing Director and others where possible, Agricultural Managers and Chief Entomologists of all the major corporations as well as the research scientists of the Agricultural Research Corporation, Ministry of Agriculture officials and other senior officials involved.

The agenda of the meeting includes:

(a) Review of the previous season's research work.

(b) Release of new pesticides following their trials approval.

(c) Evaluation of current season's pest situation and an assessment of the performance of pest control operations and chemicals.

The shift to December has been made in order to have sufficient information of the situation in the current season for an objective assessment of item (c) before the new tender is drawn up for the subsequent season. About this time the **Husbandry Committee meets** to review research on herbicides and to approve new products.

Immediately following the Pest and Disease Committee meeting is the **Stocking Sub-Committee** meeting. It is responsible for drawing up recommendations for the number of sprays for each corporation for the following year; and for indicating which alternative pesticides are comparable on a performance basis. This committee is chaired by the National Coordinator and comprises corporation chief entomologists together with ARC division heads.

There is a meeting of the **Cotton Variety Committee** at about this time to assess for the coming year what proportion of varieties of long and medium staple cottons should be grown to meet the Government's cotton marketing policy.

About one month after the completion of the stocking sub-committee meeting, the SGB tender is issued, inviting bidders to tender for the supply of pesticides for all the major corporations, and includes requirements for the Ministries of Agriculture and Irrigation. The tender includes:

(a) pre-emergent herbicides for cotton

(b) herbicides for irrigation canal weed control

(c) insecticides for cotton based on the three categories

(i) early season ULV alternatives

(ii) mid season CLV combinations

(iii) late season CLV whitefly control

(d) seed dressings

(e) avicides and rodenticides

(f) insecticides for wheat and vegetables

(g) stored product insecticides

It is usual for the tender to close 45 days after issue. If the tender is issued late for any reason, the SGB may request a shorter bid preparation period.

The bids are submitted according to generally accepted international procedures and one hour after the bid deadline they are opened in public and registered by the Opening Committee.

The bids are then assessed by the **Technical Committee** composed of research scientists of the ARC and the chief entomologist of the SGB to confirm that the products meet the technical specifications, identify the origin of the goods and accept samples for testing.

The acceptable list is handed over to the **Contracts Sub-Committee** formed by the SGB purchasing department, who prepare a table of all bids, the terms and delivery conditions and their prices expressed in foreign exchange, Sudanese pounds and for L/Cs, and an analysis of the cost per feddan. This is done by the SGB Crop Protection Department.

The results of the analyses of the Technical sub-Committee and the Contract sub-Committee pass to the **Joint Committee** chaired by the Managing Director of the SGB and attended by all the corporation managements, the ARC, and the Ministry of Finance and Economic Planning. Based on the earlier estimates of the number of sprays for each area in the forthcoming season, qualified by the final assessment of the current season (by now completed), and the competitive bids received, each corporation draws up its preferred choice of chemicals and the quantities it expects to require. This decision takes into account:

(a) the carry over stocks from the past season

(b) the need for flexibility, as the pest complex can fluctuate each year according to the climatic variations

(c) the cost per feddan

(d) the performance of the product or mixtures compared against other products

(e) the question of possible insect resistance and toxicity

(f) the reserves in case of unforeseen pest pressures and possible carry over to the following season

(g) what donor financial support is known to be available.

This committee may take one month to finalise its work and to submit its recommendations to the Ministry of Finance and Economic Planning.

The **Central Purchasing Committee** of the Ministry of Finance assesses the recommendations. Normally they accept the decisions of the Joint Committee or the basis of their technical arguments. They may query economic considerations or disparities. When the government has funds, approval of the bid results in the announcement of the award and the confirmation that Bank of Sudan will open the L/C following the appropriate procedures of import licences etc. This process, over the whole, may take two or three weeks.

In the event that no government funds are available, bilateral aid or other donor finance has to be used. This situation is now unfortunately the standard practice. In 1982/1983 foreign aid accounted for only 29 per cent of the SGB tender, but now the whole tender is financed by a consortium of donors.

2.5.2 Allocation of Finance

The Ministry of Finance customarily approach potential donors at a much earlier stage to assess interest and to obtain committments. Donors may request specific conditions or limit their donations to products tendered from their own countries. Negotiations and allocations involve considerable lobbying between donors, bidders, purchasers and Ministry of Finance. This process may take a month in clear cut and well organised, cooperative atmospheres even if all parties are in agreement. Where issues are not well understood, or the conditions of the donor are complex, and the interested parties do not follow through the procedures with diligence the operation may fail.

The functional lines of responsibility within the Ministry of Finance are not clear to outsiders. Involved in the process are:

(a) The Commodity Aid Committee (CAC) - Undersecretary of Economics.

(b) The Foreign Aid Administration (FAA) - Undersecretary of Planning.

(c) The Central Purchasing Department (CPD) - Undersecretary of Finance.

Communications between these organisations is known to breakdown. Delays are difficult to trace. It is not clear why Dutch bilateral aid for pesticides in 1985 was handled by the FAA, while British funded pesticides was handled by CAC. $5.0 million of Saudi funds was approved to buy herbicides in February 1985. The L/C was not opened until May. A further $2.5 million L/C was opened in July a month after the product should have been applied to the soil. An approval to use $1.2 million of ARP 2 funds for irrigation canal herbicides was never opened at all.

In February 1986 Consultants were advised of the recent formation of the High Committee for Foreign Exchange, entrusted with allocation of all foreign exchange and comprising the Ministry of Finance, Ministry of Commerce, Bank of Sudan, Ex/Im Bank, Sudan Gezira Board and other parties. It is hoped this committee will ease problems of allocation of finance when that becomes available.

2.5.3 Tender Pre-qualification Procedures

All pesticides used in the Sudan go through a rigorous four year testing period under the direction of the ARC before they can be registered. On completion of the tests they are approved by the Pest and Diseases Committee and are eligible for submission to the tender, though in practice the corporations may wish to assess the product within their own environment for a further year to compare the performance with their standard regime. Even changes in dose rates, or mixtures of two already approved insecticides, may necessitate a further one or even two years of large scale testing. In practice this may involve a company in seven or eight years testing (as opposed to the theoretical four years) in ten or more programmes to cover the range of dosage and mixture combinations that may be required for a single insecticide.

There is a strong pressure from several directions to try to shorten the testing period for approval of pesticides in the Sudan. This has resulted in the generally accepted two years of small scale trials being changed to a one year small scale programme, duplicated on two quite separate sites. Then two years of large scale trials plus a corporation assessment trial, are required before the Pest and Diseases Committee will approve registration of the product. This is followed by a commercial demonstration in the third year of up to 10,000 feddans for the corporations to gain field experience of its comparative performance, which the purchaser may pay for, or the supplier may donate. The Pest and Diseases committee do not meet until December to assess and approve the registration of new products tested the previous season, and therefore the commercial demonstration trial misses the current season, and so is not eligible for the tender in January for the next season.

Suggestions are now under study that the Pests and Diseases committee meet twice, once in August to approve the previous season final trials, and again in December to evaluate the current season and recommend the next season's programme. In this format two important factors are achieved:

(a) If the data submitted for the two years of large scale trial is approved, a pesticide supplier has time to import enough product (by air if necessary) to carry out a commercial demonstration trial, that season. This can then be assessed by December and, if results are outstanding, can be included into the invitation to bid in the January tender.

(b) The August meeting can approve the regular technical issues and remove these from the agenda of the December meeting, thus allowing it to concentrate on the current season scenario and problems together with next season's planning.

Once a product is approved for use in the Sudan, it is necessary to REGISTER it. The registration process is similar to the FDA registration process in USA, though it is not so comprehensive. Evidence is required in sufficient detail to ensure:

(a) The toxicological data is adequate to ascertain short term and long term human hazard and ecological effects.

(b) The product is approved for use in the country of origin.

The supplier will now promote his product by visiting corporation areas, holding discussions with entomologists, distribution of literature and arranging seminars, both in the Sudan and internationally, in which Sudanese research workers and corporation entomologists are invited to participate and/or contribute papers.

2.5.4 Bidders Procedures and Problems

Upon the invitation to bid, a supplier's agent who is required by law to be a Sudanese registered company, and is usually an agent will contact his principals overseas advising him of the bid and the quantities and conditions therein. The Chemical companies will assess the situation from a competitive point of view and will also investigate the financial implications. They may initiate discussions with potential donors, probably at high levels, to determine whether finance will be avialable, and preferably, whether it can be made captive to their specific products.

During the preparation period prices will be calculated, based on the many considerations involved, including volume of product, cost of manufacture, competitive products, dose rates, international exchange rate relationships, shipping rates and local charges. Certain suppliers may find that certain clauses in the conditions are unacceptable and may submit bids under their own terms and conditions. It will be up to the purchaser to agree to these conditions or not, and negotiate with the bidders. In some cases in the past years, conditions in the invitation have been obscure, irrelevant or even contradictory, frequently due to conditions imposed by donors in recent years. For example, all goods must be insured locally under Sudan regulations. Supplies are therefore invited on a c & f basis. However, aid donors have insisted that bids be on a c.i.f. basis with goods insured in foreign exchange, sometimes with the donor as beneficiary (on behalf of the purchaser) and at other times with the purchaser as the direct beneficiary. Both these conditions appeared in the 1985/1986 tender to the confusion of the bidders and purchasers alike.

On the due date bids will be submitted to the purchaser and treated in accordance with the procedures described in Section 2.1.1. On completion of the assessment the bidder is notified by SGB Purchasing Department that his bid is successful. He may be asked to modify his bid to make it responsive. Often bidders complain that they are awarded bids on the basis of the conditions imposed in the tender, even if these are impossible to fulfil, and the bidder has qualified his bid with his own conditions, which the purchaser may ignore. Insertion of special conditions by supplier or manufacturer has become an accepted part of the tender procedure and is open to negotiation. Examples in this case are delivery deadlines which become impossible to meet. Other complaints are that a stamp duty has been imposed which is pro rata to the bid value making it necessary to place impossibly large stamp duties on high value bids, which are only speculative, and are lost if the bid is unsuccessful. Fortunately the purchasers have not been held responsible for the collecting of this stamp duty, and disputes between the Taxation Department and CPD of Ministry of Finance (Ref. 2.5.2) have not been considered grounds for invalidating bids. Yet other complaints and confusions have arisen from the suddenly imposed import duty of 20 per cent on pesticides in 1985 without prior warning. Considerable delays and expense were incurred while negotiations took place to transfer the onus of this tax from the suppliers, who had not budgeted for it in their local charges. The corporations eventually had to issue letters of guarantee endorsed by the Bank of Sudan to the Customs Department in Port Sudan to meet the tax on behalf of the suppliers agent before the goods could be released.

The award of the bid is in the form of a letter of acceptance, followed by a contract duly signed and legally binding. This is based on International Finance Institution procedures and has been copied by other donor agencies with various amendments. It is noted that in 1985/1986 the bidder was required to produce a performance bond, "not exceeding 10 per cent of the bid value", which means that the bidder was quite entitled to produce any bond from zero to 10 per cent of the bid value, No bidder has had the courage to do so!

On receipt of the award the suppliers agent notifies the manufacturer and requests a proforma invoice. He then applies to the Plant Protection Department of the Ministry of Agriculture for a Health permit checking that the product has been registered first. With the health permit, the proforma invoice and the letter of acceptance, the suppliers agent then applies to the Ministry of Commerce for an import licence.

Assuming that by this time donor finance has been agreed, the Sudan Gezira Board then prepares the Letter of Credit stipulating the conditions and takes it to the EXIM Bank with full local payment (Sub Section 2.5.6). This key document is often the cause of considerable frustration as bankers will hold up payment even if the clauses contain spelling mistakes. Although the SGB are quite willing to correct the instructions, this particular complaint has been repeated several times by different bidders and is a cause of apparently avoidable delay. The consultants strongly recommend that the SGB officials and bidders meet and agree the letter of credit terminology before they are prepared.

One example of Letter of Credit conditions which would ease arrangemets even though it is against most donor regulations would be the stipulation that "Bills of Lading dated prior to date of L/C and stale shipping documents are acceptable". This enables a supplier to ship goods before the letter of credit is opened, thereby saving two to four weeks on delivery schedules. Suppliers are usually willing to do this knowing that payment is secure, even if SGB have not yet opened the L/C locally (Sub Section 2.5.6).

2.5.5 Insurance and Certification

Insurance has been complicated due to the conflicting stipulations of the Government of the Sudan, insisting on all insurance being placed locally, while donors insist that supplies be insured in freely convertible currency. It is probable that some manufacturers carried their own international insurance on top of the local insurance, in any case. For future supplies the consultants have recommended that two separate prices are quoted for each bid: (Ref. Revised SGB Tender document).

(a) a c & f Port Sudan price in US dollars PLUS a local delivery charge in Sudanese pounds (which includes the cost of insurance locally with the supplier agent as the beneficiary).

(b) a c.i.f Port Sudan price in US dollars (naming the purchaser as beneficiary) PLUS a local delivery charge in Sudanese pounds (which excludes the cost of insurance).

The purchaser then has the chance of matching the appropriate bid to a donor without further reference (and delay) to the bidder.

During the completion of documentation formalities, the goods would have been manufactured and/or assembled for shipment. Certificates of Analysis are demanded by the purchaser from approved laboratories but this appears to be a well known formality and does not cause problems or delays. The purchasers reserve the right to make their own analysis and refer to arbitration in the case of any dispute, or to reject the consignment in the event of serious and proven discrepancies.

2.5.6 Payment by the Purchaser

In 1985, the L/Cs had been prepared but EXIM Bank demanded and were adamant that the SGB deposit the total "local component" value in Sudanese pounds before they would open them, using a LS 2.85 to US 1.00 conversion rate (even though SGB budgetted and calculated their costs at a rate of LS 2.50 to US 1.00) EXIM also required guarantee that their commission by paid. A long delay occurred at this stage because SGB had no funds in its account to pay the EXIM Bank. Somewhere between the Commodity Aid

Committee, the Foreign Aid Administration and the Central Purchasing Department in the Ministry of Finance and the Bank of Sudan (BOS), a hold up had occurred and BOS did not release the funds to SGB. Had the suppliers not shipped the goods before the L/C opened, serious crop damage might have occurred. Eventually payment was made in four instalments. (SGB paid the first installment of LS 22 million on September 19th) The dramatic drop in value of the Sudanese Pound during the last five years is illustrated in Table 2.1. This presents great difficulty in forecasting exchange rates in advance. It should be noted that the official bank exchange rate in February 1986 was US$1.0 = LS 3.50 while the black market street rate (Wad Medani),was LS 5.00.

TABLE 2.1 EXCHANGE RATES US$to SUDAN POUND

1981 - 1982	1:0.50		
1982 - 1983	1:0.80		
1983 - 1984	1:0.90		
1984 - 1985	1:1.30	and	1:2.10
1985 - 1986	1:2.55	and	1:2.85

2.5.7 Shipment and Clearance

Assuming that all the above conditions have been satisfactorily concluded, the goods may be shipped. It is generally prudent to ship via Sudan Shipping Lines if services are available in order to secure the advantages of using the national line.

Payment may now be claimed by the Suppliers against presentation of a clean set of shipping documents directly to the donor bank for (1985/86) 90 per cent of the quoted cif (or c & f) price by the manufacturer. A further set of documents is forwarded by courier to the Supplier's agent in Sudan.

Up to this point, provided the sequence of events has had no major hold up due to disagreement or failure to follow up documentation procedure, it is possible to complete the sequence from the time of the award to the presentation of documents for payment in about 8 to 10 weeks and have the goods on the vessels travelling to Port Sudan. Thereafter without careful planning and accurate and experienced knowledge of shipping and forwarding procedures, things can go very wrong, very quickly; bearing in mind that the time frame of all the events described now puts the date somewhere into August or even early September. The new cotton crop is growing fast and receiving its first spray with the carry over stock, if any, and the purchasers are extremely desperate.

The vessels travel fast and from some Southern European ports may take only 10 to 15 days to reach Port Sudan. Even UK deliveries can be effected in 20 days. This is often faster than the shipping documents can be prepared and the mails deliver them. If there are third parties such as banks or customs involved, then document processing can take weeks, or they may even get lost altogether.

2.5.8 Clearance from Port Sudan

In these circumstances it is almost inevitable that the goods will arrive in Port Sudan ahead of the documents and the only way that they can be cleared quickly and efficiently is by a system known as "Direct Delivery", whereby it is possible to unload the consignment directly onto trucks on the quay side and have them clear of the port within hours of docking.

"Direct Delivery" entails the clearance of the goods through customs and the payment of any taxes or duties before the vessel arrives in Port Sudan. It involves the presentation of a bank guaranteed letter absolving the Port Authority for the goods release, and a copy of the bill of lading, usually dispatched from port of loading by carrier service. Provided that all such operations have been completed prior to the vessels arrival, "Direct Delivery" can ensure a schedule from quayside to warehouse of purchaser, of less than a week.

Failure to achieve "Direct Delivery" results in goods being unloaded, taken into bond and cannot be cleared until vessels "out turn" list is delivered to the Port Authority by the shipping line (often long after the vessel has departed), and then checked by the tally clerks. Goods are often double handled, which can result in considerable damage and leakage loss.

Documentation problems can lead to further delays in clearance and in demurrage charges. Goods may remain in the port for several weeks or even months.

2.5.9 Local Delivery Charges

Payment for local delivery is made directly by the corporation to the suppliers agent against his invoice accompanied by signed delivery notes. In the event of shortage of delivery, the corporation only pays for what is received. The supplier agent then claims against the insurer for losses (in local currency) and pays the purchaser for his losses locally. Insurance cover is not less than 110 per cent of the c and f value. Due to the unstable exchange rates, the payment of claims is made by the insurance company on the basis of the exchange rate used by the bank for opening the related L/C, not on the date the product is delivered to destination.

In the case of cif consignments the supplier is only paid for the delivery of goods he makes in local currency. Any insurance claim is paid to the purchaser in foreign exchange, enabling him to purchase fresh supplies if he so wishes.

The terms of the letter of credit have now been fulfilled and the SGB confirm to the EXIM Bank to inform the donor's correspondant bank to release the balance of the 10 per cent of the donor finance to the supplier.

The original documents have in the meantime arrived at the EXIM Bank, who release them to SGB, who pass them to the agent to discharge his guarantees at Port Sudan. It is known that Bill of Lading dated October 30th were not received until February 10th.

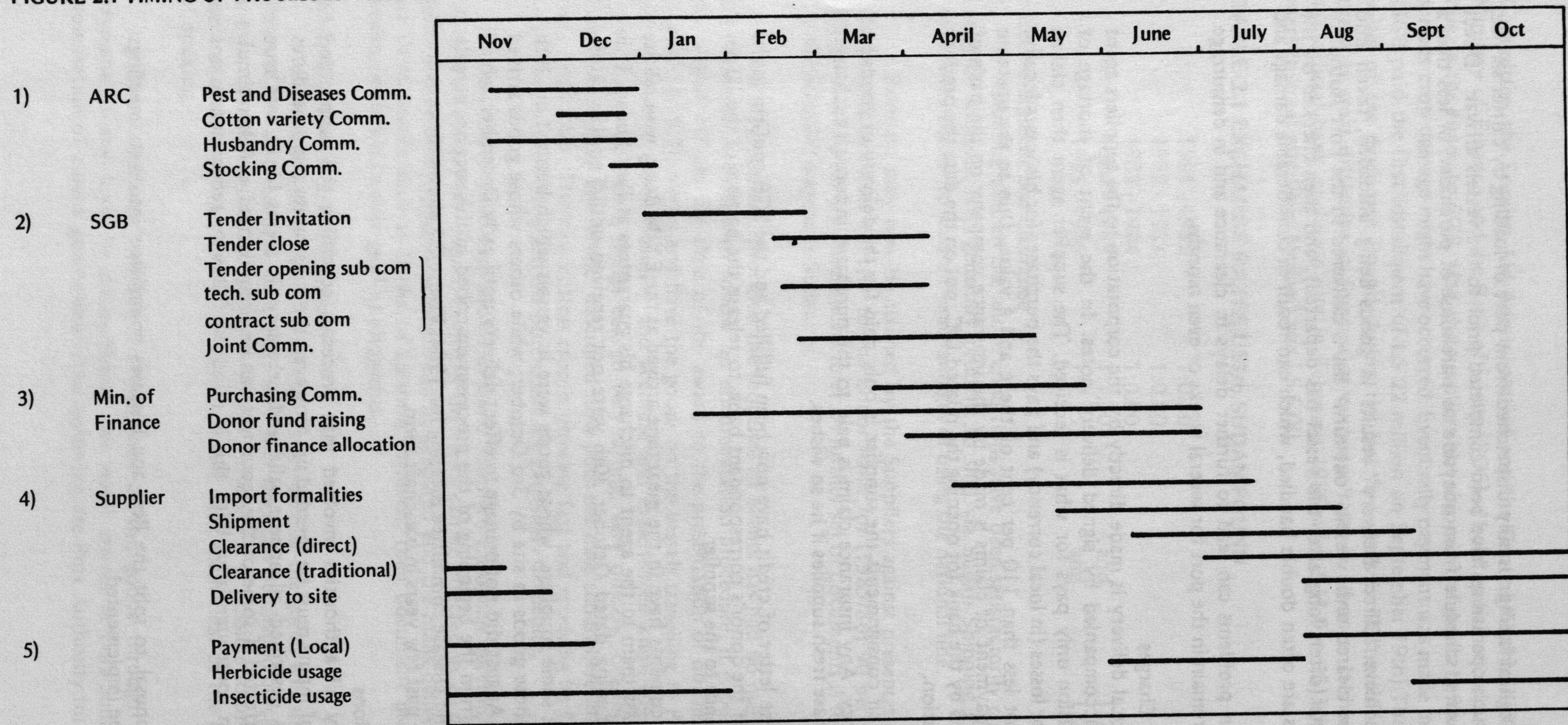
It is a fact that some suppliers, whose goods were in vessels which berthed on 29th September delivered those goods to site by 3rd October; while others whose goods arrived in Port Sudan in late August did not manage to effect delivery until early December, which is one complete year from the beginning of the processes described in this section; namely the date of the Pest and Disease committee meeting for 1984. Figure 2.1 shows the procurement pattern over the past few years in bar-chart form.

2.5.10 Recommendations

It is agreed by all authorities involved that processes governing the supply and delivery of agricultural inputs must be speeded up. However, the constraints and procedures involved in the steps described all appear valid and necessary. It seems likely that true savings can only be affected if some of the sequences can be circumvented, or taken simultaneously, rather than consequentially. With this in mind the following recommendations are made:

(a) The proposal to split the Pest and Diseases committee into two meetings should be implemented.

FIGURE 2.1 TIMING OF PROCESSES: AGRICULTURAL INPUTS 1982/1986



Notes: Lines represent earliest to latest dates of any particular process. Cumulative time can be assessed by comparing the most optimistic time scale (taking the beginning of each line) and comparing it with the most pessimistic time scale (taking the end of each line).

The first meeting between May and August should be to review the previous seasons trials results, and approve the new products, doses and mixtures that have satisfied appropriate criteria. Previous delays in computing trials results should disappear now that a computer is available for the statistical analyses. This meeting need only be attended by ARC staff and senior entomologists from corporations.

The second in December, the main meeting, would review the current scenario and any new developments that will have bearing on the forthcoming tender, including the opinions of the corporations entomologists on the new products being commercially demonstrated, that were cleared at the earlier meeting.

(b) The new tender should be issued as soon as possible after the Pest and Diseases Committee and the Stocking Committee have met and in any case by the first week of January at the latest, whether finance has been identified for it or not. It should open for at least two months and not close until mid March. The purpose for this extension is two fold:

- It states the corporations' requirements at an early date and gives suppliers and manufacturers a chance to lobby potential donors. This important source of leverage can be a powerful weapon if the SGB use it correctly, since suppliers and manufacturers often have excellent contacts in international aid circuits.

- It identifies the products specifically so that Ministry of Finance have a document with which to approach potential donors, who may only be prepared to provide aid linked to their national products. The earlier donor aid agreement can be secured the better.

In remaining open for a longer period, no harm is done provided that the tender is issued on time and more involvement by more people can really be beneficial. It is not necessary to wait until the exact quantities are known. These can be worked out at a later date or even negotiated with the manufacturers once the tender is awarded. This condition is already stipulated in the tender.

(c) The tender document should be rewritten in light of changes both in financing and SGB policies. As already mentioned some of the conditions are contradictory or irrelevant. Insurance clauses are not clear and the technical specification chapter needs up dating. A suggested draft was prepared in early February 1986 by the consultants and submitted to the SGB to use as a model for the 1986/1987 season.

(d) To simplify comparisons in foreign currencies and anomalies in exchange rates, quotes should be requested in US dollars. Certain suppliers may object to this but it is simpler for the SGB andthere will be less dispute when exchange rates fluctuate between date of bid and date of award. Bidders can always cover themselves in the currency futures market.

(e) The stamp duty based on a pro rata tender value should be abolished. Though this is outside the terms of reference of the consultancy or beyond the authority of the SGB it is nevertheless a rather imprecise form of taxation. Furthermore suppliers can simply circumvent it by inserting the price per gallon and quantifying the volume in general terms such as "for any amount".

(f) The award of the tender should be made by 15th April at the very latest, whether or not financing has been agreed. Products which have received backing can then be shipped, whilst those not yet secured, are at least identified. If at that stage, a bid which was rejected attracts a donor, it can be substituted for an unfinanced awarded one, on the basis that awards are issued "subject to finance being available, until which the purchaser reserves the right to withdraw the award or to substitute it".

(g) Upon the successful financing of a product, it is essential that the purchaser and the suppliers agent meet and draft the L/C. This simple arrangement can save much time, misunderstanding and complaints by the suppliers. It is surprising that this does not already happen. It would seem worth considering requiring the suppliers to submit their own draft of the L/C to the SGB to avoid problems such as typographical errors, misnomers etc.

(h) To surmount problems caused by late shipping, donors should agree that stale bills of lading are acceptable so that when suppliers ship ahead of the L/C formalities they know that their guarantees will be released when the original documents arrive, even if late.

(i) Insurance instructions should be classified. The consultants recommend two prices are called for the tender:

(i) c and f local delivery

(ii) cif plus local delivery

The SGB then has the choice, when identifying donors, of the most suitable option.

(j) Suppliers should ship via the national carrier if services are available at the port of loading. The national line will be more certain to call at Port Sudan, and stay in port longer, than other shipping lines, who may by-pass if other arrangements or destinations have priority. (This recommendation is already generally accepted).

(k) Sudanese law forbids the off-loading of pesticides onto the quay. Therefore it is essential to use the "Direct Delivery" clearance method. SGB officials will know how the system operates and suppliers should seek their assistance and cooperation. Failure to clear by Direct Delivery results in the product being off-loaded and dumped in a distant area, with loss and delay in its eventual clearance.

(l) It is important SGB officials know what taxes and duties their agricultural inputs will attract, both for their own budgeting and to avoid complications on arrival of goods at Port Sudan. The consultants consider any tax on agricultural inputs is detrimental. At the very least Corporations' management should receive assurances from the Ministry of Finance, at the highest levels, well before the season starts, that no duties or taxes will be imposed on agricultural inputs within the forthcoming season. Donors should consider stipulating tax free importation as a part of the aid package.

(m) Controversy over exchange rates applied when calculating the "local component equivalent" payable by the purchasing corporations caused delays of about two weeks in 1985 and was then increased weeks later. This rate is for internal accounting and must be determined before the tender is awarded.

(n) It has been suggested that the SGB tender should be split up and that individual corporations tender for their own requirements. Another suggestion is that the herbicides are split off and tendered earlier, since they are required in June (May for early planted crop).

These suggestions do have advantages, but the consultants believe that amending the established system, (with its experienced staff and understanding of procedures), offers the most appropriate method of purchasing inputs for the corporations in the short term. This is due to the economic constraints, and the need to apportion the limited finance available on a rational basis. The earlier delivery of herbicides can still be fulfilled within the one tender, if the recommendations contained above are implemented. In the longer term consideration should be given to decentralisation so that corporations tender separately for their own requirements. This would entail control of their own budgets with authority to utilise foreign exchange finance allocated to them. It would also entail establishing separate procurement departments. These disadvantages would be affected by greater flexibility, swifter processing of documents and greater competition for orders. It is unlikely that price increases would occur, since quantity tenders are already not specific.

(o) An entirely separate option would be to move from the present bureaucratic systems to using Suppliers services and cutting down documentation processes within Government bodies.

The SGB could tender for delivery, quoting as a single cif Barakat price in local currency. On award the SGB could open a local L/C for total value in Sudanese pounds with the Suppliers local bank. The Supplier would import under his own name on a Nil value licence, clear and forward goods to Barakat. The donor would pay supplier for 90 per cent cif component on evidence of shipment. The local agent would pay Bank of Sudan for the full cif component at the previously agreed exchange rate, so that on final delivery the donor would release the 10 per cent balance to the supplier.

Under this system the local agent benefits by receiving local delivery charges on delivery of goods instead of ten weeks later. Documentation and communication bottlenecks are circumvented or minimal. SGB has no problems of exchange rate conversions, and the time frame for the processes would be reduced by one, perhaps two months.

Under this system it would be essential for an exchange rate to be fixed by the donor government and GOS before the tender bid date, and for these to be fixed for the duration of bid, contract and payment periods.

(p) The complexity of the current system requires further study if new streamlined procedures are to be introduced, which would still have to fit into the overall governmental, socialistic system. It is recommended that a consultant specialist in Institution and Procedural matters should be engaged by any donor funding country, to work on these questions during the financing and importation period, in conjunction with the commercial and Government Authorities involved.

CHAPTER 3

APPLICATION OF AGRICULTURAL INPUTS

3.1 PESTICIDES

3.1.1 Insecticide Usage

The first spray applied on all schemes was ultra low volume application using non-volatile formulations from stock carried over from 1984/85 season. On New Halfa ULV application was being re-assessed in 1985 and the first spray was of new stock. One group was sprayed conventionally. SGB (Ref. 6) and other corporations now follow a clear policy to spray old stock first. Rahad policy is unclear. First sprays were with new stock, but since their store was flooded new stock had to be dumped on arrival at the entrance and thus used first. Their old stocks were relatively large at the beginning of the season, but much of this was outdated.

Cotton areas with average numbers of sprays applied on the different schemes are given in Tables 3.1 to 3.5. Total quantities of insecticides applied are given in Appendix B.

Air-sprayed insecticides can conveniently be divided into three groups, separate from soil-applied Temik.

- Early season ULV formulations (Est. 2 sprays) for control of jassid and *Heliothis.*
- Mid-season CLV formulations (Est. 4 sprays) for control of *Heliothis* and whitefly.
- Late season CLV formulations (Est. 4 sprays) for control of whitefly.

This division is rather arbitrary since the severity of the major pests and their period of onset and lapse vary seasonally. This depends primarily on rainfall in June-September, and secondarily on the southward movement of the Inter Tropical Convergence Zone, whereby warm southerly winds are replaced by cool northerlies, usually in early November.

(a) Pest status 1985

1985 was a wet year (Ref. Appendix E) and by mid-July it was predicted that whitefly and *Heliothis* would be problem pests this season.

The accumulated experience of many years has clearly shown the relationship between meteorological conditions and the relative importance of the three major cotton pests, jassid *(Empoasca lybica),* American or cotton bollworm *(Heliothis armigera),* and whitefly *(Bemisia tabaci).* This data is updated annually in the SGB spray policy document (Ref. 6) and shows the correlation between wet years with high whitefly and high early season *Heliothis,* and of dry years with high jassid populations extending through late in the season. Associated with these trends is the requirement for a greater number of sprays in the wet whitefly years. The increase to 8 or 10 sprays, however, on a long season crop of *Gossypium barbadense* cotton extending seven months to picking, cannot be considered excessive, providing spraying is cost effective.

Predictions were confirmed by mid-September with jassid populations remaining low, and controlled by heavy rains in early cotton areas in late August. Jassid caused no damage and no spraying was initiated by jassid infestations. *Heliothis* infestations on sorghum were heavy in early September and on cotton high numbers of eggs were found by mid-September (by Gezira standard; Av. of 13.6 eggs + larvae/100 plants). Egg counts continued high to early November but infestations were easily controlled. Very high populations of whitefly were encountered from September onward, and sprays of whitefly insecticide were needed earlier than normal. Entomologists generally considered these high early populations in cotton derived from migration from the wide range of early alternate host plants brought on by rains. Rapid secondary build-up in cotton was encouraged by the hot weather, high humidity and lush vegetative growth of cotton due to climatic conditions, and possibly to excessive use of nitrogen fertiliser under this season's conditions. The resulting heavy spray programme may have compounded this (Chapter 8). Despite the change in wind direction in the first week of November, temperatures remained high until mid-December. These conditions were favourable to whitefly and populations continued to rise uncontrollably until January.

Additionally, and somewhat unexpectedly, serious outbreaks of aphid occurred in the southern Gezira and Blue Nile schemes in December, and chemical control was inadequate. This was partly due to shortage of systemic aphicide (Ekatin). Aphid was also serious on Rahad, but this was mainly a result of management problems in that when the crop matured ready for picking in November irrigation should have been halted, by mid-November at the latest. However harvest of sorghum and groundnuts is accorded priority by farmers and, for reasons the Consultants have been unable to precisely determine, irrigation of cotton continues until picking can start (Ref Annex A.3).

Tables 3.1 to 3.5 also show the sowing period, areas of other crops and the date when the first spray applications to cotton on the schemes were made. Initiation of spraying depends on pest scouting to determine when insect population spray action thresholds are exceeded (Ref. Sub-section 7.2). Spraying in other sectors of a group (or block) may not start until two to three weeks later. The number of sprays applied is averaged over blocks and groups as the whole of a block is not treated each time. A scheme total for the season is approximate since areas lost through the season may not be fully taken into account.

(b) Gezira

A basic policy was established on the Gezira involving:

- Application of first two sprays as ULV.

- Initial use of carry over stocks of ULV and then CLV formulations with recommended rates increased by 10% to allow for chemical degradation.

- Selective spraying early in season according to scouting, sowing date and germination irrigation effect. Partial or frame spraying late in season depending on whitefly infestation. Blanket or prophylactic spraying to be avoided.

- Use of Temik on the medium staple Shambat and Huda varieties.

The scheme spraying policy document (Ref. 6) emphasises potential value of cultural practises, crop sanitation and beneficial insects in the pest control strategy.

In the event the whitefly levels interfered with this policy. *Heliothis* was kept under control without difficulty but some whitefly insecticide sprays of endosulfan plus an organophosphate were made in late September. These were being used from early October on 20 per cent of the Gezira, and on 65 per cent by October 20th. The numbers of sprays applied primarily against whitefly was therefore high, from six to eight on the Gezira. By mid-December stocks of recommended chemicals were almost exhausted, and problems were compounded by non-delivery of Facron (supplied under a famine-relief programme). Assistance with pesticide was given to SGB by, notably, White Nile Corporation. Taking into account the fact that whitefly is not amenable to control by air-sprayed insecticides and the very high populations that developed, the failure to control it effectively is not surprising. It is considered that the Gezira Board fulfilled their responsibility to provide pest control to cotton growers within the framework of current ARC recommendations. Consultants however must record their reservations on any policy of whitefly control based on aerial application of chemicals against adults (Sections 3.1.4, 3.1.5, and Chapters 7 and 8, Ref. 7). This is however an area outside the Terms of Reference and cannot be fully discussed in this report, but has serious implications on the economics of pest control and the benefits derived from donor aid, as discussed under the section on Temik in this chapter and in Sub-section 7.2.4).

Development of pest infestations and the efficacy of control measures can be influenced by a range of cultural and environmental conditions. Beside the direct influence of climate on the pest situation in 1985 a number of interacting factors contributed to the problem.

The heavy rainfall in late August caused serious waterlogging, with much cotton in the southerly and central zones of Gezira (and Rahad) being in standing water for two or three weeks. This undoubtedly retarded growth, caused poor root development and yellowing of the leaves was marked. The rainfall also lengthened the sowing period. As shown in Table 3.2 only 27 per cent of the Gezira was planted by July 31st, and while 100 per cent was recorded sown by August 31st planting of flooded areas extended the planting period to September 15th. An extended planting period is conducive to pest problems and damage.

Urea application tended to be a little late rather than early (Tables 3.2 and 3.13), with 96 per cent crop planted by August 20th while 40 days later, September 30th, only 83.4 per cent was treated with urea. The timing however may not be as important as the rate since under very wet, warm conditions urea is likely to cause heavy leaf production particularly where physiological shedding of early fruiting points occurs due to the waterlogged conditions. A leafy crop with early canopy closure increases pest control problems, particularly where whitefly is concerned.

Another cultural practise that results in increased pest control problems is that of poor thinning. Ideally cotton should be thinned to ONE plant per stand, with a maximum of two plants. This seldom if ever was found. A normal field would be 4 to 8 plants/stand while 10-15 could sometimes be counted. It is impossible to grow good cotton - quite aside from pest control problems - under these conditions.

Finally the uniformity of irrigation left much to be desired and the extension of irrigation beyond the beginning of February (if not mid-January) in an attempt to get the last shrivelled boll of cotton is a practise that cannot be condemned too much. It is unlikely to increase yields by more than a few pounds per feddan while resulting directly in increased whitefly honeydew secretion onto open bolls with direct loss in quality.

(c) Rahad

In the Rahad scheme pest control relied solely on use of chemicals, and there was little emphasis on alternative means such as cultural practices and encouraging beneficial insects. The August rains helped control jassid and first sprays were made for bollworm control, as soon as action thresholds were passed. Two applications were made for bollworm control. Spraying for whitefly was well under way by the second week of October, when the crop was roughly from 70 to 100 days after planting. Acala is a vigorous medium staple variety and by then in the earlier planted crop the canopy was closed and control of whitefly very difficult. By early November when the fifth spray was being applied the early bolls were opening and it was considered picking should start in mid-November. As noted above this was not done. Instead further irrigation was given and the crop remained green and conditions were ideal for continued multiplication of the pest. Spraying continued and parts of one block received eight sprays, while parts of five blocks had seven. Final applications were made around December 10th.

TABLE 3.1 COTTON AREA GEZIRA, 1985

Group	Area planted October	Number of Sprays to January 31st 1986	First Spray[1] 1985
South	35,012	9.00	September 19
Centre	29,367	8.48	September 17
Messellemia	29,376	9.13	September 23
W. Habouba	19,204	7.27	October 3
W. Shair	29,412	8.69	September 21
North	34,215	7.38	September 21[2]
North-west	30,351	5.44	October 3
Mikashfi	28,253	6.85	September 22
Huda	27,087	8.88	September 22
Mansi	27,297	9.37	September 21
Tahamid	29,182	8.90	September 28
Matug	27,748	9.19	September 21
Maturi	32,303	8.75	September 24
Gamusi	35,628	9.70	September 22
Scheme Total	**414,438**	**8.43**	

Sowing period	- Long Staple (Barakat)		July 20th - September 15th
	- Medium Staple (Shambat)		July 20th - July 30th
Other Crops	- Sorghum	477,870 fd	July - August
	- Groundnuts	102,460 fd	July - August
	- Wheat[3]	285,500 fd	Nov. - December
	- Vegetables	24,600 fd	Season long

Notes: [1] *First spray on any block in the Group, (except Note 2).*

[2] *One number, 90 fd, was sprayed on September 10th.*

[3] *Wheat received av. 1.37 sprays for aphid control.*

TABLE 3.2 COTTON SOWING AND WATERING 1985 - GEZIRA

Period Ending	Cumulative areas - fd Area Sown	Area Watered	% Final Total
20.7.85	31,881	7,725	1.86
25.7.85	113,541	36,825	8.89
31.7.85	264,823	112,167	27.06
5.8.85	365,011	200,178	48.30
10.8.85	409,588	300,547	72.52
15.8.85	415,134	371,086	89.54
20.8.85	415,685	398,113	96.06
31.8.85	415,879	415,139	100.17
15.9.85	414,438	414,014	99.90
30.9.85	411,290		99.20

TABLE 3.3 COTTON AREA RAHAD - FEDDANS SPRAYED 1985

Block	Area Planted	Number of Sprays	First Spray
1	15,300	6.09	September 9
2	14,183	5.84	September 8
3	13,400	5.94	September 11
4	17,160	5.76	September 10
5	13,340	6.44	September 8
6	16,300	6.60	September 5
7	12,690	5.79	September 13
8	16,967	5.72	September 12
9	9,975	5.79	September 10
Scheme Total	129,315	6.00	

Variety - Acala 67B
Sowing period - July 1st - August 10th

Other crops - Sorghum - 60,000 fd sown June - July
- Groundnuts - 70,000 fd sown June - July
- Vegetables - 10,000 fd sown season long

TABLE 3.4 COTTON AREA NEW HALFA - FEDDANS SPRAYED 1985-86 SEASON

Group	Area Planted	Number of Sprays	First Spray
Dubeira	11,835	4.28	October 12
Sasereb	11,835	4.76	October 12
Sidera	11,435	3.10	October 22
Dimiate	11,395	4.65	October 16
Reira	15,470	3.68	October 21
Sheik Umar	10,705	5.09	October 6
Scheme Total	**72,675**	**4.22**	

Variety - Acala 67B
Sowing period - August 5th to September 27th (optimum 15/8 - 1/9, 15/9)

Other crops
- Sorghum 145,000 fd sown July
- Groundnuts 4,000 fd sown July
- Wheat 30,000 fd sown Nov/Dec

(d) New Halfa

The pest control policy at New Halfa appeared rather more flexible than those followed on the other schemes, particularly early in the season and, as shown in Table 3.4, the number of sprays given was lower than those applied in other medium staple cotton areas. This may have been partly due to the scheme being situated far from any permanent river and in a generally more arid area, so that the pest situation was less challenging. The later sowing date may also affect the pest situation, although any advantage here should be nullified by the extended sowing period of over fifty days imposed by water shortage. First sprays were made between 35 and 70 days after sowing, which was very similar to the range at Rahad (Tables 3.3 and 3.4). This later sowing meant that early jassid attacks were not controlled by rain. Where jassid infestations appeared to rise to damaging levels early spraying was applied, and on these blocks it was noted that oviposition by *Heliothis* gave rise to larval populations, which in turn had to be controlled by spraying. Where jassid were not treated similar high *Heliothis* oviposition did not give rise to larvae, i.e. the pest was controlled by natural means, presumably either by egg parasites or predators. From observation on the Gezira (Chapter 8) the conclusion can be drawn with some confidence that beneficial insects moved into the cotton from adjacent fields of sorghum. While this conclusion is tentative, and without supporting sweep-net counts, it is felt these observations by scheme entomologists, reinforced by the reduction in spraying, encourage the possibilities of an integrated pest management, and support the contention that action thresholds of *Heliothis* egg counts are too low (Chapter 7).

Whitefly populations built up in November as on other schemes and were greater than in recent years. Control by aerial spraying was generally unsatisfactory, again as in other areas. Aphid was also a problem in the second half of December. Applications for its control were in some cases delayed due to problems experienced by the airspray contractors. Final applications were made January 7th to 12th, 1986 in Dubeira, Sasereb and Sheik Umar blocks.

TABLE 3.5 COTTON AREA WHITE NILE - FEDDANS SPRAYED 1985-86 SEASON

Region	Area Planted	Area 1st Spray[1]	Number of Sprays	First Spray
Abgar	3,090	2,890	4.16	October 17
Umger	4,980	4,800	4.40	September 23
Rabak	14,100	13,170	4.41	October 22
Umhani	9,210	8,770	4.32	September 23
El Geiger	19,520	19,040	4.89	October 7
Um Galala	16,950	15,670	4.86	September 25
Scheme Total	**67,850**	**64,340**	**4.70[2]** **4.34[3]**	

Sowing period[4] - South July 20th - September 30th. Barakat (51%)
- North August 15th - September 15th. Shambat B (49%)

Other crops - Sorghum 59,900
- Wheat 37,600
- Vegetables 1,500

Notes: [1] *Area remaining at date of first spray.*
[2] *Av. No. applications based on areas remaining at harvest (59,460 fd).*
[3] *Av. No. applications based on areas remaining at date of first spray (64,340 fd).*
[4] *ARC recommendation is that medium staple varieties should be early sown, long staple later sown. It is not known why WNAC did the opposite, but due to seasonal flooding and pumping lift heights the north area is always late.*

(e) White Nile

The White Nile area pest complex differs from that of the other corporations, varying over the length of the geographical area involved. In higher rainfall, and humidity conditions to the south *Heliothis* infestations occur over a longer time scale, while to the north, the more pronounced summer/winter variations produce infestations of whitefly similar to the adjacent Gezira blocks.

The spray policy was designed round an average of 4.5 applications over the season. The standard regime was one overall ULV spray against *Heliothis* and sucking pests followed by four CLV sprays. In the south where *Heliothis* persisted longer pyrethroid chemicals were used for the third spray mixed with a whitefly insecticide. Elsewhere the standard whitefly mixtures of endosulfan plus organophosphorous or Mitac were applied, selection depending on regional preference, stocks available.

Most cotton was planted by 20th August. The wet conditions delayed planting and as in other areas resulted in severe *Heliothis* attacks. Delivery of the new season insecticide orders was later than optimum but WNAC had carryover from 1984/85 for 1½ sprays. The first sprays were made, on average, 50 days after the sowing date, and controlled *Heliothis* effectively. Whitefly infestations were high, almost immediately, and became uncontrollable by November, in spite of efforts by the corporation entomologists. Mitac appeared to be the most effective insecticide, but still failed to hold down exploding populations. Scouting operations were hampered by lack of transport and fuel. Spray contractors had insufficient aircraft for the workload during the first month or so.

The cotton south of Kosti looked healthy and lush, except for where water shortages led to eventual abandonment of some areas. However, yield estimates by late January were low, under four kpf. It is considered failure to control early and heavy attacks of *Heliothis* in some areas resulted in carbohydrates being diverted from the last fruiting bodies to vegetative growth, which in turn leads to whitefly build-up.

The cotton north of Kosti was, in general, poor. Poor husbandry and attention to alternate crops appears to be the reason. Whitefly remained serious through to December and first week in January.

3.1.2 Aerial Application Programme

Eleven companies were contracted to spray on the six major schemes for the 1985/86 season. Of these one company failed to take up its contract and was replaced by the contractor operating the adjacent units. Two companies were allocated double unit areas, or one unit on each of two schemes. One of these two companies was understood to be linked managerially and financially with a third. Nine out of the ten companies sub-contracted for airspray operations to an external organisation, or were in effect subsidiaries of an external organisation. Only one organisation was Sudanese, and it employed expatriate pilots and ground staff. Overseas organisations were from Sweden, Poland, Bulgaria, Hungary, Austria, United Kingdom, Egypt and Pakistan. Staff were even more international.

In White Nile the contracting company Cotton Air Services, sub-contracted to Arab-Agro Services Co. They were separately committed on the Gezira and so in turn sub-contracted to Agricultural Contractors of UK and to Banair of Pakistan on a lease purchase basis. This form of sub-contracting is most undesirable since the onus of responsibility shifts across the contracting organisations, and is eventually lost.

Several of the operating contractors failed to establish themselves on site before the specified date. Others were on time but could not operate at full strength for reasons ranging from unsatisfactory airstrips, shortfall in number of aircraft, to immigration problems for expatriate staff. However in no case did this result in serious delays as alternative contractors were brought in. During the course of monitoring the donor client was notified of the problems.

The contractual obligations and practical needs of the control programme were at times diverse. The situation at New Halfa serves to illustrate this. Thirteen operational aircraft were stipulated under the contract. The contractor supplied two Thrush Commander and six Pawnee 260 aircraft, with only five pilots. One Pawnee was destroyed and from time to time unservability was noticeable, notably a Thrush Commander and Pawnee in late November. The corporation were justifiably apprehensive of the contractor's ability to fulfill his obligations if further breakdown occurred. This did not happen and since 4 to 5 operational aircraft met contractual requirements the initial aircraft numbers called for must be seen as excessive, even allowing a reasonable reserve.

Two serious flying accidents only occurred during the season, neither involving loss of life, but one aircraft was written off.

The average number of spray applications given by each corporation, by group or block, is shown in Tables 3.1 to 3.4. The number of sprays varied within groups and blocks considerably and it proved impossible to tabulate this data simply by spray round against a calendar-scale. For example on the Gezira the sixth spray round extended from 6th November to 15th December, while the eleventh round was from 17th December to 31st December. One block (El Faragin No.44) received only four applications by December 17th while another (Abu Gabe No.20) received 12 sprays (including several partial ones) by December 30th. However, to illustrate the less complex spray programming, data from New Halfa and White Nile are presented in Appendix B, Table B.6.

3.1.3 Airspray Operations

Airspray operations in the Sudan divide into two separate segments:

- Ultra Low Volume (ULV) operations in which non-volatile formulations are applied at total volumes of 0.5 to 2 litres per feddan (1.2 - 4.75 L/ha).

- Conventional Low Volume (CLV) operations in which formulations miscible with water are applied at total volumes (product plus water) of 2 to 3 imperial gallons per feddan (22 - 33 L/ha).

The physical factors which determine the efficacy/economics of any pesticide applications are the uniformity, density and quantity of pesticide contained therein, and its mode of action.

Consequently droplet sizes relative to the applied volume and meteorological conditions at the time of application are of paramount importance. Also of major importance are the biological factors which affect pesticide application. These are the 'target pest' growth stage and habits at the time of application, allied to it's accessibility relative to the plant itself.

Three of the four major pests, *Heliothis*, jassid and aphid, are relatively exposed to air sprayed insecticide in the initial stages of their life cycles within the upper one-third of the cotton plant, and in application terms may be classified together. They constitute, jointly or singly, a controllable target for aerial spraying with commercially available products, equipment and formulations. Conversely, whitefly, the most problematic pest, is more complex and in its egg and nymphal stages on the under surface of leaves is a totally concealed target in the lower one-third of the cotton plant. It cannot be classified with *Heliothis*, jassid and aphid and is not susceptible to control by aerial spraying with commercially available equipment, products and formulations, especially after closing of the crop canopy.

Airspray operations were monitored on the Gezira, Rahad, New Halfa and White Nile Schemes. General monitoring on airstrips and in the field was carried out on all four schemes. In addition an in-depth study was made on the Gezira in the form of spray assessment trials, with two supporting assessments on the Rahad scheme. These are reported in detail in Annex A.

General monitoring comprised random field observations on aircraft performance, spray deposit assessment, and observations and questionnaire recording at airstrips.

(a) Meteorological Considerations

As has already been noted the meteorological conditions at time of application critically affect spray characteristics and thus pest control achieved. Relative humidity, temperature and wind speeds have been recorded as frequently as possible during consultant visits in each of four schemes. These are presented as scatter diagrams showing diurnal variation on a monthly basis in Appendix E as Figures E.1, E.2 and E.3. Although it has been impossible to completely record any region, a study of detailed meteorological data over the past 12 years (Appendix E) indicates that the conclusions drawn would hold good for that period.

Temperatures (Figure E.1) follow a fairly regular diurnal pattern. Relative humidity (Figure E.2) shows much more 'scatter' than does temperature, especially in October, although there is a tendency to higher relative humidities in the early mornings, a fall during the day and a rise in late afternoon. Wind speed (Figure E.3) is much less predictable but the tendency is for lower wind speeds in the early mornings.

In a wind speed of 4 metres per second (mps) a droplet of 50 microns diameter has a natural trajectory which is only 0.7 degrees below the horizontal. Droplets of this size are susceptible to loss by drift which increases further as temperature/thermal turbulence rises. Poor nozzle or Micronair location on the aircraft and low flying increase the quantity of small droplets thrown up into vortices thereby increasing downwind drift and leading to even greater losses.

Where conventional aqueous application is involved both temperature and relative humidity affect evaporation of the water content of the droplet. Calculations of evaporation are facilitated if they are combined to show Evaporative Indices (EI) for each situation. These have been calculated for each of the four regions using data collected and are shown in Figure 3.1. The details from which the calculations have been made are given in Figure 3.2.

Evaporation at 0% relative humidity and 20°C is, by convention, taken as an EI of one. Other evaporative indices relate to this figure. Conditions which produce an EI of 0.5 result in half the evaporation of those which produce an EI of 1.0.

Table 3.6 shows the volume percentage of CLV spray, of different Volume Mean Diameters (VMD) which will be made up of droplets of below 50 microns diameter after a natural fall of 2 metres. When this volume is greater than 10 per cent and winds exceed 3 mps or temperatures exceed 30°C, then substandard insect control may be anticipated.

Study of the data indicates that, under conditions experienced in 1985/86 season, the limiting Evaporative Index for the VMD's specified is very seldom exceeded by the hour indicated below in any of the regions studied.

200 microns VMD	EI 0.6	0800 hours
250 microns VMD	EI 1.0	1100 hours
300 microns VMD	EI 2.0	No limit

A comparison of the data recorded for 1985 with meteorological conditions recorded by ARC Wad Medani since 1973 (Appendix E) shows a sufficiently close correlation to support the conclusion that the above limits would have been acceptable over the whole of that period.

It is considered (Ref. 8) that aircraft applications producing a uniform droplet coverage of 80 - 100 droplets per sq cm, collected on horizontal surfaces at the top level of the canopy of cotton crop, are adequate to control the cotton pests under consideration here, when the recommended dosage of an adequate insecticide is used. Such coverage at canopy level will produce the necessary minimum of 20 droplets/cm^2 at target insect site in the upper 1/3 of the plant. Figure 3.3 shows that to

FIGURE 3.1 METEOROLOGICAL DATA - EVAPORATIVE INDEX

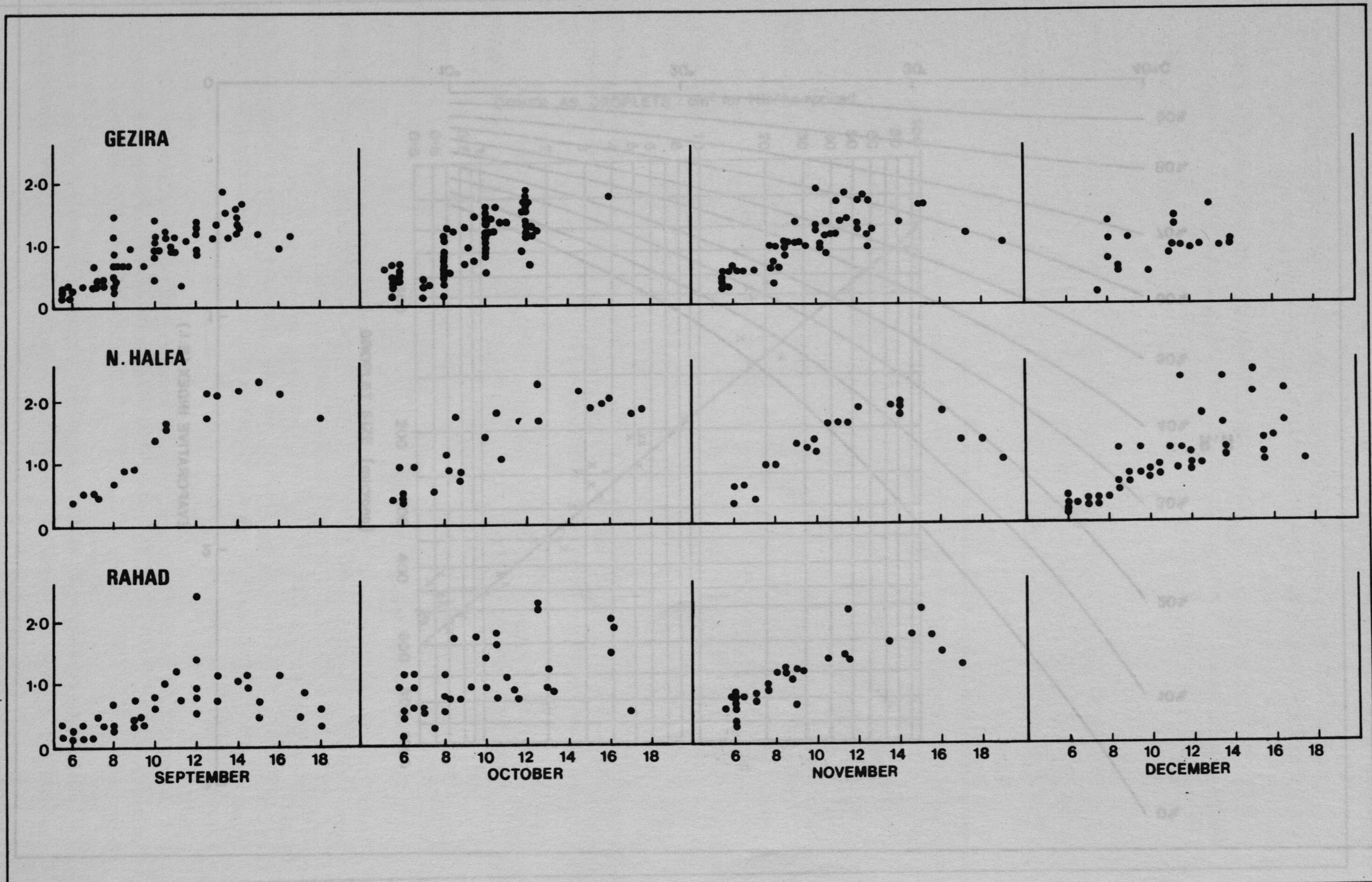


FIGURE 3.2 EVAPORATIVE INDEX - RELATION BETWEEN TEMPERATURE AND RELATIVE HUMIDITY

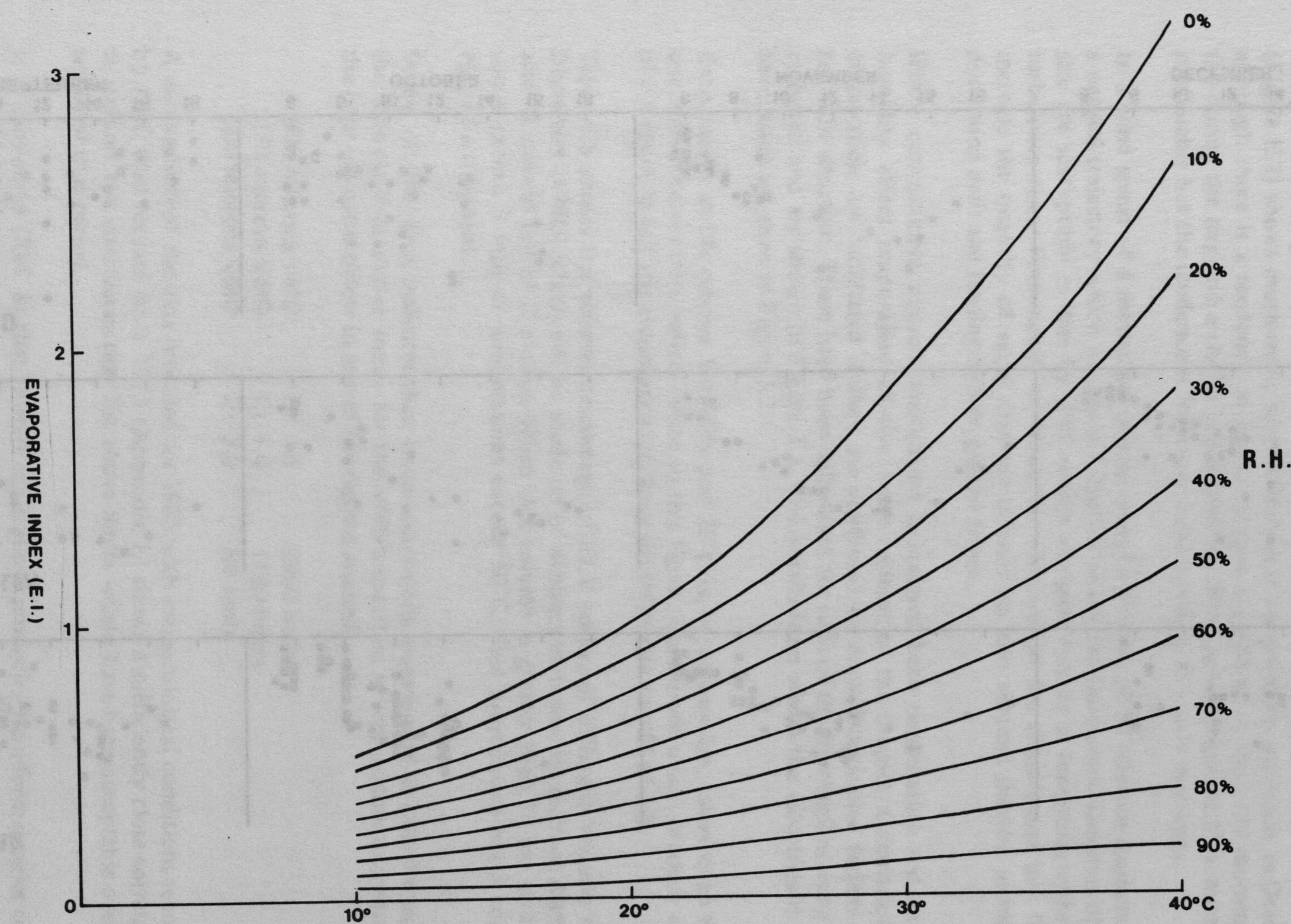


FIGURE 3.3 RELATIONSHIP BETWEEN SPRAY VOLUME, COVER (droplet/cm²) AND DROPLET SIZE

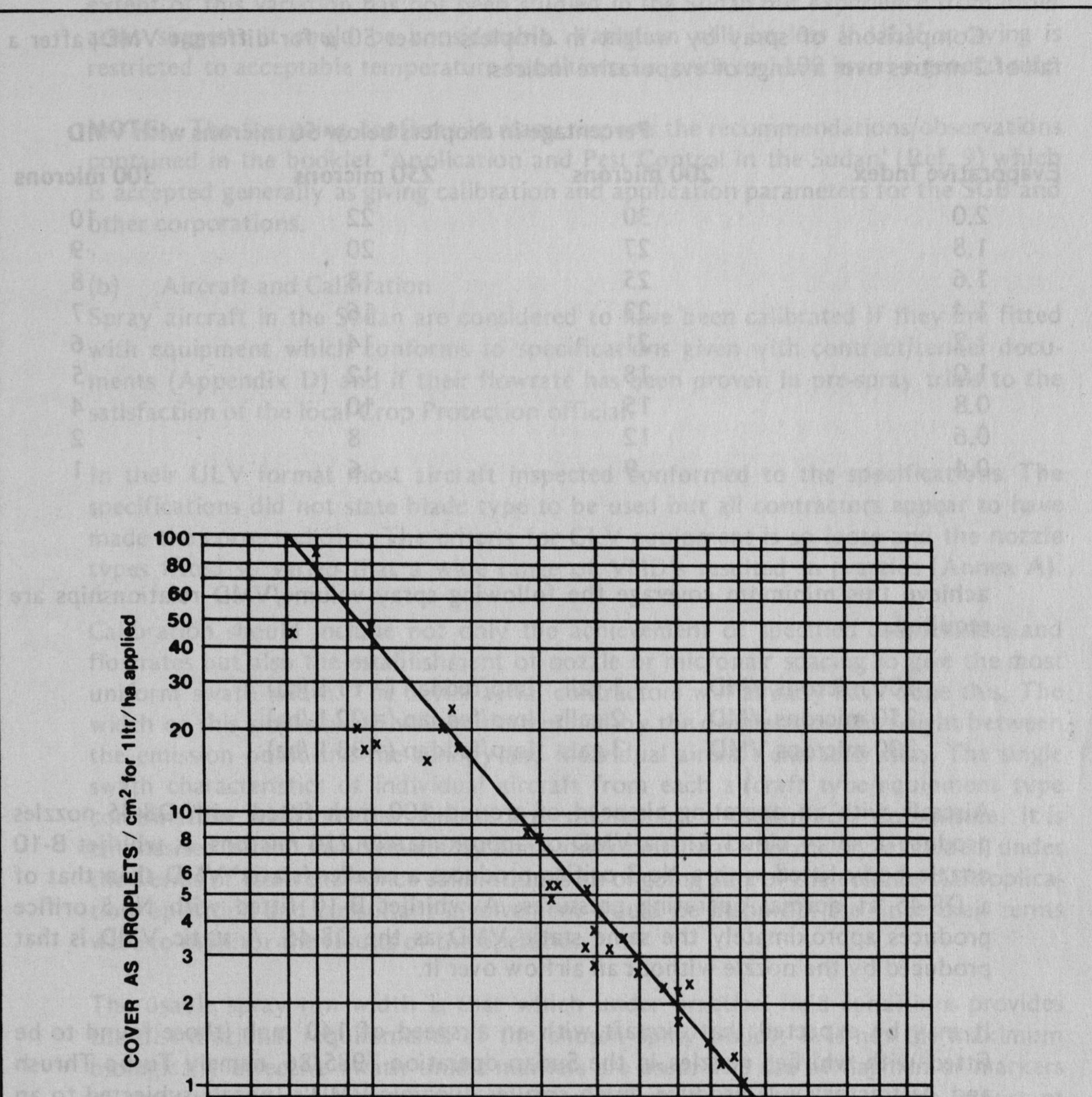


TABLE 3.6 CLV SPRAY COMPOSITION

Comparisons of spray by weight in droplets under 50 μ for different VMD; after a fall of 2 metres over a range of evaporative indices.

Evaporative Index	Percentage in droplets below 50 microns with VMD 200 microns	250 microns	300 microns
2.0	30	22	10
1.8	27	20	9
1.6	25	18	8
1.4	23	16	7
1.2	21	14	6
1.0	18	12	5
0.8	15	10	4
0.6	12	8	2
0.4	9	6	1

achieve this minimum coverage the following spray volume/VMD relationships are required.

200 microns VMD	1 gall	Imp/feddan (= 11 L/ha)
250 microns VMD	2 galls	Imp/feddan (= 22 L/ha)
300 microns VMD	3 gals	Imp/feddan (= 33 L/ha)

Aircraft with an operating airspeed of around 100 mph fitted with D8-45 nozzles produce a spray cloud with a VMD of approximately 250 microns. A whirljet B-10 nozzle body fitted with a No.3 orifice produces a smaller 'static' VMD than that of a D8-45 at normal operating pressures. A whirljet B-10 fitted with No.5 orifice produces approximately the same static VMD as the D8-45. A static VMD is that produced by the nozzle without an airflow over it.

It may be expected that aircraft with an airspeed of 140 mph (those found to be fitted with whirljet nozzles in the Sudan operation 1985/86, namely Turbo Thrush and Airtractor) will produce much smaller dynamic VMD's (nozzle subjected to an airflow) than an aircraft flying at 100 mph fitted with nozzles producing the same static VMD. In fact the VMD's produced by the Turbo Thrush and the Air Tractor are appreciably below 200 microns.

With regard to ULV treatments the same drift and turbulence problems arise relative to droplets of 50 microns and below. Using Micronair spray equipment droplets below 50 microns diameter will not constitute more than 10 per cent of emitted volume if VMD's above 100 microns are used. The same minimum coverage of 80-100 droplets per sq cm at canopy surface is provided by the following VMD/volume relationships:

100 microns VMD	0.8 litre/feddan (1.9 litre/ha)
120 microns VMD	1.1 litre/feddan (2.6 litre/ha)
140 microns VMD	1.7 litre/feddan (4.0 litre/ha)

The major problem with ULV formulations is that, at fixed rpm for the Micronair units, the VMD produced will vary according to the viscosity of the formulation in use. The viscosity varies with product, with formulation, and with temperature. The extent of this variation has not been studied in the Sudan but experience from other areas suggests it could be considerable. Variation will be less if ULV spraying is restricted to acceptable temperature conditions i.e. prior to 1100 hrs as a general rule.

NOTE: The foregoing confirms in many respects the recommendations/observations contained in the booklet 'Application and Pest Control in the Sudan' (Ref. 9) which is accepted generally as giving calibration and application parameters for the SGB and other corporations.

(b) Aircraft and Calibration

Spray aircraft in the Sudan are considered to have been calibrated if they are fitted with equipment which conforms to specifications given with contract/tender documents (Appendix D) and if their flowrate has been proven in pre-spray trials to the satisfaction of the local Crop Protection official.

In their ULV format most aircraft inspected conformed to the specifications. The specifications did not state blade type to be used but all contractors appear to have made the correct choice. The criteria for CLV equipment is so loose and the nozzle types fitted so varied that a wide range of VMD's resulted in practice (Annex A).

Calibration should include not only the achievement of specified droplet sizes and flowrates but also the establishment of nozzle or micronair spacing to give the most uniform swath width. The better aerial contractors will already have done this. The width of this single swath will be determined by the droplet size, the height between the emission point and the canopy and individual aircraft characteristics. The single swath characteristics of individual aircraft from each aircraft type/equipment type combination used in the Gezira are studied by a Calibration Committee. It is emphasised direct involvement by the Consultants was specifically excluded under the Terms of Reference since calibration is an ongoing part of the commercial application operation and consultant involvement would be inappropriate since their terms were to monitor the results of the operation.

The usable spray run width is that which under practical field conditions provides the distributional requirements of the chosen spray policy. It is not the maximum biologically effective swath unless markers are used. The use of flagmen or markers of some type is considered essential where uniformity of distribution is an important component of the spray policy i.e. any policy which requires most economic use of aircraft or chemical allied to minimum acceptable insect control.

A coefficient of distribution of 70 per cent, based on droplets/cm² on horizontal collectors at crop canopy, is considered (Ref. 8) the minimum quality of distribution that will give acceptable control of insects situated in the upper 1/3 of the crop canopy using recommended chemicals and dosage rates applied with the correct droplet size and volume (Annex A. Results of Field Monitoring). It is reasonable to assume that if lower coefficients of variation of droplet distribution can be produced with the correct droplet size and coverage density then chemical dosage rates could be reduced. Under present cost structure, where insecticide cost is the most expensive segment in the aerial application of pesticides, the increased cost of application resulting from use of markers, more accurate calibration, or an increased number of swaths, would be more than repaid by savings in chemicals or increased biological efficacy.

Aircraft should be calibrated in the early morning under conditions of calm wind, low temperature and high relative humidity. These conditions conserve the physical characteristics of the droplets thus permitting the closest measurements one can make of emitted patterns and sizes.

However it is a fallacy to imagine that the increased coverage measured under early morning conditions will provide desirable spray characteristics at later times of the day when higher evaporative conditions apply.

(c) Airstrip Operations

Airstrips divide into two main groups. One is the central or base airstrip, which provides or facilitates aircraft engineering, fuel stores, communication, central organisation, food and accommodation for aircraft personnel. The other is the airstrip from which spray operations are carried out. The base airstrip may also be used as a spray-strip during the treatment of adjacent cotton or wheat and is most frequently used for this purpose during the early cotton season ULV applications.

The risk levels are high on a spray-strip due to the intensity of operations. For this reason the majority of the consultant monitoring was aimed at spray-strips. Several of the items in the 'safety' questionnaire were directed at the activities taking place on airstrips - measuring and mixing of chemicals, loading of aircraft, refuelling and others. The full results are given in Annex C. The following synopsis identifies the major spray-strip problem areas. Data have been transposed to percentages.

		%
Drum labelling	Inadequate	100
Offloading of drums	Basically unsafe	70
Obeyance of safety regulations	Not obeyed	86
Care in handling/mixing	Careless or unsafe	74
Adequate protective clothing	Not present	76
Training and supervision	Inadequate	82

On the positive side:

Eating, drinking, smoking on spray-strip	Observed	26
Number of spray-strip staff	Adequate	70
Careful measurement of insecticides	Yes	98
Careful spraying	Affirmative	98
Return of drums	Good	96
Return of unused chemicals	Good	92
Keeping of records	Good	94

The major criticism must be directed at the aerial spraying companies. However, the criticism must be tempered by an understanding of their problems caused by late tendering, late payment of invoices and one-season contracts.

As far as safety was concerned, most operations were substandard. The contamination of landing strip staff has been quantified in Chapter 5. Inhibition of cholinesterase activity was monitored at 12½ per cent normal levels in some cases (Section 5.2) which is unacceptably and avoidably high (Annexes C, D). An increase in the average toxicity of chemicals in use, e.g. application of ethyl parathion, could under present chemical handling systems on landing strips, result in deaths.

Fire extinguishers were rarely available on airstrips. The general public was rarely excluded from the vicinity of mixing, loading and refuelling operations. Very little control was exercised of persons, animals or vehicles crossing airstrips, especially those beside villages. Several take-offs and landings were observed to be aborted.

Spillage was common from overflowing mixing units and also when disconnecting hoses on completion of aircraft loading. On one occasion this spillage was observed to be collected as mud, which was then used to kill fish in the 'tail' of the canal.

The suction of chemical from drums was a major cause of contamination due to methods used:

- single suction tubes must be transferred from one chemical drum to another when mixes are used, which is usually the case. The tubes drip during the process and, in the absence of protective gloves, bare hands are used.

- bare hands were frequently used to limit the suction pipe depth in drums when measuring aircraft or mixing tank loads.

With a few notable exceptions the supply of protective clothing was inadequate and training in the use of protective clothing and safe handling of pesticides was even scarcer, and on many occasions even soap was not available on the landing strip, although a marked improvement was noted as the season progressed.

The measuring of products was primitively executed. In many cases the potential errors were compounded by measuring from drums standing on the sloping banks of canals. It is interesting to note from questionnaires that measurement was considered accurately by 98 per cent of airstrip interviews.

During ULV operations it was noted on many occasions that, at the end of a day's operation, the unsprayable quantity of spray liquid remaining in the aircraft hopper was dumped on the landing strip. Even if this is as little as 10 litres it represents a waste of at least LS 150 every time it happens. It can be avoided by decanting through the controllable dumps with which most of the aircraft are fitted, into suitable containers such as 40 gallon drums cut lengthways, and transferred to normal drums for reloading the next day.

During CLV operations it was noted that many drums returned to Central Stores as empty, contained remnants of formulation in them which, on occasions, amounted to considerably than 5 litres.

There were no washing down platforms, which permit the control to some extent of the considerable contamination hazard from the diposal of washing water, especially on base landing strips.

Within the constraint of the relative cost of insecticide to the airspray operation it is emphasised that the most economic aerial operations result from all operational functions being geared to maximum productivity/minimum unit costs. In the Sudan aerial operations are frequently geared not to maximum aircraft productivity/

minimum application costs but to supervisory capability. This results in the uneconomic use of the aircraft component (aeroplanes, spares, pilots, engineers etc.) which is a far more costly component than supervision. In practical terms it means that contractors are required to spray on a block by block basis, frequently with several aircraft operating from the same landing strip, which increases hazard and causes refilling delay.

If four aircraft are available it is more efficient to use each one to treat a single block, working with its own filling unit, so that four blocks are completed over four days, than to allocate all four aircraft to a single block on each of four days. As a general rule, while filling units are so primitive, no more than two aircraft should use the same filling unit. Lost time due to aircraft waiting on airstrips for refilling was considerable at nearly all airstrips monitored in 1985. Lost time means increased costs and is reflected in higher tender bids.

ULV operations were delayed at the beginning of the season in many areas due to waterlogged landing strips. The provision of a limited number of simple all weather strips, possibly one at each aircraft main base, would prevent this. Provided biological justification exists for these early treatments then the economic benefits are obvious. There are other 'spin off' benefits from the provision of landing strips for use in the wet season mainly in relation to social considerations.

(d) Flying Operations

The lack of any form of marking aid is a severe limitation on the quality of spray distribution especially among pilots not experienced in agricultural flying or in flying without markers. Either moving flagmen, or automatic marking systems are essential.

While there is a need to give a pilot a degree of freedom in his spray flight pattern planning to permit the avoidance of windscreen contamination, unnecessary turns etc., this planning should also take into account supervisory requirements. There is no real need for conflict to develop in this operational sphere and it can be effectively organised as was demonstrated in the North West group SGB, where a daily written supervisory schedule was instituted. This entailed allocating each aircraft a '600 feddan' group of fields and arranging the sequence in which the different groups would be treated. Each group had a designated supervisory site and transport was organised to follow the spraying sequence.

Flying was to a high standard when considered as a whole. There were however a number of observations of turns executed in less than 20 seconds from spray on to spray off during which spraying was executed in the turn, on the descent into the field or on the climb out from it. These examples of bad spraying could have been avoided if more conventional turns had been executed.

Pilot selection of spray height was generally good. Block officials have a marked tendency to instruct pilots to fly lower without justification. Flying within an aircraft's ground cushion, due to flying lower, results in more spray being thrown up into vortices, a reduction of swath width, and peaky distribution. If the wind is so strong that aircraft must fly lower than stipulated heights then the wind is too strong for effective spraying and operations should cease. (Narrow swath spraying at 0.5 to 1.0 in height was tested under trial conditions. This is discussed in Annex A.3). Ineffective spraying, with many aircraft types, wastes insecticide costed at a minimum rate of LS 200.00 (maximum LS 600.00) per spraying minute; not to mention the aircraft application charge.

It was noted that not all pilots wore protective helmets and not all aircraft were fitted with safety harness. The latter contravenes Sudan Civil Aviation Regulations and in the event of a crash would almost certainly lead to severe pilot injury if not death.

(e) Economic considerations
The single major factor, which limits the acquisition of the best efficacy/economic combinations in the aerial application of pesticides in the Sudan is quality of treatment. This lack of quality does not arise so much from lack of men, materials or expertise as from their management in operation.

Unless a quality standard is specified and enforced in competitive contract situations there will be a tendency for price and quality to fall. The usual result, in aerial operations world-wide, is that number of applications, quantity of chemical used and contamination increase as the price and quality decreases. The current vague equipment specification, especially in respect of CLV applications, virtually provides an excuse for contractors who fail to meet an acceptable standard of application.

There is a close correlation between price and planning in their effect on quality. The positive effect is greatest when effective planning makes best use of an adequate price. The positive effect is enhanced when the time scale is such that best use can be made of available material and monetary resources. Timely payments facilitate the efficient running of an operation, create confidence among contractors and promote healthy competition. Spray contracts in the Sudan however are short-term, issued at short notice and receivable payments are not made on time. All contractors questioned stated that payments of the 65 per cent foreign exchange portion of invoiced charges were late, and no payments had been received by December 31st by some contractors, although documents were certified correctly. These delays are not conducive to an effective and collaborative spray operation.

3.1.4 Recommendations

These have been made partly on the basis of the previous sections which consider and develop the field observations made, including those presented in Annex A. In addition the recommendations presented pre-suppose general acceptance of the following policy:

- to provide the most economic spray application giving acceptable pest control. This infers the most economic use of the insecticide applied, which is the most expensive component in the application (Appendix B);
- to cause minimum safety hazard to the general public, and particularly farmers, field workers and personnel of the spraying operation teams;
- to minimise environmental pollution.

(a) Contracting Principles

Period of contract
It would be beneficial to extend the contracted period for any one treatment area to a period of three years. This would permit better forward planning by contractors, better use of resources and a better quality of application without a corresponding increase in prices. Phased introduction of three year area contracts would maintain the desirable aspect of competition between contractors.

Payments
Payments under the contract should be made on time. If Sudan's foreign exchange situation is such that this cannot be assured then donor aid for pesticides should be

linked with application.

Selection of Contractors

The selection of contractors on price alone cannot be recommended unless a quality control clause is included in the contracts. Even then the ability of candidate contractors to perform the work, their previous experience in the Sudan, and questions of social, cultural or communication qualifications or limitations should be assessed by persons experienced to do so. Final decisions should be made by the contracting agricultural corporation. Adoption of internationally advertised 'Divided Tenders' with separate technical and financial bids, the latter only opened if the technical bid is satisfactory, should be considered.

(b) Spray Parameters

VMD for use with ULV products should be between 100 and 120 microns while applications remain between 0.5 and 1.0 litres per feddan. Spraying should not continue beyond 11.00 hrs.

VMD for use in CLV applications at 2 gallons per feddan should be 250 microns up to 11.00 hrs. If spraying is necessary beyond this time then the VMD should be increased to 300 microns and the applied volume to three gallons per feddan.

A Coefficient of Variation of Distribution based on droplets collected on horizontal surfaces at canopy level should be stipulated at 70 per cent or better for ULV and CLV.

The Spray-Contractor should be required to meet these parameters with whatever equipment is fitted to the aircraft.

The Plant Protection Department should physically monitor one aircraft from each contractor of each equipment/aircraft group before the commencement of each season to ensure that VMD parameters can be met (Annex A). The distributional characteristics of each aircraft should be monitored by the Crop Protection Departments as the season progresses (Ref. Appendix C and Annex A for methodology). Guidelines in the form of specifications of aircraft which have conformed to contracted requirements could be published as an aid to contractors.

(c) Safety

Contractors should be required to meet minimum safety standards based on compulsory measurements of cholinesterase levels of landing strip and engineering staff at 7 - 14 day intervals. Voluntary analysis of cholinesterase levels among pilots should be encouraged. The wearing of pilot safety harness, as compulsory under Sudan Civil Aviation rules should be enforced. Use of a protective helmet should be recommended. A First Aid Kit and a note of nearest hospital and doctor should be on each landing strip. The presence of operational fire extinguishers during refueling operations should be stipulated.

(d) General

Contractors should be required to commence spray operations as early as possible and in any case not later than 0600 hrs if weather conditions permit. If Plant Protection officials are not present by this time, the contractor should be permitted to begin operations.

Spray operations should not be permitted in average wind strengths above 4.5 mps (9 mph) except in extenuating circumstances. Simple anemometers or wind gauges should be supplied by the aerial spraying contractor on each landing strip.

Aerial spray contractors should submit a weekly report to Plant Protection entomologist responsible for his area showing:

- the number of aircraft available for operation on each day (i.e. available for spray operations and with a pilot)

- the number of aircraft not available on each day and the reason for it (pilot sick, unserviceable, no fuel, crashed etc.)

In order to prevent misunderstandings and as an aid to new contractors it is recommended that guidelines be issued describing

- operating conditions in the Sudan

- commercial procedures (tender, finance, import, agency etc) applicable and acceptable in the Sudan

- an outline of the safety, productivity and application parameters to be met with suggestions for achieving them.

(e) Markers

Efficient marking of flight paths is essential to obtain a satisfactory standard of application. Either moving flagmen should be employed by SGB, or as part of the contractors responsibility, or automatic flagmen dropped by the aircraft should be introduced as a standard in the contract.

(f) Reduction of personal and environmental contamination on spray-strips

The following recommendations are intended as guidelines to correct the most serious aspects of contamination. Ideally a 'Code of Conduct' establishing each parties responsibility should be issued. These recommendations do not go so far as closed systems which, though ideal, would not be possible to prepare for 1986/87 season.

(i) CLV and ULV operations - loading.

To prevent contamination and possible accidents during connecting and disconnecting of loading hoses:

- Fit positive sealing loading valves onto aircraft and filling units, e.g. Kamloc valves. This reduces spillage from the present 1 - 3 litres to perhaps 10 cc.

- Fit, in addition, a delivery valve onto the pump which **must not be opened until the loading hose is connected to the aircraft** and the loader man has withdrawn. This valve **must be closed before** the loader man returns to the aircraft to disconnect the hose.

These fitments are considered imperative. In the absence of such valves ULV loading operations will remain hazardous.

For CLV operations a loading sequence of - water/chemical/water - means spillage can be water only. The sequence has been used in 1985/86.

No problems of mixing of EC formulations will occur. Use of mixing tanks causes considerable foaming in many cases which results in contaminating overflows. This can be avoided by **fitting the loading inlet at the bottom of the tank**, pointing to discharge horizontally or downwards. This reduces admixture of air, the major cause of foaming.

(ii) Mixing and measuring of chemicals (ULV and CLV)
The major cause of worker contamination on airstrips is the handling of gradual suction tubes. This hazard could be almost eliminated by fitting a 'collar' on the suction tube and locating it with a 'butterfly grub screw'. This is practical and effective only where the one tube is used for one drum at a time. **Therefore the use of a simple suction tube for two different chemicals must be avoided.** This is easily organised by fitting a suction branch with multiple inlets each with its own valve. Under Sudan systems four inlets would be ideal since two chemicals are almost always mixed.

Two branches would handle full drums of chemical A and B with two parallel branches for the part drums of A and B. Where one chemical alone is being handled then the two B branches are cut off. In the absence of a four outlet capability a simple 3-way valve with two suction inlets would be a considerable improvement.

(iii) Rinsing of EC drums
This should be done by putting a few gallons of water into each EC drum as it is emptied, rolling the drum and loading the rinse into the aircraft or mix-tank. This simple process will reduce waste and hazard.

These recommendations will help eliminate hazards from mechanics and systems. Training of staff and use of suitable protective clothing remains critical, but the provision of protective clothing has been seen to be counter-productive unless staff are trained in its use and how to keep it free from contamination, and are supervised to ensure that training is put into effect.

3.1.5 Implementation of Recommendations

- The forthcoming season 1986-87.
These were discussed with Sudan Gezira Board and were accepted in principle. It was however felt that their implementation in 1986 posed problems. Those under paragraph (a) required discussion and agreement with other organisations and time was insufficient for this. The technical recommendations under paragraph (b) assume a basic understanding by the airspray contractors of the principles involved, and doubts were expressed on this. SGB also had reservations regarding their and other Corporations capacity to undertake regular random field monitoring.

In view of these reservations the Consultants were asked to review and revise the present Airspray Contract within the present limitations. This was completed but is separate to the report. Additionally notes on monitoring the standards suggested are given.

- The Future
There is a strong feeling among the SGB, other Production Boards, insecticide suppliers and both Sudanese and expatriate Airspray Contracting organisations that improvements of the type recommended are needed. The basis on which

to build is established, but with most airspray contractors (1985/86) being technically relatively unsophisticated, with a relatively young and inexperienced - in practical fieldwork - SGB Operations Unit, and with short-term visiting consultant services, it is felt these improvements will materialise more slowly than desirable. It is therefore recommended that a consultant on Application Technology and the Management of Spray Operations be engaged on a full-time basis for one or two complete seasons to undertake implementation of the recommendations of paragraphs (b) and (c) and to strengthen, support and develop the Operations Department.

This consultant should also be involved in the application aspects of large scale experimental work of ARC. It should be noted that pre- and post-spray insect counts to evaluate pesticide performance can give misleading information unless details of the airspray operation are also taken into account. Thus records of areas treated by each company, aircraft type, pilot and the time of day and meteorological conditions should be kept and analysed with the insect counts if these are themselves reliable (Ref. Chapter 7).

3.2 PESTICIDES - SOIL APPLIED

3.2.1 Background to Use of Temik in Sudan Cotton

Whitefly is now the most serious pest in Sudan cotton and presents the most difficult problems of control. In the 1930's it was important as a vector of leaf-curl virus (Ref. 10). In the mid 1950's it had been shown that heavy whitefly infestations (Refs. 11, 12) affect plant height, percentage leaf shed, numbers of picked bolls, bollweight, seedweight, yield, ginning outturn and lint index. Between 1961 and 1964 research (Prog. Rep. Exp. Stat. Sudan - CRC) showed that high infestations resulted in direct reduction of yield of both long and medium staple cottons. Gameel (1967-68) showed correlation between level of infection and incidence of damage. High whitefly infestations are also associated with Gezira Wilt (Ref. 13).

The major cause of damage by whitefly however is the excretion of sap as honeydew, which drops onto the open bolls and contaminates the seed cotton. This results in 'sticky' cotton which is difficult to process under the conditions of humidity and heat generated by high speed machinery. This effect on quality not only makes Sudan cotton harder to sell but has resulted in discounted prices. It was estimated in 1983 (Ref. 7) that the reduction in Acala price compared with the Liverpool Index was around US $ 0.15 per lb in the 1981-82 season. In 1985-86 nine insecticide sprays were made on parts of the Gezira, of which perhaps seven or eight were specifically against whitefly, without achieving satisfactory control. The reason for this is primarily one of failure to deliver chemical applied by air above the crop to the 'target', namely the under-surface of the leaves in the lower third of the plant where both the susceptible adult stage and the tolerant eggs and nymphal stages of *Bemisia* are found. This problem has been appreciated for more than 30 years but alternative application systems to airspraying have yet to be developed for Sudan cotton production systems. It is against this background that the development of use of aldicarb (TEMIK), its drawbacks and its benefits must be considered.

Temik was first approved for use on Sudan cotton in 1966 and small-scale development continued until 1972. In 1978 development was resumed as the whitefly problem mounted. In the 1981-82 season almost 21.000 fd were treated, with estimated yield increases of 0.91 kantar/fd valued at US $ 172/fd above non-Temik treated areas (Refs. 2, 6). In 1984-85 158,480 fd were treated (Ref. 6) with yield increases reported at 1.21 k/fd valued at US $ 228.70 (Ref. 15). These are crude figures not taking account of differing areas of medium and long staple cotton planted and/or treated, their potential yield differences, nor price variations between types and seasons, but they serve as indicators of benefits as reported for the past few seasons.

Temik is used in cotton in Sudan as a 15 percent, gypsum, granule. The active ingredient, aldicarb, has extreme mammalian toxicity with an LD 50 (male rat) of 0.8 mg/kg (Ref. 14). It is highly soluble in water and is taken up by plants and translocated upwards. Unlike some other systemic soil insecticides distribution is throughout the plant and is not concentrated only in the growing points. Treated plant material is thus toxic, the hazard depending on the rate of application and time lapse since application. Temik is thus extremely dangerous material and should only be used under strictly controlled conditions. KfW, when considering the scope of donor aid for pesticides, felt constrained to decline assistance if any extremely toxic products were applied in the cotton areas in Sudan. During the aid negotiation period KfW was advised that a major project had been undertaken by specialists from the Consortium for International Crop Protection in 1983, under USAID funding, to assess hazard from use of Temik in Sudan cotton. Although full findings were not then published, KfW, after examination of those available, accepted the use of current Temik stocks, since it was preferable to dispose of these stocks swiftly in cotton thereby reducing possibilities of accident over a longer period through illicit use, poor store control, or other indeterminable means. The KfW therefore instructed consultants to carefully assess the hazard from use of Temik on the relatively small area in 1985.

Temik was applied on the Gezira and Rahad as shown in Table 3.7, during late September and October depending on crop development. It should be applied after 'green-ridging' when weeds are removed and soil cracks close about eight weeks after germination. Delays in 1985 were partly due to the heavy August/September rains.

TABLE 3.7 AREAS TREATED WITH TEMIK - FEDDANS

Gezira	Block	Feddans	% of Blocks treated	Date (Approx.)
South	95, 3, 7	15,261	97	25/ 9 - 20/10
Centre	8	5,379	80	1/10 - 10/10
Mikashfi	47, 48, 49	9,009	68	19/ 9 - 10/10
North	36	4,465	75	19/10 - 1/11
Total		**35,304**		
Rahad	1, 2, 3	4,880	11	23/ 9 - 3/10

The area treated on the Gezira represented about 22 per cent of that of 1984/85. A total of about 310 tons was used on both schemes.

3.2.2 Application Methodology

The Temik was applied by tractor, each fitted with three, tool-bar-mounted, Horstine hoppers holding 60 lb and delivering a mechanically metered microband of granules between the rows at the rate of 17 lb/fd. Six rows are treated on each pass through trailing tubes. The machine is powered by a land-wheel. Optimum operating speed was stated to be 8 kph.

The main problems observed were:

(a) Spillage of granules onto roads and headlands at the end of a tractor run along a number. This occurred when drivers did not raise the tool-bar, which automatically shuts off the applicator machines, at the end of a run before turning round. The company manufacturing Temik suggest that the machine be lifted about a metre before the end of a row. This would leave an untreated strip at both ends of the Number so the company recommends that drivers apply Temik across the ridges to finish off these ends. Such treatment was not observed in practice.

(b) Delayed or late irrigation, or water shortage. Temik should be watered in within seven days of application unless rainfall is sufficient to move it into the soil (Ref. 16). On the Gezira, tenant holdings in a Number are irrigated sequentially over approximately ten days from one end to the other. There is thus an in-built delay for irrigation water to reach parts of the area treated with Temik. Timely irrigation depends on effective communication between the irrigation authority and the Block Inspector. There were reports of difficulties here, which may explain why some blocks were still not irrigated after seven days. Temik application in the Blue Nile scheme has been considered, but rejected, because the overall supply of water is insufficient to be certain of getting water to a treated area at the right time. Adequate water supplies cannot always be guaranteed on the Rahad scheme either.

A further problem was seen where tenants irrigated their holdings shortly before Temik was due to be applied. Tractor application can only be made in dry fields so these areas remained untreated.

While drivers should be instructed to exercise greater care turning at field ends, the consultants do not support the recommended treatment across the ridges at Number ends, as this could lead to Temik remaining unwatered on top of ridges. This, together with deposits when turning, constitutes a hazard, as later it might be watered in and possibly taken up by plants used for animal or human food (e.g. cowpeas planted on field edges).

Every effort should be made to streamline communications between irrigation officials and Block Inspectors so that delays in watering are kept to a minimum and any deficiency in water is known well in advance of Temik application dates. In order to get complete coverage, Block Inspectors should ensure that tenants do not irrigate their holdings shortly before Temik application is due.

3.2.3 Effect on Whitefly

As shown in Table 3.7 only in South group was application nearly complete, 97 per cent of blocks 95, 3 and 7 being treated. Elsewhere, in Centre, North and Mikashfi groups, application was fragmentary. The effect of Temik on whitefly in blocks 95, 3 and 7 only was therefore analysed.

The adult whitefly counts reported here were recorded by scouting teams in South group according to the method described in Chapter 7.1 with counts recorded as numbers of adult whiteflies/100 leaves, five leaves/plant being examined, (2 top, 1 middle and 2 lower). Temik was applied from 1/10/85 onwards. The numbers of whitefly recorded in each block are given in Table 3.8. Figures A.E.1 to A.E.18 show mean weekly counts graphically (Annex E).

TABLE 3.8 EFFECT OF TEMIK ON WHITEFLY POPULATIONS

Mean numbers of whitefly adults/100 lvs

	Non-Temik treated					Temik treated			
Block	1	2	4	5	6	3	7	95	Mean
October	377	353	373	318	262**	386	302	606***	371
November	859***	663**	395	452	487	324**	500	340**	498
December	1,139***	762	591	1,114***	1,156***	397	531	377*	645
No. of counts	27	27	33	29	31	32	31	29	30
Overall means	856***	586	459	616	673*	368**	453	437*	549

*** p 0.01, ** p 0.025, * p 0.05.

Counts from inside Blocks only used.

Variety - Blocks 3, 7 - Barakat
- Block 95 - Hada

TABLE 3.9 AIRSPRAYS ON TEMIK AND NON-TEMIK TREATED BLOCKS 1/10 - 31/12

Number of aerial sprays

	Non-Temik treated					Temik treated			Mean
Block	1	2	4	5	6	3	7	95	Mean
	10***	9.3	8.4	10**	8.7	6***	7*	7.3	8.3

Mean NT	9.3
Mean T	6.8
Difference	2.5

*** p 0.01, ** p 0.025, * p 0.05

The counts were analysed statistically on a calendar month basis. Data from the edges were ignored. The mean numbers of whitefly adults recorded in October show that numbers were significantly lower in block 6 (non-Temik) and significantly higher in block 95 (Temik). In November numbers were significantly higher in blocks 1 and 2 (non-Temik) and lower in blocks 3 and 95 (Temik). In December numbers in (non-Temik) blocks 1, 5 and 6 were highly significantly greater than the mean and numbers in block 95 just significantly lower than the mean. Overall mean figures show that numbers in block 1 were highly significantly greater than the mean, and in block 6 marginally significantly higher. Numbers in block 3 (Temik) were significantly lower and in block 95 marginally lower. 2.5 additional sprays were made in non-Temik treated blocks (Table 3.9). Numbers of sprays were significantly greater in non-Temik tested blocks 1 and 5, and lower in Temik treated blocks 3 and 95.

These are not clear cut results as Temik applications in blocks 7 and 95 led to no significant decrease in numbers of whitefly. In addition the reduction in number of aerial sprays (2.5) on Temik treated areas will not be economic in terms of savings on the overall programme unless the yields from those blocks are considerably higher than the yields of the non-treated blocks in the group.

Temik cost Ls 117/fd, excluding application, in 1984/85. Keeping the same price but adjusting for the official exchange rate gives a cost of LS 131/fd for 1985. A saving of over four sprays, or an increase in yield of 0.58 Kpf (183lb/fd) is necessary to cover the Temik cost, assuming an average Grade 3 cotton at LS 225 per Kantar seed cotton. Further comments on the effect of Temik on whitefly numbers therefore await the final yield figures, however performance in 1985/86 was not as effective as in the past two and three seasons.

The results from Centre, North and Mikashfi groups were not analysed because of the fragmentary application of Temik and the variation in treated blocks. Yields from Mikashfi Temik area were reported superior in late February, with variety Shambat.

These somewhat anomalous and disappointing results, differing from previous seasons, may be explained by the very high populations encountered. If a low and a high population are reduced by 95 per cent (Annex A, Part 3) by an insecticide treatment then the residual whitefly of the high population, being numerically much greater, will multiply to reach a high level (or pass the action threshold level) more rapidly than the low population.

Whitefly numbers were high throughout the Gezira this season (1985/86). Comparison with data from a similar wet season (1980/81, Ref. 6) showed that the high early season populations (Sept/October - 116/415 per 100 lvs: 103/228 per 100 lvs) increased rapidly but not to the same levels by mid-season (Nov. 589:985) and were relatively moderate for the rest of the season (823:1,565 - December).

3.2.4 Hazards from Use of Temik

(a) Cholinesterase Inhibition

The toxicity of aldicarb (Temik) to man and other mammals is due to inhibition of enzyme cholinesterase in the nervous system. The enzyme also circulates in the blood, both in the red cells and plasma. The degree of inhibition (toxic hazard) can be determined by assay of blood ChE activity. The assessment of cholinesterase inhibition due to carbamate poisoning is however extremely difficult. This is because carbamate induced inhibition is rapidly reversable as compared to inhibition caused by organophosphorous poisoning, i.e. blood recovery from carbamate poisoning is very fast. However methods of assessment based on measurement of blood activity have been widely used in the control of occupational exposure and regular determinations may act as an early warning system (Ref. 17). Since no alternative method was both commercially available and practical for field use in the Sudan the Consultants attempted to monitor hazard to users of Temik with the Lovibond Kit (Ref. 26) which was being used for organophosphorous toxicity monitoring.

(b) Hazard to Man

Assessment of hazard to people using Temik was monitored at Block 3 Rahad, and Wad el Ataiya village Block 7 South Group Gezira scheme, over the period of application. At Rahad this was September 23rd - October 3rd, on Gezira it was October 2nd to 18th. Three groups of people were assessed.

(i) Villagers, who were not in contact with Temik.

(ii) Farmers, in indirect contact with Temik after it had been applied and irrigated into the soil.

(iii) Operators, in direct contact with Temik e.g. labourers, tractor drivers and loaders.

For details on how people were selected see Annex D.

One hundred and thirty tests were carried out in this programme (Group (i) - 24, (ii) - 66, (iii) - 49).

During the course of field work further data on carbamate induced cholinesterase inhibition became available. The validity of analytical methods by measuring blood cholinesterase inhibition to indicate carbamate toxicity is questioned by several authorities, more specifically that the Lovibond method is not appropriate for the test. (Pers. Comm. FBC, and Medical Research Council Toxicology Lab., Carshalton, Ref. 18). WHO have apparently also acknowledged the invalidity (Ref. 19). The Consultants therefore do not present results of the cholinesterase tests carried out. However observations over the Temik application period at both Gezira and Rahad showed no individual to have visible symptoms, and neither were any complaints of sickness reported. It is here worth noting that effects of carbamate tend to be self limiting since operators report sick before overdosing and, as stated above, recovery is quick.

In 1983/84 season a team from the Consortium for International Crop Protection, under USAID funding carried out studies on the hazard of Temik use in the Sudan to operators and the general population. Blood and urine samples were taken, frozen, transferred to USA, and analysed for acetylcholinesterase levels and aldicarb residues (Ref. 23). The major study emphasis was on urine residues. Groups sampled were divided into tractor drivers, loaders and non-contact general population. The first two groups were sampled morning and evening, the last in the morning only. Results of urine analysis showed that 38 per cent of all samples contained less than the detectable level of aldicarb (<1ppb) (as the sulfone metabolite). Of the 62 per cent containing detectable levels these ranged from 1 ppb to 271 ppb, with a mean of 31 ppb. In the first two groups analysis of 133 morning pre-work urine analysis showed 59.4 per cent contained residues above the limit of detection. Post-work afternoon samples showed 80.8 per cent of 52 samples contained detectable residues. It was calculated that the maximum level measured would be approximately 30 per cent of the No Adverse Effect Dose established for man at 0.125 mg/kg by the US National Academy of Sciences and the US Environmental Protection Agency. In an average exposed subject the level was 28 times below the NAED. No indication was found in 1983 linking use of Temik to any serious health or safety risk to man, either occupationally or to the general public.

The conclusion reached by CICP workers was that occupational exposure was unlikely to exceed the NAED level, and that use of Temik at the present rate of application in Sudan and Gezira could continue provided the present (1983/84) safety precautions were maintained or exceeded. However they warned of the possible additive hazard from exposure to aerially applied organophosphates plus Temik together with any chronic accumulation of pesticide. This required further assessment. In the season-long monitoring of organophosphorous toxic hazards, reported on in Chapter 5, the level of hazard to indirect and non-contact groups was shown to be negligible. It can be concluded that danger from additive toxic hazards is therefore minimal.

Temik is highly soluble in water and is irrigated into the soil immediately after application. Field workers move in these flooded fields barelegged and without shoes but no ill effects due to skin absorption from contaminated water were reported in 1983 (Ref 24). Irrigation water sampled 24 hours after first flooding and analysed for aldicarb had mean residues of 0.043 ppm (South Group) and 0.015 ppm (Centre Group). The maximum level recorded was 0.209 ppm, with an average of 0.089 ppm from all samples. Using this "worst case example" it was calculated that a 60 kg worker might absorb a maximum of 4 mg aldicarb (100 per cent absorption assumed after skin dries off). At that level no clinical symptoms would be expected and the possibility of a person becoming ill from exposure to such levels was considered remote.

over what time period?

(c) Hazards to livestock

Livestock, for meat, milk, skins and transport are an important part of the agricultural system on the Gezira. The hazards posed to them by the use of Temik are, in order of magnitude:

(i) Feeding on weeds, outside a Temik treated block, which have been accidentally contaminated as a result of faulty application.

(ii) Feeding on weeds cut from Temik treated numbers, by farmers.

(iii) Accidental grazing in fields of Temik treated cotton.

(iv) Feeding on cotton plants, after picking, which still contain high Temik residues.

(v) Drinking from Temik polluted water.

Assessment of the degree of risk is difficult. An Acceptable Daily Intake level for livestock has been established at 0.005 mg/kg liveweight by WHO/FAO, and at 0.003 mg/kg by US EPA. The average adult liveweight of goats on the Gezira is estimated at 30-35 kg, while that for an adult cow is 300 kg. Thus the amounts of aldicarb which these animals can harmlessly consume are 0.15 and 1.5 mg per day. The oral LD 50 for rats (the dose killing 50 per cent of a test population) of aldicarb and its principle metabolite in cotton foliage, aldicarb sulfoxide, is 0.9 mg/kg while the chronic no ill-effect levels are 0.1 and 0.5 mg/kg/day respectively. On this latter basis the amounts which goats and cows could consume per day are higher, at 3 mg and 30 mg per day.

The Consortium for International Crop Protection sampled foliage and carried out residue analysis in 1983/84 (Ref. 21). Over the 20 week sampling period residues fell from 3.2 ppm to 0.07 ppm. Using this data (Table 3.10) the amounts of foliage containing these quantities of aldicarb have been calculated together with the amount of aldicarb contained in a maximum "dry matter food requirement" for goats and cows. These are based on daily consumption of dry matter as 2.5 per cent liveweight, assuming an 85 per cent moisture content for cotton foliage, and are thus 5 and 50 kg cotton foliage per day respectively.

These calculations show that a cow eating the average daily intake of cotton foliage from a treated field would probably exceed the no ill-effect level during the first twelve weeks succeeding application. Even during week one, however, this would be unlikely to cause deaths. While no definite LD 50 for cows are available the level of

0.9 mg/kg would only be reached by a cow eating 270 kg of foliage in one day during week 1 where concentration of aldicarb is 3.2 ppm. This is simply not possible.

TABLE 3.10 ALDICARB RESIDUE IN COTTON FOLIAGE

Period since Application Weeks	Aldicarb Content[1] PPM	Kilograms foliage containing: mg 1.5	30	Estimated aldicarb content (mg) in foliage (max. daily intake) 50 kg (cow)	5 kg (goat)
1	3.20	0.47	9.4	160	16.0
2	2.29	0.66	13.2	114	11.45
4	2.10	0.71	14.2	105	10.5
6	0.65	2.31	46.2	32	3.2
8	1.70	0.88	17.6	85	8.5
10	1.37	1.09	21.8	68	6.85
12	1.10	1.36	27.2	55	5.5
14	0.20	7.50	150.0	10	1.0
16	0.09	16.67	333.0	4.5	0.45
18	0.08	18.75	375.0	4.0	0.40
20	0.07	21.43	429.0	3.5	0.35

Date of application 4.10.83
Rate of application - 2.5 kg aldicarb per ha.
Level of sensitivity of analysis - 0.01 ppm.
No. of Replicates for analysis - 3.

Notes: [1] *With Acknowledgement to Cons. Int. Crop Prot. and USAID. Table X from "Environmental Monitoring Studies on Temik aldicarb pesticide on treated cotton fields in Sudan" May 15th 1984.*

The major danger to livestock is therefore from grazing plants along field edges where contamination has occurred due to excessive spillage from turning tractors, or from machinery in transit from one field to another. It would be relatively easy for heavy spot contamination leading to concentrations of 20 to 30 ppm to occur, an order of 6 to 10 times the concentration in the field. In these circumstances a lethal dose (270-350 mg) would be contained in 4-5 kg green foliage, an amount easily consumed by a cow in a short while.

(d) Illicit use of Temik
Strict guidelines control Temik application to cotton but there is some evidence that small amounts are pilfered and used on vegetables in the Gezira and that small amounts reach the illicit market in pesticides around Khartoum (Pers. Com. Sudan/German Plant Protection Proj.). Uncontrolled application of Temik to vegetables e.g. near to harvest time, constitutes a serious hazard to people eating them as they may be contaminated by Temik residues. Farmers using Temik in these circumstances have, not surprisingly, little idea of the hazard nor any way of knowing how much to use or how long before harvest it may be applied safely. Residues in foliage and fruit of Temik applied at planting at recommended rates are reported to rarely exceed 1 ppm, and should be below the tolerances set by WHO/FAO (Ref. 16). This however is not likely to be the case where farmers treat vegetables and it is not unlikely that residues in the order of 100 ppm could be found where Temik was sprinkled round tomato plants 20-30 days prior to harvest. Consumption of such

fruit would be highly dangerous and would certainly exceed the Acceptable Daily Intake level for aldicarb of 0.005 mg/kg set by WHO/FAO.

The SGB crop protection department have established a small specialist horticultural unit in view of tenants increasing interest in vegetable production. They also include pesticides for use on vegetables in their annual tender (list in Ref. 6), and undertake extension work to advise farmers which pesticides are specifically recommended. By these means it is hoped to influence tenants away from illicit use of Temik.

3.2.5 Review of farmer opinion

During intensive interviewing of farmers on aspects of aerial spraying in the Gezira, it became clear that many held strong views on the use of Temik. As a result, farmers were asked the following questions:

(1) Is Temik good for whitefly control.

(2a) Have livestock died as the result of the use of Temik.

(2b) Has aerial spraying been responsible for livestock deaths.

(3) Have the results of whitefly control by Temik been as good in 1985/86 as they were in 1984/85. (This question was asked of tenants in blocks 3, 95, 7, which were treated with Temik in 1985/86).

The results are given in Table 3.11.

TABLE 3.11 FARMER INTERVIEWS ON TEMIK

Question	No. of farmers interviewed	Responses Yes	%	No	%	Don't know	%
1	71	54	76	9	13	8	11
2a	42	33	78	2	5	7	17
2b	29	7	24	20	69	2	7
3	12	0	-	10	83	2	17

These results must be used with caution because of possible misunderstandings between interviewer and interviewee and changes in meaning during translation.

A large proportion of farmers thought that Temik was good for whitefly control but that whitefly control in 1985/86 in Temik areas was not as good as in 1984/85 (this appropriate only to those blocks treated with Temik in 1985/86). Many farmers also expressed the opinion that Temik was very expensive. No attempt was made to ascertain if they thought the benefit derived was worth the cost of its use. A much higher proportion of farmers thought that livestock deaths resulted from Temik poisoning rather than from aerial spraying.

Farmers obviously view the use of Temik with mixed feelings, they are fully aware of the hazards (Sub-section 3.2.7), think that widespread livestock mortality is due to Temik poisoning (Sub-sections 3.2.4, 3.2.9) but also believe that Temik is good for whitefly control. The strength of feeling on livestock deaths due to Temik poisoning justifies a specific survey of livestock deaths due to unexplained causes and a review of the field methods available for detecting aldicarb (carbamate) residues in animal carcases.

3.2.6 Storage and Storekeeping

The Temik in store (267 t in the Gezira) was carry-over stock from the 1984/85 season and represented about 19 per cent of the total applied that season. Thirteen Block stores containing Temik in the South and Centre Groups of the Gezira were inspected. Two stores were inspected at Rahad, one used exclusively for Temik which contained the bulk of the carry-over stock from 1984/85, the other, (the Central Insecticide Store), contained carry-over stock returned from Block stores.

Storage facilities, such as the existence on site of fire extinguishers, electricity, running water, telephone, adequate ventilation and local medical capability to treat Temik exposure cases, were lacking in all the stores visited on the Gezira (Annex C) and both Rahad stores. A secure dedicated Temik storage area was only present at one store at Rahad and a temperature of 46°C was recorded at noon, 20/8/85, inside that store as a result of inadequate ventilation. The storage stability of Temik is stated as stable under normal conditions, and its shelf-life as 2 years minimum at 20° (Ref. 20). Degradation increases rapidly with temperature - 10 per cent loss occurs at 25°C after 700 days, at 50° after 80 days, at 60° after 12 days. In Sudan 10 - 15 per cent loss could be expected in 200-300 days (Pers. Com. Union Carbide Co.).

The standards of store control were inadequate. Some storekeepers were unaware of the quantities of Temik received in and quantities issued out. First aid capabilities were non-existent and no staff interviewed had any knowledge of emergency safety procedures. No brushes, pans, buckets, shovels, detergent or sacks to be used in the event of Temik spillage were seen in any stores inspected in the Gezira and at Rahad, and no gloves, boots, aprons or goggles were available.

No protective clothing was worn by staff handling cartons of Temik in the Gezira, or at Rahad. In some cases Temik cartons were thrown from vehicles onto the ground, and staff climbed on top of Temik carton stacks. The standard of Temik storage at the Rahad store used exlcusively for Temik was adequate. At other stores in the Gezira and at the Central Insecticide Store, Rahad, stacks were often more than 12 cartons high, the maximum recommended by Union Carbide (Ref. 20), or littered the store. Temik was stored next to, or on top of, drums of inflamable pesticide. No warning signs specific to Temik were displayed and some stores were not lockable. No personnel interviewed had been specifically trained in the handling of Temik. Most stores were dirty and very untidy and disorganised and, in some, obvious Temik spillage inside and outside the store had been ignored, and no steps had been taken to dispose of it.

The problems seen in 1985/86, a year of carry-over application could be greatly magnified during a full application season. Temik is among the most toxic of all registered pesticides. It is in the Class I Category of toxicants in the USA where it is available for application only by skilled operators certifed by law as competent to handle toxic materials (Ref. 3). Whilst it is recognised that SGB staff have very limited resources at their disposal none of the 17 facility standards listed as necessary for Temik storage by Union Carbide (Ref. 20) was met in the Block stores visited by members of the monitoring team. This not only increases the hazard to people but may also mean sub-standard results from Temik stored under extreme conditions.

3.2.7 Safety Promotion by Manufacturer

The manufacturer has a formal programme for developing and servicing Temik in the Sudan and has agreements with the SGB and Rahad Agricultural Corporation to assist in the application of the product including development of machinery, to supervise application and to actively promote safe use. This last is an essential where so highly toxic a material as Temik is involved. It is thus useful to review the manufacturers safety promotion. These may be considered under four headings:

- Product formulation and packaging
- Application methodology
- Educational and training
- Environmental monitoring

Over their "developmental period" from 1981/82 to 1984/85 the manufacturer's Wad Medani branch have been involved in all four aspects, through information feed-back to the factory in the first and actively in the other three. A company project development document has been issued (Ref. 20).

Formulation and Packaging

Temik for Sudan is a 15 per cent wt/wt granular material, based on gypsum impregnated with aldicarb and a bonding agent and coated with a flow agent (Ref. 16). It is sieved through a 60 mesh and dust content is claimed less than 0.15 per cent by weight. The granules are uniform in size and pour easily.

Packaging is in multi-layered pour-boxes with a tough impact-resistant inner and an corrugated fibreboard outer. The label is English/Arabic. The boxes are easily destroyed by burning. The manufacturer has issued Spillage Report forms, although it is doubtful if these are ever used.

Application Methodology

A strong tractor mounted applicator based on a mechanical metering system driven by a land-wheel has been developed in preference to the more complex and sophisticated pneumatic machines which were insufficiently robust and reliable. Each applicator carries a pictorial safety logo with

(a) Do Not: Smoke/Eat/Drink/Mix by hand.

(b) Do: Wear gloves/Pour Temik direct/Destroy container by burning/Wash after work or if in direct contact.

The manufacturer is responsible for training operators and providing protective clothing in the form of gloves and masks to operators. However they cannot compel their use. In 1983 the manufacturer initiated a USAID funded project which included monitoring operators through urine and blood analysis to assess the level of contamination (Ref. 23).

Education - Training

A major educational programme aimed at tenant farmers and villagers, operators, transporters and stonemen, supervisory SGB staff and doctors has been underway on an annually repetitive basis since 1981. Safety literature has been prepared in Arabic and a training film on Temik use was made and shown in block headquarters and on local TV in 1983 and 1984.

Doctors and hospitals in the area have received information on toxicity, symptoms and treatment in event of poisoning. Atropine kits have been supplied to all centres.

Meetings have been held with SGB staff and with farmers to inform them on the hazards associated with Temik and how it may be used safely.

The results of farmer interviews showed that they are very well aware of the hazards and in fact rate this as the main disadvantage of the product, especially where accidental poisoning of livestock is involved.

Environmental Monitoring

In 1983 a study was initiated, funded by USAID and sub-contracted to the Consortium for International Crop Protection. This involved assessment of residues in cotton plants and cotton seed as well as adjacent but untreated sorghum and vegetables. Degradation in soils and contamination of irrigation and village water supplies was checked. The results of these studies have been reported elsewhere and a summary of important aspects is given in Annex B. Environment Incident report forms have been issued by the manufacturer.

In summary the Consultants consider that the manufacturer of Temik has approached market development in a responsible manner which is to be commended. Obviously there are areas which still require attention, notably storage and inventory control, but the general position shows a professional and responsible approach.

3.2.8 Review of reported cases of poisoning

Cases of poisoning due to carbamates are very difficult to prove medically as sophisticated methods need to be used very soon after suspected poisoning because of the rapid reversal of the effects. It is therefore not possible to say definitely one way or the other whether poisoning due to Temik has been recorded in the Gezira this season. This does not mean however that poisoning by Temik has not taken place.

Two suspected cases of humans having been poisoned by Temik were recorded.

(1) A farmer in village Kehail, block 36 was said to have been ill after working in a Temik treated area this season. Source of information: several local farmers.

(2) One woman was said to have died in the 1984/85 season as a result of Temik poisoning after drinking Temik polluted water at Mellat Hamad Village, block 21. Source of information: Dispensary attendant.

The hazards posed to livestock by the use of Temik are summarised under Subsection 3.2.4. Doubts surround reported livestock mortality due to Temik poisoning. This is because of failure to report suspected cases of poisoning and lack of knowledge about the symptoms displayed by poisoned animals on the one hand, and the reporting of deaths as due to Temik poisoning, in the hope of getting compensation, on the other. On the Rahad Scheme a number of poisoning cases were followed up but none of those cases were proven. In Managil a number of definite cases of livestock mortality due to Temik poisoning were confirmed by group entomologists in areas where Temik accumulations on high ground had not been properly watered in. In North group a definite case of Temik poisoning was reported when two calves and an unspecified number of goats died after grazing where tractors used to apply Temik had been parked. However another case of 14 cattle dying after Temik poisoning was followed up and found to be due in fact to zinc phosphide poisoning (rat poison inadvertently spread where cattle were feeding).

Despite the low number of substantiated cases of poisoning due to Temik it appears probable that livestock deaths actually due to Temik poisoning have not been associated with this, because of the difficulty in proving its presence in the carcasses. Livestock deaths in the Gezira are recorded by vets in Wad Medani. Deaths due to pesticide poisoning are not specifically mentioned in their records and because they are not so diagnosed, deaths due to pesticide poisoning are put in the "deaths due to unknown causes" category. This constituted 25 per cent of livestock deaths in the Gezira in 1984/85 (Vet. Dept. W.M.). The proportion of this figure due to Temik poisoning is unknown but majority farmer opinion is that livestock have been poisoned by Temik on a large scale in the Gezira (Sub-section 3.2.5).

At present, despite its importance, animal production is not a formally managed part of the Gezira agricultural scheme operations. In the event of it being brought under management, the losses due to poisoning by Temik or other chemicals will need to be carefully monitored. A realistic effort should be made now to follow-up suspected cases of poisoning due to Temik. A veterinarian regularly visiting villages in Temik treated areas, counting carcasses and eliminating other likely causes of death should be appointed.

Until some formal system is instituted it is clearly not possible to assess losses economically.

3.2.9 Residues in Soil and Environmental Hazard

Residues of aldicarb in the soil and percolation into groundwater have caused concern in some countries, particularly after repetitive annual applications in agricultural crops at relatively high rates (Ref. 48). In view of proposals to expand the use of Temik in the Gezira from 1981/82 onwards it was thought expedient to monitor the build-up of residues in soil and water as part of an overall Temik Environmental Monitoring programme. The Consortium for International Crop Protection funded by USAID carried out the programme in 1983/84 when an area of 160,000 fd was treated. Their results (Ref. 21) were made available to the Consultants and relevant parts of their report are given in Annex B.

In 1985/86 a limited number of samples were taken and transported for analysis in the United Kingdom at the same laboratory as was used in 1983/84. The scope of this study had to be drastically curtailed from the original proposals due to the necessity to carry out the analyses overseas. Samples were taken in one block where Temik had been applied for four consecutive years to cotton cultivated within the standard rotation. Two other fields were selected randomly for screening of general pesticide residues and aldicarb was included in their tests. The results of the analyses are shown in Table 3.12.

TABLE 3.12 RESIDUES OF TEMIK IN SOIL

Crop	Period of Treatment	Date Dampled	Aldicarb Content - ppm Soil Sample Depth-cm 0-3	3-10	10-20
Cotton	Oct. 1982	5-10-85	ND	ND	ND
Fallow	Oct. 1983	5-10-85	ND	ND	ND
Sorghum	Oct. 1984	5-10-85	ND	ND	ND
Cotton	Oct. 1985[1]	15-10-85	0.20/0.10[2]	0.03/0.02	0.04/0.03
Cotton	Oct. 1985	4- 2-86	0.04	ND	ND

Notes: [1] *Temik treatment between October 6th and 10th, with irrigation the following day. 2.6 lb a.i./fd. Cotton sown about July 31st.*
ND - not detected within limits of glc analysis.

[2] *Two replicated analyses.*

The concentrations of aldicarb in soil sampled 10 days after application was relatively high only in the top strata of 0-3 cm. There was a sharp decline in concentration with increasing depth, falling by a factor of five to ten times by 20 cm depth. Seventeen weeks after application residues deeper than 3 cm were not detectable. The residue in the surface strata of 0-3 cm was still high at 0.04 ppm. The results support and compliment the wider study carried out by CICP in which detectable residues were found only above 60 cm depth. They also found that aldicarb residues generally had degraded to non-detectable levels within two months of application.

In both studies aldicarb residues from fields treated one or more years before were not detectable.

It is concluded that under present application systems aldicarb degrades quickly in the Gezira and there is relatively little downward movement in the soils, even within the first 10 days after application.

3.2.10 Discussion and Recommendations

Three major factors have to be evaluated when considering the use of Temik, namely:

- Does it control whitefly effectively: Here it can be stated categorically that Temik is the only insecticide yet shown to give good effects against nymphs as well as adults. Secondly control of adult whitefly by air-sprayed insecticides is not giving acceptable results at present, and no marked improvement in results can be expected even if application techniques are improved.

- Is it cost effective and how variable is cost/benefit between seasons?

- If both answers are positive then a decision on widespread use of Temik depends on whether its use can be controlled so strictly that the hazards due to toxicity inherent with Temik are not expressed.

The 1985/86 monitoring studies, taken together with the USAID project results, show that the answer to the first is positive but qualified. A final assessment of point two cannot be made until all true yields are available, and even then there must be reservations. The indications, from mid-February, are that the cost/benefit will prove to be positive. This season however, the issue is clouded by fragmentation of areas actually treated, by quality and yields, and by the interaction of annual variation in climate and pest incidence with variety and type of cotton. These factors combine to make reliance on 1985/86 yield figures comparing Temik and non-Temik blocks rather speculative when extrapolated to the coming season.

When considering hazards the findings from monitoring use of Temik show that store facilities, stock control and safety measures must be upgraded. Hazards to operators in the field appear to be insignificant as do those to farmers or workers coming into indirect contact, or villagers with no apparent contact. The hazard to livestock is high but largely is due to failure to control grazing herds, except where a few accidental spillages to road verges occurs. The hazard to the environment appears insignificant.

The following recommendations are made taking account of all factors:

(a) Storage facilities should be upgraded and Temik should only be held in Group or Block stores that are secure, have adequate space, and have full safety facilities including showers, protective clothing and materials to handle spillage.

(b) Inventory control should be tighter to preclude any possibility of diversion of the insecticide to other crop use.

(c) Irrigation scheduling should be tightened.

(d) A disengagement mechanism to prevent accidental application if the land wheel turns when travelling between fields, or turning at field ends, is essential. Perhaps a clutch automatically disengaging whenever the toolbar is hydraulically lifted could be devised.

(e) Application across field ends should no longer be officially recommended.

(f) A planned, statistically valid, study to properly assess the economics of Temik versus air-sprayed insecticides should be undertaken next season. This should be under control of an independant agricultural economist with experience in crop protection.

(g) The Veterinary Department should be invited to collaborate with SGB on a study to establish and quantify livestock deaths due to Temik and other causes. If staff or time is a constraint the study should be confined to a discreet isolated area, such as Gamusi/Maturi groups.

Summary

Providing these recommendations are fully implemented with the other present controls more strictly enforced, and bearing in mind the extreme problem faced by cotton farmers due to whitefly, the Consultants believe the use of Temik could be continued on the Gezira and Rahad, but reiterate their reservations regarding the cost/benefit relationship.

3.3 UREA FERTILISER

3.3.1 Gezira

The rate of nitrogen fertilisation recommended for cotton in the Gezira is 3N per feddan applied 45 days after first irrigation, within a 14 day period on any Number to ensure rapid irrigation and leaching into the soil. (1N is equal to 8 x 50 kg bags 46 per cent urea per 10 fd, or 18.4 kg nitrogen/fd. 3N = 55.2 kg N/fd). In 1985 this recommendation was followed in the old Gezira. On Managil extension however application was at 2N/fd (37 kg nitrogen per fd) in 1985. The reason for this reduction is that no wheat was planted in winter 1984/85, the land being left fallow. This was judged the equivalent of 1N. The urea saved was applied to sorghum, where successive sorghum crops were sown in two seasons on the same land, due to requirement for maximum food production.

Much of urea application on the Gezira was completed by mid-September, before Consultants effective fieldwork was fully under way. Subsequent monitoring showed that flooding caused problems in some areas, preventing men and vehicles getting into the fields. Application by tractor-spreader is preferred but shortages in tractors available means that private ones must be hired. The operators in turn hire spreaders from SGB, but are reported not to undertake proper calibration. This may result in improper distribution, compounded sometimes by lumpy fertiliser. The alternative of manual broadcast is widely used. On the Gezira 55.2 per cent of urea fertiliser was broadcast and 44.8 per cent applied by tractor. On Managil 44.3 per cent was braodcast and 55.7 per cent by tractor. Table 3.13 shows the breakdown for the whole scheme.

In wheat urea fertiliser was applied either as a single 2N/fd dose after sowing and before the first irrigation, or as split doses of 1N/fd before irrigation and around 30 to 40 days after germination. It is estimated that around 25 per cent was applied as a split dose on the Gezira, and this continued until early January.

TABLE 3.13 MODE AND TIME OF APPLICATION OF UREA - GEZIRA 1985.

Period ending	31.8.85		15.9.85		30.9.85		15.10.85		31.10.85	
Group	Hand	Machine	Hand	Machine	Hand	Machine	Hand	Machine	Hand	Machine
South	-	-	3036	1579	21635	10382	23053	11716	23623	11716
Centre	-	-	600	552	15869	7843	16144	11048	18274	11183
Messalamia	-	-	435	544	8341	16906	7755	20309	7759	20309
Wad Habouba	-	-	-	-	9960	7275	10555	8668	10555	8668
Wadi Shair	-	-	-	-	6142	17172	4608	23749	6814	21838
North	2211	-	9236	873	27185	6043	28205	5980	28205	5980
North West	-	-	4410	3223	15298	11840	17528	12077	17720	12077
Mikashel	-	-	-	660	4703	17480	5840	20264	6621	21009
Huda	-	-	445	-	13055	6737	16393	10292	16512	10292
Mansi	-	-	180	45	5888	20254	6600	20538	6506	20637
Tahamid	-	-	-	590	5220	17248	7029	21729	6976	21782
Maatoug	-	-	-	-	7174	10022	8465	17496	9945	17604
Maturi	-	-	-	25	17270	7080	19207	12545	19345	12705
Gamusi	-	-	430	150	21121	8391	24312	10669	25046	10259
Scheme	2211	-	18772	8240	178866	164676	195701	207081	203904	206061
% Final area			4.6	2.0	43.6	40.2	47.7	50.5	49.7	50.3

3.3.2 Rahad

Observations of urea fertiliser application, using Vicon spreaders, were made on the Rahad scheme. Application was very uneven leading to areas of thickly applied urea and areas with no fertiliser at all. Tractors did not slow down at cross field ridges and furrows (jedwals), which caused damage to the ridges and to the tractors. The colour and growth of cotton plants when examined one to two weeks after application and irrigation was quite uniform, showing little evidence of the uneven application. This was probably due to the fact that urea, being highly soluble in water, was spread with the irrigation water.

3.3.3 Summary

The use of urea fertiliser in cotton needs to be carefully assesssed in a wider sense than the direct potential for yield increases, and of possible variation due to soils. This has been investigated in depth in the past. With the increasing problems of whitefly it would seem of importance to review this work in the changed circumstances. High nitrogen fertilisation may lead to vegetative cotton with high leaf nitrogen that is attractive to whitefly,and also limits pesticide penetration to within the upper third of the crop canopy, reducing the effect on the pest (Annex A). Where the whitefly is not controlled yields are reduced and sticky cotton results. In economic terms there may be no benefit from fertilisation.

3.4 HERBICIDE APPLICATION - 1985

3.4.1 General

Use of herbicides is now standard practise in cotton. Table 3.14 shows how this has developed over the last ten years and Table 3.15 gives the herbicides currently recommended and areas treated in 1985. The most important weeds of irrigated crops are:

Cyperus rotundus	Ipomea cordofana
Ischoenum atrum	Rhynchosia memnonia
Cynodon dactylon	Abutilon glaucum
Echinochloa colonum	Heliotropium sudanicum
Sorghum sudanense	Setaria sp.
Cotonum fasilicum	

Herbicide applications in irrigated crops normally begins in June and continues to the end of July in the Gezira and Managil regions. They tend to be earlier in Rahad and rather more spread in White Nile, Blue Nile and New Halfa. It was therefore only possible to observe a few applications in Southern Gezira, but confirmation of observations was obtained in discussions with SGB and chemical company staff. Spraying is with tractor-mounted equipment and the application volumes varied from 10 to 15 gallons per feddan using Spray Systems fan-jet nozzles 8004 or equivalent. The tractors are provided through the respective Agricultural Corporations together with overall organisation and management. Much of the spray equipment and technical supervision of the spray operation was supplied by herbicide manufacturers.

TABLE 3.14 DEVELOPMENT OF HERBICIDE SPRAYING IN GEZIRA AND MANAGIL 1976 - 1986

Season	Area treated	Percentage of cotton area
1976/77	35,553	8
1977/78	209,471	45
1978/79	272,209	51
1979/80	426,978	80
1980/81	401,728	80
1981/82	382,432	87
1982/83	482,323	99.6
1983/84	480,699	96.6
1984/85	496,265	98
1985/86	354,540	85

TABLE 3.15 HERBICIDE APPLICATION 1985

		Area (fd)		
Cotton	Product	Gezira	New Halfa	Rahad
	Zorial 80	73,625	33,090	11,520
	Ronstar 25	6,615	7,585	-
	Cotodon 40	43,000	-	3,730
	Goal 24	48,655	-	2,340
	Cotoran Multi	35,405	-	-
	Stomp 500	52,840	-	9,505
	Karmex/Goal	4,865	-	-
	Karmex/Zorial	13,905	-	-
	Karmex/Ronstar	59,840	-	10,645
	Stomp/Karmex	15,635	-	-
	Stomp/Cotoran	-	4,125	-
	Ronstar/Cotoran	-	8,785	-
		354,540	**53,585**	**37,740**
Groundnut	Ronstar 25	Not recorded		
	Tok	Not recorded		
Sorghum	Sorgo prim	3,140		

The principal constraints to productivity and quality of herbicide application are:

- the rainy season hampers transport, preventing entirely delivery of products to spray site and interfering with supervision and execution of application plans. On the other hand moist soil conditions are important for good herbicidal effect;

- the operators have a habit of cleaning nozzles with nails or similar pieces of metal which destroy the ovoid shape of fan-jet orifices thus spoiling distributive patterns. A secondary effect is to increase output, which leads to increased tractor speed (good for private contractors paid by area treated) and increased breakage of spray equipment;

- the ground is uneven and considerable spray boom movement is unavoidable.

Despite the above, the quality of weed control observed was, generally, outstanding. This has partly been attributed to the moist soil conditions at application. It is suggested that further improvement could be made to distribution quality by arranging nozzles to spray at a more horizontal than vertical angle - say 30° below horizontal. Not only does this minimise the effect of spray boom movement and blocked nozzles but it also enables booms to be mounted lower and may thus reduce drift in the strong winds experienced during herbicide treatments.

The fitting of flood-jet (Spray Systems TK) nozzles may also give improvements. These have a circular instead of ovoid orifice, which in itself reduces the chance of blockage and some effect of wear. They produce wider angles and, especially when used in the "near horizontal" position, cover wide paths. This, in turn, permits wider spacing and still larger orifices, further reducing blocked nozzles and filtration problems. Flood-jet nozzles fitted to spray almost horizontally in "ridged" field conditions provide a more even coverage of the ridge surfaces (measured in terms of applied product) as a result of the overlapping trajectories of droplets produced by this method.

Volumes lower than 10 - 15 gallons are easily applied by TK nozzles in tractor applications. Reduction in applied volume would definitely aid productivity and thus help to achieve planned targets despite rainy conditions.

While good results with flood-jets are usual in other similar regions, it is recommended that experience should be obtained on limited areas under Sudan conditions as a prior step to changes on a larger scale. If trial areas with TK nozzles are considered, the Consultants recommend that stainless steel nozzles should be compared with the standard bronze material. The combination of less wear and thus better overall spray patterns usually prove adequate justification for the cost involved.

3.4.2 Admixture with Fertiliser

On New Halfa 20,060 fd were treated with the herbicide Zorial added to urea at 2N/fd, with old engine oil used as a binding agent. The rate of Zorial was planned for 6.25 kg/fd. The mixture was applied with Vicon spreaders in the northern area. Zorial has been applied successfully this way for some years, partly because the herbicide tolerates heat and dry soil conditions. Irrigation may be as much as 10 days later. However, it has been found on the Gezira that coating urea with powder formulations of herbicides and applying it before sowing results in an uneven distribution of the herbicide and loss of nitrogen (Ref. 6). This method of application was dropped on Gezira this season.

Aerial application was also used in the past (1984/85 19.5 per cent area) but has been dropped for the same reason, and also due to problems of drift onto adjacent other crops.

CHAPTER 4

PESTICIDE SAFETY

This subject received attention from both the full-term field team and a short-term specialist, whose detailed report is presented as Annex C to this report. In this chapter a summary of these findings only is given with some additional data generated in the field from schemes other than the Gezira.

4.1 STORAGE

4.1.1 Gezira

The central store for the whole Gezira is at Gorashi siding, Hassa-heisa, with an area of 30 fd having a perimeter fence. There are six or eight huge closed corrugated-iron warehouses for seed, fertiliser, baling material, etc. and two large open-sided sheds for herbicides and small quantities of pesticide. The bulk of the pesticides are stored in product-blocks of drums in the open, adjacent to the Gezira light railway. All pesticides are delivered by truck and distributed to Group and Block stores by the light railway. SGB have plans to transfer all pesticide to a new storeage site at Maragan near headquarters. Temik stocks are already held there in closed and locked stores.

All new deliveries of product are physically checked on arrival and the local agents are responsible for re-packing. All casual labour for handling drums are contract supply, with the contractor responsible for the well-being of the workers, including the event of an accident. From arrival at Hassa-heisa to delivery to Block store drums are handled five times.

Conditions in the Group and Block stores are described in Annex C, and vary between blocks. The main method of storage of 45 and 5 gal. drums is in the open with no protection at all. Security provided by fencing is frequently poor. The argument that security is unnecessary since no farmer would apply the cotton chemicals, and those for vegetables can be obtained SGB, is spurious. One farmer is reported to have died on 24/12/85 while spraying his sorghum and it is thought this was due to pesticide intoxication. The source of his insecticide was unknown (Pers. Com. Consultant Field Assistant, White Nile).

The main argument for construction of covered storage is to prevent degradation of chemicals. Air temperatures of 40°C are common. Drum temperatures rise to 60°C. This is fully accepted by SGB and an agreement has recently been concluded with the EEC to provide LS 3 million for construction of 16 stores. Their construction is due to start shortly when tenders have been evaluated and awarded. The design of these stores is based on detailed drawings provided by GIFAP (Group International des Associations Nationales de Fabricants de Produits Agrochimiques) and TDRI, London. These 16 stores are Group area stores. The Block stores will also have to be upgraded and a minimum recommendation would be half-walled roofed sheds. Costs may be held down and temperatures reduced, while retaining ventilation by using shade netting (e.g. Tildenet or Netlon) on the sides. This material has been proven by years of horticultural use in the Arabian Gulf area.

Store siting should be reviewed to avoid problems of flooding, fire-risk (fuel depots), contamination of water for human and livestock consumption, and being near to offices and houses.

In all stores a wide range of facilities are lacking, many of which could be supplied relatively cheaply. These include:

- Washing facilities and showers
- Protective clothing - overalls, boots, headwear
- Repacking equipment - pumps, funnels, buckets
- Dunnage for long-term storage
- Hazard warning signs
- Firefighting equipment
- First aid equipment

Training in use of these facilities and in general store management is seriously lacking with few of the storemen having been trained at all. Training should ensure the storemen understand the toxic hazard of the great majority of pesticides.

The lack of proper labelling is discussed in Annex C in detail. When revising the pesticide tender document labelling requirements were rewritten to include the recommendations made. A requirement to paint drums in pale colours was also included.

4.1.2 Rahad Agricultural Corporation

The central store at Rahad has a single small enclosed store, a medium covered shed area, and a far from adequate open storage area to handle the quantity of pesticide and empty drums which pass through. It is generally inadequate in every way. There is also no separate office on site, nor communication with the main office 4 kms away where the Chief Storekeeper is based. Perhaps as a result of these facts the store was also sub-standard in other ways:

- It was disorganised, untidy, had mixed herbicides and insecticides adjacent, and different products were haphazardly stored together.

- There were many leaking drums of hazardous products.

- Watchman's bed made up of old chemical cartons and wrappers on top of drums.

This situation was brought to the attention of the authorities early in the season but with little apparent effect. Comments made in Section 4.1.1 mostly apply also to Rahad.

4.1.3 New Halfa Agricultural Corporation

The central store here receives all chemicals and distributes these to five area stores, all of which are open stores. It is planned, however, to construct some buildings. At present materials needing protection from the weather are temporarily stored in other departments stores.

The New Halfa turnover of stock is far less than Gezira or Rahad so that the size of their problem is reduced. Comments made in Section 4.1.1 however still apply.

4.1.4 White Nile Corporation

Again there is a central store for the corporation near Kosti but due to the dispersed nature of the area the regional stores are as important and even larger than Kosti. In view of their level of facilities the authorities were in general to be congratulated on their efforts as evidenced by the organisation and order. This was especially at Duiem, considered to be the best layout and operation examined by the consultants (handling 20,000 fd cotton).

Conversely the store at El Geiger was considered the most hazardous being dangerously situated between three orchards and with a village canal water supply on one side, and a livestock route on the other. The storeman, family and domestic stock live in the store area, which is unfenced and without buildings, sheds, or any cover at all. The storeman's family was given a cholinesterase inhibition test (Ref Annex B). A detailed report on the situation was made to the Corporation with a request for early action on listed recommendations.

4.1.5 Recommendations

These are detailed in Annex C and summarised as follows:

- Open store areas should be converted to semi-enclosed stores (roofed, low side walls, shading, large side access).
- All store areas should be securely fenced.
- Store sites should be separated from houses, offices, fuel depots.
- Washing facilities, protective clothing, and first aid kits should be provided, and training given in their use.
- Repacking equipment should be supplied including chemical-resistant rotary pumps, funnels, sieves and buckets.
- Old stock should be stored on dunnage to reduce corrosion.
- Hazard warnings to be displayed.
- Requirements for drum labelling to be enforced.
- Firefighting equipment to be provided.
- Store management training to be introduced.
- Herbicides and insecticide storage to be separate.
- Old pesticide stocks to be disposed of (Ref. Section 4.5).

4.2 TRANSPORT AND AIRSTRIPS

Transport from Port Sudan to site was by large lorry with trailers. During the season only one accident is known to have occurred, where a trailer appeared to have had a slow smouldering fire and turned over, shedding its load, some drums of which (7 - 8) were badly burnt, while the balance (65 drums) were undamaged. According to local chemical analysis none of the drum contents were sub-standard. Taking account of the total pesticide importation loss in transit is very small over the season.

Drums were however stacked dangerously, up to five high (layered vertical and horizontal on lorries with high sides). The normal load for lorry plus trailer is 55+ 75 x 45 gal. drums. When unloaded by rolling off onto an old tyre occasional splitting of drums is inevitable. However this loss being before delivery is deemed to be at suppliers cost since repacking at the central store is suppliers responsibility.

Transport and damage between corporation stores is discussed in detail in Annex C. Delivery from block store to airstrip is the responsibility of the airspray contractors, not the corporation. It is recommended to use wood ramps plus ropes to unload drums but a requirement for this would have to be written into the contract and enforced by the corporation supervisor for there to be any hope of implementation.

At no airstrip was the situation regarding safety procedures satisfactory, although conditions were seen to improve during the season. The following aspects of airstrip safety are discussed in detailed in Section 3.1.3 (iii), in Chapter 5 and in Annex C:

- Loading operations, equipment and safety.
- Protective clothing, availability and misuse.
- Staff training and supervision, the poor level found and the importance of training staff and improving standards.
- The low level of safety as shown by the blood cholinesterase monitoring programme.

Recommendations to correct these deficiencies are made elsewhere. As noted above implementation of these depends on redefining areas of responsibility and, if this is to remain with the airspray contractors, in extending their contract periods to permit return on the necessary investment in equipment and training.

4.3 FARMERS, FIELD WORKERS AND SCOUTING TEAMS

4.3.1 Notification of Spraying

Notification of spraying is supposed to be by the corporations Crop Protection Departments to the Tenants organisations and so to the villages and farmers whose fields are to be treated. On Rahad and New Halfa schemes this system was working adequately, with 72 and 66 per cent of farmers stating they were advised in time. On Gezira only 23 per cent stated they received advice of spraying, a similar percentage to that found on the White and Blue Nile Schemes at 27 per cent. (These percentages are based on a slightly greater overall survey of 258 farmers than that of Annex C). Clearly the system is generally unsatisfactory.

4.3.2 Awareness of Insecticide Hazard

Most farmers and their families have many years experience of cotton and are aware of the hazard from spraying. If they remain in the field this is because their experience is that no harm will befall them from being sprayed with modern chemicals. Experience of endrin in the sixties was different, as a White Nile farmer said "The old chemicals were more strong". However markedly fewer persons remained in a field later in the season after the main period of weeding was over, and clearly farmers' and workers' desire to complete the job was greater than their concern over hazard. In this they are probably correct as the amount of chemical a person collects from two or three spray passes is very low. However if flagmen are introduced, as has been recommended, the hazard would be much greater from respective exposures, perhaps for many successive days. (Flagmen must be monitored for blood cholinesterase inhibition on a regular twice weekly basis).

The lack of awareness among farmers that insecticides could be absorbed through the skin (of 258 farmers questioned only 32 per cent knew) is disturbing. The more so when their knowledge of Temik hazards is so much better, due to the manufacturer's safety promotion campaign. There is great need to educate farmers on pesticide toxicity hazards. It is, however, reassuring that only 8 per cent of farmers knew of cases of persons who had shown symptoms of pesticide poisoning.

4.3.3 Recommendations

- The system of notifying farmers and workers of spray programmes should be revised and improved. Perhaps a system based on daily announcements on a Gezira radio could be introduced.

- Extension Service efforts to promote greater awareness of insecticide hazard are necessary. Chemical manufacturers should be pressed to collaborate in this promotion.

4.4 DISPOSAL OF OLD PESTICIDE CONTAINERS

A very great number of drums have to be disposed of every season. An unknown proportion of these are used for storing or moving fuel, or even are converted to lorry fuel tanks. The majority however are cut up and recycled. These are supplied from corporations either

- direct from Group or Block stores as ex-store sales;
- offered to purchasers on a tender sale basis;
- sold in bulk to an individual merchant who collects and disposes.

The prices varied between schemes and districts from LS 10 to LS 20 per drum.

None of the production corporations consider it to be their responsibility to clean drums before sale, even to individuals who purchase, perhaps unofficially, a few drums for home use. The corporations merely accept responsibility to warn purchasers of the potential hazard. At one store only, Duiem in White Nile, was effective action to wash and "fire" drums taken before sale.

The Consultants consider that the corporations should take full responsibility for cleansing of pesticide containers in the future, and recommend that a statutory commitment to this effect be enacted by government as soon as possible.

4.5 DISPOSAL OF OLD PESTICIDE STOCKS

4.5.1 The Problem

Stocks of either prohibited or outdated pesticides are held by most block or scheme stores on all corporations, and in fact there may be small numbers scattered throughout Sudan. These stocks derive either from the ban on DDT and other organochlorine pesticides, or from withdrawn recommendations, or simply from a few end-of-season drums of odd insecticides which have never been used. There are also considerable stocks of defoliant at Rahad which may have deteriorated. The quantities are indicated in Table 4.1 but these are estimates of central store stocks in most cases and are by no means accurate. For White Nile stock figures for three scheme stores are included.

The quantities involved are considerable, particularly of DDT and DDT mixtures. The recorded total of these is almost 136,500 gallons. This represents perhaps two-thirds of total stocks. All is from 10 to 15 years old and the condition of containers is extremely poor. Much of the stock is thought to have solidified. This material is a serious source of environmental pollution since the drums lie rotting in the open in areas liable to flooding, including the Hassa-heisa central Gezira store. In many cases flood water drains directly into river channels.

The organophosphorous products are of low environmental pollution hazard, but are much more dangerous to the storeman, workers families and livestock which regrettably are in the 'open-store' areas. In some cases the drum-metal was 50 per cent corroded away and storemen were afraid to move the drums. Fortunately these conditions were noted on only two or three occasions.

TABLE 4.1 STOCKS OF BANNED OR OUT OF DATE PESTICIDE

(Estimates 45 gal. drum except where indicated)

Product	SGB	Rahad	New Halfa	White Nile
DDT[1]	1464		814	276
Heliotox[1]	30(?)	7	66	13
Dimethoate	20(?)	40		
Metasystox	10			
Anthio	50			115
Citrolane			21	11
Bidrin			15	3
Hostathion			18	12
Phosvel			48	
Torak			35	
DDT/Bidrin[1]			13	
Azodrin			58 gal.	2
Ripcord/Bidrin		8		
Ekatin		6		8
Nuvacron		30		
Curacron		50		
Decis EC		80		
Torbidan[1]		350		2
Endosulphan		60		
Sevinol				22
DEF		1550 x 20 L		
Gramoxone		1880 x 5 L		

Note: [1] *Products containing DDT. The drums labelled Torbidan are believed to actually be 25 per cent DDT, packed into old Torbidan drums. This should be confirmed by analysis since Torbidan was a DDT/toxaphene/Methyl parathionmixture.*

4.5.2 Recommendation for Incineration

The scale of the problem is so great that disposal by traditional burial in a landfill site with slaked lime treatment is impossible. Use of DDT for mosquito control would be an economically desirable way to dispose of sprayable material. This is likely to be a small part only of the total. The same applies to use against Quelea of those organophosphorous products which are toxic to birds. These courses of action have been approved by the Pests and Diseases Committee but it is unlikely to absorb much of the product.

During the course of the project the recommendations for pesticide disposal were discussed with corporation officials and Shell Chemicals Sudan Co., who operate the only mobile incinerator in Northern Africa. This is available from Wad Medani and following discussions Shell quoted for incineration on a per ton pesticide basis. Site selection was discussed by SGB, Shell and the Dept. of Occupational Health and areas of responsibility were resolved.

SGB were to be responsible for transportation within the Gezira area to the site selected by the three parties. Shell Chemicals were to supervise repacking of the insecticide drums which were too corroded for transportation, and would undertake incineration at a rate per ton chemical, which would be agreed by drum dipping beforehand. The cost of incineration is high since one ton liquid fuel is used per ton product (5 x 45 gal. drums). The time required is long since rate of work (5 to 11 am) is slow.

It is recommended that a programme of incineration is begun as quickly as possible, particularly since it is understood that donor financing is available if necessary.

CHAPTER 5

MONITORING OF CHOLINESTERASE INHIBITION

5.1 GENERAL

The main objectives of the investigation of cholinesterase inhibition in human beings in the cotton regions treated with aerially applied organo-phosphate and carbamate pesticides was to determine:

- if risks to the population exist due to exposure to these insecticides
- whether any such risk apply to specific segments of the population
- the extent of the risks

A secondary objective was to ascertain if possible the reasons for any contamination discovered.

The methodology and interpretation of results has been based on the following authorities:

(a) The significance of blood cholinesterase measurements - J.C. Gage, 1957.

(b) Blood tests for users of O.P. Insecticides - E.F. Edson, 1958.

(c) Guidance Note NS 17. Biological monitoring of workers exposed to organo-phosphorous pesticides. HMSO.

Five cotton regions were chosen for study, North Gezira, South Gezira. Rahad, New Halfa and White Nile. The Lovibond Cholinesterase Kit (AF 267) was chosen for it's suitability for use in field conditions and because the consultants had used it in similar conditions with very satisfactory results.

A team, responsible for each area was trained in the use of the kits. The teams comprised one of the consultant field staff, a medical assistant provided through the Sudan Health Department, and one of the Consultants Sudanese Technical Assistants. The teams liased with the appropriate corporation authorities.

Unfortunately the Lovibond Kits were not released by the customs authorities for several weeks after arrival and this delayed start of the monitoring investigations. Furthermore the intensity of the aerial treatments varied through the cotton growing season, and the spraying season varied from region to region. 2121 analyses (Annex D) were carried out and, despite these set-backs, the interpretation of the analyses obtained are considered to be significant.

5.1.1 Methodology

The actual analytical process used is that described in Annex D. under Technique (a) of the pamphlet "The rapid field determination of cholinesterase" (Ref - 26). Many of the analyses were performed on worksites under difficult working conditions. For this reason particular attention was given to cleaning the 'finger prick' site.

Three basic groups were chosen for analysis:

- Group I consisting of persons who should have no contact with pesticides such as schoolteachers, shopkeepers, clerks etc. Persons in this group did however live in areas being treated with pesticides.

- Group II consisting of persons not working with pesticides but indirectly in contact with them such as farmers, pest scouts, entomologists, irrigation controllers or fieldworkers.

- Group III consisting of persons working directly with pesticides such as pilots, engineers, aircraft cleaners, loaders, drivers and supervisors.

It was anticipated that difficulty would be experienced in continuously monitoring particular individuals throughout the season in all these Groups. In fact a reasonable number of individuals were checked over the whole period. Due mainly to the late receipt of the kits it was not possible to obtain pre-spray analysis except at New Halfa. Every endeavour was therefore made to obtain the largest possible numbers of samples in each Group in order that significant comparisons might be made. In addition the public health spray teams working in Fau refugee camps and in Rahad Agricultural Corporation were analysed on request. Results are shown separately in Annex D.

Any analysis which appeared illogical or anomalous was carefully investigated and has been excluded from compiled Group results if jusitification was adequate. For example, persons with known hepatitis have not been included. All anomalies encountered are reported seperately (Annex D).

5.2 RESULTS OF SURVEYS - AERIALLY SPRAYED REGIONS
(See Section 3.2.4 for Temik granule ground treated area)

5.2.1 Comparison between regions and groups

Results are given graphically in Figures 5.1 to 5.4. Figure 5.1 shows notable similarity between regions and illustrates conclusively that:

- Group III, persons working directly with pesticides, is contaminated to an unacceptable degree.

- Group II, persons indirectly in contact with pesticides, show no significant contamination.

- there is no significant contamination in Group I which had no direct contact with pesticides.

The difference between regions in Group III in the case of Kosti (White Nile)is due to the low number of supervisors compared with other regions.

It can be seen from the histograms in Figure 5.1, that the 'indirect contact' and 'no contact' Groups in the Gezira show a slightly higher proportion of 87 and 75 per cent cholinesterase levels than Rahad, White Nile or New Halfa. The reason for this may be a difference between the Assistant's techniques, the fact that the villagers in the Gezira are situated in closer proximity to treated areas (Annex D - Collection, Treatment and Interpretation) the greater number of treatments, or a combination of these factors. It will be seen from Figures 5.2 and 5.3, that contamination in the 'direct contact' Group increased as the season progressed and declined again towards the end of the season. The other two Groups do not show this tendency to a significant degree.

FIGURE 5.1 CHOLINESTERASE ANALYSIS

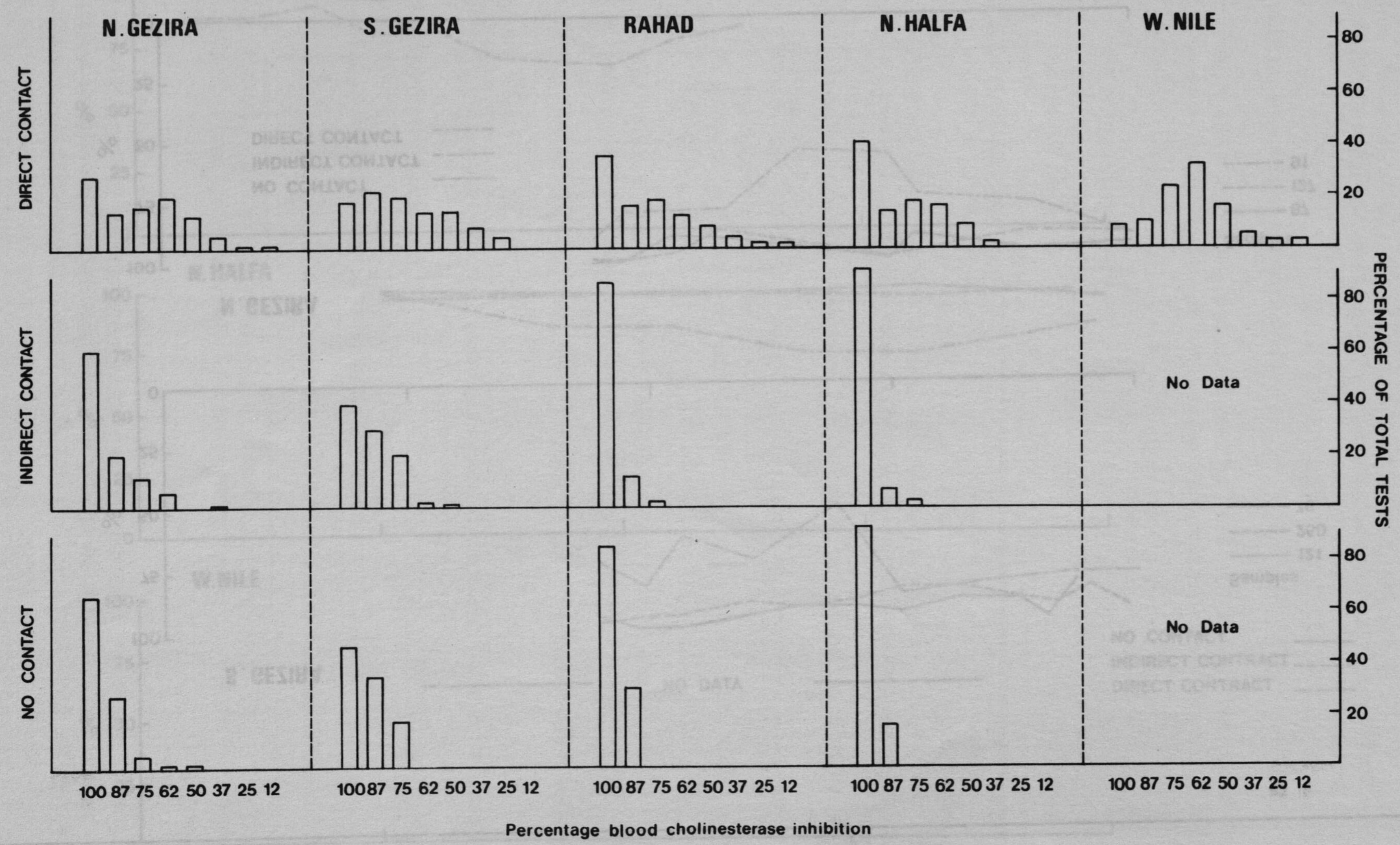


FIGURE 5.2 CHOLINESTERASE ANALYSIS

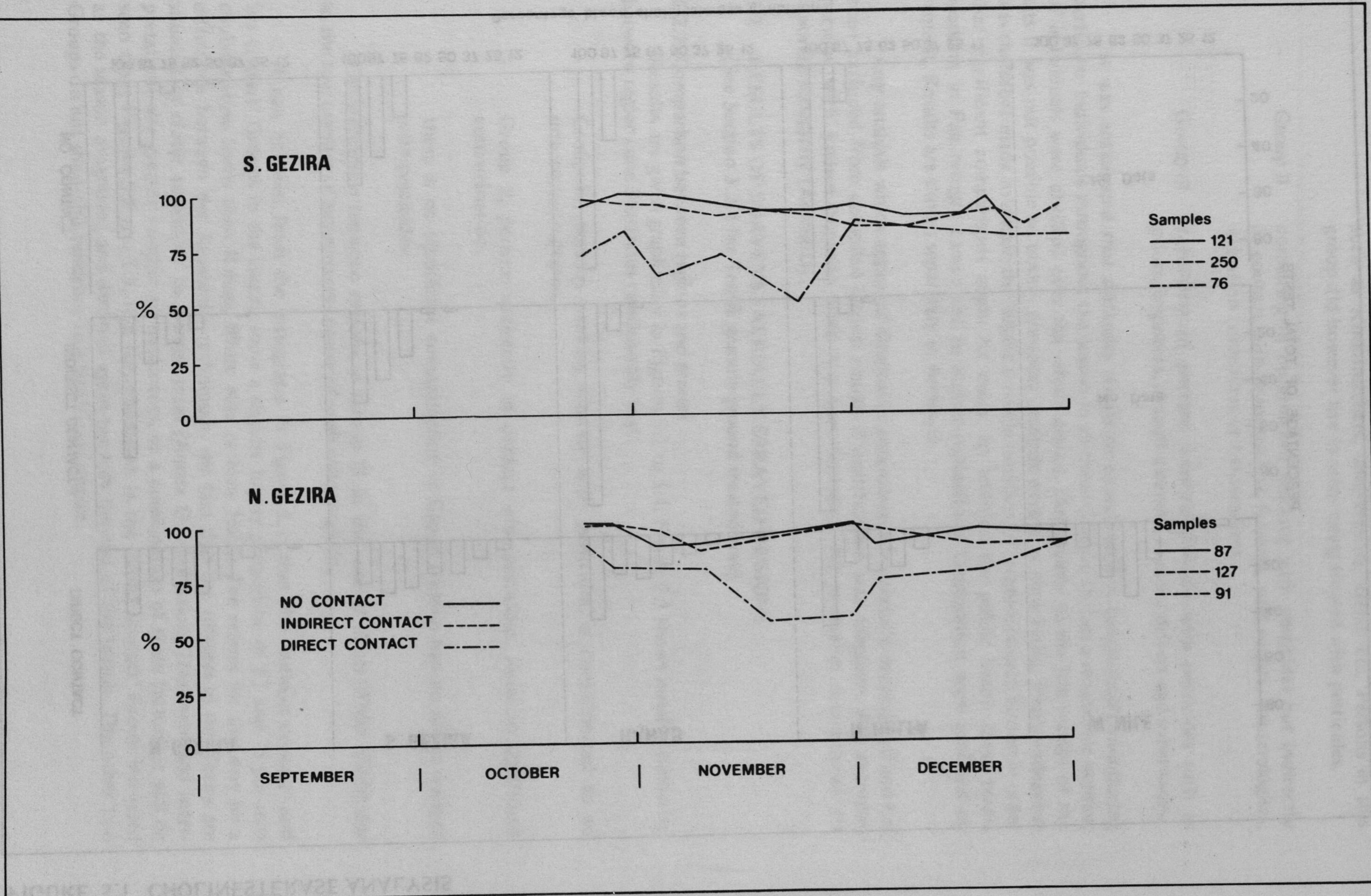


FIGURE 5.3 CHOLINESTERASE ANALYSIS

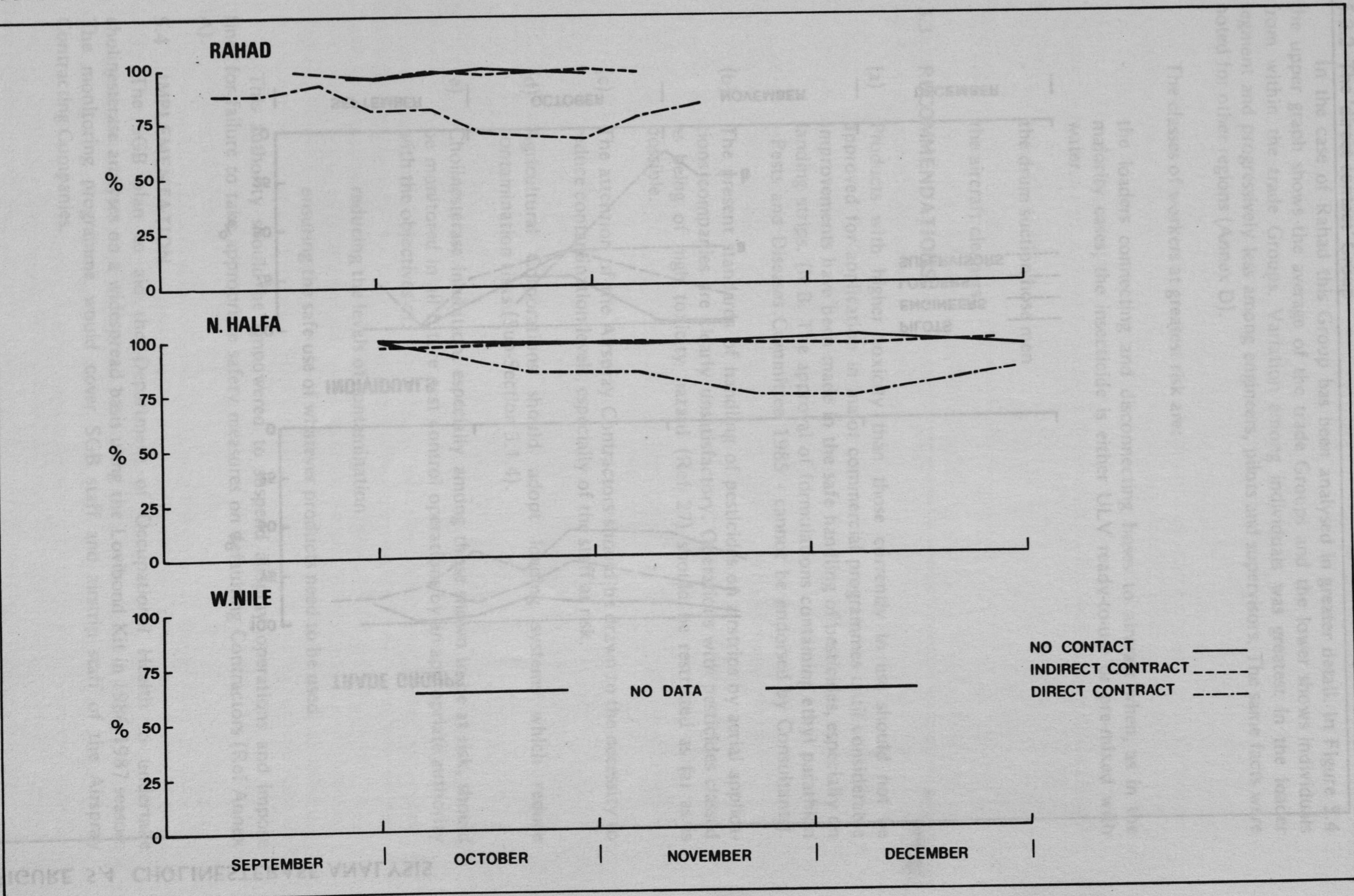
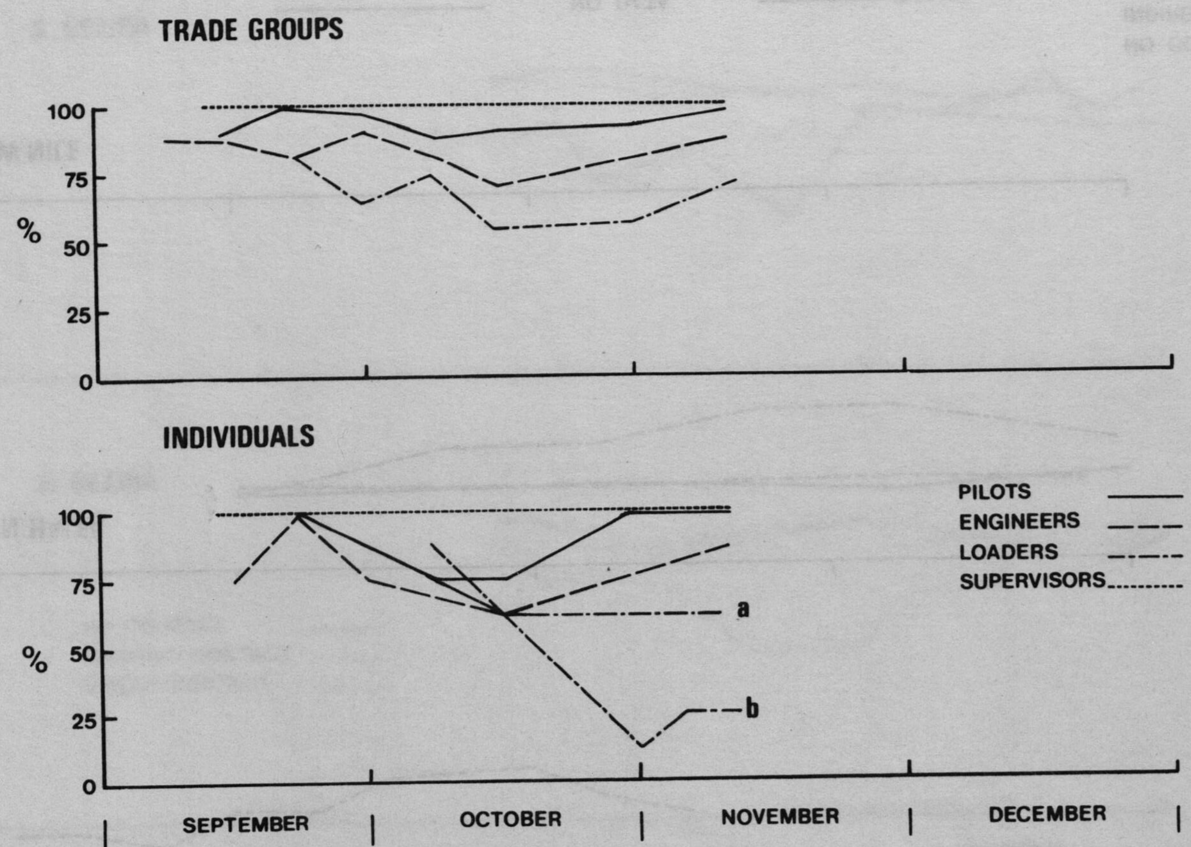


FIGURE 5.4 CHOLINESTERASE ANALYSIS



5.2.2 The 'direct contact' Group

In the case of Rahad this Group has been analysed in greater detail. In Figure 5.4 the upper graph shows the average of the trade Groups and the lower shows individuals from within the trade Groups. Variation among individuals was greatest in the loader segment and progressively less among engineers, pilots and supervisors. The same facts were noted for other regions (Annex D).

The classes of workers at greatest risk are:

- the loaders connecting and disconnecting hoses to aircraft when, as in the majority cases, the insecticide is either ULV ready-to-use or pre-mixed with water.
- the drum suction hose men
- the aircraft cleaners.

5.3 RECOMMENDATIONS

(a) Products with higher toxicity than those currently in use should not be approved for application in major commercial programmes until considerable improvements have been made in the safe handling of pesticides, especially on landing strips. (N.B. The approval of formulations containing ethyl parathion - Pests and Diseases Committee 1985 - cannot be endorsed by Consultants).

(b) The present standards of handling of pesticides on airstrips by aerial applications companies are clearly unsatisfactory. Operations with pesticides classed as being of high toxicity hazard (Ref 27) should be restricted as far as is possible.

(c) The attention of the Airspray Contractors should be drawn to the necessity to reduce contamination levels, especially of the staff at risk.

(d) Agricultural Corporations should adopt loading systems which reduce contamination risks (Sub-Section 3.1.4).

(e) Cholinesterase inhibition, especially among those shown to be at risk, should be monitored in all future pest control operations by an appropriate authority with the objectives of:

- reducing the levels of contamination
- ensuring the safe use of whatever products need to be used

This authority should be empowered to suspend airspray operations and impose fines for failure to take appropriate safety measures on defaulting Contractors (Ref Annex A).

5.4 IMPLEMENTATION

The SGB plan to aid the Department of Occupational Health to undertake cholinesterase analyses on a widespread basis using the Lovibond Kit in 1986/1987 season. The monitoring programme would cover SGB staff and airstrip staff of the Airspray Contracting Companies.

CHAPTER 6

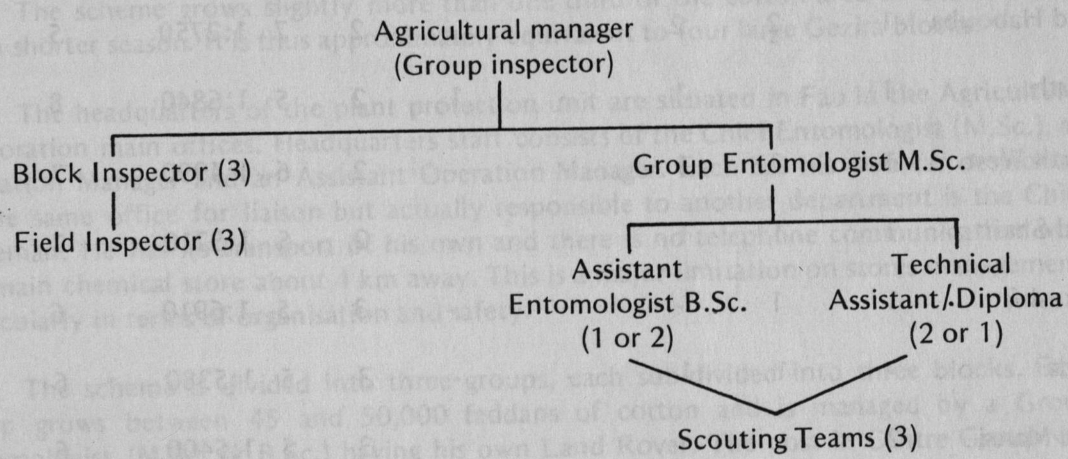
STAFF AND TRANSPORT: CROP PROTECTION DEPARTMENTS

For effective use of the agricultural inputs provided by the donor, particularly pesticides, it was essential that sufficient trained personnel with adequate transport should be available. The Consultants were required to report on this during the course of the project. The general situation on the four major schemes is reviewed in this chapter. Chapter 7 discusses the requirements for staff for scouting on the Gezira in greater depth.

6.1 THE GEZIRA SCHEME

6.1.1 Staffing I

The Sudan Gezira scheme, administered by the Sudan Gezira Board is composed of the original Gezira scheme, plus the Managil extension. It is made up of 14 administrative groups, and organised as follows:



General management of the Group is under the Group inspector who is responsible for irrigation, fertiliser distribution and harvest. The task of crop protection is the responsibility of the Group entomologist (M.Sc.) who should have three assistants. Depending on staff availability these may be one or two assistant entomologists (B.Sc.) and one or two Technical assistants (Diploma level). They act as team leaders of the scouting teams. Scout numbers and ratios of scouts per area is discussed in Section 7.1.2. Lack of staff has been cited as a reason for occasional failure to complete pest scouting and air-spray supervision to satisfactory standards on the Gezira. Staff numbers on the Gezira and Managil are given in Table 7.3.

6.1.2 Transport Situation

The number of vehicles available per group depends on the number of assistant entomologists, including the technical assistant, and the number of scouting teams in that group. Table 6.1 summarises the position. One of the two cars at the disposal of the group entomologist serves as a reserve vehicle and is for private use by the technical staff. The ratio of available operational vehicles to cotton area averaged 1:5420 fed but ranged from 1:2750 for Wad Habouba, clearly over-supplied, to 1:7060 for Gamusi. Group entomologists gave their minimum requirement as six to eight vehicles with ten persons wanting (from their own experience) seven vehicles. If the mean area for a group is assumed to be 30,000 fed for most seasons with seven operational vehicles, then a vehicle:area ratio of 1:4300 is obtained. The estimated vehicle requirement on this basis is given in the last column of Table 6.1.

TABLE 6.1 CROP PROTECTION DEPARTMENT TRANSPORT - GEZIRA 1985-86 TYPES AND NUMBERS OF VEHICLES

Group	S.G.B.			Hired			Actual		Estimated
	Land Rover	Saloon	P.U.	Land Rover	Saloon	P.U.	Vehicles	Ratio Vehicles:fed	Requirement 1:4300
South	-	2	2	-	-	2	6	1:5890	8
Centre	1	2	1	1	-	2	7	1:4330	7
Messeiiemia	1	-	1	-	1	3	6	1:4850	7
Wad Habouba	1	2	2	-	-	2	7	1:2750	5
North	1[1]	-	1	-	1	2	5	1:6840	8
North West	1	2	1	-	-	2	6	1:4990	7
Wad Shair	1	1	1	-	-	2	5	1:5710	7
Mikashfi	1[1]	1	-	-	-	3	5	1:6910	6
Huda	-	1	1	-	-	3	5	1:5380	6
Wad Mansi	2	-	-	-	-	3	5	1:5400	6
Tahamid	[1]	1	1	-	-	3	5	1:5750	7
Maataug	[1]	1	2	-	-	3	6	1:4590	6
Maturi	-	-	1	-	1	4	6	1:5410	8
Gamusi	-	1	-	-	-	4	5	1:7060	8
Average							6	1:5420	7

Notes: [1] *One vehicle unserviceable at time of survey.*

Because pest problems in the northern Gezira are generally less serious, northern Groups are considered to require fewer vehicles for pest control, which may explain the difference in current vehicle allocations. Efficient assessment of insect infestations however requires scouting intensity to be related to the area of cotton grown and the uniformity of infestation, not to the actual level of infestation. There is unlikely to be too much variation in uniformity of infestation over the Gezira. In 1985/86 season pest levels were also high in the northern areas.

The general position regarding transport was considered just adequate on Gezira and Managil in 1985/86. Scouting was not adversely affected but spray supervision may have been. It is anticipated that problems regarding transport will arise next year in view of the condition of many vehicles (Section 7.1.2). The allocation of vehicles should be reviewed in light of the above comments, taking account also of suggested increases in numbers of teams (Table 7.3), the homogenity of the group, and road links. A long narrow group would possibly need more vehicles than a rectangular one of the same size. In particular vehicle allocation to the Managil area appears to need increasing.

6.1.3 Recommendations - Transport for Gezira

The allocation of vehicles on Gezira should be reviewed in conjunction with the recommendations for changes in scouting procedures. A more realistic allocation of vehicles with regard to planted area and group layout and homogenity is needed.

Consideration should be given to use of motorcycles by Team Leaders and Airstrip Operations Supervisors.

6.2 RAHAD IRRIGATION SCHEME

The scheme grows slightly more than one third of the cotton area of Gezira over a much shorter season. It is thus approximately equivalent to four large Gezira blocks.

The headquarters of the plant protection unit are situated in Fau in the Agricultural Corporation main offices. Headquarters staff consists of the Chief Entomologist (M.Sc.), an Operation Manager and an Assistant Operation Manager. Each has his own car or pickup. In the same office for liaison but actually responsible to another department is the Chief Storeman. He has no transport of his own and there is no telephone communication with the main chemical store about 4 km away. This is a major limitation on stores management, particularly in terms of organisation and safety.

The scheme is divided into three groups, each sub-divided into three blocks. Each group grows between 45 and 50,000 feddans of cotton and is managed by a Group Entomologist (M.Sc. or B.Sc.) having his own Land Rover. The post in Centre Group was vacant during 1985/86 but is expected to be filled by mid April 1986. The blocks range in size between 14 and 18,000 feddans of cotton. An entomologist resides in and is responsible for each block. He has one team of five to six scouts with a pick-up for transport.

Communication is excellent through a good road system and a radio network linking headquarters to each Block office. Lack of transport was something of a limitation at block level but was not considered to be serious in 1985-86.

The basic staff/transport plan is similar to the Gezira but with ratios of scouts and vehicles per feddan of cotton at 1:2700 and 1:12,000, which is half the level on the Gezira. The superior road communications will certainly ease transportation problems but it seems questionable whether sufficiently intensive scouting and airspray supervision can be possible with this number of staff and vehicles. Basically this depends on how variable pest infestations are, which in turn is likely to be determined by how short the sowing period can be made over the whole scheme and how even are the early irrigations.

6.3 NEW HALFA SCHEME

The division is headed by a Chief Entomologist (M.Sc.) with extensive experience in pest management and control. He is stationed at headquarters in New Halfa together with an Operation Manager and Assistant Operations Manager. Stores administration is provided by a separate department within the headquarters with whom there is a close liaison. The same applies to a Research Department which is to a considerable extent directed by the NAAPC.

The scheme is divided into the North and South Sections each controlled by a Section Entomologist (M.Sc.). One is specialised in insecticides and the other in herbicides, thus adding to the all round expertise available. Each section contains three Groups.

Each Group is managed by a Plant Protection Inspector (B.Sc.). Five Groups are of three blocks while one Group has four blocks. Each Group grows approximately 12,000 feddans of cotton. The Plant Protection Inspector has five Technical Assistants (Scouts) each of whom has a High School education and several years' field experience in cotton. The Technical Assistants attend training courses in insect recognition and in allied subjects. They form a single scouting team per group of 12,000 feddan cotton. This is not sufficient for a satisfactory scouting programme.

The target for each Plant Protection Inspector is to scout 10 fields per 4000 feddan block each eeek. One hundred leaves for whitefly and jassid and 100 plant stands (holes) for *Heliothis* are checked. Whitefly adults, jassid nymphs, *Heliothis* eggs and larvae are counted.

Vehicles are mixture of 4 wheel drive station wagons, mainly Land Rover and light normal drive pick-ups.

Headquarters have 3 vehicles at their disposal and each Section Entomolotist has a Land Rover. At present each Plant Protection Inspector has just one vehicle for himself and his Technical Assistants but this will be increased to two for next season. The lack of telephone or radio links between Blocks, Groups and HQ results in an excessive use of available transport for purposes of communication. This not only reduced transport availability for fieldwork but also wastes a considerable proportion of senior staffs' time in travelling, which could be better employed in other directions.

The results are tabulated by Group Plant Protection Insepctors, who, with their Section Entomologists decide whether treatment is required, the chemical, the dosage rate and the application volume to be applied. This decision requires confirmation by the Chief Entomologist.

The level of staff inputs is closer to that of Rahad than the Gezira, with a ratio of 1:2000 feddan cotton. The same applies to transport with a ratio of one vehicle to 12,000 feddan of cotton. In view of the relatively greater distances on the scheme and poorer roads the position regarding transport at New Halfa was less than adequate but the planned doubling of vehicle numbers for next season should rectify this to a considerable extent.

6.4 WHITE NILE PUMP IRRIGATION SCHEMES

6.4.1 General

As noted in Section 1.2 the White Nile area extends 400 km on both sides of the river Nile, and for administrative purposes it is divided into six regions, three on each side of the river. At each of the main centres of Duiem, Kosti and Renk there are river crossing points. The regions are divided into administrative blocks which control the cotton schemes, of which there may be one to eight per block. Management is by Regional Managers, through First (Block) Inspectors, Second (Scheme) Inspectors, to Technical Assistants who carry out the day to day running at field level - agriculturalists, engineers, accountants and others. The tenants are represented by the senior tenant - the Samad - who are appointed to organise tenants cooperative work. Due to the dispersed nature and greater complexity of the scheme staffing and transport questions are discussed in more detail.

6.4.2 The 1985/86 Season

Crop Protection staff are separate from the administrative framework. Although they liaise closely at all levels, they report on technical matters to the crop protection headquarters based in Kosti, through Senior Entomologists.

The head of the department is based in Kosti and reports to the Agricultural Manager, and is known as the First Senior Entomologist. He is responsible for budgetting, purchasing, and allocating all pesticides. He must also monitor the spraying operators, evaluate product performance and carry out the day to day administration of the department.

Three Second Senior Entomologists report to him. They are based at Duiem, Kosti and Renk respectively and are each responsible for their respective two regions' crop protection activities. The Kosti based Second Senior Entomologist also acts as deputy head when the First Senior Entomologist is absent. A Spraying Operations Manager, responsible for application activities and liaison with the Airspraying Companies, also reports to the First Senior Entomologist.

The Second Senior Entomologists direct Plant Protection Inspectors, (Mafatish Ughyar) two for each region, or theorectically 12 in the WNAC. In 1985/86 there were only 10.

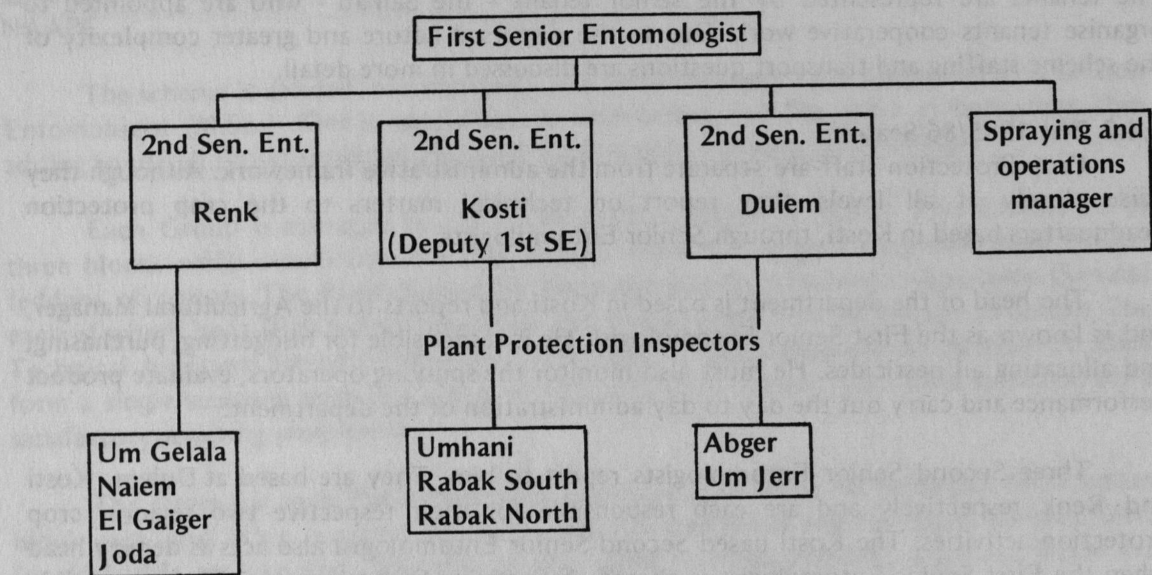
The staffing layout is shown in organogram form as Table 6.2.

Each of the Inspectors controls a four man scouting team and a spraying supervisor responsible for airstrip operations. The Inspector and his team is responsible for monitoring the pest levels on a daily basis, trying to check each scheme at least twice a week. In practice they have great difficulty in meeting their schedules due to the shortage of transport. In 1985/86 there were only three vehicles belonging to the department, and seven vehicles had to be hired. Even these were not exclusively for crop protection activities. Fuel was short and roads often flooded between fields. In practice therefore, scouting was on a somewhat ad hoc basis, and decisions rely a great deal on the judgement of the Inspectors and the Second Senior Entomologists, who selectively direct scouting operations on the basis of intuitive experience and tenants reports. In practice, they provide a reasonably realistic assessment of the situation.

Another problem, particular to the WNAC is that of staff distribution. The shift in cotton production from north to south over the past five years (Abgar and Um Jerr areas used to grow over 30,000 feddans of cotton) has not been balanced by a corresponding shift in personnel. Consequently, the establishment list shows that there are 24 men on crop protection in Duiem for only 8000 feddans of cotton (1:335 fed) whereas there are only 13 men in the comparable grades at El Geiger to monitor 19,500 feddans (1:1500). The Corporation has been unable to move staff from their home areas to the more remote and difficult schemes due to social and domestic reasons, and since they are unable to provide proper accommodation.

The position regarding staff and transport is summarised in Table 6.3 together with recommendations for next season.

TABLE 6.2 CROP PROTECTION STRUCTURE WNAC



6.4.3 Recommendations for Future (White Nile)

(a) There are theoretically enough personnel and vehicles to carry out all crop protection activities, but in practice this is not the case. Staff distribution is unequal. Hired vehicles are used for many other purposes and often break down. Fuel in White Nile is always a problem (at one stage in 1985/86 spraying was delayed over a week because there were no scouting vehicles to survey a scheme). All these problems are amenable to solution through proper planning and firm action.

(b) The Corporation has recently received 50 new vehicles under the rehabilitation programme. Two only have been allocated to Crop Protection, which is definitely insufficient. A more appropriate number would be seven or half the recommended number for field use.

(c) A serious effort should be made to balance the staff distribution engaged in crop protection activities in line with suggestions made in Table 6.3. Staff who refuse to move (where accommodation for families is available) should be liable to dismissal.

(d) The proposed radio telecommunication network should be used to relay daily pest situation reports for analytical and record purposes.

(e) There should be more tenant involvement in crop protection activity. Inspectors should undertake the training of tenant farmers in scouting techniques, so they understand threshold levels and become more interested. There is a case for tenants using knapsacks or ULVAS for spraying small outlying or their peripheral cotton areas, which are extra to the official areas, since airspray operators are not given enough insecticide to cover these areas, yet are expected to spray them (Section 3.1.1).

TABLE 6.3 CROP PROTECTION, VEHICLES AND PERSONNEL DISTRIBUTION: WNAC

				1985/86 Actuals						1986/87 Recommended (based 85/86 averages)					
				Pest control (Actual)		Pest control vehicles		Ratio per feddan						Ratio per feddan	
Regions	No. of schemes	Area feddans	Average feddans	Scouts	Staff	Perm	Hired	Staff	Vehicles	Teams	Scouts	Staff	Vehicles	Staff	Vehicles
Abgar	3	3 091	1 030	11	2	1	-	1:237	1:3091	1	4	2	1	1:515	1:3 091
Umjerr	5	4 981	996	9	2	-	1	1:452	1:4981	2	8	2	1	1:498	1:4 981
Rabak	17	14 101	829	6	4	1	1	1:1410	1:7050	4	16	4	3	1:705	1:4 700
Umhani	6	9 212	1 535	5	2	-	1	1:1316	1:9212	2	8	2	2	1:921	1:4 606
El Geigar	16	19 526	1 220	6	7	1	2	1:1502	1:6508	4	16	4	4	1:976	1:4 881
Um Gelala	12	16 953	1 412	5	4	-	2	1:1883	1:846	3	12	3	3	1:1 130	1:5 651
TOTAL		67 864		42	21	3	7	1.1077	1:6786	16	64	17	14	1:837	1:4 847

Assumptions:

1) *Each team is four men; staff could be a combination of Supervisor, Area entomologist, Technical assistant or Spraying supervisor.*

2) *Obviously, scouting and staff have to be balanced, not only against area, but number of schemes also. Otherwise, some schemes would be impossible to survey. Therefore in the bigger schemes there are fewer scouts per feddan. Also vehicle distribution has to take into account geographic distribution of schemes, and needs of the second senior entomologist, as well as scouting teams.*

3) *The above recommendations are a compromise of existing situations, taking into account the various factors - and the theoretical capability to transfer people from one region to another without difficulty.*

4) *Also taken into account are economic factors, i.e.higher yielding areas justify better protection.*

CHAPTER 7

SCOUTING AND SPRAY ACTION THRESHOLDS

7.1 BACKGROUND NOTE

Decisions on when to spray and which insecticide to apply in Sudan cotton are determined by counting pest populations. Successful pest control is therefore totally dependent on:

- Accurate pest scouting to determine populations.
- Appropriate action thresholds above which spray applications are made (subject to overall assessment by the responsible entomologist).

While both these are exceedingly important it is the first which can be identified as the critical factor in the pest control campaign; an exception being where a residual soil-applied insecticide is used. The method which is selected for scouting a cotton crop must take account of a number of factors, the major one being the degree of precision required. Other factors to be considered include:

- Area of cotton to be scouted and interval between counts.
- Pest species, their intensity, and behaviour.
- Time available for scouting.
- Staff and transport available.

In Sudan scouting is carried out not only to determine when to spray and what insecticide to use but also to assess the results of spray treatment. Performance of insecticide, and of the airspray operator, is assessed from the results of pest scouting. Decisions on purchase of the next seasons pesticides can depend on these assessments. It is therefore clear that rather precise scouting is required, considerably more accurate than the level of scouting to reach a simple yes/no spray decision. It is with this policy background to consider that an exercise to monitor scouting was carried out. The question must be asked however, as to whether scouting to assess pesticide performance across the whole Gezira (not to mention other cotton growing corporations) is necessary. In a commercial cotton growing organisation this is doubtful. It involves greater investment in numbers of trained men, supervision and recording, and in transportation. The more basic scouting to give a yes/no decision only would seem sufficient, backed up if necessary by random insecticide performance assessments which should primarily be the responsibility of ARC.

7.1.1 The Scouting System on Gezira

Procedures for pest scouting cotton in the Gezira are defined in the SGB Pest Management and Spraying Policy 1985-1986 (Ref. 6). In short it reads as follows:

Assessments of pest infestation levels on cotton are to be made twice weekly throughout the growing season Three scouting teams of seven scouts each are assigned per group, covering between 19,000-35,000 feddans. Groups are made up of 7-10 blocks and each team is responsible for sampling 2 or 3 on a regular basis. Out of the 30-40 Numbers of which a block consists, 6-10 well dispersed Numbers are selected in order to obtain a representative sample of the block. Numbers

(1500 x 280 metres) are subdivided into tenant holdings or hawashat of 10 fd. In order to avoid possible side effects the first and last hawasha (usually bordering canals) and the border rows in each hawasha are initially omitted. The latter are included later in the season when pest population density in the border rows often increases above that of the central part of the block. Border rows are also sampled if fleabeetles invade the crop. Scouts upon arrival at the hawasha should enter the field from the corners and proceed diagonally while selecting plants and making counts (Table 7.1). Scouting should start early in the morning and be finished by 11 o'clock. This scouting system is also followed by other Corporations, with some local modifications.

TABLE 7.1 SAMPLING METHODS FOR MAJOR COTTON PESTS IN GEZIRA

Species	Method
Whitefly *(Bemisia tabaci)*	**20 plants** selected at random, 5 leaves per plant, 1 top, 2 middle, 2 bottom, adults are counted.
Cotton jassid *(Empoasca lybica)*	as for whitefly
Cotton boll worm *(Heliothis armigera)*	**100 plants** selected at random. Scouted for eggs and larvae.
Cotton aphid *(Aphis gossypii)*	**100 plants** at **5-8** different sites selected at random, infested plants are counted.

7.1.2 Implementation of Scouting (1985)

Field monitoring of scouting was undertaken to ascertain the constraints adversely affecting the scouting programme, to pin-point its shortcomings, and to assess effect of such problems in terms of yield, failure to apply necessary sprays or application of extra, unnecessary sprays. The reliability of the system for assessment of insecticide performance was also considered. Consultants observed 15 teams from 9 groups on 60 occasions, with four observations made of each team. The following Groups were surveyed. In the Gezira; North, North-West, Messellemia, Wad Habouba, Maatug, South and Centre; in New Halfa the North Group, and one block in Rahad. (Unfortunately strike action by Rahad staff prevented a planned three day, detailed survey there). Scouting teams were accompanied in the field to monitor and evaluate their activities. A standard data collection form was used (Appendix F). Results are summarised in Table 7.2.

Scouting activities in general were carried out without serious transport breakdown or other interruptions and these factors were assessed as having little if any effect on the spray programmes and ultimately the crop yield.

(a) Logistical limitations

Scouting teams in the Gezira must travel quite long distances each day over dirt roads. In all groups monitored transport was always available and lack of fuel never curtailed operations. Sixty-six per cent of all cars in the Groups visited were rented. The remaining one-third owned by SGB were frequently unserviceable or sub-standard. While the scouting programme this year was successfully carried out problems next season must be anticipated if new vehicles or increased numbers of rented vehicles cannot be provided (Chapter 6.1).

TABLE 7.2 EVALUATION OF SCOUTING - GEZIRA

Summary of 13 Assessments[1], each 4 fields

	Grading	Performance	% Teams checked
Transportation situation	Good		
Number of teams per group present that day	Very good	3 teams	62
		2 teams	38
		0 teams	0
Availability of teams for scouting in general	Good	3 teams	31
		2 teams	46
		1 team	23
Scouting frequency	Good	Twice/week	25
		2-3 x/week	75
Number of scouts per team	Poor (variable)	Scouts Teams	
		4 4	32
		5 5	38
		6 2	15
		7	0
		8 -	0
		9 2	15
Secondary activities	Very good	No interference	92
		Little interference	8
Skill-training	Good	Fully trained	76
		In-training	24
General staff problems?	Very good		
Selection of hawashat randomly?	Very good	SGB Std	100
Number of hawashat/block	Very good	SGB Std	92
		Intensive	8
Are dry and wet fields sampled?	Satisfactory	All fields	69
		Dry fields only	31
Scouting pattern walked	Poor	Diagonal	8
		Other	92
Length of sampling route	Inadequate	30 m	15
		60 m	23
		100 m +	62
Time for in-field scouting	Inadequate	Walk Av/Scout	12.9min.
		Plant Av/Scout	32sec.

TABLE 7.2 continued

	Grading	Performance % Teams checked	
Number of stops per route	Poor (Variable)	10/Scout Av/Scout = 8 Range 2-15	60
Number of plants examined per stop (station)	Whitefly - good Bollworm - poor	One 1 - 6	100 -
Number of different pest species counted	Poor	Single Complex	46 54
Sampling method for whitefly	Poor	2 - 1 - 2 1 - 2 - 2	46 54
Sampling for bollworm	Very good	Whole plant[2] Top only	100 0
Sampling accuracy	Poor		
Sampling mode	Good	Centre Edges Both	46 40 14
Are counts registered properly?	Poor	Written Verbal	53 47
Time of day, always start early morning?	Poor	6.00 am 6.30 7.00 7.30 8.00 After 8.30	0 7 32 27 7 27

Notes: [1]*Data collection form given as Appendix F.*

[2] *Six teams surveyed.*

Scouting teams were evaluated with regard to number of scouts per team, constancy of number of scouts, and availability of teams in relation to other duties. The number of teams in relation to the block area to be covered was also considered. The number of scouts per team working together in the field varied from four to nine and was usually below SGB's recommended strength of seven. Differences were observed both among and within teams. It was apparent that problems with counting arise if the number of scouts per team and consequently the number of plants examined per scout fluctuates. It is considered that consistant teams of seven scouts, two of whom would be in reserve to replace possible dropouts, would be the most effective. Each scout of a team of five would have to sample 20 plants for cotton bollworm (and aphids) and four plants (20 leaves) for whitefly and cotton jassid. This would standardise the counting method and improve the quality of the result.

On all occasions two teams were available for scouting together with one team on duty to supervise the application of pesticides. Other activities, such as clean-up actions and rat campaigns did not interfere with the programme this season.

Data on numbers of teams, scouts and areas for which they were responsible are detailed in Table 7.3. If the ratio of scouts to area are examined against a mean of 1:1,250 it is seen that Centre and Wad Habouba groups have a highly favourable ratio, while North, North-West, Mansi and Messellemia are poorly served. The reasons for these anomalies are uncertain, although the southerly groups have a more diffcult pest situation generally. It is suggested that adjustments be made to the numbers of scouts and teams as appropriate. A possible list is given in Table 7.3, although this does not take full account of problems of roads, distances and seasonal variation in cotton areas sown. The numbers are based on a ratio of scout:feddan. Adjustment to ensure 5 counters from 7 scouts per team would be made by entomologists.

TABLE 7.3 NUMBER OF SCOUTING TEAMS IN RELATION TO AREA TO BE COVERED

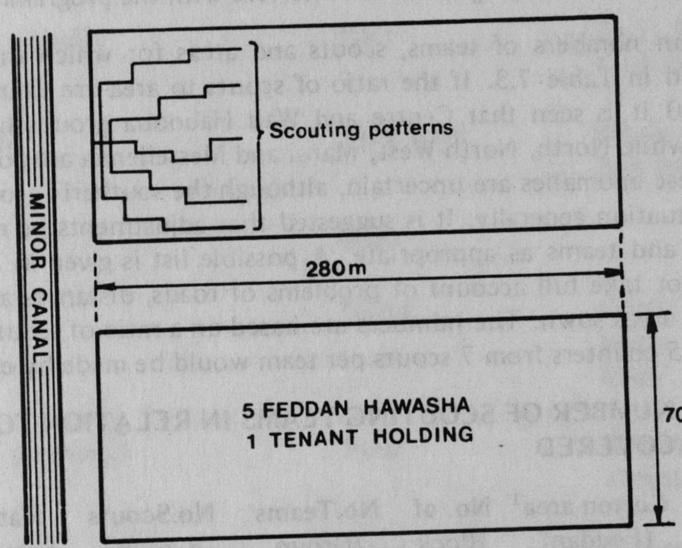
Group	Cotton area[1] (Feddan)	No. of Block	No.Teams /Group	No.Scouts /Group[3]	Ratio[3] Scout:fd	Required Nos. Teams	Required Nos. Scouts
South[2]	35 361	8	3	34	1:1040	4	28
Centre[2]	29 588	10	3	36	1: 821	3	24
Messellemia	29 078	9	3	20	1:1454	3	23
Wad Habouba	19 223	6	2	20	1: 961	2	16
Wad Shair	28 561	6	2	24	1:1190	3	23
North	34 185	7	2	22	1:1554	4	27
N.West	29 912	8	2	18	1:1662	3	24
Mikashfi[2]	27 630	7	3	23	1:1200	3	22
Huda	26 881	7	3	23	1:1170	3	21
Mansi	27 031	7	3	16	1:1690	3	22
Tahamid	28 758	8	3	26	1:1110	3	23
Maatug[2]	27 549	7	3	22	1:1250	3	22
Maturi[2]	32 050	8	3	26	1:1330	4	26
Gamusi[2]	35 305	9	3	28	1:1260	4	28
Total			**38**	**338**		**45**	**329**
Average					**1 : 1264**		

Note: [1] *Area cultivated as at December 1985.*
[2] *Southerly Groups.*
[3] *December 1985. Numbers can vary during a season, and even from week to week. These figures are thus highly theoretical.*

(b) Selection and size of scouting units

In all groups monitored selection of locations to be sampled was carried out as described by SGB. The scouting unit in which counts were seen to be made (Figure 7.1) is actually half of a hawasha, or 75 cotton rows wide, measuring approximately 70 x 280 m. Since scouts cover a distance of about 100 metres from the point where they enter the hawasha, the scouted unit area is 1/3rd of a tenant holding, or 1/6th of a hawasha. This is only 6 per cent of the area recommended by the 'Pest and Disease Committee' as representative for the Gezira.

FIGURE 7.1 EXAMPLE OF FIELD SITUATION WITH AREA COVERED BY SCOUTS INDICATED.



Hawashat were selected at random, choosing each along a different minor canal. A good dispersion over the block was obtained by varying the distance from the major canals. Depending on the actual area, SGB suggests that from six to ten hawashat are sampled, while due to variation of *Heliothis* egg/larvae between numbers, Russell Smith (1975) suggests block sampling (Ref. 28). In all cases however not more than six hawasha were sampled. It would seem more appropriate to relate the number of scouting units to be sampled to the average block size in a Group. Intensive sampling (21 hawashat/block) was carried out once in 13 cases in order to clarify an erratic pattern of infestation in one block. Selection of scouting units is not truly at random since fields chosen may be wet, or newly irrigated, or inaccessible, and thus difficult to scout. For routine surveys this simply has to be accepted.

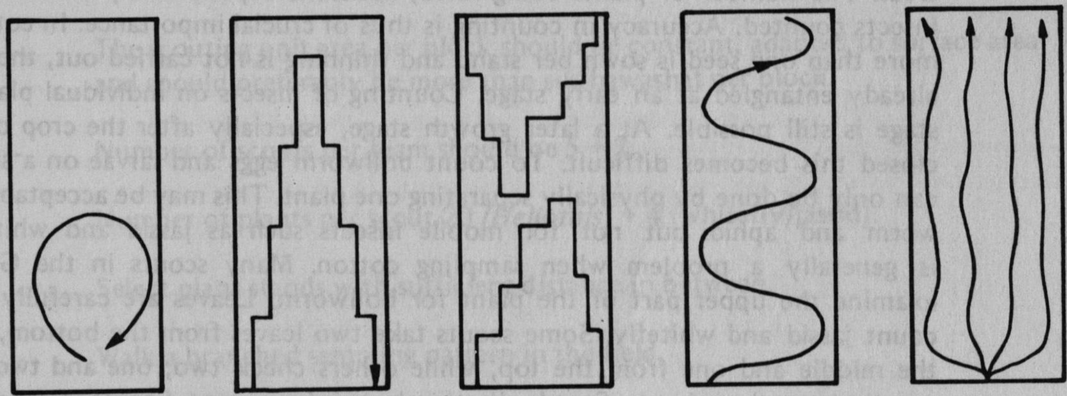
Due to possible differences in pest populations between Numbers, the same scouting units should be used for pre and post spray counts if insecticide performance is to be assessed. This does not seem to be taken into account in the SGB recommendations and little effort was made to do so. In some cases field conditions were also a limiting factor.

(c) Scouting patterns

A scouting path should be both practical and cover the sampling unit as well as possible. Figure 7.2 shows possible systems used in a number of countries (Ref. 29, 30).

FIGURE 7.2 POSSIBLE SCOUTING PATTERNS

c, as suggested by SGB; e, as suggested as a result of this evaluation; a, b and d, alternative pattern in use in other cotton growing countries.



The sampling route suggested by SGB is diagonal with scouts entering fields from the corners and walking zig-zag using the rows and cross-field jedrals for ease of transit. Observations in the different groups showed that in practice this pattern is never followed. Scouts usually entered the field from the centre of the narrow side of a hawasha. Routes followed were generally erratic and did not provide representative cover of a hawasha. Scouts sometimes walked a central route, following each other along a pathway which resulted in repetition of counts in the same parts of the field and sampling could not represent the true pest situation.

When selecting a suitable pattern, the size, situation of the field and numbers of scouts sampling simultaneously should be taken into account. There are advantages and disadvantages to the various patterns shown in Figure 7.2 depending on the situation. The system indicated in Figure 7.2e was followed by one group. It meets the above criteria and seems suitable for use under Gezira conditons.

(d) Number of Stops per route

The number of plants to be examined per scouting unit is 100 single plants for American bollworm and aphids and 20 for whitefly and cotton jassid. Scouts normally count three or more plants/stand due to poor thinning. With a team of five scouts each covering individual routes and making counts on all pests, every scout should stop 20 times at random. At each of these selected stands all plants in the stand should be checked. Each plant should be examined for bollworm and every fifth plant-stand for whitefly and jassid. In practice scouts do not follow this system but usually examine between 10 and 20 plants from stands having unthinned clusters, checking four, five or six plants. Part of this variation is due to varying numbers of scouts per team. Counting of unthinned plant clusters may have origins in previous methods. For example three-metre long stations in the row, or 10 plant stations, were counted in the past (Ref. 28).

In practice discrepancies due to low numbers of scouts or counted plants may be corrected mathematically when recording. This procedure however does not compensate for shortcomings in the system.

(e) Accuracy of observations and counts

An action threshold is the ratio of a predetermined number of insects to a fixed number of plants (or parts of plants) which reflects the pest population causing unacceptable damage. It is the key to the decision to treat (spray in Sudan) or not to treat. The number of plants being fixed, decisions depend solely on the number of insects counted. Accuracy in counting is thus of crucial importance. In cotton where more than one seed is sown per stand and thinning is not carried out, the plants are already entangled at an early stage. Counting of insects on individual plants at this stage is still possible. At a later growth stage, especially after the crop canopy has closed this becomes difficult. To count bollworm eggs and larvae on a single plant can only be done by physically separating one plant. This may be acceptable for bollworm and aphid but not for mobile insects such as jassid and whitefly. This is generally a problem when sampling cotton. Many scouts in the Gezira only examine the upper part of the plant for bollworm. Leaves are carefully turned to count jassid and whitefly. Some scouts take two leaves from the bottom, two from the middle and one from the top, while others check two, one and two leaves respectively at these levels. Standardisation here is important. Scouts in general inspect only the upper surface of the leaves for bollworm eggs and squares, buds, flowers and bolls for larvae. Counts in the Gezira (Ref. 28) have shown however that 10 per cent of eggs are laid on the lower surface of the leaves with 4 per cent on lower leaves, the stem and other parts of the plants, which scouts do not assess in the Gezira. While routine scouting does not require assessment of absolute numbers standardisation is a prime requirement to ensure uniform decisions throughout the scheme. (Conversely experimental assessment of insecticides requires absolute number assessment and hence different, specially trained teams are used by ARC).

It is worth commenting here that the problem of non-random oviposition by cotton bollworm, whereby the moth selected well grown plants in a field leading to egg aggregations, is appreciated by SGB. Scouts are instructed to select plants for counting at random for normal scouting, but on occasions early in the season they may be instructed to scout large well grown plants in an effort to obtain early warning of bollworm build-up. These counts should not be used for spray decisions.

(f) Duration of sampling

The total time spent on insect counts on 20 plants per scout per hosha was 15 minutes on average. When the time taken walking between stops and recording the data is deducted, about 32 seconds per plant are left for actual examination. This period is unquestionably too short to make the counts of individuals of the two or three pest species involved. In previous studies (Ref. 28) 15 minutes minimum per hosha was found necessary for a team of 5 scouts, to sample 50 plants for bollworm and 100 leaves for whitefly in a Number, or 1.5 minutes per plant, but only the upper plant was checked for *Heliothis*. The current procedure for counting 100 plants for *Heliothis* and 100 leaves for whitefly would require doubling that time to 30 minutes, or more for whole plant sampling for *Heliothis*.

(g) Registration of field counts

Recording of insect counts in the field was very poor. Counts were either made on bits of paper, on the hands or just memorised until the figures were noted by the team leader on the standard SGB sheets. Scouts should be provided with individual forms to record each and every count. The results should be summarised by the team leader. This would significantly improve the reliability of scouting results. Alternatively scouts could use a pegboard (Ref. 31).

(h) Constancy in scouting procedures

Scouting could be greatly improved by issuing written instructions on methodology and ensuring these are carried out uniformly throughout the Gezira. The various aspects have been discussed. The main points are summarised below:

- The scouting unit area per block should be constant, adapted to surface area and should preferably be more than six hawashat per block.
- Number of scouts per team should be 5 + 2.
- Number of plants per scout 20 *(Heliothis)* + 4 (whitefly/jassid).
- Select plant stands with sufficient distance in between.
- Walk a branched sampling pattern in the field.
- Examine same level (e.g. upper half) of the plant.
- Establish standard for counting aphid, e.g. 20 colonies/100 plants.
- Extend the scouting time per hawasha to 30 minutes minimum.
- Register every plant count on special data forms.

(i) Training and skill

Scouts from all teams in general showed adequate skill, with exception of newcomers, and many have long term experience. The general attitude to a job which may be classified as a routine one, was found to be positive. Discipline from the first till the last count is difficult with this type of work. To improve the quality, and taking the importance of this work into account, a special system of payment or a bonus should be considered.

Newly recruited scouts have first to be trained, and during this time they are not actively involved in scouting. Scouts are tested and upgraded once in two years and have to undergo a written exam. This should preferably be done once a year. Demonstration of pests and beneficial species, and a joint visit and demonstration of scouting methods should be included in this programme.

(j) Role of team leader

Each scouting team in the Gezira is headed by a team leader responsible for arranging transportation and manning for each survey, selecting sampling sites, supervising and directing scouts in the field and summarising and registering insect counts. Team leaders were all experienced and seemed competent, however they failed to direct activities of their teams, particularly regarding the scouting patterns walked and the definitive recording of data obtained by their scouts i.e. memorised numbers were accepted without question.

7.1.3 Recommendations

The present scouting system and its implementation in 1985/86 is adequate for making spray decisions. In order to upgrade it to provide the degree of accuracy needed for assessment of pesticide performance the following are necessary:

(a) Methods must be standardised throughout Gezira (or within any other corporation). To achieve this a detailed 'Guide to Scouting' should be prepared. All aspects should be covered and adhered to in the field. More specifically:

- The number of scouts/team should be standard at five out of seven.
- The distribution of scouts should be reassessed and the number of teams increased.
- If pesticide performance is to be strictly assessed pre and post spray counts should be on the same scouting units.
- The scouting pattern should be standardised as that most acceptable to all Groups. The recommended diagonal pattern should be discarded.
- The 'cover' of a block should be extended by reducing the number of plants/hawasha to 30, but increasing number of hawashat to three, i.e. same numbers of plants scouted but area survey tripled.
- The number of plant-holes counted should be standard per scout. All plants/hole to be checked, whether 1 or 10. This ensures a proper measure of infestation/unit area is obtained.
- A decision on whole plant or terminal scouting for *Heliothis* should be made in conjunction with ARC. The method should then be standardised and enforced.
- Team leaders should be instructed to extend scouting time/plant to 3 minutes per plant. If necessary morning start-time should be advanced to 6.00 am.
- The pegboard, or a written form should be issued to all scouts for recording.
- Bonus payment systems related to yield/pest control cost parameters may be advantageous. The importance of scouting should be emphasised and a sense of pride and responsibility should be engendered.

(b) Other pre-scouting aids to monitoring should be developed, e.g. for *Heliothis* using pheromone traps and whitefly using sticky yellow traps. These would provide early warnings, for example of movement of *Heliothis* moth from sorghum to cotton.

(c) Anticipating long-term requirements for IPM scouting, other systems of scouting, such as sequential scouting using population dynamics plans should be investigated.

(d) As a corollary to (c) the policy of scouting to assess pesticide performance should be reconsidered. If it is still felt to be desirable a random spot check system using a few specially trained teams should be adopted.

7.2 PEST POPULATION ACTION THRESHOLDS

7.2.1 Present Recommendations

Economic and judicious chemical control of pests depends on assessment of pest population levels, using scouting systems as discussed above, followed by the decision to treat or not to treat depending upon when the pest action threshold is exceeded. This term is preferred to the more common but improperly used 'economic threshold', which is only appropriate where fluctuating economic and biological factors (cost of insecticides, application, value of crop, climate, pest complex, beneficial insects etc.) are reviewed annually, and taken into account. It is extremely difficult to establish a true economic threshold due to the many variables involved (Ref. 32). However this difference in definition does not change the principle underlying the adoption of pest threshold levels but serves to indicate their relative accuracy and value.

An action threshold can be considered as the level above which unacceptable damage or crop loss may occur unless action (spraying in Sudan cotton) is taken. The cost:benefit of any crop protection activity, as part of the process of crop production, remains crucial to a threshold level.

For the control of cotton pests in the Gezira the following action thresholds have been adopted (Ref. 6):

- Cotton bollworm *(Heliothis armigera)*: 10 eggs + larvae/100 plants
- Whitefly *(Bemisia tabaci)*: 200 adults/100 leaves
- Cotton jassid *(Empoasca lybica)*: 50 individuals/100 leaves
- Aphids *(Aphis gossypii)*: 15-20 per cent of plants infested

Later in the season - December - Group entomologists may on their own discretion decide that levels of 400 whitefly per 100 leaves are acceptable.

Similar levels are recommended for the White and Blue Nile Schemes (Ref. 40) but differ by varying the levels with the stage of plant growth. Minor pest thresholds are also indicated in this pamphlet, as shown below:

- Spiny bollworm *(Earias insulana)*: 5-10 eggs/larvae per 100 plants
- Sudan bollworm *(Diparopsis watersi)*: 5-10 eggs/larvae/100 plants

For whitefly, these thresholds have been determined empirically (Gameel, Ref. 33) but for the other species they appear to have evolved from practical experience or have been adopted from research carried out in cotton in other countries. No original references could be traced by the Consultants. The validity of these thresholds could not be evaluated in the course of our study, and in fact is outside the Terms of Reference. In a short-term project of this sort it is clearly not appropriate to undertake such a study, however in view of their importance and the direct relationship with scouting procedures, the basis for establishment of action thresholds is discussed below in Section 7.2.3.

7.2.2 Action Threshold Spray Decisions 1985

The interpretation of pest counts, and the spray decisions taken on the basis of the current thresholds, were reviewed. Details of pest counts and spray applications were provided by Group Entomologists for 48 blocks, three or more being randomly chosen for each Group. Selected data is shown for 18 blocks (at least one per group) in Figures A.E.1 to A.E.18, Annex E, graphed as mean weekly totals from two (sometimes three) counts of *Heliothis*, jassid and whitefly. Arrows indicate days of spraying.

Examination of the 18 graphs shows that a very high percentage of decisions to spray were correct based on current recommended action thresholds. Decisions not to spray cannot be quantified from the graphs. Of 138 spray decisions for whitefly only 3 per cent were apparently wrong, and these were probably partial block sprays. Only one application out of 160 was required for jassid and the spray decisions were 100 per cent correct.

The graphs for 32 blocks were examined to assess decision on *Heliothis* sprays. It appeared that 10 decisions to spray out of 38, or 26 per cent, were made before the spray threshold was reached. This appears a rather high percentage, but could be erroneous since using averaged weekly counts masks minor peaks, particularly at low threshold levels. The spray decisions were therefore reviewed against an arbitrary action threshold of 20 eggs and larvae, to assess what affect this would have had. Of the 38 decisions 23 would have been premature, i.e. an additional 13 counts were below 20 eggs and larvae per 100 plants. Thus 60 per cent of 38 sprays against *Heliothis* made before whitefly action thresholds were reached, (treatments which can be considered as key-pest control decisions, initiating seasonal spraying) were applied while *Heliothis* numbers were under 20 eggs and larvae per 100 plants. It is not known what percentage were larvae but if a high proportion were eggs, and if even the low level of 50 per cent eggs failed to produce viable larvae, then a substantial proportion of early season sprays against *Heliothis* may have been either unnecessary, or uneconomic. This question is discussed further in section 7.2.3.

Decisions on whether or not to spray for jassid presented no problem this year since pest numbers seldom approached the threshold, and early season applications were nearly always for bollworm.

Whitefly levels rose rapidly from early October in nearly all blocks and despite rigorous spraying levels very seldom fell below the 200 adults/100 leaves threshold. The entomologists were therefore faced with a problem not of interpetation of action thresholds but of whether spraying would be economic. Was it in fact worth spending approximately LS 25 for chemical plus LS 6.40 for spraying (US $ 1 = LS 3.20) to reduce whitefly adults from one to two thousand/100 leaves to something above four hundred, in the knowledge that levels would re-escalate within ten days as nymphs hatched into adults?

Examination of figures A.E.1 to A.E.18 for the 18 blocks gives reductions of whitefly numbers after 132 sprays as:

To below 200 adult/100 leaves	18 times 13.6%
To below 300 adults/100 leaves	25 times 18.9%
To below 400 adult/100 leaves	19 times 14.4%
To above 400 adults/100 leaves	70 times 53.1%
Total	**132**

These figures clearly show that a very inadequate level of control had to be anticipated, where in only 13.6 per cent of spray applications was reduction below the action threshold obtained for a week-long period, possibly less. An initial reaction is to simply conclude that spraying was a waste of money, and many farmers interviewed in fact responded by questioning the number of sprays made. However, had "ineffectual" spraying not been made what levels of whitefly would have been reached, how long would they have persisted and what would yields be?

The answers to these questions appear to the Consultants to require indepth study of population dynamics and effect on yield which can only be undertaken by allocating a considerable area of cotton, perhaps three or four blocks in size, for experimental work where chemical control methods can be compared with non-sprayed or "pest management" systems (Chapter 8.4) under stable environmental conditions in which interaction between treatment areas is eliminated by their size. The ARC 10 fd untreated control plot is probably much too small to permit expression of the true "unsprayed cotton" characteristics, including interactions with other unsprayed rotational crops like sorghum and groundnuts.

7.2.3 Review of Action Threshold levels

The three main components used to determine threshold levels are numbers of insects, of plants, and of damage symptoms. Insects are present on the plant at different developmental stages, e.g. for cotton bollworm, as eggs and larvae (adults being mobile within the crop), and for whitefly as eggs, nymphs and adults. To assess pest levels, counting individuals at each stage would be most accurate but this is impractical. Usually one or two stages only are counted, for example, adult counts for whitefly and egg-larva counts for cotton bollworm. The problems in accurate determination of bollworm populations have been outlined in Section 7.1.

The ability to recognise the minute first instar larva, frequently hidden in terminals or squares, is an additional problem. In view of these difficulties, original 'whole plant' sampling procedures have been modified in several countries and sampling of only certain parts of the plant, or sampling for damage symptoms has been adopted. Counting of eggs and larvae of *Heliothis spp.* on terminals only is standard practice in Arizona, Arkansas and Texas. Other criteria used are the number of infested plants, damaged squares, egg/larvae per station (for example m^2 area) or damaged bolls. Table 7.4 shows how wide is the range of thresholds based on some of these systems. In view of the difficulties currently encountered in the Gezira a review and possibly alteration of the methodology would seem advisable. In the Sudan the action threshold for cotton bollworm is very low in comparison with those established in most other countries (Ref. 7). It is thought the threshold for *Heliothis* may have been established several years ago (the early 1970's) when the ratio of cotton value to insecticide cost was less adverse, and the strategy for control of *Heliothis,* then the major pest, was based on use of less potent chemicals against first instar larvae, and was critically dependent on egg counts to give early warning.

If it is assumed that scouting in the Sudan is as accurate as elsewhere, then an action threshold of 10 eggs/larvae will mean application early in an infestation cycle. An immediate consequence is the elimination of biological control of all pests through egg parasitism or predation. Further, spraying at low thresholds may be valueless if physiological shedding subsequently occurs to cause greater loss of fruiting points than through bollworm damage. Shedding may often occur without adverse effect on the final crop yield since a cotton plant's potential for boll production from the great number of fruiting points is limited by many factors other than pest damage. Pearson (Ref. 34) notes that loss of 40 per cent of fruiting points due to bollworm damage did not reduce yields in Sudan as these would be shed in any case and compensated for in the long season on the Gezira. The threshold level of 10 eggs/larvae per plant may thus be too low, and this should be further investigated.

TABLE 7.4 EXAMPLES OF ACTION THRESHOLDS IN DIFFERENT COUNTRIES

Country/State	Action thresholds for *Heliothis*
USA	
Arizona	10-12 larvae per 100 terminals
Texas	50 eggs/larvae per 100 terminals (early flowers) 100 eggs/larvae per 100 terminals (mid maturation) 25 eggs/larvae per 100 terminals (late hardening)
Arkansas	25 eggs/larvae per 100 terminals (early season) 50 eggs/larvae per 100 terminals (mid season)
AFRICA	
Botswana	50 eggs/larvae per 100 plants or 50 per cent infected plants
South Africa	50 eggs per 100 plants, or when 2-3 counts show steady increase, or 25 per 100 plants over long time
Zimbabwe	50 eggs per 100 plants
S. AMERICA	12-15 larvae per 100 plants (6,250 larvae/hectare) early mid season 21-23 larvae per 100 plants (9,400/ha) late season
Bolivia	20 small larvae per 100 plants (to 50 days pre-bloom) 10 small larvae per 100 plants (to 75 days flowering) 6.5-8.0 small larvae per 100 plants (to 140 days 1st harvest) and different thresholds for bigger larvae
AUSTRALIA	25 per cent egg infested terminals (early season) 20 per cent squares damaged by larvae falling to 15 per cent as blooming declines (mid season) or 10 per cent damaged bolls, or 50 per cent infested terminals, etc.

The threshold level for whitefly is based on counts of adults. Adult populations fluctuate substantially due to wind-disturbances and migration, and where damage due to feeding and honeydew secretion is concerned, adults are less detrimental to the crop, than the nymph. Nymphs however are too small to be counted by eye in the field. The alternative of counting nymph infestations on randomly sampled leaves, using inexpensive binocular microscopes in Block offices, would certainly be more accurate, would provide "early warning" of build up and could lead to better control. This should be investigated.

Adjustment of action thresholds over the course of the season is also an area which could reward investigation. Clearly seasonal population levels, the conditions of the crop, its potential for late season compensation and the susceptibility to yield or quality loss at different crop growth stages all must affect action thresholds. This subject appears to have received insufficient attention by researchers in the Sudan.

The effect of different levels of whitefly populations on yield and quality of cotton late in the season after boll-splitting has started should be examined in view of the high cost of insecticidal control and its relatively poor results at that stage.

Thresholds for Spiny, Sudan and Pink bollworms, which are minor late-season pests, have been set low deliberately since there is little possibility for compensatory production for damage late in the season.

7.2.4 Economic Implications.

The foregoing consideration of scouting, spray decisions and action thresholds leads to the question of economic returns on crop protection measures. It is pertinent to state that the objectives of the tenant farmer and government must differ. The farmer wants maximum cash profit on his crop at the end of the season. This does not mean he wishes a maximum yield, since high yields with high inputs but lower profit are unrewarding. The result then may be to switch to other crops, as has happened with groundnuts already, and is happening vis-a-vis cotton/wheat in White Nile. The government, and hence the production corporations, require high yields of cotton to earn foreign exchange, which may be at the expense of high local currency cost inputs; although SGB Crop Protection Management have a stated policy to reduce the cost of crop protection to the farmer (Ref. 6) and this dropped to 19.7% of total crop production costs in 1984/85, the lowest for 12 years.

Some of the factors affecting economics of crop protection are discussed below together with results of a survey carried out on the White Nile regions actual crop protection costs.

(a) Timing of Application

Action threshold levels have already been discussed. There may be considerable potential for savings in the cost of crop protection by raising thresholds. The costs of chemical treatment should be properly related to returns through prevention of crop loss, expressed as yield increases. It is necessary to emphasise the need for critical consideration of economic factors for each separate application; for each application in relation to the cost of treatments already made; and for each application in relation to the anticipated season-long programme. The problems of these assessments are considerable. The potential yields must be assessed by continual field visits by Group Entomologists backed by counts of shed flowers and bolls and by counts of "safe crop", i.e. set bolls which will not be shed unless damaged by *Heliothis*. The pattern is different for the two cotton types, and also changes as the season progresses. Only in this way can true assessment of the economic value of applications be made.

The economics of crop protection measures, being dependant on scouting, may be adversely affected by lack of fuel and transport. In 1985/86 this has only occurred in the White Nile area, where it is considered to have been beyond that corporation's control.

Correct scouting and timing does not reduce the cost per feddan of pesticides applied but improves pest control performance and thus over a season allows reduction in spraying, and may allow greater expression of biological control mechanisms, in turn reducing costs.

(b) Effective Application

Poor application was noted from time to time on all schemes in 1985/86, resulting in inadequate cover or distribution, as discussed in Chapter 3.1 and Annex A. It is not possible to quantify sub-optimal application, nor to assess loss in terms of reduced pest control, and it is speculative to appraise the potential for reduction in rates of chemical used if optimal application methodology had been achieved. However loss of ULV chemical due to dumping at the end of the day has been estimated at US $ 53,000 last season (175 aircraft-days, 2 gals/aircraft, on 775,000 fd, to give 2,100 gals at LS 72 per gal - assuming Decis/dimethoate at LS 15.81 per feddan).

(c) Selection of Insecticide

The SGB policy document (Appendix B.7: Ref. 6) gives cost/fd for the various insecticides and mixtures recommended. These range widely. As already noted choice by entomologist is limited by the policy of not applying the same mixture to any block twice in the season. Flexibility of choice of ULV products was also limited in 1985 by the fact that all products were mixtures. The recommendation for mixtures is based on the need for treating all species in the pest complex for the first half of the season, and the belief that better whitefly control at a lower overall insecticide cost is obtained with mixtures of endosulfan and organophosphorous or formamidene insecticides. This has been demonstrated in many large scale trials over ten years as far as insecticidal effect is concerned, but ARC admit (Prof. A. Balla, 1986 Pers. Com.) that full economic assessments to take account of yield and returns over a season's spray programme have not been made. The reasons for the better control obtained by endosulfan mixtures - the so-called potentiation effect - is uncertain. Research is under way to elucidate this, and the "stimulation syndrome" whereby adult whitefly are excited to fly and hence pick up greater quantities of chemical, or move upwards in the plant canopy to become more exposed, is under investigation. It has been shown by tracing whitefly marked with fluorescent dye that they fly upwind and more randomly when sprayed with endosulfan, while these phenomena were not observed when sprayed with phosphamidon (Dr R. Thomas, Pers. Com. 1985).

Whatever the reason for potentiation research results support the phenomenon. A comprehensive review was not possible and is outside the scope of the project, but results of many years trials are reported in the annual reports of ARC Wad Medani and summarised at the Annual Pests and Diseases Committee meetings.

There appear three areas where choice of insecticide might result in substantial savings:

(i) A single as compared to mixed insecticides stragegy.

The use of ULV formulations of a single insecticide only. Excellent early season 'jassid alone' control could be obtained with a number of systemic organophosphorous compounds. Very good control of both jassid and *Heliothis* could be obtained with cypermethrin alone in place of present mixtures including dimethoate, profenofos, dicrotophos, chlorpyrifos. If necessary, and subject to compatibility and flow-rate determinations, tank mixes of ULV formulations are possible.

A single CLV mid-season chemical could be used when *Heliothis* requires control but neither jassid, nor whitefly do, e.g. either a pyrethroid or endosulfan.

(ii) Low cost whitefly mixtures

Selection of the cheaper mixtures for repetitive applications over the season. The cost saving is considerable:

4 sprays Endosulfan/dicrotophos 4 x LS 17.79 =		71.16
1 spray Endosulfan/dicrotophos	17.79	
1 spray Endosulfan/amitraz	25.43	
1 spray Endosulfan/quinalphos	25.91	
1 spray Endosulfan/triazofos	22.56	
		91.69
Saving		20.53

This example gives a 22 per cent saving over four applications. It does not take account however, of possible differences in persistance of effect. Dicrotophos, being a rapidly absorbed systemic/contact insecticide, would not have more than about one week's residual. Other chemicals might have greater persistance and kill adult whitefly emerging from the 'pupal' stage for a longer period. These chemicals do not however affect the nymphs. The biocidal effect of different mixtures should therefore be considered when assessing their cost/effect. Reconsideration would also have to be given to the "once only" policy and the question of rate of development of resistance. Authoritative opinion is divided on the best way to avoid resistance build-up. The alternative of rotation of insecticides on a spatial or seasonal basis may well be superior, as has been the case with the red spider mite control strategy in Zimbabwe.

(iii) High dosage rates of single whitefly insecticide.
The use of a single insecticide against whitefly may in some cases give savings, e.g.:

Dicrotophos at 630 g.a.i./fd	LS 12.42
Dicrotophos & endosulfan at 210 & 400g.a.i./fd	17.79
Ekatin WF at 350 g.a.i./fd	LS 9.86
Ekatin WF & endosulfan at 180 & 375g.a.i/fd	17.24
Conversely:	
Amitraz. 20 at 400 g.a.i./fd	LS 29.02
Amitraz. & endosulfan 200 & 320g.a.i./fd	25.43

The scope is considerable and requires an economic reappraisal by research workers. The examples given above are selected purely on a cost basis and their mention in no way endorses their use rather than other products.

(d) Cotton quality and spray costs
In Section 7.2.2 the question of the economics of short-term reductions in whitefly populations was raised. Group Entomologists are expected to interpret the recommended action thresholds in light of actual field conditions. This involves consideration of quality as well as yield. The return on costs of spray applications through improved crop quality due to reduction of contamination of open bolls late in the season (January/February) is poor. With fifth grade cotton priced at LS 215 per kantar an increase of 46 lb/fd harvested cotton per application costed at LS 31.40 (or for eight sprays, of 368 lbs, 1.17 kpf) is needed to pay for cost of spraying plus insecticide.

Assuming spray application is sufficiently effective to improve quality to grade 1, valued at LS 235 per kantar, then an increased yield of 42 lbs/fd would cover the cost, a reduction of only 4 lbs yield increase.

Where a yield of 3 kpf is assumed the increase in value of first grade compared to fifth grade cotton totals LS 60 only. Thus with each spray costing about LS 31.40 it is clear that applying even two sprays for quality improvement will give a negative return. It is thus increased yield rather than quality that pays the farmer in terms of crop protection under the present pricing system.

(e) Costs of Crop Protection and Crop Production

S.G.B. has a firm policy to reduce cost of crop protection both in definitive terms of Sudanese pounds per feddan and as a proportion of the total cost of production. Their policy document (Ref 6 - Annex 36) details these costs from 1966/67 to 1984/85. Over this period the average number of sprays per year ranges from 4.0 to 9.2. The average over successive five year periods show that numbers of sprays have indeed fallen since the crisis period 76/77 - 80/81 while yields rise over the

TABLE 7.5 TREND IN CROP PROTECTION 1966 - 1985

Period	Av. No Sprays	Av Yield[1]	% Crop Prot. of Crop Prod.Costs
66/67 - 70/71	4.664	4.90	12.3
71/72 - 75/76	6.046	4.29	19.0
76/77 - 80/81	8.270	3.24	23.9
81/82 - 85/86	5.985	4.68[2] (4.45)[3]	25.0[2]

Notes:

[1] *These averages take no account of varying ratios of higher yielding medium staple to lower yielding long staple cotton. They are not therefore truely comparable.*

[2] *Average of four years.*

[3] *Five year average assuming 3.5 kpf for 1985/86.*

last five years. Hower the ratio of crop protection to crop production costs shows a consistant rise, despite the 1984/85 figure at 19.7% being the lowest for twelve years. This rise is no doubt due to the high proportion of crop protection being foreign exchange costs, and thus reflecting devaluation of the Sudanese pound.

TABLE 7.6 RELATION OF CROP PROTECTION COST TO CROP VALUE

	Av. Yield kpf	Value Crop/fd - LS Cotton[1]	Seed[2]	Total	Cost/fd as % Cost/fd as %
80/81	2.308	172	54	226	15.8%
81/82	3.881	365	74	439	12.9%
82/83	4.699	451	131	582	11.7%
83/84	4.930	577	158	735	16.1%
84/85	5.222	757	242	999	9.6%
85/85	(3.5)[3]	(787	162	949)[3]	(24.8%)[4]

Notes:

[1] *Assumed Grade 3 Barakat at value for year (Ref. 6: Annex 39)*

[2] *Assumed Barakat at value for year (Ref 6:Ann 39)*

[3] *( ) Assumed yield as Barakat, Valued as Grade 3 and LS 500 p.t seed.*

[4] *Assumed cost 8.4 sprays at LS 235 p.fd.*

Table 7.6 shows a steady decline between 1980/81 and 1984/85 in cost of crop protection as related to crop value. This must be considered praiseworthy. In 1985/86 there is a dramatic reversal (based on estimated not actual figures). This is not surprising in view of the devastating whitefly infestation exacerbated by cultural and other factors (Sections 3.1.1 and 7.2.4h).

(f) Economics of Application - White Nile

With the foregoing aspects in mind a survey was carried out to evaluate the costs of insecticide application during 1985/86 on the White Nile Schemes to ascertain:

- the cost of individual applications by area.
- the difference between early season and late season applications.
- The costs compared to yield potential in given schemes.

Costs were based on value of carry over stock, value of current stocks plus local delivery charges, and the costs of application. These factors were assessed both in Sudanese and in actual foreign exchange. For example while application is expressed in Sudanese pounds, 60 per cent of that is remittable and added to the foreign exchange component of the cost, but the total is included in the Sudanese cost. Results are shown in Tables 7.7 and 7.8.

The assessment was made in the White Nile Agricultural Corp. which differs from other corporations in complexity, with higher costs due to distances and inaccessability, and greater yield variations betwen regions.

TABLE 7. 7 COST PER SPRAY APPLICATION

Spray	Area treated	Cost[1]	Product
First spray	64108 feddans @ US$ 7.65 per feddan		Carryover stock 1984/85 Decis/dimethoate Mikantop 10% added for degradation.
Second spray	63518 feddans @ US$ 7.51		Thimul & Rogor, Ekalux Dursban, Birlane
Third spray	59760 feddans @ US$ 10.144		Thimul &Mitac, Ripcord, Birlane Endophos
Fourth spray	58526 feddans @US$ 11.04		Thimul & Ekalux, Dursban, Mitac
Fifth spray	34942feddans @ US$ 11.45		Thimul/Sumicidin, Birlane, Dursban, Mitac Ekalux
Sixth spray	2475 feddans @ US$ 11.52		Thimul & Ekalux, Dursban
Total average for the season		US$ 9.47	
Total area planted 67860			

Note: [1] *This figure includes the spraying costs.*

For 1985/86 the cost per feddan rises from approximately US/$ 7.50 (for early season *Heliothis* control) to US 11.50 as whitefly populations escalate over the season.

TABLE 7.8 VARIATION IN COSTS WITH RETURNS BY REGION, NORTH TO SOUTH

	Scheme	Cost per fd US$: LS	Estimated Yield k/fd Seed Cotton	Value LS Cotton	Value LS Seed	Theoretical Returns LS	% Costs of value
North	Abgar[1]	41.24:139	2.2	440	62	363	27.7
	Um Jarr[1]	45.15:153	2.5	500	71	418	26.8
Centre	Rabak[1]	45.37:149	3.5	700	99	650	18.6
	Um Khani[2]	36.29:122	3.0	675	141	694	14.9
South	El Geigar[2]	48.79:152	4.5	1,012	212	1,072	12.4
	Um Galala[2]	43.9:146	4.0	900	188	942	13.4

Note:

1 *Assumed grade 3 Shambat at LS 200/kantar; Seed LS 300/t*

2 *Assumed grade 3 Barakat at LS 225/kantar; Seed 500/t.*

There appears to be no discernable regional trend in costs of crop protection between the northern and southern regions as a case for evaluating whitefly costs versus *Heliothis* costs. On the other hand in terms of costs estimated per kantar there is considerable variation from $18.75 per kantar in Abgar to $10.85 per kantar in El Geizar, indicating that entomologists and management are not assessing the cost of spraying against the potential yield.

This aspect of economics will need to be addressed in forthcoming seasons, and guidelines prepared for field staff to base their spraying regimes against potential crop. It is clear that by mid season after the third spray, it should be possible to evaluate the present crops and stop spraying them. The yield loss would be marginal and the cross infestation of whitefly would not be a serious factor since its establishment in the good crop will have already occured. Furthermore unsprayed cotton may also serve as a reservoir for beneficial insects after an equilibrium is reestablished.

(g) Socio-economic aspects

As earlier mentioned, there are other economic implications which impinge on the use of pesticides, which bear comment.

In a few rare cases tenant farmers in some corporations have no interest in growing cotton. They may only do so because of pressure by the corporation or Govt. that they will lose their holding unless they do so, or because they divert the incentives for cotton growing such as loans, fuel allocations, and irrigation supply for growing their own crops, such as wheat or vegetables.

After planting cotton, they abandon the crop knowing the corporation will carry the losses incurred for inputs supplied. Unfortunately, this cotton still needs to be sprayed to prevent pests infesting adjacent cotton. It thus receives the requisite number of sprays, without question or accountability, even though its yield will be subeconomic, if indeed it is harvested at all. Such cases, admittedly rare, and only confirmed in one corporation area need to be confronted and solved not withstanding tenants union influence or other social pressures. It would be preferable for those tenants not to grow cotton and be provided with inputs in some other manner.

In Gezira and other areas this season tenants have grown cotton successfully, but have problems at harvest time. They have been used to using immigrant harvesters to pick their cotton, and if these are absent (as they appear to be for the 85/86 harvest) some tenants fail to pick for various reasons and the crop is lost.

(h) Cultural practices

It is unnecessary to state that inappropriate cultural practices, or failure to carry them out cannot be rectified by increased use of pesticides(ref. Section 3.1.1). Late planting poor spacing and thinning over irrigation, and late irrigation, contribute to pest control prblems. These can be easily solved by improved planning, tight management and tenant discipline. It is impossible to economically justify irrigation of mature cotton ready for harvest. With long staple cotton the idea appears to be generally accepted that extra crop can be picked if watering takes place in December. This belief is possibly simply an excuse for the tenant to obtain fodder for his live-stock. Any extra long-staple crop picked is certainly marginal and more than offset in cost by reduction in quality of the open crop due to honeydew and by the extra sprays applied to check this, often ineffectually as was the case in 1985/86.Where medium staple cotton is concerned no yield increase is possible at all.

It is understood a directive from Ministry of Agriculture not to extend irrigation has been issued but this has not been acted on. At Rahad, perhaps the worst offender, ARC have carried out demonstration plots to show the benefit of cutting irrigation. This should be expanded in all areas. Cut off irrigation dates should be imposed by ARC and Corporation management, and strictly enforced by block inspectors. This should save one, possibly two applications in medium staple cottons, and also greatly increase the quality of the crop, since spraying for whitefly at that stage of crop growth is ineffective. Any tendancy within management to extend watering to "increase yields" should be dealt with seriously. The consultants also believe that evaluation of the corporations management should be based not on the yield of cotton achieved but on profitability and the quality of crop produced. This is critical in the face of the present weak world cotton market.

(i) Variation in Yield

Variations in yields both between years ("good" and "bad" seasons) and between blocks and tenants within a year, has been the cause for debate since the early years of gravity irrigation on the Gezira. The reasons for such variations where infestations of *Heliothis* or whitefly are more or less the same are of particular interest to crop protection specialists. Ferguson 1964 (Ref. 43) discusses the climatological, soil, N fertilisation and interacting pest, weed and disease factors affecting seasonal fluctuation. The basic climatological factors resulting in a good season were determined as high pre-sowing (July/August) rains following a year of low rainfall. The opposite conditions were stated to give a bad season which was generally associated with high atmospheric and soil temperatures, particularly with clay soils. Low yields were also associated with poor nitrogen availability, inadequate irrigation or waterlogging and generally poor early season cotton growth. The effect of water-logging was considered major and not subject to any remedial action. At that period the major early pests were jassid and flea-beetle with whitefly important season long. High pest incidence was associated with bad seasons and particularly with poor soil aeration, water logging and high leaf nitrogen. There is no reason to think the basis for good or bad seasons has changed in the past twenty years but expression of the effect has been influenced.

The problem of low available nitrogen has been overcome by fertilisation and that of water stress by the gravity irrigation supply, but both of threse are subject to good management, both by the production board and by tenants.

The problems of bacterial blight and leaf curl have been almost eliminated by the resistant varieties grown while that of jassid and flea beetle is eliminated by spraying. However, waterlogging and soil problems remain intractable, while that of whitefly control has exploded. In the context of 1985/86 a potentially good season was upset by the long early period of waterlogging compounded by nitrogen fertilisation, and the potential for whitefly build-up was exaggerated by these factors and materialised due to mid season control problems.

Variation between tenant farmer yield and between blocks within a season is considered due to combination of natural and human factors. Major differences are due to soil type and irrigation management affecting root growth, nutrition and thus plant growth and yield. Human factors are tenant initiative expressed as poor pre-season, clean-up, irrigation, weeding, spacing and thinning and finally time and approach to crop picking.

Many of these factors are outside the project terms of reference for monitoring but all can affect the economics of pest control activities and the results of the seasons campaign and seasonal profitability.

(j) Overview of Socio-political Economic Aspects

It is beyond the terms of reference to comment on the economic policies of the Government of Sudan regarding the incentives offered to the tenants to grow cotton. However, observations have been made where these impinge on good agricultural practice or have in fact, become counterproductive. Furthermore, it is recognised that complex inter-relationships exist in the social and political context, which are the cause for certain decisions, which would not be considered sound economics in other countries yet cannot be ignored in the Sudan scenario. The Government is committed to producing the maximum cotton yield possible, on as great an area as is possible,this being the most important source of foreign exchange, as well as a major source of employment. In view of the fall in international commodity prices and poor sales of medium staple cotton, the policy is to step up production of long staple, high quality varieties (and the fine, medium long Shambat variety) only produced by four other countries. These varieties take longer to mature, and so are more susceptible to pest damage and need more pesticides costing more foreign exchange. This is occuring at a time when it is apparent that the most serious pest affecting quality whitefly is almost out of control.

It is the expressed objective of the Government to reduce its insecticide usage by up grading cultural practices and implementing an IPM programme by 1990 (Ref 44) (Integrated Pest Management). Adoption of this concept means a compromise between the need to maximise yields yet reduce the cost of inputs, and it is this trade off factor that needs to be clearly defined to all levels of corporation staff, especially in the field.

CHAPTER 8

ASSESSMENT OF ENVIRONMENTAL HAZARD

8.1 INSECTICIDE DRIFT DOWNWIND

8.1.1 General Considerations

Loss of pesticide from a sprayed field through airborne movement with the wind is inevitable, and causes a degree of environmental pollution. It is not impossible that insecticidal drift could also be hazardous to man and livestock. The degree of this drift is controllable within certain limits by timing of spray application, and using appropriate spray nozzles or correctly adjusted rotary atomisers. In order to assess the hazard from insecticidal drift 15 spray applications were monitored using a specially developed aerial sampling method based on acrylic wool strands placed at fixed intervals downwind of the sprayed field. The amounts of insecticide collected by the wool were subsequently determined by gas liquid chromatography. The methodology and results for eight of the studies for which data was available in time for the main report are discussed in detail in Annex A. The results for the other seven studies will be presented in a later addendum to the report (Ref. 1.4B and 8.4).

The extent to which pesticide sprays may drift downwind and away from a specific target area depends on the amount of material sprayed, the physical and chemical properties of the pesticide formulation concerned, the particle size distribution, the height from which the material is released, wind speed and atmospheric turbulence. For all sprays the drop size distribution is probably the most important factor relating to spray drift since, in general, the larger the drop the less it is affected by atmospheric conditons. The terms 'large' and 'small' when applied to drops in relation to spray drift only have meaning in comparison with the wind speed prevailing at the time of spraying since the distance drops may drift depends on how they are affected by wind speed and associated turbulence.

8.1.2 Assessment of Drift Deposits

The methodology used to sample airborne chemicals, and the basis for relating the quantities collected and analysed to the amount actually applied, is discussed in detail in Annex A, Part 1. The results of the gas liquid chromatography analysis carried out by Huntingdon Research Laboratories, Cambridgeshire, England, are not given in detail but full references are in Appendix J (Ref. 45). The interpretation of this data had not been completed in time for detailed discussion in the main report. Final conclusions will be presented in an addendum together with other aspects of environmental pollution.

The amounts of insecticides collected up to 500 m downwind of the sprayed field have been transformed to percentages of active ingredient sprayed. These data are presented in Table 8.1 and Figures 8.1 to 8.8. At 500 m downwind the amounts of insecticide recovered ranged between 0.7 and 28.0 per cent of the estimated quantity that similar collectors in the field would have held. The 28.0 per cent figure was exceptionally high. Other applications of the same chemical, endosulphan, averaged only 3.3 per cent. The mean of all recoveries at 500 m was only 6.0 per cent. There was a relatively sharp fall in the percentage of chemical recovered between 50 and 100 m. The reduction in percentage recovery between 100 and 250 m was, relatively, small. It is clear that the main fall out occurs within 100 m of the sprayed field and that by 500 m little drift fall out in terms of amount of pesticide occurs.

Analysis of droplets collected by rotating MgO_2 coated tubes showed that there was little change in droplet characteristics beyond 25 m from the edge of the sprayed field.

TABLE 8.1 SUMMARY OF INSECTICIDE COLLECTION BY DOWNWIND WOOL SAMPLERS AS PROPORTION OF ESTIMATED DEPOSITION ON AN EQUIVALENT TARGET IN THE SPRAYED AREA[1]

Study No.	Date	Insecticide	Estimated[2] in-field deposition (ug/m)	Downwind deposition as % of in-field deposition — Distance Downwind (m) 25	50	100	250	500
1	19.10	dimethoate	822.6	54.3	45.6	26.2	12.4	7.2
		cypermethrin	114.3	131.0	122.8	65.4	29.7	13.6
2	21.10	amitraz	915.3	65.4	70.2	65.0	22.5	6.4
		endosulfan	1831	59.8	60.0	52.2	17.4	4.8
3	27.10	decamethrin	6.23	65.8	46.5	33.7	4.8	1.0
4	28.10	dimethoate	2308	15.4	6.4	5.5	1.5	0.7
		alphamethrin	83.3	37.7	28.5	22.1	7.7	2.9
5	5.11	triazophos	3633	16.1	15.1	8.0	4.9	3.5
		endosulfan	6708	11.7	10.7	5.5	1.5	1.9
6	11.11	quinalphos	780.3	56.4	38.3	52.0	17.2	6.8
		endosulfan	1565	43.2	28.4	36.6	13.1	5.0
7	21.11	thiometon	696.1	5.1	4.4	5.3	5.0	6.5
		endosulfan	1305	49.6	40.0	42.1	29.5	28.0
8	30.11	chlorpyrifos	932.3	34.4	59.3	40.1	7.9	0.7
		endosulfan	1036	35.4	61.0	40.9	8.2	1.5

Notes: [1] *Data derived from that presented in Tables A.A.2 and A.A.3 in Annex A, Part 1.*

[2] *Calculated for a one metre vertically disposed wool strand, i.e. of the same dimension as the downwind samplers.*

This would mean that, downwind of this distance, evaporation is minimal and hence the ratio of chemical to droplet volume is reasonably constant and thus the quantity of chemical drifting is proportional to the number of droplets. Unfortunately the rotating MgO_2 coated tubes collected so much airborne dust that GLC analysis of chemical collected was not possible.

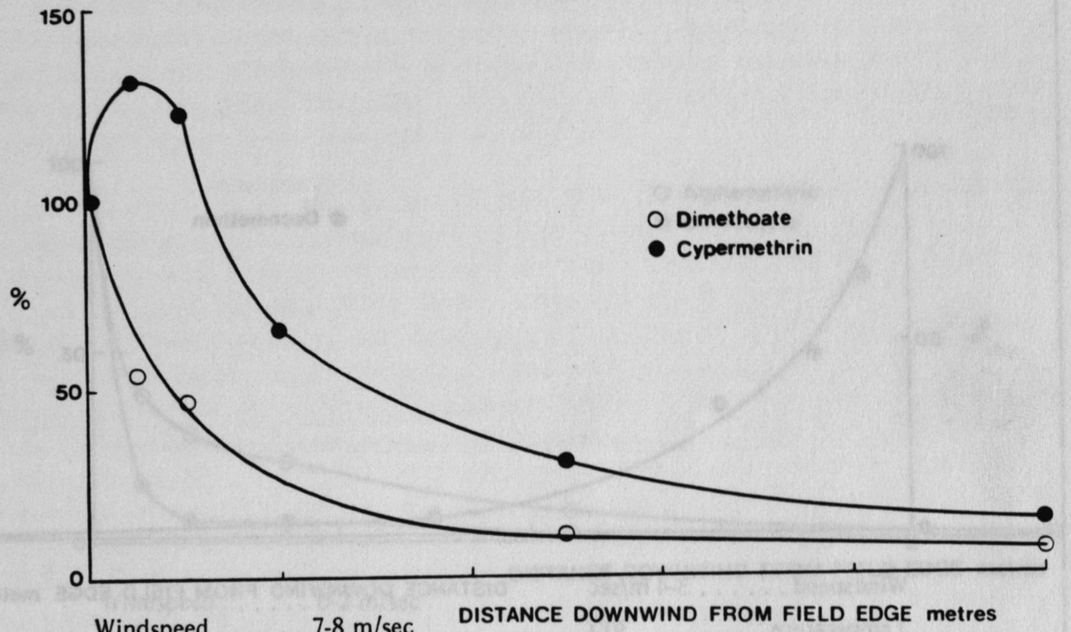
The climatological conditions at time of spraying greatly influence drift. Of the eight studies considered here the worst drift (Study 7, Tables 8.1, A.A.1) occurred under light wind conditions with a temperature of 23°C early in the morning. Serious drift also occurred with strong winds and high temperatures, (35°C) at mid-day (Study 1).

8.1.3 Hazard from Drift

The amounts of insecticide recovered from the wool samplers do not in themselves permit the direct determination of the degree of hazard that the aerial applications of

FIGURES 8.1 - 8.8 DOWNWIND INSECTICIDE DRIFT AS A PROPORTION OF MEAN IN-FIELD DEPOSITION FOR ONE METRE LONG, VERTICALLY DISPOSED WOOL STRAND COLLECTORS

FIGURE 8.1 STUDY 1 (19.10.1985)

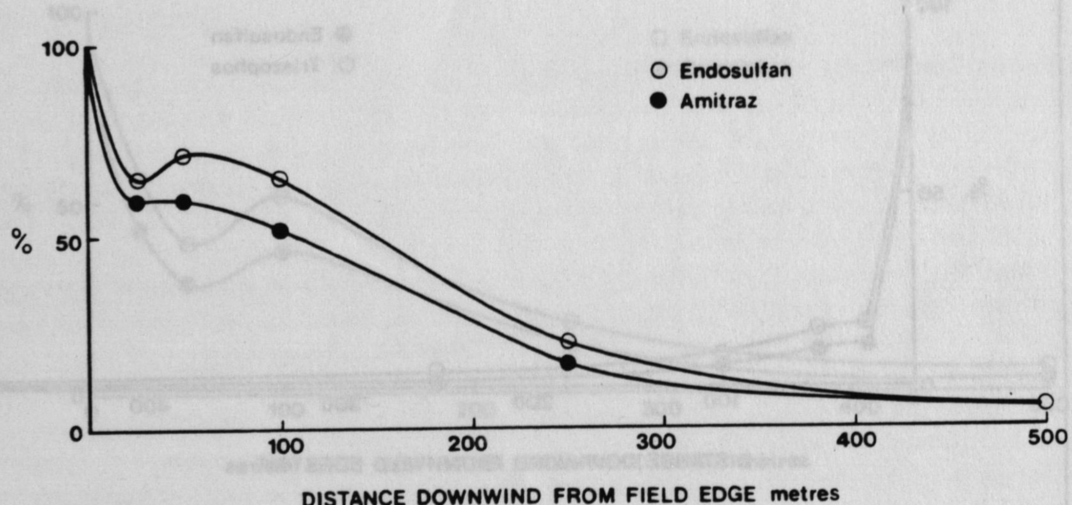


Windspeed . . . . . . 7-8 m/sec

Temperature. . . . . 35°C

Relative humidity 22%

FIGURE 8.2 STUDY 2 (21.10.1985)

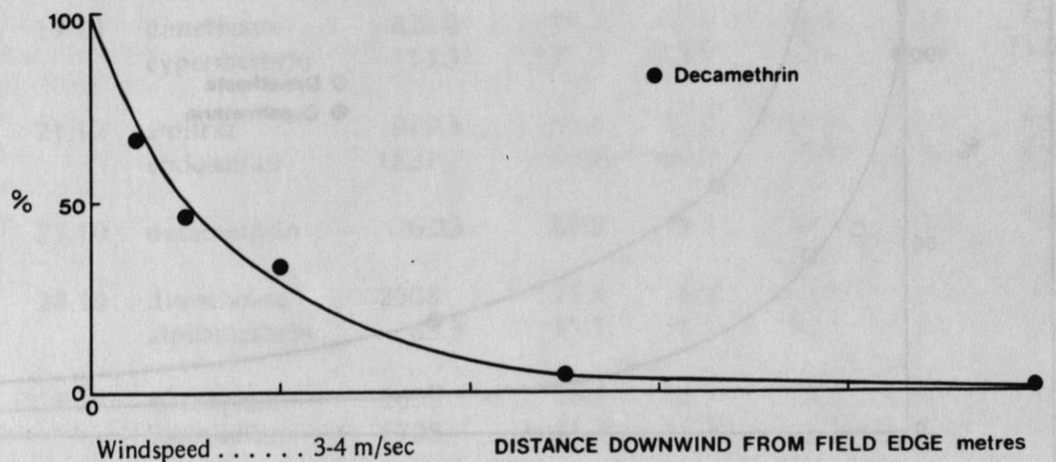


Windspeed . . . . . . 2-3 m/sec

Temperature. . . . . 30°C

Relative humidity 49%

FIGURE 8.3 STUDY 3 (27.10.1985)

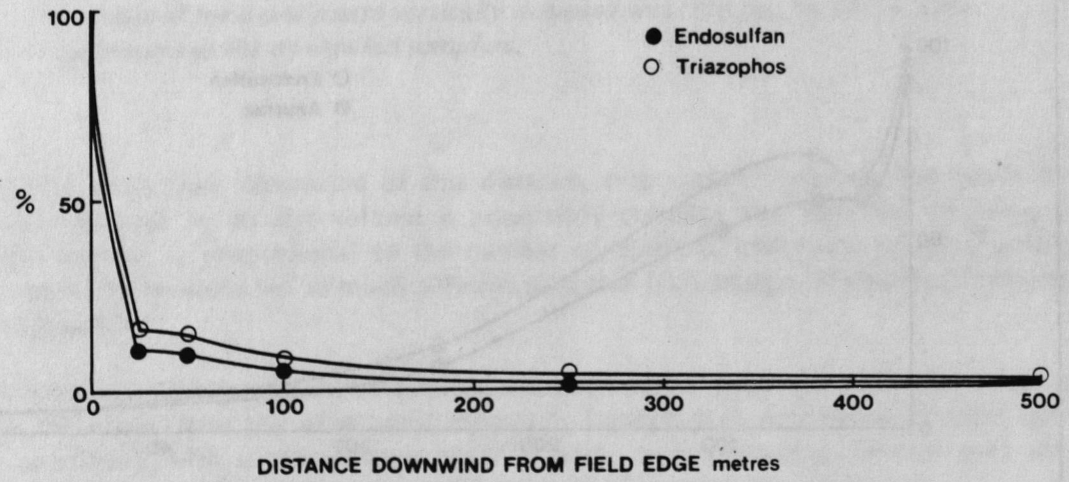


Windspeed . . . . . . 3-4 m/sec

Temperature. . . . . 30°C

Relative humidity 56%

FIGURE 8.4 STUDY 5 (5.11.1985)

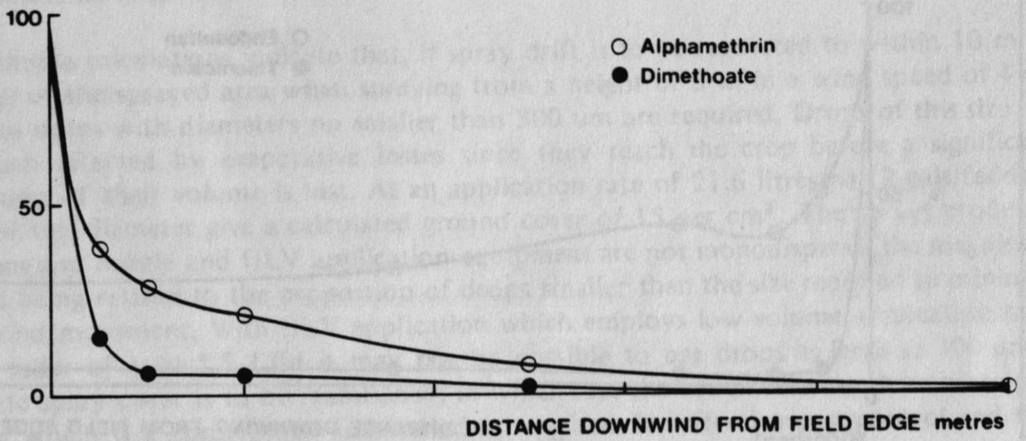


Windspeed . . . . . . 3-4 m/sec

Temperature. . . . . 27°C

Relative humidity 32%

FIGURE 8.5 STUDY 4 (28.10.1985)

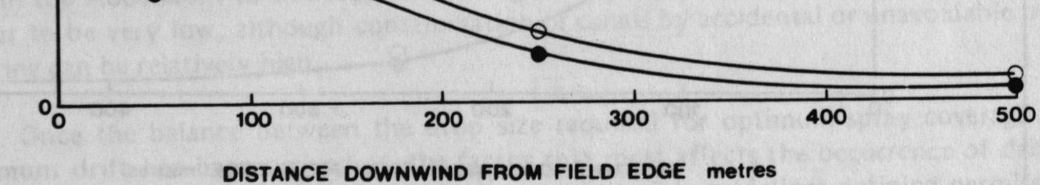


Windspeed . . . . . . 0-2 m/sec

Temperature. . . . . 31°C

Relative humidity 47%

FIGURE 8.6 STUDY 6 (11.11.1985)

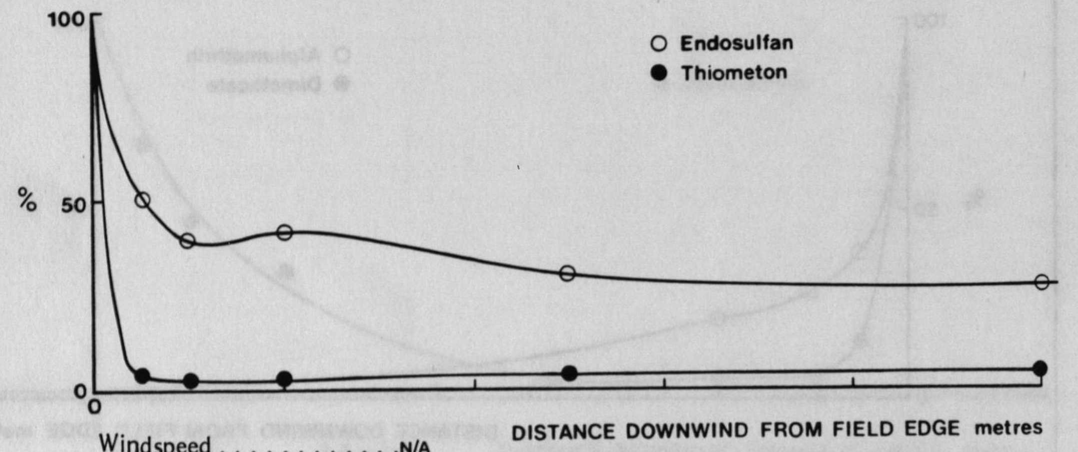


Windspeed . . . . . . 2-3 m/sec

Temperature. . . . . 32°C

Relative humidity 20%

FIGURE 8.7 STUDY 7 (21.11.1985)

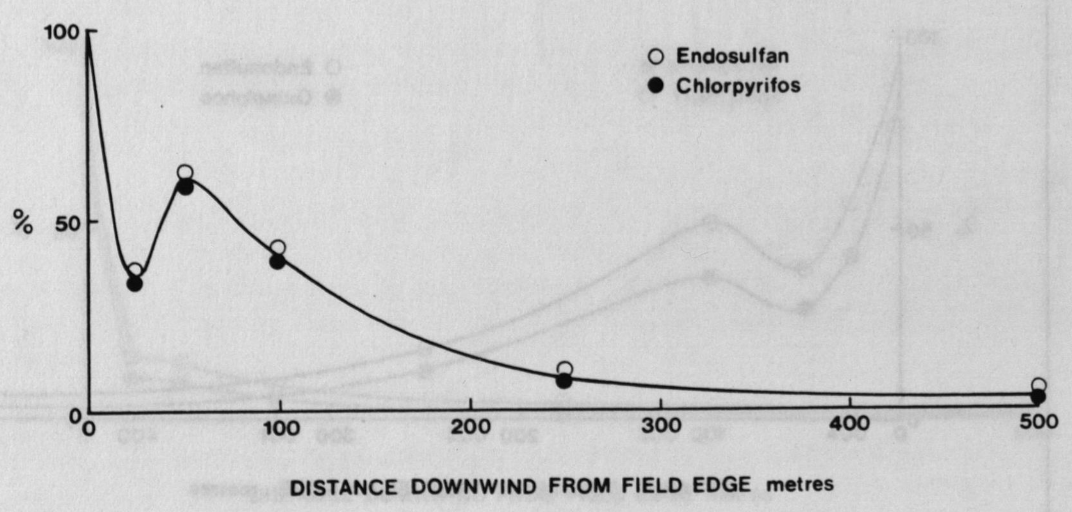


Windspeed . . . . N/A

Temperature. . . . . N/A

Relative humidity . . . . N/A

FIGURE 8.8 STUDY 8 (30.11.1985)



Windspeed . . . . N/A

Temperature. . . . . N/A

Relative humidity . . . . N/A

insecticides may present to the non-target environment. In all cases, however, the mass of insecticide collected per unit area of wool at 25 m downwind was calculated to be less than 6 per cent of that applied per unit area of ground area. At 500 m downwind it was less than 0.6 per cent except on one occasion when an early morning application gave a level of 1.6 per cent.

Some degree of drift from aerial application is unavoidable although the extent to which it occurs may be reduced by the use of spray equipment appropriately calibrated to give sprays composed predominately of drops large enough to overcome the climatic forces causing drift to take place. This can be at odds however, with the requirement for the use of much smaller drops in order to maximise spray cover.

Simple calculations indicate that, if spray drift is to be restricted to within 10 m of the edge of the sprayed area when spraying from a height of 3 m in a wind speed of 4 m/sec, then drops with diameters no smaller than 300 um are required. Drops of this size are not much affected by evaporative losses since they reach the crop before a significant proportion of their volume is lost. At an application rate of 21.6 litres/ha (2 gals/feddan) drops of this diameter give a calculated ground cover of 15 per cm^2. The sprays produced by boom and nozzle and ULV application equipment are not monodisperse, the magnitude of drift being related to the proportion of drops smaller than the size required to minimise downwind movement. With ULV application which employs low volume application rates in the order of 1 to 1.5 L/fd it may not be possible to use drops as large as 300 um if adequate spray cover is to be maintained, in which case the equipment has to be set to give a spray which is a compromise between that required for effective pest control and that which gives rise to whatever is deemed an acceptable level of drift.

Suitable conditions for spraying are difficult to define because of the numerous factors involved, but, in general, spraying should not be carried out when wind speeds exceed more than three times the sedimentation velocity of the spray Vmd. For 300 um drops released from a height of 3 m this is equivalent to a maximum wind speed of 3.3 m/sec.

Spray applications made at dusk or dawn can also be associated with extensive drift, as occurred in the monitoring programme. This is because under calm conditions small drops may not disperse into the atmosphere but can be carried considerable distances before being deposited.

The hazard to man and livestock through pesticide drift, as assessed from the limited number of studies carried out, appears to be minimal. The amounts of pesticide recovered by the downwind samplers is so small that ill-effects appear highly unlikely, either through direct contact, or indirectly through consumption of contaminated sorghum grain or vegetables. Results of analysis of pesticide residues in vegetables and sorghum subject to drift contamination are expected to confirm this conclusion and will be presented at a later date in the Addendum to this report. The degree of pollution of canals by drift would also appear to be very low, although contamination of canals by accidental or unavoidable overspraying can be relatively high.

Once the balance between the drop size required for optimum spray coverage and minimum drift has been arrived at, the factor that most affects the occurrence of drift is the adherence or otherwise of aircraft operators to sensible guidelines defining permissible operating conditions. These have been outlined in Chapter 3.1.4 and 3.1.5. If these are implemented the hazards to man and livestock will be kept as low as possible within the constraints of requirements of acceptable pest control.

8.1.4 Mosquito Control Spraying

Control of malaria and the mosquito vector is the responsibility of the Public Health Department. There are branches of the malaria control section on each of the irrigation schemes with teams of staff who carry out ground spray operations against both larvae and adult mosquitos. This includes spraying of breeding sites and appropriate areas of the villages. Fenitrothion is the main insecticide used on the Gezira while DDT is still used in other areas. Dimilin is used for larval control. The Malaria Control Section were asked whether air-spraying of villages was considered necessary, or approved of. They responded strongly that it was not, although on a few occasions it might be approved in special circumstances. They advised that routine crop spraying greatly reduced the incidence of mosquitos already, especially when ULV pyrethroids were used.

On a number of occasions it was noted that air-spray contractors were spraying villages. On investigation one of three reasons was given:

(i) The aircraft was actually disposing of equipment washing and there was no intention to spray the village.

(ii) The contractor was spraying above their own compound to reduce insect nuisance - including mosquito.

(iii) The pilot was instructed by corporation staff to spray for mosquito control.

On two occasions pilots specifically complained of these instructions. They stated they considered the instruction improper because they either did not know sufficient about the toxicity of the insecticide, or knew that it was toxic and not appropriate.

The question was discussed with SGB who advised that instructions had been issued that villages must not be sprayed on the Gezira and that, as far as they knew, no air-spraying for malaria was ever undertaken. They could not answer for other corporations.

Application of crop protection products for mosquito control must be condemned. Not only does this cause unnecessary pollution of the environment but it could result in poisoning, if for instance, near-naked infants and young children were accidentally sprayed with ULV endosulfan or chlorfenvinphos. It is recommended that aerial mosquito control operations should be forbidden in all the cotton producing schemes and the present occasional 'casual' operations subject to severe penalty. In an emergency a supervised programme using a WHO approved product might be undertaken.

8.2 WATER POLLUTION

As already mentioned (Chapter 1.4) the scope of project activity on assessment of water contamination was severely curtailed due to problems of residue analysis, and only eight samples could be transfered for analysis overseas.

Pollution of canal water following air-spray of insecticides has been studied in the Gezira, mainly by workers collaborating with the Blue Nile Health Project, and a number of papers have been published.

The effect of four insecticides on fish, anthropods and snails has been reported by Afaf Rahmin (Ref. 4). Dimethoate was found to have low toxicity to the groups studied, and deltamethrin was found to have less effect in field conditions than expected from its high toxicity in the laboratory. Chlorpyrifos was less toxic than endosulfan, but still was potentially hazardous. Endosulfan was highly toxic to fish but the most serious effects in the field were reported from the endosulfan/chlorpyrifos mixture (this mixture is important for control of whitefly). No comment was made on season-long effect of the pesticides studied nor the rate of recovery of populations.

Insecticide residues in canal and underground water and in soil from canal verges were studied by Bala (Ref. 5). Samples taken at the end and six months after the cotton spray season were analysed for DDT (last used in 1981), endosulfan, dimethoate, Birlane, Dursban and Decis. At the end of the season low levels of dimethoate and Decis were found in the soil, and low levels of Birlane and Dursban in canal water. Six months after the season only traces of dimethoate in soil were detected (0.009 ppm) in one location.

Both during and six months after spraying residues of endosulfan were detected in soil and canal water. The levels after six months ranged between 0.066 - 0.710 ppm in soil and 0.065 - 0.27 ppm in canal water.

DDT and metabolites were detected in all samples of soil and canal water and also in underground water. Contamination of underground water is considered by Bala to be due to use of DDT for malaria control rather than to leaching, since DDT is considered rather immobile and irrigation water does not percolate far in the Gezira soils, nor is there supposed to be any link between Nile water and groundwater.

The detection of endosulfan residues six months after spraying gives cause for concern in view of Afaf's finding on its toxicity to fish. More work on recovery of fish populations at different levels of field contamination would seem indicated. Some aspects of this hazard were monitored by the project.

8.2.1 Effect of Water Pollution on Fish

There are 37,380 km of waterways in the Gezira, down to and including the sub-minor canals, (Shell Co. figures, 1986) and accidental over-spraying as well as downwind drift (Section 8.1; Annex A) from the intensive aerial spraying programme can cause substantial pollution of waterways. The washing of spray equipment and mixing tanks also causes run-off into canals. Eighty-one per cent of all the sprays used in South and Centre Groups (until 5/12/85) contained insecticides known to be highly toxic to fish, including endosulfan, Thimul, Endophos, Curacron, Birlane and Dursban. Afaf et al (1985) states that Decis is less toxic under field application conditions than those chemicals and that dimethoate has a very low toxicity to aquatic animals.

Many cases of fish mortality were reported and twenty were observed in South, Centre, North, North-West, Messellamia and Wad Habouba Groups in the Gezira and also in New Halfa scheme. Six estimates of the number of dead fish/km of canal-bank were made, these are given in Table 8.2.

It is not known what per cent of the total fish population was killed, and little is known about the sensitivity of the local spp. to different chemicals. Afaf (1985) recorded high mortality of *Gambusia affinis* (Guppy) in Gezira canals after spraying with endosulfan and Dursban but no effect after Decis/dimethoate. However all chemicals had a disastrous effect on molluscs and insects in the canals.

Clearly, widespread fish mortality occurred after aerial spraying in the Gezira, a view supported by the results of interviews with farmers on the subject. Of 83 farmers interviewed, 89 per cent stated that dead fish were seen after aerial spraying. However the canals down to sub-minor level do not dry out during the year and fish populations re-establish themselves before aerial spraying starts again the following season, because of the constant replenishment of water and consequently fish from the Blue Nile via the Gezira and Managil main canals.

TABLE 8.2 EFFECT OF SPRAYS ON FISH (SOUTH AND CENTRE GROUPS 1985)

Block	Date	Estimated No. dead fish/km	Spp. of fish identified	Date last spray	Chemical applied	Toxicity to fish[2]
8	29/ 9	500	1, 2, 3, 4	28/ 9	Mikantop	High
12	5/10[1]	700	1, 2, 3, 4	4/10	Thimul/Dursban	Very high
5	23/10	600	1, 2, 3	20/10	Thimul/Ekatin	Very high
8	9/11	660	1, 2, 3	6/11	Endosulfan/ Dursban	Very high
7	17/11	360	1, 2, 3	16/11	Thimul/Ekatin	Very high
8	18/11	4	1	18/11	Thimul/Ekatin	Very high

Notes: [1] *Along 6 km on both banks.*
[2] *Martin and Worthing, 1983.*
Fish spp. identified (Y.B.A. Gideiri, 1984; Ref. 36)

No.	English Name	Local Name	Latin Name
1	Mosquito Fish	Bulti	*Tilapia nilotica* (L.)
2	Eel Catfish	Garmut	*Clarias anguilloides* (L.)
3	Nile Perch	Egl	*Lates niloticus* (L.)
4	Barbel	Binni	*Barbus* sp.
(5)	Shield Head Catfish	Gurgur	*Synodontis schall* (Block-Schneider)

(5) Observed in NW Group.

This very high fish mortality is undesirable, and its effect on the aquatic habitats of the Gezira may be profound. An example of its impact is that it has been stated that the introduction of exotic fish species to control mosquitoes in minor canals and of grasscarp for the indirect control of the snail hosts of bilharzia is impossible at present.

Although fish are not favoured food of Gezira inhabitants with mainly immigrants from Nigeria (Fulanis, Fellatas) eating them, 90 per cent of 83 farmers interviewed stated that dead fish were collected and eaten after spraying, without ill effects.

8.2.2 Pesticide in Water Used by Man

Results from the limited number of samples taken for analysis will be presented and discussed in a later Addendum. Analyses have not been completed at time of preparing this report.

8.3 EFFECT ON BENEFICIAL INSECT POPULATIONS

8.3.1 Background

The adverse effect of pesticides on natural enemies of crop pests has been well documented in many parts of the world (Ref. 37). These effects are often disastrous and can lead to pest outbreaks as a result (Ref. 34). Worldwide, cotton receives more pesticide during its growing season than other crops (Ref. 38). Pesticides have been used in the Sudan since about 1948 and increasing use has been made of broad spectrum chemicals applied from the air to control four major pests of cotton, *Heliothis armigera* Hbn., *Empoasca* spp., *Aphis gossypii* Glov. and *Bemisia tabaci* (Gennadius).

The effect of this spraying on the beneficial insect fauna (parasites and predators) of cotton was studied in the Gezira. Studies were carried out mainly in the south Gezira (Section 1.2) from September, just before spraying, to December. The crop rotation and spray programmes have been described in Chapters 1 and 3. The Numbers containing cotton were distributed amongst those with other crops or fallow. Spray drift is commonly associated with aerial spraying and although other crops were not sprayed they and fallow areas were certainly receiving quantities of chemical throughout the spray programme. There was therefore no uncontaminated control area which could be used for comparison with the treated cotton.

8.3.2 Sampling and Identification

A 28 cm diameter 100 cm long tightly woven cotton bag sweep-net on a 100 cm long handle was used to collect insects. One sweep sample consisted of 200 horizontal passes into the canopy of the crop. Each walk through a Number was begun at a random point at least 25 m away from the nearest margin. Wherever possible a Number in Blocks 7 and 95 (S. Group) 12 and 13 (C. Group) was sampled once weekly.

Initial sweeps were carried out before spraying began, in South, Centre and North groups and then continued through the season until the end of December.

Trapped insects and plant debris were transferred to large plastic bags, labelled and put in a deep freeze at 18°C until sorting. Beneficial insects and spiders were sorted on a white surface and preserved in vials containing 70 per cent ethanol. Preliminary identifications were carried out by comparison with reference specimens in the ARC insect collection and samples of all species were sent to the British Museum of Natural History for confirmatory identification.

8.3.3 Results of Sweep Sampling

It was not possible to time sweep samples so that they were always made at the same time of day. As little is known about the effects of differing temperatures and humidity on the beneficial insect fauna of cotton, movement through the crop and increased or decreased activity may be reflected in the numbers of insects caught during sampling. The sampling results therefore give a general idea of insect and spider numbers only.

One hundred and four sweep samples were obtained from cotton between 16/9 - 28/12/85 (Appendix G). (An additional 10 samples were obtained from other crops but it was impossible to relate numbers of insects to those in samples from cotton because of the difficulties in getting even sweeps).

The samples were distributed as follows: South group 68; Centre 20; North 9; Mikashfi 4; Messellamia 3. Seventeen samples were obtained before spraying and 87 after.

Table 8.3 gives the mean numbers of beneficial insects and species, and the mean numbers of spiders/sample, before and after spraying.

TABLE 8.3 MEAN NUMBERS OF BENEFICIAL INSECTS, BENEFICIAL INSECT SPECIES AND SPIDERS PER SWEEP SAMPLE

	No. of Samples	Mean No./Sample		
		Beneficial Insects	Beneficial Insect spp.	Spiders
Unsprayed	17	23	6	4
Sprayed	87	7	1	0.4
% reduction in Nos.		70	83	90

The per cent reduction in numbers of individuals and species was very high. A list of the sprays used in South group shows that all were non-specific and most were also active against spiders (Table 8.4).

Table 8.5 gives the make-up of the beneficial insect fauna as percentage parasites and predators before and after spraying, indicating that the parasites (mainly hymenopterous spp.) were virtually eliminated by spraying.

TABLE 8.4 LIST OF CHEMICALS USED IN SOUTH GROUP 1985

Chemical		Action
Birlane	BS, A	Contact, stomach
Carbicron	BS, A	Contact, stomach, systemic
Curacron	BS, A	Contact, stomach, translaminar effect kills lep. larvae/bicron
Decis	BS, A	Contact, stomach, residual
Dimethoate	BS, A	Contact, systemic
Dursban	BS, A	Contact, ingestion, vapour, residual
Ekalux	BS, A	Contact, stomach
Ekatin	A	Systemic
Endophos	BS, A	Contact
Mitac	BS, A	Contact, residual
Ripcord	BS, A	Contact, stomach, residual
Sumicidin	BS	Contact, residual
Thimul	BS, A	Contact, stomach

BS *Broad Spectrum*
A *Active against spiders*

TABLE 8.5 PERCENTAGE OF BENEFICIAL INSECT FAUNA WHICH WAS PARASITIC AND PREDATORY

	No. Beneficial Insects	Percentage Parasitic	Percentage Predatory
Unsprayed samples	391	21	79
Sprayed samples	565	3	97

Scymnus marginalis, Coccinella rufescens and *Cydonia vicina* (Coleoptera, Coccinellidae) represented 61 per cent of all predators in sweep samples, *Chrysopa carnea* (Neuroptera, Chrysopidae), 37 per cent and *Ischiodon scutellare* (Diptera, Syrphidae) 2 per cent. Hymenopterous species represented 96 per cent of all parasites recovered in sweep samples (Braconidae 80 per cent, Elasmidae 13 per cent, other Hymenoptera species 3 per cent) and *Sturmia* sp. (Diptera, Tachinidae) 4 per cent.

Table 8.6 lists the preliminary identifications of parasites and predators from sweep-net samples. Sixteen parasites and five predators of the four main cotton pests in Sudan were present in those samples.

Table 8.7 gives the parasites and predators of the four main cotton pests as recorded from the ARC insect collection. This data was accrued from specimen labels and notes in the collection, and a total of 27 parasites and 10 predators of the four major cotton pests were recorded. This is a vital source of information, in danger of being lost due to the effects of the present storage conditions on the specimens (Sub-section 8.3.6). The sweep samples contained parasites from four families out of the seven recorded in the ARC collection and predators from three families out of the seven recorded there. Parasites from three families and predators from two families not represented in the ARC collection were recorded from sweep samples but it is not known yet if these attack cotton pests (Table 8.8).

Spiders from seven identified families and at least three other unidentified families were recorded from sweep samples (Table 8.9). Large numbers of spiders were seen in unsprayed sorghum in Block 106 east of the Blue Nile.

Figure 8.9 illustrates the effects of sprays on the beneficial insect faunas in Blocks 7, 95, 12 and 13. There was a rapid and permanent decrease in beneficial insect numbers after the first sprays in all groups (Figure 8.9). Numbers remained very low throughout the spraying period in Blocks 12 and 13 where full sprays only were made (Figure 8.9). Temik was applied in Blocks 7 and 95 in early October. Despite this full aerial sprays were carried out until late November in Block 95 and early November in Block 7. Beneficial insect numbers increased at the beginning of December in Blocks 95 and 7 after the use of partial sprays (Figure 8.9). 97 per cent of these insects were represented by the Coccinellidae. *Scymnus marginalis* and *Cydonia vicina* which are recorded as predators of *B. tabaci* and *A. gossypii* and the general predator *Chrysopa carnea* (Chrysopidae).

TABLE 8.6 PRELIMINARY LIST OF PARASITES AND PREDATORS FROM SWEEP-NET SAMPLES 1985-86

Parasites

HYMENOPTERA
Braconidae
Microbracon brevicornis
Disophrys lutea
Meteorus laphygmarum
Chelonella versatilis
Disophrys nr. lutea
Apanteles sp.
Chalcidae
Brachymeria paolii
Chalcid sp.
Eulophidae
2 spp. ?
Pteromalidae
1 sp. ?
Scelionidae
Platyscelio sp.
Elasmidae
Elasmus sp.
Eurytomidae
1 sp. ?
DIPTERA
Tachinidae
1 sp. ?
Pipunculidae
1 sp. ?

Predators

COLEOPTERA
Coccinellidae
Scymnus marginalis
S. trepidulus
Coccinella rufescens
Cydonia vicina
DIPTERA
Syrphidae
Ischiodon scutellare
NEUROPTERA
Chrysopidae
Chrysopa carnea

TABLE 8.7 LIST OF PARASITES AND PREDATORS RECORDED FROM FOUR MAJOR COTTON PESTS IN THE GEZIRA (FROM ARC INSECT COLLECTION).
(Parasites reared from parasitised pests in laboratory, Wad Medani).

Pest	Parasites	Predators
Heliothis armigera Hkn.	HYMENOPTERA	NEUROPTERA
	Braconidae	Chrysopidae
	Chalonella versatilis Wlkn.	*Chrysopa carnea* Steph.
	Meteorus laphygmarum Brues.	DIPTERA
	Microbracon kirkpatricki Wlkn.	Syrphidae
	Disophrys lutea Brulte	*Ischiodon scutellare* F.
	Eulophidae	HEMIPTERA
	Euplectrus laphygmae Few.	Miridae
	Pleurotropis furvum Gahan.	*Campylomma* sp.
	Chalcidae	Anthocoridae
	Hyperchalcidia soudanensis Steff.	*Orius* sp.
	Ancryptus kassalensis Kirby	
	Elasmidae	
	Elasmus johnstoni Ferr.	
	DIPTERA	
	Tachinidae	
	Sturmia inconspicus Meig.	
	Drino imberbis Weid.	
	Exorista fallasc Meig.	
	Goniophthalmus halli Mesnil	
	Isomera cinerascens Rondani	
	Sturmia sp. indt	
Empoasca spp.	HYMENOPTERA	NEUROPTERA
	Mymaridae	Chrysopidae
	Anagrus sp.	*C. carnea* Steph.
	Dryinidae	DIPTERA
	Aphelopus sp.	Syrphidae
	DIPTERA	*Ischiodon scutellare* F.
	Pipunculidae	
	sp. ?	
Aphis gossypii Glov.	HYMENOPTERA	COLEOPTERA
	Braconidae	Coccinellidae
	Apanteles carterus Wlkn.	*Cydonia vicina* Muls.
	A. ruficrus Hal.	*Coccinella rufescens* Muls.
		Scymnus marginalis Rossi
		S. trepidulus Weise.
		DIPTERA
		Syrphidae
		Ischiodon scutellare F.
		NEUROPTERA
		Chrysopidae
		Chrysopa carnes Steph.

TABLE 8.7 continued

Pest	Parasites	Predators
Bemisia tabaci (Gennadius)	HYMENOPTERA	COLEOPTERA
	Aphelinidae	Coccinellidae
	Encarsia lutea Masi	*Cydonia vicina* Muls.
	Eretmocerus diversiciliatus Silv.	*Coccinella rufescens* Muls.
	Prospaltella sp.	*Scymnus marginalis* Rossi
	Encarsia paritenopea Masi	*S. trepidulus* Weis
	Eretmocerus mundus Merc	DIPTERA
	Encarsia sp.	Syrphidae
		Ischiodon scutellare F.
		Empidae
		Drapetis sp.
		D. aenescens Wied.
		NEUROPTERA
		Chrysopidae
		Chrysopa carnea Steph.

TABLE 8.8 FAMILIES OF PARASITES AND PREDATORS OF COTTON PESTS IN THE SUDAN (Comparison of ARC records sweep-net samples)

ARC Parasites	Sweep Samples	ARC Predators	Sweep Samples
Braconidae	Braconidae	Chrysopidae	Chrysopidae
Eulophidae	Eulophidae	Syrphidae	Syrphidae
Chalcidae	Chaloidae	Miridae	-
Elasmidae	Elasmidae	Anthocoridae	-
Mymaridae	-	Coccinellidae	Cocoinellidae
Dryinidae	-	Empidae	-
Aphelinidae	-	-	ORTHOPTERA
-	? Pteromalidae	-	Tettigoniidae +
-	? Scelionidae		ODONATA
-	? Eurytonidae		Agrionidae +

+Very small numbers, and not included in any analysis.

TABLE 8.9 SPIDER FAMILIES REPRESENTED IN SWEEP SAMPLES

Aranaeidae
Thomisidae
Salticidae
Theridiidae
Tetragnathidae
Microphantidae
Oxyopidae
3 unidentified species

8.3.4 Potential of Beneficial Insects for Control of Cotton Pests

(a) Discussion

Very small numbers of beneficial insects and spiders were present in the cotton pre-spray (Table 8.3). The effect of aerial spraying on even those low numbers was very marked, and led to the virtual elimination of beneficial insects in the crop. There is almost complete dependence on pesticides for insect pest control in cotton in the Sudan. This inevitably leads to a permanent and massive reduction in beneficial insect numbers. No evidence of resilience to spraying by the beneficial insect fauna of cotton in the Gezira was shown in this study, contrary to the findings of Bindra and Abdulrahman (Ref. 39).

Only 41 per cent of the parasite species and 50 per cent of the predator species, recorded in the ARC collection were taken in sweep-net samples (Tables 8.7 and 8.9). This decrease in numbers of species present in the area is presumed due to the use of non-specific broad spectrum pesticides as blanket aerial sprays. Most of these pesticides are also active against spiders in cotton in the Sudan. Work in other parts of the world suggests that they play a significant role in pest control (Ref. 37).

The effects of blanket sprays on beneficial insect numbers is also clearly shown in Figure 8.9. Beneficial insect numbers decreased and remained low after the first aerial sprays in all the blocks regularly monitored. However Temik was applied in Blocks 95 and 7 in early October and full sprays were stopped in November (Figure 8.9). There was a rise in numbers of predators in early December, especially *S. marginalis* and *C. carnea,* (which constituted 97 per cent of all beneficial insects) following application of partial sprays in Blocks 95 and 7 at the end of November.

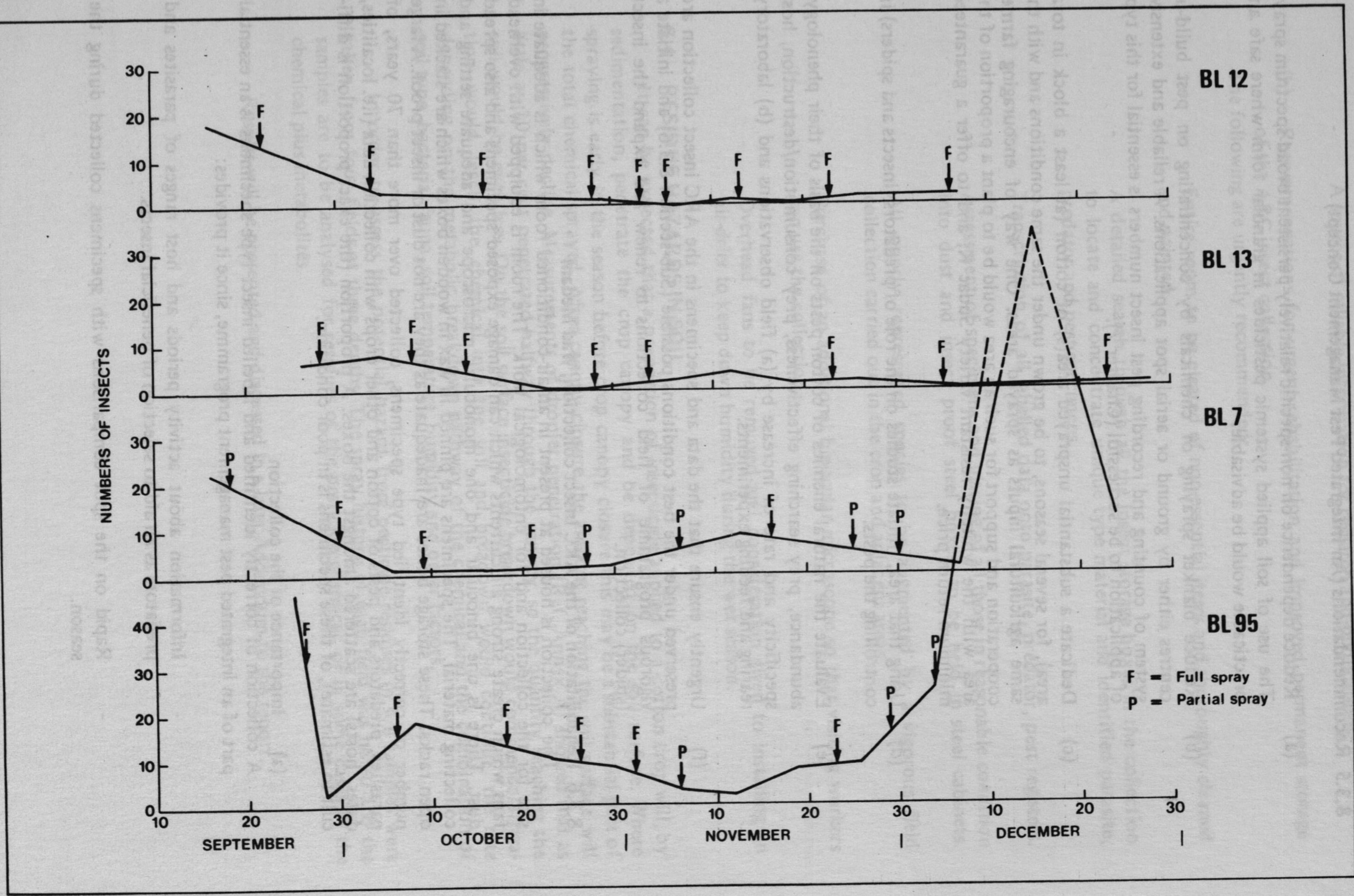
Sampling of unsprayed sorghum in November showed that large numbers of Coccinellidae were present. Sorghum constitutes a reservoir from which predators can re-establish in cotton. It was harvested in November and large numbers of predators would be expected to have invaded cotton then. This was not evident from the sampling results, presumably because invaders were rapidly eliminated by chemical sprays.

The build-up in predator populations seen in Blocks 95 and 7 occurred over a two week period in early December by which time the major cotton pest was *B. tabaci* (Figure 8.9). This rapid increase in numbers indicates that they do not show a delayed density dependent pattern of population increase, (which results in a very slow build-up in numbers) as shown by the hymenopterous parasites of *B. tabaci* (Ref. 33). Nothing is known about the biology and phenology of the Coccinellidae and Chrysopidae in cotton and sorghum in the Sudan. Species of these families however constitute a very important part of the beneficial insect fauna as they appear to be attacking *B. tabaci* (the major cotton pest) and are capable of rapid increase in population numbers when spraying is reduced or stopped.

(b) Conclusions

Blanket aerial spraying of non-specific broad spectrum pesticides on cotton in the Gezira has drastically reduced the number of parasite and predator species present in the area. The immediate effects of the first sprays is a virtual elimination of the beneficial insects and spiders present in the cotton at the beginning of the season. Subsequent sprays prevent a recovery in beneficial insect numbers. There is some indication that where partial sprays are used, as a result of Temik application, (which reduces numbers of full sprays needed in a season) the beneficial insect fauna and particularly the predators recover to pre-spray levels.

FIGURE 8.9 EFFECT OF SPRAYING ON BENEFICIAL INSECT POPULATIONS



8.3.5 Recommendations (An Integrated Pest Management Concept)

(a) Reduce dependence on non-specific relatively persistent broad spectrum sprays. The use of soil applied systemic pesticides in granular form where safe and practicable would be advisable.

(b) Reduce blanket spraying of chemicals by concentrating on pest build-up centres either by ground or aerial spot applications. A reliable and extensive system of counting and recording pest insect numbers is essential for this type of application to be successful (Chapter 7).

(c) Dedicate a substantial unsprayed area(s) of cotton (at least a block in total area), for several seasons, to be grown under the same conditions and with the same agricultural inputs as sprayed areas. One way of encouraging farmer cooperation and support for such an area would be to plant a proportion of the area with the whitefly resistant variety Sudac K, and to offer a guaranteed minimum return price.

(d) Using that area, initiate studies on the role of predators (insects and spiders) in controlling the pests.

(e) Evaluate the natural enemies of cotton pests on the basis of their phenology, abundance, prey searching effectiveness, prey consumption/destruction, host specificity and rate of increase by (a) field observations and (b) laboratory rearing and feeding experiments.

(f) Urgently ensure that the data and specimens in the ARC insect collection are preserved under the best conditions possible (Sub-section 8.3.6) and initiate a vigorous programme of field collections to renew and expand the insect (spider) collection.

8.3.6 Rehabilitation of the ARC insect collection, Wad Medani

The collection is housed at present in an air-conditioned room which is adequate in size for the collection and for entomological work. The room is equipped with overhead fans which create strong air currents which can damage exposed specimens and also spread dust. There is one binocular and one monocular microscope and adequate setting and collecting material. The specimens are pinned in wax in wooden boxes which are stacked in open racks. These storage boxes are inadequate as they are not dust or insect proof. A large number of correctly identified type specimens, collected over more than 70 years, of parasites, predators and pests of cotton and other crops with collection data (i.e. localities, dates, hosts) are scattered amongst the boxes. A proportion (the exact proportion is difficult to estimate), of these specimens is in poor condition.

(a) Importance of the collection

A collection of correctly identified and labelled insect type specimens is an essential part of an integrated pest management programme, since it provides:

- Information about activity periods and host ranges of parasites and predators as an aid to selection of beneficial insects.

- Rapid on the spot comparisons with specimens collected during the season.

- A source of reliable information for research and publications.

(b) Recommendations for urgent rehabilitation and improved permanent storage of the ARC insect collection.

The following are urgently recommended:

- Entire room to be cleared of non-essential items and thoroughly cleaned and painted.

- A detailed search through all the insect storage boxes in the collection to locate and concentrate unique type material and identified parasite, predator and pest specimens.

- Transcription of all labelled data onto parasite, predator, pest registers.

- Assessment of specimens and placing of all those in reasonable condition into dust and insect proof steel boxes, to be held in steel cabinets.

- All poorly represented species to be augmented by a vigorous field collection carried out in the crop and adjacent areas.

- Purchase of an additional binocular microscope so that visiting workers can use the collection.

- Overhead fans to be removed and consideration given to installing an air-drier to keep down humidity during the wet season.

8.4 RESIDUE HAZARDS IN SOIL

It can be expected that a proportion of insecticide applied to a cotton crop will, by sedimentation, penetrate the crop canopy and be deposited on the soil surface. Where spraying is early in the season before crop canopy closure this may be a substantial part of the total chemical sprayed. After canopy closure the amount reaching the soil surface will progressively decline. Measurements of droplet penetration (Ref. Annex A) showed that as little as 10 per cent penetrated halfway through the canopy, so the quantity reaching the soil would be even less. On the soil surface insecticide breakdown would commence. Irrigation would leach the chemical into the soil and breadown would continue, the rate depending on the metabolic breakdown pathway of the chemical and the combination of soil type, bacterial fauna, soil temperature, humidity and other factors.

In order to assess the potential hazard from pesticide residues in soil samples were taken from four fields at three depths. The spray history of each field was noted and the samples are to be analysed for residues of the pesticide chemical, or in some cases of the chemical plus metabolites.

Results will be presented and discussed in a later Addendum to the report.

- A source of reliable information for research and publications.

8.3.5 Recommendations for urgent rehabilitation and improved permanent storage of the ARC insect collection.

The following are urgently recommended:

- Entire room to be cleared of non essential items and thoroughly cleaned and painted.

- A detailed search through all the insect storage boxes in the collection to locate and concentrate unique type material and identified parasite, predator and pest specimens.

- Transcription of all labelled data onto parasite, predator, pest registers.

- Assessment of specimens and placing of all those in reasonable condition into dust and insect proof steel boxes, to be held in steel cabinets.

- All poorly represented species to be augmented by a vigorous field collection carried out in the crop and adjacent areas.

- Purchase of an additional binocular microscope so that visiting workers can use the collection.

- Overhead fans to be removed and consideration given to installing an air-drier to keep down humidity during the wet season.

8.4 RESIDUE HAZARDS IN SOIL

It can be expected that a proportion of insecticide applied to a cotton crop will, by sedimentation, penetrate the crop canopy and be deposited on the soil surface. Where spraying is early in the season before crop canopy closure this may be a substantial part of the total chemical sprayed. After canopy closure the amount reaching the soil surface will progressively decline. Measurements of droplet penetration (Ref. Annex [illegible]) showed that as little as 10 per cent penetrated halfway through the canopy, so the quantity reaching the soil would be even less. On the soil surface, breakdown would commence. Irrigation would leach the chemical into the soil and breakdown would continue, the rate depending on the characteristic breakdown pathway of the chemical and the composition of soil type, bacterial flora, soil temperature, humidity and other factors.

In order to assess the potential hazard from pesticide residues in soil samples were taken from four fields at three depths. The spray history of each field was noted and the samples are to be analysed for residues of the pesticide chemical, or in some cases of the chemical plus metabolites.

Results will be presented and discussed in a late addendum to the report.

APPENDIX A

TERMS OF REFERENCE

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Consultancy to Monitor Pesticide Usage in Sudan Cotton 1985 - 1986 Season

German government aid as a grant of DM 130 million is being provided to the Government of Sudan to assist in provision of pesticides and other agricultural inputs through the Sudan Gezira Cotton Production Board. In support of this programme a Consultancy is required. The baseline objectives of the Consultancy are to

1. Assist in ensuring the effective and efficient use of mainly KFW funds.

2. Provide reassurance to all persons concerned that useage of pesticides in irrigated cotton in the Sudan will result in minimal safety and environmental pollution hazards - in particular to

   (i) the tenant grower and field workers

   (ii) personnel of the field assessment teams

   (iii) personnel of the spraying operation teams

   (iv) inhabitants of villages in the producing areas

   (v) the general environment

It should be noted that assessment of effects on the general environment is limited to short-term effects since the pesticides used are of a relatively short residual effect.

The Consultancy will operate within the limitations set out by the Sudan Gezira Board 1985-1986 Crop Protection and Spraying Policy and will have no responsibility to amend these regulations or intervene directly in their execution. They also have no responsibility for the performance of any product in terms of biological effect nor application methodology. The Consultants will draw the attention of the appropriate authority (a Production Corporation or other Sudanese organisation) to any lapse of application contract conditions, failure to implement the regulations of the SGB 1985 - 1986 Cotton Crop Protection and Spraying Policy, or serious breach of normal safety standards, and shall make recommendations on how best to relieve the situation.

The Consultants should at the close of the season make such recommendations as they consider appropriate for amendment to the regulations for the 1986 - 1987 season within the context of (i) to (v) above, taking account of biological factors affecting selection of pesticides and the methods of their application. Recommendations should include advice on ways and means to improve the crop protection procedure in the overall context of an integrated pest management programme.

The Consultants in execution of their work programme will collaborate to the maximum with all Sudanese organisations and will utilise as far as is technically possible all facilities made available.

APPENDIX B

PURCHASES, STOCKS AND QUANTITIES OF PESTICIDE USED

HISTORICAL NOTE

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PURCHASES, STOCKS AND QUANTITIES OF PESTICIDE USED

HISTORICAL NOTE

The Sudan Gezira Board grew cotton for over twenty-five years without using any pesticides or fertilisers, relying on crop rotation and strict interseason quarantine practices to reduce pest infestations carrying over from one season to the next.

Commercial spraying operations are first recorded in 1945/46 season, when approximately 5,000 feddans were sprayed once at a cost of LS 1.287 per feddan; presumably with DDT to control jassid, which was the major pest at that time. The yield that year was 3.365 kantars per feddan (KPF).

As evidence of the cost/performance benefit became clear, spraying operations expanded rapidly and by the 1950/51 season it had risen to 0.81 of a spray over the whole area. Assuming some 300,000 feddans were planted (the Managil extension was not yet completed), probably around 250,000 fd were treated. DDT was used against jassid. That year the yield was recorded at 6.782 KPS the highest average ever achieved, and the cost of spraying was LS 1.158 per feddan. By this stage aircraft spraying was taking over from tractor spraying, no doubt due to speed, competitive pricing and flexibility of timing.

Up to this period, a private contractor (Fisons Pest Control) was engaged in both supplying the products and spraying team. It was not until 1958 that SGB began to tender for its insecticides and application services separately, and newer chemicals began to be tested. Since there was no exchange control at that time, the tender procedures were straightforward and based on payment on delivery in Sudanese currency.

By 1961/62 the number of sprays had increased to 2.25, and included the Managil extension area. Assuming there was 0.5 million feddans now under cotton, it meant that some 1.1 million acres was sprayed at a cost of LS 1.528 per feddan making pesticides an increasing cost in production (LS 1.7 million). 1961/62 season yielded the lowest harvest ever recorded (0.639 KPF) and presumably *Heliothis*, which was becoming prevalent by that time, contributed both to the increased spraying regime and the reduced yield.

At this stage, considerable competition was developing among application contractors with some half dozen companies, (mainly from UK) contracting their services. New chemicals were appearing, giving different options to the SGB, and there was greater competition between chemical manufacturers. DDT, BHC, endrin toxaphene had all been tried, and organophosphorous insecticides were becoming available. Prices reflected this, in that between the 1945/46 and the 1961/62 seasons, a period of 15 years, the cost of treating one feddan had increased from LS 1.287 per feddan to only LS 1.528 per feddan.

During the next 6-7 years, the intensity of agricultural production in the SGB areas increased considerably, with the introduction of winter crops such as wheat and vegetables. With a longer season and retained water in the canals, quarantine procedures were more difficult to maintain, and pests such as whitefly were able to survive from one season to the next on canal bank weeds and transfer to the new season cotton at an earlier stage. The pest situation became more complex and mixtures of insecticides began to be used, reflecting in higher costs and more sprays. In 1969/70 there were 5.9 sprays costing LS 4.291 per feddan (LS 12.28 million) compared to only LS 1.7 million in 1961/62.

Up to this period, Sudan's financial situation was strong in part due to the buoyant market for its high quality cottons. Exchange control had been introduced and some balance of payment problems had occurred. In 1963/64 there had been an occasion to barter its cotton crop for agricultural inputs, and back to back deals had been negotiated by chemical suppliers with brokers. However, in general, the Bank of Sudan was able to meet its obligations to suppliers of agricultural imports, albeit with some delays when the foreign resources fell below critical levels. In return, agricultural chemical suppliers were ready to supply on extended terms of credit and meet the tender obligations. There were two reasons for this. Primarily, it was because the SGB tender had now combined the input requirements of the other major crop production corporations such as Rahad, New Halfa, White Nile and Blue Nile, servicing over 1 million feddans of irrigated cotton. The tender for these inputs was now one of the largest pesticide tenders in the world, and attracted all the major suppliers.

Secondly, the international chemical industry had earlier grown very rapidly, with dozens of companies developing new compounds in a rapidly expanding market. This situation was now reversed dramatically as legislation controls governing the use of pesticides restricted markets in developed countries. With considerable overcapacity, the industry became aggressively competitive, often with Governmental support, in exporting pesticides to developing countries, where genuine need for them existed.

During the 1970's the economic situation in Sudan and elsewhere deteriorated rapidly. The oil price escalation and the fall in commodity values severely affected Sudan, like so many other countries in Africa. The balance of payments situation and its consequences on the infrastructure have been crippling, notwithstanding aid programmes. The devaluation of the local currency, complied with foreign inflation have distorted the costs of inputsout of all recognition. The cost per feddan of spraying nine times has been estimated as high as LS 250 in 1985/86, (depending on exchange rate figures used), or over thirty per cent of the crop (assumed 3.5 KPF at LS 225 pk) value. The cost benefit ratio is questionable, yet there appears little alternative, since without spraying there might be no crop at all. The outlined historical development of pesticides has influenced the whole production system over the past 30 years, and is now an integral part of it.

Consequently, when Sudan could no longer finance these inputs from its own resources, and companies refused to offer extended credit facilities, it became necessary to rely on foreign aid to finance them. The Ministry of Finance and National Economy noted that foreign aid contributed 29 per cent of the total input finance in 1982/83; 75 per cent in 1984/85 and 100 per cent in 1985/86.

World Bank, through IDA, financed 1984/85 inputs, but due to the failure of the IMF/Sudan Government negotiations in early 1985, the Bank initially refused to undertake it in 1985/86. Subsequent to the change in Government in April 1985 offers of bilateral aid from Europe were made and taken up by Sudan for agricultural inputs. Where possible the aid was used to purchase insecticides manufactured in the donor's country. The exception was the Federal Republic of Germany whereby a total of approximately US $ 21.3 million or 49 per cent of the aid grant (depending on exchange rates) was extended to cover outside suppliers as well. Because of the lateness of the finance and the complexities of the conditions governing donations from the various donor countries the inputs arrived late, but in most cases in time for use.

The Tables appendixed provide details of stock movement on the four major schemes as far as it has been possible to ascertain from the Crop Protection units involved. No attempt has been made to physically check these and all data is as provided by the authorities involved. The following points should also be noted when considering the data:

1. Carry over from 1984 are generally accurate but rely on data sent in from block stores. Quantities less than 1,000 i.g. have been excluded.

2. Drums are assumed to contain 45 g.

3. Amounts applied are calculated from the recorded area sprayed and the rate applied, or recommended where not available. Figures are therefore approximate. Loss on airstrips, by dumping, clearing aircraft hoppers or left unused in drum bottoms are not accountable.

TABLE B.1 INSECTICIDE COSTS 1985/86 SEASON (US$ FOREIGN AID COMPONENT, C & F BASIS)

Product	COTTON PRODUCTION SCHEMES									
	S.G.B.	Rahad	New Halfa	White Nile	Blue Nile	Suki	Others	Quantity		Amounts
BIRLANE 24 E.C.	(997,326	56,173	116,289	46,318	105,448	18,724		61,200 67,005[1]	I.G.	1,340,280) 1,467,409[1]
RIPCORD/BID 1/9 ULV	667,019							55,080	I.G.	667,019
KAFIL S.D. 25/18 ULV	532,916	346,800					231,200	192,200	L	1,110,916
KAFIL 10 E.C.	42,750	17,100						6,300	L	59,850
AGROSAN/HEP 5/50	540,500	162,150	129,720	54,050	10,810	32,430	64,860	92,000	Kg	994,520
KLERAT	12,500	2,500	1,250					6,500	Kg	16,250
NURELLE/DUR 14/240 ULV	700,240							41,310	I.G.	700,240
DURSBAN/DIM 48/180 E.C.	528,480							16,515	I.G.	528,480
DURSBAN 48 E.C.	588,667	318,060	178,267	189,810		89,775		47,880	I.G.	1,364,580
BRONOPOL 12	156,000							50	Ton	156,000
MITAC 20	1,318,088	355,657	398,767	213,394	257,582			106,200	I.G.	2,543,490
MIKANTOP 5/18 ULV	587,250	317,115		105,705				38,700	I.G.	1,010,070
SUMICIDIN 20 E.C.	918,351		106,785					21,600	I.G.	1,025,136
EKATIN WF 35 E.C.	566,433			45,198	72,900			42,255	I.G.	684,531
EKALUX F 48 E.C.		312,984		188,244	226,800	113,400		16,695	I.G.	841,428
EKALUX 25 E.C.			283,590					10,350	I.G.	283,590
LANNATE 90 W.P.	204,000	132,600			61,2000	10,200		20,000	Kg	408,000
DECIS/DIM 7/80 ULV	4,242,294	1,472,823	131,544	186,745	299,497	131,544		247,680	I.G.	6,467,448
DECIS 2.5 E.C.	939,200	146,750	70,440	105,660	105,660	41,090		24,000	I.G.	1,408,800
FACRON 'S' 21/12.9 E.C.	1,133,257	269,194	192,177	192,177	134,964	77,751		122,670	I.G.	1,999,521
ENDOPHOS 16/32 E.C.				330,569	260,584	153,372		22,500	I.G.	744,525
ENDOSULFAN 50 E.C.	9,375,547	2,170,334	768,325	1,152,488	1,082,079	768,325		558,000	I.G.	15,317,100
THIMUL/DIM 50/20 ULV	115,416						214,344	9,000	I.G.	329,760
POLYTRIN C 220 ULV	538,002	298,890	173,356		149,445	149,445		39,420	I.G.	1,309,138
CARBICRON 50 E.C.	168,399	168,399		57,408	38,272	34,445		27,450	I.G.	466,924
CURACRON 400 E.C.	214,460	97,208	55,118			55,118		18,945	I.G.	421,905
QUELEATOX VL 60							376,200	60,000	L	376,200
BAYLETON 25 WP	17,150							1,000	Kg	17,150
TOTAL	**25,349,661**	**6,657,679**	**2,670,555**	**2,867,765**	**2,805,242**	**1,685,045**	**2,156,404**			**42,716,945**

Note: [1] *Quantity of Birlane increased by 5805 g to utilise funds allocated for Aldrex but banned. Grand Total adjusted.*

TABLE B.2 INSECTICIDE INPUTS 1985/86 - GEZIRA

Imperial Gallons

Insecticide	Carry[1] Over	Purchases Orders	Purchases Receipts	Applied	Carry over 1.2.1986
ULV (i)					
Decis/Dimethoate	1,760[2]	162,540	162,490	69,350	83,295
Kafil S.D.	15,400[2]	20,240	20,835		20,745
Mikantop	22,000[2]	22,500	22,185	9,540	18,630
Nurelle/Dursban		41,310	41,175	33,830	6,165
Ripcord/Bidrin		55,080	55,620	6,330	55,485
Polytrin		16,200	16,515	16,090	720
Thimul/Dimethoate	5,080[2]	9,000	8,730	7,905	9,270
CLV (ii)					
Decis 2.5	8,860	16,000	16,000	3,140	9,360
Kafil 10		990	990	?	-
Sumicidin		19,350	(19,305)	14,065	1,260
CLV (iii)					
Birlane	7,650	45,540	51,345[3]	62,790	1,440
Carbicron		9,900	9,900	8,505	720
Curacron		9,630	9,630	9,915	855
Dursban	37,170[4]	20,655	22,860	64,945	-
Dursban/Dimethoate		16,515	16,470	10,530	2,475
Ekalux 25 EC	57,330	-	-	50,186	7,110
Ekalux Forte	30,780	-	-	?	-
Ekatin 35 WF	33,970	34,965	35,730	27,795	495
Endophos	93,195	-		73,560	-
Endosulfan	176,265	341,550	341,550	354,865	16,965
Facron		69,525	75,870[5]	2,095	71,325
Lannate		10,000kg	9,970kg	?	-
Mitac	76,185	55,035	54,450	115,200	-
Carry Over					
Curacron ULV	20,125[2]			17,630	-
Dursban ULV	34,315[2]			39,060	-
Cidial EC	925			-	?
Dimethoate EC	10,780			?	6,345
Temik	275t[2]			27,500	-

Notes: 1 *At 15.9.85. Excludes substantial stocks held in Block Stores.*
2 *Approximate quantities.*
3 *Includes 1935 g received from White Nile Corporation.*
4 *Quantity distributed to field reported 19,755 I. gall.*
5 *Arrived January 20th-24th 1986.*

TABLE B.3 INSECTICIDE INPUTS 1985/86 - RAHAD

Imperial Gallons

Insecticide	Carry[1] Over	Purchases Orders	Purchases Receipts	Applied	Carry over to 1986
ULV (i)					
Decis/Dimethoate		56,430		33,300	23,355
Kafil S.D.	2,250[2]	13,200	-	-	15,495
Mikantop		12,150		9,445	2,565
Polytrin		9,000		8,190	90
CLV (ii)					
Decis 2.5		2,500		-	2,430
Kafil 10		396		-	
CLV (iii)					
Birlane	1,800	2,565		1,965	1,945
Carbicron		9,900		9,020	-
Curacron		4,365		3,720	1,275
Dursban	2,565	11,160		10,720	?
Ekalux Forte		6,210		11,620	-
Endosulfan	36,000[2]	79,065		75,260	41,715
Facron		16,515		-	?
Lannate		6,500kg		5,870kg	4,550
Mitac		14,850	-	15,140	-
Carry Over					
Endophos	25,200[2]			23,020	-
Rogor	?			3,230	3,380
Sumicidin	2,700			2,820	-
Ekatin 35 WF	29,700			26,270	1,425
Decis 3.5 ULV	26,100			-	?
Ripcord/Bidrin ULV	6,075			-	?
Curacron ULV	1,675			-	1,675
Thimul/Dimethoate	3,690			-	3,690
Temik	?			-	38,000kg

Notes: [1] *Estimated visually September 1985.*
[2] *Identification of Endosulfan and Endophos drums was not certain due to labelling. The Kafil noted as ULV might have been EC.*

TABLE B.4 INSECTICIDE INPUTS 1985/86 - NEW HALFA

	Imperial Gallons				
		Purchases			
Insecticide	Carry Over	Orders	Receipts	Applied	Carry over to 1986
ULV (i)					
Decis Dimethoate		5,040		5,190	-
Polytrin		5,220	5,195	4,980	-
CLV (ii)					
Decis 2.5		1,200	1,200	120	1,090
Sumicidin	2,750	2,250		3,185	2,895
CLV (iii)					
Birlane		5,310		2,185	2,925
Curacron		2,475	2,510	2,270	55
Dursban		6,255		6,160	770
Ekalux 25		10,350		9,685	505
Endosulfan	28,110	27,990		32,585	22,610
Facron		11,790	?[1]	-	11,790
Mitac		16,650		10,830	5,710
Carry Over					
Ekatin W.F. 35	5,320			4,065	95
Endophos	9,015			8,440	75
Rogor	13,600			4,535	1,105
Ekatin 25	?				3,810
Commercial Trial					
Callisulfan/Dimethoate	-			742	-
Fastac/Birlane	-			157	
Ripcord/Bidrin	-			157	
Thimul/Dimethoate	-			170	

Note: [1] *Facron received late January.*

TABLE B.5 INSECTICIDE INPUTS 1985/86 - WHITE NILE CORPORATION

Imperial Gallons

Insecticide	Carry Over	Purchases Orders	Purchases Receipts	Applied	Carry over to 1986[1]
ULV (i)					
Decis/Dimethoate	5,415	7,155	7,155	6,815	5,700
Mikantop		4,050	4,050	2,520	1,500
CLV (ii)					
Decis 2.5		1,500	1,804	120	1,650
CLV (iii)					
Birlane	4,555	2,115	-[2]	3,070	1,450
Carbicron		3,375	3,375	435	2,900
Dursban	4,725	6,660	6,660	6,415	4,950
Ekalux Forte	1,385	3,735	3,735	2,445	1,750
Ekatin W.F.	3,090	2,790	2,790	3,795	2,050
Endophos	4,220	9,990	9,990	3,355	5,900
Endosulfan	14,460	41,985	41,985	28,030	26,350
Facron	470	11,790	(11,790)[2]	-	470
Mitac	5,495	8,910	8,764	9,870	4,350
Carry Over					
Kafil S.D.	2,285			80	2,200
Thimul/Dimethoate	3,265			2,800	450
Ekalux 25	1,745			1,745	-
Ripcord	495			120	380
Rogor	9,870			4,020	5,800
Sumicidin	4,175			810	3,350
Nurelle/Dursban	225		(225)	450	-
Curacron	5,045			1,015	4,000
Bidrin	1,610			-	1,600
Ekatin	2,915			2,350	550

Notes: [1] *Figures estimated (rounded down). Known Stock less Calculated Applied. This does not take account of considerable field losses so stocks may be lower.*

[2] *1,935 g Birlane, total stock Facron transferred to SGB.*

TABLE B.6 TIMING OF SPRAY ROUNDS.

	Spray Round Date						
	1	2	3	4	5	6	7
New Halfa							
Dubeira	12/10-22/10	29/10-12/11	13/11-26/11	20/11-14/12	10/12-7/1	11/1	
Sasereb	12/10-13/10	27/10-31/10	13/11-15/11	21/11-5/12	11/12-9/1	7/1	
Sidera	22/10-23/10	7/11-9/11	26/11-16/12	17/12	-	-	
Dimiate	16/10	31/10-1/11	14/11-15/11	3/12-4/12	15/12-22/12	-	
Reira	21/10	3/11-4/11	24/11-29/11	19/12-20/12	-	-	
Sheik Omar	6/10-14/10	17/10-29/11	28/10-15/11	11/11-28/11	27/11-17/12	13/12-12/1	7/1-11/1
White Nile							
Abgar	17/10-20/10	2/11-16/11	20/11-5/12	23/12	31/12		
Umger	23/9-14/11	16/10-27/11	20/10-18/12	13/11-5/1	16/12-14/1		
Rabak	22/10-9/11	8/11-24/11	21/11-13/12	10/12-31/12	27/12-29/12		
Umhani	13/10-23/10	22/10-13/11	6/11-29/11	28/11-16/12	15/12		
El Geiger	7/10-12/10	21/10-10/11	1/11-2/12	21/11-22/12	15/12-22/12		
Um Galala	25/9-28/11	15/10-17/12	12/11-20/12	27/11-25/1	13/12-26/1	4/1	

TABLE B.7 INSECTICIDES COST PER FEDDAN 1985/86

Group I ULV Formulations (Early Season)

Chemical Name	Trade Name	A.1 %	Cost per Feddan LS
Cyper/Profenophos	Polytrin C 220	2/20	14.42
Cyper/Chlorpyrifos	Nurelle/Dursban	1.4/24	15.66
Cyper/Dicrotophos	Ripcord/Bidrin	1/9	15.72
Cyper/Dimethoate	Kafil S.D.	2.5/18	15.80
Deltamethrin/Dimethoate	Decis/Dimethoate	0.7/18	15.81
Endosulfan/Dimethoate	Thimul/Dimethoate	50/20	15.96
Fenvalerate/Dimethoate	Mikantop	5/18	16.20

Group IIA CLV Formulations (Mid-Season Mixtures)

Chemical Name	Trade Name	A.1 %	Cost per Feddan LS
Deltam ehtrin & Thiometon/MP	Decis & Ekatin W.F.	2.5 & 35	11.1
Fenvalerate & Dimethoate	Sumicidin & Dimethoate	20 & 32	12.0
Cypermethrin & Dimethoate	Kafil & Dimethoate	25 & 32	12.0
Deltamethrin & Dimethoate	Decis & Dimethoate	2.5 & 32	12.15
Fenvalerate & Thiometon & Melthyl Parathion	Sumicidin & Ekatin W.F.	20 & 35	12.39
Cyper/Chlorpyrifos	Nurelle/Dursban	2.5/36	14.33
Fenvalerate & Quinalphos	Sumicidin & Ekalux	20 & 25	17.13
Cypermethrin & Chlorfenvinphos	Ripcord & Birlane	40 & 24	17.17
Cypermethrin & Amitraz	Kafil S. & Mitac	25 & 20	19.28

Group IIB CLV Formulations (Late Season Mixtures)

Chemical Name	Trade Name	A.1 %	Cost per Feddan LS
Thiometon & Endosulfan	Ekatin & Endosulfan	35 & 50	17.24
Methomyl & Dimethoate	Lannate & Dimethoate	90 & 32	17.36
Dicrotophos & Endosulfan	Carbicron & Endosulfan	50 & 50	17.79
Triazophos/Endosulfan	Endophos	16/32	22.56
Profenofos & Endosulfan	Curacron & Endosulfan	40 & 50	22.68
Dimethoate/Prothoate & Endosulfan	Facron & Endosulfan	21/12.9	23.40
Quinalphos & Endosulfan	Ekalux Forte & Endosulfan	48 & 50	24.21
Quinalphos & Endosulfan	Ekalux & Endosulfan	25 & 50	25.19
Amitraz & Endosulfan	Mitac & Endosulfan	20 & 50	25.43
Chlorfenvinphos & Endosulfan	Birlane & Endosulfan	24 & 50	25.95
Chlorpyrifos & Endosulfan	Dursban & Endosulfan	48 & 50	26.65

APPENDIX C

AID TO CONTRACT MONITORING 1986/87

APPENDIX C

AID TO CONTRACT MONITORING 1986/87

The recommendations made in Section 3.1.5 were discussed with SGB Plant Protection Department. While it was agreed that the developments were desirable, the opinion was expressed that the Agricultural Corporations were obliged to use aerial spray contractors who did not have the technological capability to implement the requirements. In addition it was stated that the SGB's application unit had not yet developed far enough to be able to handle the pre- and trans-season monitoring processes involved.

This document together with the revised contract should provide an intermediate solution and uses rough field methods and a general data base as a short term improvement on the present situation. The need remains for the SGB to build up a practical field unit with the capacity to develope the use of other segments of existing simple application technology and, later, to make use of more sophisticated technology which could be of major economic and environmental benefit.

The areas requiring most urgent attention are:

1. the implementation of basic standards
2. Volume Mean Diameters (Aircraft nozzle emission) for CLV sprays
3. quality of distribution

1. IMPLEMENTATION OF BASIC STANDARDS

The underlying principle should be changed to correction or prevention of faults so that spray standards are met, as opposed to "fining for default". Corrective or preventive measures should be at the expense of the contractor. This implies that the SGB (or other Corporation) technical unit must have the executive power or support to ensure the faults are rectified.

2. VMD's FOR CLV SPRAY

SGB considered that the major difficulty here was that some nozzle specifications are not available and that they were obliged therefore to accept certain vague statements from contractors, nozzle manufacturers or other sources.

Monitoring VMD using simple field comparative methods

It is possible to relate the 'static' VMD of a nozzle (for an aircraft nozzle this the VMD with no 'shatter' effect from an airflow) to its 'dynamic' VMD (a nozzle with an airflow over it, in this case). When the Sudan requirement of 250 microns VMD is considered (ref. 9; section 3.1.4 i) it may be noted from the "Use of Agriculture in Agriculture" (ref. 42 also ref. 9 and others) that nozzles which give around 450 microns 'static' VMD, when fitted at 90° to the airflow on an aircraft flying at 100 mph, give a 'dynamic' VMD of around 250 microns, at operating pressures around 30 psi.

It is reasonable to assume that any other nozzle producing a 'static' VMD of 450 microns will produce more or less the same dynamic VMD given the same conditions of fitting angle and airflow.

Nozzles producing the same VMD by the same method (hydraulic pressure, turbulent or laminar flow characteristics etc) will produce for practical field purposes the same D. Max. By using a 'standard' nozzle of known pressure to VMD relationship, fitted to a knapsack sprayer with known pressure (CP3 or air pressure type with an accurate pressure gauge), given a watersoluble dye sprayed over suitable collectors of 20 x 20 cm size one can quickly determine the characteristics of an unknown nozzle using a graduated viewing lens.

Spray Systems produce catalogues giving VMD characteristics for all their nozzles. A selection of their D1 to D16 orifices with a number 45 core permits a comparative range of VMD's from 275 to 750 microns at 25 psi. This will be adequate for most CLV situations likely to be encountered in aerial application. Comparisons of D. Max based on the methods shown in Ciba Geigy Training Manual (Ref. 18) are quickly performed. It may be noted that in this direct comparison field method spread factors do not have to be used.

VMD for aircraft with airspeeds of around 140 mph
Another major problem related to VMD that should be resolved in 1986/87 is that of aircraft with higher airspeeds. The static VMD of 450 microns which results in a dynamic VMD of around 250 microns when fitted at 90° to an airflow of 100 mph may be expected to give a much smaller dynamic VMD when fitted at 90° to an airflow of 140 mph, the airspeed of the Air Tractor and the Turbo Thrush. These aircraft are fitted with Whirljet B-10 bodies and number 3 or 5 orifices.

At 30 psi these produce static VMD's of 395 and 450 microns respectively. The dynamic VMD's of these nozzles fitted to the Air Tractor and the Turbo Thrush at 90° may therefore be expected to be much less than 250 microns. A rough field rule which can be used for the initial selection of a nozzle for fitting at 90° to these aircraft is:

$$\frac{450 \times 140}{100} = 630$$

where 450 is the static VMD which results in the required dynamic VMD of 250 microns (Sudan cotton requirement), 100 is the airspeed known to result in the required figure and 140 is the airspeed for which a static VMD is required.

Final adjustment for droplet size can normally be made by boom angle changes based on the finding of field trails. In 1986/87 there will be two constraints:

- the SGB will not be able to undertake these trials before the season begins;
- the booms with which these higher speed aircraft are fitted are aerodynamic and their angle cannot be changed

Under these circumstances one is obliged to rely on nozzle selection for 90° fitting and in this case D10-45 or D12-45 are preferred until detailed trials are carried out.

3. THE MONITORING OF DISTRIBUTION ACROSS FIELDS

Provided that VMD, applied volume and dosage rate of chemical are correctly chosen and implemented then it is generally accepted that a Coefficient of Variation of 70 per cent based on droplets per cm^2 collected on horizontal surfaces will result in a satisfactory control of cotton pests situated in the upper one third of the plant.

In the absence of some form of marking spray runs, it is unlikely that they can be evenly spaced. If at the same time run spacing has been chosen at the limit of biological efficiency (maximum aircraft productivity) then insect control will not be satisfactory. Monitoring is therefore essential and, if distribution quality is consistently below 70 per cent and a marking system cannot be used then more runs per Number will have to be made.

The monitoring for eveness of distribution during an operation necessitates a somewhat different approach from that used in an initial calibration. Initial calibration can usually be carefully planned and is carried out with experienced pilots in calm conditions (winds below 2 mps) while commercial take place in winds up to 4 mps, pilots are not always experienced, and they are quite frequently fatigued by the time the worst meteorological conditions of the day are to be met.

Despite the fact that droplet collection on vertical surfaces is greater than that on horizontal surfaces as windstrengths increase, horizontal surfaces still remain the best indicator of eveness related to run spacing. Collection on vertical surfaces usually shows more even distribution than horizontal surfaces and may be more indicative of a biological effect on insects located in the upper one third of the plant. Caution is therefore needed in the interpretation of results.

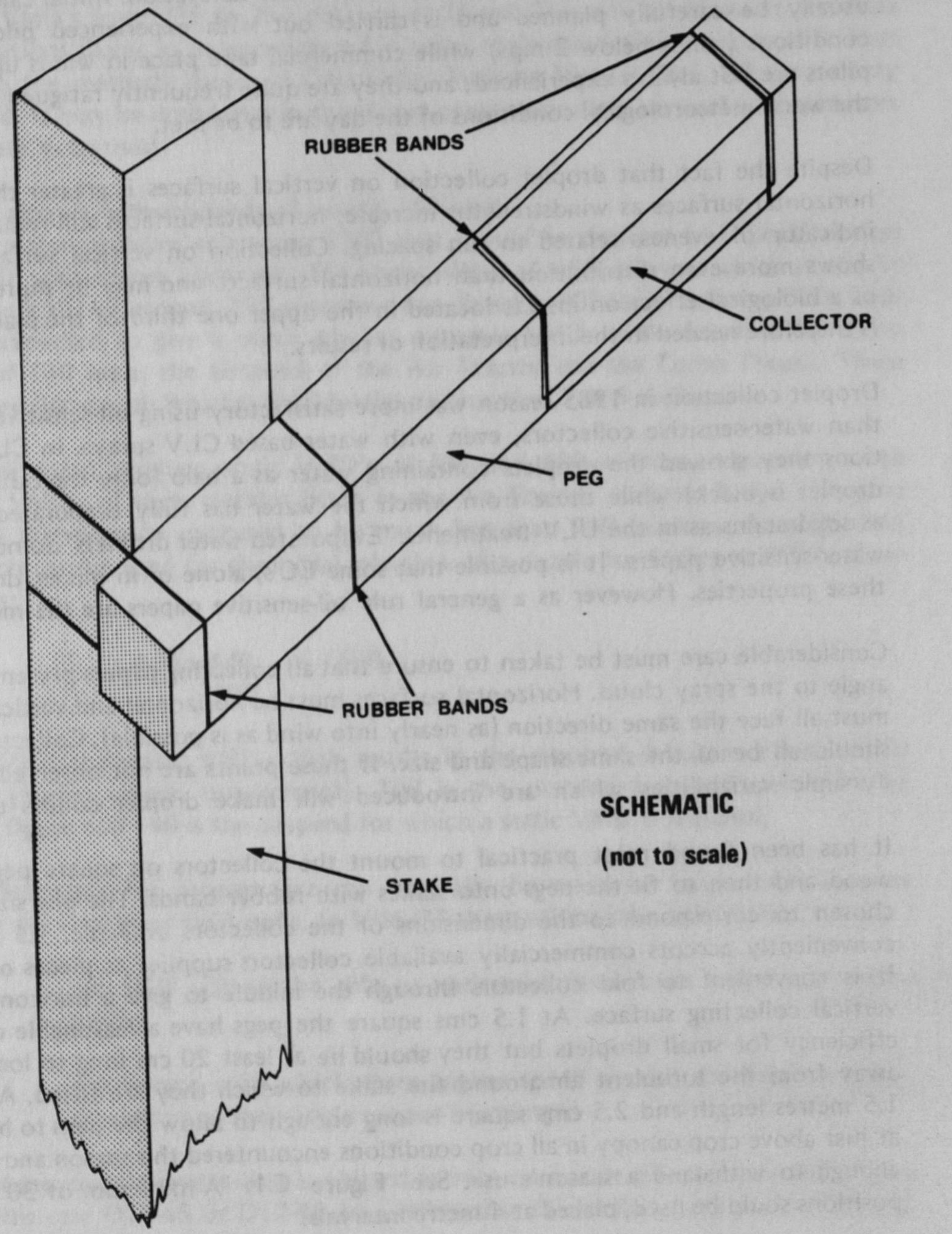
Droplet collection in 1985 season was more satisfactory using oil-sensitive collectors than water-sensitive collectors, even with water based CLV sprays. In CLV applications they showed the droplets containing water as a halo (only the outline of the droplet is black) while those from which the water has fully evaporated appeared as solid stains as in the ULV treatments. 'Evaporated water droplets' do not show on water-sensitive papers. It is possible that some EC's, alone or in mixes, do not have these properties. However as a general rule oil-sensitive papers are the most useful.

Considerable care must be taken to ensure that all collecting papers present the same angle to the spray cloud. Horizontal surfaces must be horizontal and vertical surfaces must all face the same direction (as nearly into wind as is possible). Collector mounts should all be of the same shape and size. If these points are not observed the aerodynamic variabilities which are introduced will make droplet counts unreliable.

It has been found most practical to mount the collectors on square pegs of soft wood and then to fit the pegs onto stakes with rubber bands. The peg size may be chosen to correspond to the dimensions of the collectors available. 1.5 x 1.5 cm conveniently accepts commercially available collectors supplied as pieces or as rolls. It is convenient to fold collectors through the middle to give a horizontal and a vertical collecting surface. At 1.5 cms square the pegs have a reasonable collection efficiency for small droplets but they should be at least 20 cm long to locate them away from the turbulent air around the stake to which they are fitted. A stake of 1.5 metres length and 2.5 cms square is long enough to allow the pegs to be located at just above crop canopy in all crop conditions encountered this season and are thick enough to withstand a season's use. See Figure C.1. A minimum of 30 collector positions sould be used, placed at 4 metre intervals.

Counting of droplets follows normal trials procedures. Three lens viewing positions should be counted for each collecting surface. The numbers of droplets should be calculated to a sq. cm. basis and these figures used for the calculation of CV's. Care must be exercised in relating these figures to coverage/volume relationships as wind effect is considerable.

FIGURE C.1 SCHEMATIC DRAWING OF A MOUNTING FOR DROPLET COLLECTORS



If a suitable calculator is not available then a quick guide as to the acceptability of distribution is to calculate the mean, divide this by 2, then, if less than 10 per cent of the figures (from which the mean has been calculated) fall below mean divided by two, the distribution is acceptable. The formula for CV calculation is

$$\frac{\text{Standard Deviation} \times 100 = \text{CV}}{\text{Average}}$$

APPENDIX D

S.G.B. AIRCRAFT SPRAY CALIBRATION PARAMETERS

Notes:

Spray Height

LV. 3M in light winds decreasing to 1M in wind speed of 5M/sec.

ULV. 5M in light winds decreasing to 3M in wind speed of 5M/sec.

Spraying is not recommended in calm conditions or in wind speeds above 5M/sec. ULV applications should not take place between 1030 and 1600 hrs.

Nozzles. For LV applications should be spraying systems T-JET nozzles. if other nozzles are used flow rate charts must be available.

ULTRA - LOW VOLUME APPLICATION

Aircraft Type	Speed MPH/KPH	Swath Width (m)	Runs Per No.	Volume Rate L/Fed.	Flow Rate L/min.	AU 3,000 No. of Units	AU 3,000 VRU	AU 3,000 Blade Angle	AU 5,000 No. of Units	AU 5,000 VRU	AU 5,000 Blade Angle	Remarks
				0.7	17.9		7	40				
Antonov AN-2M	100	40	7	0.75	19.2	6	7	40				
				1.0	25.5		9	40				
	161			1.5	38.3		11	40				
				2.0	51.1		11	40				
				0.7	21.9					5	65	When fitted with 8 unit VRU 7, 7, 9, 9 or 11 respectively.
Airtractor	140	35	8	0.75	23.4				10	7	65	
				1.0	31.2					7	65	
	225			1.5	46.9					7 or 9	65	
				2.0	62.5					9	65	
				0.7	21.9		9 or 11	45		5	65	
Turbo Thrush	140	35	8	0.75	23.4	6	11	45	10	5	65	
				1.0	31.2		11	45		7	65	
	225			1.5	46.9		11 or 13	45		7 or 9	65	
				2.0	62.5		13	45		9	65	
				0.7	16.4		9	40		5	55	
Thrush	105	35	8	0.75	17.6	6	9	40	10	5	55	
				1.0	23.5		9	40		5 or 7	55	
	169			1.5	35.2		11	40		7	55	
				2.0	46.9		11	40		9	55	
				0.7	19.4					5	65	
Cresco	140	31	9	0.75	20.7				10	5	65	
				1.0	27.7					7	65	
	225			1.5	41.5					7 or 9	65	
				2.0	55.3					9	65	
				0.7	15.2		9	40				
Fletcher FU-24	110	31	9	0.75	16.3	4	9 or 11	40				
				1.0	21.8		11	40				
	177			1.5	32.6		11 or 13	40				
				2.0	43.5		13	40				

ULTRA - LOW VOLUME APPLICATION

Aircraft Type	Speed MPH/KPH	Swath Width (m)	Runs Per No.	Volume Rate L/Fed.	Flow Rate L/min.	AU 3,000 No. of Units	AU 3,000 VRU	AU 3,000 Blade Angle	AU 5,000 No. of Units	AU 5,000 VRU	AU 5,000 Blade Angle	Remarks
				0.7	15.9					5	60	
Cessna	115	31	9	0.75	17.1				8	5	60	
Husky				1.0	22.7					7	60	
	185			1.5	34.1					7 or 9	60	
				2.0	45.5					9	60	
				0.7	15.6		9	40				
Kruk	100	35	8	0.75	16.8	6	9	40				
PZL-106A				1.0	22.4		9	40				
	161			1.5	33.5		11	40				
				2.0	44.7		11 or 13	40				
				0.7	14.5		9	40		5	55	
Cessna	105	31	9	0.75	15.6	4	9	40	8	5	55	
Agwagon/				1.0	20.8		9	40		7	55	
Agtruk	169			1.5	31.2		11	40		7	55	
				2.0	41.6		13	40		9	55	
				0.7	12.1		9	35				
Cmelak	87	31	9	0.75	12.9	4	9	35				
Z-37				1.0	17.2		11	35				
	140			1.5	25.8		11	35				
				2.0	34.4		13	35				
				0.7	10.8		9	40		3 or 5	55	
Pawnee	95	25.5	11	0.75	11.6	4	9	40	8	5	55	
235				1.0	15.5		9	40		5	55	
	153			1.5	23.2		11	40		7	55	
				2.0	31.0		11	40		7	55	

Note: Pressure is not given as it varies with the formulation and temperature.
The VRU number may be changed in order to achieve the correct flow rate.

LOW VOLUME APPLICATION - 2 GAL/FEDDAN (21.6 L/HA)

Type Aircraft	Speed MPH	Speed KPH	Swath Width (m)	Runs Per Number	Flow Rate L/min	All 5,000 VRU	All 5,000 Pressure PSI	All 5,000 Pressure KG/CM	All 5,000 Blade Angle	All 5,000 No. of Angle	Remarks
Antonov AN-2M	100	161	35	8	203						7 nozzles 3 blocked at end of port boom and 5 at end of starboard boom.
Kruk PZL 106A	100	161	28	10	163						
1. Turbo Thrush 2. Air Tractor	140	225	28	10	227	13	40	2.8	75	10	Airtractor fitted with 8 units not to be used.
Thrush	105	169	28	10	171	13	25	1.8	65	10	If used with boom and nozzles - 3 nozzles under the fuselage.
Cessna Husky	115	185	25.5	11	170	13	35	2.5	65	8	
Cessna Agtruck	105	169	25.5	11	155	13	30	2.1	65	8	
Fletcher FU-24	110	177	25.5	11	163						5 nozzles blocked at each end of each boom.
Cmelak Z-37	87	140	25.5	11	129						
Pawnee	95	153	21.5	13	119	13	20	1.4	60	8	If used with boom and nozzles 3 nozzles under the fuselage.
Cresco	140	225	25.5	11	207	13	33	2.3	75	10	Provisional.

APPENDIX E

METEOROLOGICAL DATA

APPENDIX E

METEOROLOGICAL DATA 1973-1985 FROM S.G.B. BARAKAT

TABLE E.1 TEMPERATURE AND RELATIVE HUMIDITY

Year	Month	Monthly Maximum Temperatures °C			Monthly Minimum Temperatures °C			Monthly Relative Humidity %		
			Range			Range			Range	
		Mean	From	To	Mean	From	To	Mean	From	To
1985	Sept.	34.7	30.0	38.8	22.0	20.2	24.0	74	95	59
	Oct.	38.2	35.0	40.0	23.2	19.5	25.0	52	76	29
	Nov.	36.1	32.5	38.5	18.0	12.0	25.2	39	61	16
	Dec.	33.6	26.7	38.4	17.2	10.5	22.3	56	63	26
1984	Sept.	38.0	34.5	41.1	22.1	17.1	25.2	61	80	34
	Oct.	40.2	36.3	41.2	23.6	19.6	27.0	40	60	21
	Nov.	36.1	29.4	40.0	18.3	11.7	24.8	34	57	22
	Dec.	33.7	29.5	38.3	16.4	10.2	20.8	44	64	25
1983	Sept.	37.1	31.5	40.1	23.2	20.3	25.8	80	95	64
	Oct.	39.3	37.3	40.4	21.7	18.0	24.8	43	72	28
	Nov.	37.5	35.0	39.3	18.9	13.0	24.3	33	55	17
	Dec.	34.4	26.8	38.0	17.5	10.5	22.5	45	67	19
1982	Sept.	37.0	30.7	39.6	22.7	20.5	24.7	70	88	57
	Oct.	37.7	34.2	39.7	22.1	19.0	27.5	54	78	20
	Nov.	34.5	30.0	39.0	16.0	9.6	20.6	38	54	25
	Dec.	33.1	30.0	37.3	13.9	11.0	20.7	43	63	30
1981	Sept.	33.9	25.0	38.8	22.3	17.0	27.9	76	91	65
	Oct.	38.6	35.4	40.7	22.6	19.0	25.0	48	83	27
	Nov.	35.6	31.3	39.0	18.7	12.0	23.3	35	47	19
	Dec.	35.1	32.7	38.0	17.4	12.8	20.0	46	61	25
1980	Sept.	38.0	31.9	41.0	23.1	21.2	24.7	67	84	48
	Oct.	39.3	36.3	41.3	22.9	20.4	24.8	55	85	27
	Nov.	38.0	31.9	41.0	23.1	21.2	24.7	67	84	48
	Dec.	34.1	25.8	40.0	15.9	9.0	20.5	44	61	26
1979	Sept.	36.0	26.5	40.0	22.5	19.5	24.4	69	88	53
	Oct.	38.7	33.0	41.5	23.1	19.7	25.7	51	76	25
	Nov.	37.7	29.3	40.5	20.7	12.1	25.2	39	24	51
	Dec.	32.0	20.8	34.7	13.6	9.9	19.3	35	45	24
1978	Sept.	36.3	33.2	39.1	21.9	19.4	23.7	70	86	55
	Oct.	38.2	35.5	40.1	22.3	19.6	24.7	54	73	35
	Nov.	34.7	31.5	38.3	16.3	11.8	24.3	34.5	56	26
	Dec.	33.6	26.6	37.5	16.0	9.8	21.5	43.3	64	28
1977	Sept.	37.4	34.0	41.4	21.8	19.6	24.7	66	78	41
	Oct.	36.1	33.5	39.4	19.2	11.1	24.0	48	73	20
	Nov.	36.0	32.5	38.5	16.4	11.6	23.0	33	50	19
	Dec.	32.7	27.2	37.0	14.8	9.8	20.1	31	54	20
1976	Sept.	35.9	31.7	38.0	21.8	19.8	24.4	68	91	53
	Oct.	37.9	29.3	41.0	22.4	20.0	25.6	51	66	25
	Nov.	37.4	32.2	38.6	21.8	14.4	23.4	37	78	19
	Dec.	38.3	31.4	37.5	18.2	14.3	22.4	45	60	21
1975	Sept.	32.9	26.6	36.6	21.9	19.3	23.7	81	90	68
	Oct.	37.2	33.3	39.0	20.3	18.5	22.4	59	81	27
	Nov.	36.8	34.7	39.5	19.5	14.7	22.9	41	61	26
	Dec.	32.8	26.2	37.5	15.0	8.3	20.4	39	69	26
1974	Sept.	34.9	30.5	37.2	22.1	19.3	24.0	72	90	58
	Oct.	38.8	34.3	40.7	21.5	18.0	25.0	50	67	32
	Nov.	37.0	33.9	39.2	19.3	16.1	22.7	40	59	27
	Dec.	32.3	27.5	37.1	14.2	7.8	18.3	34	59	25
1973	Sept.	35.4	27.6	41.0	22.4	19.4	25.6	74	91	54
	Oct.	37.9	30.5	40.8	22.6	20.2	27.7	55.3	79	35
	Nov.	35.3	32.5	37.2	16.0	12.6	21.9	36	56	17
	Dec.	33.6	30.7	37.9	16.6	13.0	20.4	47.8	63	28

TABLE E.2 RANGE OF TEMPERATURE AND RELATIVE HUMIDITY

Year	Month	Maximum Temperatures 1973-1985			Minimum Temperatures 1973-1985			Relative Humidities 1973-1985		
			Range			Range				
		Mean	From	To	Mean	From	To	Mean	Max	Min.
1973	Sept.	36.0	26.5	41.4	22.3	17.0	27.9	71.4	95	34
To	Oct.	38.3	29.3	41.5	22.1	11.1	27.7	50.8	85	20
1985	Nov.	36.4	29.4	41.0	18.8	9.6	25.2	38.9	84	16
	Dec.	33.8	20.8	40.0	17.2	7.8	22.5	41.7	69	20

TABLE E.3 MONTHLY RAINFALL, mm, GEZIRA SCHEME Mean

	Cotton Growth Period						
	June	July	August	Sept.	Oct.	Nov.	Total
80/81	20	138	116	6	2	-	282
81/82	27	99	42	71	4	-	243
82/83	17	35	75	42	12	-	181
83/84	29	45	49	44	1	-	168
84/85	5	16	9	21[1]	-	-	51[1]
85/86	56	68	110	42	2	-	277

Note: [1] *Low in comparison to Wad Medani figure of 80.1 mm, and 147 mm.*

TABLE E.4 MONTHLY RAINFALL WAD MEDANI

Average for 1951 - 1980 mm

J	F	M	A	M	J	J	A	S	O	N	D	Total
-	0.4	5.2	9.4	47.8	48.3	117.7	79.3	71.9	41.7	6.7	-	(428.4)
Actual Yearly Average 1970-1985												289

Rainfall, while low, varies greatly. Between 1970 and 1985 mean annual rainfall ranged from 146.8 (1984) to 438.7 mm (1985). In 1985 the recorded rainfall at Barakat was 386 mm, with 220 mm recorded in August.

FIGURE E.1 METEOROLOGICAL DATA - TEMPERATURE (°C)

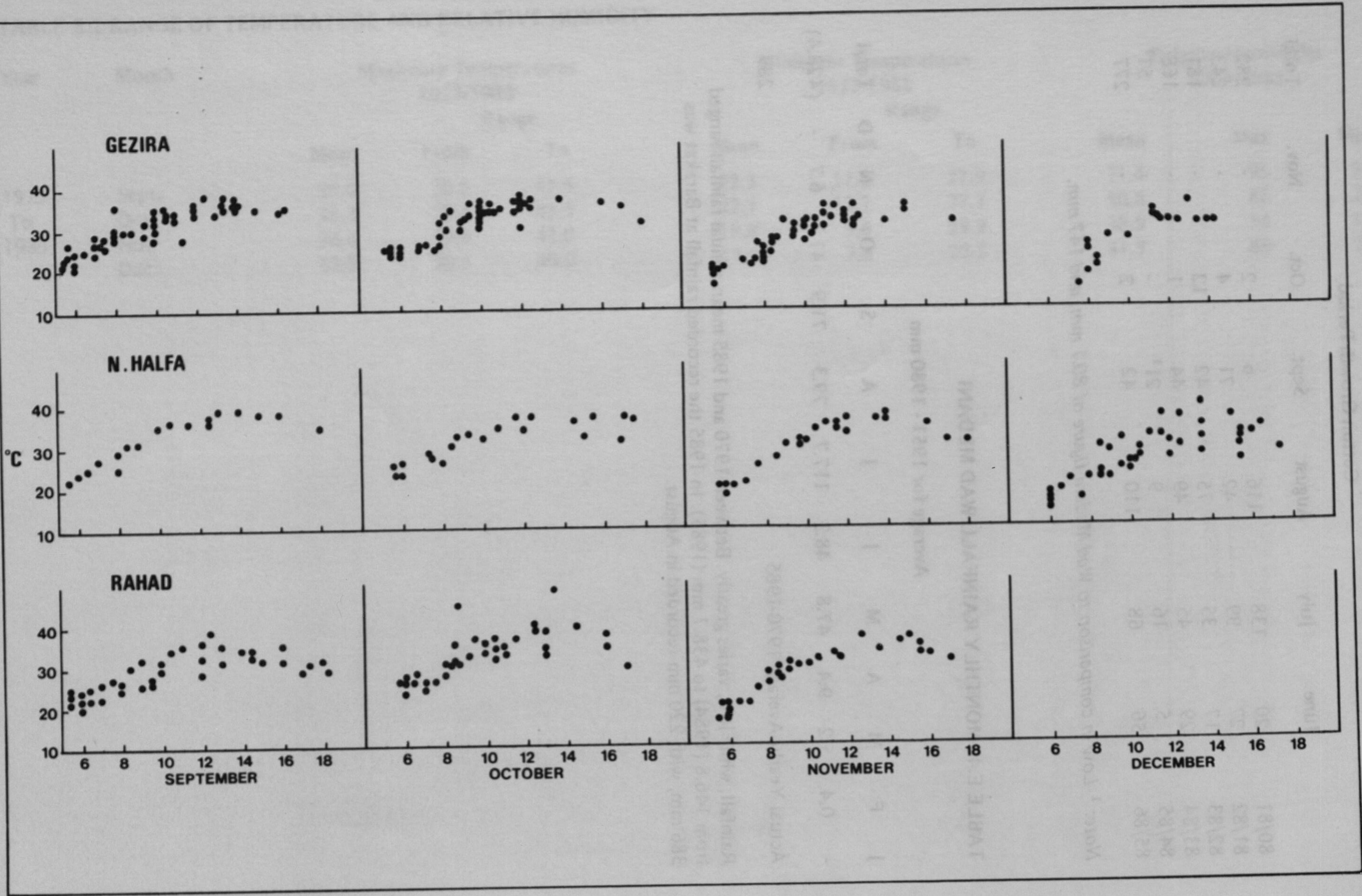


FIGURE E.2 METEOROLOGICAL DATA - RELATIVE HUMIDITY (%)

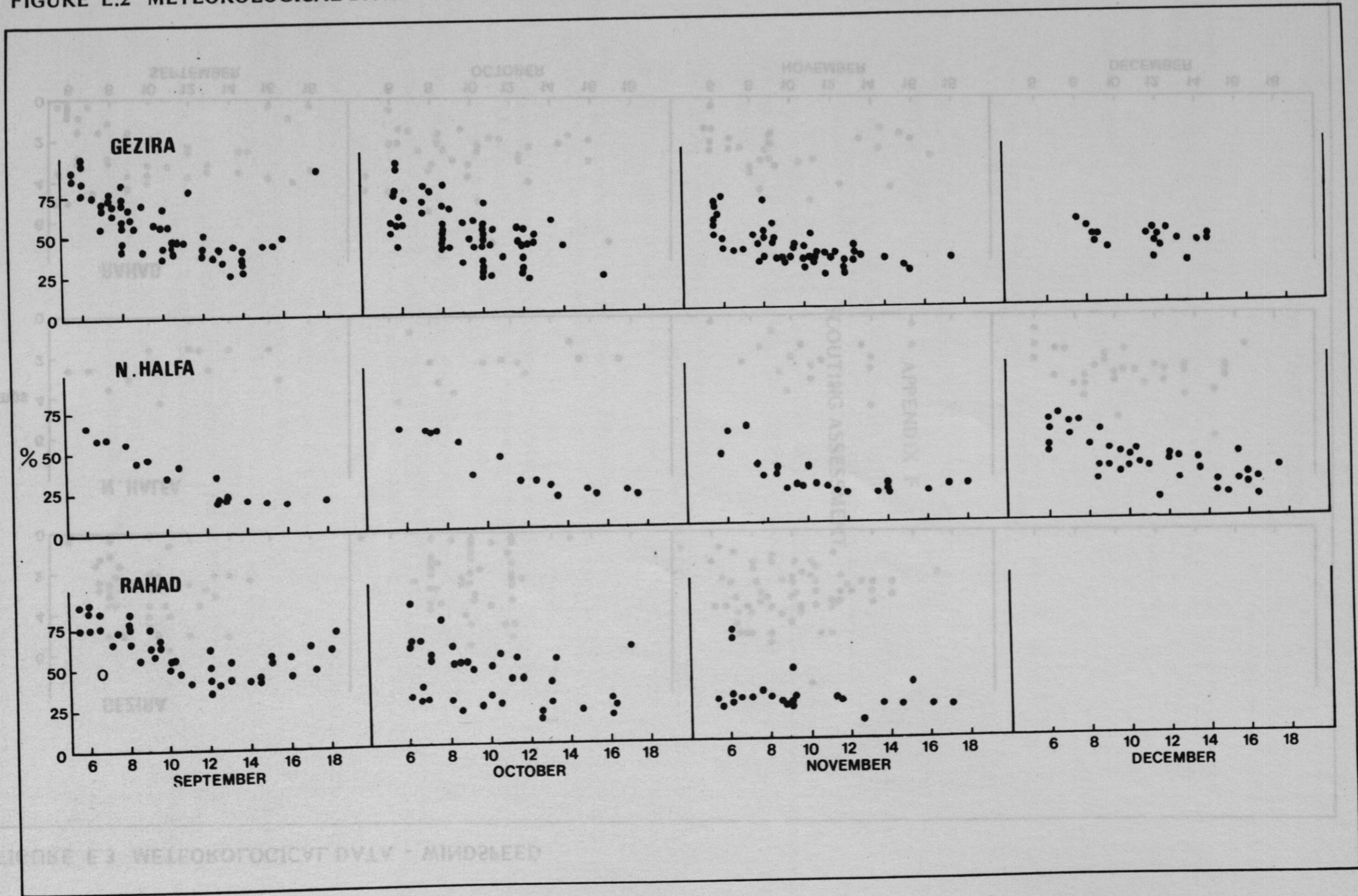
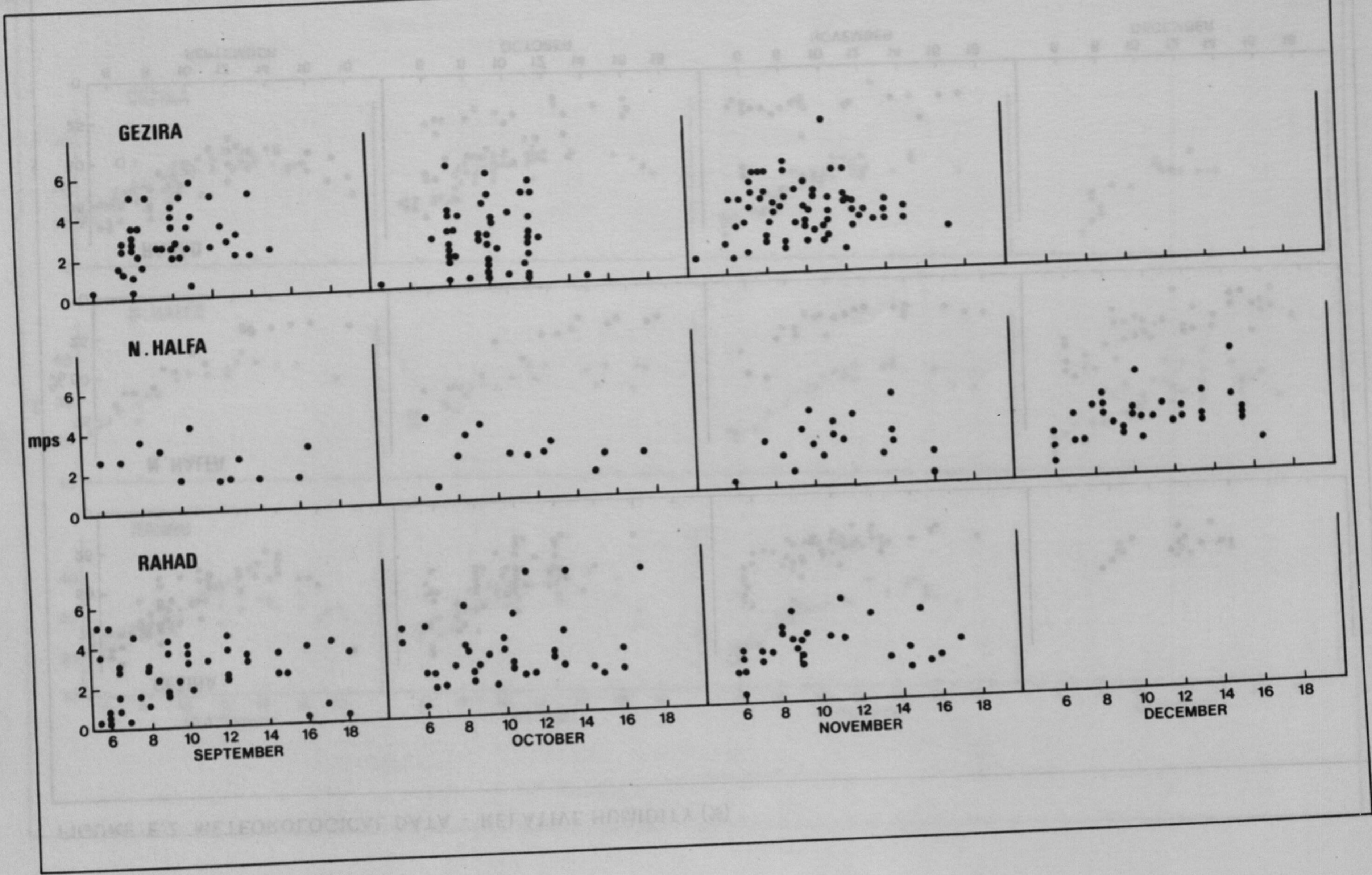


FIGURE E.3 METEOROLOGICAL DATA - WINDSPEED



APPENDIX F

SCOUTING ASSESSMENT

APPENDIX F

SCOUTING ASSESSMENT

Group:
Block:
Number:
Contact person:

Date:
Time:
Quest. Nr.:

A B C

1. How many cars are available for scouting in the Group, (A) hired, (B) from SGB?

2. Are all cars (A) always, (B) usually, or (C) seldom available for pest scouting?

3. Is fuel for these cars (A) always, (B) usually or (C) seldom available?

4. What is (A) the number of scouting teams present in the Group today. (B) How many teams are involved in scouting activities?

5. How many times per week does a team go out (A). Is this frequency constant throughout the season? yes or no, in (B). If no, ask why not - - - - -

6. What is the number of scouts in each team today? Team 1 (A), team 2 (B), team 3 (C).

7. Are scouts asked to perform other duties on days when scouting should be done? Tick (A) if answer is yes, (B) if no. If yes give details about type of activities - - - - - -

8. What number of scouts in each of the teams (A), (B), and (C) who received adequate field training. 4(b) means 4 received adequate training out of 6 in team (A). Adequate is: being able to distinguish all stages of the 3 major cotton pests and the most common minor ones.

9. State special problems with regard to scouting teams if any, e.g. recruiting problems, individual transport problems of scouts, private activities of scouts etc.

10. How are the sampling units (nusias) selected? Tick (A) if standard method, (B) if other. If (B) describe.

11. Is todays sampling method (A) a standard one (6-10 hoshas per number/block), or (B) intensive sampling (20-30 hoshas per number/block?) If (B), why?- - - - - -

	A	B	C

12. Are: (A) dry areas sampled only, (B) dry and wet areas, or (C) wet areas only?

13. Do scouts in the field follow (A) a radiating pattern, (B) a diagonal one, or (C) an other? If (C), describe.

14. What is the estimated distance (one way) walked by the scouts in one run. (A) 30m, (B) 60m, (C) 90m. Put 90 + in (C) if more than 90m.

15. What is (A) the time taken for one full walk. (Take average of 2 scouts). (B) the time taken for examining one plant (stop, stand). Take average of 2 scouts. Full walk means from the car into the field and back to the car.

16. What is the number of stands (stops, plants) counted/ made A) by scout x and B) by scout y.

17. What is the number of plants counted at one stand/stop, (A) for WF + J; B) for ABW.

18. Are all scouts sampling for all 3 major pests (A) or are some counting WF + J and others ABW (B).

19. What is the 'sampling pattern' for WF + J on one plant? (A) 2, 1, 2 or B) 1, 2,2. (2 top, 1 middle, 2 bottom etc.)

20. Are plants checked for ABW from top to bottom? (A) yes, (B) no.

21. Is the scouting, (A) accurately, (B) not accurately done according to your observations. (Check at least 2 scouts). If (B) put one tick in C) if due to limited time and two ticks if due to lack in experience.

22. What is the number of plants per nusia checked (A) for WF + J, and (B) for ABW.

23. Did you observe the standard sampling pattern in the field (A), or were field edges given more attention (B).

24. Are counts in the field registered on paper (A), or called out to teamleader (B).

25. Is the sampling done only during the first hours of the morning (A) or at late hours (B).

APPENDIX G

INSECT SWEEP SAMPLING DETAILS

APPENDIX G

INSECT SWEEP SAMPLING DETAILS

Block No.	Sample No.	Mean No./Sample Beneficial insects	Beneficial insects spp.	Spiders
1	S 2	8	1	0
2	S 2	2	1	0
3	S 5	6	1	0.2
5	S 8	1	0.3	0
6	U 1	11	7	4
	S 6	2	1	0.3
7	U 3	31	7	4
	S 10	19	2	0
8	U 3	32	8	4
	S 7	6	1	1
9	S 1	0	0	0
10	S 3	6	1	0
12	U 1	18	3	0
	S 7	9	8	0
13	U 1	6	3	2
	S 9	2	1	0.3
14	S 3	0.3	0.3	0
15	S 2	1	1	0
16	S 1	1	1	0
17	S 1	18	1	0
21	S 1	0	0	0
36	U 6	20	6	2
	S 3	1	1	0
95	U 1	46	5	2
	S 10	18	2	3
96	S 1	4	2	0
97	S 1	0	0	0

S = Sprayed cotton
U = Unsprayed cotton

APPENDIX H

REHABILITATION OF PESTICIDE RESIDUES/QUALITY CONTROL LABORATORY, WAD MEDANI

The problems encounted regarding local analysis for pesticide residues have been discussed in section 1.4 and in the specialist consultants report (Ref 25). In this the options for local collaboration in analysing samples of soil, water, food and downwind drift collectors had to be rejected for a range of technical and managerial reasons.

The separate section of the laboratory charged with testing and analysis of physical and chemical characteristics of new and carryover pesticides is severely handicapped. While their old laboratory situated in the Plant Protection Department can undertake certain work the new laboratory cannot be commissioned since the building (inspected by the Consultants) is collapsing and is unsafe. Furthermore if it does collapse highly valuable equipment will be destroyed. At present no analysis of carryover stocks can be undertaken.

SGB policy is to assume a 10 per cent loss of active ingredient in carryover stocks and they lift application rates accordingly. This level is based on average losses analysed over a number of years. For 1986/87 carryover ULV by SGB alone is valued (Foreign exchange C & F component only) at US$ 4,345,320. Thus ULV insecticide alone with a true value at well over $434,500 will be assumed lost by degradation when first sprays are made next year. Even complete rebuilding of the laboratory would not cost 25 per cent of this sum. Clearly rehabilitation should [illegible] consideration of any pesticide financing programme.

APPENDIX H

REHABILITATION OF PESTICIDE RESIDUES/QUALITY CONTROL LABORATORY, WAD MEDANI

SGB is participating in [illegible] study on pesticide degradation being carried out by a University student as his MSc thesis. In this study - discussed in detail by the student and the consultants - seven selected insecticides are to be stored:

(a) In the open with no protection.
(b) In open-sided stores.
(c) In walled closed stores.

The drums will be sampled at regular intervals and samples frozen until analysed by gas liquid chromatography. The trial will continue one complete season.

Consultants were asked to assist by financing and procuring analytical equipment and chemicals but unfortuately funds from KfW were not available. The study is well planned and executed and, subject to GLC analysis which is with the University of Gezira facilities, should produce valuable results.

It is therefore recommended that the German technical assistance organisation (GTZ) should assess the general situation regarding equipment requirements, including repairs and replacements for present items, and rehabilitate the Residue Analysis laboratory.

It is also recommended that a laboratory technician be posted to the Residue laboratory for a season to train staff in the Sudan in proper use of equipment and the techniques of GLC analysis, taking account of the criticisms noted by TDRI (Ref. 25).

It is also recommended that the Quality Control laboratory building be either repaired or if necessary completely rebuilt. This should be a pre-requisite for any future pesticide financing programme.

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APPENDIX I

REFERENCES

APPENDIX I

REFERENCES

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APPENDIX J

THE SUDAN GEZIRA BOARD SCHEMES

FIGURE J.1 GEZIRA SCHEME

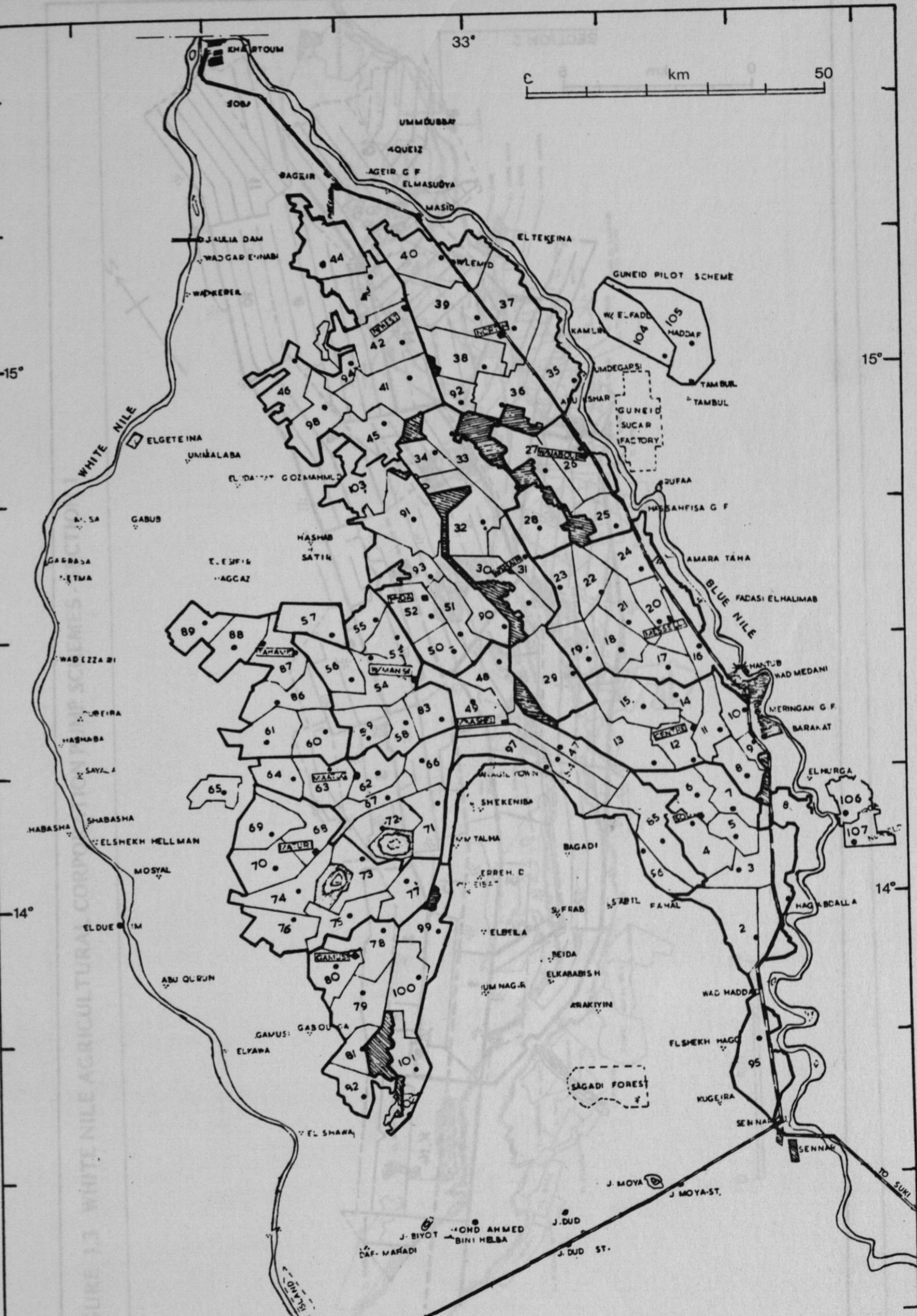


FIGURE J.2 NEW HALFA SCHEME

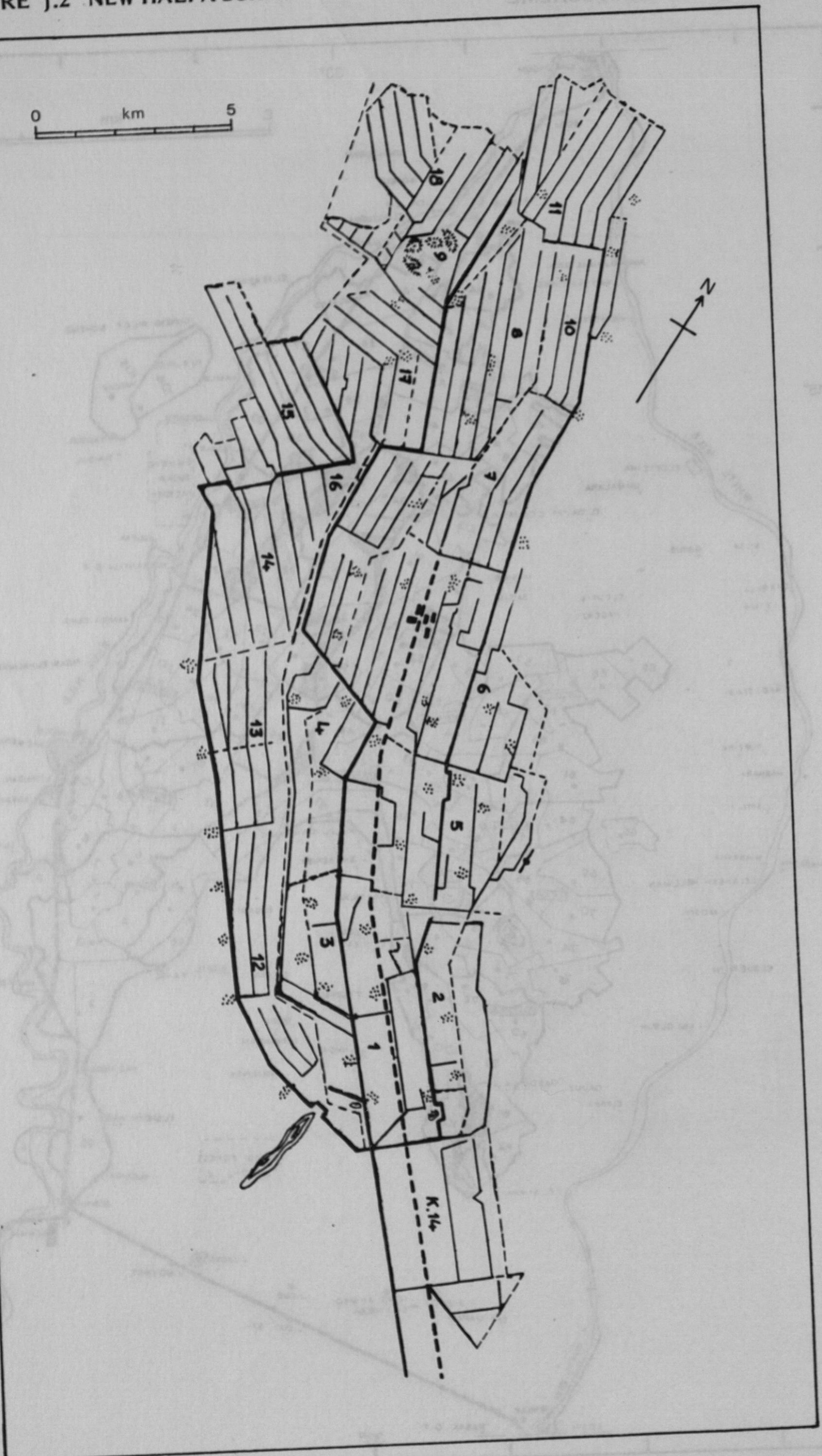


FIGURE J.3 WHITE NILE AGRICULTURAL CORPORATION PUMP SCHEMES - SECTION 1

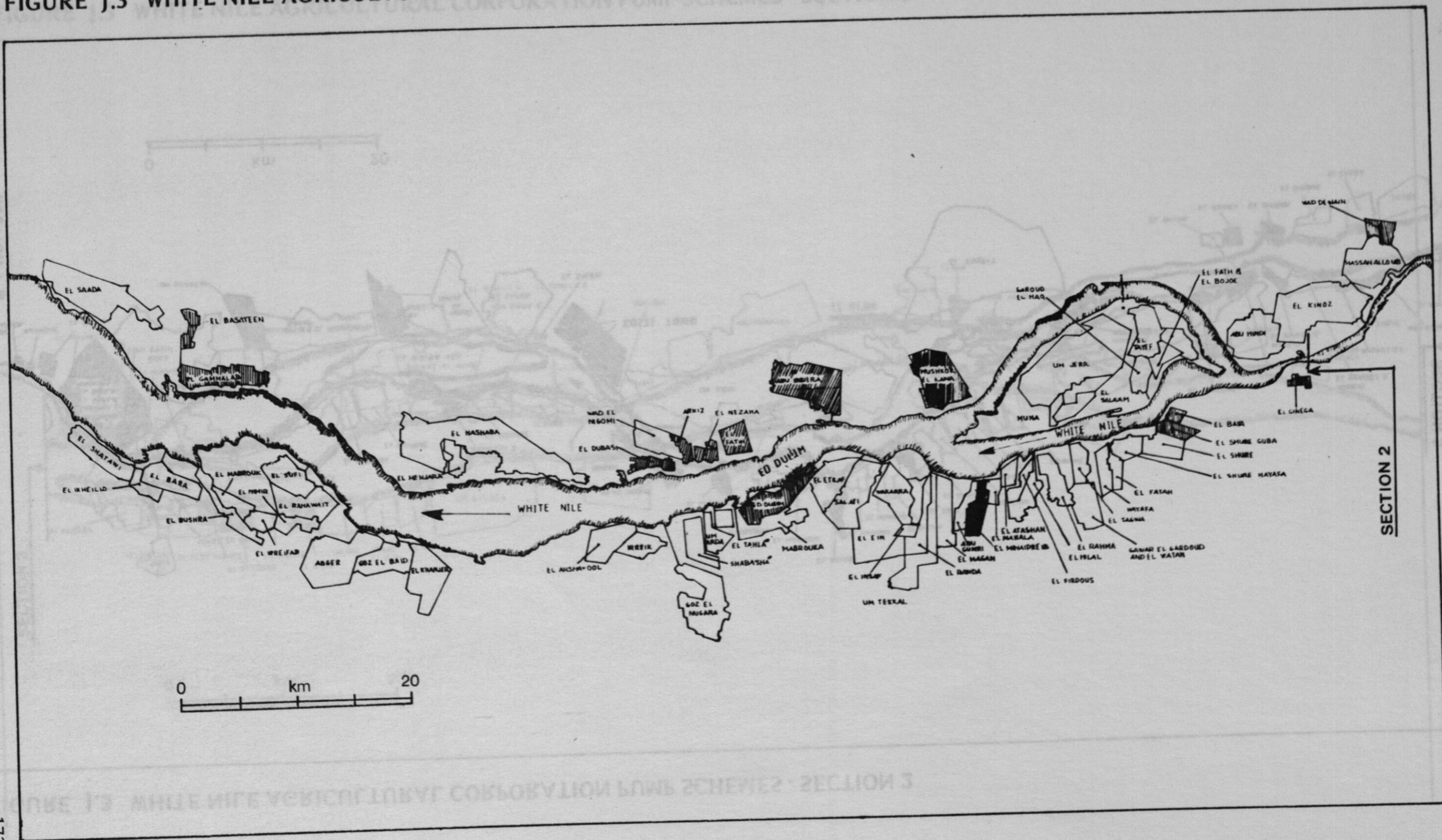


FIGURE J.3 WHITE NILE AGRICULTURAL CORPORATION PUMP SCHEMES - SECTION 2

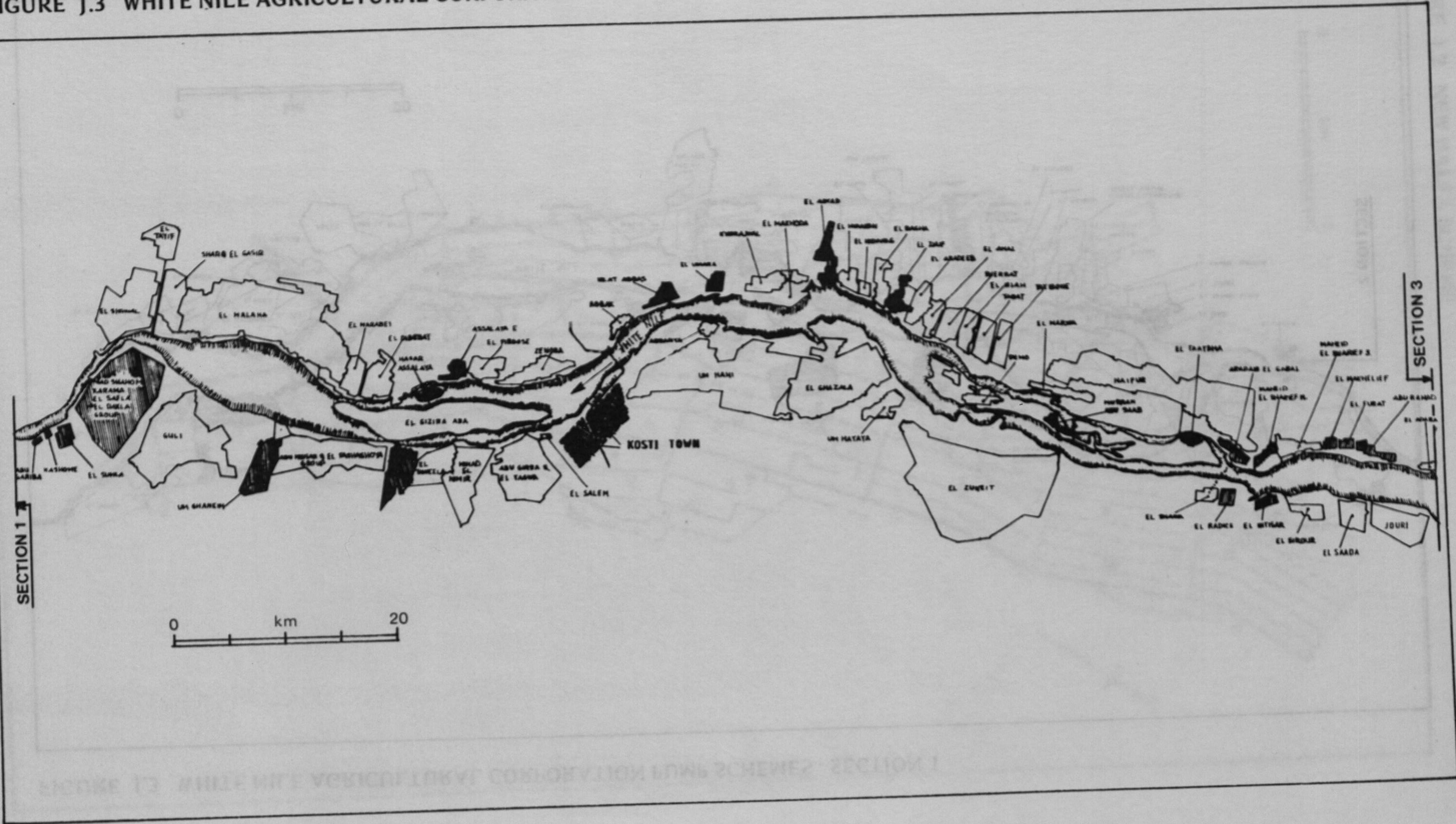
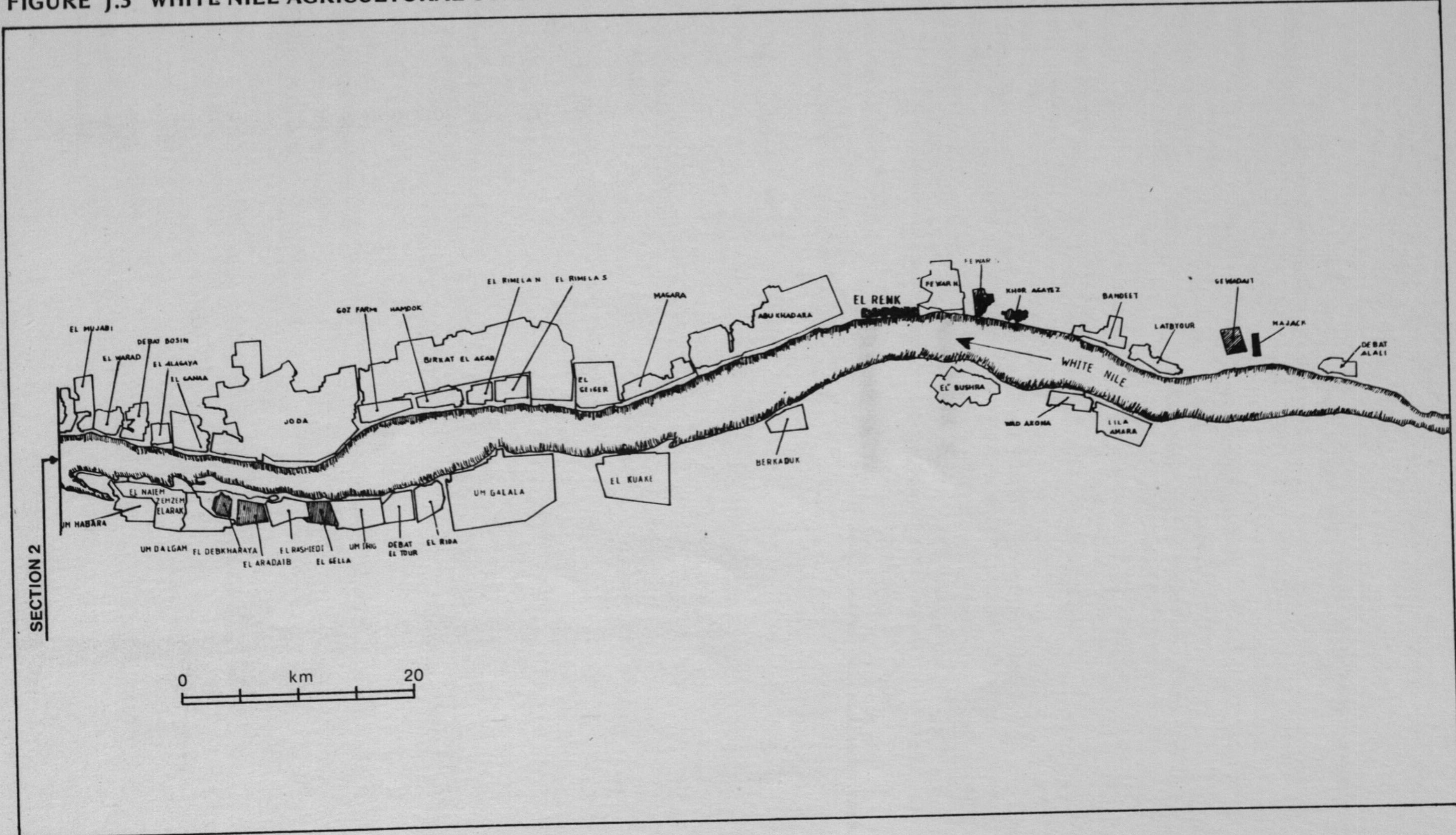


FIGURE J.3 WHITE NILE AGRICULTURAL CORPORATION PUMP SCHEMES - SECTION 3



APPENDIX K

PERSONS SEEN

APPENDIX K

PERSONS SEEN

This list notes the more senior persons with whom discussions were held, or who provided the consultants with advice or information.

Sudan Gezira Board	
Sd Abdulla Mohd. Zeibeir	Managing Director
Sd Galal Mohd. Osman	Mgr. Crop Protection Dept.
(Dr) Mohd.Gamar Khatib	Dep. Mgr. Crop Protection Dept.
Sd Abdulla Mursall	Tech. Officer Protection Dept.
Sd Wageih Samoya	Head Agron. Seed Propagation
Sd Ibrahim Ali Musalim	Mgr. Planning/Econ Studies
Sd Amin Khier Allah	Act. Mgr. Supplies Dept.
Sd Abdulla Razab	Chief Storekeeper
Sd Salah Disoughi	Coordinator Gezira zone Crop Prot.
Sd Abdulla Aziz	Administration Assistant
Sd Hassan Mohd.Saeed	Entomologist N. Group
Sd Abdul Azim ban Negr	Entomologist S Group
Sd Jair el Nabi	Entomologist N.W. Group
Sd Ahmed Gaffar Ahmed	Entomologist Messalamia Group
Sd Ahmed Adam	Entomologist Centre Group

and others too numerous to name individually.

Blue Nile Agric Corporation	
Sd al Hadu	M.D.
Sd Reduwan	Head Crop Protection
Rahad Agricultural Corporation	
Sd Yousif Adam Dien	Head Crop Protection
New Halfa Agric. Corporation	
Sd Gellabi	M.D.
Sd Fateh Abdul Ghadir	Head Crop Protection
Sd Sherrif el Din Hassan	Entomologist/Weed Control
Sd Anwar Farah Ali	Specialist Entomologist
Sd Hassan Mohd. Nur	Operations Mgr. (Spraying)
White Nile Corporation	
Sd Mustafa Hamid	Act. M.D.
Sd Ajelli Abdu Rahman	Head Crop Protection
Sd Abu Gassim Hamdullah	Entomologist Renk area
Sd El Sheik A el Gadi	Entomologist Kosti
Agricultural Research Council	
Dr. Hassan Khalifa	Director (until October 1985)
Dr. Osman I. Gameel	Acting Director
Professor Ahmed Naseir Balla	National Coordinator Entomology
Dr. Asim Ali Abdul Rahman	Entomologist, Integrated Pest Control
Dr. G.B. Zorghani	Senior Entomologist/Analytical Chemistry
Dr. Musa Abdullah	Taxonomist

Pesticide Analysis Laboratory	
Dr. Khalid H. Abbadi	Director
Mr. S.I. Shaaban	Head Residue Analysis
Department of Public Health - Gezira	
Dr. Abdul Rahman Kintibhai	Director (until October 1985)
Dr. Faried Mahmoud Khalifa	Director
Dr. Amin Ahmed el Hag	Head Occupational Health
Mr. Faisal	Head Malaria Control
Ministry of Finance and Economic Planning - Khartoum	
Dr. Mohd .Kheir el Zubeir	
Sd Bushra el Fatih	
Sd Fatih el Eid	
Others	
Sd Hassan Omran	Union Carbide
Sd Sir el Khatim	Ciba Geigy
Sd Kamal	Bittar & Co.
Sd Mohammed Adros	Yaddoum Spray Co.
Sd Ranjit Kumar	Yaddoum Spray Co.
Sd Suliman Mudathir	Shell Chemicals
Mr. Peter Garvie	Shell Chemicals
Mr. Bernard Videau	Rhone Polence
Mr. Jose Gonzales	Rousel-Uclaf
Mr. Peter Coutts	Hoechst
Mr. David Watson-Cook	Hoechst
Dr. Rebecca Thomas	I.C.A.P.
Dr. R. Courshee	I.C.A.P.