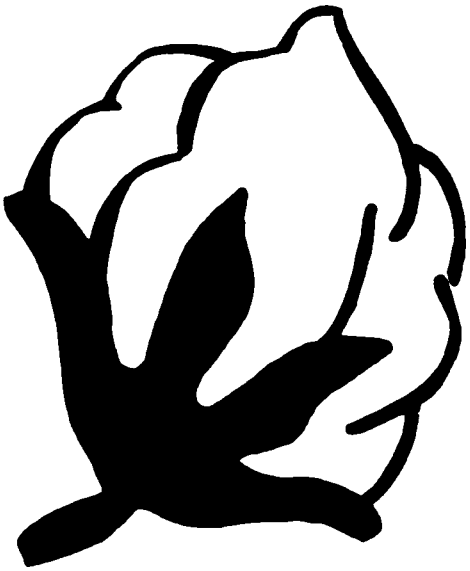

THE ICAC RECORDER

International
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Committee

Technical
Information Section

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- **Update on cotton production research**
- **Nouvelles recherches cotonnières**
- **Actualidad en la investigación de la producción algodonera**

Contents

Introduction

Rob Jarvis of Zimbabwe contributed the first article as a background paper for participants of the 60th Plenary Meeting. Cotton production started in Zimbabwe in 1940 as an alternative crop to tobacco, and for twenty years cotton production did not increase much. Real increases in production started in the 1960s, and in the next ten years rose more than forty times to 141,077 tons. In Zimbabwe, cotton is grown by large-scale commercial growers and smallholder farmers. The smallholder share increased from 8% in 1980/81 to 85% in 2000/01. Because of the lack of irrigation water and poor management practices, average yields are much lower on smallholder farms than on large-scale farms. Most cotton is grown on red or brown sandy clay loam soils. The most destructive pest is the pink bollworm, and it is very important to deprive it of food sources so that it does not overwinter successfully. Planting timing and destruction of cotton stalks are strictly followed. Hairy varieties are grown to control jassid. A number of other bollworms and sucking insects also attack cotton, and pesticides are applied with molasses as an additive to avoid evaporation. Genetically engineered Bt cotton will be officially tested in Zimbabwe during 2001/02, though a formal decision has not been made by the government to start commercial production. Many more details on cotton production, including classing and grading, research and extension are given in the article.

The second article is on the rehabilitation of cotton production in Nigeria. Nigeria has great potential to expand cotton area and improve production, but farmers have no incentive to do so. Cotton yields are among the lowest in the world. During the mid 1990s, Nigeria produced almost 450 kg/ha of lint, but for the last four years the average yield has been less than 50% of that level. There are other reasons, but the low yields are mainly caused by non-availability of good quality planting seed. Calendar spraying is officially recommended and although economic thresholds have been established, they are not yet available as an official recommendation. Pests are not serious, and cotton is sprayed an average of 3-4 times per season. The article lists the reasons for low yields and the areas of high priority according to the cotton production revitalization program under consideration in Nigeria.

The government of Benin is not a member of the ICAC, but the head of ICAC's Technical Information Section visited the country in late April 2001. Although Benin is a small country, it is one of the largest cotton producers in the region. In less than ten years, cotton area more than tripled, from 123,000 hectares in 1990/91 to 400,000 hectares in 1998/99. Benin has depended on varieties developed in other countries and started its own breeding program recently, but it will take a few years until the locally developed varieties become available to farmers. Previous policies encouraged planting only one variety throughout the country and the application of only one set of production technologies. Lately, this concept has changed and now technology is being developed for different sets of production conditions. Significant changes are expected in the cotton industry with no impact on cotton research, which is handled in

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the public sector and supported by ginning and marketing organizations. An Interdisciplinary Association on Cotton, supposed to include all segments of the cotton industry, has been established. The Association started working already and will take over most of the functions of predecessor institutions by the end of this year. How Benin can improve yields is discussed in the article also.

The Technical Information Section has updated the data on cost of production of raw cotton. The report has been published and is available from the ICAC Secretariat. A pdf version is available at a lower cost.

The leaf curl virus is not very important on cotton. However, it became a devastating disease in Pakistan in 1992/93 causing a significant decrease in production. Because cotton production conditions in India are similar to Pakistan's, the disease moved to India, but fortunately, the spread has been limited to certain parts of the cotton growing areas. Pakistan has also been able to contain it. There are no chemical measures to control the disease unless you eliminate the vector, whitefly, which is almost impossible. ICAC sponsored a five-year project funded by the Common Fund for Commodities involving Pakistan, the UK and the USA. The project, called "Genome Characterization of Whitefly-transmitted Geminivirus of Cotton and Development of Virus-Resistant Plants Through Genetic Engineering and Conventional Breeding," started in January 1, 1996. After a one-year extension, the project will conclude at the end of 2001. A final workshop to disseminate the results of the project will be held in Pakistan from November 12-15, 2001. The workshop is expected to attract reputed researchers and become an international biotechnology conference. Researchers from all over the world are invited. For more information on the meeting, contact the Project Executing Agency at the addresses below, or the ICAC Secretariat.

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Zimbabwe: Cotton Production and Research

Rob Jarvis, General Manager, Quton Seed Company, Zimbabwe

History of Production in Zimbabwe

Zimbabwe is a landlocked country in southern Africa and has common borders with South Africa, Botswana, Namibia, Zambia and Mozambique. The country is typified by fairly open savannah woodland, with altitudes varying from 600 meters above sea level to a peak in the eastern border mountains of about 2,500 m above sea level. A watershed of higher ground bisects the country from the east down to the southwest. Most of the cotton producing areas are to the northeast, north and west of this watershed with a reasonable production area of both irrigated and dryland cotton in the southeastern Lowveld area.

Cotton has been grown in the country since the late 1940s but only really picked up in the late 1960s when the country was looking for alternatives to replace tobacco as a foreign currency-earning crop. This increase coincided with the availability of pesticides, scouting techniques and spray methods that allowed the control of cotton pests and the development of locally adapted hairy-leafed and therefore jassid-resistant Albar varieties from germplasm that had been imported from Uganda in the 1950s.

Production increased rapidly from 3,600 tons of seedcotton in 1963 to 141,077 tons in 1973 and reached a new peak in 2000 at 353,000 tons. Initially the crop was grown mainly by large-scale commercial farmers, but since independence in 1980, the crop has been increasingly grown by smallholder farmers in communal areas and on resettled land. The total hectarage now grown is around 400,000 each year.

Zimbabwe Seedcotton Production 1963–2000 (tons)

Intake year	Large scale	Smallholder	Total
1963	3,237	389	3,626
1970	79,899	15,121	95,020
1980	145,533	12,000	157,533
1990	102,281	84,719	187,000
2000	55,000	298,000	353,000

Yields in Zimbabwe are variable, and in the smallholder sector they are very rainfall-dependent. In good seasons seedcotton yields average 1,000 kgs/ha, but is more often between 700-800 kgs/ha for this sector. Large-scale farmers can achieve yields in excess of 4,000 kgs/ha with irrigation, but their average is around 1,800 to 2,000 in most years.

Rainfall and Climate

The cotton crop is grown in the summer rainfall season, which typically starts in November, usually the second half of the month, and continues through to March in most seasons, with some limited rainfall in April. Rainfall in the cotton growing areas varies from 500 mm in the low-lying dry areas to about 900 mm in the better areas in most seasons. However, Zimbabwe's rainfall is typified by great season-to-season variation and there is often a mid-season break or drought that may last a month or more. The rainfall is brought about by the southern shift of the Inter-tropical Convergence Zone (ITCZ), a low-pressure system which moves south and north with the sun and the change in seasons, taking the rainfall with it.

Daytime temperatures in the summer months are between 30-35°C maximum and 18-24°C minimum. As winter approaches the minimum will drop below 12°C and this effectively stops

cotton from further development, especially if frost occurs.

The winter months are characterized by warm sunny days and cold nights and this is one of the main reasons why Zimbabwe cotton is so rarely affected by degradation due to persistent rain on open seedcotton.

Soils and Fertility

Most cotton is grown on red or brown sandy-clay loams, with better crops expected from the heavier soils that have clay percentages in excess of 30%. However, a large proportion of the crop is grown on soils that have clay contents as low as 10-15% and in dry seasons or periods within a season, these crops suffer from moisture stress very quickly. The lighter soils are not very fertile, especially if they have been growing cotton and other crops for a number of years, being typically deficient in potash and phosphates and requiring top-dressing of nitrogen to boost yield potential. Heavy red fersiallitic clay soils are also prone to potassium deficiencies as the ions are bound up by the clay particles and may not be available to a growing crop. It is important not only to measure the total amount of potassium in the soil, but also its proportion relative to the overall bases present to be sure that it is available to the growing crop.

Heavy soils are difficult to cultivate with ox-drawn equipment especially when dry, and weed pressure can be extreme when the rains set in. This often limits the total area that smallholder farmers can manage successfully.

Land Preparation and Farming Systems

The bulk of the hectarage grown by smallholder farmers is prepared by ox-drawn equipment. Good farmers will prepare the land by early ploughing in April and May, with the bulk of cotton crops following maize as the major rotational crop. This early ploughing operation conserves moisture from the previous season and allows the farmer to get in early for the next summer crop. Less organized farmers often have to wait for the first rains in the summer to allow them to cultivate the land and prepare a seedbed. This means that their seasons are invariably shorter than the optimum length with the consequent negative effect on yield potential.

With the large scale sector there is a wide range of rotational crops particularly where irrigation is available. Many of these commercial farmers will plant their cotton after a winter wheat crop or after summer soybeans or maize. In the drought-prone 1980s these farmers developed special techniques to grow cotton using minimum or even zero-tillage techniques which left a large volume of surface stover on the soil and allowed the cotton to be fertilized and planted in special trash-freeways made for the purpose. These trash-farming techniques allowed much more efficient moisture conservation during dry periods. Farmers who traditionally plough or use rip-on-row techniques have to conserve moisture by wet-ripping just prior to crop canopy or by making potholes in the inter-row in which rainfall can accumulate, thus avoiding run-off during heavy storms.

Conversely, in moving from cotton to a winter wheat crop these farmers have also developed techniques which allow cereal establishment after a slashing operation only, and the cotton stalks then rot in-situ with the new irrigated wheat crop growing around them.

Planting Dates and Systems

Both farming sectors try to plant their cotton as early as possible to maximize season length. In the large-scale sector many have access to irrigation and they can get their crops established prior to the onset of the rains. However, the better dryland farmers in both sectors will dry-plant at least some of their crops, and if there is residual moisture from the previous summer these crops can often get away with the first showers of the season.

Most planting is done by machine, with smallholder farmers using tractor and ox-drawn planters and their commercial counterparts employing a range of tractor-drawn equipment from simple plate planters to the latest precision air seeders. Some will hand plant into ready-made planting holes or furrows. Growers on average plant 20-25 kilograms per hectare of acid-delinted seed, but those with irrigation and better equipment may plant as little as 10-15 kgs/ha. Recommended planting depth is a maximum of 20-25 mm.

Most growers will plant their crops at the standard spacing of 1 meter between rows and thin their stand down to 1 plant every 20-30 cm in the row. Closer in-row spacing is recommended for later plantings. Thinning is done 10-14 days after emergence and gap-filling is recommended for two or more missing plant stands. However, this should be done as soon after emergence as is practicable.

Weeds and Weed Control

Grass weeds are normally the major problem in the early part of the season, with broad-leaf weeds becoming more prevalent as the rains persist. Early season weed control is essential and dramatic drop-offs in yield result from poor weed control in the first eight weeks of the season. Commercial farmers will use a range of herbicides from pre-plant incorporated grass and broadleaf herbicides to directed post-emergent sprays using contact and systemic chemicals such as Gramoxone, Bladex and Roundup. On irrigated lands and in wet seasons problem weeds include the nut sedges and *Commelina* and *Ipomoea* spp, difficult to control effectively.

Both commercial and smallholder farmers will use tractor or ox-drawn cultivators if available and invariably cotton crops will have to be hand-weeded at least once, and often up to three times, to clean out all the weeds. Lack of resources often limit smallholder farmers from effectively managing their crops especially if they try to grow crops on five hectares or more and only have their immediate family to do the fieldwork.

Pests and Pest Control

A key aspect of pest control in Zimbabwe is the strict adherence to the legislated earliest dates of planting and latest dates for crop destruction. This ensures a dead period when there are no cotton plants growing, thereby depriving both pink (*Pectinophora gossypiella*) and red bollworms the food source they need to over-winter in large numbers. Once harvesting is complete, smallholder farmers release their cattle into cotton crops and all green material is rapidly eaten, leaving just standing stalks which are destroyed by chopping out and burning when dry.

Zimbabwe Cotton Planting and Destruction Dates

Activity	Lowveld	Rest of country
Planting date	5 October	20 October
Slashing date	1 August	15 August
Destruction date	15 August	10 September

The major sucking pest, the jassid *Empoasca* spp., is controlled by leaf-hairs bred into the Zimbabwean varieties. However during the early part of the season, especially if the weather is dry, sucking pests such as aphids and thrips can be a problem. Once squaring and flowering start, however, the bollworms become a major problem with *Helicoverpa*, spiny (*Earias biplaga*) and red bollworms (*Diparopsis castanea*) being the most common. Other sucking pests such as the lygus bug (*Taylorlygus vosseleri*), helopeltis (*Helpeltis schoutendeni*) and stainers (*Dysdercus* spp.) can be a problem, especially in wetter seasons. If spraying has been overdone, then red spidermite (*Tetranynchus cinnbarinus*) and sometimes whitefly (*Bemisia tabaci*) can be a problem in very dense crops in the latter part of the season.

During the early 1960s scouting techniques were developed which, when combined with suitable spraying systems and pesticides, allowed effective control of pests which would otherwise decimate the crop. Many smallholder farmers still use knapsack sprayers to control pests, but there is an increasing swing to ULV sprayers because of their greater efficiency and ease of use. Smallholder farmers often have problems in securing adequate supplies of clean water and large scale farmers will use a combination of hand-held ULV, tractor mounted boom, sleeve and air-blast sprayers and even aerial spraying to control pests.

The scouting and pest control recommendations in Zimbabwe are based upon economic thresholds that have been determined based on thorough research. Sprays are applied when pre-determined levels are reached or exceeded, and the most selective and softest pesticide is used whenever possible. Pesticide management revolves around strategies designed to target specific pests and not predators, to hit the pest when it is most vulnerable and to manage their use in such a way that resistance does not build-up. Zimbabwe was the first country to implement an acaricide rotation scheme and to implement a pyrethroid window, and most recommendations for pesticide rates are designed around low dosages, which are effective against the most vulnerable stage of the pest in its life cycle. This particularly applies to the synthetic pyrethroids, which target the first instar bollworm larvae based upon egg thresholds being exceeded after scouting. Pesticides are usually applied with molasses as an additive, which limits evaporation and has a positive biological effect on the pesticide's effectiveness with certain bollworm pests.

In certain localities other pests can be a problem and these include termite species and cutworms that can devastate stands, whereas elegant grasshoppers and some leaf-eating caterpillars damage foliage. Leaf miners are becoming more prevalent. Various types of mammals such as Kudu antelope, jackals and monkeys can eat the green bolls, and farmers have to be very careful to keep their domesticated stock out of cotton fields during the growing season.

Diseases

Several diseases are endemic in Zimbabwe and they are controlled by inbred plant characteristics, such as bacterial blight resistance, verticillium wilt and alternaria leaf spot tolerance. Ramularia can be a problem in wetter seasons as are a range of boll-rots that develop when late rains persist as the cotton opens.

Seedling diseases are not usually a problem and all planting seed is now dressed with a fungicide to provide some protection. Where seedling diseases are prevalent they are controlled by a combination of seed treatment and furrow dressings. At the time of planting however ambient temperature conditions are normally at their peak, and seedlings emerge quickly and grow vigorously and are less prone to seedling diseases.

Crop Growth and Management

Extension advice to growers centers around several key non-negotiables to achieve higher yields. These include spending time and effectively supervising planting and doing it early to maximize season length especially under dryland conditions, keeping the crop weed-free during the first eight weeks, then scouting and spraying effectively during the flowering and boll formation period. Moisture conservation in a cotton crop is essential to keep any rain where it lands and not allow erosion to take hold, and to prevent water accumulating in low-lying spots in the field where it can cause waterlogging.

Fertilization of the crop is preferably determined from soil analyses but may be more commonly based upon soil types and previous crops grown and yield expectations. Growers are encouraged to maintain the soil pH in the 5.2 to 5.5 range (calcium chloride scale). They will apply agricultural lime to redress any low pH problems.

Typically, however, a cotton farmer will apply lime once every 3 to 5 years and annually a compound fertilizer rich in potash and phosphates and relatively low in nitrogen (but with some sulphur and boron included) as a pre-planting basal dressing. For soils deficient in potash the recommendation is to apply

extra muriate of potash at 20-30cms depth before planting. Potash deficient soils are very prone to the defoliating forms of alternaria, which can devastate crops at the peak boll formation when the draw on potash is at its greatest. Foliar applications of this key element have not been successful.

Nitrogenous top-dressings are applied at first flower, and on lighter soils may be split into two or three applications with last being applied at no later that 12 weeks post emergence. They are usually applied by hand or may be broadcast through tractor drawn Vicon applicators and are normally applied as ammonium nitrate, although urea can also be used.

Commercial farmers use irrigation to supplement summer rainfall and base amounts applied upon pan evaporation data. Irrigation equipment varies from flood to overhead sprinklers, center pivot and some drip systems. These farmers often have to apply growth regulants to control crop size for ease of management. Growth regulators are usually applied in split applications with two-thirds the recommended rate applied just prior to first flower and the remainder two to three weeks later. Some use foliar sprays of combination fertilizers that have minor nutrients such as molybdenum as well as limited amounts of N, P and K.

Crop Harvesting, Grading and Delivery

Crops are almost entirely harvested by hand in Zimbabwe. Pickers are encouraged to in-field grade and pick using two polythene bags tied around the waist, with one used for clean bolls and the second for any trashy, stained, weak or immature locules. Farmers are supplied with polythene picking bags by the ginning and marketing companies to minimize the risk of contamination from woven-fiber polypropylene bags that might otherwise be used.

Seedcotton is usually sorted and checked again before being packed into jute cotton packs that typically hold 200 kilograms of seedcotton. These packs are sewn using cotton string supplied by the ginning companies with a label affixed to the pack that identifies the grower, the variety and the stage of the crop, distinguishing seed from commercial crops by its shape. Each variety grown has its own color label allowing the ginning companies to segregate seedcotton easily.

At the buying depot, the seedcotton is sampled and graded according to the list indicated in the table below and paid according to this grade. The graders are regularly checked by a National Arbitrator who is employed by the whole industry and any grower who wishes to dispute a grade has access to an arbitration procedure which can be brought into play at a relatively low cost. Most ginning companies operate a computerized payment system and they will deduct for any credit issues previously made, transporter charges and pack hire before making payment to the grower. Checks are readily cashable, often at the cotton depot itself or in nearby local businesses.

Zimbabwe Seedcotton Grades

Seed Cotton Grade	Normal Differential or Price	Comment
A	+ Z50c/kg	Usually only 20-30% of crop, very limited amounts of trash, soil or insect stain.
B	Base grade Currently Z$21.20/kg	Usually around 50-60% of crop, some trash, soil, insect stained and weak, immature locules evident.
C	– Z20c/kg	20-30% of crop, increased amounts of trash, stained, weak and immature cotton.
D	Z$14.00/kg	Usually less than 4% of crop, heavy trash, stained, weak and immature levels of seed cotton.
Polypropylene contaminated seedcotton	Z$4.00/kg	To heavily penalize growers who contaminate their crops with man-made polypropylene fibers, and encourage them to screen their cotton carefully before delivery.

Research in Zimbabwe

Research is primarily the mandate of the Cotton Research Institute (CRI), a part of the Department of Research and Specialist Services in the Ministry of Lands, Agriculture and Rural Resettlement. This Institute operates a multi-disciplinary approach and has sections covering the following key areas: breeding, agronomy and physiology, pathology and cotton pest research. It utilizes its own station at Kadoma for most of the on-site work and conducts off-station trials in cotton growing areas on other government-owned research and experiment stations as well as utilizing cooperative farmers for on-farm research. CRI uses the research sites run by the Commercial Cotton Growers Association and by Quton Seed Company to further extend variety and agronomic testing. Quton has been licensed to produce and market the commercial varieties developed by CRI and pays a royalty on these sales.

At the moment CRI is still a government department but there are plans to commercialize it and perhaps in due course to privatize it completely. This is being done initially by having a management committee comprising key stakeholders in the industry to oversee its research programs, finances and plans, and allowing CRI to operate an Agriculture Revolving Fund for income generated by products and services from its activities. Since 2000, it has been earning a royalty on seed sales from varieties released for commercial production and it has also started to charge for services done for outside organizations and companies such as screening work on herbicides and pesticides. There is certainly pressure on the government by the cotton industry to take the privatization of CRI to its logical conclusion so that its programs and emphasis can meet the needs of the industry more effectively and the industry can ensure that it is properly staffed, resourced and funded.

A commitment to finance this has already been agreed to by the key stakeholders provided government cedes the requisite control to them.

Breeding

CRI runs a fully-fledged breeding program that has been in operation since the Institute started in the early 1920s. The breeding program draws upon germplasm from all over the world and, by crossing and intercrossing adapted material with suitable donor germplasm, develops improved varieties mainly through a pedigree breeding system for local conditions. Some key progress that has been made in recent years by CRI's breeders include the upgrading of the inherent fiber quality characteristics of Zimbabwean cultivars, the increase in lint outturns to around 40-43%, improvements in aphid and alternaria tolerance and maintaining jassid and bacterial blight resistance. Some of the new releases are of significantly higher seedcotton yield potential and have large storm proof bolls that lend themselves to efficient handpicking. They have recently produced a long staple variety that is adapted to both dryland and irrigated conditions, thus allowing smallholder farmers the opportunity to grow more lucrative cotton.

The breeding program has mini-ginning equipment and a fiber testing laboratory, and all material from single plant selections through strains, lines and varieties is tested for seedcotton yields, seed size and lint outturns to key quality characteristics such as length, strength, elongation, micronaire, fineness and maturity. New releases have to be equal to or better than existing commercial cultivars in most respects, and their fiber qualities have to be as good as the mainstream cultivar Albar SZ 9314, released in 1998. Current aims of the breeding program are to improve fiber strength and elongation as priorities and to develop earlier maturing varieties but without compromising other attributes.

Agronomy and Physiology

When a new variety is released it is thoroughly investigated for key production practices so comprehensive recommendations can be made for its successful production. These include planting date comparisons, nutritional levels, weed control and herbicide screening, spacings and population studies, irrigation needs, use of growth regulators, management techniques involving plant mapping and monitoring of key growth indicators and reaction of the crop to different environmental conditions. This section also conducts work on organic and inorganic fertilizer applications and on tillage techniques to improve moisture holding and to extend the crop growth period.

Pathology

All the breeding material is screened for bacterial blight resistance and suitable populations of segregating germplasm developed for screening for verticillium wilt tolerance. The pathology section investigates any disease outbreaks that occur and assesses new varieties for tolerance to known pathogens such as alternaria and ramularia.

Cotton Pest Research

Pest research centers on an integrated management system, trying to combine scouting for pests (and predators) with economic thresholds, using the softest approach to control problems. Pesticide evaluation is based upon determining the lowest effective dosage rates, effectiveness in controlling the target pests at its most vulnerable stage and effect on beneficial insects. Spray application timing and methods are investigated and recommendations made for any new technology offered. Work is also done with any spray adjuvants and additives and these are compared with existing recommendations for use of molasses as an anti-evaporant.

Several landmark strategies have been evolved over the years which have contributed to the success of the Zimbabwean cotton industry and these include pesticide management strategies, spray techniques, including the addition of molasses to spray mixes, and pesticide rotations, both within and between seasons and areas in the country.

Other Players in Research and Crop Development

Commercial Cotton Growers' Association

The Commercial Cotton Growers' Association runs a series of sites around the country under the management of its Cotton Training Centre, where they provide facilities and trial management expertise to CRI and at the same time conduct some agronomic and physiological work of their own to meet growers' specific research needs. Their work is concentrated upon minimum tillage techniques, use of growth regulators, defoliants and ripeners, machine picking, irrigation management, root and growth hormone seed treatments and locale-specific needs including large scale variety comparisons.

Cotton Training Centre

The Cotton Training Centre run by the Commercial Cotton Growers' Association in Kadoma provides practical courses in scouting, pest management, picking and production for a range of clientele from smallholder farmers to farm supervisors, and even extension and research professionals from Zimbabwe and other countries. Over the last twenty years the Centre has had a huge impact on the extension advice available and provided to the industry and this has undoubtedly had a positive effect upon crop production practices.

Quton Seed Company

Quton Seed Company is a wholly owned subsidiary of The Cotton Company of Zimbabwe (Cottco) and it has started its own breeding program to complement that of CRI. Quton, in conjunction with its parent company, Cottco, will organize large scale growing of multiplication crops that allow gin testing of any new variety on a commercial scale and provide significant volumes of lint for mill tests prior to official release.

Quton is testing Zimbabwean cultivars in several countries in the region with the specific aim of developing markets for Zimbabwean seed where appropriate. Quton also does some work

on seed treatments that can boost yield potential and crop vigor such as the use of seed treated fertilizers and aphicides. These are usually done in conjunction with the relevant pesticide supplier and CRI.

Quton has been licensed to produce the commercially released varieties in Zimbabwe and operates a dilute acid delinting plant at Glendale. Quton places particular emphasis on seed quality and every batch of seed is thoroughly tested for pH, light seed content, germination, purity, and vigor. The seed must meet exacting standards that are well above the legislated minima before being released for sale. Each year the company produces between 9,000–10,000 tons of planting seed and markets it through the ginning companies who sell directly to farmers. Retail sales are made for cash and on credit and seed is sold in 25 or 10 kg packets. In 2000, a new seed treatment with Cruiser was commercialized for the first time and farmers have shown their willingness to pay higher prices for treated seed to benefit from the sprays saved and higher yield achieved from these vigorous crops.

Genetically Engineered Cotton

To date no extensive testing of genetically engineered cotton has taken place in Zimbabwe. However, a Biosafety Act was gazetted in 2000 and the mechanism is now in place to allow testing of genetically engineered crops under the supervision of the Biosafety Board. Monsanto Zimbabwe, Quton and the Cotton Research Institute have submitted a joint application to field-test Bt cotton in the 2001/02 season, and have received initial approval. This will be followed with testing of other GE cottons such as herbicide-resistant cultivars in due course.

The cotton industry in Zimbabwe firmly believes that this new technology must be investigated and that sooner rather than later gene transfers should take place into locally adapted material, where it will have the greatest chance of success because of the broader adaptability of local cultivars. The country has not yet taken a position on whether or not to promote GE cotton and there are serious implications for the beef and dairy industries, which derive a large proportion of their feed stuffs from cottonseed cake and sell their products in potentially sensitive markets. However, Zimbabwe will be able to meet any labeling requirements for GE products from cotton very easily if necessary, because of the variety management systems already in place.

Crop Extension and Input Supply

The success of the Zimbabwean cotton industry is also the result of the effort put into crop input supply, extension and promotion by the ginning and marketing companies. The Cotton Company in particular plays a leading role in supplying key inputs for cash and on credit to selected growers. Their input scheme is based upon groups with track records in repaying advances made and, at present, about 25% of all the active growers in any one year get some inputs from Cottco on credit. This has undoubtedly boosted yields and made cotton an attractive cash crop for smallholder farmers in very difficult economic conditions. Bulk buying of inputs by Cottco and its major competitor, Cargill Zimbabwe, and the availability of these inputs at lower cash prices at all rural depots has made cotton growing very convenient.

The government operates an extension arm called Agritex that has the mandate to provide services for all agricultural activities, but they are largely under-funded and inadequately resourced in most respects to make a marked contribution in a single crop like cotton.

Acknowledgements:

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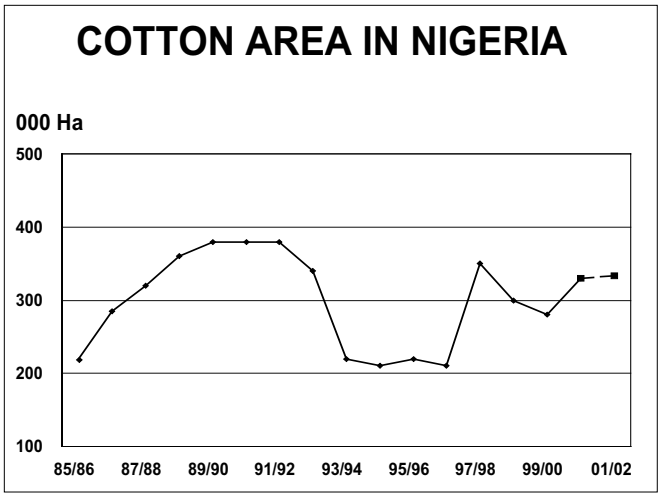
Rehabilitation of Cotton Production in Nigeria

Cotton production in Nigeria has seen highs and lows both in area and yields. During the 1970s there was a significant increase, and area reached 704,000 hectares in 1976/77. Prior to 1984/85, cotton area in Nigeria fluctuated around 400,000 hectares. But since 1985/86, it has fluctuated between 200,000 and 400,000 hectares. Nigeria has great potential to expand cotton production to a much larger area if farmers were provided with good quality seed, high yielding varieties and support by government programs. The government has decided to rehabilitate cotton production and is seriously considering a program that will increase area.

Role of the Central Bank of Nigeria

The Agriculture Finance Department of the Central Bank of Nigeria plays an important role with respect to developing plans for improving cotton production in Nigeria. The Agriculture Finance Department is represented on all committees dealing with ongoing cotton programs and with new plans to be introduced for research or for direct application by farmers. Through the Agriculture Finance Department, the Bank has played a significant role on the Cotton Rehabilitation Committee to develop the draft Cotton Rehabilitation Program, now under active consideration by the government of Nigeria, for finalization. The



Agriculture Finance Department is not a lending agency for agricultural production, and there are commercial banks for this purpose. The three main responsibilities of the Department are:

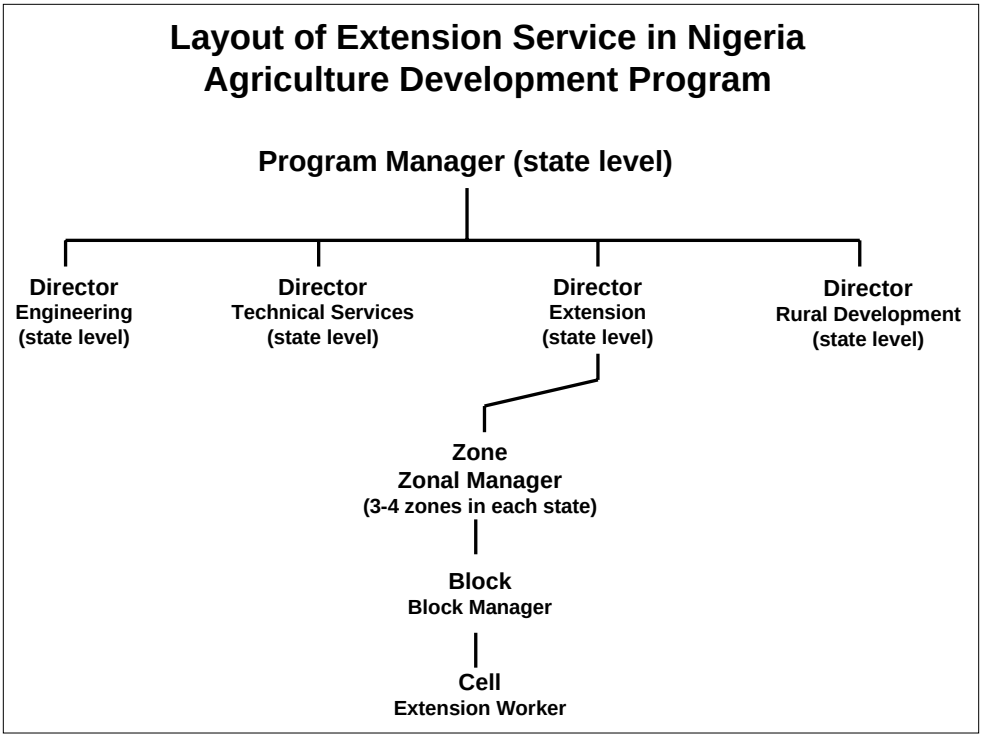
- Farmers approach commercial banks to get credit and loans for inputs, but commercial banks do not grant loans until the Agriculture Finance Department provides guarantees on behalf of farmers that loans will be paid back on time. If a farmer fails to pay back the loan as stipulated in the loan agreement, the commercial bank would approach the Agriculture Finance Department, who will pay 75% of the loan provided the defaulter is not able to pay because of crop failure.
- The Department closely monitors developments in commodity industries, including cotton, and advises the federal government of Nigeria to take appropriate measures. Accordingly, if the Department feels that certain measures could be taken to improve the performance of the cotton industry, proposals are made to the government to initiate specific programs. The initial focus of the Department has been on export commodities, but it is now monitoring all commodities.
- Lately, the Department has begun to consider financing agriculture development oriented industries in the rural sector and a micro credit scheme will be started soon. Still, the Department will not be involved in direct loan schemes but will help small industries to make use of micro credit programs.

Structure of Technology Dissemination

The Federal Ministry of Agriculture is directly involved in cotton development, research and extension. Two important departments of the Ministry are the Department of Agriculture, responsible for cotton development and extension; and the Department of Agricultural Sciences, responsible for research in agriculture including cotton.

Many years ago the federal government, in collaboration with state governments and with financial help from the World Bank, started a program called the Agriculture Development Program. World Bank support has ended, but the program still continues from local resources. Under this program, an extension outfit covering all crops, and now even livestock, was established at the basic level. The basic structure of the extension service is given below and indicates that cotton growers do not get satisfactory advice on production technology. Lack of expert advice could be one of the major reasons for low cotton yields in Nigeria.

The cotton producing area in the country is divided into three regions: North, East and South, responsible for 65%, 30% and 5% of production respectively. The southern region has comparatively less pest pressure but yields are lower than in other regions. On average, cotton area gets over 1,400 mm of annual rainfall. The role of the federal government is overall coordi-



nation, but actual extension work is a state responsibility. The front line extension worker is the one that is based at "cell" level. On average, each extension worker at cell level deals with roughly 1,000 farmers who may be growing a variety of crops. Nigeria tried to intensify the extension activities of other crops, particularly maize and wheat, and witnessed major increases in production, but a similar program is not contemplated for cotton in the near future.

Cotton Revolving Fund

The Nigerian Cotton Board played an important role in the cotton sector in Nigeria. Among other responsibilities, the Board had to produce quality seed and make it available to cotton growers. In an effort to privatize the cotton industry as has been the case in other countries in the region, the Nigerian Cotton Board was abolished in 1986 and no other organization was given the responsibility of seed production. In 1994, the Cotton Revolving Fund was established to take over the role of the Board to produce pure quality planting seed and supply it to farmers. The Revolving Fund is a joint venture between the government of Nigeria providing 60% of the funds, and the private sector, to contribute to the cause of quality seed supply to growers. The Fund is almost independent and, at present, it is chaired by a person affiliated with the textile sector.

The cotton seed production system involves four sectors that need to improve their coordination: the Nigerian Seed Service of the Ministry of Agriculture, the Cotton Revolving Fund, private companies responsible for seedcotton ginning, and the Agriculture Development Program. The Nigerian Seed Service is mainly responsible for production and supply of seed to farmers. The seed is supplied through the Agriculture Development Program, while funds are provided by the Cotton Revolving Fund. Seedcotton is ginned by private companies supposed to maintain purity, but it is not clear how the required isolation/separation is being implemented, and the success of their efforts is not known. Indications from different sectors show that farmers do not get good quality seed. Even if good quality seed is produced, farmers have lost faith in the seed production system. One of the disadvantages of having abolished the Cotton Board is the lack of good quality seed to farmers. Unless the current system of seed production is restructured, it will be difficult to restore faith in the seed production system.

The Cotton and Agricultural Processors Ltd. is a private company contracted every year to gin seedcotton for seed purposes. Seed is not delinted but treated with a fungicide. During the current year planting seed was sold at 9 U.S. cents/kg (12 naira/kg) compared to 7 U.S. cents/kg (9 naira/kg) for crushing seed.

Research on Cotton

The Institute for Agricultural Research is one of the sixteen institutions in Nigeria that have a mandate to conduct basic as well as applied research on cotton covering all disciplines. The Institute is based in Samaru/Zaria and has an independent program on cotton. Although the program is called the Fiber Research Program, it works only on cotton and is currently headed by an entomologist. The Program is affiliated with the Faculty of Agriculture of the Ahmadu Bello University, Zaria.

Pest Control

A variety of pests attack cotton throughout the growing period. First, aphids appear as early as three weeks after emergence and may continue as a major pest for the next three months. During this period, whitefly—not a serious pest yet although the population is increasing—may also appear. Leafhopper may become a problem in pockets only. *D. volkerri* is significant between 7-12 weeks after emergence. Six types of bollworms may attack cotton: *Helicoverpa armigera, Diparopsis watersi, Pectinophora gossypiella, Earias insulana, Earias biplaga* and *Cryptophlebia* spp. However, the cotton bollworm is the most serious pest, followed by the African bollworm. *Cryptophlebia* usually appears late in the season, when maize is ready for harvest and the pest starts migrating to cotton fields.

On average, cotton is sprayed at least 3-4 times every year. Often, one to two additional sprays may be required for economical control against all pests. Currently, calendar spraying is practiced throughout the country. Although thresholds for various pests have been established by researchers, they are not available yet as recommendations. If a farmer has to spray cotton four times during a season, the following schedule is recommended.

First spray	6 weeks after planting
Second spray	8-9 weeks after planting
Third spray	10-12 weeks after planting
Fourth spray	12-14 weeks after planting
	(It is advised to use mixtures)

The population dynamics of pests are changing, and there is fear of new pests attacking cotton. Thresholds may be adopted in the near future. All these factors require strict vigilance on the part of researchers.

Fertilizer Use

Nitrogen and phosphorous are applied every year by almost all farmers. In Nigeria, cotton is usually underfertilized. Each farmer applies about 40 kg of phosphorous as a basal dose while 60 kg/ha of nitrogen is applied between the 3-6 week stages. Potassium, if applied, is 20-25 kg/ha as a side dressing, 5 cm away from plants. The reason for the low fertilizer use is the high cost of fertilizers. There are two sources of supply: government and open market. Fertilizer supply from the government is limited and not available to all farmers, but prices are lower than in the open market.

Development of Varieties

Only locally developed varieties are grown in Nigeria. The three varieties grown on a commercial scale are Samcot–8, Samcot–9 and Samcot–10. "Samcot" comes from Samaru cotton. Samcot–8 is grown in the eastern region and Samcot–9 in the

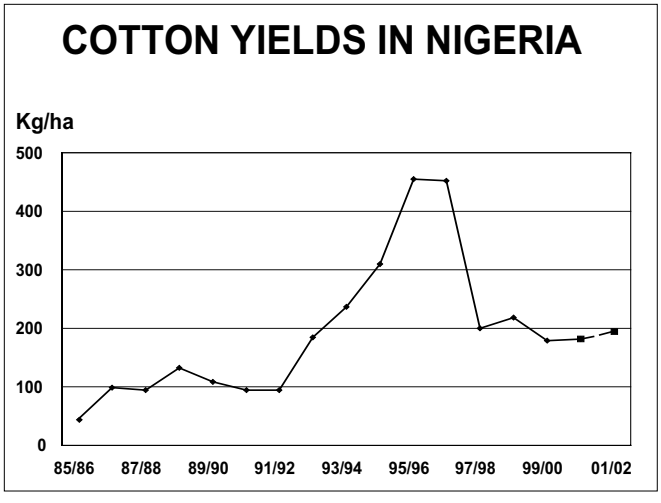
northern region. Samcot–10 is more suitable for high rain areas and thus is grown in the southern region. Samcot–9 and Samcot–10 have been selected from the same cross. Samcot–8 will soon be replaced with a new variety introduced from Benin but supposed to have been bred somewhere else. Hybridization is the most popular method adopted by breeders in Nigeria. Progeny row selection is followed until F_7, when progenies are mixed for bulking strains. Progenies are grown in ten-meter rows and single plant selection is based on the performance of individual plants. Bacterial blight is a problem and races 2, 9 and 10 have been found to occur. All commercial varieties must have genetic resistance to the disease. Reba B50 and W296 have been used as the basic source of resistance to the blight.

Cotton Yields

Nigeria did not have any increases in yield until 1991/92. Between 1992/93–1995/96, cotton yields experienced exceptional increases. In four years, the national average yield in Nigeria more than quadrupled, from 95 kg/ha in 1991/92 to 455 kg/ha in 1995/96. Since 1997/98, the average yield in Nigeria has been around 200 kg/ha.

The current yield in Nigeria is way below potential. Cotton is not getting the proper attention and, consequently, yields have been seriously affected discouraging cotton growers to confidently invest in cotton production. The following factors are considered to be responsible for low yields:

- Good quality planting seed is not available. Farmers are not satisfied with the current commercial varieties.
- The cotton bollworm has become a problem spreading to most of the cotton area. Pest pressure has increased and losses due to bollworm attack have significantly increased.
- In addition to a wider spread in area and increase in pest population, the cotton bollworm has developed resistance to insecticides, making it difficult to control.



- The plant protection problem is Nigeria is complex. Underdosing is common and the purity of the available pesticides is doubtful, which could be a factor in the failure of insecticides to control the cotton bollworm.
- Farmers would appreciate more assistance from the government.
- Farmers are not aware of proper pest control methods; are not able to identify the different insects; and the majority of them do not adopt the recommended production technology.
- Cotton is under-fertilized because fertilizers are expensive, thus resulting in lower yields.
- The extension system is not very effective and farmers do not get proper advice to grow cotton successfully.

Components of the Rehabilitation Program

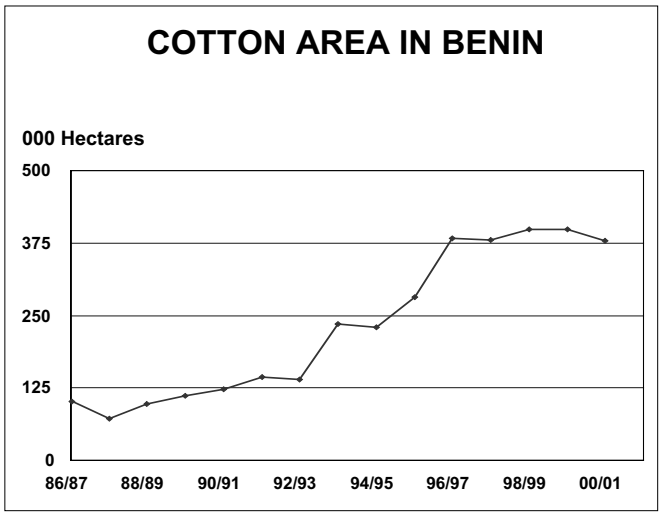
Many details about the Rehabilitation Program are not yet available. A draft report, still being discussed at the end of April, is available. However, discussions with officials of the Ministry of Agriculture, Ministry of Commerce and Agriculture Finance Department of the Central Bank of Nigeria indicated that the following issues would have high priority in the Rehabilitation Program. The government is serious and it is anticipated that the cotton production sector will undergo a thorough reconsideration and ultimately a program to revitalize cotton production in Nigeria will be devised.

- Seed production is blamed as one of the major reasons for the current state of affairs and will have a much higher attention than it has today. How it will be improved is not known, but quality seed production for planting will be among the top in the priority list.
- The seed supply system will also be improved by making sure that all farmers get good quality seed in sufficient quantities and on time for planting.
- Farmers face financial difficulties to buy inputs. Commercial banks charge high interest rates because of low recovery rate, which discourages farmers to get loans for inputs. Loans will be provided at concessional interest rates and their timing will also be improved.
- Marketing of cotton will be improved so that farmers get a good price for their product.
- Fiber quality will be improved, particularly by growing longer staple cotton varieties.
- There may be many other areas of research, production, extension, marketing and financing where significant changes are expected to occur. It is hoped that once the revitalization program is implemented in Nigeria, it will have a positive effect on cotton production in the country.

Cotton Production in Benin

Cotton area has increased in Benin in the last ten years, making it one of the largest producers in West Africa. Cotton was grown on 103,000 hectares in 1986/87, 123,000 hectares in 1990/91, and 282,000 in 1995/96. During 1998/99 and 1999/00, cotton was grown on 400,000 hectares. However, low yields in the last three years affected cotton area in 2000/01. ICAC statistics indicate that in 2000/01 only 379,000 hectares were planted and ICAC forecasts suggest that average cotton yields will be even lower in 2001/02 and that area will not increase in 2001/02.

Cotton area in Benin is divided between the North and South. The North region grows two-thirds of the total. Only one variety, STAM 18—adapted from Togo—is grown in both regions. Although cotton is rainfed in both regions, there are a number of significant differences between the two.



Research on Cotton

There is no separate ministry of agriculture, and the Ministry of Rural Development is responsible for research on all aspects of agriculture. The National Institute of Benin for Research in Agriculture is the apex organization for research and has fourteen programs, including crops and livestock. One of them is the Directorate of Research on Cotton and Fibers, based in Cotonou, with fourteen stations throughout the North and South cotton areas. Although the Directorate of Research on Cotton and Fibers is a government institution, universities and the Interdisciplinary Association on Cotton (Association Interprofessionnelle du Coton – AIC) provide strong support. The main support from AIC is toward conducting research, while the Ministry of Rural Development pays the staff.

The Directorate of Research on Cotton and Fibers works in close collaboration with CIRAD-CA of France. The Directorate, under arrangement, has three CIRAD-CA staff members working fulltime in the disciplines of agronomy, entomology, and breeding and genetics. The agreement for agronomy and breeding is for four years, while the arrangement for the collaborative work in entomology is extended on a year-to-year basis. CIRAD staff works with local staff, and all the work is for Benin growing conditions.

The research program on cotton is new, and whatever has been done in the past is being updated to suit current production practices and recent changes in the cotton production system in the country. Although research has been going on for years, there is a need to revise the production technology, as the whole input supply system is going to change and farmers are expected to grow new varieties.

Agronomic Research Program

Agronomic research on cotton in Benin is conducted in collaboration with the Cotton Program of CIRAD-CA. The team is comprised of five agronomists, one from CIRAD-CA and four from Benin, in addition to a number of junior technicians based at various stations throughout the cotton-growing areas. The main objectives or lines of agronomic research are as follows:

Agronomic Requirements

The cotton program is trying to ascertain the agronomic re-

Characteristics of Cotton Growing Regions in Benin

North Region	South Region
1. Has one rainy season from end of June to November.	1. Has two growing seasons: a) March to July – 1,200 mm rainfall. b) End August to December – 400-600 mm rain.
2. Average annual rainfall is 900–1,000 mm.	2. Average annual rainfall is 1,500-1,800 mm.
3. Planting season starts from the 3rd week of May.	3. Planting starts from end of June.
4. Planted variety is STAM 18.	4. Planted variety is STAM 18.
5. Soil type is “ferrugineux tropicaux.”	5. Soil types are “ferrugineux tropicaux” and “ferralitiques.”
6. Require NPK, sulfur and boron.	6. Require NPK, sulfur and boron but the requirement for K is more than in the North region and less P is required compared to the North region.
7. Average yield is 1,500 kg seedcotton/ha.	7. Average yield is 1,100 kg seedcotton/ha.

quirements of farmers so that technology can be developed accordingly. Agronomists work in collaboration with farmers to define field production practices clearly.

New Technologies

A number of new agronomic techniques are being tested, including narrow row, high-density plant stand and late-planted cotton. Experts advise to plant cotton early but some farmers have to delay planting due to various reasons. Agronomists are working on late-planted cotton to enable farmers to grow the late crop successfully.

Growth Regulators

Growth regulators have been tried for years but no conclusive recommendations have been derived so far. Recently, research has shown that although the use of growth regulators is discouraged, it does have a positive effect on yield in some areas. It has been concluded that if growth regulators are applied in the central part of the North Region, which covers around 50,000 hectares, cotton yields will increase by about 200 kg seedcotton/ha.

Diversification of Recommended Production Practices

The National Society for the Promotion of Agriculture (Societe Nationale pour la Promotion Agricole – SONAPRA) used to control the cotton production sector for years. SONAPRA promoted only one set of production practices irrespective of the fact that some producers were good at growing cotton while others needed more advice. The cotton sector is going through changes and the role of SONAPRA in cotton production has been reduced. In the last two years, technological packages for various zones within regions have been created. The conclusion about the positive impact of growth regulators is just one example of agronomists trying to perfect production practices and develop different packages for the cotton growing areas.

Plant Modeling

It has been realized that cotton growers are not going to use modeling. However, studies are underway to revise the GOSSYM-COMAX model, developed by CIRAD and the U.S. Department of Agriculture, for suitability under Benin conditions. Efforts are also underway to assess the maximum potential for yield under Benin cotton growing conditions.

Fertilizer Needs

Benin cotton-growing soil is rich in iron but poor in sulfur, and it is necessary to apply boron every year. A complex fertilizer proportion is recommended, containing 150 kgs of NPK, sulfur and boron, 14:19:23:5:1 respectively, to be applied every year. Most farmers follow the recommendations. Additional nitrogen in the form of urea is also recommended. Because cotton in Benin is rainfed, fertilizer applications cannot be timed perfectly as with irrigated cotton, but applications of 150 kgs of NPSB fertilizer twenty days after emergence, and 50 kgs of urea at early flowering stage are recommended. Excessive height is not usually a problem. However, in areas where height is a problem, growth regulators are used effectively. The average plant height obtained with the recommended fertilizer doses is about one meter.

Entomological Work

Pest Problem

A variety of insects attack cotton in Benin, but the cotton bollworm *Helicoverpa armigera* is the most serious pest. If seed is not treated, *Nisota podagrica* appears at the early stage and glandless varieties are attacked more than normal varieties. Sometimes, aphids like *Aphis gossypii* and *Earias insulana*, and *Earias biplaga* may also appear and cause some damage at the pre-boll formation stage. At the early stage, *Earias* spp. can cause damage to the terminal shoot, thus resulting in plant topping. Egyptian spiny bollworm *Earias insulana* is more significant in the North Region, and the spiny bollworm *Earias biplaga* population is higher than other species in the South Region. Leaf roller *Sylepta derogata* is present throughout the season and becomes significant toward the end of the boll formation stage, but it is very sensitive to organophosphates and can be easily controlled with low doses of many chemicals. Some *Spodoptera* species can cause damage but not every year, and the damage is not serious.

The cotton bollworm population increases from September onward and requires spraying a number of times until the end of the season. Sudan bollworm *Diparopsis watersi* and *Earias* spp. are controlled while spraying against the cotton bollworm. However, it is believed that if insecticides are not sprayed against the cotton bollworm, as could be the case with Bt cotton, *D. watersi* and *Earias* spp. could become problems. The pink bollworm *Pectinophora gossypiella* could also appear, and the false codling moth *Cryptophlebia leucotreta* has more chances of appearing in the South Region.

It is recommended to spray cotton six times per season. A variety of products are used, but it is still recommended that calendar spraying be followed, with the first spray at 45 days after planting to kill the over-wintering population of the cotton bollworm; thereafter cotton should be sprayed every fourteen days. It is recommended, and it has been adopted, that only endosulfan products be used for the first spray. For the next two sprays, a mixture of pyrethroids and organophosphates should be used. The last two sprays should be made with pyrethriods and aphicides. This recommendation is made only if aphids become a problem.

Entomological Research

The main objectives of the entomological research in Benin are as follows:

- Entomological research on cotton in Benin is more or less along the lines followed by CIRAD programs in various countries. As with other countries in the region, Benin is working on low doses of insecticides, particularly pyrethroids, with the objective of minimizing and delaying the development of resistance.

- Cotton bollworm has reportedly already developed resistance to pyrethroids. Data show that LD_{50} has already reached 135% resistance in the case of cypermethrin. Thus, entomology has a high priority for the management of resistance of the cotton bollworm to pesticides.
- Pest populations are continuously monitored throughout the crop period by staff posted at thirteen stations to keep track of the pest situation over the years.
- In order to study the population dynamics of important bollworms affecting cotton, different kind of traps are used throughout the year. The data collected in the last few years do not show any peaks for the bollworm during the season.
- Entomologists work in collaboration with breeders to screen new genotypes for resistance to pests and investigate the sources of resistance.
- Entomologists collaborate with agronomists to study the effect of high-density plant stand, growth regulators, etc., on pest population, versus insecticide use.

Breeding

The breeding program in Benin started in 1996 and is at a preliminary stage. Benin has relied on a single cotton variety or a few varieties for a long period, always developed in other countries. There is much to be done to prove that work is going in the right direction and it will only become valid when a locally developed variety is released for commercial cultivation. It is not sure yet when it will happen, but it could be in 4-5 years. The main objective of the breeding program is to develop varieties similar to or better than the only currently grown variety, STAM 18. Yield is of course the primary criteria, but quality will not be sacrificed for the sake of adopting local varieties. With help from CIRAD, the program seems to have taken off on sound scientific grounds and in the right direction.

Crosses are made regularly every year and single plant selections are made in the F_2 generation. Selected plants are screened not only for yield but also for quality. Selected plants are grown in thrice replicated trials in the F_3 generation. In the F_3 generation, selection is made for crosses and lines within crosses. In the F_4 generation, again selected plants are grown in unreplicated progeny rows. Similar progeny rows are followed during the F_5 and F_6 generations, and only 8-10 crosses/progenies are retained. Multi-location trials are conducted in the F_7 generation at farmers' fields when the number of progenies is reduced to only three lines/strains and, ultimately, to only one.

Input Supply

Fertilizers and insecticides are supplied by private companies. At present, there are nine companies engaged in the supply of inputs. Farmers are organized in unions and they submit their requirements to the company working in the region. Each company, through competitive bids gets to supply inputs to an area. The farmers' union in that area submits its requirements to the company. If a company works well—supplying good quality fertilizers and insecticides at reasonable prices and on time—it may continue to supply inputs in that area for many years but, if its performance is less than satisfactory, it may have to bid in another area and reduce its business.

Input-supply companies also educate farmers in cultivation practices and optimum use of inputs, and they are supposed to identify new concerns and inform farmers' unions and other appropriate authorities. Input-supply companies are supposed to join the Interdisciplinary Association on Cotton and contribute to cotton research and, although they have not joined yet, will do so soon.

Interdisciplinary Association on Cotton

The Interdisciplinary Association on Cotton (AIC) is a newly created association of ginners and farmers that started functioning in November 2000. It is supposed to include all segments of the cotton industry. Some other segments, like fertilizer/insecticide dealers, are still watching the start of the organization and are expected to join ultimately. However, at present, farmers are the segment that seems more active and interested in AIC. AIC is taking over most of the functions of SONAPRA, which was controlled by ginners.

In 1992, the government of the Republic of Benin decided to privatize the cotton industry except research. Although private gins started working in 1994, SONAPRA continued to play its usual role of seed supply, extension services, marketing, and most of the ginning. SONAPRA still owns ten gins, while eight others are owned by eight different companies. It is expected that SONAPRA will be privatized before the end of 2001 as AIC has already come into being. The main functions of AIC are:

- To continue supporting research as SONAPRA did in the past. AIC will not undertake research but will provide funds to the Directorate of Research on Cotton and Fibers, particularly for research that can be directly applied by farmers. AIC, along with farmers' associations, will determine a price for seedcotton and negotiate it with the government. The fixed price will include the funds required to support research.
- To support extension activities and carry out this mandate in close collaboration with cotton farmers' associations. In April 2001, AIC was hiring extension workers for the 2001/02 season.
- To take over seed production now done by SONAPRA, which charges AIC for this service.
- To take over cotton fiber quality control.
- In the past, SONAPRA would pay on average 40% of the expected total value of seedcotton in advance to farmers and SONAPRA itself was the guarantee against the 40% advance payment. Now farmers are required to present a guarantee to purchase inputs from private dealers; AIC will provide

this guarantee so that farmers can buy fertilizer and insecticides without financial problems.

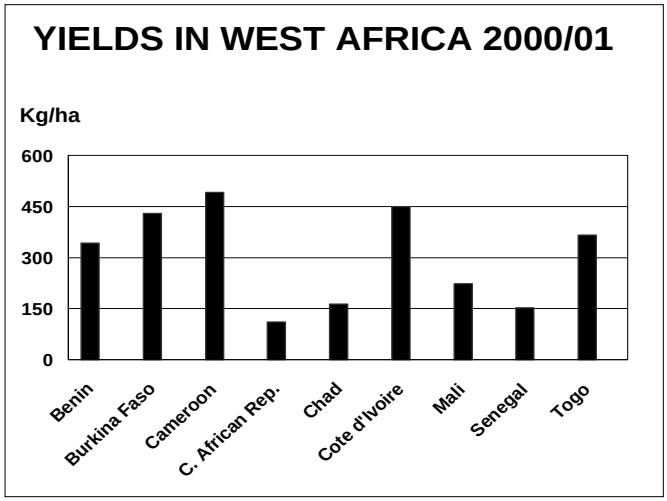
- AIC will build roads in rural areas for better movement of cotton.

How Benin Can Increase Yields

Benin has great potential to improve yields, and it is assumed that changes underway will have a positive impact on cotton yields. In 2000/01, the average lint yield in Benin was 343 kg/ha, lower than in four other countries in West Africa. For the last twenty years, the average cotton yield in Benin was more than 343 kg/ha.

Not only can Benin achieve higher yields, but it can surpass the world average in the next five years. Some of the factors that could contribute to improved yields are:

- Benin has grown varieties developed in other countries. Whether these varieties are the best for Benin conditions is yet to be determined. There are differences in yields between the North and South regions which confirm the high response of cotton to local growing conditions and the importance of developing different varieties for each region. If this is achieved, yields will go up.
- SONAPRA has promoted uniform agronomic practices across Benin. Although the area under cotton is not large, growing conditions are different in the two regions. Agronomic work is in the right direction to perfect a set of production practices for both regions and within regions, particularly in the North Region.
- In general, plant stands in Benin are not optimum. There is a need to improve planting methods and increase the number of plants per hectare.
- Herbicide use is just beginning and most weeding is still done either manually or mechanically. Poor weed control is responsible for the current low yields in Benin, and more efficient weed control has the potential to improve yields.
- An important reason for weak plant stands is the dilution of cotton inputs, including seed. Inputs provided for cotton are used by farmers for other crops. Consequently, cotton is not properly nourished and the required doses of insecticides are not used. It is hard to ascertain how often farmers divert inputs, but it could be frequently because of the non-availability of inputs and the desire to protect food crops from pests. Fertilizers can be diverted to other crops more easily than insecticides. Another reason for the dilution of inputs is that farmers are growing a larger area of cotton and the supply of inputs has not expanded as much.
- Although there is a recognized need to improve production technology, at this time even the currently recommended technology is not followed. The adoption of recommendations shows great potential and could certainly have a positive impact on yields.



Short Notes

- **Mechanism of Resistance to Bt Toxin**

  So far, the fear that bollworms will develop resistance to the Bt toxin has not been realized. The mechanism by which resistance in bollworms might develop is not completely understood, and researchers in the USA are trying to establish the basis for resistance. Researchers have used tobacco budworm *Heliothis virescens* gut cells, cultured in a laboratory, to demonstrate how the Bt toxin causes mature budworm gut cells to swell, burst and die. As the toxin-containing cells were killed, the remaining cells in the mid-gut started producing cytokinins—substances that signal budworm gut cells to multiply and rapidly differentiate to form new mature cells. If the insect received high doses of the toxin, all or most mid-gut cells were killed and there were no remaining cells to produce cytokinins in sufficient quantities to send messages to produce new mature mid-gut cells. But if the toxin was received by the target bollworm in lower doses, only a small quantity of mid gut-cells were killed and enough cells were produced to compensate for the cells killed. Consequently, the target bollworm was able to survive on low doses of the Bt toxin. Researchers have concluded that resistance development is quite possible because some cotton varieties express Bt toxin more than others. Similarly, some parts of the cotton plant express the protein more than others.

  When the U.S. researchers working with the tobacco budworm washed the Bt toxin from the cultured gut cells exposed to low doses, the ratio of cell types returned to normal and the bollworm recovered from the toxin effects. This is one of the early theories on how bollworms could de-

velop resistance to some toxins, and at the same time it explains why low doses of the toxin do not kill all insects. It has been observed that in order to have good control of the target bollworm, the toxin must be expressed in high doses and should be able to kill all or the majority of mature gut cells simultaneously, before signals are sent and the insect starts creating replacement cells.

(*AgBiotech Reporter*, Freiberg Publishing Company, 2302 West 1st Street, Cedar Falls, IA 50613, USA, Vol. 18, No. 4, April 2001)

- **Healthier Oil from GE Cotton**

According to news coming from the Plant Industry Division of the Commonwealth Scientific and Industrial Organization (CSIRO) in Australia, researchers have developed a transgenic cotton variety capable of producing healthier cooking oil and margarine from cottonseed. Cottonseed oil is extensively used in the food industry for several purposes, but it is generally subjected to a process known as "hydrogenation," which can produce cholesterol-raising transfatty acids as a by-product. Hydrogenation makes cottonseed oil suitable for human consumption in different forms. However, Australians have genetically-engineered the cotton plant in such a way that oil from the improved cottonseed is suitable for cooking purposes without the need for hydrogenation. Products made from this oil will be healthier because they will not contain transfatty acids.

To produce the new oils, scientists "switched off" genes in cottonseed that normally convert oleic acid—a monounsaturated fatty acid—into a polyunsaturated fatty acid. Polyunsaturates are nutritionally valuable, but they break down under extreme heat, making them unsuitable for cooking. The hydrogenation process converts the polyunsaturates in conventional cotton back into monounsaturates, but in transgenic cotton researchers have prevented the formation of monounsaturates. Turning off the gene that produces polyunsaturates has produced a high-oleic cottonseed oil. According to researchers, no foreign gene has been added to the transgenic cotton, but a very small amount of the cotton plant's own DNA has been reintroduced. The healthy high-oleic cottonseed oil will remain stable under high temperatures, making it a suitable replacement for hydrogenated and saturated oils in food. Transgenic genotypes are available for testing, but commercial production still has to go through many stages. If everything goes well with the new genotypes, it will take 4-5 years until the new varieties are planted on a commercial scale.

(Online at http://www.monsanto.com/monsanto/biotechnology/default.htm)

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After the great success of the World Cotton Research Conference–1, held in Brisbane, Australia in 1994, and the World Cotton Research Conference–2, held in Athens Greece in 1998, the World Cotton Research Conference–3 (WCRC–3) will be held in Cape Town, South Africa, from 9-13 March 2003 under the auspices of Cotton SA and the Agricultural Research Council of South Africa.

The theme of the WCRC–3 will be "Cotton Production for the New Millennium." All aspects of production research and fiber quality will be discussed. The Conference will embrace all disciplines and will cover aspects such as seedbed preparation, seed production, growing, irrigation, plant protection, crop management, nutrition, plant physiology, modeling, transgenic cotton, organic cotton, harvesting, contamination, ginning and quality measurements and dissemination of production technology.

Please, return the preregistration form to:

Dr. M. Rafiq Chaudhry
Head
Technical Information Section
International Cotton Advisory Committee
1629 K Street, Suite 702
Washington DC 20006-1636, USA
Tel: 202-463-6660 Ext. 22
Fax: 202-463-6950
Email: rafiq@icac.org
Internet: http://www.icac.org

PRE-REGISTRATION FORM

This form is also available on the Internet for on-line pre-registration at the ICAC web page at <http://www.icac.org/icac/meetings/meetings.html>. Additional information will be available in the next brochure that will be published in early 2002. To enable us to draw up a program for the WCRC–3, please complete and return the pre-registration form.

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☐ My company would like to put up an exhibition stall at the conference (send a separate request to the Organizing Committee for additional information and booking)

☐ I plan to go on the field trip

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Additional information on the Conference can also be obtained from the Organizing Committee at the following address:

Dr. Deon Joubert, Chairman of the Organizing Committee
ARC Institute for Industrial Crops
Private Bag X82075
Rustenberg, 0300, South Africa
Tel: 27-14-5363150-7, Fax: 27-14-5363113
E-mail: director@nitk1.agric.za

Proceedings of the World Cotton Research Conference–2

Chief Editor: Fred M. Gillham

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