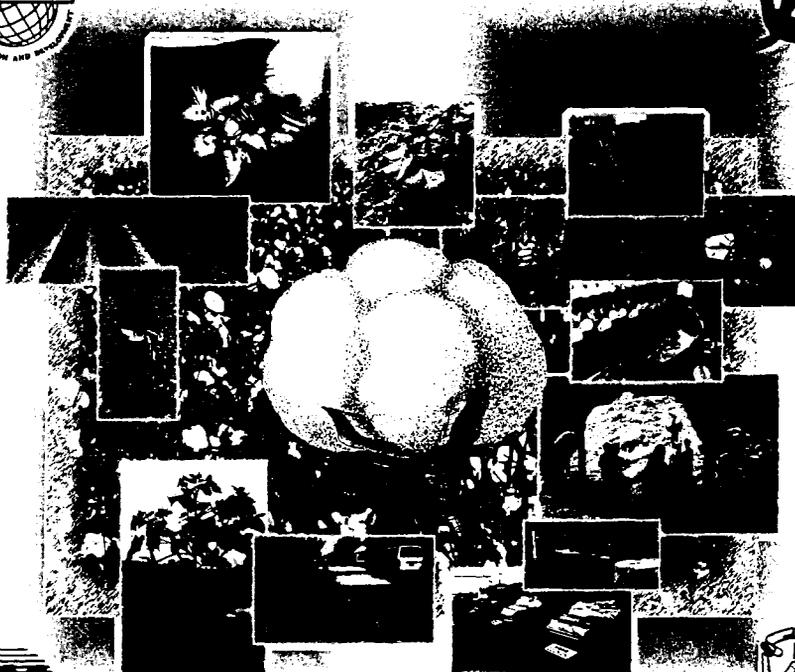


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Cotton Production Prospects for the Next Decade

Fred E. M. Gillham, Thomas M. Bell, Tijen Arin,
Graham A. Matthews, Claude Le Rumeur,
and A. Brian Hearn



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**Fred E. M. Gillham, Thomas M. Bell, Tijen Arin,
Graham A. Matthews, Claude Le Rumeur,
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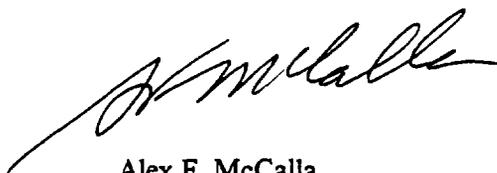
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FOREWORD

Over the past decades, the performance of cotton industries has varied widely between countries. In some countries, industries have experienced decline or stagnation, whereas in others they have expanded rapidly. Globally, cotton is facing challenges that affect not only its competitiveness with man-made fibers in the textile industry, but also the sustainability of production. This is the case even in countries with dynamic cotton industries. Serious concerns relate to the environmental implications of pesticide use in cotton production, requiring more widespread adoption of Integrated Pest Management (IPM) strategies, with strong support from research and extension programs. The most serious challenges for cotton industries, however, are likely to result from the liberalization of markets and the removal of subsidies. There is also a need for strengthening the linkages between the growers, the ginners and the textile industry. With consumption increasing steadily and expansion into new areas constrained by the availability of land and water, increases in production will need to come from increased yields. The introduction of new technologies, including new varieties, will be crucial for this to be achieved.

This study, 'Cotton Production Prospects for the Next Decade,' was undertaken through a collaborative initiative by the World Bank, the International Cotton Advisory Committee, the Common Fund for Commodities and the Canada-Egypt-McGill Agricultural Response Program. Its aim was to foster economic progress in developing countries that depend on cotton. The report incorporates the findings of nine independent country study teams, along with the discussions and conclusions of an international workshop held in Ismailia, Egypt from November 14 to 17, 1994. It is, therefore, the transmission of views of the study teams and of the participants to the workshop which we are facilitating through this report.

It is hoped that the report will be of value to government agencies, industry, multilateral and bilateral organizations in helping them assess the merits of cotton related development projects, and in designing cotton programs and related policies.



Alex F. McCalla
Director
Agriculture and Natural Resources Department

ABSTRACT

This report is based on studies conducted in Brazil, China, Egypt, India, Mali, Mexico, Pakistan, Tanzania and Uzbekistan. The studies systematically addressed the global problems facing cotton production and the significance of government policies in promoting efficiency and effectiveness in the cotton sub-sector. China, India, Pakistan and Uzbekistan were selected as four of the world's top five cotton producing countries. Egypt produces fully irrigated, speciality cotton which has the best quality of its type in the world. Until recently, Brazil was the sixth highest cotton producer in the world and also the sixth biggest consumer. Mexico has been an important producer but production has declined, largely because of government policies on alternative crops. However, its proximity to the USA placed it in a unique position for the study. Finally Mali and Tanzania represent two countries which have environmental similarities but differ in the organization of their cotton sub-sectors. Local, in-country consultants were appointed to examine a number of issues, including seed development, cultural practices, labor resources, the role of institutions and government policies and the marketing system. Each case study was reviewed nationally at a meeting of all institutions involved in cotton.

The study was sponsored by the International Cotton Advisory Committee as the International Commodity Body for cotton and co-financed by the Common Fund for Commodities, the World Bank and the Canada-Egypt-McGill Agricultural Response Program with the World Bank as the project executing agency. Case studies were launched in the Spring of 1993.

Initially, the study was intended primarily to identify and find appropriate solutions to technical problems to raise yields and increase incomes. However, in the course of the study, it was recognized that there were significant interrelationships between the technology to raise yields and government policies so the work was expanded to address the linkages between the technical, institutional and policy aspects of cotton production and marketing.

When the project was initiated, countries around the world were beginning to question the role of governments in economic activities. In 1990, the governments of most cotton producing countries were heavily involved in production and marketing cotton because of its economic and social importance. This included China, the USSR and the USA which accounted for some 60% of world cotton production. The reasons for these policies differ in different countries, depending on their objectives. Thus some countries produce cotton for export while others have strong textile sectors and export mainly value added products in the form of cotton yarn, fabrics or piece goods. The study demonstrated that because of these factors, production aspects cannot be studied in isolation from other aspects of the cotton industry and related government policies.

During the last four years, many countries, including many of the study countries, have reduced or plan to reduce the role of government in economic decision-making in cotton. These movements toward greater private sector control of the cotton industry have been encouraged by international economic and financial organizations.

The most common technical weaknesses revealed in the studies were in seed production and the development of varieties with the fiber attributes required by modern, high speed rotor and ring spinning mills, combined with high yield potential and ginning outturn and resistance to adversities which differ in different countries. In countries where cotton is irrigated, there are problems with irrigation scheduling to satisfy changing plant needs as the season progresses while minimizing the risk of waterlogging and salinity. This is usually associated with supply driven systems and also involves drainage. The implementation of Integrated Pest Management strategies has been complicated by liberalization of pesticide marketing and the removal of constraints on the movement of seed cotton both within and between countries. In several countries, unregulated use of pesticides has contributed directly to serious problems with pesticide resistance in major cotton pests while uncontrolled movement of seed cotton could contribute to the spread of diseases such as bacterial blight, *Xanthomonas malvacearum*, and of insect pests such as the pink bollworm, *Pectinophora gossypiella*. Competition for labor often results in delays in land preparation and planting, weeding and thinning. In some countries, this reveals a need to develop adapted equipment for use by smallholders to facilitate more timely field operations. When cotton prices are low, the cost of labor in some countries results in a considerable amount of cotton from the later bolls being left unpicked.

Rising costs of inputs, in some cases coupled with import duties on agro-chemicals, without a commensurate increase in price has reduced the returns on cotton. Currently, this effect is being offset by high prices resulting from a shortfall in the Chinese crop due largely to pyrethroid resistance in the bollworm, *Helicoverpa armigera*, population and in the Pakistan crop due to the incidence of leaf curl virus disease. Close attention has been paid to the relationship between both seed cotton and lint equivalent farmgate prices and the international value of the cotton produced.

The use of local, multi-disciplinary teams of consultants, some of whom are directly involved with policy making and cotton research, has been an important feature of the study. The first outcome is that the conclusions, key issues and recommendations presented are those visualized by local experts. The second is that it enabled experts in different fields of cotton production to work together and to appreciate the interactions between their respective fields, giving them a complete overview of their cotton sub-sectors.

This report represents the culmination of this study, incorporating the findings of the country study teams, and the essentials of the discussion and final conclusions of an international workshop at which all study teams were represented. This has been a comprehensive but not exhaustive study, not least, because so many countries are in a transition stage in liberalizing their cotton sub-sectors. Furthermore, the study did not go sufficiently deeply into the interactions between cotton production and the textile industry and only touched on risk management. In many cases the key issues and recommendations presented call for further, detailed study to determine their merits and feasibility. However, it is expected that the study will be of particular value to donor organizations in assessing the merits of cotton related development projects and to national governments in developing their cotton programs and policies.

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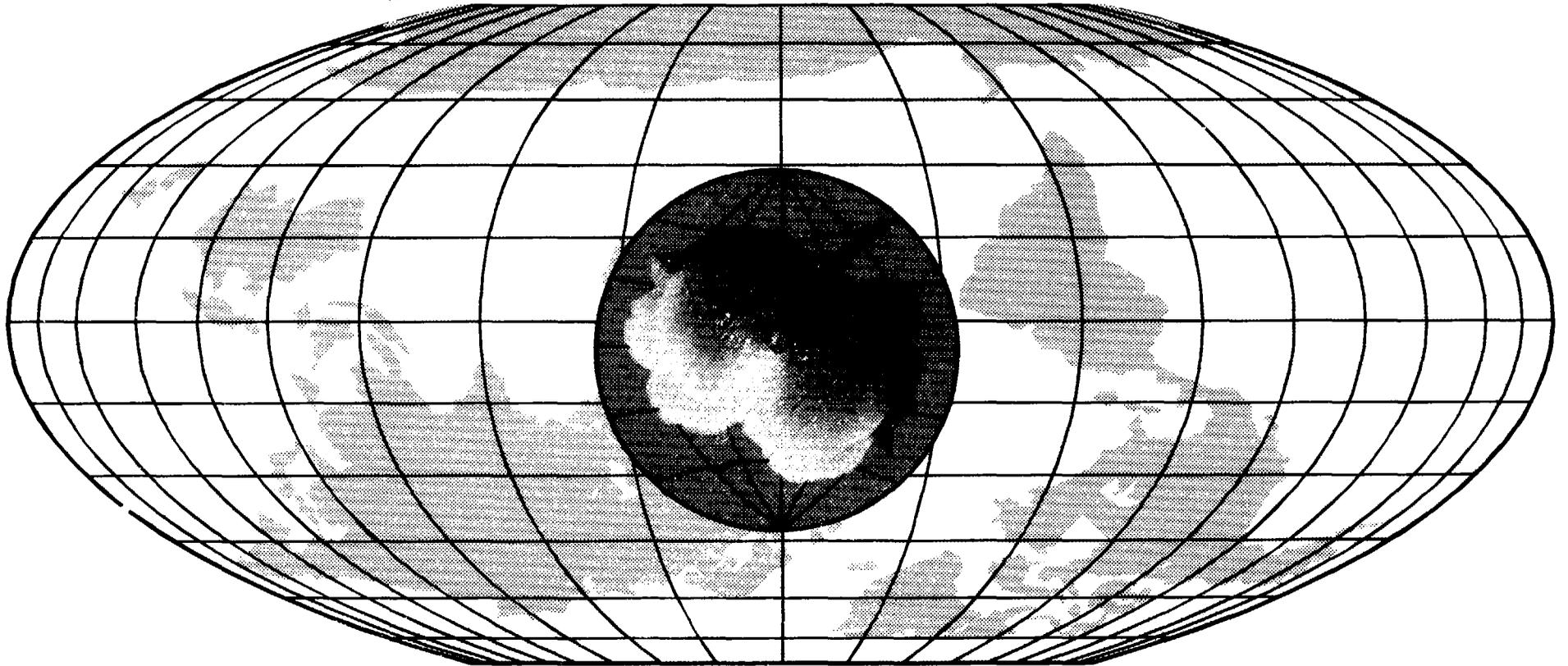
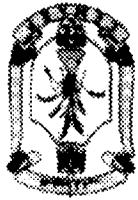
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LIST OF ACRONYMS AND ABBREVIATIONS

General

BCGA	British Cotton Growing Association
CEMARP	Canada-Egypt-McGill University Agricultural Response Program
CFDT	Compagnie Française pour la Développement des Textiles
CGIAR	Consultative Group for International Agricultural Research
CIRAD CA	Centre de Coopération Internationale en Recherche Agronomique pour le Développement: Département des Cultures Annuelles
CIS	Commonwealth of Independent States
COMECON	Council for Mutual Economic Aid
COTLOOK A INDEX™	Average price quotations for medium count cottons prepared by Cotton Outlook, Liverpool
cm	centimeter
CPI	Consumer Price Index
CRC	Cotton Research Growing Corporation
DRC	Domestic Resource Cost
ECGC	Empire Cotton Growing Corporation
ELS	Extra-long staple
FAC	Francophone African
FAO	Food and Agriculture Organization
FAS	Foreign Agriculture Service, U.S. Department of Agriculture
FMT	Shirley Development Fineness/Maturity Tester
FSU	Former Soviet Union
GATT	General Agreement on Trade and Tariff
GDP	Gross Domestic Product
GOT	Ginning Outturn
ha	hectare
HVI	High Volume Instrumentation
ICAC	International Cotton Advisory Committee
ICM	Integrated Crop Management
IPM	Integrated Pest Management
IRCT	Institut de Recherches du Cotton et des Textiles Exotiques
IRRI	International Rice Research Institute
ITMF	International Textile Manufacturers Federation
kg	kilogram
LCV	Leaf Curl Virus
LS	Long Staple
MADIA	Managing Agricultural Development in Africa
mt	metric ton
NAFTA	North American Free Trade Agreement
NGOs	Non-Governmental Organizations
NYCE	New York Cotton Exchange
OECD	Organization for Economic Cooperation and Development
ODA	United Kingdom Overseas Development Administration
OTA	United States Office of Technology Assessment
SAP	Structural Adjustment Program
SMS	Subject Matter Specialist

T&V	Training and Visit
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Brazil

AGF	Aquisição do Governo Federal / Federal Government Purchase
BMCG	Campina Grande Commodities Stock. in Paraíba
BMF	Commodities Stock & Futures
CMN	Conselho Monetário Nacional / Monetary National Council
CNPA	Centro Nacional de Pesquisa do Algodão / National Center for Cotton Research
CONAB (former CFP)	Companhia Nacional de Abastecimento / National Supply Company
EGF	Empréstimos do Governo Federal / Federal Government Loans
EGF/COV	Empréstimos do Governo Federal com Opção de Venda / Federal Government Loans with Purchase Option
EGF/SOV	Empréstimos do Governo Federal sem Opção de Venda / Federal Government Loans without Purchase Option
EMBRAPA	Empresa Brasileira de Pesquisa Agro-pecuária / Brazilian Company for Agricultural and Cattle Raising Research
EMBRATER	Empresa Brasileira de Extensão Rural / Brazilian Company for Rural Extension
IAC	Instituto Agrônômico de Campinas / Agronomical Institute of Campinas, in São Paulo
MERCOSUR	Southern Common Market of Argentina, Brazil, Paraguay and Uruguay.
PGPM	Política de Garantia de Preços Mínimos / Minimum Price Policy (MPP)

China

CAAS	Chinese Academy of Agricultural Sciences
CJC	Cotton and Jute Company
CRI	Cotton Research Institute
NCCR	Northern Cotton Growing Region
PPI	Plant Protection Institute
SCCR	Southern Cotton Growing Region
SMC	Supply and Marketing Cooperatives

Egypt

AERDI	Agricultural Extension and Rural Development Institute
ARC	Agricultural Research Centre
CAAES	Central Administration for Agricultural Extension Services
CAPM	Central Administration for Pest Management
CATGO	Cotton Arbitration and Testing General Organisation
CEA	Cotton Extension Agents
CTSC	Cotton Technical Support Committee
GAAES	General Administrations of Applied Extension Services
MAFLR	Ministry of Agriculture, Fisheries and Animal Resources and Land Reclamation
MEFT	Ministry of Economy and Foreign Trade
NARP	National Agricultural Research Program
O&M	Operation and Maintenance
PBDAC	Principal Bank for the Development of Agricultural Credit
PPRI	Plant Protection Research Institute
TIC	Textile Industries Corporation

India

AEO	Agricultural Extension Officer
AICCIP	All India Coordinated Cotton Improvement Project
CCI	Cotton Corporation of India
CICR	Central Institute of Cotton Research
CIRCOT	Centre for Research on Cotton Technology
ICAR	Indian Council of Agricultural Research
NAFED	National Agricultural Cooperative Marketing Federation of India
VLEW	Village Level Extension Workers

Mali

AV	Association Villageoise / Village Association
BNDA	Banque Nationale de Développement Agricole / National Bank for Agricultural Development
CFA	Communauté Financière Africaine
CFDT	Compagnie Française pour le Développement des Textiles / The French Company for Textile Development
CMDT	Compagnie Malienne pour le Développement des Textiles / The Malian Company for Textile Development
COPACO	Compagnie Parisienne de Coton
CRRA	Regional Agronomic Research Centres
DIT	Direction Technique d'Industrie / Technical and Industrial Management Service
ESITEX	Ecole Supérieure des Industries Textiles / Textile Industry Higher Education School
IER	Institut d'Economie Rural / Rural Economy Institute
IPR	Institut Polytechnique Rural / Rural Polytechnical Institute
HUICOMA	Huilerie Cotonnière du Mali / Mali Cottonseed Oil Company
OHVN	Office de la Haute Vallée du Niger
OSRP	Office de Stabilisation et de Regularisation des Prix / Office for Price Stabilisation and Regulation
SOSEA	Société de Services pour l'Europe et l'Afrique
SYCOV	Syndicat des Producteurs Cotonniers et Vivriers / Cotton Producers' Trade Union
WAMU	West African Monetary Union
ZAER	Zone d'Alphabétisation et d'Extension Rurale / Zone of Rural Expansion and Literacy

Mexico

ASERCA	Apoyos y Servicios a la Comercialización Agropecuaria / Support and Services for the Commercialization of Agriculture
BANRURAL	National Rural Credit Bank
INIFAP	National Institute of Forestry, Agriculture and Animal Husbandry
FERTIMEX	Fertilizer Company of Mexico
FIRA	Agricultural Trust Fund
PROCAMPO	Program of Direct Rural Support
SAHR	Ministry of Agriculture and Water Resources

Pakistan

ADBP	Agricultural Development Bank of Pakistan
arhi	Marketing Commissioner

CCRI	Central Cotton Research Institute
CEC	Cotton Export Corporation
CLCV	Cotton Leaf Curl Virus
DDA	Deputy Director of Agriculture
EADA	Extra Assistant Director of Agriculture
FSCD	Federal Seed Certification Department
KHARIF	Wet season (mid-April to mid-October)
MEP	Minimum Export Price
NIAB	Nuclear Institute for Agriculture and Biology
PCCC	Pakistan Central Cotton Committee
RABI	Dry season (mid-October to mid-April)

Tanzania

AR	Grade A Seed Cotton
ACES	Assistant Commissioner for Extension Services
BR	Grade B Seed Cotton
CALD	Commissioner for Agriculture and Livestock Development
CRDB	Co-operative and Rural Development Bank
CRC	Cotton Research Corporation
ECGA	Eastern Cotton Growing Area
FEPU	Farmers Education and Publicity Unit
NASACO	National Shipping Agencies Company Ltd.
NALERP	National Agriculture and Livestock Extension Rehabilitation Project
TACOCA	Tanzania Cotton Co-operatives Alliance
TARO	Tanzania Agricultural Research Organisation
TFC	Tanzania Fertiliser Company
TCMB-	Tanzania Cotton Marketing Board
TCLSB	Tanzania Cotton Lint and Seed Board
TISCO	Tanzania Industrial Studies and Organisation
VEW	Village Extension Worker
WCGA	Western Cotton Growing Area

Uzbekistan

AAS	Academy of Agricultural Sciences
ASTC	Agricultural Senior Technical Colleges
SCSE	State Committee for Science and Engineering
SOYUZHLOPOK	Institute of Cotton
SPTU	Rural Junior Technical Colleges

MEASURES AND BALE SIZES

General:	1 Kilogram	= 2.205 Pounds
	1 Metric Ton	= 2,205 Pounds
	1 Hectare	= 2.471 Acres
Brazil	Arroba:	= 15 Kilograms
	1 Bale of Lint	= 220 kg
China	1 Bale of Lint	= 80 kg
Egypt	1 Feddan	= 0.420 Hectares or 1.037 Acres
	1 Kentar	= 157.50 Kilograms (unginned seedcotton)
	1 Metric Kentar	= 50.00 Kilograms (lint or ginned cotton)
	1 Ardeb	= 120.00 Kilograms (cotton seed)
	1 Bale of Lint	= 6.53 Metric Kentars or 326.50 Kilograms (lint cotton)
India	1 Lac	= 100,000
	1 Crore	= 10,000,000
	1 Bale of Lint	= 170 kg
Mali	1 Bale of Lint	= 220 kg
Mexico	1 Bale of Lint	= 220 kg
Pakistan	1 Bale of Lint	= 170 kg
	1 Bale of Yarn	= 181 kg (400 lbs)
	1 Maund	= 37.324 kg
Tanzania	1 Bale of Lint	= 181 kg (400 lbs.)
Uzbekistan	1 Bale of Lint	= 220 kg

INTRODUCTION

World Bank Technical Paper Number 231, "Cotton Production Prospects for the Decade to 2005, A Global Overview" (Eisa et al 1994), was prepared in 1991 to provide background information for the nine country cotton study which is discussed in this document. It was updated in 1993 prior to publication in February 1994. Although it is a recent publication, rapid changes have occurred in policies on cotton production, particularly with regard to government interventions, input pricing, price support and cotton marketing. Cotton production has suffered setbacks in some countries, notably the impact of leaf curl virus disease in Pakistan and India and the development pyrethroid resistance in *Helicoverpa* populations in China, India and Pakistan.

The nine country study of Cotton Production Prospects for the Next Decade was initiated because projections on consumption indicate a steady increase as a result of population growth, increased per capita consumption in some countries, an increasing share of the fiber market as a result of new spinning technology and increased public awareness of the advantages of cotton, particularly in the USA and Europe. However, some projections over the same period suggest that there could be a decline in the area planted to cotton because of the need to produce more food. The increase in production, therefore, may have to come from higher yields and not from area expansion. The intention of this study was to use case studies of key cotton producing countries to determine where and how the increase in yield will be achieved in a sustainable agricultural system. Even if cotton/food crop price ratios rise, any significant expansion in cotton area seems unlikely. There has been none in the last forty years (Figures 1; Table 1.2).

Cotton is grown in over seventy countries and is one of the most important cash crops in the world. The fiber is used universally as a textile raw material while cottonseed is a major source of vegetable oil and cottonseed cake which is a source of high quality protein for stock-feed or, with careful processing, for human food. Cotton plays a vital multi-sectoral role in the economies of many developing countries in Asia, Africa and Latin America, earning foreign exchange and providing employment for millions of people in the agricultural and related processing and textile sub-sectors. Foreign exchange earnings may come from the direct export of raw cotton or from the export of value added cotton based textiles.

Over the past fifty years, cotton lint production has increased from an annual average of 5.24 million mt between 1946 and 1950 to a projected 19.12 million mt between 1991 and 1995 (Figure 1). Initially, the increase resulted from area expansion from an average of 26.27 million ha between 1946 and 1950 to 35.44 million between 1951 and 1955 (Figure 1). New areas came into production as a result of the work of the British Empire Cotton Growing Corporation (ECGC) and the French Institut de Recherches du Coton et des Textiles Exotiques (IRCT), mainly in Africa, expansion of irrigation in Central Asia and the impact of new pesticides which made it possible to move into areas which had previously been considered unsuitable for cotton because of the incidence of insect pests. Since the mid 1960s, however, the area planted to cotton has remained fairly constant at between 32 and 34 million ha and most of the increase in production has come from yield enhancement, resulting from improved varieties, agronomic practices and crop protection, going from a five-year average lint yield of 200 kg/ha between 1946 and 1950 to a projected 582 kg/ha between 1991 and 1995 (Figure 2).

A great deal of the increase in world production occurred in the former Soviet Union (predominantly Uzbekistan) and the Peoples' Republic of China. These two countries, together with the USA, produce about two thirds of the world's cotton. Spectacular increases in production also occurred in Pakistan, Australia and Southern Africa. Over the past twenty years, several countries, notably in South East Asia, have introduced programs to encourage cotton production in order to reduce reliance on imports to supply the needs of their rapidly expanding textile industries. While these countries are never likely to become major cotton producers, if they achieve even partial self sufficiency, it will influence world trade in raw cotton.

The governments of most cotton producing countries are heavily involved in cotton production and marketing because of its multi-sectoral role in the economy and its socio-economic and strategic importance. This was discussed in World Bank Technical Paper 231 (Ibid). In practically all cases this involves some form of price intervention or stabilization to bolster grower confidence, prevent wide fluctuations in production caused by price volatility, or to provide supplies of fiber to domestic textile industries at prices below the international level. This may be a fixed price for a specific grade of seed cotton, declared in advance of the season with premiums and discounts for grades above and below the standard grade or it may be a minimum price which only comes into play if the international price for a standard grade falls below this level. The fixed price may be based on long term averages to stabilize the farmgate price or it may be related to the current lint equivalent price on the international market. Government intervention may also involve input subsidies and procurement which affect input price and supply and/or import/export taxes, quotas etc. which affect trade. The various types of policy are discussed in Chapter 3.

Government interventions influence domestic production, the domestic textile industry and the international cotton, yarn and textile markets. Arguments for their justification include economies of scale, quality control, logistical barriers and environmental concerns. Some of the arguments have economic/technical justification while others do not. However, while cottonseed is a valuable source of vegetable oil and protein, cotton is grown primarily to supply the raw material needs of the textile industry, an industry that relies on regularity of supply and quality. Thus studies of cotton production economics and policy should be complemented by an understanding of their impact on the markets for cotton lint, yarn and textiles.

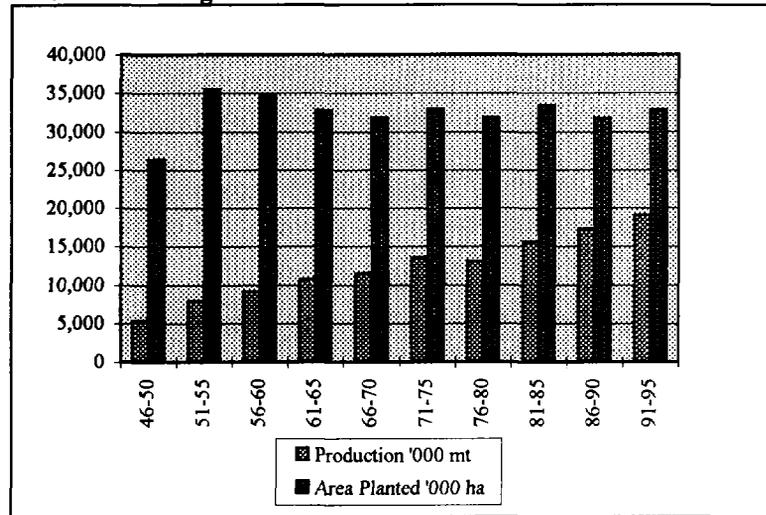
Initially, the study "Cotton Prospects for the Next Decade" was intended to be a study of technological innovations that could lead to the necessary yield increases. However, because the interdependence between production and the textile industry influences government policies and these policies influence yield through their impact on the application of new technology, the scope of the study was widened to encompass policies on input supply and pricing, the farmgate price for seed cotton/lint and marketing. The importance of the textile industry in several of the countries in the study necessitated consideration of government policies on these industries.

The study was conducted in Brazil, China, Egypt, India, Mali, Mexico, Pakistan, Tanzania and Uzbekistan. China, India, Pakistan and Uzbekistan were selected as four of the world's top five cotton producing countries. Egypt produces fully irrigated, speciality cotton which has the best quality of its type in the world. Until recently, Brazil was the sixth highest cotton producer in the world and also the sixth largest consumer. Mexico has been an important producer but production has declined, largely because of government policies on alternative crops. Finally Mali and Tanzania represent two countries which have environmental similarities but differ in the level of management of their cotton sub-sectors.

Local, multi-disciplinary teams of consultants were employed to conduct the country studies. The country reports were reviewed in each country at a meeting attended by the study team and representatives of all sectors of the cotton industry. The World Bank employed international consultants to review the draft documents and to assist in the preparation of a synthesized draft report, a draft document on Challenges and Recommendations and a draft document on Country Policies. These documents were discussed at the Ismailia International Workshop, 'Cotton Production Prospects for the Next Decade' which was organized by the Canada Egypt McGill Agricultural Response Program, in cooperation with the Egyptian Government, from November 14 to 17, 1994. Representatives of each of the study teams and specialist consultants participated in this workshop to identify common conclusions of the case studies and to discuss the study follow-up.

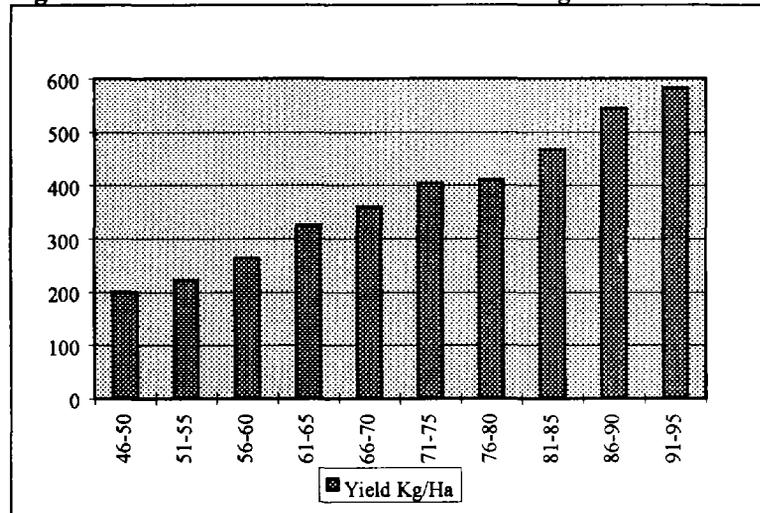
This document is a synthesis of the reports of the target country study teams. Chapter 6 brings together their conclusions and recommendations which formed the basis of discussions at the Ismailia International Workshop, and provides a summary of the workshop discussions.

**Figure 1: World Cotton Production and Hectarage:
Five Year Averages 1946 to 1995**



Source: ICAC

Figure 2: World Cotton Yield: Five Year Averages 1946 to 1995



Source: ICAC

CHAPTER 1

COTTON: ITS ORIGINS AND AREAS OF PRODUCTION

Historical Background

Cotton differs from other field crops in that it is an oil crop which is grown for its fiber, an outgrowth from the seed epidermis. Fibers develop as elongations of surface cells in the seedcoat and being part of the seed, follow the same developmental pathway. Cottonseed constitutes about 65 percent of the seed cotton and contains about 17 percent oil and 24 percent protein. The oil which is semi unsaturated, is used for cooking, soap making and other purposes. During oil extraction, the rest of the seed embryo is converted into protein rich oil-cake, a valuable stock feed.

Normal cotton seed contains a pigment known as gossypol which is toxic to non ruminant animals, rendering cottonseed cake suitable for ruminants only. However, with careful processing, high quality, protein rich cottonseed flour can be produced which is sufficiently low in free gossypol to make it suitable for human consumption. This has been used in Central America for the production of a protein rich beverage known as 'Incaparina' which is fed to children to prevent protein malnutrition. Glandless (gossypol free) varieties have been developed but they are more susceptible to insect pests. Despite this, they have been grown successfully in parts of Texas and West Africa to produce protein rich flour for baking and other culinary purposes. A number of countries, including Brazil, China and Mali, are developing glandless cotton varieties. Research is also under way to develop varieties with glanded vegetation but glandless seed to overcome the problem of the insect susceptibility of glandless cotton but to produce gossypol-free seed.

Cultivated cottons fall into three main groups, based on fiber properties. Group I is the Egyptian, American Egyptian or Pima and Sea Island Extra Long Staple *Gossypium barbadense* cottons. The fiber is long and fine with a staple length in excess of 32 mm and a Micronaire value below 4.0. Group II consists of the American and African Upland Medium Staple *G. hirsutum* cottons. The staple length is about 25 to 30 mm and the Micronaire value ranges from 3.8 to 5.0. These two groups of New World, allotetraploid species account for 8.0 percent and 90.0 percent of world production, respectively. Group III contains two diploid species of Asiatic or Old World Short Staple cotton, *G. arboreum* and *G. herbaceum*, the former being the most widely grown. The lint of these species is short and coarse with a staple length less than 25 mm and a Micronaire value in excess of 6.0. They are grown commercially in India, Pakistan and other parts of South East Asia and as dooryard crops in parts of Asia and Africa, accounting for about two percent of the world cotton production.

Gossypium spp. are widely distributed and wild species have been discovered in all continents that extend into the sub-tropics. The wild, lintless species are perennial, xerophytic shrubs which occur naturally in arid regions of the tropics and sub-tropics. They occur commonly in the beds and on the banks of creeks and streams that are dry for most of the year but some are sufficiently drought tolerant to spread to dry, rocky hillsides or over arid, stony or

rocky plains. They are plants of open association, suffering severely from heavy competition in the seedling stage or under overhead shade (Hutchinson, Silow and Stephens, 1947). Many of these characteristics are found in the cultivated species which are sensitive to weed competition and relatively drought tolerant. They are capable of giving some yield under drought conditions which would cause most other crops to fail. The Old World, diploid species are more drought tolerant and insect resistant than the New World, allotetraploid species.

The seed fibers of true cottons consist of long, fine, flattened and convoluted hairs called lint that can be easily detached from the seed and short, coarse hairs called fuzz or linters that are firmly attached to the seed (Hutchinson, 1959). The presence of seed fibers in linted cottons in both the Old and New World species probably provided the main impetus for their domestication (Lee, 1984). Hutchinson (1954) concluded that *G. herbaceum* race *africanum* which is found in Southern Africa, is truly wild and represents the closest modern relative to the progenitor of the diploid species. This race gave rise to the primitive cultivated race *acerifolium* which spread northward following the development of an annual habit and led to the races *persicum* in Arabia and the very early race *kuljianum* which was adapted to the hot summers of Central Asia. Primitive perennial *G. herbaceums* spread to India and gave rise to the earliest forms of *G. arboreum*. This moved into the alluvial areas of what is now Bangladesh where the perennial northern form of *G. arboreum* developed. These forms spread throughout the areas of the Old World which were suitable for the production of perennial cotton. However, the success of cotton as a textile material necessitated the production of cotton in areas where perennial growth was not possible. The need was first filled by *G. herbaceum*, giving rise to the evolution of the race *wightianum*. This was followed by the development of annual *G. arboreums* which spread throughout the cotton producing areas, relegating the perennial forms to relic status (Hutchinson, 1959). Hutchinson *et al* (1947) considered that the evolution of cotton growing and spinning occurred in an area that already had the technology for spinning and weaving flax (*Linum usitatissimum* L.) and wool. This is given credence by the findings of cotton remains in Nubia (Chowdhury and Burth, 1971) and at Mohenjo-Daro in Pakistan, dating from about 2,700 BC (Gulati and Turner, 1928; Lee, 1984).

The spread of domesticated cottons was closely connected to commerce and industry. Mohenjo Daro was a flourishing metropolis at the heart of the Indus civilization. The Churka or Jerka had been invented to remove cotton fiber from the seed and although this was still a laborious process, it was much faster than hand separation (Lee, 1984)¹. Churkas can still be found in some of the villages of South East Asia. Cotton spread from the Indus westward into the Middle East and eastward into other parts of South Asia, South East Asia and China. Archeological records from China reveal that cotton was widely grown more than 2,000 years ago. It is believed to have reached China along one of two trade routes, *G. herbaceum* along the northern route from Arabia through Iran and Pakistan into Xinjiang and later Gansu and Shaanxi Provinces and *G. arboreum* along the southern route from India through Burma, Thailand and Vietnam to Yunnan, Guangxi and Guangdong Provinces (Wang *et al*, 1994). *G. arboreum* spread through China into Manchuria, Korea and Japan where only early maturing annuals could survive, giving rise to the evolution of a distinctive race, *G. arboreum* var. *sinense* (Hutchinson, 1959).

It has been established that New World cottons are allotetraploid with twenty six pairs of chromosomes, consisting of thirteen pairs from the "A" genome and thirteen from the "D"

¹ This consisted of two wooden pinch rollers of about 30 cm long and about 25 mm in diameter, with one slightly smaller than the other. Fibers were drawn between the two rollers and separated from the seed

genome, symbolized as 2(AD). The "A" genome is homologous with Old World cottons and the "D" genome is homologous with New World wild species. Central to the problem of the evolution of New World species is how the parent forms came together to permit hybridization. Hutchinson *et al* (1947) hypothesized that new World, tetraploid species may have evolved under domestication, following the introduction of an Old World cotton, probably *G. arboreum*. The Old World taxon then hybridized with a New World taxon, possibly *G. raimondii* Ulb., giving rise to the prototype from which the tetraploid species of *Gossypium* diverged (Lee, 1984). The alternative theory places the hybridization much earlier, without human intervention. Harland (1939) considered a trans-pacific land bridge while Saunders (1961) discussed the possibility that hybridization occurred before the super continent Gondwanaland split up. Be that as it may, the Indians in South America were growing and utilizing cotton for thousands of years. The oldest cotton found in the New World which was shown to be *G. barbadense*, was in a large mound, made up of human refuse, at Huaca Prieta at the mouth of the Chicama River in Northern Peru (Hutchinson, 1959). Carbon dating of material at the bottom of the mound places it at about 2400 BC. These primitive cottons of western South America may be regarded as representatives of the source material from which the *G. barbadense* cottons of other areas arose, including the modern Tanguis of Peru, Sea Island and Egyptian (Hutchinson, 1959).

The spread of New World cottons also depended on commerce but was initially more closely connected to migration. Seven races of *G. hirsutum* have been identified in Central America and three of these, races *punctatum*, *marie-galante* and *latifolium*, have given rise to all the cultivated Upland cottons. The *marie galantes* gained in fineness and staple length through introgression with the finer components of *G. barbadense* and are found as tree cottons in the Caribbean and as moco cotton in north east Brazil. They also became established in parts of West Africa but are not known elsewhere beyond the New World (Hutchinson, 1959). Race *punctatum* was the cotton of eastern Mexico and Honduras and spread along the coast and islands of the Gulf of Mexico as far as Barbados (Ibid). Annual forms of *punctatum* developed into the Hopi cottons which were part of a northern migration into the American southwest, involving maize, beans and squash (Lee, 1984). *Punctatum*s also spread into Africa and supplanted the Asiatic cottons right across Africa, south of the Sahara. They were found to have a high level of resistance to bacterial blight, *Xanthomonas malvacearum*, and have been an important component of recent breeding programs (Hutchinson, 1959). Apart from the West African *punctatum*s, all the annual forms of *G. hirsutum* belong to the race *latifolium*. The center of origin was in what is now the state of Chiapas in Mexico where it was predominantly photoperiodic, flowering only in short days. Forms that were capable of flowering irrespective of day length were developed in the southeastern United States and gave rise to all the cottons to which the name Upland applies (Ibid).

The Sea Island forms of *G. barbadense* were introduced into the south Atlantic coastal regions of what is now the United States in 1785. The annual habit of these cottons was a matter of pre-adaptation (Lee, 1984). Stephens (1975, 1976) hypothesized that Sea Island cottons might have become day neutral as a result of introgression from a photoperiodic form of *G. hirsutum* into a coarse fibered form of *G. barbadense* before 1785. The progeny were day neutral and had the distinctive fiber properties for which Sea Island cotton is known (Lee, 1984). In the early 1820s, Sea Island hybridized with Jumel's tree cotton which was probably a perennial form of *G. barbadense* from Peru, in Egypt, giving rise to the distinctive Egyptian cottons (Balls, 1912). Egyptian cotton later gave rise through hybridization, to the Pima cottons of southwestern United States (Bryan, 1955) and the limbless or zero varieties of Uzbekistan (Lee, 1984).

The invention of the spinning jenny by Arkwright in 1769 was the first major step in the development of modern textile technology and paved the way for the industrial revolution in Europe. Development of New World cotton production was handicapped by the separation of fiber from seed. The invention of the saw cotton engine by Eli Whitney in 1795 solved this problem and revolutionized cotton production. This is reflected in the increase in production from 683 mt in 1790 to 45,550 mt in 1815. The name "cotton engine" became abbreviated to "cotton gin," a name that has gained universal acceptance.

Efforts to improve the performance of the Churka gave rise to the invention of the McCarthy roller gin in 1840. These gins were gentler on the fiber than Eli Whitney's saw gin and were simpler and easier to maintain. Roller gins became the standard system for long staple cotton and became widely accepted as the standard method of ginning medium staple cotton in many parts of Africa and Asia.

The higher yield and quality of the New World cottons resulted in the gradual replacement of Old World cottons in the textile mills of England. The United States was the main producer of this cotton and the economy of the Southern States flourished as cotton plantations grew. However, this economy was based on slave labor and eventually contributed to the War between the States (1861-64). Cotton production plunged during the war from an average of 763,319 mt between 1855 and 1859 to 463,003 mt for the period 1860 to 1864 and 481,602 mt between 1865 and 1869. The drop in American production stimulated cotton production in India and Egypt and to efforts to grow cotton in Australia, South Africa, the Tokar Delta in Sudan and elsewhere. Cecil John Rhodes who made his fortune in South Africa from diamonds, originally went there for health reasons to help his brother grow cotton in Natal.

The Southern States gradually recovered from the war and by the early part of the twentieth century, the United States totally dominated world cotton production with an average annual production for the five years 1902-06 amounting to some 62 percent of the world total of 4.18 million mt. About 75 percent of the United Kingdom cotton imports came from the USA. The British Cotton Growing Association (BCGA) was established in 1902 to reduce reliance on the USA and the drain on hard currency reserves by increasing production in the Empire. Funds were subscribed by Associations of employers and operatives, by large firms connected with the cotton trade and by private individuals. The Association investigated almost every country of the Empire where there appeared to be a reasonable chance of producing good quality cotton on a commercial scale. Ginneries were established to gin and bale cotton lint, for export to the United Kingdom (Bell and Gillham, 1989). Twin cotton research stations were established at Giza in Egypt and at Wad Medani in the Gezira in Sudan, the latter in 1918.

The Empire Cotton Growing Corporation (ECGC) (later the Cotton Research Corporation (CRC)) was established in 1921 under Royal Charter with "the objective of extending and promoting in the interests of our Empire the growing and cultivation of cotton in our Dominions, Colonies, Protectorates, Protected States and in any country or place over which we have or may have any mandate or control." The British Cotton Growers Association (BCGA) was taking care of the commercial aspects of cotton production so the ECGC concentrated on research and experimentation to establish a sound foundation in suitable territories on which to base the new industry. The policy decided on was to encourage cotton production by local peasant farmers rather than to embark on large scale, estate production.

The ECGC worked in the anglophone countries of Africa, India, the West Indies and Australia. It covered a very wide range of climatic conditions, offering a unique opportunity to

study cotton growth and development in all its aspects. The main aim was to improve the yield of cotton lint without loss of quality and if possible, to improve quality concurrently. Emphasis was placed on plant breeding since advances in yield can be achieved through the introduction of higher yielding varieties with little or no extension effort whereas the adoption of new production technology takes time and requires considerable extension input.

Developments in France followed a similar pattern to those in the United Kingdom. The *Compagnie Française pour le Développement des Textiles (CFDT)* was established to look after cotton marketing and ginning and the *Institut de Recherches du Coton et des Textiles Exotiques (IRCT)* was established to conduct cotton research in the francophone countries of West Africa. The CFDT provided facilities for adaptive research and extension. The French tropical research institutes have been restructured and the IRCT now forms part of the *Centre de Coopération Internationale en Recherches Agronomique pour le Développement: Département des Cultures Annuelles (CIRAD CA)* which has central research facilities located in Montpellier, France.

Although widely scattered and only meeting occasionally, the staff of the CRC and the IRCT demonstrated the advantages of working as a team in order to maintain continuity and integration of their research policy. Recently CIRAD CA has turned its attention to the development of research within the framework of regional networks. They do not play a direct role in the coordination of the Regional Network for the Mediterranean and Middle East but this activity is carried out by a former Director General of the IRCT. They have held meetings to convert their francophone African network into a network covering all cotton growing areas in sub-Saharan Africa. These endeavors have had the support of the International Cotton Advisory Committee (ICAC) and the Food and Agricultural Organization (FAO). Regional networks have also been established in Latin America. In many developing regions of the world, future progress in research and development appears to lie in regional cooperation. The ultimate goal is an international network and the first step in this direction occurred with the First World Cotton Research Conference held in Brisbane, Australia in February 1994 which was financed by the FAO, the ICAC and the Australian Cotton Research Fund. The hope is that resources will be available for this to be a regular event at intervals of three to five years.

After the Africa colonies gained independence, the British and French organizations moved in different directions. The CRC continued to work on a contract basis for several years but eventually ceased operation in 1974. The IRCT (CIRAD CA) continued to work in West Africa and expanded its activities to become a consultant on cotton projects in many countries in other parts of Africa, Latin America, the Middle East and South East Asia.

The BCGA dropped its managerial role and became a consulting organization, now forming part of the Cargill group. The CFDT continues to play an active role in the development of agriculture and industry in francophone West Africa. Following independence, each country in the region established its own cotton development company and with the assistance of the CFDT, continues to provide many functions and services in both agricultural and industrial development. This includes applied research, the multiplication and distribution of adapted varieties, the development of animal drawn and motorized cultivation equipment, the introduction of appropriate production and crop protection practices, the setting up of cooperatives to manage inputs, agricultural credit, machinery and marketing, shelling units and oil mills, soap production units, acid delinting facilities, power plants, roads, transport and handling, and management services in agricultural development. These activities have been extremely important in the development of the region.

Just as the war between the States in America had devastated the cotton economy of the South in the 1860s, the cotton boll weevil, *Anthonomus grandis* Boh. which entered Texas from Mexico in 1895, devastated the economy during the early part of the twentieth century. Sea Island cotton had been produced in the coastal areas of Georgia and South Carolina and on the islands of the coast but being late maturing, it was devastated by the weevil and production ceased. In order to ensure continued supplies of long staple cotton, the Lancashire Fine Spinners and Doublers purchased a tract of land near Greenville in the Mississippi Delta to produce long staple cotton. This became the Delta and Pine Land Company at Scott, Mississippi which remained in British ownership until it was purchased by the Prudential Insurance Company in the 1970s. Long staple cotton did not do well in the Delta and was replaced by medium staple Upland cotton. This failure, coupled with a poor Egyptian crop in 1920, resulted in the Firestone and Goodyear Tyre Companies investing in the development of Pima cotton in Arizona.

The development of new insecticides following the Second World War revolutionized cotton production. Spectacular yield increases were achieved in traditional cotton producing areas and cotton production expanded into areas which were formerly considered unsuitable because of the incidence of insect pests. The area planted to cotton increased from an annual average of 26 million ha between 1946 and 1950 to 35 million between 1951 and 1955. This was a major factor contributing to the increase in world cotton production which rose from an average of 5.2 million mt to 7.9 million mt despite a relatively small increase in yield from 199.6 to 222.2 kg/ha lint for the two periods, respectively (Table 1.1, 1.2 and 1.3). However, over-reliance on insecticides created new problems. The elimination of natural enemies and the development of insecticide resistance resulted in resurgence of known pests and pests which had previously been of little importance became major pests. This resulted in greater awareness of the need to develop insect control strategies which recognize the need for discriminate use of insecticides at certain stages of crop development but place greater reliance on biological control, particularly early in the season, by delaying the introduction of chemical control and using selective chemicals whenever possible. Integrated Pest Management (IPM) has become the key to sustainable cotton production.

The need to ensure regular supplies of cotton for the textile industry resulted in the development of several large scale irrigation schemes, one of the most notable being the Gezira Scheme on the Blue Nile in Sudan. During the latter part of the 19th Century, the Delta Barrage and Delta Irrigation Scheme were developed in Egypt. This was followed by the Aswan Dam (1902) and barrages at Asyut (1902), Esna (1906) and Zifta (1908) and extension of the Aswan Dam (1912). The Sukkur Barrage on the Indus River in Pakistan was built in the 1930s to irrigate cotton for the British textile industry. Major irrigation development occurred on the Amu Dar'ya and Syr Dar'ya Rivers in Central Asia to produce cotton for the textile industry of the Former Soviet Union (FSU). Irrigation development intended primarily for cotton production also occurred in Arizona and California in the United States, in Mexico, Israel, Australia and most recently, in Turkey.

G. barbadense is native to Brazil and when the Portuguese arrived, they found the local Indians growing, spinning and weaving cotton. The colonists soon established the first subsistence farms (roças), growing a few plants around their houses for domestic use. The industrial revolution transformed cotton into an export commodity with cotton going to the textile mills of England. From then until the 1930s, cotton production fluctuated with the demand of the English textile mills. At the time, the Northeast Sententrional was the major cotton producing region but with the drop in coffee prices in 1929, cotton production became consolidated in Brazil, par-

ticularly in the State of São Paulo which took over from the Northeast as the major cotton producing region.

China has a long history of cotton production, the production of Old World cotton going back more than 2,000 years. However, Upland *Gossypium hirsutum*, introduced in 1865, has almost entirely replaced Old World cotton as the commercial crop of China. Long staple *G. barbadense* was introduced in the early 1950s from Central Asia and is confined to production in Xinjiang Uigur Autonomous Territory.

Cotton was first introduced into Egypt in 1820 by a French textile engineer, Louis Alexis Jumel who was strongly supported by Khedive Mohammad Ali Pasha. Several cultivars and varieties were brought in for trial and in 1860, the first local cultivar, Ashmouni, was selected in the village of Ashmoun in Menoufia Governorate. The American Civil War gave a big impetus to cotton production in Egypt. Ashmouni was grown throughout the delta except for a small area of Sea Island in the north of Gharbia. This was followed by the variety Metafifi which was discovered in a field of Ashmouni and probably arose from a natural cross between Ashmouni and Sea Island. Metafifi replaced Ashmouni in the Delta and was introduced to the United States where it gave rise to the development of Pima between 1910 and 1918. Prior to 1920, most variety improvement arose from selection within existing varieties. A program of hybridization and selection was established in 1920 and continues to the present (Stead, 1981).

By the early 1950s, Egypt had established a name as the most important producer and exporter of long staple. Cotton emerged as the single most important cash crop and became a major contributor to the national income and foreign exchange earnings (Oteifa *et al*, 1994).

Prior to 1914, most cotton types grown in India were annual forms of *G. arboreum*. Over the next two decades, Upland cotton, *G. hirsutum*, almost entirely replaced *G. arboreum*. Currently *G. arboreum* varieties account for about 16.0 percent of the Indian crop and 3.3 percent of the Pakistan crop. During the colonial period, most cotton development in the region occurred in the Indus Valley. At the time of separation in 1947, about 40 percent of the crop was produced in what became Pakistan while nearly 100 percent of the textile industry remained in the Indian Union. Since then, India has gone from being a large net importer of cotton, exporting only around 8,500 mt of Bengal Desi, *G. arboreum*, cotton to becoming a major exporter of medium staple, *G. hirsutum* and long staple, *G. barbadense* cotton.

Cotton has been grown in the southern part of Mali since the XI century. This would have been an Old World species, probably *G. acerifolium*. A French technical mission traveled through Western Sudan, now Mali, in 1888 and took cotton samples for trial by the French textile industry. However, modern production of cotton only began in 1930 when a program on rainfed cotton was initiated in the irrigated area of the Office du Niger. In 1946, the IRCT set up an extension strategy in Mali. Extension activities were taken over by the CFDT. In 1974, the Compagnie Malienne pour le Développement des Textiles (CMDT) was created through an agreement between the Government of Mali and the CFDT in the form of a public, limited company with mixed economy.

Modern Upland cotton is believed to stem from a center of diversity near the border of Guatamala and Mexico (Hutchinson *et al*, 1947). Archeological remains of *G. hirsutum* have been found mostly in Mexico, the oldest being dated to about 3500 to 2300 BC. Thus Mexico, being located in the center of origin of the New World species *G. hirsutum*, has a very long history of cotton production. During the Spanish colonial period from the XVI century to 1810, the

textile industry was increasing in importance and by 1806, several thousand workers were employed in the processing of wool and cotton. With the cost and problems of transportation, it is likely that the industry used locally produced cotton. By 1897, the industry consisted of 107 mills with 14,000 looms and 463,000 spindles. It employed 21 thousand workers and consumed 24,267 tons of lint. The area planted to cotton that year was 124 thousand ha.

After the second world war there were major developments in cotton production in Mexico. However, the commercial climate favored the export of Mexican cotton to the USA, Europe and Asia and import of cotton from the USA for the domestic textile mills. The peak production of 1,288 thousand tons was achieved in 1965 although the harvested area began to decline in 1956. Lint yields increased from between 700 and 750 kg/ha in the 1950s to 1,057 kg/ha in 1987. Since then, the harvested area and the yields have declined.

Major developments in cotton production and processing also occurred in the Indus Valley nearly three thousand years BC and this was an important step in the evolution of the Old World cotton species. Indeed, as was the case in India, prior to 1914, all the cotton types grown in what is now Pakistan were annual forms of *G. arboreum*. Small quantities of *G. hirsutum* were introduced in 1884 but production never became established. In 1914, pure seed of the variety 4F was introduced and grown on about 800 ha. Within two decades, Upland cotton attained dominance and accounts for over 95 percent of the crop.

Unlike the other countries in this study, the development of cotton production in Tanzania is comparatively recent, commercial cotton production having begun in the 1930s. Production was mainly directed towards supplying the textile industry of the United Kingdom. Uki-riguru research station was established near Mwanza in the Western Cotton Growing Area as a seed farm in 1930. A second station was established at Lubaga near Shinyanga at the same time and with the same objectives. In 1939, the Government of Tanganyika asked the ECGC to take over research work at both stations. They appointed two plant breeders to the WCGA and also appointed a plant breeder to work at Ilonga in the Eastern Cotton Growing Area. Emphasis was on variety development since yield advances arising from improved varieties can reach the farmers without any extension input whereas any changes in production technology requires a considerable amount of extension to attain acceptance. Production in Tanzania peaked at an average of 71,000 mt during the period 1971-75 but declined to average only 49,000 mt during the period 1981-85. Recently, there have been significant increases in production.

Cotton production has a long history in Central Asia. Cotton fabrics manufactured in Bukhara and Samarkand were popular as early as the X century while export of cotton fiber and cloth to Russia was well established in the XVI century. There was active development of the textile industry in Tzarist Russia, requiring expansion of cotton production. Progress in developing cotton production was disrupted by the First World War and the October Revolution. However, by the late 1920s the FSU embarked on a program to make the region self sufficient in cotton. This resulted in major irrigation development on the Amu Dar'ya and Syr Dar'ya Rivers during the 1940s. Ultimately, this resulted directly in the ecological disaster facing the Aral Sea. Uzbekistan became the biggest cotton producer in the region, accounting for over 60 percent of the total crop of the FSU.

In many countries, cotton is produced by smallholders who place first priority on food crops. The area planted to cotton is often determined by the availability of family labor. This presents many problems which are not experienced by medium or large scale growers.

Masses of statistical information on cotton production is available but the world of cotton is dynamic and historical data on their own are of little value unless they are presented in a manner that not only provides an understanding of the situation in a specific country at a particular time but also of the situation of the world of cotton as a whole. An understanding of cotton production, the infrastructure supporting it, including research, and the textile industry is important in charting future trends in cotton producing countries.

Geographic Distribution (Areas of Production)

About 55 percent of the world cotton production occurs between 30° and 37° North latitude where the USA, and the PRC (excluding Xinjiang) are located. Uzbekistan and Xinjiang in China are the major producers north of this latitude with small quantities also produced in Greece, Bulgaria, Rumania, and Spain, amounting to about 16 percent of the world total. Thus about 71 percent is grown north of latitude 30° N and ripening before the first frost in October/November. Most of the balance of the crop is produced between 30° North and 30° South latitude with under 10 percent in the Southern Hemisphere, ripening in May to July and over 20 percent in the Northern Hemisphere, ripening from December to February. In the tropics, the production period is determined by the water supply and the dry season for ripening and harvesting. Outside the tropics, it is determined largely by temperatures. The wide range of conditions under which cotton is grown spreads the supply through most of the year.

Brazil

Brazil falls in the center of origin of *Gossypium barbadense* with a small area in the northern part of the country representing an overlap region between the centers of origin of *G. barbadense* and *G. hirsutum*. Thus Brazil is rich in genetic resources in the form of wild relatives of the New World commercial species, including the species *G. mustelinum*. This material has been used as a source of natural variability in plant breeding programs in Brazil and various other countries of the world.

The main cotton producing areas of Brazil are in the northeast, the mid west and the southeast. The northeastern Setentrional area is semi arid, accounting for under 10 percent of the national production. The mid west and southeast, grouped together as the Meridian area, account for the other 90 percent of the crop with the southeastern states of Paraná (57.2 percent) and São Paulo (21.3 percent) accounting for nearly 80 percent, the remaining 10 percent coming from the mid western states of Goiás, Mato Grosso do Sul and Mato Grosso. However, cotton production in the southeast is tending to decline because of competition from alternative crops. The main expansion is likely to come from large scale, mechanized development in the mid west.

China

The cotton belt in China extends from 18° to 46° N and 76° to 124° E. However, this is misleading because it can be divided into three distinctive regions, the Yangtze River Valley with 30.6 percent of the production in 1990, the Yellow River Valleys with 61.3 percent and the Northwest Inland Cotton Producing Region with 7.8 percent. In southern China, there is some scattered production of cotton. Cotton is produced in fourteen provinces with the main concentration in Shandong, Henan, Hebei, Jiangsu and Hubei Provinces which fall between 28° and 37° N and 111° and 120° E, and Xinjiang Uigur Autonomous Territory, the most northerly cotton producing region in the world, where it extends from 37° to 46° N and 76° to 90° E. These provinces account for 83 percent of the national total. The cotton growing areas have an ade-

quate frost free period and accumulation of heat units to ensure a good yield potential. The Northwest Region is arid and relies on irrigation but the thermal conditions and hours of sunshine facilitate high yields and quality.

Major changes are occurring in the distribution of cotton growing areas in China because of the development of pyrethroid resistant bollworms, *Helicoverpa armigera*, in the Yellow River Valley. The main expansion in production is in the Northwest while the traditional cotton producing provinces in the Yellow River Valley, Shandong, Hebei and Henan, are tending to cut back on cotton planting because of the severity of the pyrethroid resistance problem.

Egypt

The cotton producing areas of Egypt extend from about 24° to 31° 30' N latitude and 30° to 32° E longitude. The climate becomes harsher with increased distance from the Mediterranean Sea. The Extra Long Staple varieties Giza 45 and Giza 70 (Isis) are grown in the lower Delta Governorates of Damietta and Daqahliya, the better quality Long Staple varieties are grown in the upper Delta and Middle Egypt and the most heat tolerant, lowest quality varieties, Dandara and its replacement, Giza 80, in upper Egypt.

India

India is the only country in the world that grows all four cultivated cotton species. The country is divided into three main cotton growing zones, the northern *G. hirsutum* and *G. arboreum* zone in the states of Punjab, Rajasthan and Haryana, accounting for about 1.7 million ha, the central *G. hirsutum*, *G. arboreum* and *G. herbaceum* zone in the states of Gujarat, Madhya Pradesh and Maharashtra, the major cotton producing region, accounting for 4.4 million ha and the southern *G. hirsutum*, *G. arboreum*, *G. herbaceum* and *G. barbadense* zone in the states of Andra Pradesh, Karnataka and Tamil Nadu, accounting for about 1.5 million ha.

Mali

Cotton is grown in the south of Mali at latitudes of 10° to 14° N and longitudes of 4° to 10° W, along tributaries of the Niger River. This is an irrigated area but irrigation water is used mainly for rice, cotton being grown as a rainfed crop.

Mexico

The main cotton producing areas of Mexico can be grouped into four regions, Sonora/Sinoloa, Laguna/Delicias, Mexicali and Chihuahua. In 1987, the share of the crop grown in each of these regions was 37, 30, 13, 11 percent, respectively. Small amounts, accounting for 9 percent of the crop in 1987, are grown in other states. Favorable prices for maize (corn) resulted in a sharp decline in the area planted to cotton in major regions. Most of the crop is irrigated.

Pakistan

Pakistan extends from towering mountains in the north to the ocean in the south. It is bisected by the Indus River and its tributaries which incorporate one of the greatest irrigation systems in the world. The cotton belt extends over about 1,200 km. between latitudes 23° and 33° N latitude, at altitudes ranging from 153 meters (500 ft) in the north to 27 meters (90 ft) in the south. Soils are alluvial in origin and vary from sandy loam to clay loam with clay dominant towards the south. The country is divided into four provinces, the North West Frontier Province,

Baluchistan, Punjab and Sindh, the latter two being the main cotton producing provinces. In 1993-94, Punjab and Sindh had 2,266 and 526 thousand ha, respectively, with 1,000 ha divided between the North West Frontier Province and Baluchistan.

Rainfall is mainly during the summer from July to September when the climate is hot and humid. Sporadic rain may also occur between January and March. The amount of rain varies from over 762 mm (30") in the north to 152mm (6") in the south but the intensity and distribution are too irregular to produce satisfactory rainfed crops. Parts of the system are also subject to periodic flooding which can cause serious crop losses. Temperatures in May and June are as high as 40° to 45° C, often reaching 50° C on individual days. Winter temperatures often fall below freezing in the Punjab and upper Sindh but the lower Sindh is frost free. There are two distinct cropping seasons for Summer (Kharif) crops from April to October and Winter (Rabi) crops from October to April/May. Some short season crops are sandwiched between these main cropping seasons. The main crops are Wheat, Cotton, Rice, Maize and Sugarcane.

The agriculture of the Indus Valley depends entirely on the canal irrigation system emanating from the rivers. The flow during the winter months accounts for about 16.0 percent and during the summer, about 84.0 percent of the total supply, with June to August accounting for 80.0 percent of the total. Water is supplied on a weekly basis, making irrigation supply driven. The supply is regulated through a series of dams which store water until it is needed during relatively dry periods. This cannot be varied according to crop water requirements. The total irrigated area amounts to about 16.96 million ha, of which 11.74 m.ha are irrigated from canals, 4.26 m.ha from tubewells and the rest from other sources. The cultivated area has increased from 19.8 m.ha in 1975/76 to 21 m.ha in 1991 as a result of an increase in irrigation facilities. The potential land area available for further irrigation expansion is 8.8 m.ha, if irrigation supplies can be augmented.

Tanzania

The cotton producing areas of Tanzania extend from about latitude 2° to 8° S and longitude 31° to 38° E. At these latitudes, the differences between day and night length and temperature are very limited. Some tropical areas also have extended periods of overcast weather which limits solar radiation. These factors impose a limit on the potential yield. There are two main cotton producing areas, the Western Cotton Growing Area (WCGA), located in the north-west of the country around the southern part of Lake Victoria, extending from latitude 2° to 6° S and longitude 31° to 35° E produces about 95 percent of the crop while the Eastern Cotton Growing Area (ECGA), located in the region beyond 35° E and 6° S, produces the balance of the crop.

Uzbekistan.

Uzbekistan is the second most northerly cotton producing area in the world, extending from 37° to 44° N latitude. The whole crop is irrigated with water from the Amu Dar'ya and Syr Dar'ya Rivers. The draw down in water flow in these rivers and intensive use of agro-chemicals has resulted in the disastrous environmental deterioration of the Aral Sea.

Smallholder Cotton Production

The level of cotton production ranges from large scale, mechanized estate production to smallholder production in which most field operations are done by hand, often by the farmer and his family without the assistance of employed labor. Large scale producers enjoy many advan-

tages over smallholders and generally achieve higher yields because mechanization and chemical weed control enable them to carry out field operations in a timely fashion. In some countries, they are aided by advanced technology which is used to interpret data on insect pest populations, the weather and plant development, aiding farmers in making management decisions on spraying, irrigation and fertilizer applications. Smallholders give food security precedence over cash crops, leading to late planting, thinning and weeding and resulting in reduced yields and often, increased insect activity. The importance of food crops is so ingrained that changes are unlikely, even with intensive extension. However, even though the economic return of smallholders are often disappointing and provides little incentive for farmers to grow the crop, smallholder production is regarded as sociologically important because it provides seasonal labor opportunities and promotes rural cash flow, exerting a stabilizing influence. Furthermore, the deep rooting habit of cotton makes it a valuable rotation crop.

The degree of mechanization in smallholder production varies widely from country to country. In the simplest form of production, all tillage and cultivation is by hand and is often late and of doubtful effectiveness. Even with good insect control, yields are usually disappointing. The use of draft animals for plowing improves the timeliness and effectiveness of land preparation and could lead to more timely planting but competition for labor for planting and cultivation may remain a major constraint to higher yields. The introduction of animal drawn tillers, planters and cultivators could improve timeliness in other field operations, leading to increases in both yield levels and stability.

Some of the advantages of scale could be achieved through consolidating cotton growing areas so that a group of smallholder plots can be treated as a single unit. This would enable farmers to share equipment and labor resources and would have the additional advantage of facilitating a restricted planting period, an important aspect of insect pest management. When this is combined with the introduction of animal drawn tillage and cultivation equipment in food crop production, improvements are likely in overall farming standards, leading to major improvements in the yields of all crops as a result of more timely field operations.

In the francophone countries, consolidation has paved the way for the establishment of farmers cooperatives which procure small tractors and other equipment for the group. Cooperatives in Greece provide for the mechanization of all field operations in cotton production, including spraying and harvesting. Consolidation of cotton plots in itself provides some advantages but when this is combined with the development of farmers cooperatives, the productivity and economic status of the community as a whole is raised.

Large scale producers also enjoy advantages in marketing. Based on 580 kg/ha lint yield (approximately 1,700 kg/ha seed cotton, the current world average), 37 ha would produce a 100 bale contract. Large scale producers in the USA and Australia are able to contract most of the crop, often before planting. It would take 75 to 150 smallholders, averaging a quarter to one half hectare and assuming that they attain this yield, to produce 100 bales. Thus individual smallholders do not produce a marketable commodity and clearly, cotton produced by a number of smallholders has to be brought together before it is marketable. Historically, this has often been done by a government or parastatal enterprise but it can also be accomplished by a cooperative or by private traders. Logically, the cotton ginneries are the first point where seed cotton from a number of individual growers can be physically combined into marketable lots although this function may be performed by intermediaries who purchase seed cotton from the growers.

Organization and Role in the Economy

Cotton plays a major role in the economies of many developing countries. For example, in India over 60 million people derive income from the cotton/textile sector (Bell and Gillham 1989). No crop competes with cotton's potential for value added in processing (Hitchings 1984).

In Pakistan, the textile industry employs over 35 percent of the industrial labor force, the export earnings from cotton and textiles amounts to over two thirds of the total exports earnings and the oil extracted from cotton seed accounts for 85 percent of the vegetable oil production in the country (Ahmad and Ali 1993).

Three quarters of the export earnings of Uzbekistan are derived from the sale of cotton lint (Kim *et al*, 1994) and forty percent of the workforce depend on cotton for employment. Cotton growing in 1992 accounted for 52 percent of total gross agricultural income.

Cotton is grown on 450 thousand ha or about 9 percent of the total land under cultivation but 40 percent of the population of Tanzania depend on cotton as a source of income. The textile industry relies on locally produced cotton, utilizing 30 percent of the total crop while cottonseed contributes 70 percent of locally produced vegetable oil. During the past decade, cotton lint exports have contributed an average 15 percent to foreign exchange earnings, second only to coffee. Increased production in 1992-93 made cotton the leading export, accounting for 22 percent of export earnings (Tisco, 1994).

The population in China's major cotton growing areas is 250 million and 50 million households grow cotton. Cotton only occupies between two and three percent of total cultivated area but the value is seven to ten percent of total agricultural output value. The textile industry employs 9 million workers and textiles contribute about 25 percent of the total export value.

Cotton remains an important crop in Egypt but its importance has diminished due to the pressure to grow food crops. Cotton's share of summer crop area has declined from a peak of 66 percent in the 1960s to about 20 percent of the land in the 1990s. Both the quantity and value of exports declined from the decade of the 1970s to the 1980s by 14 and 7 percent respectively. However, lint exports remain the fifth largest earner of foreign exchange behind the remittances of workers abroad, Suez Canal fees, oil revenues and tourism. The textile industry is the largest domestic employer.

The cotton sub-sector in Mali has grown at a rate of 8.4 percent per annum in recent years, it has contributed 15 percent to the increase in GNP and represents 50 percent of the Mali exports. The cotton zone is the richest in Mali with an average annual income five times the national average. This is due to the monitoring activity of the CMDT and the diversification policy which has made the cotton zone into the granary of the country. The marketing of Mali cotton has been characterized by reliability of cotton production and quality, leading to regular customers until the 1980s when increased production necessitated diversification in clientele. On the other hand, the domestic uptake of cotton has declined, largely because of cheap imports from Asia. However, the value of cottonseed has increased domestically because of the development of small oil mills (Deme *et al*, 1994).

The importance of cotton to Mexico and Brazil is primarily through the textile sectors which are rapidly expanding in both countries. Cotton production is a major activity in both countries but in Brazil, cotton is produced almost exclusively for the domestic textile industry

while in Mexico, the textile industry utilizes a lot of imported cotton, mainly from the USA, most of the domestic crop being exported because its quality tends to be too high for the local mill needs. In Mexico, cotton occupied 7.8 and 7.3 percent of the area planted to field crops during the decades of the 1970s and 1980s, respectively, but the area has declined to around five percent in the 1990s. The entire cotton/textile complex in Brazil employs ten million people.

Performance of the Cotton Subsector

This section outlines the recent performance of the cotton sub-sectors in the nine study countries. Unless otherwise stated, all yield and production data are in terms of lint.

Brazil

During the 1950s, the development strategy in Brazil concentrated on the industrial sector to the detriment of the agricultural sector. Nonetheless, cotton production increased from a five year average of 292 thousand mt in the period 1946 to 1950 to 735 thousand mt between 1986 and 1990, with record production of 965 thousand mt in 1989-90 (Table 1.1). This made Brazil the sixth largest producer in the world. It is also the sixth largest consumer of cotton and production was previously in balance with consumption. Since 1990, production has declined and is projected to average 580 thousand mt between 1991 and 1995. In 1992-93 national production was only 410.5 thousand mt, about 62 percent of the production of the previous year and only 42 percent of the 1985 level. The Meridian Region which is responsible for over 87 percent of the national crop, had its worst year, with official estimates highlighting a remarkable decrease in the production in the major cotton producing states of São Paulo and Paraná. This has resulted in the most serious crisis in twenty years, necessitating a four fold increase in imports from 108 thousand mt in 1991-92 to over 400 thousand in 1993-94. The main cause of the decline in production has been a decline in area planted to cotton from an average of 2.404 million ha in the period 1966-70 to an average of 1.568 million ha estimated between 1991 and 1995 (Table 1.2). Yields have tended to increase steadily since 1946 from an average of 149 kg/ha during the period 1946-50 to 370 kg/ha average during the period 1991-95, about 63 percent of the world average for the same period (Table 1.3).

Increased production is occurring in the States of Mato Grosso and Mato Grosso do Sul where the main development is large scale, mechanized production and bulk handling. This should reduce reliance on labor and eliminate contamination with jute, polypropylene and polyester fibers from picking bags and ties. Mechanical harvesting will necessitate investment in new ginning equipment with ancillary dryers and seed cotton and lint cleaners. The introduction of dryers and cleaners to existing ginneries would cost an estimated US\$ 152,000 while new installations with a capacity of 15 bales/hour would cost an estimated US\$ 1,360,000. High capacity equipment would cost an estimated US\$ 2,143,000 per installation. An outline of the relevant equipment with approximate costs and are discussed in Chapter 2.

The development of the industrial sector resulted in the top quality cotton being absorbed domestically while the lower quality was procured by the government and held indefinitely until it could be exported to Asian textile manufacturing countries. The government also operated a price support system similar to the Loan Program in the USA. Under this support, the crop peaked at 970,000 mt in 1985. This coincided with a record Chinese crop and a sharp decline in cotton prices. The government could not maintain the program and began moving into a market economy by removing import protection. While this protection of cotton producers was being removed, the subsidies on inputs remained. The last good crop produced in Brazil was

860,000 mt in 1986. Since then, competition with alternative crops, cheap cotton imports and the high labor requirements for cotton have seriously jeopardized continued cotton production. The future appears to lie in large scale, mechanized production in the west which will introduce logistical transportation problems in getting the crop to the spinning mills in the east.

China

China produced an annual average of about 2.5 million mt in the period 1971-75 and 2.2 million mt for the period 1976-80 (Table 1.1). Rapid expansion in production followed the implementation of reforms in marketing in the 1980s, leading to an average production of 4.03 million mt during the period 1981-85 and of 3.97 million mt during the period 1986-90 (Table 1.1). This represented, an increase of nearly 80 percent during the 1980s on the production during the 1970s. However, the area planted to cotton increased by only about 10 percent from an average of 4.77 million ha during the 1970s to 5.38 million ha in the 1980s (Table 1.2), most of the increase in production having come from an increase in yield from 455 kg/ha in the 1970s to 742 kg/ha in the 1980s (Table 1.3), an increase of 63 percent. The 1984 crop was a record 6.26 million mt. The government introduced controls to limit cotton production, bringing it down to 3.54 million mt in 1986. Production remained at about 4.0 million mt during the rest of the 1980s but then improved prices increased the competitive position of cotton and production rose to 4.5 million mt in 1990 and 5.68 million mt in 1991. The aim is to sustain production at this level through the 1990s.

China has demonstrated its capacity to raise production to match domestic demand but they face a crisis. Unrestricted distribution of registered Pyrethroid insecticides has resulted in excessive use, contributing to the development of a high level of resistance in the bollworm, *Helicoverpa armigera*, population. Initially, this was confined largely to Shandong, Henan and Hebei provinces and contributed to a decline in yield from 860 to 660 kg/ha and in production from 5.7 to 4.5 million mt in 1992-93, even though there was an increase in area planted from 6.5 to 6.8 million ha (ICAC, 1994) (Table 1A.2). During the 1994-95 season, the resistant population in other cotton growing areas tended to enlarge. This is likely to have a dramatic effect on the planted area, yield and production until the problem is resolved.

Egypt

Egypt is still the major producer of the finest cotton in the world but production has declined sharply over the past twenty years. Of the nine varieties currently in cultivation, four are extra long staple and five are long staple types. The ELS types are grown exclusively in Lower Egypt while of the LS types, only Giza 75 is grown in both Lower and Middle Egypt. The highest yields have been obtained from the ELS varieties Giza 70 and Giza 76, followed by the LS varieties Giza 77 and Giza 75. The lowest yields are attained from the ELS variety Giza 45, the premier quality variety in Egypt and Giza 31 (Dandara), a hardy LS variety grown in Middle Egypt. Yields are generally higher in the Delta Governorates than in Middle and Upper Egypt. In order to maintain quality standards and prevent mixed bales of lint, the areas and ginneries for each of the nine varieties are clearly demarcated and controlled by government decree.

Until the late 1960s, cotton in rotation with short season berseem clover gave the highest return and was the preferred option. The area planted to cotton remained above 700 thousand ha from 1951 to 1970 (Table 1.2) and production increased from an average of 362 thousand mt during the period 1951-55 to 480 thousand mt during the period 1966-70 (Table 1.3). Yield increased from 489 kg/ha to 675 kg/ha for the same two periods. The cotton area started to decline

in the late 1970s and early 1980s from 685 thousand ha (1.63 million feddans) in 1970 to 521 thousand ha (1.24 million feddans) in 1980 and 353 thousand ha (840 thousand feddans) in 1992 because of farmer disenchantment with the government controlled crop. Cotton's share of the summer cropping area has fallen from 50 percent to only 20 percent. The output of raw cotton fell from 445 thousand mt (8.9 million metric kentars) in 1970 to 300 thousand mt (6.0 million metric kentars) in 1992. During the 1980's, there was a decline in yield which accounted for a considerable amount of the reduced production. However, the situation appears to have turned around with 1993 yields back to the level of the 1970s.

India

Cotton production in India progressed steadily from an average of 543 thousand mt during the period 1946-50 to 2.19 million mt during the period 1991-95 (Table 1.1). The area planted to cotton increased from 5.14 million ha to 7.56 million ha for the same two periods, respectively (Table 1.2). Thus production increased 400 percent while the area planted to cotton increased by only 144 percent. Yield increases from 105.8 kg/ha to 290.1 kg/ha for the two periods, an increase of 274 percent (Table 1.3), accounted for most of the increase in production. The area planted to cotton actually decreased from 7.98 million ha in 1961-62 to 7.54 million ha in 1992-93 but production increased from 739 thousand mt (4.35 mn bales) to 2.04 million mt (12 million bales) for the two years, respectively. The increase in production is largely accounted for by the increase in yield from 106 kg/ha in 1961-62 to 309 kg/ha in 1992-93. Despite this increase, average yields in India for the period 1991-95 are only about 50 percent of the world average and of the countries in the study, only Tanzania has lower yields (Table 1.6). The yield of irrigated cotton in 1992-93 was 570 kg/ha compared to 130 kg/ha for rain-fed cotton. The yield of irrigated cotton is close to the world average of 582 kg/ha for the period 1991-95.

India has experienced problems with pyrethroid resistance, particularly in Andhra Pradesh. The average number of spray applications is 10 but some parts of the Punjab and Haryana are reported to be spraying up to 25 to 35 times. A contributing factor, once again, has been unregulated distribution of registered pesticide products. This has resulted in excessive, indiscriminate use of pyrethroids. All pesticides are supposedly registered but then there is no control on the quality or distribution of products reaching the farmers. The leaf curl virus which has devastated the crop in Pakistan is reported to have found its way into the Punjab in India. The impact of these two problems will become apparent over the next two to three years.

Efforts are being made to contain leaf curl virus in India in the short term by chemical control of whiteflies which are the main vector, identification of resistant genotypes and roguing and destruction of infected cotton plants and weeds. Long term measures proposed include the establishment of a buffer zone along the international border where the only cotton varieties permitted will be Desi cotton, *G. arboreum*, which is more resistant to the virus and a second buffer zone where resistant varieties of *G. hirsutum* will be permitted. It is proposed that the disease should be monitored as a long term undertaking throughout the country. The crops in the buffer zones are to be protected from whiteflies and a ban is proposed on the production of Okra (Bhindi), *Abelmoschus (Hibiscus) esculentus*, a common alternative host of CLCV, between March and June to prevent a build up of the disease and its vector in advance of the season.

Mali

Production in Mali increased from 6,381 mt of seed cotton in 1960 to 319,000 mt in 1992. This translates into an increase from 2,230 mt to 127,000 mt of lint for the same years,

respectively. An increase in ginning outturn (GOT) from 35.0 percent in 1960-61 to 42.3 percent in 1992-93 was an important factor contributing to increased productivity. The area planted to cotton increased from a five year average of 62.6 thousand ha for the period 1966-70 to 213 thousand ha for the period 1991-95. The increase in area was accompanied by an increase in average yields from 198.1 kg/ha to 543.7 kg/ha for the same periods, respectively. Thus the increase in production from an average of 12.4 thousand mt to an average of 115.8 thousand mt for these periods was largely accounted for by the increase in yield (Table 1.6), the average yield for the period 1991-95 being close to the world average (Table 1.3). In order to keep pace with increased production, the ginning capacity increased from 5,100 tons in 1960 to 272,700 tons of seed cotton in 1991. However, this expansion in ginning capacity has not kept pace with the increase in production. By 1992, the seed cotton production of 320 thousand mt exceeded this ginning capacity. The increase in production is largely attributable to the improvement in varieties from Allen 33-57 in 1960 which had a seed cotton yield of 225 kg/ha and produced 6,380 mt of seed cotton, to ISA 205 B, released in 1988/89 and yielding 1,330 kg/ha. Considerable support for the breeding program has been received from the IRCT (now CIRAD CA).

Prior to independence, the CFDT served all the francophone West African countries, providing services in extension, seed production, the procurement and distribution of inputs and marketing. Following independence, each country established its own public limited company. The CMDT continued to provide these services in Mali. The company is being restructured according to World Bank requirements in order to allocate a greater share of the lint value to the growers. This is still in a stage of transition.

Mexico

Cotton production in Mexico increased from a five year mean of 119 thousand mt for the period 1946-50 to 481.4 thousand mt for the period 1966-70. Since then, it has declined to only 86.4 thousand mt for the period 1991-95 (Table 1.1). Yields increased from a five year mean of 299.8 kg/ha for the period 1946-50 to 1030 kg/ha for the period 1986-90. This was followed by a decline to 729.7 kg/ha for the period 1991-95 (Table 1.3). Thus the decline in production was almost entirely due to a decline in the harvested area which had increased from a five year mean of 396 thousand ha for the period 1946-50 to 927 thousand ha for the period 1956-60 but has been in steady decline since then, to 118.4 thousand ha for the period 1991-95 (Table 1.2). The harvested area was 353 thousand ha in 1981-82 and was still 251 thousand ha in 1991-92. Since then, there has been a sharp decline to 40 thousand ha in 1992-93 and only 35 thousand ha in 1993-94. Production was 323 thousand mt in 1981-82 and was still 187 thousand mt in 1991-92 but then it fell to 31 thousand mt in 1992-93 and 2 thousand mt in 1993-94. Exports declined from 173 thousand mt in 1981 to only 4 thousand mt in 1992.

The main reason given for the decline in production is the rising costs without a commensurate increase in price. Subsidies, particularly on maize (corn) have also made other crops more profitable. Cotton production in Mexico is strongly influenced by its proximity to the USA and will come under even stronger influence now that NAFTA and GATT have been approved. The quality of Mexican cotton is too high for lower count yarns produced for coarse fabrics such as denim so mills import lower quality Texas cotton. For this and logistical reasons, a great deal of the Mexican crop is left for export.

Pakistan

The area planted to cotton in Pakistan has increased from an average of 1.22 million ha for the period 1946-50² and increased steadily to 2.85 million ha for the period 1991-95 (Table 1.1). Lint production increased from an average 181.9 thousand mt to 1.86 million mt (1.07 million to 11 million bales of 170 kg) in the corresponding periods. The increase in production was largely due to the increase in yield, from an average of 193 to 653 kg/ha for the two periods, respectively. The increase in acreage arose from an improvement in the availability of water and mechanization while the yield increase arose from improved crop protection and varieties and higher use of fertilizers. The increase in GOT from 32.0 percent in the original varieties to 37.0-40.0 percent in the variety S12, S14 and CIM70 made a significant contribution to the increase in production. Further progress has been hampered by the incidence of the leaf curl virus which caused a serious decline in the yield of the new variety because it proved to be susceptible to the disease. In order to overcome the problem, the old variety, CIM240 which was resistant, was re-issued in 1994. However, the older variety has a lower yield potential and GOT.

The recommended practices to minimize losses caused by the disease include management practices which will ensure vigorous growth to enable plants to outgrow the infection, control of the whitefly vector, the use of systemic insecticidal seed dressings such as Imidacloprid (Gaucho®) to control sucking pests, preventive sprays, weed control to eliminate wild alternative host plants and avoidance of alternative host crops such as okra and cowpeas in proximity to cotton, roguing of diseased plants and crop rotations. Host plant resistance is undoubtedly the prime approach to control of CLCV and this could be aided by biotechnology to develop resistant transgenic plants, provided an appropriate source of resistance is available.

The quality of cotton has made steady progress. The staple length has increased from 22.2 to 23.8mm for the early varieties to 27.0 to 28.6mm for the more recent varieties. Very little cotton is less than 27.0mm and a staple length of 27.8 to 28.6mm is common.

Tanzania

Tanzanian cotton production peaked during the period 1971-75 when it was 71,200 mt. During the 1980s, it declined to only 46,800 mt in 1981-85 but then began to improve to average 71,800 mt. Yields peaked at 266 kg/ha in 1966-70 and then declined to only 138 kg/ha in 1981-85. There has been a slight recovery to 197 kg/ha for the period 1991-95. The main reasons for the decline in production during the 1980s was a shortage of funding for the maintenance of ginneries, a decline in road conditions and general lack of transport to move cotton to the ports and an inability to provide adequate working capital to pay farmers for their produce at the time of delivery. This resulted in a serious backlog in deliveries of seed cotton. The situation was exacerbated by low prices in the mid 1980s which prevented the country from maintaining the infrastructure necessary to handle and gin the crop. The Government of the Netherlands provided aid during the 1980s to restore the transportation system and to rehabilitate the ginning sector. Efforts to restore production during the 1990s have been partially successful but there are serious problems with seed supply and marketing. Privatization of marketing has initially had serious repercussions. Cotton has been moved across variety demarcation lines for ginning, leading to mixed varieties. Tanzanian cotton still gains a premium as roller ginned cotton but the premium for regularity and cleanliness previously enjoyed because it is a hand pick crop with a high de-

² Separation from India occurred in

gree of regularity has been lost. In 1993-94, problems arose because cotton was sold without keeping the TCLSB informed and contracts were made in good faith which could not be filled.

Table 1.6 compares cotton production in the two African countries Mali and Tanzania. Mali has ongoing support in cotton research from CIRAD CA and in adaptive research, extension, marketing and other services from the CMDT which also receives support from the CFDT. Since the demise of the CRC, cotton research in Tanzania has had periodic support from the FAO and from the ODA in the UK but the ongoing program has been handicapped by lack of funding and lack of maintenance of essential laboratory and field equipment. Extension is largely ineffective while the cooperative ginneries and the Lint Marketing Board have had serious financial problems, leading to delays in procurement of the crop, often over several years and inadequate maintenance of ginning equipment. The impact of these differences between the two countries is reflected in the performance of the cotton sector over the past thirty years. Mali has shown steady progress in area planted, yield and production while Tanzania production, area and yield peaked in the 1970s at about the time of the demise of the CRC. All three, production, area and yield, declined during the 1980s but are showing some signs of recovery in the 1990s. The decline can be attributed to the lack of effective research and extension and to the general political and economic conditions which prevailed in the country

Uzbekistan

The area planted to cotton in Uzbekistan has declined steadily from a peak of 2.1 million ha in 1987 to 1.9 million in 1990, 1.7 million in 1991 and just over 1.66 million in 1992. The decline continued in 1993 and 1994 and the area is expected to stabilize at about 1.4 million ha. Reliable earlier data separating Uzbekistan from the other FSU republics are not available.

Prior to the demise of the Soviet Union, cotton production in Uzbekistan was primarily for the Soviet and Eastern Block textile industries. In order to meet the demand, production expanded into marginal areas. Trade was almost entirely barter of cotton for food crops so food production was secondary to cotton. Since the demise of the Soviet Union, Uzbekistan needs to become more self sufficient for staple food products and needs to maintain cotton production through increased yields while eliminating marginal areas from production. This has resulted in the planned decline in the area planted to cotton. However, cotton yields have not shown the expected increase because of lack of inputs due to the shortage of foreign exchange.

Table 1.1: Five Year Average Production of Cotton Lint in Metric Tonnes by Country from 1946 to 1995

M Tonnes	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
USA	2609.4	3068.6	2831.7	3240.1	2306.8	2580.9	2558.6	2590.0	2853.6	3670.2
Brazil	291.6	365.2	327.8	483.4	583.3	599.6	503.3	687.6	735.2	580.2
China	169.8	605.7	1258.5	1180.1	1794.1	2493.4	2183.4	4034.4	3974.1	4719.4
Egypt	311.4	362.5	387.2	445.2	480.1	493.6	419.9	457.6	357.7	328.2
India	543.6	681.7	830.2	1038.4	1056.0	1176.8	1235.9	1422.9	1841.5	2192.8
Pakistan	181.9	263.1	272.6	362.0	493.8	651.1	545.0	751.7	1376.8	1859.8
Mexico	118.7	288.8	440.2	477.3	481.4	376.9	289.1	269.4	211.6	86.4
Cent. Asia	519.9	1255.0	1491.5	1617.7	1995.7	2447.2	2627.1	2676.6	2668.1	2320.0
Other	570.1	985.0	1302.1	1823.8	2266.9	2700.9	2671.7	2678.5	3216.9	3361.2
Non USA	2707.0	4807.0	6310.1	7427.8	9151.2	10939.5	10475.3	12978.8	14381.9	15448.0
Total	5316.4	7875.6	9141.7	10667.9	11458.0	13520.4	13033.9	15568.8	17235.5	19118.2

Source: ICAC World Statistics October 1994

Table 1.2: Five Year Average Areas in Hectares Planted to Cotton by Country from 1946 to 1995.

Hectares	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
USA	8603.7	9252.3	5914.3	6053.0	4240.0	4867.3	4712.2	4412.9	4064.4	4909.4
Brazil	1950.7	1875.9	1748.4	2225.9	2404.0	2402.1	1952.1	2783.7	2446.0	1568.6
China	2347.0	5285.6	5902.4	4451.9	4743.3	4856.6	4678.5	5757.0	5005.9	5995.2
Egypt	552.9	741.5	752.2	735.5	711.7	651.7	537.8	459.5	431.4	379.0
India	5139.8	6651.0	7968.6	7926.2	7816.6	7625.7	7675.0	7798.0	7243.3	7558.6
Pakistan	1224.8	1298.8	1412.6	1416.2	1702.4	1915.5	1906.3	2200.4	2508.8	2849.2
Mexico	395.9	820.8	927.0	821.9	686.2	470.0	314.3	292.0	205.4	118.4
Cent. Asia	1456.2	2385.4	2131.4	2371.1	2467.5	2774.7	3005.1	3208.5	3414.0	2957.0
Other	4603.5	7128.0	7906.7	6807.0	7047.1	7360.0	6992.6	6443.9	6361.0	6510.4
Non USA	17670.9	26187.0	28749.3	26755.7	27578.8	28056.3	27061.7	28943.1	27615.9	27936.4
Total	26274.6	35439.3	34663.6	32808.8	31818.8	32923.6	31773.9	33356.0	31680.3	32845.8

Source: ICAC World Statistics October 1994

Table 1.3: Five Year Average Yield of Lint in Kg/Ha by Country from 1946 to 1995.

Kg/Ha	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
USA	303.3	331.7	478.8	535.3	544.1	530.3	543.0	586.9	702.1	747.6
Brazil	149.5	194.7	187.5	217.1	242.6	249.6	257.8	247.0	300.6	369.9
China	72.4	114.6	213.2	265.1	378.2	513.4	466.7	700.8	793.9	787.2
Egypt	563.3	488.9	514.8	605.3	674.6	757.4	780.7	995.9	829.1	866.0
India	105.8	102.5	104.2	131.0	135.1	154.3	161.0	182.5	254.2	290.1
Pakistan	148.5	202.5	193.0	255.6	290.0	339.9	285.9	341.6	548.8	652.7
Mexico	299.8	351.8	474.8	580.7	701.5	801.9	919.8	922.6	1030.0	729.7
Cent. Asia	357.1	526.1	699.7	682.3	808.8	882.0	874.2	834.2	781.5	784.6
Other	123.8	138.2	164.7	267.9	321.7	367.0	382.1	415.7	505.7	516.3
Non USA	149.1	183.6	219.5	277.6	331.8	382.4	387.1	448.4	520.8	553.0
Total	199.6	222.2	263.7	325.2	360.1	404.2	410.2	466.7	544.0	582.1

Source: ICAC World Statistics October 1994

Table 1.4: Five Year Average Production of Cotton as a Percentage of the World Total

% of Crop	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
USA	49.76	38.96	30.98	30.37	20.13	19.39	19.63	16.64	16.56	19.20
Brazil	5.56	4.64	3.59	4.53	5.09	4.51	3.86	4.42	4.27	3.03
China	3.24	7.69	13.77	11.06	15.66	18.74	16.75	25.91	23.06	24.69
Egypt	5.94	4.60	4.24	4.17	4.19	3.71	3.22	2.94	2.08	1.72
India	10.37	8.66	9.08	9.73	9.22	8.84	9.48	9.14	10.68	11.47
Pakistan	3.47	3.34	2.98	3.39	4.31	4.89	4.18	4.83	7.99	9.73
Mexico	2.26	3.67	4.82	4.47	4.20	2.83	2.22	1.73	1.23	0.45
Cent. Asia	9.92	15.94	16.31	15.16	17.42	18.39	20.16	17.19	15.48	12.14
Other	10.87	12.51	14.24	17.10	19.78	20.29	20.50	17.20	18.66	17.58
Non USA	50.24	61.04	69.02	69.63	79.87	80.61	80.37	83.36	83.44	80.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: ICAC World Statistics October 1994

Table 1.5: Five Year Average Area Planted to Cotton as a Percentage of the World Total

% of Area	1946-50	1951-55	1956-60	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
USA	32.75	26.11	17.06	18.45	13.33	14.78	14.83	13.23	12.83	14.95
Brazil	7.42	5.29	5.04	6.78	7.56	7.30	6.14	8.35	7.72	4.78
China	8.93	14.91	17.03	13.57	14.91	14.75	14.72	17.26	15.80	18.25
Egypt	2.10	2.09	2.17	2.24	2.24	1.98	1.69	1.38	1.36	1.15
India	19.56	18.77	22.99	24.16	24.57	23.16	24.15	23.38	22.86	23.01
Pakistan	4.66	3.66	4.08	4.32	5.35	5.82	6.00	6.60	7.92	8.67
Mexico	1.51	2.32	2.67	2.51	2.16	1.43	0.99	0.88	0.65	0.36
Cent. Asia	5.54	6.73	6.15	7.23	7.75	8.43	9.46	9.62	10.78	9.00
Other	17.52	20.11	22.81	20.75	22.15	22.35	22.01	19.32	20.08	19.82
Non USA	67.25	73.89	82.94	81.55	86.67	85.22	85.17	86.77	87.17	85.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: ICAC World Statistics October 1994

Table 1.6: Production, Hectareage and Yield for Mali and Tanzania - Five Year Averages from 1946 to 1995 (Lint Data)

Year	'000 Metric Tonnes		'000 Hectares		Yield Kg/Ha	
	Mali	Tanzania	Mali	Tanzania	Mali	Tanzania
1946-50		8.0		64.6		123.8
1951-55		12.0		80.8		148.5
1956-60		29.0		147.2		197.0
1961-65	6.0	41.0	N/A	196.0	N/A	209.2
1966-70	12.4	68.2	62.6	256.6	198.1	265.8
1971-75	22.2	71.2	71.6	283.0	310.1	251.6
1976-80	46.0	55.2	105.4	367.8	436.4	150.1
1981-85	47.8	46.8	100.4	339.6	476.1	137.8
1986-90	83.4	58.4	165.2	386.0	504.8	151.3
1991-95	115.8	71.8	213.0	363.8	543.7	197.4

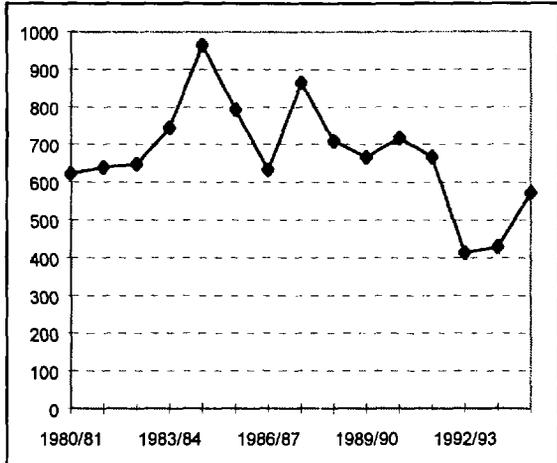
Source: ICAC World Statistics October 1994

Annex 1.1

Cotton Production and Area in the Study Countries

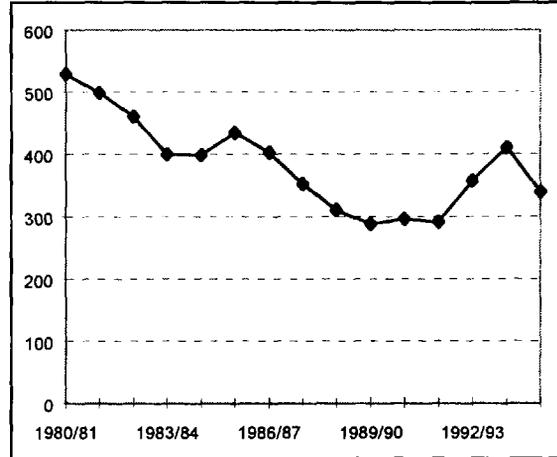


Figure A.1.1: Brazil - Total Cotton Production ('000MT)



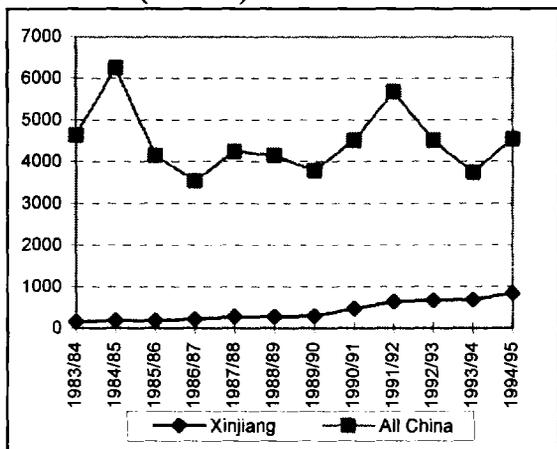
Source: ICAC

Figure A.1.4: Egypt - Total Cotton Production ('000MT)



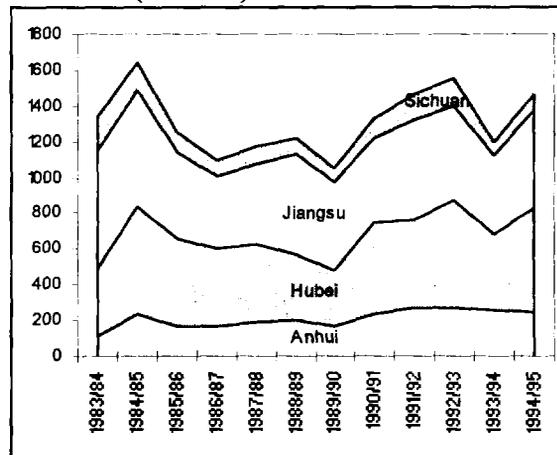
Source: ICAC

Figure A.1.2: China - Total vs. Xinjiang Production ('000MT)



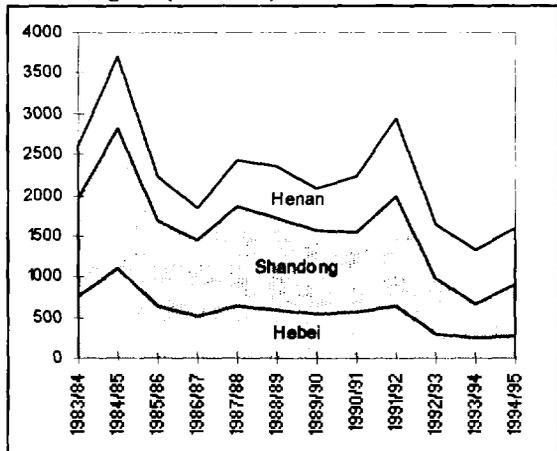
Source: ICAC and China State Statistical Bureau.

Figure A.1.5: China - Production in Central Provinces ('000 MT)



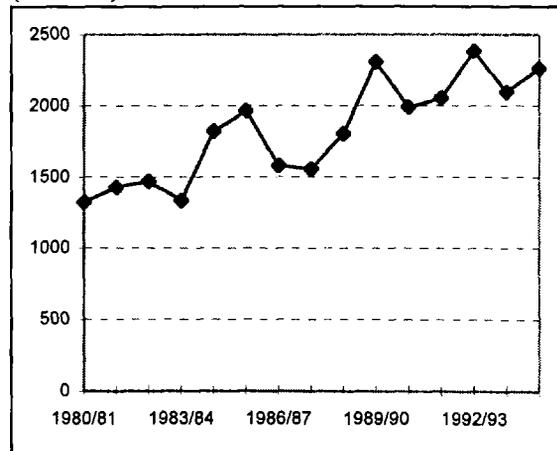
Source: China State Statistical Bureau 1993/94 and 1994/95 data are estimates

Figure A.1.3: China - Production in the Yellow River Region ('000 MT)



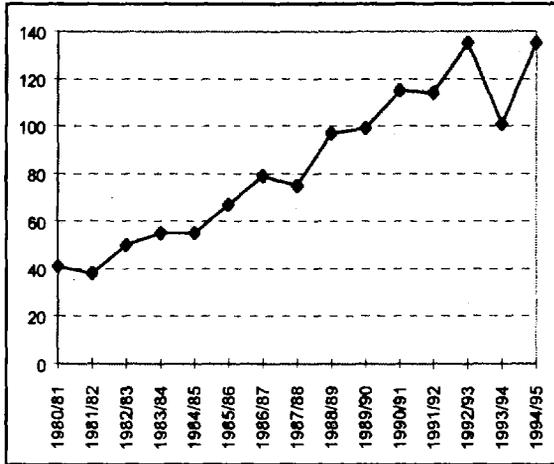
Source: China State Statistical Bureau 1993/94 and 1994/95 data are estimates

Figure A.1.6: India - Total Cotton Production ('000MT)



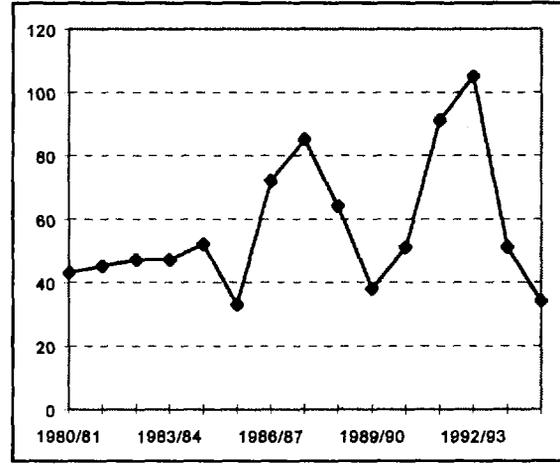
Source: ICAC

Figure A.1.7: Mali - Total Cotton Production ('000MT)



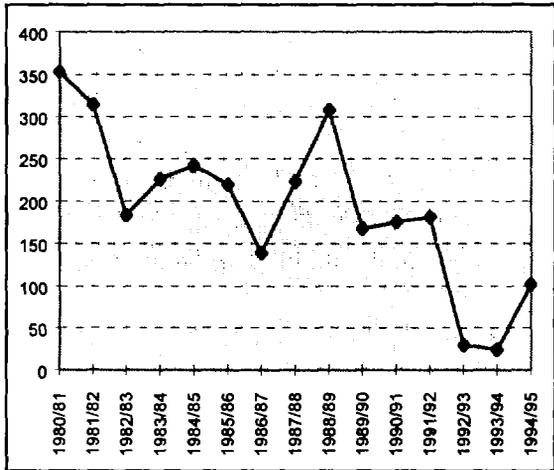
Source: ICAC

Figure A.1.10: Tanzania - Total Cotton Production ('000MT)



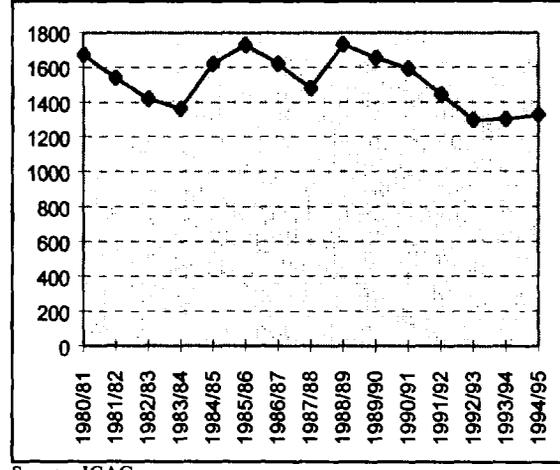
Source: ICAC

Figure A.1.8: Mexico - Total Cotton Production ('000MT)



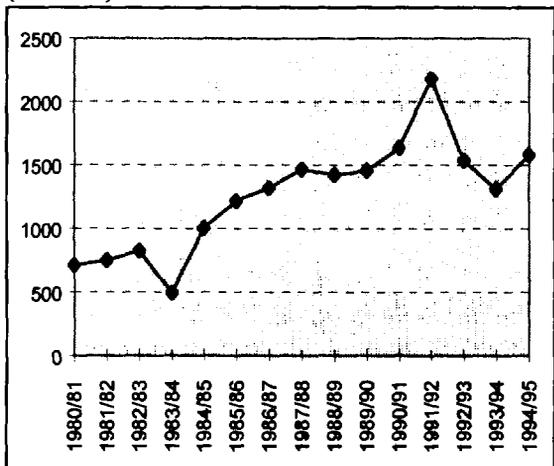
Source: ICAC

Figure A.1.11: Uzbekistan - Total Cotton Production ('000MT)



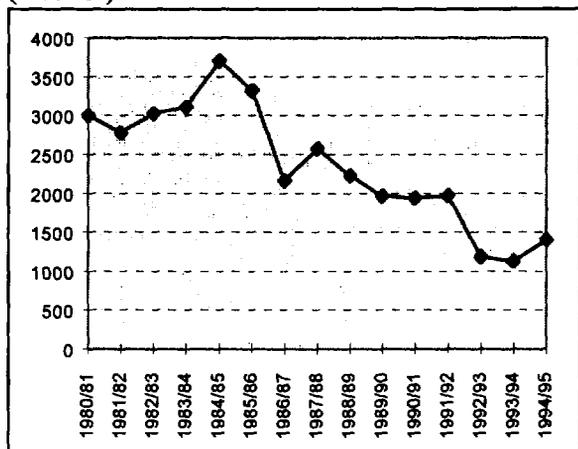
Source: ICAC

Figure A.1.9: Pakistan - Total Cotton Production ('000MT)



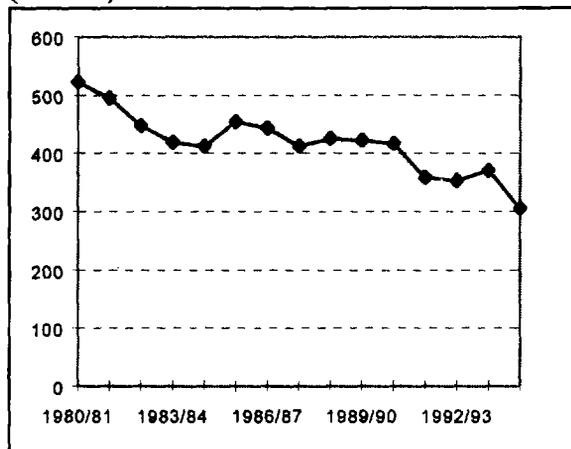
Source: ICAC

Figure A.1.12: Brazil - Total Cotton Area ('000 Ha)



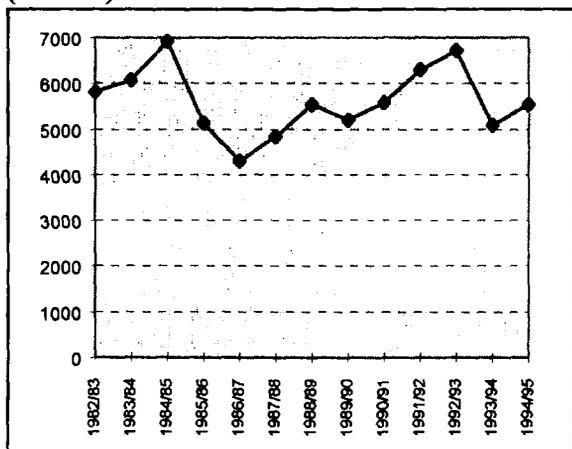
Source: ICAC

Figure A.1.15: Egypt - Total Cotton Area ('000 Ha)



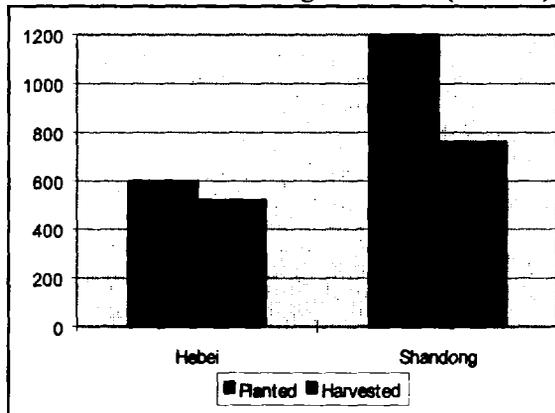
Source: ICAC

Figure A.1.13: China - Total Cotton Area ('000 Ha)



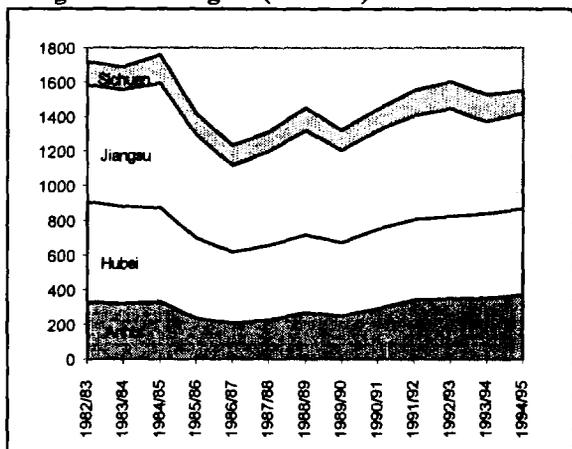
Source: ICAC

Figure A.1.16: China - Planted vs. Harvested Area in Hebei & Shandong in 1993/94 ('000 Ha)



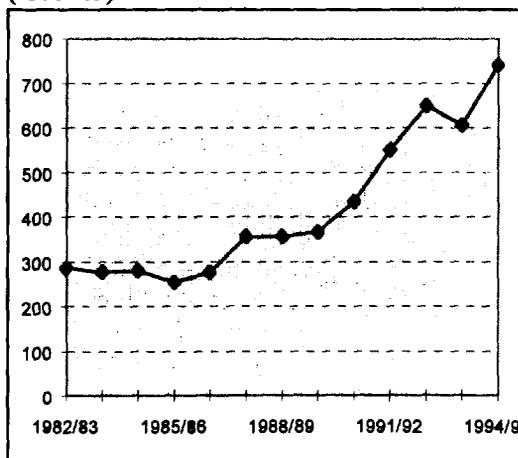
Source: China State Statistical Bureau. 1993/94 and 1994/95 data are estimates.

Figure A.1.14: China - Cotton Area in the Yangtze River Region ('000 Ha)



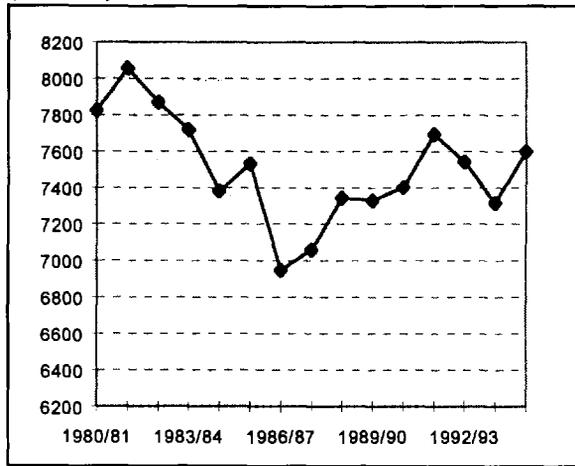
Source: China State Statistical Bureau. 1993/94 and 1994/95 data are estimates.

Figure A.1.17: China - Cotton Area in Xinjiang ('000 Ha)



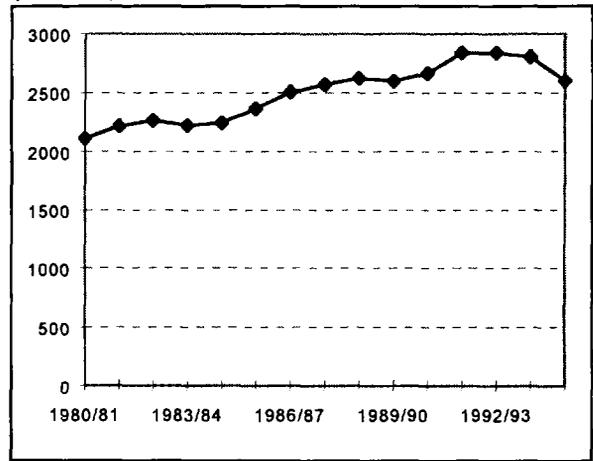
Source: China State Statistical Bureau. 1993/94 and 1994/95 data are estimates.

Figure A.1.18: India - Total Cotton Area ('000 Ha)



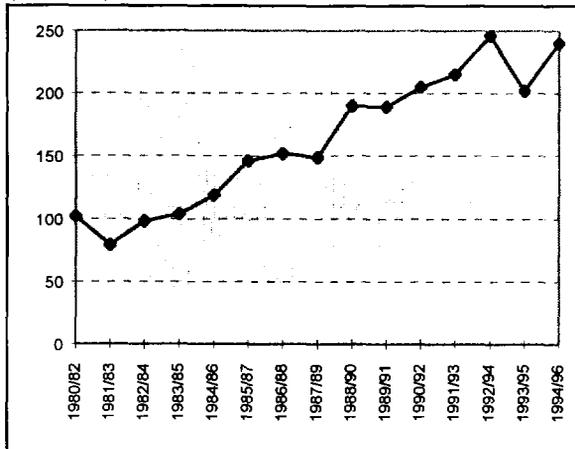
Source: ICAC

Figure A.1.21: Pakistan - Total Cotton Area ('000 Ha)



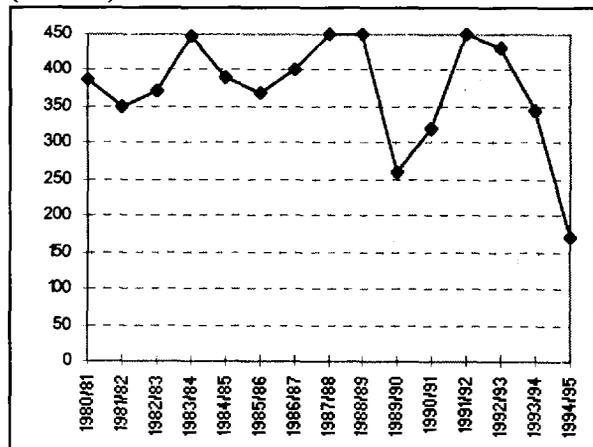
Source: ICAC

Figure A.1.19: Mali - Total Cotton Area ('000 Ha)



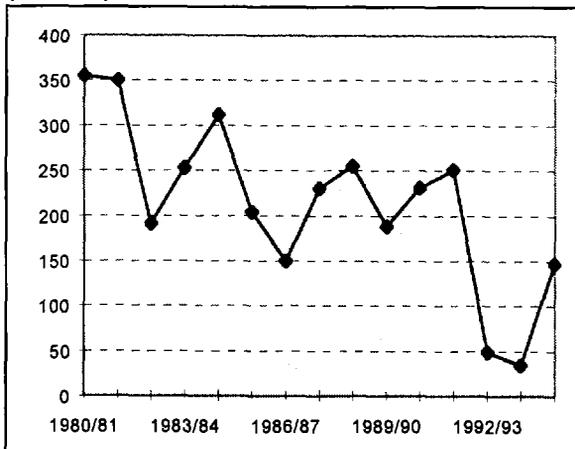
Source: ICAC

Figure A.1.22: Tanzania - Total Cotton Area ('000 Ha)



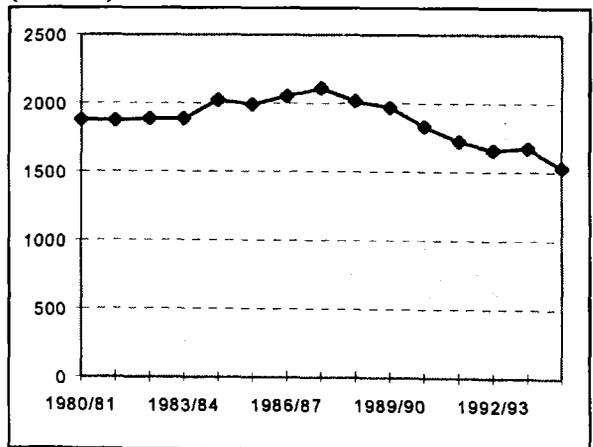
Source: ICAC

Figure A.1.20: Mexico - Total Cotton Area ('000 Ha)



Source: ICAC

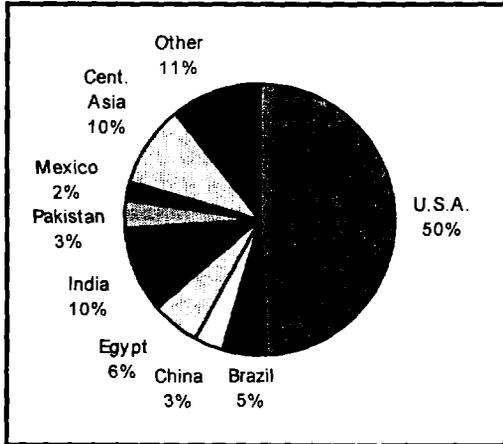
Figure A.1.23: Uzbekistan - Total Cotton Area ('000 Ha)



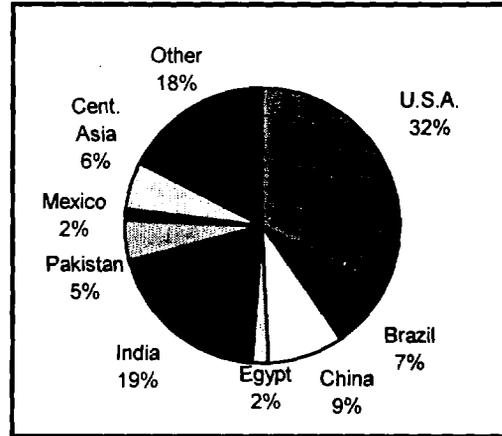
Source: ICAC

Figure A.1.24: World Cotton Production and Hectarage by Country as Percent of the Total Five Year Averages from 1946 to 1995

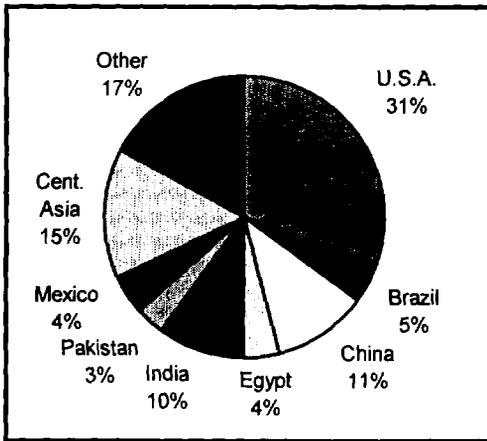
(A) Production Percent 1946 to 1950



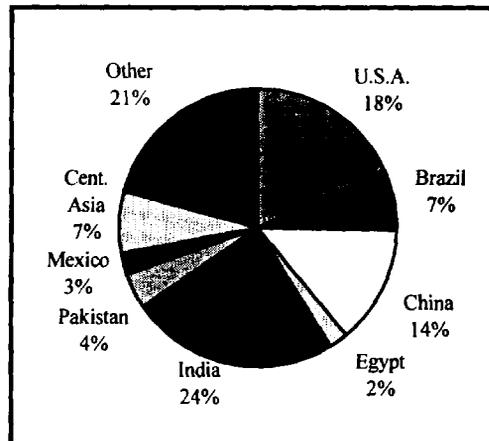
(B) Hectarage Percent 1946 to 1950



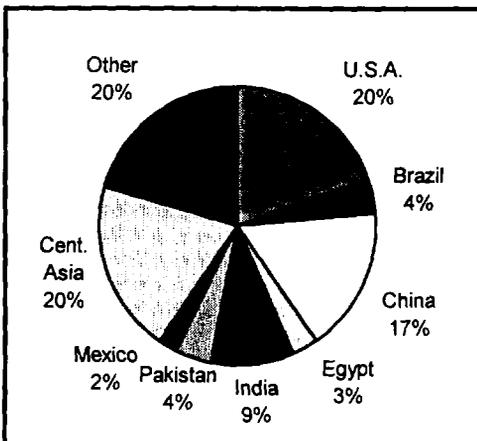
(C) Production Percent 1961 to 1965



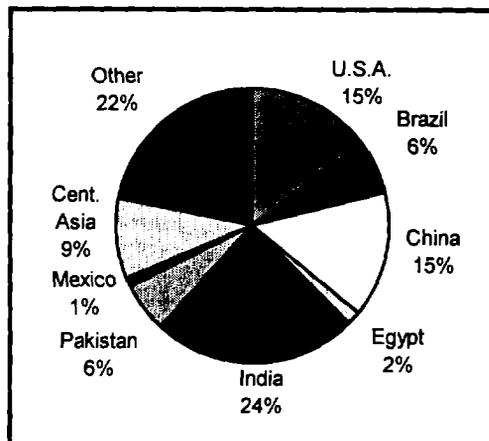
(D) Hectarage Percent 1961 to 1965



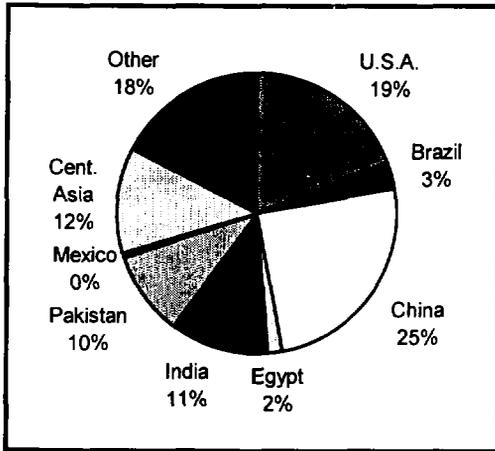
(E) Production Percent 1976 to 1980



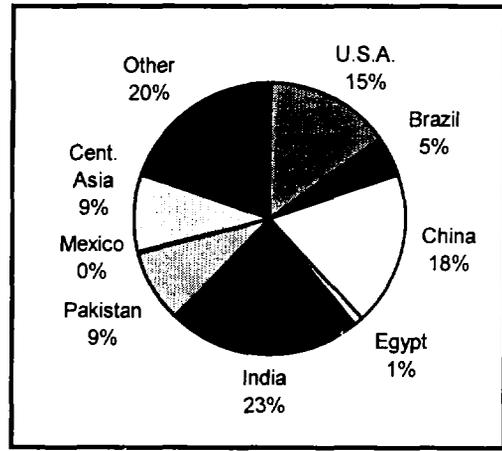
(F) Hectarage Percent 1976 to 1980



(G) Production Percent 1991 to 1995



(H) Hectarage Percent 1991 to 1995



CHAPTER 2

TECHNICAL ISSUES

The Cotton Fiber

The basic fiber type of cotton is determined by the species but considerable genetic variation exists in quality among varieties within species. Varieties of cotton fall into distinctive groups based on fiber properties, within the limitations imposed by the species. However, the environment influences the final quality of cotton lint. Cool night temperatures below 20° C, even as early as flower bud initiation, can have an adverse effect on fiber maturity. Any factor that causes early defoliation or reduces the efficiency of the leaves such as a severe red spider mite infestation or drought will reduce fiber quality. The effect of adverse environmental conditions is far more pronounced on maturity than on other fiber characteristics.

The primary components of yield consist of the number of plants per unit area, the average number of bolls per plant and seeds per boll and the average weight of fiber per seed. The components of fiber weight per seed consist of the average number of fibers per seed, the average fiber length and the average fiber weight per unit of length. However, the weight of fiber per unit of length is determined by fiber fineness and maturity and is thus a component of quality. Thus fiber length, fineness and maturity, are primary components of quality and secondary components of yield. This introduces correlations between components of yield and quality which can hamper selection for any specific improvements in yield, lint percentage or fiber characteristics. Furthermore, any adverse conditions that affect fiber development influence both quality and yield. Fiber strength is not a component of yield but is influenced by fiber structure and maturity and is, therefore, indirectly correlated with yield (Kerr, 1966, 1967).

The main measurements of cotton fiber are length, length uniformity, micronaire and strength. Length and perimeter are negatively correlated and genetically controlled while seed and fiber wall development are influenced more by the environment. The micronaire value combines fineness and maturity but because of the negative correlation between fineness and length, within a variety, the micronaire indicates maturity. Maturity and mechanical, insect or disease damage, influence strength. Thus provided fiber is undamaged, micronaire also indicates strength. These variety specific relationships have been used in cotton classing in Central Asia.

Changing Demand in the Textile Industry

Major changes have occurred in textile technology over the past forty years, leading to changes in the emphasis on fiber quality requirements. Operating speeds have increased many fold and the number of check points where adjustments can be made to correct raw material deficiencies have been reduced. Economic pressures to contain rising manufacturing costs have driven the need for faster, more automated systems in the textile industry. The objective is to manufacture yarns with different diameters and weight per unit length for various end uses (Exhibit 2.1). The actual processes of yarn manufacture - blending, cleaning, carding, drawing, roving and spinning - have changed little over the past 100 years but there have been major changes in processing speed, control technology and package size (Perkins et al., 1984). For ex-

ample, the cards in older systems were independent of other operations and had a capacity of about 5.4 kg. per hour while in modern systems, blending, cleaning and carding have been combined into a single, continuous process and carding rates have increased to 45 kg. per hour or more. Modern machinery can produce higher quality yarn than older systems from similar raw cotton but the higher speeds and changes in spinning technology have changed the emphasis on different fiber parameters and have placed greater demands on the quality of the raw material.

Spinning is the final, most costly part of the conversion of fiber into yarn so it is logical that the main changes in yarn production have been in spinning systems. Two principles of open-end spinning, rotor spinning and friction spinning, were introduced in the early 1970s. This was followed by air-jet spinning and wrap spinning. Cotton fibers are short and require cohesive forces to hold the structure together. In ring and open end spinning systems, cohesion is provided by twisting the yarn structure while yarn is bound together by its own fibers in air-jet spinning and by a continuous filament of man-made fiber in wrap spinning (Price, 1986).

Ring spinning is the most versatile system in commercial use and is capable of producing high quality yarns which vary from coarse yarns for use in products such as household goods and canvas to the finest yarns for use in speciality apparel fabrics, from cottons differing widely in fiber properties (Exhibit 2.1). However, the productivity of ring spindles is limited by the spindle and traveler speed. With this system, the yarn package is rotated through a full revolution to introduce each turn of twist. Rapid rotation consumes a great deal of power and this limits spindle speeds to a maximum of 25,000 rpm (Ishida, 1991). However, with the aid of low machine costs and automation, ring spinning remains the most viable means of producing fine count yarns and is the most efficient way of converting fiber into yarn.

Rotor spinning systems spin clean drawing sliver, bypassing the roving stage. Fibers are teased from the beard offered by the end of the drawing sliver and hurled into an airstream which carries them into the inside of a rapidly spinning cup or rotor where they are distributed in a groove round the perimeter by air currents and centrifugal force. The layers of fiber are continuously twisted together and withdrawn in the form of yarn from the center of the rotor (Perkins, 1984; Price, 1984). Each twist in the yarn requires a full rotation of the rotor and modern machines operate at up to 130,000 rpm. Rotor spinning is expected to account for over fifty percent of all spinning in the USA by the year 2000 with ring spinning accounting for 40 percent and the other ten percent distributed between friction, airjet and wrap spinning (Deussen 1984). The change to rotor spinning has had an important impact on the consumption of cotton by short staple spinners. Otto (1991) estimated that between 1981 and 1989, cotton's share of the short staple market for both ring and rotor spinning increased from 71 to 75 percent and that 75 percent of the cotton consumed by this sector is used for 100 percent cotton yarn.

The development of new spinning technology has changed the emphasis on different fiber parameters. Strength and fineness are important in all yarn production systems but more so in the new spinning processes than in ring spinning. Cleanliness has taken on increased importance both because of its effect on yarn quality and spinning efficiency and because of the abrasive effect of particulate foreign matter on high speed rollers. Little is known about surface friction in cotton but it has importance in air-jet and friction spinning. In order to operate these new systems efficiently and to produce quality yarn, spinners require greater uniformity, less short fiber and higher strength in finer, more mature cotton. Price (1986) pointed out the clear advantages of using finer, mature fibers with improved strength, length and length uniformity since this would give a higher maximum yarn strength with lower twist and also equivalent yarn strength with lower twist, leading to higher productivity. Deussen (1993) pointed out that the

capabilities of the machines often surpass those of the available raw material but Gannaway et al (1995) (Tables 2.5 and 2.6) demonstrated that it is possible to produce varieties with fiber properties that could be spun beyond the limits of present day rotor spinning frames.

Meeting Spinning Mill Requirements

Cotton is an international agricultural commodity, the supply and quality of which are subject to the influence of the environment. The price is subject to the influence of world supply and demand, frequently making it subject to speculation. The real and most quantifiable users of cotton are the spinners, cotton being the primary raw material of the spinning industry. Thus by producing the type of cotton that the spinners want, higher prices can be expected and producers will have no difficulty in marketing their product (Shigeaki Izawa¹; 1994). This has been demonstrated over the past thirty years by Zimbabwe which has developed a high reputation for producing long runs of very regular cotton, leading to a steady market. Box 2.1 summarizes the steps taken to achieve this.

Box 2.1: The Zimbabwe Cotton Industry

Varieties	The Cotton Research Institute, Kadoma breeds all cotton varieties. Breeding program uninterrupted for over sixty years. Annual release of Breeder Seed. Essentially single variety country with clearly demarcated areas and designated ginneries for additional varieties.
Seed Increase	Seed multiplication on a three-year cycle and managed by Cotton Marketing Board (CMB) with supervision by Ministry of Agriculture Seed Services. No seed in cultivation more than three years.
Seed Cotton Price	Base price declared in advance, based on continued reviews against the Liverpool 'A' Index during the delivery period from March to September.
Seed Cotton Grades	Established by consensus between growers and the CMB, based on color, stain and trash. Lower grades based on expected reduction in lint grade due to color/trash.
Farm Packaging	Seed cotton is packed in jute wool packs with cotton twine ties, eliminating a possible source of contamination.
Quality Control	Farmers hand pick the seed cotton and payment is based on the seed cotton grade. It is then classified according to fiber properties and separated into stacks of similar cotton. Stacks are ginned separately, ensuring long runs of regular cotton.
Bale Wrapping	Bales of lint are wrapped in cotton fabric, eliminating a second possible source of contamination and tied with wire ties.

The guiding principles for spinners in purchasing cotton are quality, delivery and price in that order. They desire cotton with high spinnability, delivered as contracted and marketed at a reasonable price. It is often argued that the sole concern of spinners is price and that they do not pay for quality. This argument may hold true for speculators but not for spinners (Ibid. 1994). In the past, producers that produced long runs of regular running cotton such as California,

¹ Chairman of the Raw Cotton Committee, Japan Spinners' Association

Greece, Tanzania, Uganda and Zimbabwe have enjoyed price premiums. This has entailed single variety areas and single variety ginneries to prevent mixed bales and reliability of supply which usually involves some form of risk management. Regularity can be improved still further through pre-ginning selection on the basis of fiber properties. This applies particularly to small-holder cotton which is delivered to the ginnery in small quantities. Free choice of varieties and unregulated marketing may not be in the best interests of the textile industry.

The development of High Volume Instrument Testing equipment in the USA has been necessitated by the fact that in most parts of the cottonbelt, cotton loses varietal identity when it enters the ginnery. It is then necessary to test every bale and to use sophisticated equipment and computer software to select bales with similar fiber characteristics to make up marketable lots. However, the volume of production provides considerable latitude in this process, a luxury that smaller producers do not enjoy (Table 2.1). Note: the top five producers represent less than 10 percent of cotton producing countries but account for nearly 75 percent of the total cotton production.

Table 2.1: Summary of 1993 Cotton Production (thousands)

	Metric Tonnes	Bales (217kg)
China	4,508	20,774
USA	3,531	16,271
India	2,329	10,732
Pakistan	1,559	7,184
Uzbekistan	1,296	5,972
Turkey	574	2,645
13 Countries	100 to 500	460 to 2,304
51 Countries	> 100	> 461
Total	17,970	82,811

HVI testing is universally accepted by the industry and is becoming a requirement, enabling cotton to be marketed more directly on textile mill needs rather than the traditional grade, staple and micronaire. This has contributed to the development and acceptance of high quality varieties. Nonetheless, HVI lines are expensive and difficult to maintain and calibrate. Experienced buyers can anticipate the performance of cotton

through knowledge of the variety and area of production so the merit of introducing HVI testing into minor cotton producing countries would be questionable if the principle of single variety areas and ginneries with pre-ginning quality control, supported by efficient variety improvement, maintenance and seed multiplication, is followed.

The variety determines fiber quality. Fiber length, length uniformity, fineness, maturity and strength determine the spinning potential of cotton from a particular variety, fiber length

Box 2.2: Fiber Quality and Spinning Potential

·length	length of yarn spanned by each fiber; determined by variety.
·length uniformity	yarn uniformity and spinning efficiency; influenced by mechanical handling.
·short fiber	yarn appearance and spinning efficiency; created during ginning and cleaning.
·fineness	number of fibers in cross section of yarn; closely correlated with fiber length and determined by variety.
·maturity	neps ² , regularity and dye ability; strongly influenced by environment.
·strength	more important in open-end and air jet spun yarn; determined by variety but influenced by maturity and fiber damage

² Neps are small tangles of immature cotton which show up in dyed fabric as white spots. Seed coat neps consist of small pieces of seed coat with fibers attached that show up as black specks in the fabric.

being the primary factor that determines the potential end use. The impact of the different components of quality on spinning potential are summarized in Box 2.2. However, cotton is a natural fiber and so variability exists between and within bales, even when the cotton comes from the same variety in the same field and from the same pick. This variability influences yarn properties and spinning efficiency which are directly related to the quality of the cotton being processed. Physical measurements and classification of the cotton are necessary to control variations in processing efficiency and yarn quality. However, a number of bales, varying from five to as many as fifty, are used to make up a specific mill "mix" or laydown and it would be impractical to attempt to obtain bales which are identical in all respects. Commonly, therefore, a number of bales with similar fiber characteristics are blended together in order to keep the average and range of properties constant and to ensure that yarn characteristics are maintained and repeated over a period of time. This calls long runs of regular running cotton to ensure extended periods of trouble free operation and the production of the uniform, regular yarn required by the fabric manufacturers. This cannot be achieved if bales are excessively variable as a result of random mixing of cotton from varieties that differ widely in fiber properties (Table 2.3). Clearly, single variety production areas served by single variety ginneries can best achieve this end but if it necessary to grow more than one variety, at the very least, they must have similar fiber properties.

With the exception of the San Joaquin Valley (SJV) in California, variety development and seed distribution in the USA is handled by private companies, giving most growers a wide choice of varieties. As a single variety area, the SJV built its reputation as a producer of quality cotton. Following the introduction of Breeder's Rights Legislation in the 1960s, private seed companies were given access to this market but with the proviso that in order to maintain the reputation of the area for quality cotton, all registered varieties must meet fiber quality standards. The one variety cotton law in California has been criticized on economic grounds (Constantine et al, 1994). However, this criticism does not take sufficient account of the historical benefits of the legislation to the industry as a whole.

Considerable advances have been made in improving yield and ginning outturn (GOT) of SJV cotton since the private breeders entered the market. This has been attained without loss of the distinctive spinning characteristics of SJV cotton which are unique among US cottons and have also been improved over the past 50 years (Table 2.1 and 2.2) (Bragg et al. 1995). SJV cotton is classified as 28.6mm (1 1/8") compared to 27.8mm (1 3/32") for other California cottons, fitting it ideally into the spinning of fine (40s to 60s) count, combed yarns for high quality cotton fabrics (Exhibit 2.1). Similar progress is being made in developing new Pima varieties for California but again, without losing sight of the importance of quality (Table 2.2 and 2.3).

The data in Tables 2.2 and 2.3 are averages of data from surveys of quality of US cottons from different regions over the period 1990 to 1993. Exhibit 2.1 demonstrates the end uses of cotton from the different types listed in these tables. All varieties were not represented in all years but the data are indicative of varietal differences and of progress being made in variety improvement. Thus HS 26 succeeded Paymaster 145 and shows significant improvements in fiber length and strength. HS 26 has become the variety of choice in under irrigation in the Texas Plains because these improvements render it highly suited to the production of Denim. Similarly, Acala Maxxa and Acala Royale show major improvements in strength over Acala SJ2 and GC 510. The data on Acala Royale also show significant improvements in fineness without any change in Micronaire, reflecting an increase in maturity, thus coming closer to the spinner needs for finer, more mature cotton. Clearly mixing of varieties between types would introduce an unacceptable level of variability but even mixing of varieties within types such as Acala SJ2 with

Acala Maxxa or Acala Royale or of Paymaster 145 with HS 26 would increase variability significantly and could have a negative impact on spinning efficiency unless the varieties concerned have similar fiber properties.

Table 2.2: Yarn Strength of Major US Varieties with Different Spinning Systems and Yarn Counts

Variety	Carded Ring Spun			Carded Rotor Spun			Combed Ring Spun		
	22s	36s	50s	10s	22s	30s	22s	36s	50s
Short Staple Texas/Oklahoma									
PM 145	1885	1679	1497	2123	1812	1648			
PM 200	2511	2302	2128	2435	2092	1891			
HS 26	2285	2041	1840	2346	1970	1768			
Medium Staple South East and Delta									
DPL 20	2112	1927	1731	2178	1847	1659			
DPL 50	2129	1925	1696	2196	1830	1643			
DES 119	2252	2033	1768	2356	1954	1764			
Sv 453	2265	2001	1851	2206	1822	1627			
DPL 51	2333	2177	1936	2265	1956	1696			
DPL 5415	2192	1968	1695	2246	1871	1655			
DPL 90	2307	2115	1847	2399	2057	1838			
Long Staple West (SJV)									
Acala SJ2	2684	2441	2268	2608	2199	1983	3072	2853	2660
GC 510	2961	2786	2630	2731	2407	2190	3357	3157	3056
Acala Maxxa	3057	2787	2706	2781	2376	2113	3416	3140	2999
Acala Royale	2990	2778	2638	2712	2394	2142	3286	3167	2953
Extra Long Staple									
Pima S-6							3977	3656	3454
Pima S-7							4469	3995	3861

Source: USDA ARS Cotton Division Fiber and Processing Tests Survey of Leading Varieties 1990-93

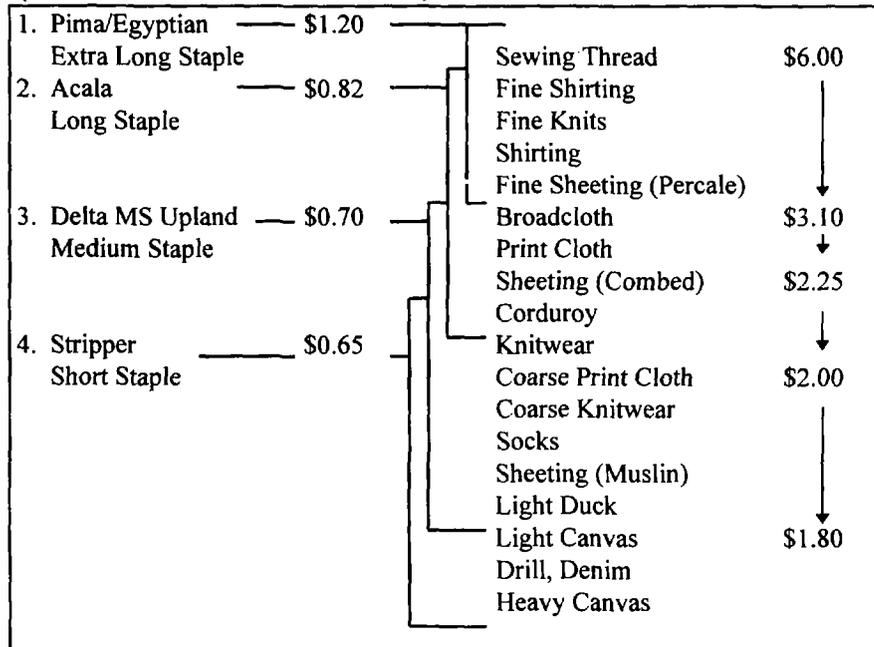
Table 2.3: Fiber Properties of Major US Commercial Cotton Varieties

Variety	UHM	Uniformity	Micronaire	Fineness	Maturity	Strength
	ins.	Index %	Value	Millitex	Ratio	gm/tex
Short Staple Texas/Oklahoma						
PM 145	0.99	79.7	3.7	161.3	0.860	23.9
PM 200	1.08	81.4	3.7	145.7	0.879	28.5
HS 26	1.03	81.4	4.1	175.2	0.899	28.9
Medium Staple South East and Delta						
DPL 20	1.10	82.3	4.1	173.6	0.907	26.8
DPL 50	1.10	82.1	4.4	179.9	0.957	26.7
DES 119	1.10	83.6	4.5	183.0	0.980	26.9
Sv 453	1.12	81.8	4.4	171.0	1.026	29.0
DPL 51	1.13	82.8	4.5	183.5	0.971	28.8
DPL 5415	1.12	81.5	4.3	176.4	0.956	30.0
DPL 90	1.09	82.0	4.4	174.1	0.980	29.2
Long Staple West (SJV)						
Acala SJ2	1.14	83.1	4.2	177.5	0.917	30.2
GC 510	1.13	83.5	4.2	163.9	1.000	29.9
Acala Maxxa	1.14	82.9	4.2	166.0	0.955	32.2
Acala Royale	1.13	83.1	4.3	149.9	1.097	32.9
Extra Long Staple						
Pima S-6	1.31	86.3	4.2	160.2	0.982	37.1
Pima S-7	1.34	86.9	4.0	137.4	1.102	44.5

Source: USDA ARS Cotton Division Fiber and Processing Tests Survey of Leading Varieties 1990-93

Changing production between types according to price signals would be impractical because the price signals are driven by the supply and demand within the type. This could lead to periodic changes, precluding the development of markets based on a reputation for producing a particular quality of cotton. Furthermore, the cotton type is often dictated by the environment and plant breeders need clear-cut objectives if they are to produce improved varieties.

Exhibit 2.1: Relative Values & Use of the Four New World Cotton Types (Prices Based on 1988 US Estimates)



Source: Crill R. (1990):

These data utilize 1988 price estimates. Prices for different quality cottons have changed as a result of supply and demand but the end uses of different fiber types remain valid and the relative values of lint and the yarn they produce are also valid, subject to variation caused by supply and demand.

California currently grows nearly 500,000 ha of cotton, half of which is controlled by 230 of the State's 2,400 growers. The annual production is nearly 650,000 mt (nearly 3,000,000 bales) which is similar to the production of Turkey or Brazil, the sixth and seventh largest producers in the world. One company controls nearly 10 percent of this total, placing it about 27th among the world cotton producing countries. With this scale of production, most growers would have a limited number of varieties and would be likely to plant only one major variety with other varieties included to fit into specific environmental niches such as areas with wilt infestation or a high level of salinity. This is reflected in the distribution of varieties in the San Joaquin Valley where 77 percent of the cotton area is planted to Acala Maxxa, a product of the California Planting Cotton Seed Distributors (CPCSD), with other varieties that are suited to less than ideal conditions or with specific characteristics such as nematode tolerance and/or *Verticillium* wilt resistance that fit them into specific niches, occupying the other 23 percent.

This cannot be compared with the majority of developing countries which have relatively small production, mainly in the hands of smallholders. These countries must decide which cotton type they should produce, a decision that is often dictated by the environment and then

find a market niche by proving their reliability through regularity of supply and consistency of quality within the specific cotton type. In order to achieve this, they need to produce the highest possible quality within this type and to keep variability to a minimum. This often calls for a trade off between quality and yield.

Quality Improvements and Variety Development

The requirements for developing high quality varieties include (Meredith, 1991):

1. Well defined breeding objectives;
2. Adequate genetic variability;
3. Appropriate instrumentation and evaluation methods;
4. Price incentives;
5. Time: 10 years from start to finish.

Breeding objectives usually include yield, lint percent and quality. Earliness and host plant resistance are often included. Disease resistance and salt and drought tolerance depend on the local requirements.

Several programs aim at improving the value of cottonseed by including glandlessness as a selection criterion. The seed of glandless or gossypol free cotton produces food quality protein with minimal processing but glandless plants are more susceptible to insect pests. Efforts are being made to develop varieties with normal, glanded vegetation but glandless seed through inter-specific hybridization.

Box 2.3: Consequences of Selection for Individual Criteria

Selection for: yield alone	Consequence: decreased fiber length; increased coarseness.
lint percent alone	increased coarseness; decreased length; decreased seed weight.
fiber length alone	decreased yield; decreased lint percent.
fiber strength alone	decreased yield; decreased lint percent.
Concomitant Selection: yield and quality	Consequence: slow improvement in both.

Increasing interest is being shown in naturally colored cotton. Cotton varieties with various shades of brown and green were available from genetic stocks and have been improved for commercial production but so far, this is a fairly small market.

Progress in variety improvement is conditioned by the relationships between the components of yield and quality and the correlations between length and fineness and between strength and yield (Box 2.3). Recently developed breeding lines in Texas have excellent quality but they are unsuitable for production because of low yields (Table 2.4). One line in particular which has fine, mature fiber with excellent spinnability is so loose in the open boll that it is almost impossible to pick before it falls to the ground (Gannaway et al, 1995). Despite these difficulties, cotton quality has improved steadily as a result of prolonged, concomitant selection for yield and quality. Improved instrumentation to measure fiber properties and spinning performance has contributed to this improvement and to greater efforts by plant breeders, growers and ginners to respond to textile industry quality needs.

Biotechnology

Genetically engineered cotton is likely to play an increasingly important role in cotton improvement over the next decade. However, the implementation of this technology in developing countries faces a number of technical, economic and legal problems.

The International Service for the Acquisition of Agri-biotech Applications (ISAAA) was incorporated in 1991 with the objective of facilitating the acquisition and transfer of agricultural biotechnology to developing countries in order to assist them in the implementation of a more sustainable agriculture that will provide more food and a safer environment. Their projects concentrate on non-commercial food crops grown by poor farmers, crops such as cotton which are not covered by CGIAR/IARCs programs and tropical tree species that have an impact on biodiversity in natural and managed forests, concentrating on near-term applications that have had proven success in developed countries (Altman and James, 1993).

Technical Implications

The main lines of research being followed are the development of insect and/or herbicide resistant, genetically transformed varieties. Several varieties are being increased in the USA, pending registration which carry the Bt gene from *Bacillus thuringiensis*, rendering them toxic to Lepidopterous insects. Good results have been obtained with these varieties in minimizing the damage caused by cotton bollworm, *Helicoverpa zea*, tobacco budworm, *Heliothis virescens* and pink bollworm, *Pectinophora gossypiella* (Herzog, 1995). Varieties are available with tolerance to Glyphosate (Roundup) and to Bromoxynil (Buctril) and varieties with tolerance to sulfonylurea based herbicides (Grooms, 1992) are likely to be available in the USA within the next few years. These varieties make it possible to use over-the-top applications of a wider range of herbicides which were previously unavailable for cotton to control persistent weeds (Wilcut, 1995).

Currently, additional Bt genes are being added or 'Pyramided' to increase the number of endotoxins produced by the plant in order to delay the development of Bt resistant insect populations. These varieties with improved resistance are in an advanced stage of development and are expected to be released during the next few years. It is unlikely that herbicide resistant varieties will play any role in countries that rely mainly on mechanical and hand cultivation for weed control but Bt cotton could play an important role in cotton production in many countries, particularly those with pyrethroid resistant *Heliothis/Helicoverpa* populations, provided the technical and financial and legal problems associated with these varieties can be resolved.

Financial Implications

Financial returns from the development and introduction of transgenic cotton would be expected by (Meredith, 1995):

1. the originating company;
2. the plant breeders who develop adapted commercial varieties from the Bt cotton breeding lines;
3. the organization responsible for seed multiplication;
4. the organization responsible for seed distribution.

Ultimately these costs would come into the cost of seed to the grower. How this could be accomplished in developing countries remains a difficult question.

In the USA, Monsanto, the developers of Bt cotton, has proposed that growers pay a registration fee of \$30 per acre. A certificate would then be issued for the purchase of the appropriate quantity of seed from the seed dealer to plant the registered area. Safeguards would be necessary in the event of replanting and to ensure that growers do not retain their own seed for the following year. Under this proposal, in developing crop budgets, the cost of seed would become a fixed cost and no longer a variable cost. Thus in addition to training the players in the pesticide industry, the seed companies, the research institutes, extension agents, the crop consultants (where applicable) and growers in the complexities of growing Bt cotton, it would also be necessary to train the bankers who provide the growers with credit.

Legal Implications

The biotechnology company Agreetus of Middleton, Wisconsin, U.S.A. won the exclusive US rights to all genetically engineered cotton. Monsanto and Calgene, the two major companies working on transgenic cotton, have struck deals with Agreetus. There are concerns that academics will not work on genetic engineering in cotton for fear of transgressing this broad patent (Mestel, 1994). These patents could have a negative impact on crop improvement in future and could lead to worldwide monopolies. The USDA and a competitor of Agreetus have challenged the cotton patent. The patent office has accepted the USDA point of view but the patent remains valid and Agreetus has the right to respond to the patent office. The matter could take two to three years to resolve.

Integrated Crop Management

The period from seeding to the onset of flowering is critical in successful cotton production. Field performance, whether successful or disappointing, can usually be traced back to events or circumstances encountered earlier in the year. If the yield potential has been reduced by late planting, poor weed control, delayed thinning, inadequate fertility or any other cause, pesticide use in any form during the later stages of crop development will have little effect. No matter how effective integrated pest management may be, it will not enhance the yield of a poorly growing crop.

Successful crop establishment necessitates the use of high quality planting seed. Weed competition during the early stages of crop development can cause significant yield reductions. However, excessively high plant populations resulting from excessive seeding rates can have the same effect as weed competition. Furthermore, the act of thinning causes disturbance to the root system of the plants left behind, leading to seedling shock and retarded seedling development. Timely planting, weeding and thinning are essential components of integrated crop management but they are often not achieved because of competition for labor at this critical period.

Setting the fruiting positions on the lower sympodia has the effect of containing vegetative plant development by channeling plant energy into fruit production rather than vegetative growth. This leads to a more open canopy and better light penetration, resulting in better boll retention and reduced losses through boll rots. Good early crop retention shortens the boll setting period and thus the maturity period of the crop without loss of yield, simultaneously reducing the late season exposure to insect pest attack. However, techniques are needed to protect the early fruiting positions without disrupting IPM strategies that call for the conservation of natural enemies of the major cotton pests. Recently developed insecticidal seed dressings may provide the necessary protection against sucking pests and the augmentation of populations of natural

enemies of Lepidopterous insects such as practiced in Uzbekistan is worthy of consideration and further study.

Techniques have been developed to monitor crop development as an aid to crop management. This involves plant mapping to determine the vigor of the plant and how the crop is being set. The ratio of plant height to node number indicates if the plant is growing too vigorously or not vigorously enough. Such factors as the node number of the fruiting branch carrying a white flower on the first fruiting position at a particular stage of crop development, the fruit set below and the number of nodes above this position are indicative of the earliness of the crop and the potential yield. Monitoring is often supported by foliar chemical analysis to determine the nutrient needs of the plant. This information can be used in deciding on the application of additional fertilizer or growth regulator and the justified for continued crop protection.

Early season crop losses may occur as a result of poor crop development, early season insect infestations or adverse climatic conditions. In Syria, Pakistan and the Indian Punjab, high temperatures early in the season cause serious fruit shedding. China follows a practice of pruning off the early fruiting bodies to divert the plant energy to the crop in the middle and upper canopy. High thrips populations frequently destroy terminal buds, disorganizing normal crop development and causing shedding of the early flower buds resulting in a bushy crop and delayed production of fruiting bodies. In sub tropical areas, jassids may cause serious damage to leaves and may even kill plants, dramatically reducing seedling development and leading to reduced yield and quality.

These conditions can be detected and identified through routine monitoring of crop development. However, none of the country reports make any mention of crop monitoring. These techniques are widely applied in countries such as the USA and Australia but their adaptation to countries where most cotton is produced by smallholders would entail serious logistical problems and would probably necessitate a regional rather than a farm by farm approach.

Most cotton varieties have the ability to compensate for early crop loss by producing new growth and new flower flushes later on, provided moisture and fertilizers are available. Thus farmers are often not concerned about early season crop loss and may not even be aware of losses caused by weeds or nematodes. However, the consequence of early season shedding is vegetative plants with virtually no bottom crop, the crop being produced mainly on the top canopy. This has two important implications:

- The bottom and middle plant fruiting bodies are frequently protected even if they are likely to shed due to poor light penetration and unfavorable micro-climatic conditions in the canopy of excessively vegetative plants;
- The top crop is very difficult to protect late in the season in a bushy canopy, placing the crop at risk due to poorly controlled late season insect attacks. Moreover the development of sucking pests is encouraged by late season vegetative growth, resulting in the risk of lint quality losses.

The interest for the farmers would be best served by producing an early crop, avoiding a protracted cropping period to reduce late season risks and assure a manageable plant structure. Many cases of insecticide resistance could have been avoided if correct plant management had been practiced. Attempts to maximize production sometimes leads to major problems and ultimately, to economic losses.

IPM is only effective on well managed, healthy crops. Integrated Crop Management incorporates all aspects of crop production and protection and is essential for successful crop production, leading to good returns on investment in a sustainable agricultural environment.

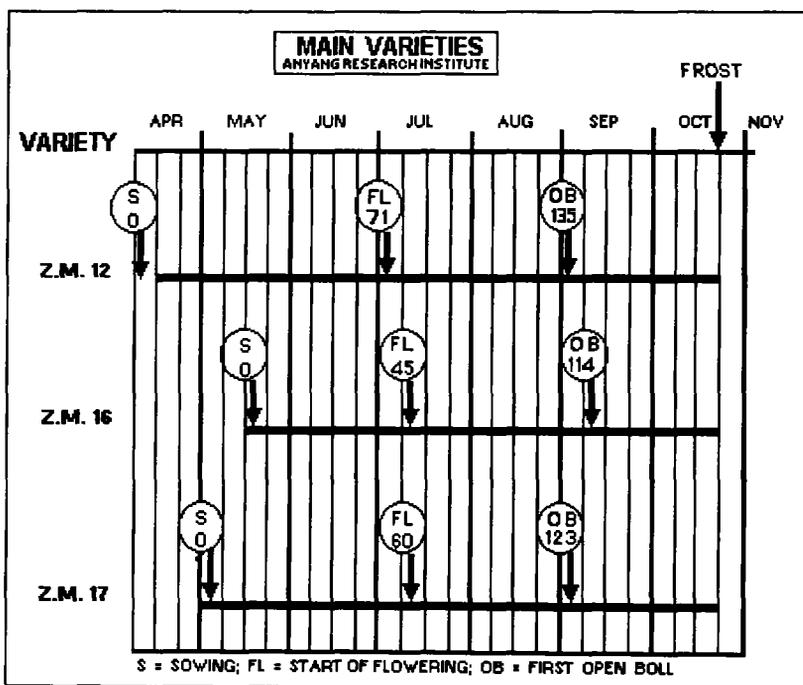
Variety Improvement in the Study Countries

All nine study countries have government run plant breeding programs. In addition, India has a strong private breeding sector producing hybrid varieties which account for about 29 % of the total cotton planting seed. Government programs may be run by the Central Government, the Provincial or State governments or both. In order to be effective, all breeding programs require fiber and spinning test facilities and efficient means of field testing new breeding lines and varieties under the full range of environmental conditions that cotton encounters in the country concerned. The final variety selection and registration should take into account the needs of the growers, the ginners and the spinners. This generally involves some form of Variety Registration Committee which represents all these sectors and is enabled to accept or reject a new variety on the basis of its performance in area wide trials over a minimum of three years.

The breeding objectives of the countries in the cotton study all include higher yields, quality and lint percentage. The development of open end spinning which has been replacing ring spinning in an increasingly large segment of the spinning industry has resulted in greater emphasis being placed on fiber strength as a specific selection criterion. Other changes in textile technology have necessitated greater importance being attached to fiber length uniformity, fineness and maturity without loss of other attributes such as length and yield.

Early maturity is important but for different reasons in different countries. In Egypt, India and China, earliness is necessary to permit a second crop in the rotation while in Uzbekistan, it is necessary to fit the crop into a relatively short season. Earliness is also of importance in reducing the exposure of the crop to the depredations of insect pests by escaping the late season generation of harmful pests. Other objectives vary according to local conditions but may include host plant resistance to certain diseases and insect pests, and tolerance to drought, salinity

Exhibit 2.2: Differences in the Rate of Development of Chinese Cotton Varieties



early frost etc. However, earliness may result from improving the photosynthetic efficiency of the plant, leading to the onset of flowering with fewer heat units and/or to improved boll retention. The latter is a product of both variety and management. It is unlikely that any major short-

ening of the period of boll maturation from bloom to boll burst will be achieved without a serious reduction in quality and yield. Exhibit 2.2 demonstrates the differences in the period from sowing to the onset of flowering in different varieties in China.

Brazil

The main objectives in the breeding programs of both Meridian and Sentrional regions of Brazil are to improve yields in well adapted varieties which incorporate resistance to the main diseases and pests and have fiber characteristics which meet the needs of the domestic textile industry. The boll weevil, *Anthonomus grandis*, has become a major limiting factor in the Sentrional Region and is also present in the Meridian region. Early maturity has become increasingly important to escape some of the ravages of this pest. Being in or near the centers of origin of both the New World cotton species, Brazil has a wealth of genetic resources for incorporation in the breeding program. The utilization of wild races of *Gossypium* is an important aspect of the program.

The main breeding program in Meridian region is at the Instituto Agronomico do Campinas (IAC) in São Paulo. The variety IAC 20 is the only one in the region and is also grown in parts of the Sentrional region. A new variety with superior fiber characteristics has just been released. The main breeding station for the Sentrional region which works on both arboreal and herbaceous cotton and is located in Campina Grande, Pernambuco, is run by the national research organization EMBRAPA. In addition, the Paraná cotton cooperative OCEPAR has a cooperative variety development agreement with the French organization CIRAD CA.

China

The Chinese Academy of Agricultural Science Cotton Research Institute at Anyang, Henan Province, coordinates the breeding activities of 38 cotton research units throughout China with the objective of developing high yielding, high quality, multiple adversity resistant varieties. After two five year plans, the varieties Zhongmian 12, Zhongmian 16, Sumian 2, Zhongmian 17 and Yumian 4 have been released. The fiber strength of these varieties has been improved significantly to meet the needs of the spinning industry. In addition, resistance to *Fusarium* wilt and *Verticillium* wilt have been combined and the yield potential and level of wilt resistance have been improved to compare favorably with international standards. New varieties cover 85 percent of the cotton area of China. The fiber strength of a new long staple has been significantly improved. A newly developed low gossypol (glandless) variety has insect tolerance, yield and quality comparable to conventional varieties.

Earliness is crucial in the Yellow River valley to fit cotton into a cotton-wheat double cropping system to meet the demand for increased production of both crops. The growing period aimed for is 100 to 120 days and the varieties should be suitable for relay cropping with wheat when sown either in the spring or the summer. In the Yangtze River Valley, the target is a growing period of 110 to 135 days and suitable for growing in either monoculture or relay cropped with wheat. In Xinjiang, the emphasis is on spring sown, monocultured, short season upland and long staple cotton. Other objectives include drought and salinity tolerant cotton, low gossypol cotton and hybrid cotton. The work on hybrid cotton incorporates both cytoplasmic and nuclear male sterility and has produced high yielding combinations from a set of three parent lines. Molecular biology or genetic engineering has been added to the breeding program.

Egypt

The cotton breeding program in Egypt is located at the Cotton Research Institute in Giza. This is supported by a cotton research stations at Kafr el Sheikh in the lower Delta and at Sids in Middle Egypt. A Genetic Engineering Research Institute has been established to work on the development of transgenic cotton varieties. Initially, this will concentrate on the development of *Gossypium barbadense* types carrying the Bt gene from *Bacillus thuringiensis* which produces endotoxins against Lepidopterous insects.

The main objectives of the breeding program are to maintain the original quality and yield characteristics of commercial varieties and to develop new varieties with improved quality and yield and with resistance to *Fusarium oxysporum* and tolerances to the stress of heat, salinity and waterlogging. New varieties are not released unless they show significant improvement on an existing variety. The cotton producing areas of Egypt have been categorized according to soils and climate and clearly demarcated into variety zones. The ELS varieties longer than 35 mm ($> 1 \frac{3}{8}$ "") are grown in the governorates closest to the Mediterranean Sea, the LS varieties longer than 32 mm ($> 1 \frac{1}{4}$ "") in the rest of the Delta and the hardest varieties in Middle and Upper Egypt, as shown in Table 2.4. Consideration is being given to the introduction of upland varieties for production in upper Egypt, specifically to supply the domestic mills with medium staple cotton.

In Governorates that have more than one variety, the areas for each are clearly demarcated and the cotton from each variety can only be ginned at designated, single variety ginneries. The preservation of Egypt's reputation for quality cotton depends on the maintenance of the single variety zone and single variety ginnery system to prevent mixed bales of lint. This has to be taken into account during the process of privatizing ginning and marketing in Egypt.

India

Indian cotton production is strongly influenced by variations in monsoonal activity to the point where the very nature of the extremes (of rainfall) are said to have engendered an almost fatalistic approach. Consequently, there is a tendency to accept the irrelevancies of averages on their face value and to concentrate research efforts on more tangible lines of work, mainly in the field of genetics and crop improvement (Bell and Gillham, 1989).

Being the original home of the Asiatic cottons, India has a wealth of genetic resources. The national gene bank is located at the Central Institute for Cotton Research, Nagpur and holds 4,005 accessions of *G. hirsutum*, 390 of *G. barbadense*, 1,701 of *G. arboreum* and 400 of *G. herbaceum* in addition to 24 wild species and 400 perennials. This material is used in the breeding program to improve specific characteristics of commercial cotton varieties, particularly related to adversity resistance and the development of hybrid cotton varieties. Genetic and cytoplasmic male sterility from the American variety Gregg and the D genome species *G. hark-*

Table 2.4: Distribution of Egyptian Varieties

ELS Types	
Giza 45	Damietta
Giza 70 (Isis)	Baheira
Giza 76	Baheira
Giza 77	Kafr el Sheikh; Gharbiya
LS Types	
Giza 75 (Lotus)	Menufia; Dakahliya; Gharbiya; Sharqiya; Beheira; Qaylubiya; Al-Fayum
Giza 80	Beni Suef; Al-Minya
Giza 81	Sharqiya
Giza 83	Asyut
Giza 31 (Dandara)	Asyut; Sohag

nessii are being exploited in new hybrids. Wild Australian species *G. australe*, *G. sturtianum* and *G. bickii* are being used to introduce delayed morphogenesis of gossypol in the embryo, leading to a normally glanded plant with glandless (gossypol free) seed in order to improve the quality and utilization of cottonseed byproducts. Other important characteristics being studied include resistance to bacterial blight, jassid and whitefly, storm resistant bolls and increased boll size. The program also utilizes this material to develop more compact, early maturing varieties with naked seed to improve oil recovery and improved fiber strength.

The breeding program is divided between the three production zones, each zone having its own breeding objectives which are determined by the zonal agro-climatic and other parameters applicable to cotton farming in that zone. The general objectives include improvements in quality, in yield through improved photosynthetic efficiency, leading to an increase in biomass but with a higher harvest index, giving a more fruitful, less vegetative plant, in yield stabilization through adversity resistance, and in increased farm income through a reduction in the duration of the crop (early maturity) and a higher Ginning Outturn (GOT) to give a higher lint return for the same seed cotton yield. The program also aims to improve the oil and protein content of the seed to increase the value of the byproducts.

The report on India discusses the possibilities of utilizing biotechnology in the future but does not indicate the current involvement of India in this field of research.

Mali

The variety which was mostly spread at the beginning of this century was the *Gossypium hirsutum* race *punctatum* which had supplanted the old-established Asiatic cottons, *G. herbaceum* var. *africanum*, right across Africa south of the Sahara. This was replaced by the upland variety Allen in 1920 which was subsequently replaced by a natural hybrid variety discovered in Mali, known as N'kourala. During the 1940s, the first varieties selected by IRCT (now CIRAD CA) developed at their stations in Bouaké, Cote-d'Ivoire, Bambari, Central African Republic and Bebedja, Chad were introduced to replace N'kourala. The Ntarla experimental station, near Koutiala was used to test these varieties. Re-selections of the Nkourala and Allen were cultivated till 1965 when BJA 592 was introduced, followed by BJA 592-SM67 in 1974. These were replaced in 1980 by the B163, from the Central African Republic. The most recent varieties cultivated throughout Mali are ISA205 with different reselections, ISA205B and ISA205G. Some new varieties are being disseminated, including STAMF and STAM 42 from Togo, GL 7, a glandless (gossypol free) variety from Cote d'Ivoire and NTA 88-6 developed in Mali). Clearly, CIRAD CA and the neighbouring francophone countries of West Africa are cooperating with Mali plant breeders and are playing a major role in variety improvement.

The variety selection is organized around two major objectives, adaptation to Mali conditions and high GOT with good fiber quality and a low incidence of neps. The introduced varieties are established varieties which are maintained and increased in Mali, with close attention to isolation standards and the removal of off-types. A progeny row breeding system is followed on both normal and glandless varieties. The latter are currently of less importance than the normal varieties but they could increase in importance because of the increased value of their seed as a source of human food.

CIRAD CA provides technical support for cotton research in francophone West Africa and most of the genetic resources come from its affiliated stations. So far, this does not include integration of biotechnology in the research program.

The contribution of variety improvement to the profitability of cotton is difficult to separate from the contributions of improved cultivation techniques, fertilization, crop protection, etc. However, significant progress has been made in increasing lint yield through increased GOT to over 40.0 percent and there have also been major improvements in the intrinsic quality of cotton fiber. These improvements have raised the returns to the growers without the extension input necessary to improve cultural practices and crop protection.

Mexico

The objectives of the breeding program are to develop varieties which are adapted to local conditions and which have a high potential for yield, quality and fiber percentage. Considerable progress has been made in developing new varieties with high quality and yield potential. However, at best, they were only planted on about 4,000 hectares, American varieties being favored by the growers and the merchants. The reason for this is not clear but promotion and the prestige of the well known seed companies certainly influences farmers' decisions. Locally bred varieties are only marketed through government channels. New varieties released by the research station in Obregón, Sonora have out-yielded the check variety Deltapine 80 and have superior strength (Hernández-Jasso and Pérez-Solis, 1993; Cruz-Medina and Hernández-Jasso, 1994). New varieties developed by the research station in Torreón, Laguna also out-yielded Deltapine 80 and had superior fiber quality in trials reported in 1994 (Palomo and Godoy). In addition, they are early maturing and have tolerance to *Verticillium* wilt.

Cotton could make some degree of a come-back as subsidies on prices for competing crops, notably maize, are removed. However, currently it is grown on a limited scale and since imported varieties find favor with the growers and local cotton breeders are in such close proximity to their competitors in the USA, the future of a domestic breeding program is questionable.

Pakistan

Plant breeding in Pakistan is carried out at the federal level at the Cotton Research Institutes of the Pakistan Central Cotton Committee (PCCC) at Multan and Sakrand and at the provincial level at the research stations in Faisalabad, Multan and Tandojam. The main objectives are quality and yield improvement, early maturity, a sympodial habit, heat tolerance, particularly in the Punjab, and resistance to the jassid, *Amrasca* spp. Emphasis has been placed on fiber length in improving fiber quality. Fiber strength of Pakistan cotton has never been a problem and was not considered in the selection process. In the last decade, however, changes in textile technology have accentuated the importance of the micronaire values and fiber strength and greater attention is now being paid to these characteristics in the breeding program.

The original variety, 4F, was a short staple, monopodial, late maturing variety with a GOT of about 32.0 percent. Breeding lines with greater heat tolerance have been developed, the maturity period has been shortened by about 14 days and with the increase in early boll set, the plant structure has been modified to give a shorter, sympodial habit. Significant progress has also been made in improving fiber quality and GOT. The staple length of the latest commercial varieties is around 28.6 mm (1 3/32") and the GOT 40.0 percent.

At one time, root rot was a serious problem but this has been overcome through rotation with berseem clover. In wet years, bacterial blight, *Xanthomonas malvacearum*, can be a problem and resistant varieties have been developed. However, the introduction of acid delinting for planting seed has largely overcome this problem. The major disease at present is the leaf curl virus (LCV) which is transmitted by the white fly and has caused serious crop losses over the past few years. The incidence of this disease has increased with the release of the highly susceptible variety S-12. Vegetable production has expanded and serves as a host for the virus and the whitefly. Genetic stocks with resistance to virus are, however, available and the hybridization work has been started to transfer virus resistance in commercial cultivars.

The early Pakistani cotton varieties had small bolls, weighing only about 2.5 gms. Selection has resulted in an increase in boll weight to 3.0-4.0 gms in the latest varieties, MNH-93, S12 and CIM 240. Generally, this had little effect on yield because the increase in boll weight is associated with a smaller number of bolls. However, the increase in boll weight would improve hand picking efficiency.

The Central Cotton Research Institute (CCRI), Multan maintains a collection of about 1,200 varieties of *G. hirsutum* from 34 countries and of 30 related species. About 15 species have been used in hybridization with local varieties, giving rise to biotypes with resistance to jassid, bacterial blight, drought and leaf curl virus. These lines are being utilized in the development of improved cultivars.

Some wild species have useful characters such as pink bollworm, *Pectinophora gossypiella*, resistance in *G. thurberi*. However, many potentially useful inter specific crosses have failed because they lead to sterility. Developments in genetic engineering open up possibilities to overcome this problem and could open the way for greater utilization of useful characters such as leaf curl virus resistance from wild species. In Pakistan, genetic engineering, molecular biology and different techniques for gene transfers and structuring transgenic plants, are just in initial stages at the Punjab University and the Nuclear Institute of Agriculture and Biology (NIAB) and have yet to be exploited for crop improvement.

The possibilities of utilizing hybrid vigor have been explored without success and although genetic and cytoplasmic male sterile lines are available, they have not been exploited.

NIAB has undertaken studies in mutation breeding and has developed the variety NIAB-78 through this method. However, irradiation induced mutations have not given rise to the development of any varieties or breeding lines with commercial potential.

The plant breeding program has made major contributions not only in changing the plant habit towards earliness, improved boll retention, higher yields and improved fiber quality but also in improved GOT. Based on an estimated 10 million bale crop, the increase in GOT alone from 32.0 percent to 37.0-40.0 percent accounts for an estimated 1.3 million bales worth about Rs.6.5 billion annually. These improvements, coupled with an efficient seed multiplication program, benefit the farmers without any major extension effort.

Tanzania

Plant breeding in Tanzania is nominally conducted at two research stations, Ukiriguru near Mwanza in the Western Cotton Growing Area (WCGA) and Ilonga near Kilosa for the Eastern Cotton Growing Area (ECGA). However, the plant breeding program is struggling to

survive because of lack of funds, particularly to support the field trial component in different districts of the two areas. The fiber laboratory has fiber testing equipment but is not operational because of a lack of spare parts.

The main objectives of both the Tanzania programs is higher yielding varieties with resistance to bacterial blight, *Xanthomonas malvacearum* and jassid, *Empoasca spp.* In the WCGA, drought tolerance is of greater importance than in the ECGA.

Uzbekistan

Four institutes are involved in the development of new cotton varieties in Uzbekistan. The Scientific Amalgamation of Biologists (formerly the Institute of Experimental Biology of Plants) and the Institute of Genetics (formerly the Institute of Phytopathology) come under the Academy of Science while the Scientific Production Complex, SOYUZHLOPOK (Institute of Cotton) and the Scientific Industrial Amalgamation (Breeding and Seed Technology of Cotton, also known as the Institute of Breeding and Seed Production), come under the Academy of Agricultural Science

The Scientific Amalgamation of Biologists has branches in the Fergana Valley and in the Tashkent area. Regional laboratories include a State Farm in the Tashkent area and a sub-station in the Bayaut Rayon of Syr Dar'ya oblast, between Tashkent and Djizak. Research includes plant physiology, biochemistry, genetics, genetic engineering, breeding, ecology, wilt resistance, crop water requirements and salt tolerance. *Verticillium* wilt is the most serious problem of cotton in the Republic and the Institute has undertaken intensive theoretical and practical work on this problem. Their varieties includes the Tashkent varieties, varieties prefixed by the initials AN (Academy of Science) and, more recently, the early maturing variety Ulduz. The variety AN-Bayout-2 has high salt tolerance and is widely grown in saline areas of Bukhara, Djizak, Syr Dar'ya and Tashkent oblasts.

The Institute of Genetics was only recently established from the Institute of Phytopathology which was under military control before the break up of the Soviet Union. The work of the Institute which now comes under the Academy of Science, includes genetic engineering with emphasis on host plant resistance to pests and diseases and selection for low water requirements and a high cottonseed oil content. A possible relationship has been observed between oil content, seedling vigor and drought tolerance. Varieties developed by the Institute are tested independently of the other institutes and are released directly into the seed multiplication scheme.

The Scientific Production Complex is responsible for developing cotton growing technology and for breeding both long and medium staple varieties with improved strength and lint percentage. The Institute has twelve sub-stations, covering all oblasts and all ecological zones. Competition exists between the four cotton breeding institutes but only this institute covers the whole country. Their breeding work has gained wide recognition and has involved close cooperation with China where Uzbek varieties have performed well, particularly in Xinjiang which is on a similar latitude. Their varieties cover over one million hectares in Uzbekistan and are also grown in Tadjikistan, Turkmenia, Kazakhstan and Kirgizia. They developed all the long staple varieties grown in the Central Asian Republics.

Breeding work on type I long staple, *G. barbadense* varieties is conducted at the field station in Termez. Great success has been achieved in developing so-called zero type varieties which carry the bolls directly on the main stem, have very restricted sympodial branch develop-

ment and reduced water requirements. The same success has not been achieved with medium staple varieties. Salinity is not a problem in the Termez area. All long staple varieties are *Fusarium* wilt tolerant. Earliness is an important criterion and success has been achieved in reducing the vegetative period (emergence to 50 percent of plants flowering) from 135 - 140 days to 119 days. The target is 110 days. The variety Termez-16, developed at Termez, is the long staple variety of choice, covering 98 percent of the long staple area.

An array of brown and green linted cotton varieties has been developed. It is of considerable ecological and industrial importance and is of particular interest to the military for camouflage uniforms because naturally colored fabrics do not show up as much as dyed fabrics.

The Scientific Industrial Amalgamation (the Institute of Breeding and Seed Production) has its headquarters and central experiment base in Tashkent with experiment bases at Kzil Ravat in the Namangan oblast, Akkurgan in the Tashkent oblast and Surkhan in the Surkhan Dar'ya oblast. Its varieties include the long staple Karshy-8 and S-6037, the latter to be replaced by Sultan-5, and the Medium staple S-4727, S-9070, S-6524, S-6530, Namangan-77, Chimbai 3010, Kzil Ravat, Namangan-1 and Fergana-3.

One of the weaknesses in the variety program in Uzbekistan is that new varieties do not replace older varieties. This has resulted in an excessive number of varieties in cultivation. The main constraint to reducing the number of varieties is considered to be changes in wilt biotypes which necessitates fairly frequent changes of variety. However, varieties grown on only a small area for several years could be withdrawn from cultivation since improved varieties are available. This could apply to the medium staple varieties Kzil Ravat and Namangan-1 which are grown on a limited area but the report suggests that it does not apply to long staple varieties or to short season varieties that are used mainly for replanting. The number of varieties has been reduced from about 47 in 1993 to 20 in 1994. Bukhara Oblast is taking a lead in reducing varieties and in maintaining quality by moving in the direction of becoming a single variety oblast with Bukhara-6 as the variety of choice.

An extensive collection of wild species of *Gossypium* from many regions of the world has been collected by various Institutes and is used in breeding for earliness and wilt tolerance. The Tashkent State Agrarian University has also undertaken cotton genetic studies on a collection of monogenic lines.

The fiber testing facilities available to Uzbek plant breeders are limited. Time consuming fiber test methods are used, particularly in assessing fiber length, severely restricting the number of tests that can be conducted. There are some small scale spinning lines but they require reconditioning. Classical time consuming methods, involving extraction of oil from the seed with consequent destruction of the seed, are used in assessing the oil content.

Variety Maintenance and Seed Production

A number of factors such as cool weather, excessive rainfall and poor seedbed preparation can contribute to poor plant stands. However, low quality seed is a major cause of poor plant stands directly through poor viability and indirectly, through poor seedling vigor, leading to an increased susceptibility to seedling diseases and early season sucking pests.

Many factors during crop development, pre- and post-harvest handling influence cottonseed quality. Harvested seed contains mature, well developed seeds, light immature, insect damaged and diseased seeds and heavy, deteriorated seeds. Careful management, harvesting, handling and ginning minimize seed damage. Delinting facilitates seed treatment, grading and the free flow of seed during seeding.

Planting Seed Production in the Study Countries

With the exception of Mali, cotton planting seed production is weak in all the countries in the study. Mexico could also be regarded as an exception because most of the planting

seed comes from US seed companies. In China, India and Pakistan, as much as 50 percent of the crop is planted to farmer's own seed despite the fact that about 28 percent of the Indian crop is hybrid. With continuous production of cotton from the same original source of seed without selection, genetic drift would cause changes in variety performance, particularly with regard to quality. In the absence of quality controls on planting seed, seeding rates in most countries are excessive and unless this can be reduced to an acceptable level through the introduction of high quality seed, it would not be possible to maintain an economic seed program because of the amount of land necessary to satisfy the excessive demand.

Brazil

Seed production in the Meridian Region of Brazil is well organized, particularly in Paraná where it is handled by the Organization of Cooperatives of Paraná State (OCEPAR) and São Paulo where it is handled by the Coordination for Integral Technical Assistance, CATI and the IAC. In the Sententrional Region, seed production varies from one state to another. In Rio Grande do Norte, the government run seed program is efficient but in other states, it is generally ineffective. The Meridian region produces only one variety and surplus seed from São Paulo and Paraná finds its way throughout the country.

China

China has initiated a seed multiplication program based on special ginneries equipped with acid delinting and seed treatment facilities but seed grading could be strengthened. The seed dressings used have been developed by the Beijing Agricultural University and incorporate pesticides against both diseases and insects, trace elements and plant growth regulators. Several

Box 2.4: Requirements for Producing Quality Planting Seed

Seed Multiplication:

- Maintenance of the genetic purity of the variety;
- Prevention of physical deterioration at all stages of multiplication;
- Timely production of sufficient, high quality, disease free seed;
- Delinting and grading to remove immature and insect damaged seed;
- Seed treatment with appropriate fungicides and/or insecticides.

Maintenance of Varietal Integrity:

- Annual release of fresh breeder seed;
- Supervision of seed multiplication;
- Clear demarcation of single variety areas and ginneries;
- Regulation of seed cotton purchasing and ginning to prevent mixing.

Seed Certification:

- Periodic inspection of seed plots;
- Roguing off-type plants;
- Supervision of ginning and processing to prevent mixing;
- Germination tests to assess both vigor and viability.

of these multi-functional products are available. This program is in its infancy but 136 units have been established in quality cotton base counties. Within these counties, a network has been established of stock farms, ginneries and seed increase areas to produce, supply and market seed. Farmers in these areas are not permitted to retain their own seed and all planting seed must be supplied by the county. This program requires further expansion because despite the program, about 50 percent of all planting seed is farmers own seed. This applies particularly to the Yangtze River Valley.

National standards for seed propagation were published in 1992 by the National Standards Bureau. Three systems are used for variety maintenance, the first being a progeny row system, the second, self pollination in a bulk of cotton and the third, storage and periodic release of breeder seed designated Ultra Seed Stock. Seed certification is handled by Provincial Technical Supervision Bureaus. Seed control stations have seed certifiers. A Cotton Quality Supervision, Certification and Testing Center was set up by the Ministry of Agriculture in 1990. This center is responsible for certification of seed passing between provinces and of arbitrating any disputes. Certification standards are being formulated and personnel trained.

Egypt

Egypt has an elaborate program for the maintenance of varietal purity, based on a progeny row system. Foundation seed is produced from yield tested progenies within a limited number of selected families. Registered seed is then produced on government farms in different regions. Each seed producing government farm handles only one variety to prevent crossing or mixing. Registered seed is distributed to contract growers and agricultural cooperatives who produce their crops under the supervision of the Seed Department of the Ministry of Agriculture and Land Resources and are under obligation to return the seed to the Department. Certified seed is sold to farmers.

The main weaknesses of the Egyptian seed multiplication program are that all varieties are maintained at the research station at Kafr el Sheikh where the utmost precautions are taken to isolate the varieties from each other to prevent crossing but they are then all ginned at the same gin where mixing could take place. The excessively high seeding rate of 70 kg/feddan or about 178 kg/ha which is double the recommended rate of 75 kg/ha. This makes it virtually impossible to satisfy the demand for planting seed from Certified Seed so a considerable amount of gin run seed is planted. The only treatment it receives is heat treatment after ginning to control pink bollworm. The seed generally has low viability with germination rates of 50-60 percent are common. Satisfactory stands could be obtained with good quality, delinted and graded seed with seeding rates of 25 kg/ha or less.

Despite the low viability, the high seeding rate leads to excessive plant stands and problems with thinning. Delayed thinning can seriously reduce yields while any thinning with high plant populations leads to root damage in the retained seedlings, opening the way for micro-organisms. A program has been proposed to establish specific single variety seed processing units and seed certification to improve the quality of planting seed but this would not be viable with the current high seeding rates.

India

Seed production and distribution in India is controlled by the Seeds Act (1966) and the Seeds (Control) Order (1984). The seeds used by farmers are Certified Seed, Truthfully Labeled

Seed, Neighbors Seed or Self Grown Seed. A high percentage of the planting seed falls into the last two categories. With the onset of privatization in 1994-95, more than one variety has been permitted at individual ginneries and since such a high percentage of seed is farmer's own or neighbors seed, mixed varieties have been inevitable. Certified seed is seed that has been certified by the statutory seed certification agency and complies with regulations and specifications regarding isolation, trueness to type and seed viability. Seed that complies with these specifications but is not certified by the state agency is labeled Truthfully Labeled Seed.

Seed is produced by both the private and public sectors. The private sector concentrates on hybrid seed which is usually sold as Truthfully Labeled Seed. The public sector handles 30-40 percent of the certified seed but less than 10 percent of the Truthfully Labeled Seed while the public sector handles 60-70 percent of the certified seed and over 90 percent of the Truthfully Labeled Seed.

In the public sector, Breeder Seed is supplied by the cotton research stations who are responsible for variety maintenance. This is grown by State Seed Corporations on their own farms or through contract growers to produce Certified Seed. Seed certification staff are responsible for inspecting seed crops, roguing out off-types and ensuring that growers carry out instructions regarding seed purity. Growers receive a certificate which goes to the ginner where this seed cotton is stored, ginned and bagged separately under the supervision of the Seed Certification Agency. Seed is identified at all stages in accordance with the variety and generation of increase. Similar procedures are followed by the private sector except that they produce their own Breeder Seed and generally do not get the seed certified.

Planting seed is distributed in the public sector through the Primary Agricultural Cooperatives (PACS) and is sold to the farmers as the in kind component of the crop loan package. The private sector distributes seed through trader outlets for sale on a cash basis.

Seed treatment varies across states. In Maharashtra, all certified seed is acid delinted by the State Seed Corporation before sale to the farmers while in Tamil Nadu and Karnataka, certified seeds are sold without treatment. Treatment with chemical seed dressings is insignificant but many farmers apply cow dung to the seed before sowing.

Mali

The cottonseed production in Mali includes 3 main phases. The first is the responsibility of the genetic and variety improvement unit at the research stations and deals with the first three generations of multiplication G1 to G3. Emphasis in this phase is seed quality and purity. The final phase aims to produce enough seed for the CMDT to sow 40 to 50 hectares per variety. The second phase is conducted by and through the CMDT Seeds Division which has three field agents and a coordinator who collaborate with the seeds growers. The seed growers are chosen according to their technical skills and knowledge of cotton production. Throughout the season, the Seeds Division agents supervise the fields of these growers and may reject any field that does not comply with the contract requirements. Seed producers are paid the first choice (A grade) price, plus 5 CFA Francs which is 90 CFA Francs/kg at current prices.

The Seeds Division agents schedule harvesting and ginning. During this period, they take charge of the passage of seed cotton from the weigh bridge through storage, ginning, bagging and tagging, ensuring that the tag bears details of the variety, the year and the generation of increase. Samples are drawn from each lot for germination and purity tests. The seeds are

packed in 60 kg-bags, sufficient for sowing 2 hectares and is delivered to the growers, free of charge with 2 small bags of an appropriate fungicides-insecticides for which they pay. Seed treatment is carried out at sowing time. The extension wing of the company ensures that farmers plant at acceptable seeding rates and use fresh seed each year.

The seed scheme always plans 25 percent reserve of seeds in cases of re-sowing. The multiplication coefficient varies from 18 to 25 according to varieties and climate conditions but 18 is normally used for purposes of calculation. The present multiplication program requires 3 multiplication generations to satisfy the needs of the whole cotton zone in any given variety.

Mexico

Most of the cottonseed planted in Mexico comes from the U.S.A., the major supplier being the Delta and Pine Land Company in Scott, Mississippi. Other suppliers include Stoneville, Rex, Coker (now part of Stoneville) and Arizona Pima.

The Government of Mexico is responsible for assuring varietal purity, seed certification, treatment, storage and distribution of seed of locally developed varieties. Ginning and phytosanitary control of this seed is supervised by the Ministry of Agriculture. However, under the 1991 Seeds Act in Mexico, private companies can produce planting seed commercially.

Pakistan

A strain/variety is constituted by bulking the progenies of plants selected from a base population. They may number 50-100 progenies, depending on the pre-basic seed requirements, forming the base for maintaining the strain from year to year. The seed of the typical progenies is bulked to form the pre-basic seed for further multiplication in basic and certified seed stages. Since there is almost no natural crossing, selfing the flowers is not considered necessary for maintaining purity. Any row which is not true to type in field and laboratory tests is culled.

Pre-basic seed is planted in a block to produce basic seed for the Punjab Seed Corporation/Seed Companies for increase to the certified seed stage. Certified seed may be raised in one or two steps, depending on the facilities available and the quantity required for distribution. During all stages from pre-basic to certified seed stage, the crop and the seed obtained therefrom is inspected and managed for purity by the Federal Seed Certification Department (FSCD) which inspects the crop and the seed to verify/authenticate the observations of the seed agencies.

The Punjab and Sindh Seed Corporations were formed in the Government sector under the Seeds Act (1976) to deal with the seed multiplication and supply program. Under the charter, these Corporations were to take over pre-basic seed from the breeders and propagate it further through basic seed and certified seed stages at the Government farms or in the fields of registered growers to achieve the laid down targets of seed supply. A National Seed Council was formed at the Federal level with Provincial Seed Councils at the provincial level to regulate the system of seed multiplication and supply. A Federal Seed Certification Department was created to supervise quality seed production at all stages and to verify the purity and the viability of the seed to be distributed to the growers.

Under the Cotton Control Act (1949), it is obligatory for the Government to supply 100 percent of the seed requirements of each registered variety. The Seed Corporations could not handle this quantity of seed so in late 80s, the Government brought the private sector into this function. Initially, the Punjab Seed Corporation supplied 100 percent of the seed requirements

but now it supplies only 35 percent of the total needs. The Sindh Seed Corporation has not developed and almost all their seed is brought in from Punjab or supplied by the provincial ginning factories. Recognized private seed companies supply about 16 percent of the requirements, the remaining approximately 50 percent being supplied by the informal sector, mainly the gineries.

The Seed Corporations distribute their seed through their own sale points, through private dealers located throughout the province and through Agricultural Supplies Corporations which have their own numerous sale points. The Punjab Seed Corporation provides seed for sale to cooperative societies and through branches of cooperative banks. Private companies have their own dealers while the ginning factories supply seed, usually on credit, to the growers who bring their seed cotton to them for ginning. Seed from these informal sources is generally of good standard because it comes from good growers but prolonged production of cotton from unselected seed will result in genetic changes and can lead to a decline in both yield and quality.

The staple length and uniformity ratio could be improved if the supply of certified seed could reach the 100 percent level. Thus the overall position of seed supply is not satisfactory. The private sector has not come up to expectations and the informal sector dominates seed supply. The handicaps faced by the private sector include lack of easy credit for the seed companies, precarious supply of basic seed and exacting seed laws. The country report recommends that seed companies with appropriate technical and financial capabilities should be helped to produce their own pre-basic and basic seed, low interest credit should be available to them against seed as collateral, and seed certification from FSCD should be desirable to ensure that farmers get pure, quality but not compulsory, provided the seed companies have their own strict quality controls and put the tags/labels on the seed under truthful labeling system, subject, of course, to checking and inspection by FSCD.

Under the Seeds Act, certified seed should have at least 90 percent purity and viability of 75 percent, although relaxation in germination percentage may be allowed under special circumstances. Genetic purity of seed required under the Act/Rules, is 99.95 percent for pre-basic, 99.90 percent for basic and 99.8 percent for certified seed. Under 'Truthful-in-Labeling' system, the minimum limit of this purity is relaxed to 96.0 percent.

The seed produced by the registered private sector is certified by the Federal Seed Certification Department. The seed coming from informal sources is generally derived from the produce of big growers who usually get quality seed for planting their crop.

To ensure purity and to avoid mixing of seed during ginning and storage operations, the Punjab Seed Corporation buys the entire produce of the registered growers and gins the same in their own or hired ginning factories. The seed thus obtained, after testing for purity and viability, is stored in gunny bags in ventilated godowns till the time of distribution. Since the weather is generally dry during the storage period (December - March), ordinary ventilated godowns are considered to be satisfactory for the storage of seed. The gunny bags or cloth bags, having about 20 kgs or 40 kgs seed according to the requirement, are stored in 7-8 layers with enough room at the top for ventilation.

The laboratory tests and field experiments have shown that the treatment of seed with fungicides has no benefit either for germination or for the crop yield. The high soil temperatures, (above 30°C in general) at the time of sowing, induce germination before the fungi can gain access. Bacterial blight bacterium, *Xanthomonas malvacearum*, infects seedlings even at this high temperature but recently, farmers have started acid delinting the seed on their own to

make it flow more freely through the planter and this has effectively controlled bacterial blight. Consequently, no fungicidal treatment of seed is practiced.

Tanzania

Seed multiplication in Tanzania is extremely weak. This has been exacerbated by market liberalization, permitting free movement of seed cotton across variety demarcation lines, leading to mixed seed. The research station releases fairly large quantities of Foundation Seed regularly for multiplication by the cooperatives with the intention of multiplication in an area that is free of plants of earlier releases. However, farmers receive seed free and excess seed is often kept from one year for planting the next year. There is no seed certification so there is no guarantee of the maintenance of varietal purity. Efforts are being made to correct this situation by making the Tanzania Cotton Lint and Seed Board (TCLSB) responsible for seed multiplication. However, there is a need for a seed certification program for cotton and other crops.

Uzbekistan

Under the Soviet Union, the number and choice of varieties was centrally controlled and ginneries were relatively large. This provided tight control on ginning, ensuring that each seed cotton stack was confined to the same grade of a single variety. The central authority was also responsible for the quality and purity of planting seed. Consequently, they built up a reputation for long runs of uniform, well packaged bales of cotton.

Under the present system, varieties are developed by the research institutes and are then passed on to the Ministry of Agriculture for maintenance on Elite Farms and seed multiplication on contract farms while the Ministry of Cotton Processing is responsible for ginning and marketing planting seed. Thus three separate organizations handle the seed. The seed supply system has no mechanism for variety maintenance beyond the Elite Farms and no facilities exist for grading planting seed, for effective testing for viability and vigor or for appropriate seed treatment and storage. Consequently, excessive seeding rates are common and replanting is normal. This leads to mixed varieties and uneven plant stands due to multiple planting, contributing further to further deterioration in planting seed and fiber quality (World Bank 1995).

Once the variety is released, the originating plant breeder plays no further role in its maintenance or seed production so there is no feed back from Elite Farms on varietal performance and no mechanism for the removal and replacement of old varieties with new, improved varieties. The situation could be improved through greater coordination of the activities of the three organizations to give the plant breeder a greater say in variety maintenance and through certification of seed beyond the Elite Farm stage.

The selection of varieties is not regulated as it was before and farm managers are able to substitute varieties of their choice. Consequently, seed cotton from different varieties is almost certainly being mixed. This could have an adverse effect on the reputation and marketability of Uzbek cotton. This situation could be aggravated by privatization of ginning with the replacement of large ginning units by small units, serving individual farms. Each ginnery would be in a position to retain its own planting seed, thus removing any control on the variety planted, the quality of the planting seed, the regularity of the lint and the compilation of records on the area planted to cotton by variety and oblast.

Variety maintenance and seed multiplication are handled by Elite Seed Farms which use a progeny row system for variety maintenance and produce Elite (Breeder) and Reproduction 1

(Foundation) seed. The later generations designated Reproduction 2 (Registered), Reproduction 3 (Certified) and Reproduction 4 (Farm) seed are produced by contract seed producing farms. Gineries handle planting seed of more than one variety so mixing is inevitable. Planting seed is double machine delinted and screened with no further treatment or grading. Germination tests are based on radical emergence without consideration of the rate of root development and at only one temperature so there is no testing for seed quality or vigor. There is one acid delinting plant which handles about 25 percent of the country's seed requirements but the acid delinted seed is not graded. Furthermore, the facility handles several varieties so mixing is inevitable.

The World Bank is working with the Government of Uzbekistan to support the establishment of private seed companies and to convert collective seed farms into private farms. Each company would produce seed of only one variety and would have its own ginery and seed treatment line, incorporating acid delinting, gravity table screening and fungicide treatment. This would be supported by independent seed certification, working to International Seed Testing Association (ISTA) standards for viability and vigor (Ibid).

Fiber and Spinning Test Facilities

The correlations between the components of yield and quality make it essential for plant breeders to be supported by adequate fiber testing facilities to facilitate concurrent selection for both yield and quality. Final selection of new varieties should also be based on spinnability which is not necessarily reflected in fiber test data. This calls for spinning test facilities for testing small samples of cotton.

The fiber attributes of major concern in plant breeding are fiber length, strength, fineness and maturity. The Fibrograph which is incorporated in HVI systems, is the most widely used instrument for measuring length and uniformity. These measures can be used effectively in plant breeding programs but the measurement of strength, fineness and maturity present problems.

The traditional methods of measuring fineness and maturity involved microscopic examination and counting of fibers that had been treated with caustic soda to determine maturity and weighing sections of fiber cut from an array to determine the mean fiber weight. The maturity determined from the microscopic examination and the mean fiber weight are used to determine the standard fiber weight which is the weight per unit of length of fully matured fibers and is an index of fineness. This is a very costly and time consuming operation. The Micronaire was developed to give a measure of linear density of the fiber and it is widely used in marketing and spinning cotton. However, the Micronaire measurement is a combination of fineness and maturity. Within a variety, the fineness and length are closely correlated and are genetically determined so the Micronaire provides a measure of maturity. However, when comparing varieties or breeding lines, fineness and maturity cannot be differentiated on the basis of a Micronaire reading. The Fiber testing laboratories that support a breeding program require additional equipment such as the Shirley Development Fineness/Maturity Tester (FMT) for this purpose.

Table 2.5: Fiber Quality Parameters of Four Genotypes and Paymaster HS26 as Control

Geno- type	High Volume Instrument Tester					Fineness Maturity Tester		
	UHML inch	ML inch	UI percent	Strength gms/tex	Elongation percent	Micron aire	Maturity percent	Fineness dtex
Control	1.04	0.85	82.1	27.3	7.9	4.44	88.4	1.70
#2	1.17	0.98	83.2	34.3	6.4	4.15	91.0	1.51
#3	1.10	0.91	82.6	31.3	6.4	4.22	90.7	1.55
#4	1.22	1.02	84.1	37.4	5.8	3.55	90.9	1.25
#5	1.20	1.01	84.1	38.0	6.7	3.79	93.1	1.32

Source: Faerber and Gannaway, 1995

Very fine, mature, low micronaire cotton genotypes have been developed in Texas which give excellent spinning performance. The micronaire value has been reduced significantly by reducing fineness without any reduction in maturity, using the FMT instrument to differentiate between the two (Table 2.5). The resulting genotypes produce fine, mature cotton that can be rotor spun into yarns that are superior in quality to those produced from the control, Paymaster HS26, with a reduction in the nep count (Table 2.6). The FMT ensured that the reduction in micronaire value was achieved by reducing intrinsic fineness without any reduction in maturity (Gannaway, et al., 1995). If the low micronaire value had been due to immaturity, the resultant yarn would have been very irregular and neppy. These results show that high quality cottons can be spun into fine count rotor yarns at the highest speeds possible today. They also show that when fineness and maturity are differentiated in the breeding program, cottons with greater fineness but high maturity can be developed which give nep levels that are fully acceptable in modern textile manufacture. The problem arises in combining this level of quality with an equally high agronomic performance.

Several systems have been developed to determine the bundle strength of cotton fiber. The Pressley strength tester became accepted as the standard method of strength testing in the trade although the Stelometer, developed later, gave an assessment of both elongation before rupture and bundle strength. The latter is more closely correlated with yarn strength than Pressley strength and has been accepted by the International Textile Manufacturers Federation (ITMF) as the standard against which new strength testing equipment is compared.

Table 2.6 : Yarn Quality of Four Genotypes and Paymaster HS26 as Control

Geno- type	14 Tex Weaving Yarn TM 4.5			14 Tex Knitting Yarn TM 4.1		
	Max. Force cN	Tenacity cN/tex	Neps	Max. Force cN	Tenacity cN/tex	Neps
Control	158.4	10.64	159	147.0	9.95	175
#2	190.1	13.20	116	178.2	12.38	124
#3	179.0	12.09	153	159.3	10.96	176
#4	217.7	14.84	130	191.5	13.04	159
#5	222.3	14.64	116	193.5	13.24	127

Source: Faerber and Gannaway, 1995

An automated strength test system developed for the HVI test lines has become widely accepted in the trade. However, the HVI strength test results have shown an interaction with variety. Thus two varieties which have similar Stelometer and yarn strengths may differ significantly when tested on the HVI strength tester (Table 2.7). Furthermore, the correlation between HVI strength and yarn strength is poor (Table 2.8). This suggests that the HVI strength measurement is influenced by fiber characteristics other than strength and its use in selection programs could lead to the development of other undesirable fiber characteristics such as coarseness. This renders HVI strength unsuitable for plant breeding (Howle and Taylor, 1995; Taylor et al, 1995).

Table 2.7: Comparison of Fiber Strength Measurements with Yarn Strength of Varieties, 1993

Variety	Fiber Strength (gms/tex)				Yarn Strength (lbs)	
	Stelometer	MCI	Spinlab	Universal	Rotor Spun ¹	Ring Spun ²
Acala 1517-88	23.4	31.0	31.4	22.8	12.4	120.8
PD 5529	22.4	27.1	26.4	20.9	11.8	117.0
PD 3	21.3	27.3	27.4	20.3	11.5	114.5
PD 5365	21.8	29.5	30.0	21.7	11.4	114.3
DP Acala 90	20.8	29.7	31.1	20.9	11.3	112.8
Coker 315	21.0	26.1	27.5	20.2	11.0	109.5
DES 119	20.8	28.3	26.0	19.3	10.6	107.8
Coker 320	21.7	25.7	27.3	20.0	10.5	105.3
Georgia King	20.5	28.4	29.0	20.0	10.5	102.8
DP 5415	19.9	30.0	30.1	19.6	10.2	97.5
DP 50	20.1	26.9	26.0	18.4	9.8	91.3
L.S.D.(0.05)	1.2	1.7	1.9	0.6	0.8	7.1

¹/ Single End Tenacity of a 22's rotor spun yarn

²/ Skein Strength of a 22's ring-spun yarn

Source: Howle and Taylor, 1995; Taylor et al, 1995

Fiber laboratories used by plant breeders can use HVI equipment for measuring length and length uniformity but they need additional equipment such as the Shirley Development Fineness Maturity Tester (FMT) to differentiate between fineness and maturity and an instrument such as the Stelometer to verify any HVI data on bundle strength.

Table 2.8: Correlations of Fiber Strength Measurements with Yarn Strength, 1993

Instrument	Ring - Spun		Rotor - Spun		Average	r ²
	Skein Str	Tenacity	Skein Str	Tenacity		
Stelometer	0.907	0.849	0.913	0.856	0.880	0.774
MCI	0.104	0.210	0.269	0.387	0.243	0.059
Spinlab	0.290	0.306	0.405	0.422	0.356	0.127
Universal	0.850	0.837	0.926	0.907	0.880	0.774

Source: Howle and Taylor, 1995; Taylor et al, 1995

Fiber tests are required early in the selection program while spinning tests are normally conducted during the later stages. However, the amount of cotton available for the earliest stage of spinning test is too limited for spinning on a production line. Small scale spinning test lines developed by the Shirley Institute in England, have been widely used in many countries but they are no longer being manufactured and spare parts usually have to be improvised. This is an area of weakness in many breeding programs.

Brazil

Brazil has a well equipped fiber laboratory at the IAC. A successful method has been developed for using the Fibrograph and Micronaire to differentiate between fineness and maturity. It has been used with considerable success for a number of years at IAC but has not found acceptance in other countries.

China

China has a well equipped fiber laboratory at the Cotton Research Institute in Anyang. The equipment includes an HVI line. However, although they have a newly developed small spinning mill next to the Institute, they do not have small scale spinning test equipment to compare the spinnability of cotton from different breeding lines until sufficient lint is available for a commercial size test.

Egypt

Egypt has a technical laboratory at the CRI in Giza which is equipped to conduct a wide range of tests on breeding lines and to conduct technological research on textile and ginning technology. The laboratory is also equipped with an HVI line.

India

The Central Institute for Research on Cotton Technology in Bombay, India provides fiber and spinning test facilities for use by the plant breeders. This is a well equipped institute with interests in all aspects of cotton textile technology. They have an HVI line which is extensively used in selecting for high strength in the breeding program and has contributed to the development of two high strength varieties, Pusa 2-95 and Pusa 2-98. There is no indication as to the relative role of HVI strength tests and spinning tests in selecting these lines.

Mali

Mali has access to the Technology Laboratory of CIRAD CA in Montpellier, France. The success of the West African breeding program in developing high yielding varieties with a high GOT and no loss of quality is a tribute to the work of the breeders and the support they have received from the fiber laboratory.

Mexico

No mention is made of the fiber or spinning test facilities available to the plant breeders in the Mexico country study.

Pakistan

Pakistan Central Cotton Committee (PCCC) has fiber testing facilities in Karachi where they also conduct textile research and micro spinning facilities at the CRI, Multan. The halo length, the hand staple tuft method and sometimes Baer diagrams were used in the past for the determination of fiber length. Currently these measurements are determined on the Fibrograph.

Tanzania

Tanzania has a fiber and spinning test laboratory at the Ukiriguru Research Station but the equipment is in need of repair. The fiber laboratory has the necessary fiber testing equipment but it is not operational. They have a small scale spinning plant which is in working order but cannot be used because the air conditioning system has broken down. Support will be forthcoming from the World Bank National Agricultural and Livestock Research Project, Credit No. 1970TA. The TCLSB has HVI equipment at its laboratory in Dar es Salaam which is used for grading and classing commercial cotton lint.

Uzbekistan

The fiber test methods used in Uzbekistan provide reliable data but are slow and require a great deal of operator skill and judgment, introducing operator bias. The Plant Breeding and Seed Production Institute has a Shirley small scale spinning line which needs reconditioning. Thus the number and range of tests that can be conducted is severely limited, making it difficult for plant breeders to maintain quality standards in a program with major emphasis on earliness. Limitations in spinning and fiber test facilities at sub-stations necessitates quality assessment using traditional, subjective, hand pulling methods.

Agronomy

Good agronomic practices are the key to successful crop production. This is a rule for any crop, but it is especially true for cotton. Of course a good variety, adapted to a given environment, is needed to start with, but it will only produce a satisfactory yield, if good crop management is performed. Cotton is a crop that has to be really 'tamed' from A to Z to achieve its optimum production potential .

Cotton is produced in the study countries on farms that vary from large to very small-scale under irrigated to rainfed conditions, with assured and non assured rainfall. These conditions affect the potential yields in the different areas. Moreover, there are major differences in cropping practices which are factors to be considered in explaining the yield differences.

Type of Crop

With the exceptions of northeast Brazil and northern Peru where perennial varieties are maintained for at least four years in the same fields cotton, a perennial plant, is grown as an annual. Ratoon cotton is grown in some countries but is generally discouraged because of its influence in pests and diseases. Perennial and ratoon cotton crops are generally grown with minimal labor and inputs in non assured rainfall areas, generally giving poor yields.

Influence of the Climate and Management

Within the study countries cotton is cultivated under various conditions:

wheat crop is harvested, the seedlings are ready to transplant into the wheat stubble. This enables the wheat to mature and still permits adequate time for the cotton crop to mature.

In **India**, agroclimatic conditions vary considerably in different parts of the country and even in the same area. This multitude of different situations created by this diversity is difficult to understand without detailed cropping calendars. There are numerous varieties and types of crop, from high yielding F1 hybrids to 'Desi' cotton. Long staple production either from Hybrids or *G. barbadense* is quite substantial and essentially 'organic'. All kinds of cropping pattern, from completely irrigated crops to crops grown with non-assured rainfall, are present. This explains the big diversity in varieties, crop management and the low national average yield.

Overall farming conditions are good but inputs vary from very high in the high yielding irrigated and assured rain fall areas to nil in the very low yielding locations with scanty rainfall .

Mali is very similar to **Tanzania** in term of climate and soils. The crop depends only on rain and is planted mainly on small and medium sized farms. The big difference between the two countries is in the organization of the sub-sectors. Mali has real leadership in term of management with excellent links between research, extension and marketing, especially in term of varieties. This has allowed a steady increase in area and production for the last three decades. Tanzania lacks this leadership.

Cotton production in **Mexico** is almost entirely irrigated. The climate, soils and water ensure high yields of consistent quality but production has declined because government policies have favored food crops, giving them a competitive advantage.

In **Pakistan** cotton is an irrigated crop cultivated by large scale farmers and smallholders. The increase in production has been due to a tremendous intensification effort in which research has played a very important role. Farmers have shown an eagerness to adopt new techniques. The recent problems created by a cotton leaf curl virus have created a certain reduction in acreage and in production.

Even though cotton is grown in **Tanzania** as an annual, rainfed crop, yields are rather poor and well below the production potential of the varieties planted, due to a number of difficulties in the organization of the sub-sector. If farmers obtain a fair price for their cotton and if good seeds, inputs and farm equipment become available in a timely manner at a reasonable price and the sub sector has an efficient, logical organization including good leadership, the country can be expected to regain and even increase its production quickly. The premium price which Tanzania enjoyed for its cotton could also be regained on the world market, but only with reorganization of the sub-sector with emphasis on cotton quality.

In **Uzbekistan**, cotton is entirely irrigated due to the climatic conditions prevailing during the cotton season and is cultivated in big state (sovkhoz) and collective (kolkhoz) farms. The recent political changes are likely to lead to part of these big units being split into smaller units. It will be interesting to follow this evolution in term of production, the availability of inputs and prices. Greater attention is being paid to the production of food crops, bringing about a reduction in the cotton area. The likely impact of this is not yet clear. This may not necessarily lead to a reduction in production if farmers receive a good price for their cotton.

Crop Establishment

Successful cotton production depends on establishing a uniform stand of vigorous plants at the optimum planting time. Delayed planting invariably leads to significant reductions in yield. Many factors can hamper crop establishment but climate and soil temperatures are among the most important. Optimum soil temperature conditions have been established in many countries but in countries with more extreme climates, the season is often too short to allow any flexibility in planting time.

In north China, soil temperatures at planting time are too low to allow quick germination and normal seedling growth. The use of plastic mulch has become popular to overcome this problem, permitting planting to take place about three weeks earlier than would be possible without the mulch. More than 20 percent of the crop is established using this technique. This technique enables the season to be extended but in a given location, there is a complete lack of homogeneity in the stage of plant development between fields with and without plastic mulch. Insect pests, particularly Aphids, *Aphis gossypii* and bollworm, *Helicoverpa armigera* are provided with host plants over a prolonged period, settling and developing on the older plants and then migrating onto the younger plants. Plants are able to compensate for early crop loss but the delayed maturity prolongs the crop cycle, thus extending the period of exposure to insect pests and it could also lead to crop losses caused by early frost.

Another technique developed in north China to permit earlier cotton planting is to sow the cottonseed between the rows of wheat before it is harvested. Wheat is sown in strips, leaving free rows at regular intervals for cottonseed to be sown. This has interesting ramifications:

- beneficial insect populations increase on wheat aphids and then migrate to cotton seedlings;
- the cotton seedlings are provided with a protected microclimate;
- earlier planting extends the cropping period

This technique has also important draw backs:

- the tight cropping sequence precludes normal land preparation which would destroy overwintering bollworm *H. armigera*, pupae. Since the introduction of the new intercropping technique, the bollworm population has increased dramatically, including increased damage to wheat in the spring;
- the extended cotton season provides host plants for an additional bollworm generation, providing a potential for a bigger infestation for the next year.

Pakistan experiences very hot winds which hinder pollen germination, causing young bolls to shed. When this occurs late in the season, it can lead to young flowers becoming desiccated and mummifying onto the plant. Heat tolerant varieties have solved this problem. Late season varieties come into flower as the monsoon season approaches, bringing higher humidity and minimizing the problem.

Early season pest damage to young seedling delays fruit setting, decreasing the yield potential, particularly when there is a climatic limitation to the season. When there is no such limitation, the protracted season extends the period of exposure to insect pests, leading to reduced yields and quality.

Thrips damage seedlings in Egypt and Pakistan. The damage reduces seedling internode elongation and causes shedding of early buds, leading to a loss of fruiting positions on the bot-

tom of the plant. Even though the plants may compensate for these losses, they cause a protraction of the cotton season. The introduction of upland cotton to commercial production in Egypt would exacerbate this problem since *G. hirsutum* is more susceptible to thrips and bollworm than *G. barbadense*.

Importance of Fertilization

Fertilization is a very important means of intensifying crop production and of preventing soil degradation but information on this issue is generally deficient.

In China, the application of organic fertilizers has been the rule for decades. However, this practice seems to be declining because of limited traditional sources such as cattle manure, home compost and complementary products, at least for application on part of the land. In Mali, Pakistan and India, animal manure is also quite widely used by small and medium scale farms but chemical fertilization is, nevertheless, widely applied. Research is quite well organized to determine which macro and minor elements are needed but some areas, particularly Tanzania, require further study and extension effort.

Among the chemical fertilizers, nitrogen is most widely used for many reasons, not least, price and availability. Farmers appreciate the rapid response to N in cotton fields, the flush green crop is frequently seen as an indication of a good production potential. In fact N should be used with caution. Excessive N in the presence of abundant water early in the season can lead to delayed flowering and an excessively vegetative plant, creating problems with crop protection later in the season. When crop duration is limited by climate in the same way as the US rainfed crop and as it is in the case of Mali, Tanzania, north and northwest China and Uzbekistan, studies indicate that the plant requires adequate but not excessive supplies of N during the seedling stage and up to blooming. At least part if not all N fertilizer should be applied at the time of sowing and the rest before blooming. Unfortunately a balanced application is very seldom the case. N deficiency prior to blooming restricts plant growth and prevents the development of an adequate plant framework to carry a good crop. On the other hand, excessive late application of N induces late vegetative development at the expense of fruit production and boll development.

The situation outlined above applies to Pakistan. Very little N is applied at planting, the first application of Urea frequently being made at the time of first irrigation. Farmers apply one bag of Urea every other irrigation or even sometimes at each irrigation from 40 days onwards. The internode development of the young seedling is limited by delayed first irrigation and insufficient available N. After the first irrigation when there is excess N and frequent watering, there is typically excessive vegetative development. The fruiting bodies at the bottom of the plants receive insufficient light and shed or rot due to an excess of humidity inside too dense a canopy. The plants then compensate but maturity is delayed and plants get still bigger. Under these conditions wheat which normally follows cotton is planted late or not planted at all and the protracted cotton season creates favorable condition for late season pest development, particularly for aphids, whitefly and bollworm, leading to reduced yield and poor quality lint.

In North China, late applications of N fertilizer delay plant senescence and increase the proportion of post frost harvest and hence decrease lint quality and its commercial value.

In Mali the cotton compound fertilizer (N.P.K.S.B) is mainly applied at the earliest 3 to 4 weeks after planting at 150kg/ha. Additional Urea is recommended at 50kg/ha at the start of flowering. Organic manure is recommended at 8-10 tons/ha every three years. Here again the

duration of the crop is limited by the length of the rainy season, and the delayed application of fertilizer could reduce the crop potential. It would certainly be of interest to consider applying the full fertilizer treatment at planting. However, this could be risky under insecure rainfed conditions.

In many countries, farmers associate the early application of fertilizers, especially N with excessive weed growth. Even if this were the case, young seedling require favorable conditions for rapid, productive growth in order to compete with weeds. Starving the cotton crop is not an effective means of weed control.

Plant growth regulators and terminating chemicals are not widely used. Mechanical harvesting is fairly common in Uzbekistan but there are problems with the availability of foreign exchange to procure appropriate defoliant. Furthermore, two organophosphate defoliant which are popular in other countries where mechanical harvesting is practiced, were banned because of the risk to human and animal health. Farmers are left with one of the original defoliant, Manganese chlorate, as the only choice.

Conservation Tillage

The early development of cotton is slow and consequently, there is a considerable time lapse before the plant canopy provides any form of protection. During this period, soil is exposed to the erosive forces of rain and water losses as a result of run-off can be considerable. This applies particularly to rainfed cotton. A great deal of work is going on in the USA on reduced tillage systems (Bogusch and Supak, 1995). This may include the use of cover crops which has some similarity to relay cropped wheat and cotton in China. However, this protects the soil but it also protects any insect pests that are pupating in the soil.

A considerable amount of research has been conducted in West, East and Central Africa on tied ridging, also known as dike cultivation. In Texas, this is being combined with irrigation in what is known as low energy precision irrigation application (Lege et al, 1995). In these systems, ties or dikes are constructed across the furrow at about four meter intervals, depending on the slope, to form a series of basins which hold water, reducing run-off and increasing infiltration. Under rainfed conditions, this increases the supply of water in the soil while in irrigated cotton, it reduces the amount of water required per irrigation.

Potholing is a second water conservation strategy which was studied in Zimbabwe. This involved growing cotton on beds with two rows to a bed. Small holes are cut at intervals along the top of the bed between the rows of cotton to hold water and increase infiltration. The use of tied ridging and potholing, either separately or in combination, can result in a considerable reduction in run-off and an increase in amount of water that infiltrates the soil and becomes available to the plant. This can have a significant impact on yields in a dry year but may have little effect in a wet year. However, the appropriateness of these techniques depends on the soil type and the pattern of rainfall.

Evaporation losses can be reduced significantly by plowing at the end of the rainy season after the crop has been harvested instead of at the beginning of the season before planting. This has the effect of increasing the water reserve in the soil for use as the crop develops. Infiltration rates can be improved by a light cultivation after rain to break any crust that may have formed in order to improve water infiltration during the next wet period.

Irrigation and Drainage

Irrigation can increase cotton production in the world either by enabling the crop to be grown in arid regions where it would otherwise be impossible or by increasing yields with supplementary irrigation under rainfed conditions. It also has the potential to degrade the environment, both on and off the farm. Degradation can limit or reduce production directly by damaging resources used in production while the threat of degradation can reduce production indirectly by legislation or international agreements aimed at its prevention.

In the nine countries of the study 61 percent of the area and 80 percent of the production of cotton is irrigated, compared with 53 percent and 73 percent respectively for the world (Hearn 1995). Irrigated cotton is not uniformly distributed around the globe but varies among climatic regions. A broad belt of irrigated cotton extends from Spain in the west to the Xinjiang province of China in the east. These regions have Mediterranean or desert or near desert climates, and cotton is fully irrigated without significant rainfall during the growing season. This type of production is represented in this study by Egypt, Uzbekistan, Pakistan, the northern zone of India, and Xinjiang province of China and Mexico.

By contrast, in Central and South America, in Africa south of the Sahara, and in SE Asia cotton is almost entirely rainfed. These are tropical and subtropical summer rainfall areas. In this study Brazil, Mali and Tanzania represent this type of production.

Between these extremes cotton is grown with varying amounts of supplementary irrigation in semi-arid and humid regions. China irrigates most of the cotton grown in the east (Yellow River and Yangtse valleys) despite a relatively humid climate, 75 percent according to Bell & Gillham (1989), 95 percent according to ICAC (1993). In India 13 percent of the crop in the central region and 18 percent in the southern region receives supplementary irrigation.

Not unexpectedly the higher the proportion of the crop irrigated in a country the heavier is the yield. On a global basis the mean yields of rainfed and irrigated cotton are 391 and 854 kg lint per ha respectively (Hearn 1995). This is reflected in the yields in the study countries. However the higher yield associated with irrigation cannot be attributed to irrigation alone. Irrigated crops usually receive heavier technological inputs such as fertilizer and pesticides because under these conditions, inputs, particularly fertilizers, are more efficient in raising yields than under rainfed conditions.

Irrigation is of major importance in cotton production in six out of the nine countries in study: China, Egypt, India, Mexico, Pakistan and Uzbekistan. Brazil has a small area of irrigated cotton with plans for more. Irrigation can be characterized not only by its extent, which is the percentage of the area of cotton irrigated, but also by the dependence on irrigation, which is the degree to which rainfall supplements irrigation. Both extent and dependence vary amongst the six countries as shown in Table 2.9.

Table 2.9: Irrigation Extent and Dependence of Six Countries

Country	region/zone	rainfall (mm) during season	extent % irrigated	dependence*
Egypt	lower	0	100	I
	middle	<10	100	I
	upper	<20	100	I
Uzbekistan		30 - 70	100	I
Pakistan		100 - 200	100	I+R
Mexico		25 - 2000	84 - 95	I and I+R
China	NW - Xinjiang	0 - 200	100	I
	N - Yellow R	500 - 700	75 - 95	R+I
	S - Yangtse R	700 - 1000	75 - 95	R+I
India	north	200 - 400	100	I+R
	central	800 - 1200	29 - 40	R+I
	south	400 - 1000	29 - 40	R+I

* I irrigation with no or negligible rainfall during season.

I+R irrigation supplies most of crop water requirements but rainfall makes a significant contribution.

R+I rainfall supplies most of crop water requirements but some crops receive supplementary irrigation.

Irrigation Practices

Water Supply

The major source of irrigation water in all countries in the study is rivers regulated by reservoirs, fed to farms via canals. In Uzbekistan, Pakistan, northern India and NW China rivers are fed by melting of winter snows, which results in seasonal variation in supply. By contrast in Egypt the Nile is fed by rainfall in tropical regions beyond the southern border. Groundwater from bores (tube wells) is a lesser but important source of supply in several countries. This is of particular importance in India and Pakistan, especially to increase the cropping intensity. In Pakistan 31.0 percent of all irrigation water in the cotton season is drawn from wells, mainly to supplement canal water at critical times. Supplementary irrigation of rainfed crops in India and China is mainly with well water, except for China's Yellow River area where well water and canal water are equally important and conjunctively used.

Three countries report that there is potential to increase the supply of irrigation water. In Pakistan some of the Indus River water still reaches the ocean, and in part could be stored with new dams increasing the irrigated area by 10 percent (1.6 M ha) but this development is not expected in the next decade. In NW China production could be increased by diverting more of the snow melt from the Tsien Shan mountains eastwards. Brazil, currently with negligible irrigated production, will grow cotton as one of the crops in a project to irrigate one million ha in the Sententrional region. Uzbekistan reports that the amount of water and land devoted to cotton production is being reduced in order to increase the amount of water available to the Aral Sea and for production of food and other crops. In all countries there is the potential to use water more efficiently which would effectively increase the supply for cotton production. However, in China's Yellow River Valley there is a shortage of water for irrigation resulting from falling groundwater tables and sedimentation of wells.

In Egypt, Pakistan, India and Uzbekistan the canal systems were designed up to 100 years ago before modern knowledge of the actual crop water requirements, and in some cases, when cropping intensities (percentage of area cropped in a year) were only half or one third of current levels. Such systems may therefore be inadequate for current needs. They operate on the rigid 'turn' system whereby water is only available in the distributor canal that supplies a group of farms on one day a week so that all the users on one canal take turns with users on other canals in using the water. Consequently irrigation is described as supply driven, the implications of which will be discussed later.

Methods of Irrigation

Surface irrigation in its various forms is the commonest method of irrigation in the countries in this study, which faithfully reflects the global scene where 94 percent of cotton is irrigated by surface methods (Hearn 1995). Furrow irrigation is used exclusively in Uzbekistan and Mexico, and the Yellow River region of China. Egypt uses the 'hawwal' system in which the ridges are flooded to half their depth. The Yangtse region of China uses flood and check systems, Pakistan and India use a mixture of flood and furrow. There is very limited sprinkler irrigation in China and India, and similarly limited drip irrigation in Uzbekistan. In China, 27 percent of cotton irrigated from wells utilizes thin, hard, buried plastic tubes that reduce water use by 20-30 percent. These reticulated systems are not compatible with gravity driven canal systems in these countries, and their cost makes them uneconomic at current yield levels.

Frequency, Number, Timing & Amount

The country reports describe irrigation practices in terms of the number of times crops are irrigated during a season (4 countries reporting) and/or the frequency of irrigation in terms of days between irrigations (5 countries reporting), and the volume of water used per season (5 countries reporting). Not surprisingly there is a very wide range, as these data reflect variation in soil water holding capacity and evaporative demand, both of which vary among and within countries. The data provide good descriptions of what farmers do, but not why they do it, and are therefore inadequate for comparing one country with another, or for evaluating the practices in a country. The data describe the results of the tactical decision making at a farm level, but do not tell us anything about how farmers go about the business of deciding when to irrigate. There are two aspects to sound practice - getting the timing right and getting the amount of water right. Data on crop water requirements based on evaporative demand and soil water holding capacity are needed in order to:

1. evaluate application and conveyancy efficiency (how much of the water available is used in evapotranspiration (ET)),
2. evaluate agronomic water use efficiency of the crops (kg of lint or seed cotton per volumetric unit of water used in ET),
3. evaluate the risks of salinity and rising water tables,
4. compare countries and regions.

In the canal systems of Pakistan, India and Egypt the decision to irrigate is supply driven - that is, the time to irrigate is determined by when water is available in the canal, which is usually once a week on a turn system. A similar supply driven system may prevail in Uzbekistan, though the report describes the decision making as 'empirical' meaning it is based on the experience of the operator who subjectively evaluates the state of the crop and soil. The reports for Mexico and the Yangtse area of China refer to decision systems or programs developed by re-

search, but do not describe their technical or scientific content, nor the extent of their adoption. In Uzbekistan a computer-based scheduling system has been developed and tested that not only determines when each field should be irrigated, but it also estimates the amount of water needed for each field and collates the requirements for all the fields supplied by one canal so that the engineer responsible knows how much water to release into the canal for the next 10 days. There is a proposal to extend this system from one district to the whole country with the support of the World Bank. The rainfed crops in the Yellow River Valley of China only need supplementary irrigation in spring and early summer while those of the Yangtse River Valley need it in mid summer (July and August).

Evaluation of Irrigation Practices

It has been suggested that supply driven systems cause over-irrigation, as crops may be irrigated whenever water is available in the canal whether they need it or not. However over-irrigation can only occur on a season long basis if supply exceeds demand for the whole season, which is not the case. Supply driven systems have the potential for over-irrigation early in the season, when supply is greater than demand, and for under-irrigation mid and late season when supply is less than demand. Whether or not such over- and under-irrigation actually occurs cannot be determined from the information given in the reports. Both over- and under-irrigation will reduce yields. Too frequent irrigation early in the season promotes vegetative growth,

Table 2.10: Crop Water Requirements Based on Evaporative Demand, Water Applied and Yield

Country, Climate and Region		ET for season mm	Rainfall for season mm	Deficit for season mm	Water applied mm	Yield lint kg/ha	Application efficiency	WUE ¹ kg/ha/mm
Arid Climates								
Egypt	Lower	969	12	957	619	920	1.55	0.95
Egypt	Middle	1044	7	1037	762	945	1.36	0.91
Egypt	Upper	1390	0	1390	1071	923	1.30	0.66
Uzbekistan	North & west	824	96	729	1370	830	0.53	1.01
Uzbekistan	South & east	1232	35	1197	2500	830	0.49	0.67
China	North west	860	136	724	675	930	1.07	1.08
Semi-arid Climates								
Pakistan		826	213	613	1102	647	0.56	0.78
India	North	817	269	548	220	400	2.49	0.49
Humid Climates								
India	Central	813	973	-160	200	120	-	0.15
India	South	1049	598	451	756	275	0.60	0.26
China	Yellow R	654	671	-16	?	462	?	0.71
China	Yangtse R	710	790	-80	169	903	-	1.27

¹ WUE Plant Water Use Efficiency

pushing the balance between vegetative and reproductive growth in favor of vegetative growth and resulting in rank crops with concomitant heavy boll shedding, reduced yields, problems with pest control, boll rot and defoliation. Under-irrigation in mid and late season results in water stress that reduces yields. In this situation, well water can provide a valuable supplement.

Although data on crop water requirements based on evaporative demand are lacking from the country reports, suitable data are available from other sources (FAO 1987, HMSO 1977, pers comm June McMahon, pers comm Wayne Meyers), and are included in Table 2.10 together with the seasonal amounts of water applied and yields from the country reports.

Seasonal ET ranges from 654 mm in the Yellow River region of China to 1390 mm in upper Egypt. Differences among regions mainly reflect differences in the amount of advective energy (energy in hot dry winds) available to the crops and the length of the season. Rain falling during the cotton season ranges from nil in upper Egypt to nearly 1000 mm in the central zone of India. The deficit for the season is crop evapotranspiration less rainfall. For a particular field, run-off should be included in the water balances.

The water applied is the amount given in, or calculated from, the country report. As far as can be judged from the reports these are the amounts delivered to the farm gate, though it is not always clear whether it is the amount at the canal head or the farm gate. Therefore these amounts may not represent the same entity for each country, and comparisons should be made with caution. The amounts reported are in various units and have been converted to mm. (It is understood that the data in the China report is cu m per ha, not mm.) For Pakistan the water applied is the mean for all summer crops calculated from water available at the farm gate (in million acre feet) for the whole country and the area of summer crops in ha. In Uzbekistan the figure in the table is the mean for the country, but in some regions almost 3 times as much water is used (36000 cu m per ha, or 3600 mm) which could include excessive water for leaching salts.

The last two columns of the table are attempts at a technical evaluation of irrigation practices. Because of the qualification already made they should be accepted with caution. Application efficiency is the ratio of evapotranspiration deficit to water delivered to the farm. WUE is the yield of lint per ha per mm of water used in evapotranspiration.

Engineering Efficiency

The application efficiency values in Table 2.10 estimate how efficiently water delivered to the farm gate is used in meeting the evapotranspiration requirements. They take account of losses from intra-farm channels and by deep drainage from the fields, but not losses during conveyance to the farm gate. Loss by deep drainage may include water used to leach accumulated salts to combat salinity.

For Egypt, north west China and north India, the application efficiency apparently exceeds unity, which means the water applied was less than the deficit. This result indicates that irrigation was not sufficient to meet the deficit, or the water table is close enough to the surface for crops to draw water from it (probably true for Egypt), or ET for the season is over-estimated.

In Central India and both regions in eastern China the deficit for the season is negative, which means that the rainfall exceeded evapotranspiration for the season. This does not mean crops do not need or respond to irrigation because there may be periods of deficit during the season. However, it does mean that application efficiency cannot be calculated for the season.

Although application efficiency does not take account of losses during conveyance in the inter-farm canal system, some information on this topic can be gleaned from some country reports. In Uzbekistan, if 13700 cu m per ha is the amount at the farm gate and 33000 cu m per ha is the amount at the canal head (in the report 54-58 cu km is said to be used to irrigate 1.7 M ha

of cotton), then over 60 percent is lost in the inter-farm canals alone, which is not consistent with the 36 percent reported in the text as lost from both inter- and intra-farm canals. However, it is more likely that 54-58 cu km is the amount used to irrigate all land (4.2 M ha), in which case the 36 percent loss is consistent with 13700 cu m per ha delivered to the farm, and up to 26000 cu m per ha in some regions is lost or used for winter leaching of salts. In Pakistan 70 percent of the water at the canal head is delivered to the farm, implying a loss during conveyance of 30 percent. Some of the conveyancy losses are evaporation but most are seepage from canals into the groundwater which contribute to rising water tables.

Agronomic Efficiency

The term water use efficiency (WUE) is used in various ways (Hearn 1995):

1. **physiological WUE** - the ratio between the rates of photosynthesis and transpiration gives the amount of CO₂ fixed per unit of water transpired over a short time span (1 day or less).
2. **plant WUE** - the yield (biological or agronomic) produced in a season per unit of water transpired giving the biological WUE or agronomic WUE respectively of the plants. It measures how efficiently plants use the water that passes through them.
3. **crop WUE** - the amount of agronomic yield produced in a season per unit of evapotranspiration, thus taking account of soil evaporation (the E of ET) as well as crop transpiration. It measures how efficiently crops use the water for evapotranspiration.
4. **field WUE** - the increase in agronomic yield produced by irrigation per unit of water pumped or diverted for irrigation, thus taking account of engineering irrigation efficiency (how much of the water released or pumped for irrigation is used in ET).

Any calculations to establish WUE figures are based on the assumption that all biotic and abiotic crop production factors are optimally managed. This study focuses on crop WUE which is statistically estimated in Table 2.10. Carbon dioxide and water vapor exchange are linked by sharing a common diffusive pathway through the stomata, and both are driven by solar radiation. It might therefore be expected that the amount of CO₂ fixed per unit of water transpired (physiological WUE) should be a unique constant for a crop, and consequently that the crop WUE might also be constant. However, neither physiological WUE nor crop WUE are unique constants because there is one source of energy for photosynthesis (solar) and two sources for transpiration (solar and advection). The proportion of advective to solar energy is not constant but varies between environments, being high in desert climates such as upper Egypt and Uzbekistan and low in humid climates such as eastern China and southern India. Consequently crop WUE is lower in desert climates than in humid climates, all else being equal. Irrigation practices influence variation in soil evaporation (E) as a proportion of ET, also contributing to variation in crop WUE.

The values in crop WUE in the table show a wide variation, some of it attributable to variation in advection and soil evaporation, but most are associated with other factors affecting yields such as poor crop and poor management. All values fall short of those obtained in fully controlled research with intensively irrigated crops for which values range between 2.27 and 3.76 kg lint per ha per mm (Hearn 1995). In Australia values of 2.25 kg lint per ha per mm are common for well managed commercial crops.

Sustainability

Cotton production is not sustainable when it depletes or degrades non-renewable resources, either those used in cotton production, or resources affected by cotton production. The potential of irrigation to have a major impact on the environment has been noted, but the issue has not been adequately addressed in the country reports. Three major environmental issues are involved: (i) salinity and rising water tables, (ii) contamination of groundwater, and (iii) degradation of wet lands and lakes.

Salinity and Rising Water Tables

Salinity is inevitably a threat where irrigation plus rainfall is less than the evaporative demand. All irrigation water, even the best quality, contains some salts which accumulate in the soil if not leached out. If irrigation plus rainfall exceeds evaporative demand as usually occurs in humid regions, there is a net downward movement of water through the profile and salts added by irrigation are leached. In arid regions the threat becomes a reality. In past millennia, salinity has caused the demise of irrigation systems and the civilizations dependent on them. The extent to which cotton production is affected or threatened globally by salinity is not known. Shalhevet & Kamburov (1976) report that more than half the irrigated area in 24 major irrigation countries is affected by salinity. Without exception, all the countries with desert and Mediterranean climates in the broad belt of irrigated cotton that stretches from Spain to central Asia, and those with similar climates in the west of North and South America, have salinity problems. Egypt, Pakistan, the northern zone of India, Uzbekistan and NW China fall in this belt and all mention salinity problems in their reports. In Uzbekistan 50 percent of the irrigated area is affected by salinity, with 20 percent described as medium or high. In Pakistan 15 percent of the irrigated area is affected. Brazil also reports salinity problems in its small irrigated crop.

Saline soil or saline irrigation water reduces the availability of soil water to the crop. Its effect on crop growth is, therefore, similar to severe water deficit. In many crops salinity also has a toxic effect but cotton is able to exclude the sodium ion. Cotton is one of the most salt-tolerant field crops; only barley is marginally more tolerant (Hoffman et al 1983). Herein lies a danger; salinity may be allowed to get worse before action is taken. Varietal differences in tolerance to salinity have been reported (Fowler 1986) and varieties with increased salt tolerance have been bred in Uzbekistan. However, such varieties will only gain time for a few years until salt levels increase further, unless a stable, acceptable soil salinity state is reached.

Where salinity is an inevitable hazard, the primary curative and preventative solution is to ensure a net downward flow of water through the root zone by applying additional irrigation, with adequate drainage to remove the excess where there is a risk of raising the water table. These are primarily engineering, not agronomic issues, though the extra water needed for leaching reduces the field WUE. Disposal of saline drainage water is a concomitant problem. Return to rivers and water courses creates environmental problems. The options are discharge into the ocean (e.g. Pakistan), into evaporation basins (e.g. Australia) which involves sacrificing land, or recycling saline water to irrigate more tolerant crops. China, Egypt and Uzbekistan specifically mention extra water requirements for leaching, the last two quantitatively.

Rising water tables associated with over-irrigation exacerbate the salinity problem by causing secondary salinisation. Rising water tables are in turn exacerbated by the need periodically to apply irrigation in excess of the ET requirement in order to leach salts out of the profile. The risk of rising water tables can be reduced with improved technology to schedule and

apply water in order to avoid excessive irrigation. Fifty percent of the irrigated area of Uzbekistan is affected by shallow water tables resulting from over-irrigation and leaching for salinity control. Drainage is an urgent priority. In Pakistan 10 percent of the summer cropped irrigated land is still affected by shallow water tables, but 6 M ha have been reclaimed in the last 33 years with a series of 50 Salinity Control and Reclamation Projects (SCARPs) in which 20,000 vertical drains (tube wells) were installed and 10,000 km of drains were excavated. Egypt, the northern zone of India, and NW China also have problems with shallow water tables. Egypt has a national drainage scheme which is being implemented with assistance from the World Bank. In the Yellow River and Yangtse River Valleys of China drainage is required not only for salinity control but also because heavy rainfall causes flooding, shallow water tables and water logging. Elsewhere, drainage appears to be generally adequate in China, Egypt and Pakistan, but is described as poor in Uzbekistan and Mexico.

Contamination of Groundwater and Rivers

Cotton production carries a significant risk for contaminating groundwater and rivers with nutrients, salt and pesticides, because it is often a heavy user of agricultural chemicals. Irrigation in excess of ET requirements, and leaching for salinity management increase the risk of groundwater pollution. The risk to water courses is related to discharge of contaminated runoff and drainage water. More efficient irrigation to minimize water use will reduce the risk while leaching for salinity management should be accompanied by effective drainage. The risk of runoff in irrigated production, can be reduced by engineering work. Engineering solutions for dealing with drainage water were discussed in the previous section.

Degradation of Wetlands and Lakes

Diversion of water from a river for irrigation, if not replenished, deprives ecosystems downstream of water, resulting in their degradation. To put this into perspective, cotton production only occupies 7.3 percent of the world's irrigated land, and uses a smaller fraction of the water resources but probably contributes much more to the world economy. For example in Australia, cotton uses only 15 percent of the irrigation water but produces 35 percent of the export revenue generated by irrigation. These facts should be taken into account in the allocation of water resources to cotton production. If water supplies for cotton are restricted as a result of political action, using water more efficiently becomes of even greater importance. It is a major issue in Central Asia where there has been a massive reduction in the area of the Aral Sea (Musaev 1993, Perara 1993), to which the Uzbekistan country report gives due prominence.

Proposals for the Improvement of Irrigation Efficiency

Despite the potential of irrigation to increase production on one hand and to degrade the environment and reduce production on the other, and despite the mention in the country reports of salinity and rising water tables as a result of irrigation, there is relatively little reference in the country reports in the challenges and recommendations, or in the problem and objective trees³, to irrigation and its associated problems, with one exception, Uzbekistan. There are several reasons why other countries may not have done this in their reports:

There is not enough information to determine which, if any, of these explanations applies in any one country. However four related challenges common to most countries warrant

³ Refers to Problem and Objective Trees in Country Reports.

emphasis: (i) modifying the operation of canal systems, (ii) introduction of new irrigation technology, (iii) introduction of irrigation scheduling and (iv) pricing of irrigation water.

Modifying Old Systems

Modification of old, large canal systems needs to be investigated jointly by agronomists, engineers and economists. With myriads of small farms, long lead times between the source and farm for release of water, and without on farm storage, operating large canal systems on a demand basis is not easy. It is unlikely to be possible for farmers to be able to order water on an individual basis, as in Australia for example. However the possibility should be investigated of limiting flows in canals to the average demand for the stage of the season. Increased storage in dams and reservoirs may be needed to facilitate the storage of more of the early season river flows, and to match canal flows to the current requirements of crops. This would have to be accompanied by education of farmers to water crops only as needed both in respect to timing and amount.

There is further potential to increase the efficiency of old systems. In view of the losses from inter- and intra-farm canals, there is scope for more concrete lining and coverage of canals. Better land leveling with sufficient gradient of between 0.5 and 3.0 percent, would result in faster irrigation with smaller volumes of water and less drainage losses. Gradient leveling could be improved by the use of laser leveling or development of simpler technology. These recommendations should, however, be economically justifiable in all cases.

Introduction of New Technology

The opinion in most countries, apart from Uzbekistan, is that drip and sprinkler systems are neither compatible with gravity fed canal systems, nor economic at current yield levels. However drip irrigation, and similar fully reticulated precision systems, that deliver water direct to the soil at frequent intervals, have advantages for salinity and water table management, and their use should not be dismissed without being explored. Low cost, low pressure drip systems are being developed (Miller 1990). The use in China of thin hard buried plastic tubes for irrigation from wells is worth investigation with view to its use in other countries.

Drip irrigation, with its precise application of small controlled quantities of water, has great potential for preventing the over-irrigation that causes the risk of salinity, rising water tables, contamination of groundwater, and downstream ecological degradation, particularly on light-textured soils where excessive percolation of drainage water into the groundwater table occurs with conventional methods. However, drip irrigation systems are costly so economic considerations also need to be considered.

Drip irrigation makes it much easier to keep the soil water content within the narrower limits of availability caused by salinity, and thus allows cotton to be grown on soils or with water that would otherwise be too saline (Shalhevet 1984, Mantell et al 1985, Anon 1983). Moderately saline water (<2000 ppm) can be used either alone or conjunctively with fresh water. The options for conjunctive use of fresh and saline water are (i) fresh water on sensitive crops, saline water on tolerant crops, (ii) blending, (iii) applying fresh and saline water alternately and (iv) applying fresh water for part of the season, preferably the early part when crops are most sensitive, and saline for the rest. Drip irrigation enables moderately saline drainage water and urban domestic wastes to be recycled, reducing requirements for fresh water (Shalhevet 1984, Afanas'ev et al 1991, Rhoades 1983, Bradford & Letty 1992, Bielorai et al 1984, Oron & Malach 1987, Papadopoulos & Stylianou 1988).

Introduction of Scheduling

Irrigation scheduling is the use of objective scientific criteria for deciding when to irrigate the crop. There are three components: current data from the crop, a data base and a knowledge base. It does not have to involve the use of hi-tech hardware or software but can consist of a simple 'rule of thumb' that incorporates the three components. However, scheduling by itself is not going to prevent over-irrigation unless it takes into account the amount of water applied as well as the timing. Too much water can be applied at the right time, just as easily as when irrigation is too frequent. Noontime wilting is sometimes used as an indicator but is only applicable when water is readily available at all times, such as from tubewells in Pakistan.

Research is needed into scheduling for 'turn' systems. For example, could scheduling be used to determine whether to irrigate this turn or to defer irrigation until the next? Could scheduling be used to determine the amount of water to apply? If so, techniques are needed to apply specific volumes of water onto fields of small holdings.

Pricing of Irrigation Water

Pricing of irrigation water is a sensitive issue. The World Bank is committed to pricing water eventually, but is feeling its way cautiously. The tenet that 'water belongs to the people' is enshrined in the culture of many countries in the study. In several countries, use of water is influenced, if not controlled, by Shari's Law which prohibits the selling of water and states that water belongs to the people (Caponera, 1973). Consequently water is traditionally supplied free, as in Egypt and Uzbekistan, or with a minimal annual charge for operational costs as in Pakistan and the northern zone of India. No information is given for China, and in Mexico it is not clear if the transfer of the administration of the irrigation zones to the farmers under the government's new economic strategy will result in pricing of water. Farmers do not pay on a volume basis in any of the nine study countries.

Although charging full cost of water would be unpopular, it is highly desirable in order to provide an economic incentive for farmers to use water more efficiently and adopt water conserving practices. One possibility would be to give each farm a free allocation of water based on climatological crop water requirements and to fine farms for use of water in excess of the planned allocation. The fines could be heavy (much greater than the marginal value of the water) and strictly enforced. As is the case for scheduling, this would require a simple technology to measure the volume of water taken by each farm and an effective means of enforcement. Several metering devices are available for this purpose.

Concluding Remarks on Irrigation

It is clear that there is considerable scope in all the study countries to increase production of cotton, and make it more sustainable, by improving the efficiency of irrigation, even though this is only recognised in Uzbekistan. Improved agronomic efficiency (yield per unit of water used in ET) will come from raising yields, partly by improving irrigation agronomy but mainly by removing other limitations to yield, both of which require action by the farmer. Improved engineering efficiency (volume of water used in ET per unit volume of water at canal head or pumped from a bore) requires action from both the farmer and the engineer operating the system. When these improvements are achieved it will result in more production from less water, and with increased sustainability and less risk to the environment. The water saved can be used to irrigate more land to increase production further or to conserve the downstream environment.

Crop Protection

In general cotton production is seriously affected by insect pests and weeds in all countries but detailed data on crop losses are sketchy. Worldwide losses due to these causes are estimated at 70,218 thousand mt, made up of 11.8 percent due to weeds, 15.4 percent due to insect pests and 10.5 percent due to diseases (Oerke et al, 1994). Thus plant diseases have had less impact, but there are significant exceptions, including the present problem of leaf curl virus in Pakistan and an increasing problem of *Fusarium and Verticillium* in soils in several countries. Although the cottonbelt in the USA covers a wide range of environmental conditions, data on crop loss estimates in the US have been included as indicative of the severity of losses caused by specific weeds, diseases and nematodes.

Weed Control

Cotton seedlings are very sensitive to competition, particularly during the first six weeks. Some of the weeds that are major problems in the USA are among the world's most noxious and are among the most widely reported in the cotton study reports (Box 2.5). They include bermudagrass, *Cynodon dactylon*, purple nutsedge, *Cyperus rotundus*, barnyardgrass, *Echinochloa crus-galli*, goosegrass, *Eleusine indica*, johnsongrass, *Sorghum halapense* and common purslane, *Portulaca oleracea* (Murray, et al, 1992). Morningglory, *Ipomoea* spp. is the most important US weed, causing an estimated reduction in yields across the cottonbelt of 21.1 percent in 1990. This was followed by cocklebur, *Xanthium* spp, which caused yield losses estimated at 11.1 percent (Byrd, 1991). Nutsedge, *Cyperus* spp. is the most widespread narrow leaf weed, causing crop losses in the US estimated at 8.5 percent in 1990. However, the extent of damage caused by these weeds varied considerably in different parts of the belt.

Box 2.5: The Major Weeds in the Nine Study Countries

Digitaria spp.	Ipomoea spp.	Abutilon theophrasti
Echinochloa crus-galli	Portulaca spp.	Chenopodium spp.
Cyperus rotundus	Setaria spp.	Amaranthus viridis
Sorghum halepensis	Commelina communis	Convolvulus arvensis
Xanthium spp.	Cynodon dactylon	Trianthema spp
Amaranthus retroflexus	Paspalum spp.	

Due to the wide range in the distribution of cotton growing areas and different ecological conditions in the nine countries, regional studies would be needed to gain a full understanding of the weed situation and its economic impact.

Most countries rely on cultural weed control on at least two to three occasions, for example after irrigation or rain when more weed seeds germinate. On large farms as in Uzbekistan, tractor cultivation is routine, but inter-row cultivations do not remove weeds within the row, and may damage the cotton roots. Delayed weeding leads to strong competition for light, water and nutrients, between weeds and young seedlings, including the rhizosphere, frequently resulting in excessive internode elongation, leggy, weak plants and loss of the bottom fruiting bodies, promoting vegetative growth.

Weeding is a very labor intensive operation and labor for weeding is frequently a problem in countries such as Tanzania, Mali and India because of competition with other crops. On small farms, the demand for labor over the first few weeks of plant growth limits the area that

can be effectively weeded. There are instances as in Tanzania where oxdrawn or tractor schemes prepare more land for cotton than can be weeded by traditional means.

Appropriate equipment for mechanical weeding is not always available or affordable by small farmers. In Mali the local production of well adapted bullock drawn equipment is well organized and the report indicates that the yield is directly correlated with the available equipment per farm. This indicates that mechanical weeding has played an important role in the intensification of the crop, by facilitating better timing of field operations. Moreover, the availability of equipment enables smallholders to pay more attention to their food crops.

Use of herbicides, such as fluometuron and trifluralin is generally limited to the large farms which sometimes use a band treatment, supplemented by inter-row cultivations. The use of herbicides varies considerably between countries. The possibilities of using herbicides are understood at least at the research level, but the potential economic impact of introducing these products is not always clear. One of its main considerations for small and medium scale farmers is that even though the use of herbicides involves an investment, it would allow them to 'buy' time for other important tasks.

In China, the use of herbicides is said to be increasing, with mixtures used to extend the spectrum of weeds controlled. Polythene mulch is also used to increase soil temperatures and promote early growth. Trifluralin is applied before sowing to control grasses and then cultivators cover the Polythene strip which continues to act as a barrier, preventing weed germination in the intra-row. The Pakistan report discusses the development of herbicides which would need a strong extension input to create farmer awareness of the merits and demerits of these products. Farmers are accustomed to taking care of weeds when they are present in the field but the introduction of prophylactic measures at planting, requiring the application of a product before any weeds are present, calls for education. Post emergence application would certainly be more easily understood, but this would require special equipment to prevent damage to the seedlings. Moreover, timelines in the use of post emergence products is as important as timely weeding since delayed applications would not prevent the impact of the weeds on yield.

The feasibility of smallholders using herbicides is supported by data from the Cote d'Ivoire in West Africa where up to 20 percent of cotton acreage is treated, mainly with post-plant - pre-emergence products, frequently mixed with a contact herbicide when weeds have grown on the ridges prior to planting. In Mali, three liters per hectare Ultra Low Volume, Controlled Droplet Application (ULV/CDA) pre-emergent herbicide sprays have been applied with a 'Handy' sprayer. There is no indication of the extent of this practice but it is understood that only about 10 percent of the area is treated, mainly with pre-emergence products and especially on bigger farms. Since the end of the 1993 season, herbicides have only been available in Mali from the private sector. The regulation of agro-chemicals needs to be considered in all its aspects, including the evolution of this technique under prevailing conditions. This aspect is discussed later in this section and in Chapter 5 on Regulatory Functions.

In general little information is provided either on active ingredient or on the importance of herbicide consumption in the study country reports. The Brazil report mentions only the active ingredients applied, either alone or in mixture but gives little information on the extent of herbicide use. In neighboring Argentina, pre and post emergence herbicides are applied either by hand or mechanical sprayers but on a rather limited scale.

Data are available on the active ingredients available on the market in India, but not on the importance of herbicides at the farmer level. It is obvious that in such a complex situation, due to the wide range in the distribution of cotton growing areas and different ecological conditions, a regional, in depth study would be needed to obtain a better image. This is true for all aspects of crop production.

No mention is made of the area treated in China, even though quite a lot of detail is given regarding the interest in the use of herbicides. Basically cotton is planted in small to very small fields where mechanical (hand) weeding is the rule. Where big farms are concerned, the use of herbicides is more common when plastic films are used to allow earlier planting and induce earliness. Under these conditions, weed control is up to 96.0 percent and the persistence of the products is improved, especially when a mixture of active ingredients is applied.

In Uzbekistan, herbicides have been used in the past but financial restrictions on inputs have curtailed the use of all types of agro-chemicals over the past few years.

The main weed problem in Pakistan is created by *Trianthema monogena*, which if not controlled in time, creates big losses, due to its 'creeping' habit and massive production of seeds which are easily transported by irrigation water. Chemical control is performed with pre-plant products, incorporated at the time of seed bed preparation or at planting. This treatment results in a very clear increase in yield and better bottom crop production when compared with hoeing once or twice, but it is not widely applied. There is a lack of interest caused by price and absence of extension. About one percent of the farmers, particularly large scale growers, use herbicides regularly. This technique requires development where justifiable. The problem with controlling *Trianthema* is serious in rainy weather which does not permit tractor cultivation.

Late sowing of cotton is often due to the need for the farmer to give priority to sowing and weeding food crops. This was noted in the Tanzania report, but is a feature of all small-scale farms relying on family labor. Unfortunately there are no effective post-emergence broad-leaved herbicides available to apply to cotton, yet farmers in areas of unreliable rainfall usually wait to see if a crop is established before committing time and effort to weeding. Improvement in cotton could therefore be achieved also by changes in the establishment of maize and other crops, such as use of band treatments with herbicides.

Weeds are recognized as an important problem which can reduce yields significantly. However, relatively little work has been done to develop systems appropriate to the smallholders so that they can manage a larger area of cotton relative to their other crops.

Transgenic Herbicide Tolerant Varieties

Tremendous advances have been made over the past few years in the development of chemical and mechanical weed control methods but despite this, broadleaf weeds like morning-glory, *Ipomoea* spp. and cocklebur, *Xanthium* spp. and narrow leaf weeds like nut sedge, *Cyperus* spp. continue to reduce yields and quality even where chemical control is widely practiced. Pre-emergence and pre-plant incorporated products may not work well in abnormally dry or wet weather and pre-plant incorporated products cannot be used in no-till or relay cropping situations. Virtually all post emergence broadleaf herbicides require directed applications which are time consuming and can only be made effectively when the cotton seedlings are higher than the weeds (Sunderland et al. 1995). Even then, most of these products cause substantial crop injury, resulting in delayed maturity and reduced yield and quality.

The recent development of transgenic, herbicide tolerant varieties has widened the range of products available to farmers for post emergence application. BXN cotton is one of the first of these varieties to be marketed. A gene from the soil bacterium *Klebsiella ozaenae* that produces the enzyme nitrilase has been inserted in certain cotton varieties. Nitrilase restructures nitriles which are present in bromoxynil and renders the herbicide inactive. Bromoxynil (Buctryl) is an old contact herbicide that is widely used on graminaceous crops to control broad leaf weeds. When used on BXN cotton, bromoxynil effectively controls some of the worst broadleaf weeds including morningglory, *Ipomoea* spp., cocklebur, *Xanthium* spp., velvetleaf, *Abutilon theophrasti*, hemp sesbania, *Sesbania exaltata* that are resistant to the normal range of herbicides used on cotton (Murdock and Toler, 1995). Glyphosate resistance enables farmers to use this product against the persistent and difficult to control weeds such as nut sedge, *Cyperus* spp. and Johnsongrass, *Sorghum halepensis* (Wilcut, 1995).

Very little has been done to enable herbicides to be used by smallholders. It is unlikely that herbicide resistant varieties will play any role in countries that have not developed the technology to use herbicides but rely mainly on mechanical and hand cultivation for weed control.

Diseases

Table 2.11 summarizes the estimated crop losses due to various diseases across the cottonbelt in the USA in 1992 total crop of 3,531 thousand metric tons.

In China, estimated losses due to wilt diseases were about 100,000 tons of lint, with about 16 percent of the cotton growing areas either lightly, moderately or heavily infested (Shen, 1985). According to Bell (1992) the current losses worldwide due to cotton wilt are about 1.5 million bales of lint, worth more than US\$1 billion. *Fusarium* wilt is estimated to cause losses of 0.2 percent in the USA, but individual fields may suffer far greater losses (Hillocks, 1992). It has been suggested that 10.0 percent of a crop may suffer wilt before yields are affected. Losses caused by leaf curl disease in Pakistan are estimated at about 30.0 percent although some estimates placed the figure as high as 38.0 percent in 1993-94 against the benchmark production of 2.18 million mt in 1991-92.

As mentioned above, control of the important diseases is primarily by host plant resistance (e.g. *Xanthomonas*) and crop rotation (e.g. *Verticillium* and *Fusarium*), but there are a number of seedling diseases which occur principally when plant growth is slow immediately after germination of the seed. Seedling vigor, which is dependent on seed quality, is one of the main factors in influencing losses due to the seedling disease complex. In Uzbekistan where soil temperatures are low at the time of sowing, the effect of brown root rot necessitates the annual resowing of 230 - 330,000 hectares (i.e. about 20 percent of the area). Seedling diseases are checked in some countries by fungicidal seed and/or soil treatments. Acid delinted seed is preferred where machine sowing is practiced, as this removes pathogens from the surface of the seed, although some infection can still survive under the seed coat. In China, just over 30 percent of the cotton area is established by transplanting seedlings, and 20 percent is sown under

Table 2.11: Losses Due to Diseases in the 1992 USA Crop of 3,531,000 mt.

Cause of Loss	'000 mt	Percent
Seedling Diseases	181.48	5.14
Nematodes	114.67	3.25
Ascochyta Blight	102.19	2.89
Boll Rots	84.04	2.38
Verticillium	53.38	1.51
Phymatotrichum	35.27	1.00
Leaf Spots	16.17	0.46
Fusarium	12.61	0.36
Bacterial Blight	5.52	0.16
Total	605.33	17.14

polythene mulch sheets. Both techniques enable early establishment of the crop and reduce the effects of seedling disease.

Pakistan has a major problem with the cotton leaf curl virus disease, transmitted by whiteflies. The problem is similar to that in the Sudan in the 1920s where plant resistance has been successful, so the main approach must be by host plant resistance. However in an IPM program other aspects of disease spread must be considered including a reduction of the vector both on cotton and alternative host plants.

Nematodes

Several nematodes have been reported, including *Meloidogyne incognita* widespread in cotton areas, however, the main problems seem to be associated with inadequate rotation and the presence of wilt diseases. The toxicity of nematicides and their cost has limited the control of nematodes. In China changing to irrigated paddy fields with rice is said to reduce nematode populations in 2 - 3 years. In Egypt, *Gossypium barbadense* is regarded as generally resistant to nematodes. In Pakistan nematodes are not considered to do serious damage due to high soil temperatures and clay content of the soil.

Yield losses due to nematodes are difficult to identify when the nematodes are associated with diseases such as wilt. Furthermore, poor performance caused by nematodes is often attributed to poor soil fertility, drought stress, pH or weak fields (Goodell, 1995(a)). Table 2.12 summarizes the crop loss estimates attributed to nematodes in the USA from 1982 to 1992. The apparently alarming increase from 35 thousand metric tons in 1982 to 115

Table 2.12: Estimated US Crop Losses Caused by Nematodes

Year	Loss in Bales	Loss in '000 mt	Production '000 mt	Loss Percent
1982	161,023	34.942	2,605	1.34
1983	97,540	21.166	1,692	1.25
1984	294,081	63.816	2,826	2.26
1985	255,568	55.458	2,924	1.90
1986	238,975	51.858	2,119	2.45
1987	209,686	45.502	3,214	1.42
1988	215,570	46.779	3,355	1.39
1989	238,975	51.858	2,655	1.95
1990	337,436	73.224	3,376	2.17
1991	476,151	103.325	3,835	2.69
1992	528,432	114.670	3,531	3.25

Source: National Agricultural Statistical Service, USDA, Oct. 1993

thousand in 1992 is, at least in part, due to improvements in differentiating between the different causes of crop loss. Mean figures can also be misleading because of the wide range in the severity of infestation. These figures show a range of 1.25 to 3.26 percent but severely infested fields can lose as much as 50 percent of their potential yield (Starr, 1995).

None of the country reports gave precise estimates of losses due to nematodes. This could be due to an absence of data on the incidence of nematodes or to incorrect interpretation of the causes of crop loss. Clearly this is an area that requires attention, starting with training in the accurate identification of nematode species and in the assessment of nematode population densities (Goodell, 1995(b)).

Insect Pests and Integrated Pest Management

Over the last 40 years, emphasis has been placed on chemical control of pests (insects, pathogens and weeds), but the problems of major pests becoming resistant to pesticides, increasing importance of other pests, the cost of inputs and incidence of poisoning has led to the devel-

opment of integrated pest management. This involves harmonious blending of different control tactics, including biological, cultural and chemical controls, to minimize any adverse effects on the environment. Where chemical control is needed, the IPM approach is to reduce the number of applications by improving crop monitoring (scouting and pheromone trap data) and using actual thresholds to decide when to spray, with more efficient applications of selective pesticides.

The major insect problem is not the same in each country although bollworms (*Helicoverpa* spp., *Heliothis* spp. and *Pectinophora gossypiella*) are important in most of the countries reviewed. The boll weevil (*Anthonomus grandis*) is confined to the Americas, and in the last decade has had a major impact on cotton production in Brazil. Cotton leafworm (*Spodoptera littoralis*) is a major pest in Egypt. There is little mention of losses due to early season sucking pests. Consequently, the possible use of systemic insecticides as seed dressings or soil treatments against seedling pests is not discussed.

Cotton production in the study countries varies from large to small-scale farms and from irrigated to rainfed farming, thus affecting the potential yields and impact of pest infestations, the severity of which is influenced by the overall cropping practices and climatic conditions in each region. As an example, diversified irrigated cropping in the Nile delta has undoubtedly allowed good survival of natural enemies such as lacewings, and some pest infestations, such as the *Helicoverpa* bollworm, have been less than in rainfed crops in sub-Saharan Africa. In contrast the range of bollworm hosts, namely pigeon pea, chick pea, sorghum, maize, tomatoes, etc., in southern India has resulted in severe, prolonged infestations of bollworm. Expansion of maize areas in Tanzania is considered to be the cause of increased bollworm infestations on cotton. Major outbreaks of leaf curl virus in Pakistan are associated with susceptible varieties and increased populations of whitefly *Bemisia tabaci*, that survive periods without cotton on melons and other horticultural crops, the extent of which is increasing where irrigation is available.

Since the 1950's there has been increasing reliance on chemical control of insect pests, especially where the agrochemical industry has few if any restrictions on which products could be marketed to cotton growers. However, the extent of insecticide use has varied significantly between countries. Where excessive use has already occurred resistance to certain insecticides has developed. As in other cotton growing countries, such as Thailand (Cox and Forrester, 1992) and Australia (Forrester et al, 1993), resistance is considered to be a problem in Mexico, India and now in China (Anon, 1993). Resistance to insecticides by bollworms is not a problem at present in countries where pesticide use has been regulated as in Mali, Tanzania and Egypt.

In Mexico, India and more recently in Pakistan (from 1980) and China (since about 1985), there is freedom to market a wide range of formulations of single active ingredients or mixtures. Typical products include cypermethrin and chlorpyrifos. Use of these products has not been controlled within any cotton growing area so growers have used many different insecticides. With a lack of appropriate advice, growers initial reaction to poor control due to resistance is to increase the dosage, frequency of application or use of an ad hoc mixtures of two or more insecticides, all of which exacerbate the situation. Subsequently, when growers realize that the crop is no longer profitable, they change, wherever possible, to alternative crops. In Thailand, for example, the area of cotton grown decreased due to resistance of bollworms to pyrethroids, necessitating increased fiber imports to satisfy the local textile industry (Cox and Forrester, 1992). Since 1994, there has been a major reduction in the area of cotton sown in China.

In contrast, in Egypt, the Government has maintained a close control of insecticide use on cotton, with a current recommendation to limit the number of applications to 3-4 per season,

using an acylurea insect growth regulator, usually in combination with an organophosphate in the first spray, then an organophosphate and a carbamate. In Mali, each of the applications, usually 4-6 per season, has been a combination of pyrethroid with organophosphate. Similarly in Tanzania endosulfan or a pyrethroid ULV spray has been restricted to 6-8 applications. In practice many growers are said to use only 1-3 sprays per season and there are reports that the average is only 0.75 sprays per season. The reduced number of treatments is partly because of lack of inputs, but also because of lack of credit. Changes in the insecticide distribution system may lead to less expensive products becoming available, but these may not be of acceptable standard or appropriate for the area.

Only in Uzbekistan has there been a drastic reduction in insecticide use since 1980; partly due to the reaction to their overuse which resulted in extensive health problems and pollution of the Aral Sea area, and partly due to the apparent success of releasing parasitoid wasps, *Trichogramma pintori* and *Bracon herbator*, against noctuid pests (cutworms and bollworms) in an environment with an extreme cold winter. Since Independence, the availability of insecticides has been restricted by lack of foreign exchange.

In relation to many other factors affecting cotton production, integrated pest management may seem to be a small factor, but it must be recognized as one of the crucial factors. Without good economic pest management, there have been drastic falls in production, with growers switching to other crops, as witnessed in Thailand, China and Mexico and failure to produce acceptable lint in the Sudan due to excessive honeydew. In contrast production has increased in area such as francophone west Africa since 1975, following the widespread introduction of well organized ULV spraying (Cauquil, 1987).

Good cotton production also depends on the farmer obtaining a fair price for his efforts. While much of the expenditure on crop protection has been on insecticides, good integrated pest management will require a diversion of expenditure to crop monitoring and alternative tactics, such as the purchase of pheromone traps, natural enemies, new high quality seed of a resistant cultivar, improved stalk removal and changes in cropping practices.

Insect Infestation Data

One of the difficulties in assessing the crop protection programs is lack of data on pest populations. Variations in pest numbers in different locations and during seasons is not indicated in the reports. Some countries, such as Pakistan, have established an insect pest monitoring or warning system and claim that scouting has reduced the number of sprays from 10-12 haphazard treatments to 3-5 applications. Scouting also reveals changes in pest status. Thus a comparison of data from 1977 (Exhibit 2.4) (Vaughan, 1978) and 1990 (Exhibit 2.5) with the graphs in the present Pakistan report (1993) (Exhibit 2.6) shows changes in pest status with *Helicoverpa* and *Aphis* now included as pests and increased infestations of whiteflies and pink bollworm.

In introducing integrated pest management, one way of improving the timing of pesticide treatments and choice of chemical is by routine crop monitoring and using economic or action thresholds. It has been argued that economic thresholds (ETs) are not easy to determine and crop monitoring is too complicated for farmers to do. It may be that some national organization is needed to provide some data to compare areas and seasons, but crop monitoring by individual farmers has proved successful where it is simplified, directed at key decisions and quick. Thus in Central Africa a pegboard (Beeden, 1972), based on a sequential sampling technique, was aimed only at deciding how many bollworm eggs were present, but when numbers exceeded an

action threshold spraying would be required. More specialized sampling programs aim to determine the population of natural enemies, but the detection of beneficial species, apart from coccinellids or lacewings is difficult for individual farmers.

If some data are collected nationally it would be easier to assess if a particular control program was appropriate or not. Accumulation of such data over several years in a system allowing easy retrieval should indicate trends and facilitate planning.

Application Technology

The choice of application technique varies significantly between the countries but despite the importance of accurate application and concern about environmental pollution, few details are given. The Mexican report only mentions application in relation to herbicides; referring to manual, mechanical and aerial application. However, frequently, applications are made with the wrong nozzles or when weather conditions are unfavorable. Herbicides are not extensively used in any of the study countries so most of the following comments relate to insect control.

Aerial application has been used in many cotton growing countries for insect control but for various reasons, most are endeavoring to phase it out. In Egypt the policy is to have 70 per cent of applications with ground equipment rather than aircraft as fields are often small and insecticides have been applied to areas beyond the cotton fields. Unfortunately, traditional ground spraying techniques in Egypt using a portable line system with a stationary pump at the edge of the field, grossly contaminate the laborers. Efforts are being made to improve the situation.

In Uzbekistan aerial application was dominant, but with the trend to biological control, recent applications of acaricides, in particular, have been with an oscillating tractor-mounted mistblower which uses air as the carrier and blows the insecticide across about 12 rows.

State farms in China and the Government Pakistan have used aerial application, whereas the main application technique has been with manually operated knapsack sprayers. The quality of the sprayers and nozzles has been poor with leakages contaminating operators and irregular spray distribution. Similarly in India, the use of manually operated equipment is dominant, with many farmers using very cheap, syringe type sprayers (Matthews, 1993) which give an intermittent spray and excessive operator contamination. Another important factor is the lack of spray reaching the under surfaces of lower leaves where whitefly is a problem. Apart from Malawi, no country has encouraged the use of a rear mounted vertical boom ('tailboom') on knapsack sprayers to reduce operator contamination and improve insecticide distribution within the crop (Matthews, 1989). The capital cost of this equipment is greater than a standard knapsack, but in the long-term, there are benefits in terms of operator safety and improved spray distribution.

In China the larger state farms use tractor mounted boom sprayers and also apply plant growth regulators to keep plant height more manageable. Nozzles pointing laterally into plants have been used between the rows.

In Mali and Tanzania, the main method has been ultra-low volume (ULV) spraying with hand-held battery-operated spinning disc sprayers. This technique has the main advantage of allowing farmers to increase yields in areas where water supplies are poor. The main problems have been the increasing costs and packaging of small quantities of oil based formulations to avoid farmers measuring out the pesticide, as well as the supply of good quality batteries, although the number of batteries needed has been reduced by the improved design of sprayers.

Exhibit 2.4: Pakistan Punjab Agroecological System 1977-78

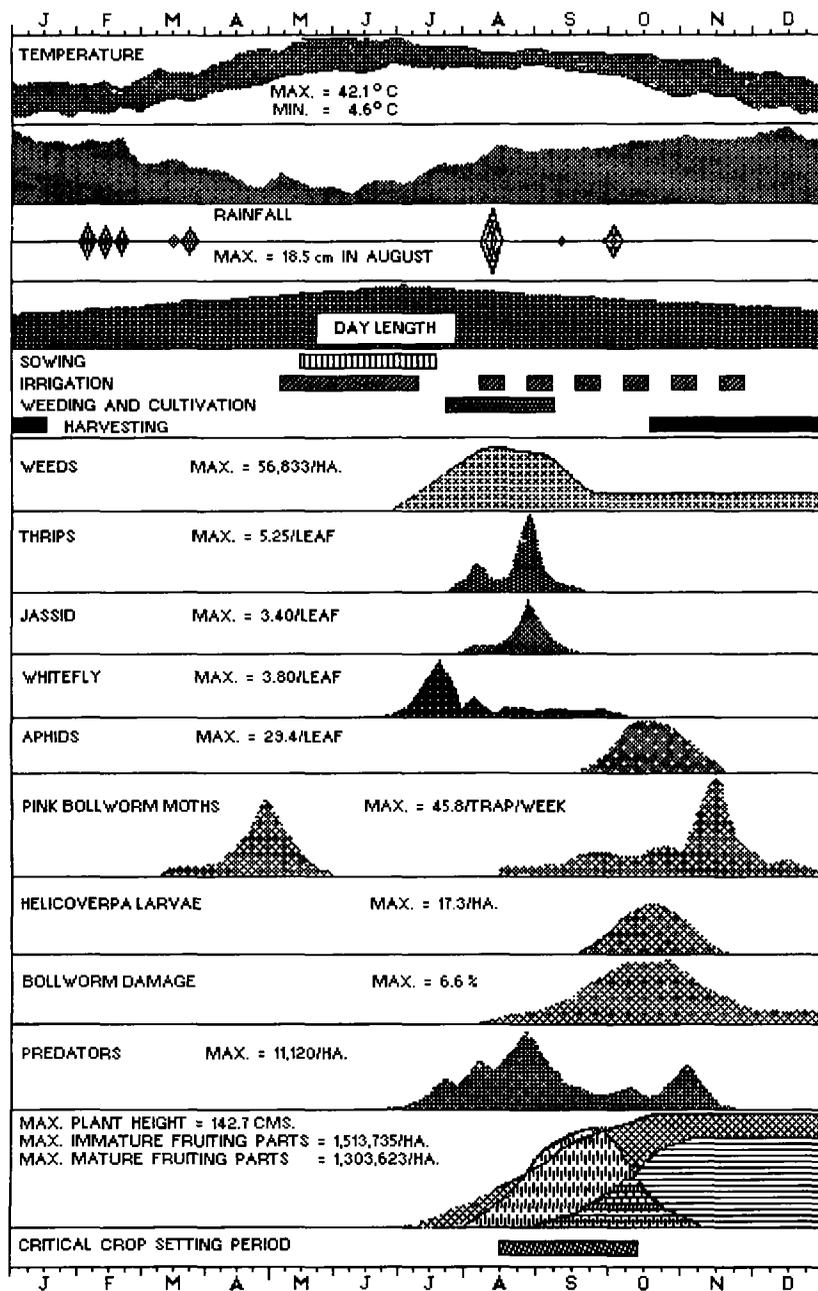


Exhibit 2.5: Pakistan Punjab Agroecological System 1990-91

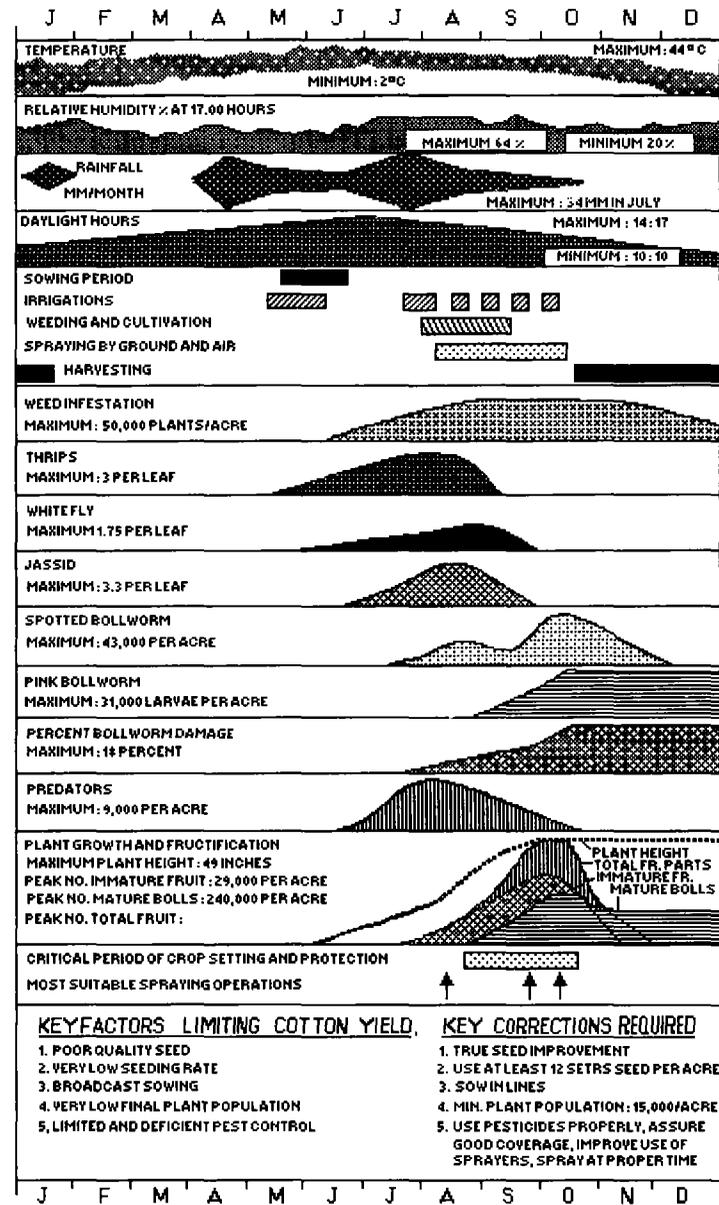
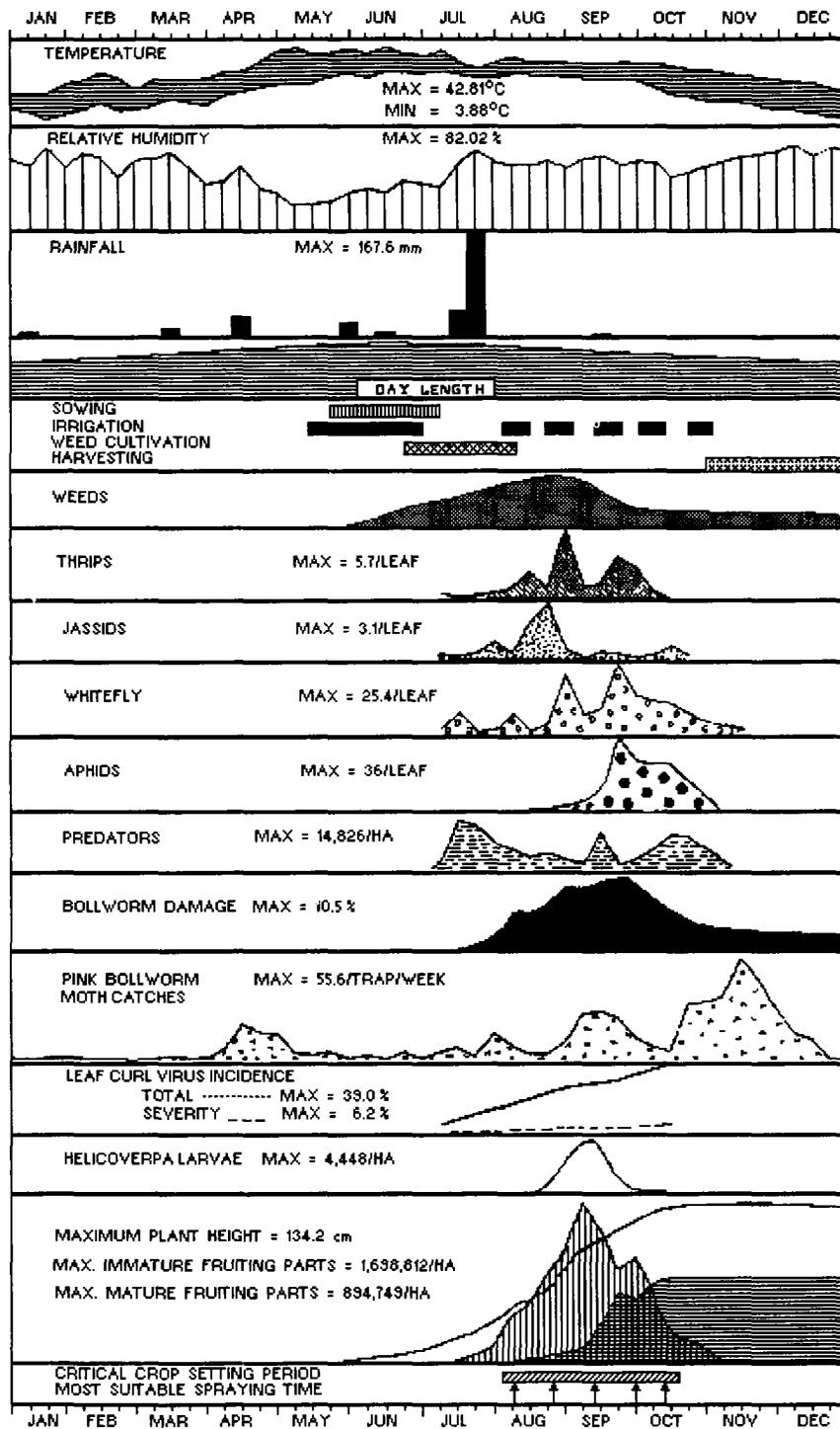


Exhibit 2.6: Pakistan Punjab Agroecological System 1993-94



In francophone Africa, there is a new trend to revert to water-based formulations using only very-low volumes (VLV) (Matthews, 1989b), namely 10 litres of water per hectare in contrast to the requirement for more than 100 litres per hectare with knapsack sprayers. A new spinning disc applicator requiring fewer batteries has been introduced specifically to meet the requirements of very-low volume spraying with conventional formulations. However, the distri-

bution of small packages of insecticide, training and aiding accuracy of application are crucial factors that need urgent attention for the smallholders. Too often in the past, insecticides were supplied to villages in 200 liter drums, although individual 250ml cans have been used in parts of West Africa.

Table 2.13: Variation in Insecticide Application Between Countries

Country	Area of Cotton (ha)	Number of Applications	Insecticide	Application Technique
Brazil	1.4 million		Pyrethroids and some others	Mostly tractor some aerial, ulv and knapsack
China#	5.6 million	2-30	Various	Mostly knapsack
Egypt*	0.4 million	3-4	IGR/OP/carbamate	aerial/ground HV
India#	7.1 million	0-30	Various	Mostly knapsack
Mali*	250,000	4-6	Pyrethroids + OP	ULV
Mexico#	25,000	4-30	Pyrethroids	Aerial
Pakistan#	2.5 million	4-6	Various	Mostly knapsack some tractor
Tanzania*	400,000	6-8 (1-3**)	Essentially only pyrethroids	ULV, ED
Uzbekistan	1.6 million	0-2	Sulphur	Tractor air-assisted

* Countries with specific recommendations and regulated supply of pesticides.

** number actually applied by farmers as opposed to recommendations.

Countries with major problems of insecticide resistance.

The 'Electrodyn' ULV sprayer has been used in Tanzania and Brazil, (Smith, 1989), but is no longer being actively promoted, despite many technical advantages. The main advantages were the elimination of water in areas of low rainfall, no mixing by the farmer and good coverage on plants that were not too large. The main problems are the limited range of active ingredients that can be formulated for the equipment and the restriction on the supply of the equipment to one multi-national agrochemical company.

One particular application technique may not be suitable for all countries or all farmers within a country. Smallholders need more advice and training together with a more reliable source of recommended inputs. Most areas need adaptations of better quality, more reliable knapsack sprayers and specific nozzles. The use of very-low or ultra-low volume technology is warranted to enable farmers to respond and treat their fields rapidly when action thresholds are reached, particularly where water supplies are limited. Tractor mounted sprayers should have 'droplegs' to spray between the rows of cotton or the horizontal boom should be fitted with an airsleeve to create turbulence within the crop and improve penetration to the lower leaves. Aerial spraying should be phased out wherever possible and replaced by ground equipment.

Other Aspects of Integrated Pest Management (IPM)

a) Cultural Controls

A closed season is legally required in most cotton growing countries, but is difficult to implement fully where growers retain the stalks as a fuel. Better removal of unharvested bolls

reduces the risk of pink bollworm survival with stalks. Shredding and ploughing in crop residues is the best policy where tractor equipment is available, as this improves the organic matter content in the soil. In parts of China the stalks are harvested and processed into hardboard, but the economics of this process may not be appropriate in other countries. The situation in the north-east of Brazil is complicated as perennial arboreal cotton is extensively grown, despite very low yields and the arrival of the boll weevil.

Information on cropping practices is seldom sufficiently detailed to determine their impact on crop protection. In Egypt, irrigation and a sequence of other crops grown in the vicinity of cotton seems to provide a good environmental diversity, allowing natural enemies to survive the winter and re invade cotton fields. In north-west China (Xinjiang), some state farms have planted poplar tree wind-breaks that are considered to be beneficial in providing overwintering habitats for natural enemies. A similar approach would be beneficial in Uzbekistan which has a similar cold winter, especially as greater survival of coccinellids would reduce the early aphid problem. In Uzbekistan and certain parts of China, lack of rotation is increasing pest problems.

In the other countries there are undoubted problems with the sequence of rainfed crops, for example in India, various legumes, including pigeon pea, and maize and other food crops influence the survival of bollworm, *Helicoverpa armigera*. Maize in Tanzania and irrigated wheat in China are important factors influencing bollworm infestations. While there are areas of cotton monoculture in China, some areas have a cotton-soybean-groundnut or cotton-rice rotation. Plans to increase the extent of a cotton-maize-alfalfa rotation in Uzbekistan could influence the severity of *Helicoverpa* infestation but relative planting dates could be important factors. Further information is needed from Mexico regarding the proximity of irrigated and rainfed crops, but experience elsewhere is that within one area both irrigated and rainfed cotton should have very similar sowing dates.

Synchronized sowing should be more feasible with irrigation, provided sufficient equipment and labor is available but on some schemes, inadequate water supplies or equipment result in sowing dates being spread over several weeks. Similarly in rainfed areas, erratic distribution of rain can force a protracted sowing period. Where there is a range of sowing dates within an area, pests from the early sown crop cause extremely serious infestations on the later crops which already have a lower potential yield due to seasonal weather changes.

Sowing diversionary crops is difficult in rainfed areas as most crops need to be sown at the same time, and in areas of low rainfall, there are very few suitable crops which are drought tolerant. In these circumstances cotton is often grown more or less as a monocrop. In Tanzania, farmers prefer to grow maize despite low rainfall, whereas sorghum would be more suitable and is less favorable to bollworm since it tends to have more natural enemies. Single lines of maize in cotton fields are claimed to reduce bollworm as cannibalism occurs on the maize cob, but the timing of tassling relative to the onset of flowering is critical and the survival of a single larva per plant could lead to a damaging infestation on cotton.

The increasing areas of vegetables, especially tomatoes and cucurbits, for example melons in Pakistan, usually grown with irrigation close to cotton fields, is a key factor in the increase of whiteflies. In several countries insecticide use on these horticultural cash crops is increasing throughout the year, and without any regulation, the incidence of resistance to insecticides, especially pyrethroids, is in part due to selection occurring on these non-cotton hosts. This emphasizes the need for IPM strategies to include all crops grown within one agro-ecosystem.

b) Quarantine

The arrival of boll weevil in Brazil in the 1980s was possibly due to movement of cotton by road from Venezuela. Its spread is now continuing into Paraguay and Argentina, increasing the difficulties of crop protection. Similar long distance movement of cotton pests includes the pink bollworm, *Pectinophora gossypiella*, from India to Egypt and subsequently to North America. The threat of further spread of major pests and diseases remains as a result of the movement of seeds or seed cotton from infested to non-infested areas. This is being exacerbated by privatization of marketing which is leading to uncontrolled movement of seed cotton for ginning both within and between countries.

A quarantine zone prohibiting the growing of cotton in the southern districts of Tanzania, bordering Mozambique and Zambia, has been in force for many years to prevent the spread of red bollworm, *Diparopsis castanea*, northward to the major cotton areas in the east and west of the country. Recent investigations found red bollworm on cotton grown in the southern part of the quarantine zone, showing that it was essential to enforce the non-cotton zone to protect the major cotton growing areas elsewhere in Tanzania (Kabissa and Nyambo, 1989).

Egypt has extremely rigid quarantine regulations regarding the importation of cotton lint. Cotton may only be imported from non-weevil infested cotton growing areas and it has to be fumigated before shipment and on arrival in Egypt. Furthermore, it can only be utilized in spinning mills away from the cotton growing areas of the Nile Delta, limiting imports to spinning mills in Alexandria and Suez. Similarly, all cotton imported into the USA has to be fumigated.

The fumigant usually used for cotton lint is methyl bromide. This product has been placed under the category of controlled substance under the Montreal Protocol because of its volatility and its contribution to the destruction of the ozone layer. It has already been banned in countries such as Holland and the US Environmental Protection Agency has initiated a program to eliminate its use in the USA by 2001. A similar program is being followed in Australia. Alternative products are available but they do not have such a broad spectrum and have more specific application. This matter requires critical consideration because quarantine regulations regarding the movement of seed cotton, cottonseed and lint are crucial components of IPM.

c) Host plant Resistance

Gossypium barbadense is probably more resistant to certain cotton pests than *G. hirsutum*, as the latter had much more serious bollworm infestations when grown in the Sudan and Egypt. Selection for jassid resistance has continued in Africa since the 1920's and is a key factor in the survival of cotton plants in the absence of other control techniques. In India jassid resistance is also of utmost importance, adopted at farm level, but farmers still need to control other pests. Resistance to other cotton pests is less apparent, although some reports refer to quicker maturing varieties.

Breeding for resistance to Bacterial blight disease, *Xanthomonas malvacearum*, has been very successful in Africa and elsewhere. Resistance or tolerance to wilt, notably *Fusarium* in Tanzania and both *Fusarium* and *Verticillium* in Uzbekistan is claimed, but lack of seed quality control and/or crop rotation is exacerbating these diseases.

One feature of the China report was the large area of glandless cotton sown in the Hebei province. The lack of gossypol would be expected to increase the susceptibility of the plants to more serious insect infestation. A change in pest status was not noted. Glandless cotton has also

been introduced into Cote D'Ivoire where it is mainly grown in the wetter 'forest' area with yams and upland rice in contrast to the drier areas with maize. There is some early leaf damage due to flea beetle, but good crops have been obtained. This contrasts with attempts in Zimbabwe where glandless plants were totally destroyed by maize chafer beetles. Some glandless cotton is also grown in Texas in areas of low insect activity

Plant breeding has focussed on lint quality, but the outbreak of leaf curl virus in Pakistan and similar problems emphasize the need for careful selection of varieties to maintain pest resistance. Selection of smaller, faster maturing varieties in contrast to the traditional indeterminate types, helps reduce the period of exposure to pest infestation and makes spray application easier.

d) **Bio-control**

The lists of natural enemies included in the country reports give no indication of their prevalence or impact on cotton insect pest populations. There is evidence that predators, such as ants, spiders, coccinellids and lacewings do have an impact, although sole reliance on biological control usually results in relatively low yields of cotton.

The release of natural enemies has been extensively organized in Uzbekistan as mentioned above. Four tons of *Trichogramma* were released in 1992. None of the other countries has a definite policy to release natural enemies over a region against cotton pests. Several reports mention the release of natural enemies, for example in Mexico and India, but details of the areas involved are not stated. In some cases releases have been confined to relatively small experimental areas, but in Mexico, the impression is that releases are increasing with fewer insecticide sprays applied. In India 7,320 million bio-agents were released in 1992-93, but there is no indication of the impact of these releases. The report from Brazil also mentions release of *Trichogramma*, but with no indication of the area involved.

Conservation of natural enemies is crucial in many countries, such as Egypt and parts of China, and has been enhanced by specific policies such as avoiding early applications of insecticides, improved control of irrigation and promotion of the use of pheromones (see next section).

The difficulty in many areas with a single rainfall season is the prolonged dry period between cotton seasons. In contrast to the situation in Egypt, few natural enemies may survive and the subsequent build-up of the populations is slow, so any broad spectrum insecticide applied at the early part of the season can seriously delay or prevent the activity of the most important natural enemies.

It may be argued that the cost of rearing natural enemies is too high, but if environmental pollution costs are included and new techniques of mass rearing can be developed, augmentation of natural enemies needs more careful evaluation. Thus in Europe several natural enemies are produced for use in glasshouses. In addition *Trichogramma* is produced for control of stem borer in maize and of noctuid pests.

e) **Pheromones**

The most extensive use of pheromones has been in Egypt as a confusion technique against pink bollworm *Pectinophora gossypiella*. Three main types of pheromone product are now used. A micron-encapsulated formulation can be sprayed, but the main emphasis has shifted to hand applied 'twist-tie' or 'band' dispensers that emit the pheromone gossyplure over

a period of up to six weeks. In Egypt the application of pheromone has enabled the number of insecticide sprays to be reduced and delayed to later in the season, allowing bees to survive.

Studies with a similar approach in Pakistan have not reached such an advanced stage. This is partly due to the greater importance of the spotted bollworm *Earias vittella* for which a pheromone has also been synthesized. The application thus needs to include two pheromones to cover both bollworms. With an effective closed season, pink bollworm is not considered such an important pest in Tanzania.

In Uzbekistan, the pheromone of *Helicoverpa* is used to monitor the arrival of moths to time the release of *Trichogramma*.

Pheromone traps with grandlure have been used in Brazil and neighboring Paraguay to detect the spread of boll weevil following its discovery in two areas of Brazil in the early 1980's.

In some areas such as North Carolina, USA., 'sticks' impregnated with the boll weevil pheromone grandlure and an insecticide have been used to lure and kill boll weevils. There is no mention of this technique being used Mexico or Brazil. However, where it has been used, it is claimed that it enables elimination of early season insecticide sprays which would otherwise destroy the initial populations of natural parasitoids and predators. For example, it is reported to have succeeded in large scale, area wide trials in Nicaragua in 1993 and 1994, reducing insect control costs from \$229 per acre in 1990-91 to just \$24 per acre in 1993-94 (Daxi et al, 1995).

Lure and kill technology may also have application in reducing other cotton pest populations in the cotton crops or alternatively, in the crops preceding cotton as a means of reducing insect activity in the cotton crop. An example would be the control of spotted bollworm, *Earias* spp. on okra in Pakistan to stop the build up before the cotton season. There have been some lure and kill experiments, but further-research is needed to establish the way in which the technique is used (e.g. density of attractive points in a field) and whether attracting and killing male moths has an economic effect on subsequent pest populations.

f) Transgenic Bt Cotton

Considerable progress has been made using genetic engineering to insert specific genes into cotton. Most progress has been made with the Bt gene which increases the toxicity of the cotton plant to Lepidopterous pests. Genetically engineered Bt cotton could play an important role in many countries, particularly those with pyrethroid resistant *Heliothis/Helicoverpa* populations, provided the technical, financial and legal problems associated with these varieties can be resolved. However, the removal of target pests by Bt cotton has been reported as leading to an increase in the incidence of secondary pests that are not affected by the Bt endotoxin (Turnipseed, 1995). While the number of bollworms and leaf-feeding larvae is reduced, the plant is still susceptible to sucking pests. Thus in introducing this technology to areas outside the USA, further selection is needed to transfer this character into cultivars that are resistant to jassid and other insect pests and to diseases.

Another concern is that if growers plant only cotton with the Bt gene, the Lepidopterous pests will be selected for resistance very rapidly, hence discussions on resistance management strategies have already started. It is recognized that with this product, the question is no longer if but when Bt resistance will develop. In laboratory feeding trials with pink bollworm, *Pectinophora gossypiella*, the selective dosage rate which was initially 1g/l of lyophilized leaf material from a Bt cotton variety in a standard laboratory diet, giving a 90 percent selection coefficient,

had to be increased by at least 0.1 g/l in most generations after the third generation (Bartlett, 1995). Clearly the use of genetically engineered cotton will have to be used as part of an IPM program on an area-wide basis so that its use is carefully monitored and adjusted as necessary to avoid the problems similar to those caused by the unregulated use of a wide range of insecticide sprays. The technical problems related to prolonging the life of Bt cotton varieties call for diligent implementation (Deaton, 1995). It is proposed that this can be accomplished by:

1. Deployment of the Bt cotton varieties with other IPM strategies;
2. Monitoring Bt cotton varieties twice weekly for any indication of resistance developing in target pests;
3. Optimum dosage of the Bt endotoxin to control the more resistant individuals in the population;
4. The use of refugia consisting of strategically planted alternative host plants or of non Bt plants of the Bt varieties either in seed mixtures or as separate plots adjacent to the Bt cotton. Theoretically, the non resistant moths developing in the refugia would mate with resistant individuals developing on the Bt cotton and so dilute the resistant population. The separate refugia area is favored over the mixed seeds;
5. Multiple genes for resistance, described as Pyramiding.

The success of Bt cotton would depend on a region wide approach and on active involvement of a number of participants, including:

1. the pesticide industry;
2. the seed companies;
3. research institutes;
4. extension agents;
5. crop consultants (where applicable); and
6. growers.

In developing countries, the cost of seed is likely to be too high for small-scale growers unless the technology is routed through Government breeding programs under an aid program.

Other factors

There are extensive areas of cotton grown on large farms, but in many countries cotton is the cash crop of smallholders. Efforts to train very large numbers of these farmers in new technology do not always succeed in competition with commercial incentives, thus in areas, such as Thailand and India with overuse of agrochemicals, the farmer seeks advice from the salesman who are generally working longer hours and more accessible to the farmers.

Promotion of T&V (training and visit) extension principals to contact farmers can only be effective if the 'package' of extension information is acceptable to the local farming community. In introducing integrated pest management, one of the key issues will continue to be the necessity to ensure that essential components of an IPM program are followed by all farmers within a prescribed area. Traditionally uprooting cotton by a set date has been established legally in some countries, but other components of IPM such as the use of pheromones also require area-wide treatment to be effective. Similarly, if natural enemies are to be conserved or released the choice and timing of insecticide applications needs careful regulation. Furthermore, as some of the major cotton insect pests are polyphagous, the whole cropping system and rotations within

an agroecosystem should be considered more fully than previously. Exhibit 2.7 demonstrates the pathways from problem identification to farmer recommendations and Exhibit 2.8 gives the components of IPM and the interactions in their implementation.

Exhibit 2.7: The Flow from Identification of the Problem, Through the Development of New Technology to the Transfer of this Technology to the Farmers

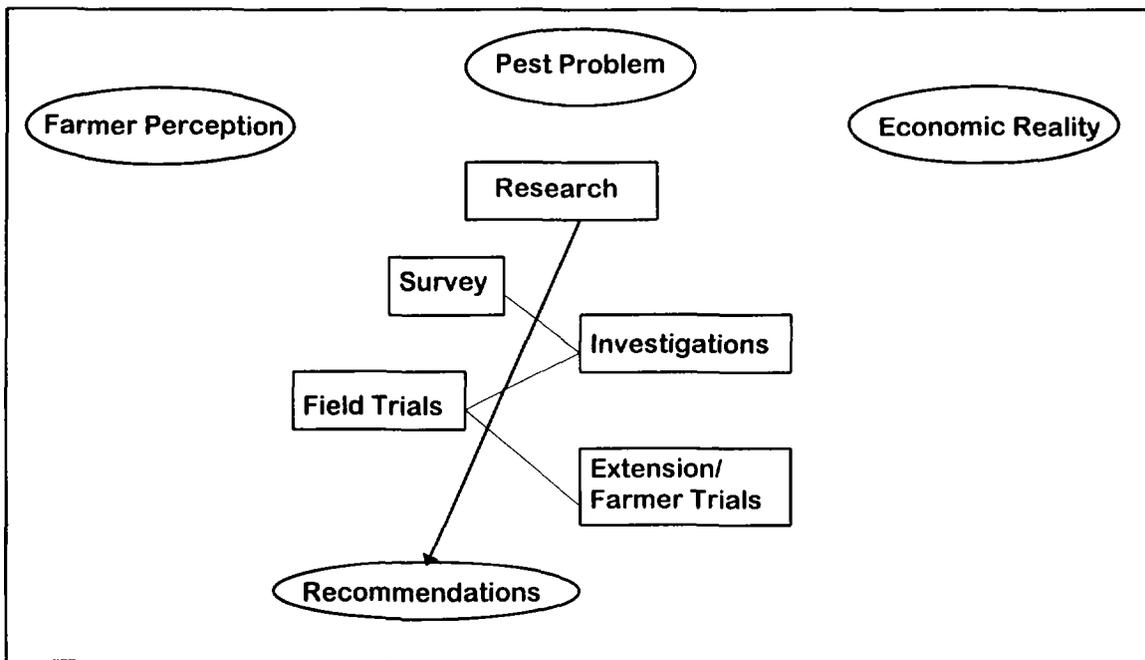


Exhibit 2.8: Components of IPM and Interactions in their Implementation

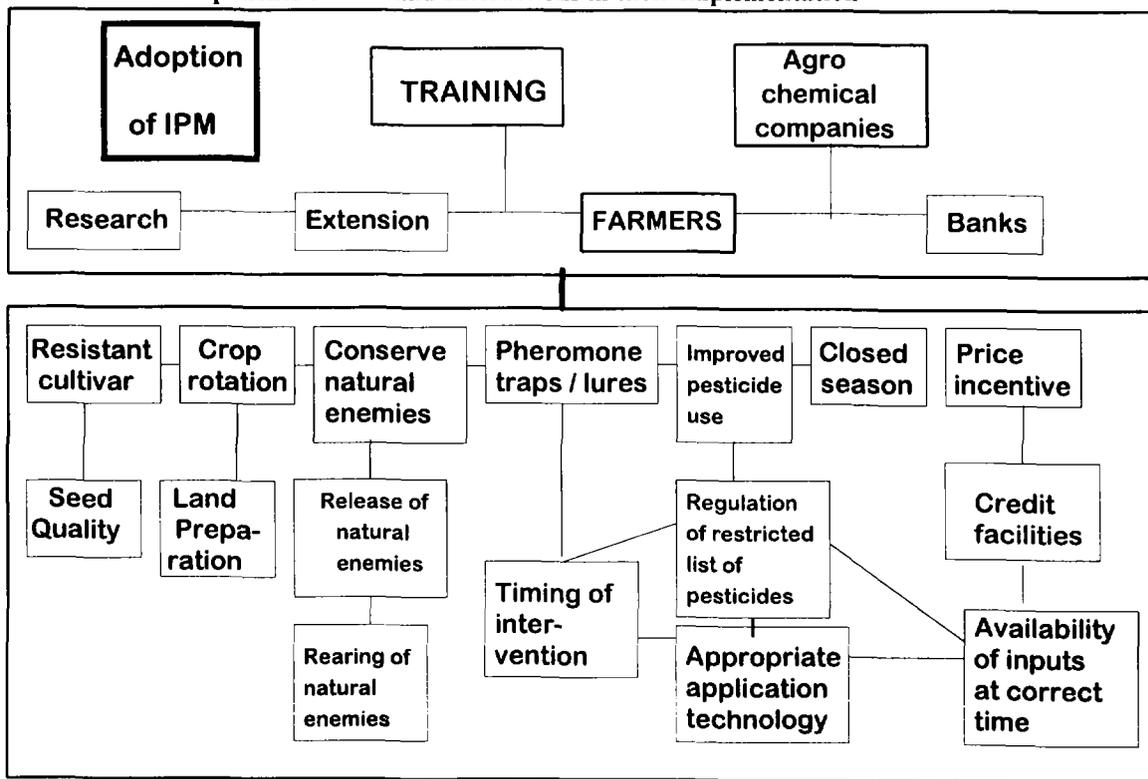


Exhibit 2.9: Linkages in Cotton Production

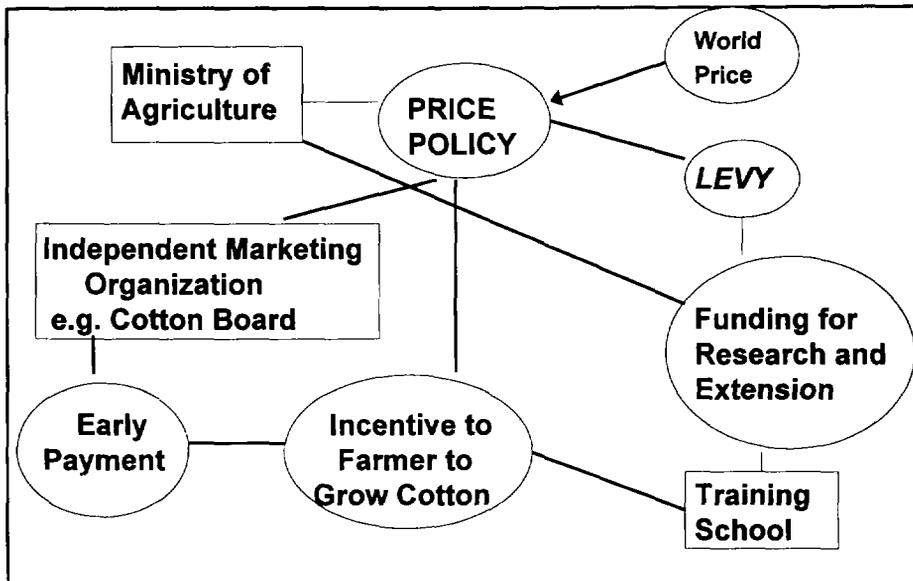
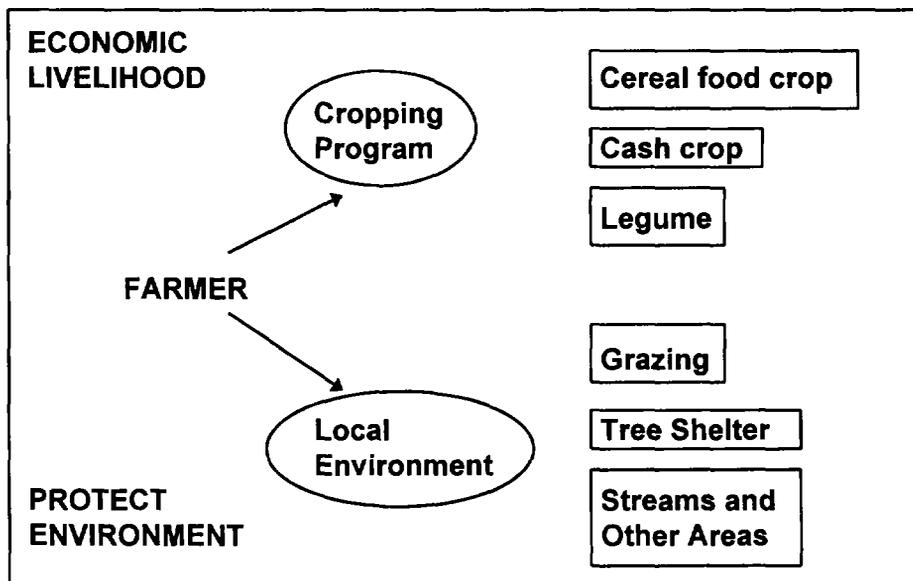


Exhibit.2.10: Linkages between Farming and the Environment



Integration of control tactics

Many of the control tactics advocated as part of an integrated pest management program can only be used successfully if they are adopted on an area-wide basis. This was recognised over 50 years ago when several Governments introduced a closed season to control pink bollworm. The same philosophy is needed to use insect pheromones as a confusion technique (as illustrated in Egypt), the release of transgenic cottons and, as discussed Chapter 5, area-wide regulation of pesticides is an essential component in resistance management strategies.

Further research is needed on the overall cropping system in specific areas to determine whether it is possible by suitable cropping and agronomic practices to conserve natural enemies in

order to minimize the need to release them each year, as in Uzbekistan, or to reduce the survival of pests to reduce the need for any chemical control. Clearly, implementation of an IPM program goes beyond the individual disciplines of entomology, pathology and weed science and requires a holistic crop management program, involving many organisations, both in the government and private sector.

Harvesting

Hand Picking

In most developing countries, cotton is hand picked. Fluffed out cotton that feels dry is ready for picking. Deterioration from weathering begins within about seven days of opening so picking should commence when 3-4 bolls are open. Grading starts with picking and pickers should be trained to separate clean, undamaged cotton from trashy or stained cotton. In many countries, farmers pick in the morning, often spreading it out in the sun to dry and separate clean cotton from stained and trashy cotton in the shade during the afternoon. This is more time consuming than separating clean from unclean seed cotton during picking but it is widely practiced.

Picking efficiency depends on training, boll weight, plant shape and size and yield. It declines during later picks as pickable bolls become scarce. When prices are low, late bolls are often left because of cost. The problems associated with utilizing labor with a low level of training for picking is discussed in the Brazil report (Stamm et al., 1994).

Mechanization

Cotton in most of the study countries is hand picked. However, a variable amount, depending on climatic conditions, is machine picked in Uzbekistan while the westward expansion in Brazil into Mato Grosso and Goiás is expected to be into large scale, mechanized production. The need to investigate mechanical harvesting is being considered in Pakistan. Hand picked cotton has an advantage in marketing but the cost and availability of labor and the duration of the picking period may necessitate mechanization.

There are three main types of mechanical picker, the US spindle pickers which have vertical picker bars with horizontal spindles and are relatively selective in picking, making it possible to have more than one pick, strippers which strip seed cotton and any green bolls from the plant, making it a once over operation and the Uzbek vertical spindle pickers which are intermediate. Spindle pickers are heavy and require a considerable amount of maintenance and precise adjustment. Strippers and Uzbek pickers are much lighter and cheaper and easier to maintain and adjust. However, spindle pickers give the highest quality cotton.

Mechanization of cotton picking is not simply a matter of procuring a picker and picking the crop. It is part of an overall farming system, going all the way from land preparation to ginning. Efficient machine operation depends on uniformity in plant development and regular ripening of the crop. This calls for precision in land preparation and crop establishment, high quality seed and production practices which are directed towards compact plants and uniform opening. Seed cotton storage and transportation need to match the amount of cotton picked each day. Modules have become the most widely used storage and transportation system. The ginnery design and ancillary equipment have to be geared to the type of machine being used. Finally weed control is critical, early in the season to avoid plant competition to ensure uniform development and late in the season to ensure that the seed cotton is free of weed seeds, particularly grass seeds.

Contamination of Seed Cotton

Contamination of cotton with foreign matter has caused the textile industry serious problems for many years. Sources of contamination vary considerably and are often associated with the method of picking, handling and packing seed cotton and of packing baled lint. The commonest forms of contaminant in hand picked cotton are polypropylene strands from picking bags and pieces of jute, raffia or some other form of tying material used for the delivery of cotton bags to the ginnery. When cotton is spread in the sun to dry, it is exposed to other forms of contaminant such things as human hair. The commonest contaminants in mechanically picked cotton are grease or oil and slivers of rubber from doffer pads of poorly maintained machines.

Contaminants may also emanate from the bale wrapping material, particularly in older systems where the bale wrapping is applied directly on the ginned cotton, under the bale ties and is cut on the two sides of the bale after baling to remove the classers' samples. In modern systems, the samples are cut automatically during baling, the ties are placed directly round the compressed cotton lint before applying the wrapping which is in the form of a sock, applied outside the ties after the samples have been removed.

Grading should start in the field during picking in order to minimize foreign matter in the seed cotton. With mechanical harvesters, this entails good crop management and precise setting up of the picking machine. For hand picking, it entails careful training and supervision of the pickers and avoidance of potential contaminants in picking, packing and tying material. Ideally, only cotton containers and cotton twine ties should be used for handling seed cotton and only cotton bale wrapping should be used. Any woven polypropylene material should be avoided at all stages of cotton handling. Cotton bale wrapping is used in China and Uzbekistan while in India, packing material specifications are more stringent for export bales than for bales destined for domestic consumption. Economic considerations are usually cited as determinants in the choice of wrapping material. Financial incentives may be necessary to expand the use of non contaminating bale wrapping material.

Storage of Seed Cotton

Storage becomes a ginnery problem once seed cotton is delivered. However, in many countries, particularly where cotton is produced by smallholders, seed cotton is stored on the farm, sometimes for a protracted period. Every effort should then be made to ensure that it is protected from weathering and contamination and that it is dry when it goes into storage.

Storage of seed cotton varies widely between countries. Generally, ginning occurs during the dry season so, seed cotton is stored in the open in most countries although some ginneries have closed storage to protect it from inclement weather. The type of storage depends, to some extent, on the type of picking. In countries where cotton is mechanically picked, delivery and pre-ginning storage has traditionally been in some form of trailer or more recently, in modules. In countries where it is hand picked, it is usually delivered in some form of trailer or in containers which may be gunny bags or special sacks such as those used in Tanzania, squares of hessian or cotton cloth such as those used in Uganda or woolpacks such as those used in Zimbabwe.

A period of storage of most seed cotton awaiting ginning is inevitable and some ginneries consider it necessary to allow a period of conditioning prior to ginning. Seed cotton is often stacked in its original container but in China and Uzbekistan, it is stored in large heaps of approximately 400 mt. Each heap has a tunnel through the middle for ventilation. The ginning

season in Uzbekistan extends over ten months and concern has been expressed about deterioration of cotton in storage. However, lower grades of cotton are ginned first since they are most likely to deteriorate. This means that higher grades may be in storage in excess of six months. The moisture content of seed cotton in storage rather than the method of storage *per se*, is the primary consideration in minimizing deterioration prior to ginning. Seed cotton moisture should be monitored regularly during extended periods of storage. A rapid rise in temperature indicates a moisture problem, necessitating ventilation to reduce the moisture content or immediate ginning to prevent deterioration (Gillham and Bell, 1994). In Uzbekistan, any stacks that show an increase in temperature are force ventilated by using a large fan to push air into the stack to reduce the moisture content. In the US, temperatures in excess of 67° C are considered to be indicative of a serious moisture problem which could lead to extensive fiber deterioration if the seed cotton is not ginned immediately (Willcutt et al, 1987).

Sorrenson and Wilkes (1959) determined the safe storage period for seed cotton destined for the production of planting seed at various moisture levels, packed in densities of seven to twelve pounds per cubic foot (Table 2.14). Clearly, even dry seed cotton intended for planting seed should be ginned as soon as possible.

Table 2.14: Safe Storage of Seed Cotton

Moisture Content of Seed Cotton (Percent Wet Basis)	Days Storage
8-10	30
10-12	20
12-14	10
14-15	< 3

Source: Sorrensen and Wilkes (1959)

Modules were introduced to provide short term storage for seed cotton to eliminate the limitation imposed on the pace of mechanical harvesting by the availability of trailers. Provided seed cotton moisture is below 10 percent, little change occurs while it is in a module. In the event of a rise in temperature due to excessive, modules can be ginned rapidly to minimize fiber deterioration.. Modules could be considered as a replacement for other current storage systems.

Ginning

Gin Types

Roller gins are gentler on cotton fiber than saw gins and are used universally for long staple cotton. Saw gins are used for upland cotton wherever it is grown with the exception of India and Tanzania where essentially all upland cotton types are roller ginned. Roller ginned cotton enjoys a premium over saw ginned cotton but the main reasons for this are historical and the lower cost of roller gins and greater ease of maintenance. However, the capacity of saw gins is many times higher than that of roller gins so they have lower land and labor requirements.

The gins in Egypt, India and Tanzania are mainly reciprocating knife type roller gins. The capacity of the installation could be increased and the labor requirement reduced by replacing these gins with rotary knife or rotobar gins with automatic feed control. This type of gin is used for all long staple cotton in Uzbekistan, the USA and elsewhere.

The ancillary equipment installed in ginneries varies appreciably and is largely determined by the location and the amount of foreign matter expected in seed cotton. On average in the USA, hand picked seed cotton contains about 48 kg of foreign matter, mainly leaf and bract fragments, per ginned bale of 217 kg (about 620 kg seed cotton) spindle picked cotton contains an average of 92 kg of foreign matter per bale and stripper picked cotton, about 336 kg per bale.

Carefully picked and graded seed cotton has a trash content below this figure and would require minimal seed cotton cleaning equipment and no lint cleaners. The cleaning stages increase as the expected foreign matter increases. Many roller gin installations used for hand picked cotton have no cleaners and are often hand fed. Lint is also often conveyed by hand to the press. Exhibit 2.9 outlines the cleaning stages required for saw gins with different types of picking:

Exhibit 2.11: Equipment Requirements for Cleaning and Ginning Cotton Picked with Different Systems

Hand Picked	Spindle Picked	Stripper Picked
Feed System	Feed System	Feed System
Feed Control	Rock and Green-Boll Trap	Rock and Green-Boll Trap
Cylinder Cleaner ¹	Feed Control	Air-Line Cleaner
Tower Drier	Tower Drier	Feed Control
Extractor Feeder	Cylinder Cleaner	Tower Drier
Saw Gin Stand	Stick and Green Leaf Machine	Cylinder Cleaner
Condenser	Tower Drier	Stick and Green Leaf Machine
Press	Cylinder Cleaner	Tower Drier
	Optional Cylinder Cleaner ¹	Cylinder Cleaner
	Extractor Feeder	Stick and Green Leaf Machine
	Saw Gin Stand	Stick and Green Leaf Machine ¹
	Saw-Cylinder Lint Cleaner	Extractor Feeder
	Saw-Cylinder Lint Cleaner	Saw Gin Stand
	Condenser	Saw-Cylinder Lint Cleaner
	Press	Saw-Cylinder Lint Cleaner
		Condenser
		Press

^{1/} Optional equipment depends on location and the amount of foreign matter expected

^{2/} Cylinder Cleaners would all be five to seven cylinders

The approximate costs of these items in the USA are given in Table 2.15:

Table 2.15: Approximate Costs of Ginning Equipment

Item	Cost US\$
Unloading Equipment	125,000.00
Separator Feeder Control	100,000.00
Drying Equipment (single stage only)	120,000.00
Cleaning Equipment (single stage only)	220,000.00
Ginning/Feeding Equipment	470,000.00
Trash Handling Equipment	80,000.00
Lint Cleaning	300,000.00
Battery condenser	85,000.00
Bale Press/Handling Equipment	400,000.00
Total	1,900,000.00

The moisture content of seed cotton is critical for efficient gin operation and to preserve intrinsic fiber quality. Cleaning is more efficient in dry cotton but cotton that is too dry during ginning, accumulates on metal surfaces as a result of the build up of static electricity. Fiber strength is also inversely related to moisture content so as the moisture content decreases, the cotton becomes more brittle, leading to increased fiber damage. On the other hand, cotton that is too moist does not separate into locs but remains in wads which can choke the ginning machinery. The ideal moisture range for cotton ginning is 6.5 - 8.0 percent for upland cotton and 5.0 to 6.0 percent for Egyptian/Pima cotton. Cotton that is very dry may give problems in spinning, despite a period of conditioning in the mill. A moisture content of 8.0 to 9.0 percent in baled cotton is acceptable and results in improved mill performance. Moisture regulating systems are usually fitted between the final stage of seed cotton cleaning and the gin stand to bring the moisture content up to the optimum level following drying and cleaning. Moisture is also often added to the ginned lint on the lint slide feeding into the press (Gillham and Bell, 1993).

A differentiation should be made between lint percentage and ginning outturn. Lint percent is the percent of lint in clean seed cotton and is determined by the seed weight and the weight of lint per seed. It is largely determined by the variety but the expression of lint percentage is influenced by any environmental factor that influences fiber or seed development. Thus stress caused by drought or sucking pests and leading to premature defoliation will reduce fiber maturity and reduce the lint percent. The ginning outturn, on the other hand, is the percent lint in seed cotton as it is delivered to the ginnery and is determined by the lint percentage, the weight of leaf trash and other foreign matter and the moisture content before and after ginning. The method of picking exerts a significant influence on GOT. Thus using the trash figures given above, a variety with a lint percent of 35.0 percent would be expected to give a GOT of 32.5 percent if hand picked (48 kg of foreign matter), 30.3 percent if spindle picked (92 kg of foreign matter) and only about 23 percent (336 kg of foreign matter) if stripper picked. The foreign matter includes losses in the form of undeveloped seeds or motes. The GOT is also influenced to a varying but small degree by what is known as invisible loss, made up of dust and fiber fragments that escape into the air.

Ginning Season

The ginning season varies in different countries from about 100 days in the USA to ten months in Uzbekistan. The legal ginning season in Egypt is 150 days but there are recommendations that this should be extended. The delivery rates in the USA are high because of mechanical harvesting and the use of modules. The ginning season is short to minimize the risk of deterioration in storage. Fire is always a threat in stored cotton. The season becomes more protracted with hand picking because of the length of the picking period and relatively low rate of delivery. The extended ginning season in Uzbekistan could lead to fiber deterioration but it provides work for many employees over most of the year.

Capacity and Age of Ginneries

In the majority of the study countries ginneries operate with excess capacity. For example in, Egypt and parts of Brazil, the capacity utilization has been below 50 percent. The exceptions are Mali, where for a few years now the actual amount of cotton ginned has exceeded the capacity of the existing ginneries and Tanzania where ginneries have deteriorated and suffers from the non-availability of spare parts. Aid from the Netherlands helped to rehabilitate some of the Tanzania ginneries.

In most countries, the existing gins are old, leading to frequent breakdowns of the gins and quality problems in the lint. In Mexico, of the 110 registered ginning plants, 60.0 percent have been in operation more than 30 years, 10.0 percent between 20 and 30 years, 10.0 percent between 10 to 20 years, 10.0 percent less than 10 years and the remaining 10.0 percent is newly plants, assembled from parts of old machines of variable age. In India, nearly 75.0 percent of the gins are in the range of 50 to 100 years old. In Tanzania, most ginning facilities were installed between the 1920s and the 1960s. Some ginneries were established with second-hand machinery from Uganda or other local ginneries, making the age estimation of equipment very complicated. In Brazil, 80 of the saw gins have an average age of fifty years while 90 others were introduced in the mid-50s. In Egypt, some of the ginneries date back to the early 20th century. A gin rehabilitation program in 1973 modernized some of the old ginneries, added new ones, and was able to rationalize the use of labor, improve the ginning environment for workers, the cotton quality, and productive capacity of the gins. In Mali, where the oldest ginnery dates back 30 years, the crisis in the cotton sector has prevented the modernization of old gins and investment in new ones. In most countries, maintenance is sometimes neglected due, to a degree, to the non-availability of spare parts. However, in most countries, ginnery rehabilitation and non-modernization are likely to continue rather than construction of new ginneries.

Ginning technology has changed little over the past fifty years except in the design of higher capacity gins and cleaners to cope with high delivery rate and more trashy condition of machine-picked cotton. The newer higher capacity machines are more costly (as an example the cost of steel in a saw increases by the square of the diameter; whereas the number of teeth increase only in direct proportion to the diameter). Modern US, high capacity gins are designed for more efficient loading of the saw teeth, causing the cotton to be plucked off the seed in larger tufts. Even though this does not effect the spinning performance of the fiber, the appearance to the naked eye is called 'lumpy' and historically by US. classing standards was called 'preppy'. Trash particles are also more visible because they are larger and on the outside of the tufts. The lint cleaners both comb out the lumps and break up the large trash particles that are not removed from the combed fibers, leaving small particles known as pepper trash. However, the use of HVI has enabled other fiber attributes, which are more important in spinning than fiber appearance, to be measured rapidly resulting in changes in the assessment of quality standards. The trend in countries where cotton is mechanically picked is towards reduced lint cleaning since the cleaners in textile mills can cope with large trash particles more effectively than small particles.

The need for any form of cleaning is minimal in countries where cotton is hand picked, in particular, lint cleaners designed for machine-picked cotton are generally not necessary although they are sometimes installed to improve preparation. Many roller gin installations in developing countries have no cleaners and seed cotton is fed to the gins by hand.

Transportation costs, the availability of surplus labor and the necessity for farmers to have contact with the marketing channel, are factors that influence the location and capacity of ginneries. These factors are likely to preclude the construction of modern ginneries which are prevalent in the United States and Australia. The efficiency of operation is influenced by the delivery rate of cotton, the feeding rate for high capacity feeders and the necessity to import spare parts. When high capacity gins are installed in countries where cotton is hand picked, they generally operate inefficiently because of problems with the rate of delivery of seed cotton to the ginneries and of feeding the gins.

Ginneries do not improve but can preserve fiber quality by operating below design capacity in order to gin more gently and minimize fiber damage. However, the means for the de-

termination of fiber quality and price incentives must be in place otherwise ginneries tend to overclean seed cotton and lint to improve grades, causing deterioration in fiber quality. Regulation of ginning costs also contributes to poor quality ginning. As spinning rates have increased, the preservation of quality has become increasingly important. Gins are usually, and are generally inefficient entities in the marketing channel

New Ginning Technology

Selective or cage ginning is a recent concept developed by the USDA Ginning Research Laboratory in Stoneville, Mississippi. Initially, the intention was to remove the long fibers on the cage gin and to gin the balance on a saw gin. However, about 95.0 percent of the fiber can be removed on the cage gin leaving very little for the saw gin. The main advantage is that it does less damage to the fibers, thus enhancing the spinning performance of cage ginned cotton. There appears to be little difference in yarn quality between roller and cage ginned cotton but the cage ginned lint of Upland cotton produces better yarn than that of roller ginned cotton of the same variety (Wilkes and Mehner, 1990). However, so far, cage ginning has not found favor because the price differential for the cage ginned cotton is not sufficient to render it economically viable.

CHAPTER 3

WORLD COTTON POLICY

Introduction

Historically, the governments of many cotton producing countries have intervened heavily in cotton production and marketing. Many countries considered that their cotton policies promoted the development of the industrial sector, increased government revenue, supported the incomes of farmers, employed surplus labor, increased export earnings, helped reach economies of scale, provided quality control, provided a supportive infrastructure and arrested environmental concerns. Some of these market interventions have economic, social, and-or technical justification while others do not. This chapter documents and discusses the impact of these policies for the nine countries in the study; Brazil, China, Egypt, India, Mali, Mexico, Pakistan, Tanzania and Uzbekistan. Since it is not possible to describe the detailed policies of individual countries, the discussion centers around broad categories of aggregate level policies, input policies and price policies, grouping countries into categories when possible. Nonetheless, detailed policies are presented in some categories for some countries in order to suggest either an evaluation of a specific policy or to place a country in a specific category. However, the impacts suggested in this chapter are static in nature and are attempted only in order to illustrate the relative inefficiencies of certain policies and the taxation of certain sectors to support policy goals.

Aggregate Level Policies and the Cotton Sector

In their efforts to provide for economic well being, governments may provide political and economic stability, production and marketing activities, and policies to change inflation, the balance of payments, unemployment, and budget deficits. The effects of these economy-wide activities often affect the production and economic health of the cotton sector per se, sometimes profoundly. In the nine-countries studied, central government control of production, marketing, exchange rate and trade policy seem to have been especially crucial to their cotton sectors. However, the role of government in these activities has recently changed, rather sharply in some countries.

With the exception of Pakistan and India, all the countries in the study have recently withdrawn, to varying degrees, from their historic roles in their economies moving away from central government control of production and marketing in various ways to a more open system in which private enterprises perform more of these activities. In some cases, such as Mexico, the economic system has already changed substantially. Over the last few years, Mexico has privatized some of its key economic sectors while its new land reform policy enables the sale and lease of former communal farmland. Barriers to trade have been sharply reduced in step with its recent entry into the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA), and the government encourages foreign investment. China is also changing to a more open economy in which small landholders have replaced huge, Soviet-style centrally controlled farming operations. However, changes in China are happening more slowly than in Mexico, and the degree of ultimate change remains unknown. In both cases, the final impact of changes in central government control on cotton production could ultimately be significant. Chinese farmers, for example, have demonstrated a capacity to greatly expand and contract production in response to

price incentives. Between 1984 and 1986, following a record crop in 1984 that caused a sharp drop in prices, cotton production was cut by over 40 percent. Historically, China often gave preferential support to the cotton sector but the competitive advantage of cotton under a more market-oriented system remains to be seen.

Exchange rate policy effected the cotton industries of several study countries, including Brazil, Egypt, India, Mali, and Pakistan. Historically, these and other countries over-valued their exchange rates to promote their emerging industrial sectors, often including, and sometimes specifically, the textile industry. Overvalued exchange rates reduce the cost of imported equipment for manufacturing while reducing the foreign demand for raw agricultural products, making them more cheaply available for domestic use. The cotton sub-sectors of several countries fell prey to this exchange-rate policy, and suffered significantly. An analysis of specific examples relative to the impact of the exchange rate on inputs and on farmgate prices in Egypt indicate that the decrease in the relative farmgate cotton price was large in the first half of the 1980s and was magnified by real exchange rate appreciation and reduced direct protection. During the latter half of the 1980s the increase in the foreign price was only partially reflected in the farmgate price as the increases and decreases in the real exchange rate and direct protection were greater than had prevailed during the previous five years. During the period 1989 to 1992, direct protection increased substantially, resulting in a marked increase in farmgate prices in the face of declines in both foreign prices and in the real exchange rate. The further decomposition of the relative farmgate price into policy and non-policy related factors indicates the magnitude of the move to increase the farmgate cotton price. However, this also illustrates the difficulty in linking farmgate support prices to international prices with formulas of moving averages of historical price that do not reflect market signals.

Further insight into the indirect or exchange rate subsidy is provided by observing the dramatic differences in the official and free market exchange rates for Egypt during 1989 and 1990 (Table 3.1). There is a lag between the time of purchase of chemicals and their use. Thus many of the pesticides used in 1991 and 1992 were purchased in 1990 or earlier. The US dollar cost of the materials imported for use in 1992 was US\$

31.34 million and a local currency cost of LE 50.5 million at the official rate but LE 91.45 million at the free market rate. The official rate at the time of importation averaged 1.611 LE-\$ compared to an average free-market rate of 2.918 LE-\$. On February 27, 1991 the Government of Egypt adopted a free market exchange rate system but retained a "primary rate" which was to be maintained by the Central Bank within 5 percent of the average free market rate. The primary rate was intended for use in the importation of "essential supply commodities," including fertilizer and cotton pesticides. The indirect subsidy for imports of pesticides used in 1991 was LE 45.9 million. The subsidy on pesticide imports into Egypt was terminated in July 1991 but the indirect subsidy was only reduced to LE 40.9 million in 1992 due to the lag in purchase relative to use (Table 3.2).

Table 3.1: Official and Free Market Exchange Rates in Egypt, 1989-1990

Year	Exchange Rate LE-US\$	
	Official	Free Market
1989	0.707	2.54
1990	1.11	2.73

Source: Unpublished Data, USAID, Cairo

Table 3.2: The Cost of the Cotton Pest Control Program in Egypt, 1991 to 1993

Item	Units	1991	1992	1993 ¹
Value of Pesticide Used				
Import Cost	US\$(1,000)	31,476.2	31,335.6	25,172.8
At Official Exchange Rate	LE(1,000)	34,809.1	50,498.3	73,546.2
At Market Exchange Rate	LE(1,000)	80,729.1	91,446.0	80,601.6
Indirect Subsidy	LE(1,000)	45,920.0	40,948.2	7,055.4
Cost of Pest Control Components				
Chemical Program	LE(1,000)	111,809.0	157,629.5	152,528.3
Manual Program	LE(1,000)	24,277.4	24,867.7	20,937.7
Administrative Cost	LE(1,000)	6,190.3	9,493.2	14,340.5
Total Cost of Components	LE(1,000)	142,276.7	191,990.2	187,806.5
Total Cost of Pest Control ²				
Total Cost of Pest Control ²	LE(1,000)	188,196.7	232,938.6	194,861.9
Charges to Cotton Farmers	LE(1,000)	17,834.6	17,927.6	16,081.1
Total Subsidy	LE(1,000)	170,362.1	215,011.1	178,788.4
Direct Subsidy	LE(1,000)	124,442.1	174,062.9	171,725.3
Area of Cotton				
Area of Cotton	Feddan	851,283.0	840,287.0	884,310.0
Total Seed Cotton Production ³				
Total Seed Cotton Production ³	1,000 Kentars	5,051.0	6,006.0	6,876.0
Cost per Feddan				
Total Pest Control Cost ²	LE-FD	221.0	277.2	220.4
Charge to Farmers	LE-FD	20.9	21.3	18.2
Total Subsidy	LE-FD	200.1	255.9	202.2
Indirect Subsidy	LE-FD	53.9	48.7	8.0
Direct Subsidy	LE-FD	146.2	207.2	194.2
Cost per Kentar				
Total Pest Control	LE-Kentar	37.2	38.8	28.3
Charge to Farmer	LE-Kentar	3.5	3.0	2.3
Total Subsidy	LE-Kentar	33.7	35.8	26.0
Indirect Subsidy	LE-Kentar	9.1	6.8	1.0
Direct Subsidy	LE-Kentar	24.6	29.0	25.0

Source: Unpublished Data, USAID, Cairo

¹ 1993 Data are Preliminary

² Includes Indirect Subsidy

³ One kentar Seed Cotton = 157.5Kg.

Dethier (1989) estimated the effects of both cotton and input price policies, and exchange rate and trade policies for Egypt and found that the exchange rate and trade policies were especially onerous during the period 1960 - 1972 when the implicit tax on the cotton sector ranged from 50 to 200 percent. In a more recent study, Bautista and Gehlar (1994) sub-divided the changes in the relative farmgate price of cotton over time into factors that arise from changes in government policies and from changes in world market developments. They related these factors to changes in border prices, in the real exchange rate, in nominal protection, and in the marketing margin. Since cotton producers are indirect exporters, any appreciation of the real exchange rate and increased direct taxation has a negative impact on their returns. Real exchange rate changes are a function of domestic macroeconomic policies (the current account balance, trade policy and the nominal exchange rate) and several external factors (e.g. the external terms of trade). This is illustrated by the following calculations (Table 3.3).

Other trade policies affected the economic health of cotton sub-sectors in several countries, notably Brazil and Pakistan. Tariffs, import quotas and licensing requirements were used to protect so-called infant industries from foreign competition. This limited the importation of machinery, fertilizer and pesticides, to the detriment of agriculture. Other policies placed quotas or tariffs on cotton exports to ensure adequate supplies for domestic textile industries.

Table 3.3: Percent Changes in Relative Farmgate Cotton Prices in Egypt

Changes in	1979-84	1984-89	1989-92
Relative Farmgate Price	-33.0	7.4	31.2
Exogenous Factors	-12.9	50.8	-14.4
Policy Related Factors	-20.1	-43.4	45.6
Relative Foreign Price	-20.5	44.2	-11.4
Real Exchange Rate	-6.3	-10.4	-3.5
Exogenous Factors	7.6	-16.6	-3.0
Policy Related Factors	-13.9	5.3	-0.5
Direct Protection	-6.2	-26.4	46.1

Source: Bautista and Gehlar (1994)

Hamid *et al* (1990) estimated the considerable negative effect of an overvalued exchange rate and trade restrictions on cotton in Pakistan. During the past three decades cotton production may have been cut by as much as 44 percent by a combined overvalued exchange rate and direct intervention through trade policies.

Input Policies and the Cotton Sector

Each of the nine countries have pursued policies that influence input use, usually involving subsidies on irrigation water, fertilizer, pesticides, seed, machinery, credit and-or crop protection. At times inputs have been subsidized to compensate for exchange rate, trade and cotton price policies which discriminated against cotton production. At other times inputs were subsidized to promote cotton production for the country's important textile sector, to encourage production for export earnings, or employment in the labor-intensive cotton sector *per se*. In some cases policy makers aimed to increase the welfare of farm families, especially smallholders. At times governments subsidized new technologies to encourage their use. However, the likely impact is that subsidization of domestic inputs through import licenses, tariffs, or other measures which can be imported dramatically slows technology transfer to the farm sector. This study concludes that this technology transfer is essential to the cotton-textile industry in the decade ahead.

This section which focuses on policies for irrigation, fertilizers and other chemicals, and credit, demonstrates that government input policy often yielded undesirable effects. This also typifies the policies and their effects for pesticides and machinery. The policies for seed and crop protection, and for agricultural research and extension are discussed elsewhere in the report.

Irrigation Policy

Even though cotton is relatively drought tolerant, irrigation is necessary for cotton in many regions. In six of the study countries, China, Egypt, India, Mexico, Pakistan and Uzbekistan, most of or all the cotton acreage receives either full or supplementary irrigation. Policy makers and producers see irrigation as a means to increase both cropped acreage and yield.

In most but not all cases, governments rather than private enterprises build dams and canals for surface irrigation systems, making irrigation the single largest government investment in agriculture (Knudson, *et al.*, p73, 1990). The scale of the project often dictates that governments provide funds and administer water allocations. In addition, farmers frequently receive water at little or no cost, as for example in Egypt and Uzbekistan.

A host of factors determine the economic success of these projects, not the least of which is the macro-economics and sectoral policy environment discussed elsewhere. In their recent study of World Bank irrigation projects in Africa, Barghouti and Subramanian (1990) found that 'Overvalued exchange rates, suppressed producer prices, deficit-induced reductions in capital and operating budgets of public programs, and other similar government interventions have stood in the way of success in many irrigation projects.'

When the government provides irrigation water free of charge, or at very little of its total cost, it affects both on-farm water use and off-farm interests. Farmers tend to use free water lavishly, and often have no incentive to use water-saving irrigation technologies and management strategies. As long as water remains plentiful, off-farm interests and other farm interests are not affected. But if lavish farm use precludes others from the use of a fixed and scarce water supply, competing interests suffer. In India, for example, Bell and Gillham (1989) find 'Irrigation water is not always available either in sufficient quantity or at crucial stages of crop development.'

Over-application of water, in conjunction with over-application of fertilizers, also encouraged by subsidies, can lead to environmental problems. For example, a recent study in India found that subsidies on fertilizers and irrigation water encourages wasteful consumption of these resources and thereby contributes to environmental degradation (World Bank, 1994). Similar conclusions were drawn by Knudson *et al.* (1990) who found that in India, Pakistan, and Mexico, water subsidies have contributed to serious waterlogging and salinization problems.

Under-priced water can easily lead to corruption as the beneficiaries of cheap water seek to influence those who distribute its limited amount, and the politically powerful and well-to-do are the chief beneficiaries. Under-pricing water also often means that project funding must come from general government revenues, and irrigation agencies become less answerable to farmers (*Ibid.*).

Alternatives exist. Governments can charge for irrigation water, and in some cases farmers can provide their own irrigation 'infrastructure' and pay the full operating cost of lifting and distributing water. Seckler (1990) reports, for example, that in Nigeria, farmers are paying the operation and maintenance costs '... with collection rates in the range of 70 to 100 percent.'

Fertilizer Policy

Many countries, including the nine study countries, have subsidized fertilizer (Table 3.4). In some cases, government monopolies produced and distributed fertilizer and pesticides at subsidized prices. In an early study, Knudson *et al.* (1990) concluded that the cost to the government was frequently substantial.

Some of these countries have recently chosen a more market-oriented system and for budgetary

Table 3.4: Fertilizer Subsidies in Selected Countries

Country	Year	As Percent of	
		Price	GDP
Egypt	1984	46-76	n-a
India	1980-85	n-a	0.4
Mexico	1985	n-a	0.4
Pakistan	1980-84	n-a	0.7
Tanzania	1981-82	n-a	0.4

Source: Knudson, *et al.* p. 73 referring to other studies

n-a - not available

reasons, have cut subsidies and relinquished control of the agro-chemical sector. The Ministry of Agriculture and Land Reclamation (MALR) in Egypt previously provided both credit and subsidized inputs through the Principal Bank for Development and Agricultural Credit (PBDAC). This support has been phased out, the fertilizer plants have been sold and subsidies have been cut or eliminated, permitting private dealers and government cooperatives to supply fertilizers. Similar action has been taken in Mexico. The Egyptian government subsidy on pesticides has also been reduced. Pakistan provided fertilizer free of charge from 1947 to 1965, but by 1980 had stopped subsidies. There is no subsidy on the import of pesticides into Pakistan and for the past five years, the government has permitted the importation of generic name brands to reduce the cost. Tanzania (Table 3.5) and Uzbekistan have recently at least partially liberalized the agrochemical markets.

Table 3.5: Tanzania Fertilizer Subsidies (Percent)

Year	1990-91	1991-92	1992-93	1993-94	1994-95
Subsidy	78	55	40	25	0

Source: Tisco, 1994

The Chinese Ministry of Commerce (now Ministry of Internal Trade), the General Supply and Marketing Cooperative, The National Agricultural Production Material Corporation and National Agricultural Machinery Corporation previously managed all production materials such as chemical fertilizers, pesticides, and diesel. Chemical fertilizers and diesel oil were allocated according to state determined quotas, with all prices fixed by the state. Most cottonseed for planting was obtained from retention of seed produced on the farm and loans to support production were provided by the state. In essence, a completely fixed quantity and price system was in place for all inputs and the amount of fertilizer sold was in direct proportion to the amount of cotton the farmer produced. Parts of this policy have been decentralized but to an unknown degree. Furthermore, the Chinese introduced a policy of linking cotton purchases to grain sales in the early 1980s to ensure grain supplies to cotton farmers at a reasonable price. The initial subsidized grain allocation was two kilograms of grain for every one kilogram of cotton produced above the quota. This was reduced to 1.5 kilograms in 1984. The grain subsidy was abolished in 1985 and replaced with subsidies on fertilizer and diesel from 1987-1992. The government allocated fertilizer in direct proportion to the amount of cotton produced (Wang *et al*, 1994).

Table 3.6: Producer Incentives in China

Year	Grain (kg)	Fertilizer (kg)	Diesel Oil (kg)	Down Payment (yuan)
1981	2	80		
1982	2	70		
1983	2	70		
1984	1.5	70		
1985-86	Unified	0-20		30
1987-88	Unified	70	5.0	
1989-90		70	10.0	
1991-92		70	5.0	cancelled
1993	Unified	24 yuan		45

Source: Wang *et al*, 1994

Note: The grain allocation was for 1 kg of cotton purchased above quota. Fertilizer and diesel oil were allocated for every 100kg lint purchased. The down payment refers to the cash amount paid to the farmer in advance interest free.

The base subsidy during the period 1987-88 allowed farmers to receive 70 kilograms of fertilizer and five kilograms of diesel at parity prices for every 100 kilograms of cotton sold to the Cotton-and-Jute Corporation. During 1989 and 1990, the diesel supplement was increased to 10 kilograms with some provinces increasing the fertilizer bonus to 100 kilograms and more. During 1991 and 1992, the diesel allocation was reduced to five kilograms and additional fertilizer supplements by provinces were discontinued. In 1993 the input subsidies were converted into cash equivalents of 24 Yuan-100 kg of production (Table 3.6).

In Egypt the central government previously allocated fertilizer by crop. In the case of both China and Egypt neither approach provided for efficient fertilizer use. They fail to recognize which farmer, on which field, will produce the greatest value from an added increment of fertilizer. Government control and allocation of fertilizers at subsidized rates creates other problems and government agencies must decide on the distribution when supplies are limited. Finally, since the amount of government subsidy going to an individual farm depends on the amount used, the largest farms receive the greatest subsidies, an outcome often at odds with goals to reduce the income gap.

As shown for India, subsidization of fertilizers encourages over application, leading to environmental problems (World Bank, 1994). The cost of continued subsidies on fertilizer, brought about by protecting an inefficient urea industry, is currently estimated at about 0.7 percent of the GDP. The nitrogen fertilizer industry is controlled by a combination of an import monopoly by the Mineral and Metals Trading Corporation (MMTC), a single fixed nationwide wholesale price for each fertilizer, a cost-plus pricing scheme for each fertilizer plant and large subsidies provided by the central government. In July 1991 India commenced a move towards liberalization of the fertilizer industry as the subsidy for fertilizer had grown to about one percent of GDP and accounted for more than 50 percent of central government spending on agriculture. However, the effort was reversed by a series of actions from August 1991 through June 1993 (Purcell and Gulati, 1993). Imports of seeds, pesticides, farm machinery, plastic piping and other farm inputs are effectively blocked by import licensing and high tariffs, restricting the ready transfer of technologies to the Indian farm sector. Partial liberalization of input supply commenced in April 1993 when agro-industries were allowed to export 50 percent or more of their product and obtain imports duty free.

Credit

Overview

At least five of the countries in the study, Brazil, China, Egypt, India and Mexico have often subsidized credit, hoping to promote the use of certain inputs, expand production, increase farmer welfare generally, and/or promote the welfare of smallholders. Now, however, Egypt and Mexico are reducing subsidies. In other countries, various formal and informal markets supply credit needs. In Pakistan, farmers receive credit from government agencies, but also from input suppliers, ginneries, cooperatives and commercial banks. In Tanzania, cooperatives and informal credit markets provide credit for inputs and production activities.

The results of subsidized credit frequently run counter to expectations. The budgetary costs of subsidized credit have often been especially high because of extraordinarily high default rates and negative real rates of return associated with fixed interest rates in inflation-ridden economies (Feder, et. al., 1989). As Knudson *et al.* (1990) found, government-subsidized credit crowds out private lenders. Since credit is fungible, once the loan is made there is little to ensure that it goes to the intended purpose. In many countries, government policies have worked nega-

tively and depressed returns in agriculture, while borrowers could obtain higher rates of return elsewhere. Knudson (1990) refers to studies in Mexico, Pakistan and the Philippines which show only 25 to 50 percent of agricultural loans going to increase agricultural investment. Finally, subsidized loans often lead to the substitution of machinery and other purchased inputs for labor, a problem which exacerbates existing unemployment. Binswanger *et al.* (1990) and Purcell and Gulati (1993) show this to be a problem in India. The country report for Brazil indicates a similar outcome. Katula and Gulati (1992) indicate that the annual subsidy to Indian farmers through concessional interest rates and bad debts is in excess of \$US 1 billion.

Mexico

Historically, the Agricultural Trust Fund in the Bank of Mexico or Fondo de Garantia y Fomento para la Agricultura, Ganaderia y Avicultura (FIRA), a second tier lender, and the Banco Nacional de Credito Rural or National Rural Credit Bank (BANRURAL) provided more than 50 percent of agricultural credit (Table 3.7). This large percentage has crowded out private lenders because interest rates have been subsidized.

Table 3.7: Volume of Credit Dispersed by Source of Funds in Mexico (Mil US\$)

Year	FIRA		BANRURAL		TOTAL	
	Amount	Percent	Amount	Percent	Amount	Percent
1989	1,520	49.1	1,576	50.9	3,096	100.0
1990	2,014	64.0	1,131	36.0	3,146	100.0
1991	2,303	68.9	1,040	31.1	3,343	100.0

Source: Banco de Desarrollo, Secretaria de Hacienda (World Bank, 1992a)

Unpaid loans have been a major problem as shown by transfers to the rural financial system that represented 0.61 percent of GDP in 1992 when the 0.02 percent of AGROSE-MEX is included (Table 3.8).

Table 3.8: Transfers to the Rural Financial System in Mexico (Million US\$)

	1986	1988	1990	1991	1992
BANRURAL	552	867	348	296	1754
FIRA	9	13	54	79	89

Source: World Bank 1992a

Note that BANRURAL neither mobilized resources nor increased rural loans over the 1989 to 1991 period and in 1991 the overdue loans remained the same while lending volume decreased. The number of small borrowers dropped from an average of 500,000 between 1987 and 1989 to 200,000 in 1991. In 1990-91, BANRURAL implemented a policy of demanding repayment from the previous production credit loan before releasing a loan for the next production cycle. This resulted in a reduction in cotton production by many Edijos (the Mexican communal agricultural production system) and small scale cotton producers. The BANRURAL role in financing

Table 3.9: Hectares of Cotton Financed by BANRURAL, 1988-93 (1,000 Ha)

Year	1988	1989	1990	1991	1992	1993	1994
Financed	145	86	73	50	6	0	12

Source: Muñoz *et al.*, 1993

the cotton sector has diminished considerably (Table 3.9). On the other hand, FIRA doubled its loan value from 1987 to 1991 while the loan repayment rate remained at a very high 98 percent.

In the irrigated cotton regions of Mexico, the distribution of land between Ejidos and private ownership is 44 and 56 percent respectively. Most of the small farmers do not have access to the banking system because of a lack of collateral and the fact that the small average investment loan requirement of US\$ 2,000 is less than the minimum U.S. \$18,000 loan of commercial banks. The technical assistance program to assist low income producers under FIRA which reimburses commercial banks that make loans to this sector through an interest rate margin, has not been successful and the number of loans beneficiaries under this program fell from 242,065 in 1988 to 62,545 in 1991. Program Nacional de Solidaridad (PRONASOL) operates two welfare programs directly related to financing farmers. Solidaridad para la Produccion (PAP) provides municipal grants which are lent to farmers at a zero interest rate. Empresas Solidaris (Programa de Apoya para las Empresas de Solidaridad), established on December 4, 1991, focuses on the "avencindados" and "sons of ejidatarios" who, as a result of the reforms of Article 27 of the Mexican Constitution, no longer have a right to land.

Brazil

The Valor Básico de Custeio or Basic Disbursement Value (VBC) is a theoretical cost structure for each crop, broken down by productivity level, and used as a basis for calculating official credit availability for farmers. The "BTN" or National Treasury Bond index used, for adjusting minimum prices and credit, was abolished on January 30, 1991 when prices were frozen at the BTN value of 126.8621, the final value for February 1991. Lending limits based on historical yield and limits were established for two different regions and three different farmer categories (Table 3.10).

Table 3.10: Credit Limits as Percent of Productivity Level of Cotton in Brazil

Region	Small Farmers		Medium Farmers		Large Farmers	
	90-91	91-92	90-91	91-92	90-91	91-92
Mato Grosso	80	80	50	60	40	50
Others	80	80	50	40	40	20

Source: USDA - FAS Attache Report 1993

However, the "1993-94 Agricultural Crop Plan" of July 20, 1993 included a new production credit policy based on "product-equivalency" in an attempt to stimulate production. In addition to increasing MPPs by 5.5 percent in real terms, lending limits were increased to about US\$ 250,000 per producer. The yield categories for determining the VBC were reduced from seven to four with the funds released at three different times (35 percent-Aug., 30 percent-Oct., and 35 percent-Feb.). Lending limits for two producer categories of mini-small and other were set at 100 and 90 percent of the VBC respectively. Interest rates were set for mini, small, and all other categories at six, nine, and 12.5 percent, respectively.

Brazilian credit policy under the vetoed 1994 farm bill applied a discretionary cost-of-living index to both farm loans and to variations in the guaranteed minimum purchase price. The government had been using this discretionary authority since April 1994 by freezing minimum prices and collecting interest equal to cost-of-living index plus a spread on farm loans. Under a recent congressional override of this veto in early April 1995, the government is denied this discretionary authority and the final outcome (political or legal) of an increase in minimum prices, a retroactive rebate on interest loans or some combination of the two, is very uncertain.

Two programs, the Federal Government storage loans (Empréstimos do Governo Federal (EGF)), and the Government stock purchase program (Aquisição do Governo Federal (AGF)) operate in combination with the MPP. The EGF has two components, EGF-COV (Com Opção de Venda), Federal Government loans with purchase options or a non-recourse loan that gives farmers the alternative of delivering the crop (used as collateral) to the government at the due date and EGF-SOV (Sem Opção de Venda), a Federal Government loan without a purchase option. The EGF-Special was introduced in 1992 to allow extension of the EGF for an additional period. The Preço de Liquidação de Estoque (PLE) allows farmers to sell the commodity under EGF at the prevailing market price, the Government subsidizing the difference between the sales price and the cost of EGF. PLE has not been implemented for cotton but is similar to the "marketing loan" program for cotton in the U.S. AGF is a guarantee by the Government to purchase any quantity of cotton at the MPP. Direct sales at the MPP are restricted by the availability of funds and are one source of the AGF, the other being farmer defaults under EGF-COV (Tables 3.11 and 3.12).

Table 3.11: Value of AGF and EGF in Brazil: Seed Cotton and Lint, 1984-1991 (US\$)

Year	AGF		EGF	
	Seed Cotton	Lint	Seed Cotton	Lint
1984	104	67,350	87,667	93,329
1985	458,394	319,222	199,818	123,707
1986	56	67,351	488,844	375,390
1987	0	7,472	203,999	146,426
1988	0	31,152	237,257	147,588
1989	0	194	56,077	29,581
1990	0	0	18,444	6,632
1991	0	0	19,003	10,109

Source: World Bank 1993

Table 3.12: Brazil: AGF Purchases & EGF Entries as Percentage of Cotton Production

Year	AGF Purchases	EGF Entries
1975	9.7	51.0
1985	6.0	13.0
1987	11.0	42.0
1988	1.5	38.0
1989	0.2	15.0
1990	0.0	4.0
1991	0.0	7.0
1992	0.0	3.0

Source: World Bank 1993

The stocks under AGF and EGF result from the fact that the Brazilian textile industry generally uses the higher grades, leaving the lower grade, primarily grade 7 and below, to ultimately become AGF cotton. The low prices in certain years resulted in farmgate prices falling below the MPP. Cotton movement for export has been restricted by exchange rate policies and export taxes.

Cotton Price Intervention

General

Cotton is the basic raw material used in the textile industry and the major source of foreign exchange earnings for several developing countries. However, in some developing countries, the cotton fiber is the major foreign exchange earner while in others, textiles are the major exchange earner and the cotton fiber may or may not be domestically produced. These factors influence government policies and programs which affect the location of cotton production, consumption and prices. The governments of most cotton producing countries are heavily involved in cotton production and marketing (Bell and Gillham, 1989). Cotton policies in the major developed countries

of the US and the EC are designed to stabilize and maintain farm income. However, in the case of the US, the policy includes market expansion. In major textile manufacturing countries that are also major cotton producers, textiles are not only the major source of foreign exchange but large employers of unskilled labor. In these countries, cotton policy is directed towards providing the domestic textile industry with fiber at a low cost while expanding the textile industry, commensurate with the further increase in cotton production.

Government policies directed towards cotton have different purposes in different countries. Cotton production is directly or indirectly affected by the policies of supply control and price and income stabilization in many countries, by some form of subsidy in all countries and by effective price minimums in most countries (Bell and Gillham, 1989).

Categories of Price Intervention

Eisa *et al.*, (1994) grouped cotton price intervention policies into four broad categories:

- Category I: policies designed to boost farm income while interfering as little as possible with the level of market prices;
- Category II: policies designed to control the cotton sector through extensive state regulation;
- Category III: policies designed to manage domestic cotton prices so as to boost exports of textiles and apparel; and
- Category IV: policies following a free market system.

Most African cotton producing countries are export oriented and fall under Category II. The farmer receives a price announced at the onset of the marketing season that may or may not be augmented if the marketing organization receives higher than expected returns. Farmers in these countries historically have sold to a state or parastatal agency that had a monopoly on marketing. In the case of francophone West Africa, cotton research has been supported. In Southern and Eastern Africa there is a trend towards more 'privatization' by removing the state granted monopoly on marketing. Tanzania is reflective of this category. These countries could just as easily be placed in an expanded Category III that would include state regulation to promote the exports of cotton fiber. However, to facilitate the discussion, the four categories suggested above are maintained. Category I as included in this study is more completely defined to include policies designed to maintain and stabilize farm income. Category II countries include those who use extensive regulation to control the cotton sector.

The policies of most of the study countries were briefly summarized in the previous report (Ibid). They are expanded in this document to include all study countries from both a historical perspective and the viewpoint of movement to more liberalized marketing. The internal impact of these policies is also evaluated.

Category I:

USA., Brazil, Current Tanzanian Policy and Proposed Egyptian Policy

United States Policy

The United States policy roughly fits into Category I as government payments are made directly to farmers (as well as other market participants - merchants and mills) and are generally considered not to interfere with market transactions or distort prices in the short run. However, it

has probably distorted or changed historical price relationships. Furthermore, the transfer payments to farmers are a substantial part of farm income in many years and without this subsidy, production would be dramatically curtailed (Ibid).

Total payments to farmers averaged US\$992 million from the period 1986-1993, consisting of total payments of US\$7.045 billion and US\$889 million for deficiency payments and loan deficiency payments respectively. Deficiency payments are the difference between a target price and an average farmgate price and are calculated on a payment base times an average yield subject to payment limitations. Loan deficiency payments are the difference between the price received by farmers for cotton entered into and redeemed from the USDA loan program. The US Cotton Program increased the price received on a base acre equivalent to 7.7 US cents and 12.9 US cents per pound depending on whether or not growers were subject to payment limitations.

Brazilian Policy

The Brazilian policy fits into Category I as no direct price intervention is involved other than the use of two loan programs, the government storage loans and the government stock purchase program which are used in combination with a minimum price to support farm income. Credit availability, as determined by the Government as a percent of the productivity level, combined with the minimum price, has influenced cotton plantings. With the removal of the import tax on raw cotton, Brazil could resemble free market Category IV, although the state value added export tax restricts and distorts export trade. Brazilian policy has moved towards liberalization even though exchange rate policy has had an impact on the cotton sector in widely different ways at different times. The financial crisis during the late 1980s and early 1990s rendered the non-robust Brazilian loan support program ineffective while state determined credit allocation to commodity sectors resulted in inefficient resource allocation to crops. However, cotton production is recovering from the recent low level of 414,000 mt of lint produced in 1992-93 (964,000 mt were produced in 1984-85) and shifting to areas where resource allocation is more efficient.

The policy which persisted until 1990 served to assure the Brazilian textile industry of a domestic supply of fiber. With taxation on cotton imports, the textile industry utilized the higher quality Brazilian cotton while the lower quality domestic cotton migrated to the loan program where various taxes and exchange rate distortions usually resulted in prolonged storage and delayed, cheap export sales. The movement of lower priced low grade cotton into the loan program resulted in a low valued export sale relative to the value paid for more expensive higher grade imported cotton. This disparity still exists when exports and imports are adjusted for the significant quality differences. The import tax on cotton lint has been eliminated, but the state value added tax for exports remains. However, export revenue is relatively unimportant due to the excess of cotton consumption over production.

a) General

The Brazilian Government policy relative to cotton production is (1) the establishment of minimum product prices (MPP) and government loan programs, (2) setting production credit limits, and (3) making production credit available below market interest rates.

b) Producer Prices

Minimum price proposals are prepared by the Companhia Nacional de Abastecimento (CONAB) and submitted to the Agricultural and Finance and Planning Ministries. These two min-

istries issue the operational norms. The recommended prices are submitted to the Conselho Monetário Nacional (CMN). Banco de Brazil is in charge of financing and purchasing the produce and the commercial banks operate the Empréstimos do Governo Federal (EGF) scheme under rules from the Central Bank.

Annual seed cotton minimum and market prices eroded from 1977, had a brief recovery in 1984 and 1985 before the impact of the large Chinese crop of 1984 and new U.S. cotton legislation resulted in the resumption of the downtrend which continued through 1992 as the shortage of funds for the loan programs since 1988 resulted in ineffective Government policy.

c) Trade

The export tax or ICMS (State Value Added Tax) is 15 percent. Tariffs on raw cotton imports decreased from 55 percent in 1986 to 10 percent in 1988 and were eliminated in 1991.

Although the Brazilian cotton sold for export is low grade, the imported cotton is both Cotlook™ "A" and Cotlook™ "B" type cotton as most of the expansion in the textile industry is in the denim sector. Data for 1989 and 1990 illustrate the disparity between the price paid for imported cotton and the price of cotton sold for export (Table 3.13). During this two year period, cotton was imported at an average price of 71.50 U.S. cents per pound and exported at an average price of 45.70 US cents per pound, a difference of 56 percent. This clearly illustrates

Table 3.13: Cotton Lint, Quantity and Revenue. Nominal US\$: 1989-1990

Year	Export		Import	
	Quantity (mt)	Revenue (US\$)	Quantity (mt)	Cost (US\$)
1989	174,831	157,741	132,153	203,799
1990	108,678	127,938	25,521	44,772

Source: USDA - FAS Attache Report, 1990 and 1991

* It is assumed that the above data do not reflect the 10 percent import tax or the 15 percent ICMS export tax.

the dilemma facing the Brazilian cotton industry in general and the export of low grade lint in particular. Part of the reason for the price disparity is the low grade of Brazilian cotton for export, a problem in itself. If no adjustment is made for grade, the producer has been paid more than the export value. As an example, consider the year 1990 when the producer received an average seed cotton price of 19.02 U.S. cents per pound. A 35 percent ginning outturn (GOT) would give a lint equivalent price of 54.34 U.S. cents per pound which exceeds the export value of 40.92 U.S. cents per pound for the same year (this analysis assumes that the purchase and sale of cotton occurred in the same year when in actuality, the cotton movement into the loan probably occurred several months prior to the export sale).

d) Conclusions

- Historically, direct price intervention at both the producer and consumer level has been a feature of Brazilian agricultural policy. The MPP program was the major form of intervention at the production level from 1984 to 1988. Although the program is still in place, a lack of availability of funds has eroded its effectiveness. As an example, the producer's share at farmgate of

¹ Cotlook Limited is a leading source of international cotton news. The Cotlook "A" Index is the average the cheapest quotations, CIF North Europe in US cents/lb of 14 growths of Middling, 1 3/32" quality cotton while the Cotlook "B" Index is the similar average of a number of growths of Strict Low Middling, 1 1/32" to 1 1/16" quality cotton. These indices are widely used as indicators of the competitive level of international offering prices.

domestic lint revenue as measured by wholesale prices in Paraná has averaged 71.5 percent from 1990 through 1993.

- The fact that the MPP has resulted in the Government acquisition and marketing stocks of low grade cotton for export, often at a time when prices were depressed and at a low value relative to other crops, has prevented a major merchandising industry from developing.
- The EGF program has also probably resulted in the lack of development of private financial services.
- Similarly, the MPP has probably kept the level of investment by private agents in marketing instruments at a low level, and had an impact on the resource allocation both to individual crops and consequently the allocation of land to specific crops between regions.
- The elimination of the import tariff, declining world cotton prices and absence of an effective support mechanism has caused Brazil to move from being a large exporter to a net importer.

Tanzanian Current Policy

Tanzania is another country in transition. Reforms in the cereal trade commenced in the late 1980s. However, the decision to reform the market for the major export crops (cashews, coffee and cotton) that was announced in April 1991 has moved slowly as policy announcements have not been followed up by the necessary legislative changes. Historically, intervention in the cotton economy was pervasive.

Legislation on seed cotton processing and marketing was passed by the Assembly in August 1993 and became law in October when the Tanzanian Cotton Marketing Board (TCMB) became Tanzania Cotton Lint and Seed Board (TCLSB) which now functions as a regulator of production and marketing and no longer has a monopoly on marketing. During the 1994-95 season, seed cotton was purchased by the unions, private societies, the TCLSB and private companies. Data from the Western cotton Growing Area (WCGA) suggest that 13 percent was purchased by private buyers and 87 percent by cooperative unions and TCLSB. The private buyers are Pamba Industries and Kishimba International Traders (Kagera Region), Virian Co. Ltd. and Serengeti Agro Products (Mara Region), Kishimba International Traders, Agro Marketing Ltd. and Milemba Oil Mill (Mwanza Region) and Lalago Ginnery and Cargill (T) Ltd. (Shinyanga Region). The performance of the private sector was low because of late receipt of permits and lack of assurance of ginning facilities. There were probably also delays in making financial arrangements. Their performance is expected to improve in 1995-96 because they have commissioned their own ginning facilities and they are more aggressive. Producer prices in 1994-95 ranged from Tshs 112 to 130 with an average of Tshs 120 for AR seed cotton. Marketing margins are not available².

Proposed Egyptian Policy

The Egyptian cotton industry is moving rapidly towards decentralization. Farmers are free to plant any crop, within the limits of varietal zoning. With the exception of water, the input sector has been privatized and most subsidies eliminated although subsidies on some pesticides are being maintained. Minimum purchase prices are still in effect but 17 of the 38 ginneries have been leased to the private sector with an option to buy and farmers can gin at any single variety ginnery. Export pricing has been modified to more closely reflect the current world supply-demand for both upland

² Additional data provided by TISCO in March 1995.

and Egyptian type cottons. The concept of 'Administered Pricing' still prevails but weekly adjustments can be made in the offering prices. A tender system is being considered. Cash markets are in the process of being established.

Category II:

Historical and Current Uzbekistan Policy, Chinese Policy which overlaps Category III and Historical Egyptian Policy

Uzbekistan

a) Introduction

The Uzbekistan cotton sector is controlled through extensive state regulation. Cotton policy is characterized by state production orders, highly subsidized fixed input prices, and fixed output prices that determine artificial profits. The state production order is in the form of a quota to be produced with the area, variety and input level specified by the State. Marketing is also centrally planned by the Government Ministry of Industry State Committee on Forecasting and Statistics (UZKHLOPKOPROMSBYT), which has a monopoly on purchasing and ginning cotton. Cotton marketing is 'fragmented' and apparently coordinated by the institutions involved. Three layers of government, presidential or executive, ministerial, and sub-ministerial, are involved in marketing. The major executive and ministerial sales are barter. Sub-ministerial sales are for the collective farm's share of output (now one third) and are generally for cash (rubles or hard currency) used to purchase hard currency imports to avoid the export tax.

b) Trade Policy

The current marketing system involves both barter and cash with barter agreement with former USSR Republics reportedly involving primary grains, oil and fertilizers, and barter with international cotton merchants involving grain only. Steel barter with a Korean firm are an exception. Since the value of grain is fairly well established in international markets, price discovery (whether or not hard currency denominated) is likely to be fairly efficient. Barter with the former USSR republics are another matter entirely. This exchange could be mutually beneficial under current conditions of low transportation costs that are fixed in terms of rubles (Table 3.14). Uzbekistan is a land locked country so all rail shipments of cotton have to be negotiated with the neighboring states that are traversed by the railway.

Table 3.14: Quantity and Price of Uzbek Cotton Sales

Shipment	Quantity (1,000 mt)	Price (roubles-mt)
Former Soviet Union	466.2	180,076
Hard Currency	600.7	337,200
Domestic	204.45	39,350
Total or Average	1271.35	165,747

Source: Bell T.M. Unpublished World Bank data, 1993

The cash sales made to international merchants also involve barter inasmuch as these sales are subject to an export tax if hard currency proceeds are not used to purchase inputs. Input needs of certain industries are reportedly assessed and these industries are allocated cotton which is sold for US\$. Proceeds are used for hard currency imports. At present two-thirds of the cotton quota is sold under state order with the remaining one-third theoretically sold by District or Oblast Associations representing collective farms, assuming there is no shortfall in production. Since these associations have no marketing expertise, several government entities (primarily UZAGROIMPEX) handle such sales for a 2 percent commission (in some instances \$10-ton is reported) and the col-

lective farm can use the remaining proceeds as it deems necessary, subject to the export tax. It seems as though most of the proceeds of cotton produced in excess of two-thirds of the quota is used to finance hard currency imports, although some regional cotton officials appear to indicate otherwise. The justification for export taxes seems to be to correct exchange rate imbalances while the zero export tax applied when proceeds are used to purchase hard currency imports implies that the problem is being addressed.

c) Other

The impacts of the policy on price are largely due to the breakup of the former Soviet Union, the formation of the common soviet trading bloc known as the Council for Mutual Economic Aid (COMECON) and the decline in cotton consumption in this area. This has resulted in different selling methods, including large quantities of barter sales, that have probably significantly distorted historical price relationships with other growths.

Cotton policy in Uzbekistan emanates from the days of the USSR and has changed little, except that the area planted to cotton has been decreased from a peak of 2.1 million hectares in 1987-88 to 1.5 million hectares planted in 1994-95, due both to environmental considerations caused by the previous policy and the need for increased food crop production.

There is no correlation between the current method of seed cotton payment at the farmgate and international cotton prices. Nevertheless, the state prices and area devoted to fine-filtered cotton production has reflected the change in the relative prices of Pima to upland type cotton in the past few years. Incentives to increase production and/or increase efficiency were very limited until above-quota export allocations were introduced for farms four years ago.

The average cotton farm grows about 1,600 hectares of cotton and supports about ten people per hectare, only one of whom is directly involved in cotton production. Workers receive a monthly wage and theoretically own the collective farm, even though the state retains ownership of the land. However, if workers move from one farm to another, they receive no compensation.

The Uzbekistan government feels that the state or cooperative farm organization is justified for several reasons. Cotton is a crop that requires a large amount of vertical integration at the farm level. Both economies of scale and application of inputs require large units. Seeds must be carefully monitored or production will be adversely affected. Pest control is completely ineffective if not applied in a uniform fashion over a large area. The short harvesting season requires mechanized harvesting which has large "economies of scale".

The amount of cotton that can be marketed by the collective farm subject to an export license has increased to 5, 15, 20, 25, and 33 1-3 percent over the past four years, respectively. However, this only applies if the quota is met and exports are subject to a tax if proceeds are not used to purchase hard currency inputs. UZCONTRACTORG, the state commercial contracting organization under the Ministry of Foreign Trade, issues export licenses and approves contracts of cotton lint for export for both cash and barter. This agency also allocates the rail cars for export shipment. District cotton authorities sell through several state entities, the largest being the State Agency for Export and Import of Agricultural Products (UZAGROIMPEX). Import requirements of state-controlled importers are allocated cotton by UZKHLOPKOPROMSBYT. The share of the lint revenue accruing to the collective farm is relatively low. The question of allocation of these proceeds to the individual workers through wages or in the form of bonuses to management is

largely unanswered. It appears that the hard currency proceeds go to the collective farm and then first to capital investment, and second to improving the welfare of the collective farm as a whole. Farms that export above quota amounts are taxed less than those that only meet the quota and export only the permitted percentage.

d) Policy Reforms

The transition from a system of completely subsidized input and output prices with no link to international prices to a market oriented system will move very slowly but change is absolutely necessary if the system is to become efficient. A system has to be developed that will achieve both efficiency and minimum market disruptions. This may be costly and require large international assistance to enable farmers to survive the long transitional process. Both inputs and outputs must ultimately be priced at international prices for sustainability. Uzbekistan has several other problems, including the necessity to import large quantities of grain and to move raw cotton fiber across Russia, regardless of the port or rail system used. The use of export licenses cannot be justified from the viewpoint of protection of a textile industry that only utilizes 200-250 thousand tons of fiber. The Uzbeks appear to be justifying this license because of (1) exchange rates and market distortions, (2) evaluation of contracts and assured contract sanctity, and (3) state plans that require coordination of all cotton in barter with Russia which controls railroads and rail car availability. Both short and long term problems in the implementation of changes are vast.

e) Return on Cotton Growing

Numerous questions have arisen relative to yields, production costs, and rates of returns in the various oblasts. Cotton farms are completely isolated from world cotton prices and only receive about 20.0 percent of the value of lint sales. This is reflected in the eroding financial rate of return on cotton production expenditure which has declined from 41.7 percent in 1985 to slightly over 13.0 percent in 1992. Given the artificial nature of the production costs, yield is perhaps the best indicator of cotton profitability if comparisons are to be made with other cotton growing countries. However, from the Uzbekistan point of view, when the cotton output is adjusted for grade, some of the better yielding areas have the lowest rates of return. As examples, the Andijan, Bukhara, and Ferghana regions achieve relatively high yields but rates of return are relatively low. The only apparent definitive conclusion is that cotton profitability decreased from the mid 1980s to 1992, the last year of available data.

f) Grading

The question of payment for seed cotton versus lint cotton depends to a large degree on the relationship between the grading standards used for seed cotton and the standards used for lint. Data indicate the seed cotton grade 2 was 40 percent while the lint cotton grade 2 was 49 percent of the crop during 1992, indicating that the difference between seed cotton grading and lint grading is depressing the farmgate price relative to the lint value. The absence of correlation between the method of seed cotton payment at the farmgate and the grade of the cotton fiber is being addressed.

Chinese Policy

a) General

Chinese policy fits into Category II although the textile industry is the largest in the world and could place China in Category III. The government has always attached particular importance to cotton production, seeking to influence the sector by implementing a series of policies through-

out its history. The main policy goals have been (a) formulate a purchase price that will result in sufficient cotton being produced to supply the domestic textile industry while insuring the income of cotton farmers, (2) guarantee grain supply to the major cotton producing areas, and (3) provide a timely supply of inputs, such as chemical fertilizers, pesticides, and plastic sheeting to the farmers. However, recently these goals have not been achieved because of problems facing cotton production.

Chinese policy involves both extensive state regulation and policies designed to boost exports of textiles and apparel. Problems relate both to cotton production and the growth of non-state mills relative to state run mills. Generally speaking the Chinese have offered a procurement price to farmers which is sufficient to maintain a relatively constant acreage in both the Yangtze River and in Xinjiang but the farmers in the Yellow River region or so-called Northern Plains have proven to be very responsive to returns from cotton growing (both prices and yields) and significantly altered cotton plantings accordingly. Furthermore, the marketing margin exceeds twenty percent from farmer to mill which is relatively large by international standards. As new machinery was installed in the state run mills, the older machinery was purchased at discount prices by rural entities who could then compete and procure cotton fiber at a lower price than the state mills. This unofficial policy of allowing the development of rural textile industries commenced in the mid 1980's when excessive cotton supplies, insufficient warehouse capacity to store the cotton stocks, low spinning capacity, and large rural unemployment existed. This led to the establishment of large numbers of rural mills that now supply over 66 percent of China's domestic textile needs and a state textile industry that has seen output stockpiled while profit margins eroded due to the necessity to raise the prices paid to cotton farmers and because of the importation of cotton fiber.

In October, 1992, the 14th National Peoples Congress agreed to decentralize several controlled commodities and shift autonomy to the provinces. The Cotton Conference held by the State Council in early March, 1993 adopted measures which were implemented on April 1 and aimed at decentralization the cotton market. Selected provinces were to practice a limited open market for cotton. This planned decentralization which called for cotton produced in excess of the provincial quota to be sold in the open market, was only partially implemented due to the decline in cotton production. The Cotton and Jute Corporation, an agency of the Ministry of Internal Trade, was given responsibility for maintaining a floor price. However, these decisions are now obsolete. The state became the only buyer once again in the summer of 1994 as production problems persisted. The government is striving to maintain a very tight control but it seems to be failing.

b) 1950-1984

From 1954 to 1984 the government was the sole purchaser and seller of cotton. In both the North and Central regions, delivery quotas were established through the planning mechanism. The base price differed from province to province and was paid until that quota was filled. However, from 1979 to 1983, quotas were based on average production levels between 1976 and 1978 which proved to be a low base because of expanding demand for cotton. During this period, production the Northern province was stimulated by paying growers a 5 percent bonus on all production. The price increases averaged 39.5 percent from 1977-1980 and 74.0 percent from 1977-83.

c) 1984-Current

In 1984 the cotton policy was replaced by the contractual purchase policy. A down payment to support farmers during the growing season was provided. A higher price was paid for pur-

chases above the quota to encourage farmers to expand production and to expand cotton acreage in the Northern provinces. The bonus initially was set on 80.0 percent of production above the quota in the Northern provinces for 1984 but was gradually reduced to 70 and 60 percent in 1985 and 1986. The initial bonus was paid on only 20 percent of above quota production for the Southern provinces but raised to 40 percent for the same years. The readjustment of this premium especially in the Northern provinces resulted in the area planted to cotton decreasing in both 1985 and 1986 after the record 6.921 million hectares that were planted to cotton in 1984. Since 1987, the premium has remained at 70.0 percent of above quota production for both areas (Table 3.15).

Data indicate that the average price paid by the Cotton and Jute Corporation has equalled the base price but the actual prices to farmers have declined since 1990 due to the decline in average grades. This is much greater for the Northern provinces than for China as a whole because of the significant decline in production in these provinces due to the insect problems. Production in Xinjiang, a region that produces high grades, increased significantly during this period (Table 3.16).

Table 3.15: China: Purchase Prices for Quota and Above Quota Cotton Production (Yuan-100kg)

Year	Overall			North China			South China		
	Fixed Price	Added Price Subsidy	Actual Price	Fixed Price	Added Price Subsidy	Actual Price	Fixed Price	Added Price Subsidy	Actual Price
1977	210		210	U	U		U	U	
1978	230		230	U	U		U	U	
1979	265	29	294	A	A		A	A	
1980	292	50	342	A	A		A	A	
1981	292	53	345	A	A	369	A	A	321
1982	292	66	358	A	A	376	A	A	329
1983	292	73	365	A	A	376	A	A	337
1984	292	58	350	20	80	362	60	40	327
1985	292	50	342	30	70	353	60	40	323
1986	292	44	336	40	70	344	60	40	322
1987	292	61	353	30	70	353	30	70	353
1988	292	61	353	30	70	353	30	70	35
1989	412	61	475						
1990	539	61	600						
1991	539	61	600						
1992	539	61	600						
1993	599		660						
1994			810						

Source: Wang *et al* 1994

Note: The actual price contains the fixed price, added price for additional purchase and additional price subsidy of the Northern cotton growing region. U refers to Uniform Price; A refers to added price for additional purchase

Table 3.16: Average Purchase Price of Standard and Mixed Grade Seed Cotton in China (Yuan-100kg)

Year	Grade		Year	Grade	
	327	Mixed		327	Mixed
1981	345	312	1989-First	423	
1982	358	324	1989-Second	473	495
1983	365	342	1990	600	634
1984	350	342	1991		647
1985	342	322	1992		612
1986	336	322	1993		
1987	353	356	1993	800	
1988	353	400	1994	1000	

Source: Wang *et al.*, 1994

In 1988, a new incentive policy was implemented in the form of inter-provincial (inter-municipal for autonomous regions) allocation and transfer of cotton. This provides for a subsidy of 128 Yuan-ton to be paid by the Ministry of Finance to the Province (municipality in autonomous regions) for each ton of cotton transferred from the province to be used for the purchase of grain.

d) Supply Price to the Mills

During the period 1988-1993 the base price for Grade 327 increased from 367 Yuan-100 kg to 600 Yuan-100 kg, representing an increase of 63 percent. During the same period, the average margin, with 1990 and 1991 data missing, was slightly over 20 percent (Table 3.17).

Table 3.17: Differences between Supply and Purchase Price in China for Grade 327 (Yuan-mt)

Year	Basic Price	Purchase Price	Supply Price	Price Differential	Difference (percent)
1987-88	2,691	3,528	3,440	524	18.0
1988-89	2,691	3,528	3,860	1,169	
1989-90	4,116	4,728	5,100	984	
1990-91	5,387	6,000	6,480	1,093	20.3
1991-92	5,387	6,000	6,480	1,093	20.3
1992-93	5,387	6,000	6,480	1,093	20.3
1993-94	5,988	6,600	7,284	1,296	22.0

Source: Wang *et al.*, 1994

Note: The actual purchase price includes part of the added price for additional purchase. The added price is subsidized by Central Finance and is not included in the cost of cotton purchasing and selling

However, data for individual provinces indicate that the margin could be higher. As an example, data from Hubei indicate that the sales price to the textile industry for 1992 for the standard grade 327 purchased at 300 Yuan-50 kg would be 358.49 Yuan-50 kg.

e) Government Subsidies

The cost of Government subsidies can be estimated directly from the 30.62 Yuan-50 kg paid to the Cotton Companies plus the 12 Yuan-50 kilograms paid to the farmers in lieu of the diesel and fertilizer subsidy. These calculations

give the following cost of the cotton program to the Government without considering the 128 Yuan-ton paid to the provinces (municipalities in autonomous regions) and 25 Yuan ton paid for cotton transfers out of the region to support grain purchases by farmers and to support research respectively (Table 3.18).

Table 3.18: Cotton Subsidy (million Yuan)

Year	1988	1989	1990	1991	1992
Purchase	3,778	3,306	4,091	5,290	4,258
Subsidy	2,238	2,335	2,920	3,379	2,138

Source: Wang *et al*, 1994

f) Support to Cotton Production

The provision for utilizing fees from cotton sales to support cotton production through technical demonstration and extension was apparently replaced by another provision that allowed 25 Yuan-50 kilograms to be transferred out of the province for use in support of cotton production.

Historical Egyptian Policy

Egypt is an example of a country that is in transition from Category II to a policy that closely resembles Category I. Prior to the move towards decentralization, cotton was known as the 'Government' crop. Planting was required and numerous ministries were involved in the cotton and textile industry. The MALR set production targets by variety and by Governorate. The Governorate, in turn, required farmers in districts in designated cotton areas more than 12 kilometers from Cairo to plant one third of their land to cotton. The procurement price was set by the MALR after approval by the Higher Policy Committee, representing several ministries. The 31 spinning mills were controlled by a holding company, the Textile Industries Corporation (TIC) under the Ministry of Industry (MOI). Since 1990-91 the Ministry of Treasury (MOT) has paid the difference between the procurement price for cotton plus the ginning and transportation cost less the cost charged to the mills for raw cotton. The Ministry of Public Works and Water Resources provides free irrigation water but imposes charges for fuel for irrigation pumps.

The Egyptian Cotton Authority under the Ministry of Economy and Foreign Trade (MEFT) which includes six Cotton Procurement and Marketing Companies (CPMCs), five ginning companies, and one pressing company, had a monopoly on marketing and distribution.

Historical Tanzanian Policy

For three decades, cotton producer prices were set by the Government, taking into account not only (1) the production level of cotton, (2) expected world market prices, and (3) inflation and exchange rates, but also, commencing in the mid 1980s, (4) the level of profit and loss incurred by the marketing unions and board. This coincided with the record Chinese crop.

Previously, cotton marketing was under the control of regional cooperative unions with the Tanzanian Cotton Marketing Board (TCMB) as the marketing agent, using a system of tenders. Unions had been in existence for decades but were dissolved in 1976 and authority was transferred to new Government-created crop authorities. Unions were reintroduced in 1984 but had a weak financial and managerial base. Marketing progressed from the Tanganyika Lint and Seed Market-

ing Board (1956) which followed the earlier Uganda Lint and Seed Marketing Board. The newly created Tanzanian Cotton Authority took over the function in 1973 and was restructured and renamed the TCMB in 1984. In 1990, lint ownership was transferred to the unions.

The overvalued TShilling has acted as a disincentive to cotton production. The fixed exchange rate forced farmers to accept a lower price than would have prevailed on the open market. Traders of non-traditional export crops such as cardamon, sugar, grapes, flowers etc. could retain more than 50 percent of export proceeds sold on the open market, a provision that was not allowed to producers of traditional row crops, including cotton. In 1993, the unions were allowed to retain 10 percent of external sales to maintain and expand a deteriorating ginning industry. However, currently the cotton unions are technically bankrupt with enormous debt.

The intervention in pricing resulted in:

- increases in cotton prices not commensurate with the rate of inflation and since yield increases have been non-existent, production has suffered.
- the inability of the Government to support cotton prices in 1985-86 and 1986-87, when the prices paid to farmers was greater than the export price, resulted in large losses to the unions and TCMB. These were the years of low world prices caused by the record Chinese crop.

The impact on the cotton sub-sector has been severe. In the four years preceding the 1985-86 and 1986-87 marketing seasons (1981-82-1984-85), the producer received an average 86 percent of the export price. The Cotlook™ "A" Index in 1980-81 reached 94.20 average for the year and the Cotlook™ quote for Tanzania AR Type 3 was 103.25. The Chinese record crop of 1984 caused the Cotlook™ "A" Index to drop to 47.63 in 1985-86 and for the Tanzania AR Type 3 quote to drop to 55.81. This sharp drop in price contributed to financial problems which resulted in the farmgate price from 1987-88 through 1992-93 declining to an average of 46 percent of the lint value. Cotton yields were also depressed by the insolvency of the unions and TCMB that resulted in input shortages. This has contributed to soil degradation while the low throughput of the ginneries exacerbated their financial problems. These data suggest that the low prices in 1985-86 were a major contributor to the succeeding financial problems of the TCMB and the unions.

Malian Policy

In Mali, parastatals have been involved in all aspects of cotton production and marketing, even though several changes have been made over the past few years. In the area of cotton production, Compagnie Française pour le Développement des Textiles (CFDT) took over the ginning and marketing function from the Institut de Recherches du Coton et des Textiles Exotiques (IRCT) in 1952. The IRCT, originally established in 1946 as an outgrowth of the Cotton Union of the French Empire was then able to concentrate on research. A year after Mali gained independence in 1960, the government signed an agreement with the CFDT under which the Compagnie Malienne pour le Développement Textiles (CMDT) was created as a public limited company with a mixed economy. This agreement was renewed in 1969 and in 1974. The CMDT operates in regions (zones) that produce 98 percent of Mali's cotton while Office de la Haute Vallée du Niger (d'OHVN), created in 1972 operates in the remaining zone located near Guinea, Cote d'Ivoire, and Burkina Faso. CMDT controls all ginning and is both a profit seeking commercial entity and a public organization assigned with numerous responsibilities for rural development outside the cotton sector.

Until the CMDT agreement, prices were fixed by the Office of Price Stabilization. Prices are now set by the State, CMDT, and by producer representatives (added in 1992). This committee administers the cotton stabilization fund. The price of 85 CFA per kilogram was constant from 1985-1994. Rebates were given by CMDT, dependent on the export sales price but were limited to 20 percent of the raw cotton purchase value. Prices were increased to 115 CFA francs per kilogram in 1994 after the 100 percent devaluation of the CFA. The first Cotlook™ quote for African Franc zone cotton was 60.67 in 1984-85. This declined to 48.8 in 1985-86 as a result of low world prices but the CMDT apparently came through this crisis in better financial shape than the TCMB.

In 1988, after the liquidation of SOMIEX (the state export agency) cotton exports were handled by COPACO (the marketing arm for African cotton of the French parastatal Compagnie Cotonniere). COPACO was created with the CFDT, the CMDT and other West African National Companies as shareholders and accounts for over ninety percent of Mali's cotton exports.

Exchange rate policy probably contributed to the moderation of the increase in cotton production over the past few years (lint production averaged 114,000 mt from 1988-89 to 1993-94 after increasing from 41,000 mt in 1980-81 to 97,000 mt in 1988-89) because the CFA franc was tied to the French franc which appreciated against the US dollar, while cotton prices were generally declining. However, the maintenance of a lint yield in excess of 600 kilograms per hectare and subsidized input prices, aided in large part by an increase in the ginning outturn, resulted in gradually expanding cotton production from 1985-86 to 1993-94. The CFA franc was devalued by 2:1 in 1994. However, the price responsiveness of farmers is well illustrated since devaluation resulted in fixed farmer procurement prices being increased from 85 to 115 CFA francs and later to a reported 125 CFA francs per kilogram (farmers also receive a rebate from export marketing) and plantings apparently increased by more than 20 percent in 1994, the first substantial increase since 1985. This devaluation illustrates the impact of exchange rates on cotton production. After devaluation and with a higher price for cotton, the net income for cotton farmers increased by 36 to 44 percent, depending on the type of farming, after adjustments were made for the higher costs of imported inputs. This seems to imply that the cotton sector is taxed to support rural development, the public task assigned to CFDT.

Category III:

India and Pakistan

Comparison of Indian and Pakistan Policy

Both India and Pakistan manage domestic prices so as to boost exports of textiles and apparel. However, there are dramatic differences between the policies of the two countries. Indian internal policies are based on support for the handloom sector and require that non vertically integrated spinners supply 50 percent of their yarn output to this sector. In addition, there is a tax on yarn, resulting in a non-competitive spinning industry. The exports of weavers are also restricted by Multi-Fiber Agreements (MFAs) with the result that fabric exports typically flow to countries that do not possess high technology finishing but have quotas for the export of apparel under existing MFAs. The policy of Pakistan is geared entirely towards the export of cotton yarn. Technological differences between the Indian and Pakistan textile industries are immense. However, this is partially explained by the interaction of power and labor costs with the size of the domestic industry. Modern technology significantly increases power requirements which can be partially overcome by low technology, labor intensive ring spinning.

The desire for increased export earnings from either yarn or high value added textiles produced by an industry that also provides employment for large numbers of unskilled laborers, has resulted in cotton policies that attempt to provide a domestic source of raw cotton to supply an ever-increasing output of the textile industry at a price that will enable the industry to make a profit. Both India and Pakistan use a minimum price to maintain or increase cotton planting and both subsidize inputs to some degree. Low mill prices have been maintained by the use of export quotas in India and a variable export tax in Pakistan. However, this is less the case now that production is affected by leaf curl virus and world stocks are low. The cotton policy of India and Pakistan is evaluated by these countries in terms of the growth rates in the textile industry. In the case of Pakistan this resulted in reduced fiber exports while in the case of India, annual import needs were eliminated and India has become an occasional exporter of cotton fiber. This illustrates the trend towards shifting raw cotton consumption to major cotton producing countries which parallels a trend towards increased consumption in countries in close proximity to cotton producers.

The internal price policies of India and Pakistan provide domestic mills with cheaper cotton than is available to cotton importing countries and export policies ensure that the domestic mills have adequate supplies before cotton is made available to international markets. This factor, among others, has resulted in the growth rate of cotton consumption in these countries exceeding the growth rate in non-cotton producing countries. In both India and Pakistan, farmgate cotton prices have been less than the world price and have not reflected international prices.

Pakistan

a) Introduction

Pakistan cotton policy can be summarized as simultaneously supporting grower prices while keeping the domestic price of cotton down through an export duty, in order to keep yarn profitable to an expanding textile industry (Table 3.19).

Table 3.19: World and Pakistan Cotton Yarn, Fabric and Garment Trade

Year	Yarn Exports			Fabric Exports			Garment Exports	
	World	Pakistan		World	Pakistan		World	Pakistan
	1,000 mt	Percent		1,000 mt	Percent		Mil. US\$	% Share
1980	829	97	11.7	1309	78	6.0	75	2.5
1985	999	145	14.5	1627	106	6.5	206	6.7
1986	1188	203	17.1	1852	106	5.7	n-a	n-a
1987	1461	243	16.6	2093	123	5.9	n-a	n-a
1988	1322	236	17.9	1985	124	6.3	336	7.2
1989	1497	331	22.1	2253	139	6.2	394	8.0
1990	1522	436	28.4	2197	156	7.1	494	8.1
1991	1562	474	30.4	2250	170	7.6		
1992	1629	571	35.1	2236	179	8.0		
1993	1733	567	32.7	2262	162	7.2		

Source: ICAC World Textile Outlook (1994) (updated)

b) The Minimum Price

The minimum guaranteed price to growers was introduced for the 1976-77 season. Although there is no limit to the maximum price to growers, cotton lint export policy has served to keep prices lower than would have been the case if growers had access to the open market. Normally, the domestic market price has remained above the export price with the exception of a brief period in 1991-92 when Pakistan had a record cotton harvest. The Cotton Export Corporation (CEC) is charged with supporting cotton prices by purchasing cotton from farmers.

c) Cotton Export

The export of cotton was nationalized in November, 1973 when the Cotton Export Corporation CEC was established. However, deregulation occurred in 1987-88 when private export began to be permitted. During 1987-88, the private sector had to purchase lint from the CEC, but since 1988-89, it has been able to procure cotton in the open market. However, CEC is exempted from numerous procedures and requirements applicable to private sector exporters.

From 1988-89 through 1991-92, two prices, the Minimum Export Price (MEP) and the Benchmark Price (BM) were set by the Government of Pakistan. The MEP represented the cheapest value at which cotton could be bought for the international market and the BM was the maximum internal price paid for cotton. The MEP was set daily whereas the BM was generally set for the season but could be altered. The export duty was a variable percentage of the difference between the BM and MEP.

The price paid by the domestic mills was the MEP less the export duty. Since the new crop MEP was not announced until

Table 3.20: Pakistan: Export Duty as Percent of MEP-BM 1991-92

Aug. 1988 - Oct. 1991	Nov. 1991	Dec. 1991	Jan.-Aug. 1992
100	90	75	60

Source: ICAC Unpublished Data

December, exporters could not forward sell new crop cotton, thus giving domestic buyers first option. Generally speaking, this also resulted in a lower export price than that of growths from competing countries, due both to the seasonality of cotton prices and forward sales of competing growths prior to the start of the marketing year. The MEP is generally based on the Cotlook™ "B" Index. Obviously, this system favored the domestic mills (Table 3.20)

On August 19, 1992, Pakistan's Economic Coordination Committee approved a change in the cotton policy. The Benchmark system for calculating export duty was abolished. The tax per pound for an MEP of 44 cents-lb. or less is zero and increases progressively at a declining rate as the MEP increases. For example, the tax rate is 8.98 percent for a MEP of 50 cents-lb. an increase of 1.21 percent from the 6.67 percent tax at a MEP of 49 cents-lb. However, the tax rate for a MEP of 52 cents-lb. of 10.09 percent is only an increase of 1.10 percent. The impact on the domestic mill industry is that at prices less than 44 cents-lb., mills have lost their competitive advantage while the advantage progressively increases as prices rise. The farm sector has gained inasmuch as they receive a percentage (albeit declining) of increases in the MEP. Part of the apparent loss by the mill sector was offset by eliminating the excise tax on cotton yarn. This tax varied between one and six rupees per kilogram of yarn during the three season from 1988-89 to 1991-92, averaging around three rupees per kilogram or a tax of about 2.4 cents per pound on cotton used in spinning. This was 12 percent of the average 20 cents per pound advantage that Pakistan mills received due to lower internal cotton prices during the same period.

d) Cotton Imports

Cotton imports normally are subject to taxes amounting to 27 percent. These include a sales tax (15 percent), iqra (education) tax (5 percent), import license fee (6 percent), and flood relief tax (1 percent). These taxes were temporarily rescinded on Jan 12, 1994 due to the small Pakistan crop and high internal prices. The duty free import of cotton is allowed only as long as domestic supplies are inadequate to meet spinning requirements.

e) Domestic Mill vs. Cotlook™ "B" Mill Prices

Pakistan spinning mills have enjoyed a great advantage over foreign mills. The domestic price for lint in Karachi averaged about 79.0 percent of comparable international growths during the three years preceding the 1985-86 marketing year. During 1985-86, a year when changing U.S. Farm Policy and a record Chinese crop resulted in depressed international cotton prices, the domestic Pakistan prices were about equal to international prices. In the 6 years following the new U.S. Farm Policy (1986-87 to 1991-92), average Pakistan domestic prices were only 64.5 percent of comparable international cotton prices. This gave the Pakistan textile sector a large comparative advantage in cotton spinning and as a consequence, yarn exports increased dramatically (Table 3.19). However, cotton production problems during both 1992-93 and 1993-94 have dramatically altered the situation. During 1992-93, the spot Karachi price averaged 85.5 percent of the Cotlook™ "B" Index and during 1993-94 it was 97.0 percent. The actual price paid by mills during 1993-94 probably exceeded this index because they imported cotton during the marketing year when international prices were relatively high.

f) Conclusion

Intervention in the pricing system gave apparent favorable short term results until a combination of (1) import duties on sugar which resulted in expanded sugar production and (2) lower Pakistan cotton yields resulted in increasing internal prices and cotton shortages. Improved price linkages to international markets will be necessary to maintain the cotton area and encourage farmers to utilize inputs more efficiently.

India

a) Introduction

Government regulations influencing the cotton sub-sector operate at all levels of the cotton-textile industry, primarily through the Ministry of Agriculture (MOA) and the Ministry of Textiles (MOT). The policies can be grouped as (1) cotton specific, (2) textile specific, or (3) general commodity policy.

b) Minimum Price

The Commission on Agricultural Costs and Prices (established as the Agricultural Prices Commission in 1967-68) recommends support prices for two cotton types, medium staple F.414 and H.777 and long staple H-4. The prices take account of production costs plus a sufficient margin of profit to sustain the farmer interest in cotton growing and encourage the adoption of improved production technology. The costs of three key inputs, fertilizer, pesticides and labor, and the parity with production economics of competing crops are taken into account. The Commission's recommendations result in a government announcement of support prices on these varieties and the Textile Commissioner then fixes the support prices for other varieties on the basis of market

differentials, quality parameters, ginning outturn, etc. Sometimes these prices are used to encourage the production of a new variety or to discourage production of an outdated variety.

c) Cotton Marketing at the Farm and Regulated Market Level

Seed cotton is sold either to the public sector Cotton Corporation of India (CCI), the cooperative marketing federations, or the private sector (traders, ginnery owners operating as individual business proprietors, partnerships and private limited companies). The marketing federation in Maharashtra has a monopoly on cotton procurement. CCI is charged with supporting prices.

Cotton marketing laws are enacted in most of the states under the Agricultural Produce Markets Acts which has 480 regulated markets in the country. The purpose of the regulated markets is to prevent unfair trade practices. In general, they are managed by a committee comprising elected representatives of growers, buyers, and commission agents that also collects the market cess. However, only about 20 percent of the farmers sell through regulated markets, the remaining 80 percent selling either to village merchants or sub-dealers acting on behalf of merchants. It is estimated that 80 percent of seed cotton sales occur in regulated markets. About 30 percent of total production is purchased by CCI and the marketing federations with the remainder purchased by the private trade. In general, CCI is the major supplier to the National Textile Corporation. The state marketing federations purchase on behalf of the state cooperative spinning mills and the private trade purchases cotton for private mills. Variations include the supply of private mills in Tamil Nadu by CCI and the purchase of lint from cooperative marketing federations and the private trade in other states by the cooperative spinning mills of Karnataka.

Marketing by farmers differs dramatically from state to state. In Gujarat, there are 500 primary cotton cooperatives, operating under seven Regional Cooperative Cotton Marketing Unions and 145 cotton ginning, pressing and marketing societies. Under this system, an advance 65 to 70 percent payment is made to growers when seed cotton is delivered, the final payment being made after processing and sale of the lint. Indications are that recently farmers have received from 93.4 to 96.4 percent of the final price. However, a lot of the success of these cooperative may be linked to their ability to obtain export quotas.

At the other extreme, the monopoly created by the Maharashtra Raw Cotton (Procurement, Processing and Marketing) Act of 1971 results in farmers illegally tendering cotton for sale outside the state. Prior to 1986-87 the state government guaranteed prices for each variety at about 10 to 15 percent above the support prices announced by the Government of India but as a result of intervention by the government, purchases now are at support levels only except in years of low production, when the state government can pay advance bonuses to create price parity with other states to avoid smuggling. At the end of the season, profits are distributed in a 75:25 ratio to growers and the Price Fluctuation Fund. Losses are always debited to the Price Fluctuation Fund. The Cotton Control Act does not allow mixed cotton varieties to be pressed into a fully pressed bale.

Government imposed levies involve (1) levies between one and two percent on seed cotton sales (regulated market cess) and (2) a trading sales tax for both seed cotton and lint that varies between three and four percent from state to state.

d) Cotton Processing and Transportation

The Cotton Transport Act requires a license for transportation and places restrictions on the free transport of both seed and lint cotton in order to avoid mixing of varieties.

Rules under the Cotton Ginning and Pressing Factories Act provide for prices to be fixed by a committee consisting of the revenue district heads, grower representatives, representatives of ginning and pressing factories and an expert on ginning and pressing. Modifications to this procedure are currently being considered.

e) Textile Policy

The MOT attempts to maintain low domestic prices compared to international prices in order to (1) encourage value added textile exports instead of cotton exports, (2) to control cloth prices, and (3) to keep hank yarn prices at low levels.

Under the Essential Commodities Act, the MOT is empowered to dictate to the mills (1) product mix, (2) prices, and (3) stock levels. The government in the past imposed a stock level, equivalent to three months' spinning requirements, when India faced a deficit cotton situation for mills, in order to prevent strong spinning units from cornering cotton. Stock requirements were relaxed as India moved to a cotton surplus situation and mills were permitted to hold six months requirements with additional inventory allowed for exporting mills. However, the levels were reduced when prices increased substantially in 1992-93 and were re-imposed during the price escalation in late 1994. Stock limitations may also be imposed on other participants in the marketing chain. In view of the stock level, the MOT advises the Reserve Bank of India when to tighten or ease credit availability as prices increase or decrease in order to control the level of speculative stocks in the hands of traders.

The MOT ensures availability of hank yarn by requiring spinning mills to produce 50 percent in this form (excluding captive consumption requirements, exports, etc.). Off-take by the handloom sector is not guaranteed. No direct price controls are exercised on hank yarn but certain types of hank yarn buyers are exempted from excise taxes and often receive price support when prices increase substantially. The hank yarn sector utilizes about 25 percent of yarn production and produces 28 percent of cotton cloth. Fifty four percent of the hank yarn is in 10 to 20s count with slightly over 20 percent in the 1 to 10s count. Recent prices for the hank yarn sector are not available but during the period from 1985-89, hank yarn prices were slightly above comparable prices for the same counts of cone yarn.

f) Cotton Trade

India has shifted from being a cotton deficit to a cotton surplus trading nation since 1979-80 with imports occurring when natural calamities affected production. This has had an impact on the policy announced in 1986 of making 500,000 bales available annually for export. With the exception of inferior non-spinnable cottons like Assam Comillas and Zodas, staple cotton exports are governed by quotas. Exports of different varieties of cotton are subject to quantitative ceilings and are allotted to CCI, the National Agricultural Cooperative Marketing Federation of India (NAFED), other State Cooperative Marketing Federations and the private trade. Generally CCI and NAFED which are involved in supporting prices, have the largest available cotton surplus and receive the largest allocation made by the Textile Commissioner.

g) Conclusions

The long term (1981-82 to 1992-93) minimum support price (MSP), compounded at an annual growth rate of 6.5 percent, is less than that of all competing crops except sugarcane in the central zone. The growth rate of the MSP for the last five years has been 10 percent which exceeds all

crops except groundnuts in the central zone. However, a more accurate measure of the impact of the increase in the MSP is to compare the growth rates adjusted for the increases in yield for the same period which were from 166 kg/ha in 1981-82 to 272 kg/ha in 1992-93, an increase of 64 percent. This indicates that the area was maintained by both increasing prices and by increased yield. Recently, favorable monsoons have ensured higher yields but price increases and technological yield enhancement will be necessary to sustain the level of production.

The following conclusions may be drawn from the Indian policy:

- Physical legislative measures are difficult to implement.
- Low fixed ginning charges have resulted in outdated ginning technology and a high trash content in cotton lint. The removal of fixed ginning charges is currently being considered.

Comparisons with the Cotlook™ Indexes suggest that domestic cotton costs for Indian mills were around 56, 76, and 89 percent for the period 1981-82 to 1992-93 for varieties similar to Egyptian LS, Cotlook™ "B", and Cotlook™ "A" type cottons, respectively.

However, if comparisons are based on staple lengths, the protection coefficients drop to 50, 70, 71, and 84 percent, respectively. The implication is that farmers subsidize the domestic textile industry and that LS cotton is under-utilized (Table 3.21).

Table 3.21: Nominal Protection Coefficients; Indian Cotton Varieties

	Comparison Based On			
	Cotlook™ Grouping		Staple Length	
Indian Variety	Intl. Variety	NPC	Intl. Variety	NPC
J-34	Texas	0.76	Memphis	0.70
H-4	Mexican	0.89	Acala-California	0.71
DCH-32	Giza 67-69-81	0.56	Giza	0.50
S-4	California	0.89	Tanzania AR-3	0.84

Source: Ferguson 1994

Foreign cotton lint prices are CIF Northern European port.

Insurance charges are Rs. 50 per ton of cargo.

Freight charges (Rotterdam to Bombay) were taken as \$1,100 per container (20 tons).

CIF prices ex Rotterdam and freight and insurance added for Rotterdam-Bombay.

International prices are converted into rupee prices at the yearly average of the rupee : \$ exchange rate.

The nominal protection coefficient (NPC) is calculated as the average landed domestic price divided by the average landed international price.

Data on the farmer share of the domestic lint dollar are difficult to obtain as these prices are not collected by the Government. However, some general conclusions can be reached in light of the above discussion. The monopoly procurement in Maharashtra seems to result in cotton sold outside the state (especially in times of high prices) indicating a low return to the grower. Despite the fact that maximum grower returns are likely to accrue to the farmer under the cooperative marketing system, only about 20 percent of the cotton moves through this marketing channel, indicating that special interest groups dominate marketing. Limited data relating the seed cotton price for J-34 at the regulated market level with the domestic lint price for 1991-92 and 1992-93 indicate that the seed cotton price was 41 to 42 percent of the lint cotton price exceeding the normal 33 to 34 percent ginning outturn of this variety. However, this does not imply that the farmer receives a fair share as only 20 percent of farmers sell through regulated markets. The distortion is probably due to the fact that the average monthly prices are not weighted by quantities and the seasonality of lint prices seems to indicate that the major appreciation in lint value goes to the holder of the lint stocks.

The use of the export quota as a means of price control has resulted in (1) Indian cotton being priced at a discount to foreign growths with comparable spinning properties and (2) lower returns to growers of longer staple cotton since over 95 percent of yarn is 40s count or less.

Other regulations also result in inefficiencies. An example is the Cotton Transportation Act that not only prevents the mixing of varieties at the ginnery but also prohibits the mixing of ginned bales of different varieties while they are being transported.

Category IV: Mexico

Mexico falls into Category IV although historical differences in credit availability between private and communal farmers and support prices for maize have been major factors influencing recent cotton production trends.

Historically Mexico's agricultural policy favored "Nutritious Basic Products" as priority was given to food self-sufficiency, primarily grains and beans, prior to joining the General Agreement on Tariffs and Trade (GATT) in 1986. The first North American Free Trade Agreement (NAFTA) was signed in June 1990 between then Presidents Salinas and Bush. After joining GATT but prior to NAFTA the Mexican Government began to gradually remove input subsidies, leading to a significant increase in production costs. However, the continued support of maize and dry edible beans proved to be a detriment to other crops. Low cotton prices, combined with a decreased role of the rural lending institutions, a tougher repayment policy and reduced input subsidies proved to be disastrous for cotton production. In 1991 when it was apparent that the states of Baha and Sonora which historically accounted for around 66 percent of Mexican cotton production, planned to grow no cotton, the Ministry of Agriculture and Water Resources (Secretaria de Agricultura y Recursos Hidraulicos (SAHR)) announced the implementation of a support package for cotton production which became effective on January 29, 1993. This proved to be completely ineffective due to low cotton prices.

Support and Services for the Commercialization of Agriculture (Apoyos y Servicios a la Comercialización Agropecuaria (ASERCA)) is the Mexican Government agency that provides support and services to the commercialization of agricultural products. The Program of Direct Rural Support (Programa de Apoyos Directos al Campo (PROCAMPO)), a new income support program applicable to all crops, was initiated by President Salinas On October 4, 1993. The phasing-in and operation of PROCAMPO is supervised by SARH through 33 state delegations, 193 rural development districts, 712 support offices, a central structure, and 16 ASERCA regional centers.

PROCAMPO will be in operation for fifteen years, with the real value of the payments remaining constant for the first ten years and declining gradually from the 11th year. Areas planted to cotton and other crops during the three years prior to December 1993 are eligible. The eligible farmers received 330 new pesos/ha during the autumn (fall)-winter of 1993-94 and 350 pesos/ha during the summer. The maximum payment permitted by the Mexican Constitution is for 100 hectares for individuals and 2,500 ha for societies. Farmers receive this aid with no conditions on the crop grown, consequently the payments are regarded as more market oriented than those of any other countries since farmers make production choices based on market signals rather than price supports. PROCAMPO allows cotton to compete more favorably with grains and consequently, cotton production is slowly recovering from the very low figure of 24,000 mt of lint produced in 1993-94 (308,000 mt were produced in 1989-90). However, financing through state run institutions continues to impede the development of all sub-sectors.

In a separate program designed to promote good crop hygiene practices and geared particularly to aid the control of pink bollworm, *Pectinophora gossypiella*, farmers receive payments of between 700-1,000 new pesos/ha after the crop is harvested, the fields are cleared and crop residue destruction requirements have been carried out. In the event of these practices being neglected, the money is used to pay contractors to remove and destroy crop residues.

ASERCA has developed a system for transmission of market information and developments by television and other means to interested parties. It has also initiated a pilot program to support at least a minimum price for cotton farmers who pledge the expected production from a specific area to be hedged by buying put options on the New York Cotton Exchange. Farmers maintain control over the sale of their cotton but in the event of a price drop, ASERCA exercises the options and reimburses the farmer the difference between the options strike price (adjusted for the options premium paid) and the spot prices when the farmers sell their crop.

Regulatory Policy

Regulatory policy issues were discussed in detail in previous sections and include pesticide policy, environmental policy, seed policy, and grading standards. Generally speaking, there is a need for government to be involved in policies that are concerned with environmental issues and sustainability of agricultural systems. The lack of regulatory policy on pesticide registration and distribution can lead to indiscriminate use of pesticide, leading to hazards for human and wildlife health and to the development of pesticide resistance in target pests. Integrated Pest Management is incompatible with indiscriminate pesticides use and normally necessitates an area wide approach. While government regulation of pesticide registration, quality and distribution, supported by effective research is necessary, government involvement in pesticide application is not necessarily effective, as shown by experience in Egypt and Uzbekistan.

Seed policy typically involves seed certification which entails ensuring that the planting seed available to farmers has a high level of varietal purity and high quality in terms of both viability and vigor. The maintenance of varietal purity entails varietal zoning for cottonseed production and single variety ginneries.

Cotton classification and grading standards can best be set and monitored by organizations outside the marketing channel that are independent of commercial bias.

Risk Management and Price Signals

This study could not address all the policy and marketing issues that are essential elements in sequencing the move to privatization of the cotton-textile industry. Nevertheless, the case studies do suggest a number of interesting policy option approaches.

The vast majority of cotton growers in the world are smallholders who do not, by themselves, produce a marketable commodity. In order to become marketable, the produce of many growers has to be brought together in sufficient quantity to attract a buyer. Furthermore, these farmers do not have access and cannot react to market signals. This cannot be compared with the situation in most of the USA and Australia where production is large scale and many farms have their own ginneries, ready access to market signals and the ability to react through instruments such as the New York Cotton Exchange. In most of the countries where smallholder production is the norm, there is an apparent need for non-distorted prices, a method of assuring a minimum price to

provide a safety net in case of production disaster, instruments in place that assure timely payment for seed cotton, timely availability of inputs and unbiased market information in order to ensure the success of the cotton/textile industry. Australian farmers operate without minimum prices because of the scale of production, the yields achieved and by using futures marketing. Much of South America also operates without minimum prices since the crop reaches the market when prices are normally at a seasonal high and are more accurately forecast due to the completion of the Northern Hemisphere harvest and because of the involvement of international traders. Currently, US farmers have the loan program which ensures a minimum price. In many developing countries, governments have absorbed this risk because of the importance of cotton to the national economy. However, with the removal of government interventions, alternative means of risk management need to be developed and put in place to avoid disrupting production and the flow of trade.

Cotton is an industrial raw material and price signals should be transmitted without distortions through the entire cotton-textile industry. Distortions in the cotton-textile complex occur both worldwide due to the MFAs and in the individual countries where distortions are created by textile policies on imports and exports of textile products, textile machinery and manmade fiber. These internal price distortions have significant impacts in several of the study countries (China, India, Pakistan and Egypt) as well as a minor impact in Brazil. In addition, cottonseed oil and cottonseed cake are important by-products of the cotton industry but their value is ignored in the marketing channel of some countries because the farmer sells seed cotton and the cottonseed byproducts are acquired by a state owned and operated ginning and crushing sector. In other countries where farmers sell seed cotton, the value of the seed is either incorporated in the farmgate price or offset against the ginning costs.

Exhibits 3.1 and 3.2 illustrate the various interactions in the textile industry from the producer of raw cotton to the retailer of finished textile products. The first chart illustrates the areas where domestic and foreign trade occurs at all stages in the industry. In several countries fabric and textile imports are limited and authorized on a case-by-case basis while exports are subject to licenses. Exhibit 3.2 indicates ineffective price signals that can occur through the textile industry.

The need for instruments to support the transition to more open economies requires that the microeconomics, including all these marketing interactions, be considered in detail.

Summary

Cotton policy is in transition as countries move towards decentralization of the cotton sub-sector. Many of the reasons for price intervention have changed and in many instances, intervention has not produced the desired results. Moreover, the world cotton industry was operating under different circumstances in the pre and post 1985 period when US cotton legislation changed dramatically. Policies that were previously effective may no longer be appropriate. Egypt which is discussed in detail, is a good example.

Policies followed in India, China and Pakistan have facilitated the development of the textile industry and significantly increased cotton production although production problems are now being encountered in all three countries, leading to declining production. These difficulties which are outlined above, are likely to cause an erosion of profit margins for spinning mills as producer prices and/or importation of cotton increase to compensate for the shortfall in domestic supply for the textile sector. These countries have been slow to liberalize marketing.

Historical statistics, taken at face value, cannot be utilized to project the consumption shifts that are likely to occur in the decade ahead, due to the demise of the textile industries in the former Soviet Union and Eastern Europe and the expansion in the textile industries of Brazil and Mexico. Both countries have shifted from net exporters to net importers of cotton due to decreasing cotton production and rapidly expanding textile industries. The removal of the cotton import tax, Brazilian proximity to Paraguay, low transport costs from West Africa and the Common Market Trade Agreement between Brazil, Argentina, Paraguay, and Uruguay (MERCOSUR), are factors which favor expansion in Brazil while GATT and NAFTA membership, are favorable factors in Mexico. Both countries have liberalized the cotton-textile sectors and cotton production appears to be rebounding. The financial institutions remain as major impediment to cotton production in both countries.

There is a great contrast between the impact of government policy and parastatals in Tanzania and Mali. Tanzania is reflective of other East African countries where there was poor training of cotton professionals, inefficient administration and an absence of any integration of research, extension, production and marketing. Nonetheless, it would be difficult to exceed the payment of 86 percent of the export value of lint as a farmgate price which was achieved in the early 1980s, prior to the record Chinese crop of 1984-85 and the impact of changes in US farm policy resulting from the Farm Bill. These factors contributed, at least in part, to the financial woes of the TCMB and the Cooperative Unions which resulted in the farmgate price declining to only 45 percent of the lint value. Both research and extension have suffered from lack of funding and the seed multiplication program has collapsed. Since 1985, the area planted to cotton has been variable and production has been erratic, partially as a result of the decline in GOT from 36.0 to 34.0 percent from 1985-86 to 1993-94 and still further to 32.0 percent in 1992-93. Furthermore, declining quality has resulted in a loss of premiums. By contrast, good leadership and management and integration of adaptive research, extension and production in Mali ensured that supplies of pure, quality seed were available to the farmers and that new developments in varieties and production technology reached them rapidly. Since 1985, the cotton area, lint yields and production have increased, due to the continued improvement in production technology and to the increase in the GOT from 36.8 percent in 1985-86 to 42.3 percent in 1993-94. In both countries, exchange rates have had an impact on cotton production and profitability.

In all three study countries in Africa, Egypt, Tanzania, and Mali, moves towards liberalization are progressing rapidly. In Egypt, the response was due to crises resulting from previous policies while in Tanzania, the crisis arose, at least in part, as a result of the impact of the low prices in the mid 1980s brought about by the record Chinese crop of 1984-85 and the new 1985 US cotton legislation.

The foundations of the world cotton trading system go back a long time and were established to suit the problems inherent in trading raw cotton under forward contracts. Rules and arbitration systems were established by associations in accordance with particular customs of the cotton trade and the country or countries concerned. Changes in the patterns of cotton trade are challenging the existing order. New cotton trading companies have emerged and new regions are selling cotton on the international market but few of these traders have the attitudes traditionally associated with international trading. Some are willing to learn but others are openly challenging traditional concepts. In 1994, some governments imposed excessive export levies on cotton or banned exports outright in order to protect domestic textile industries in the face of short domestic supply. These actions lead to the breach of previously agreed, legally binding contracts. In one country, contracts were signed by one party but prices increased so another

party sold the cotton and the contracts could not be filled. These actions cause long term, serious damage to the reputation of countries as reasonable and consistent trading partners and have far reaching international consequences (Grobien³, 1995).

The Committee for International Cooperation between Cotton Associations (CICCA) is committed to promoting fair and equitable trading practices, to the private and mutual resolution of disputes and only where necessary, to arbitration when mutual resolution becomes impossible. Education in the principles of international trading is essential and several CICCA Cotton Associations travel widely for this purpose (Ibid).

Removal of trade barriers have also resulted in uncontrolled movement of seed cotton both within and between countries. Quite apart from the effect that this could have on varietal purity, certain diseases such as bacterial blight, *Xanthomonas malvacearum*, *Verticillium* wilt and virus diseases and insect pests such as boll weevil, *Anthonomus grandis* and pink bollworm, *Pectinophora gossypiella*, overwinter in cotton seed and can be dispersed in seed cotton. Other boll feeding pests such as the red bollworm, *Diparopsis* spp. the spiny or spotted bollworm, *Earias* spp. and seed feeding insects such as the cotton stainer, *Dysdercus* spp. and the dusky stainer, *Oxycarenus* spp. could also be transported in seed cotton. In one instance, seed cotton is being transported from West Africa to Brazil, Greece and Spain. If this contains a disease or pest that is not found in any one of these countries, it could conceivably threaten the future of cotton in that country. In the case of Brazil it could threaten the future of cotton throughout South America and even Central America and the United States. The history of the spread of pink bollworm from India to Egypt and then to the USA and the spread of boll weevil from Venezuela to Brazil are cases in point. Currently boll weevil which was introduced into Brazil in seed cotton, is threatening cotton production throughout Brazil, Paraguay and Argentina. The removal of barriers to trade, therefore, need to be preceded by adequate quarantine regulations to prevent the spread of pests and diseases.

³ Fritz Grobien is Chairman of the Committee for International Cooperation between Cotton Associations

Exhibit 3.1 : Cotton Textile Marketing Flows

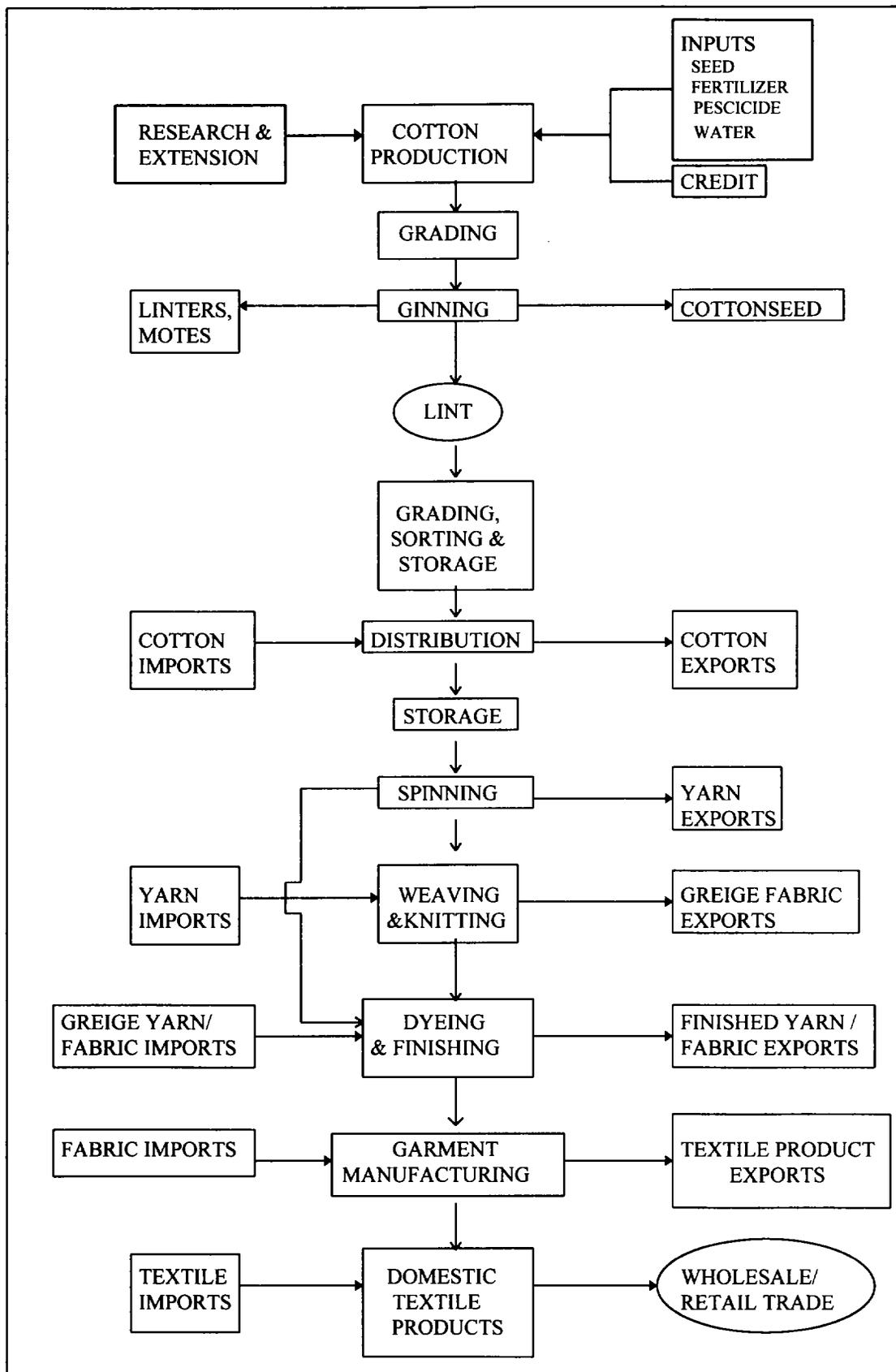
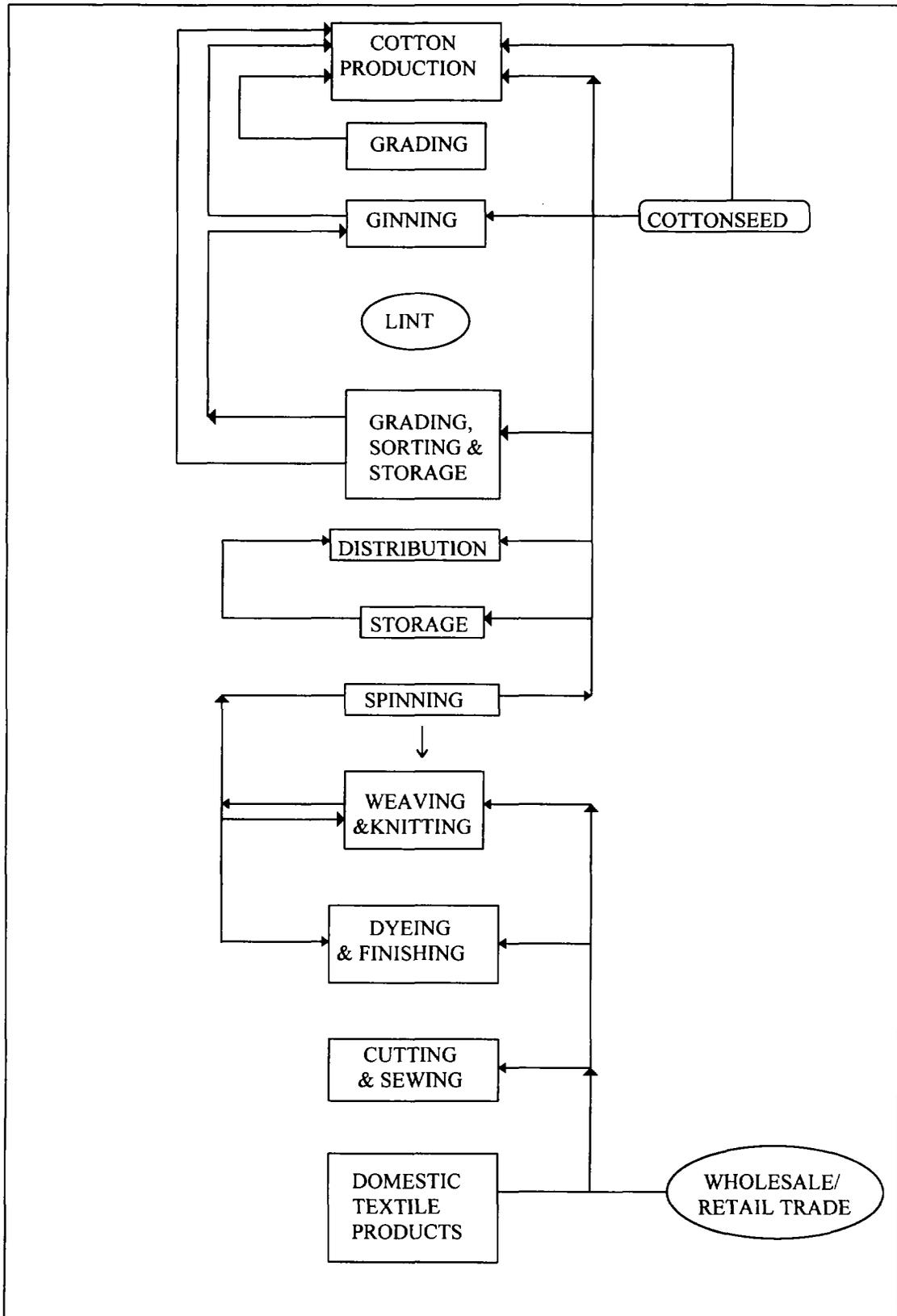


Exhibit 3.2 : Flows of Price Signals Through Textile Industry



CHAPTER 4

MICRO ECONOMICS

Introduction

Cotton policy and production technology have had a great impact on the economics of cotton production, processing and marketing. The previous chapter on policy discussed the role of parastatals in setting prices and their involvement in the cotton marketing and input sectors. This chapter looks at the results of this policy from the point of view of the farmer, ginner and agents involved in the marketing of cotton.

It was seen earlier that prices determined by most governments are not directly linked to international prices. The first section of this chapter gives a brief discussion of how seed cotton producer prices are determined in different countries with a documentation of price trends over the past decade in both nominal and real terms. This is followed by a cross-country analysis of profitability of cotton production and the incentives to produce better quality cotton. In this framework, the section also tackles the issue of risk management and price stabilization, as well as by-product utilization, labor availability and mechanization questions which are gaining more and more relevance in cotton producing countries. The next section discusses marketing and ginning operations in the study countries. Special emphasis is placed on the analysis of farmer's share and marketing margins as factors determining the efficiency of the cotton sector in a country. The final section discusses international competitiveness of cotton in study countries.

Factors Affecting Seed Cotton Production

This section analyzes the factors affecting the farmer's preference to grow cotton as a single crop over other crops, as part of a rotation or over other economic activities. Relative profitability is the main determinant in this choice. The main elements of profitability are price, yield and costs. The discussion of price will include the farm-level price compared to international prices and the prices of alternative crops, including how prices are determined and reasons for divergence from international (border) prices, long-term farmgate price trends, and the effect of relative cotton prices on area, yield and production. Other aspects to be discussed are price stability and its effects on production, the terms and timeliness of payments and quality premia. The section on costs will discuss the costs of inputs, capital and marketing in case the farmer is charged for the collection of seed cotton from his farm.

Farmgate Prices

The producer price plays an important role in determining production of and area allocated to cotton. For example in China, over the past 15 years farmers have responded to changes in prices (revenues) by increasing or decreasing the area planted to cotton. In addition, in China, the changes in the price ratio of grain to cotton (wheat in Northern China and rice in Southern China) has played a role in the fluctuation of production. Whenever this ratio was over 8:1 (cotton : wheat in Yellow River), cotton production increased and vice versa. Producer prices also influence the yield level as they affect the amount of inputs used.

Determination and Differentiation of Seed Cotton Producer Prices

In Uzbekistan, China, Mali, Tanzania and Egypt, cotton prices are set by the state. In the latter two, liberalization is in progress. In Egypt the government price is a floor price only. Tanzanian cotton prices have been liberalized but the TCLSB on behalf of the Government sets an indicative floor price based on prevailing world market prices. Prices are supported in Pakistan and India, but the support program in Brazil has been ineffective in recent years. Mali farmers receive a rebate based on export revenue. Mexican prices are determined by the free market.

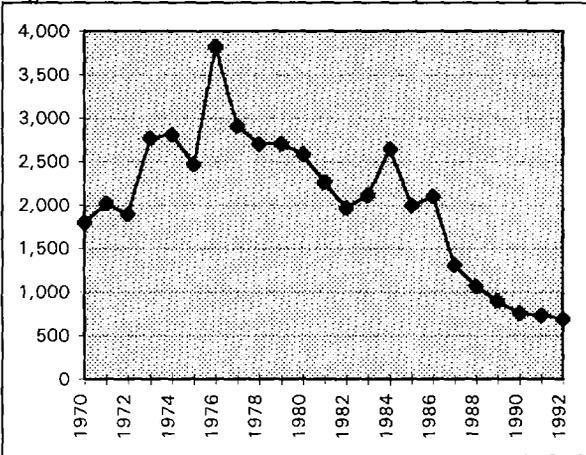
A decreasing amount (now two thirds) of the production (state order/quota) is procured by the state at predetermined prices in Uzbekistan. The rest can be sold by the collective farm if the quota is fulfilled and subject to government contract approval and export license. Since 1987, seed cotton producer prices in Mali have been fixed jointly by the State and the CMDT, with the addition of producer representatives, in the framework of the 'Contract Plan'. The producer price is differentiated according to quality and the marketing channel. Village Associations (AVs) who carry out 80 percent of all delivery to ginneries, receive a rebate.

In Pakistan, Brazil and India the producer price is market determined, but the governments of Brazil and India retain a significant influence on it through minimum support prices, and trade restrictions (export quota or taxes) or minimum export prices. In **Pakistan**, the farm gate price of seed cotton depends mainly on the lint market. Lint prices, in turn, are determined primarily by the local textile mills which consume an increasing share of the production (average 63.3 percent in the 1980s and 87.5 percent in the first four years of the 1990s). Prices are largely determined by the spinning margin and government policies (e.g. the Minimum Export Price Policy). Ginners have an advantage in price negotiations, usually not honoring the quality differentials announced by the government and only giving the benefit of higher ginning outturns (GOT) in cases of seed cotton deliveries in big lots. However, the role of the support prices in providing signals about government concerns over cotton production has been unequivocally encouraging for the growers. In **India**, the seed cotton producer price is determined by market forces, though there is a government established Minimum Support Price (MSP), supported by CCI (Cotton Corporation of India). At village level sales, the farmer is usually at a disadvantage to the buyer. In regulated markets, on the other hand, price is determined by auctions/bids and farmers have the option of refusing the price offered. In **Mexico** the origin of production is not a determinant in fixing seed cotton prices, since prices are determined at the ginning plants by ginners. Transportation is a part of the credit the farmer negotiates with the ginner before planting.

Producer Price Levels and Trends

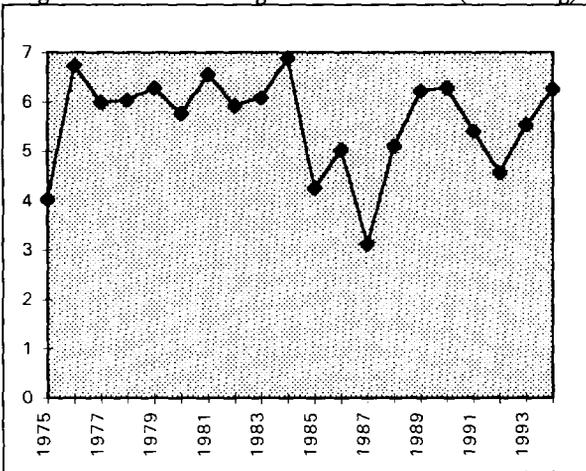
In the majority of the countries studied, nominal seed cotton producer prices increased during the 1980s and the early 1990s but real prices increased in only a few cases, making cotton progressively less remunerative compared to competing crops. Policy had an impact on the price trend. In countries that managed to support prices effectively (India, Pakistan, Mali, and Egypt) a constant or upward trend existed. However, except in Egypt, real price increases were generally non-existent or minimal. Compared to international prices, the farmgate price for seed cotton has been depressed in several of the countries studied (China, Egypt, India, Pakistan, and Uzbekistan) due to government policies. Methods of reducing farm level prices have varied. Some of the more common methods include overvalued exchange rates (Brazil, Pakistan and Tanzania) and export restrictions on cotton (Pakistan, Egypt, India, China). These policies are often justified as a means of encouraging the local textile industry and value added exports.

Fig. 4.1: Brazil - Real Producer Prices ('000 CR/T)



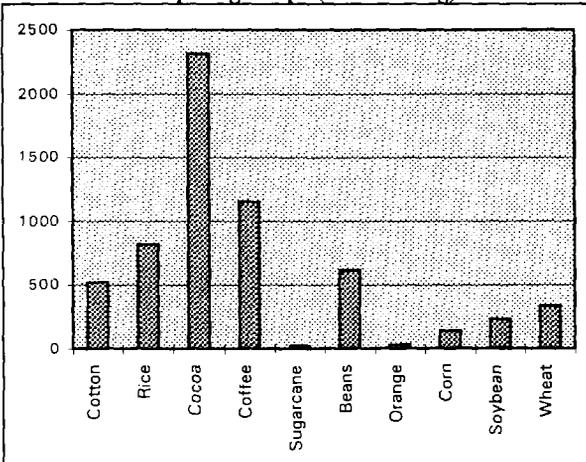
Source : Brazil Country Report

Fig. 4.2: Brazil - Average Producer Prices (US\$/15Kg)



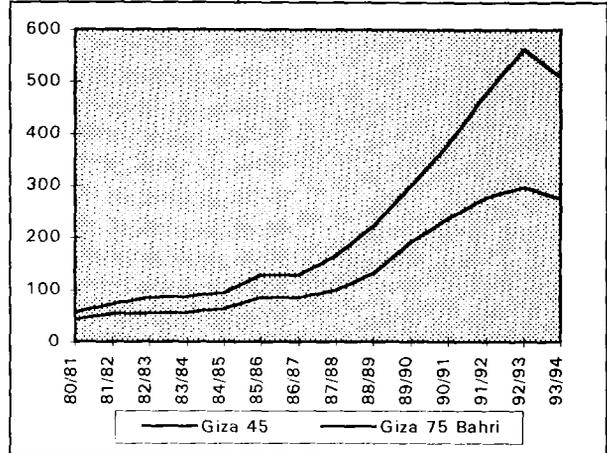
Source: Brazil Country Report

Fig.4.3: Brazil - 15 Year Average Producer Prices for Cotton and Competing Crops (US\$/'000Kg)



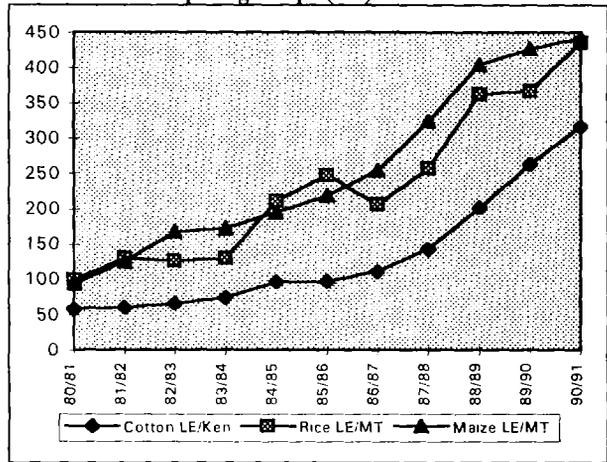
Source: Brazil Country Report

Fig. 4.4: Egypt - Nominal Price Trends for Two Major Varieties (LE/Kantar)



Source: Egypt Country Report

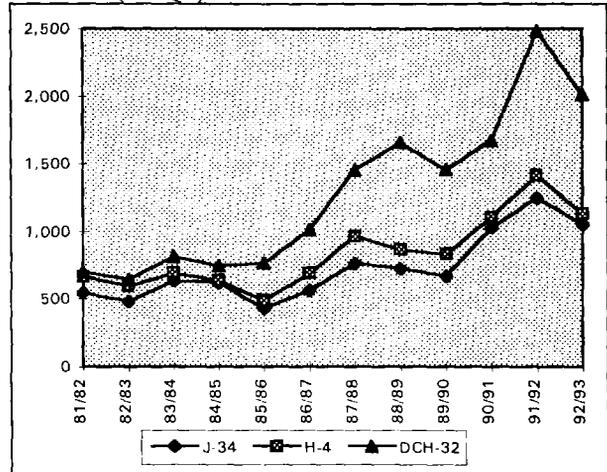
Fig. 4.5: Egypt - Index of Real* Producer Prices for Cotton and Competing Crops (LE)



Source: Nassar and El Saadany, 1993

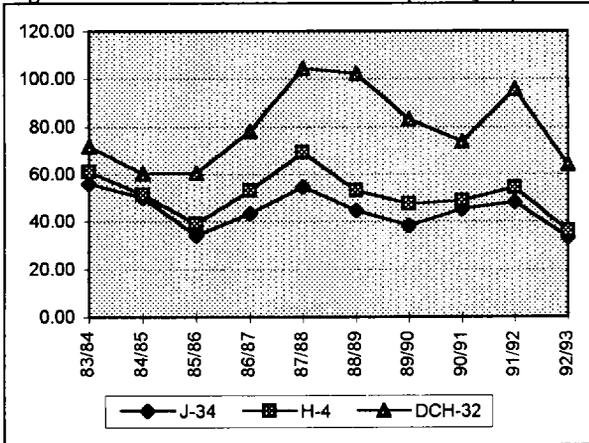
* Deflated by consumer price index 1977/80 = 100.

Fig. 4.6: India - Nominal Producer Prices for Three Varieties (Rs./Qtl)



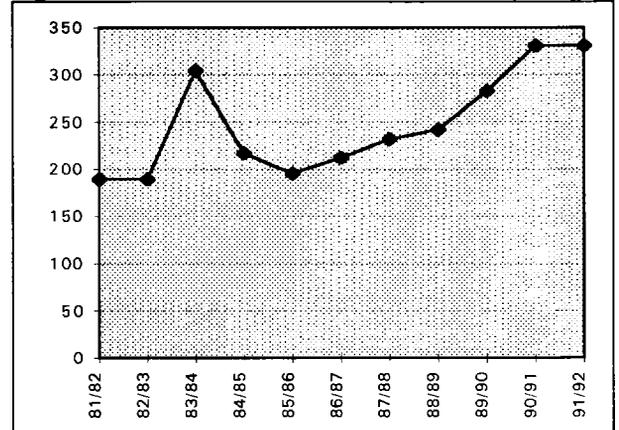
Source: India Country Report

Fig. 4.7: India - Real Producer Prices (US\$/QTL)



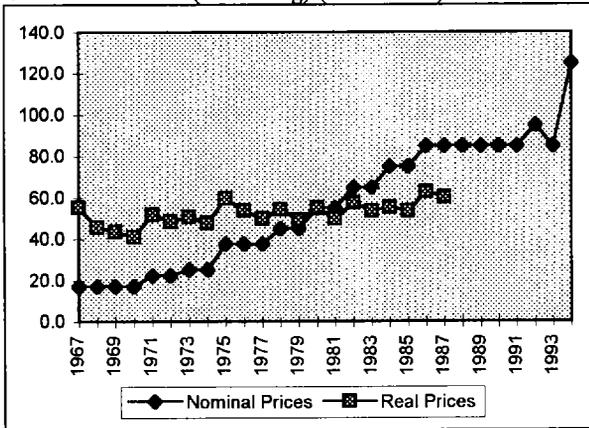
Source: India Country Report

Fig. 4.10: Pakistan - Producer Prices for B-557 (Rs/40Kg)



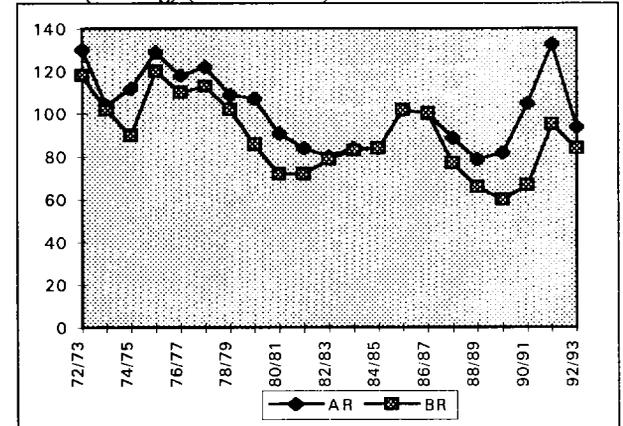
Source: Pakistan Country Report

Fig. 4.8: Mali - Nominal and (Index of) Real Producer Prices for Cotton (CFAF/Kg) (1972 = 100)



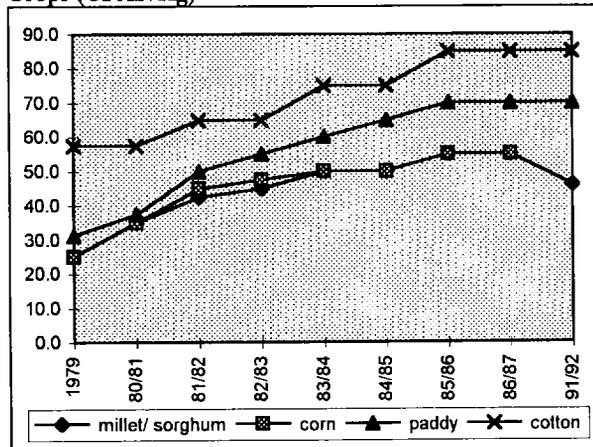
Source: Mali Country Report

Fig. 4.11: Tanzania - Index of Real Seed Cotton Producer Prices (TSh/Kg) (1986/87=100)



Source: Tanzania Country Report

Fig. 4.9: Mali - Producer Prices for Cotton and Competing Crops (CFAF/Kg)



Source: Mali Country Report

After nationalization, the **Egyptian** cotton industry insulated farm level production from world markets. Farmgate prices as a percentage of the lint value were very low until 1993/94 when market decentralization resulted in significantly increasing prices (Figs. 4.4 and 4.5). Failure to establish a farmgate price that was competitive with alternative crops, especially berseem clover, coupled with the Government requirement that in cotton designated areas, farmers plant 1/3 of their land to cotton, resulted in declining yields brought on by delayed plantings (cotton yield is particularly sensitive to time of planting), probable diversion of subsidized nitrogen fertilizers, originally scheduled for cotton, to other more profitable crops, unharvested cotton left in the field due to the economics of second and third harvests, and a general lack of correct application of inputs (e.g. incorrect timing of irrigations that resulted in excess water at critical plant development stages, causing excessive vegetative growth leading to yield reductions).

Changes were made in the calculation of farmgate prices, based on a moving five-year world average export price but this was too long to respond to changing market conditions and was calculated using historical "administrated" prices that ignored the spinning value of the Egyptian cottons relative to other types. In the short-run, demand for these cottons has been very "inelastic" and historically, they have had a near monopoly on world supply. The supply shortages at the farm level created pricing strategies commensurate with short-term demand. Egyptian production failed to respond to high relative prices that were not passed down to the farmgate. However, they were passed to the farmgate in numerous other countries (the USA, China, India, Israel, the former Soviet Union, and China) where ELS cotton production and exports expanded, displacing the higher priced Egyptian types. Consequently, the Egyptian types met very little export demand and were used by the local textile industry in spinning low count yarns that could have utilized upland type cotton at substantially lower cost.

In **India** and **Pakistan**, low farmgate cotton prices have not reflected international prices. The India country report noted that domestic prices are between 9 percent and 44 percent below international values (Figs. 4.6, 4.7 and 4.10).

In **Mali**, the exchange rate policy probably moderated the continued increase in cotton production over the past few years (lint production averaged 114,000 tons from 1988/89 to 1993/93 after increasing from 41,000 tons in 1980/81 to 97,000 tons in 1988/89) as the CFA franc was tied to the French franc which appreciated against the US \$ while cotton prices were generally declining. However, the maintenance of a lint yield in excess of 600 kilograms per hectare and subsidized input prices, aided in large part by an increase in the GOT, resulted in gradually expanding cotton production from 1985/86 to 1993/94. The CFA franc was devalued by 2:1 in 1994. The farmers' price responsiveness is well illustrated since this devaluation has resulted in fixed farmer procurement prices being increased from 85 to 115 CFA francs (and later to a reported 125 CFA francs) per kilogram of seed cotton. Plantings apparently increased by more than 20 percent in 1994, the first substantial increase since 1985. The impact of the exchange rates on cotton prices is shown in Figs. 4.8 and 4.9.

The price trend in Mexico follows international prices since they are determined by market forces. They decreased in comparison to maize prices which were supported by the Mexican government prior to PROCAMPO. In the 1990s, escalating input prices and lack of financial support resulted in a dramatic drop in cotton production. In **Brazil**, nominal producer prices declined dramatically over the past 20 years. Recently, real cotton prices have tended to follow international prices. (Tables 4.1-4.3)

Tanzanian cotton prices have been declining in real terms since the mid-1970s except for a brief increase in the mid-1980s and in the 1991/92 season (Fig. 4.11). This was arrested as large world crops and a change in US Farm Policy resulted in the inability of inefficient parastatals to support prices. Since then prices have tended to follow world prices although a much smaller farmer's share has mitigated price increases. The overvalued TShilling has acted as a disincentive to cotton production. The fixed exchange rate forced farmers to accept a much lower price than would have prevailed on the open market. In the four years (1981/82-1984/85) preceding the 1985/86 and 1986/87 marketing seasons, the producer received an average 86 percent of the export price. From 1987/88 through 1992/93 the average has declined to 46 percent.

In **Uzbekistan**, the cotton farm is completely isolated from world cotton prices and only receives about twenty percent of the international value of lint sales. (A recent agreement with the World Bank will raise this value to 40 percent for the 1995 crop). This is reflected in the constant decline of the return on expenditure since 1985 from 41.7 percent to slightly over 13 percent in 1992. (Prices are theoretically set to return 25 percent on investment to the state or cooperative farm. Exponential inflation and the absence of a historical series on the exchange rate between the ruble and the US \$ precludes the presentation of a price series. The Uzbekistan currency was changed from the ruble to the SUM in 1994.

In **China** a time series of nominal procurement prices which have increased over the past 15 years, fails to reflect price differentials between regions. The latter, in the form of price bonus, input supplies and grain, have been used to encourage production. Regional shifts in cotton production have been great over the past 15 years. In general, price encouraged production in the Yellow River Region until 1984/85. Prices essentially remained constant in the South (Yangtze River) for the next 3 years but declined in the North (Yellow River). Commencing in 1988, all areas received unified prices. A price of 300 Yuan/50 kg of lint was established in 1990 and remained constant through 1992. Yield problems, especially in the Yellow River area, necessitated increases in cotton prices to the current 700 Yuan/50 kg of lint to maintain farmer enthusiasm for cotton growing. The result has been a large increase in planting in the high-yielding Xinjiang region, a relatively constant area in the Yangtze River region where yield has not declined and large decreases in cotton area in the Yellow River Region, where pyrethroid resistance has significantly reduced yields.

Cotton Price Volatility

Unusually large and sometimes unanticipated changes in price from one year to the next have raised concerns within the world cotton community regarding price volatility. In order to put this problem in perspective, the ICAC compared calendar year average prices of cotton and 29 other commodities for almost three decades. The cotton price was assessed from the average Cotlook™ "A" Index (Table 4.1).

A striking similarity was revealed across commodities. Almost without exception, prices were relatively stable during the 1960s but then rose sharply in the 1970s and began dropping in the 1980s. The year to year variability in prices increased significantly, beginning in the 1970s, for 25 of the 30 commodities studied (ICAC, 1989). The commodities whose prices were less stable than cotton include fish meal, aluminum, palm oil, jute and copra while those that are more stable include beef, bananas, wheat, soybeans and copper.

The study was updated in May 1995¹ and indicated that price volatility has not increased and, in fact, decreased for most commodities. In general, commodity prices that were less stable than cotton in the original study were also less stable in the updated data while prices that were more stable remained more stable.

Year to year cotton price movements have been large recently because of problems faced by some major cotton producers but history indicates that similar price movements have occurred in the past. Thus the Cotlook™ “A” Index dropped 26 percent from 1984 to 1985, and an additional 20 percent in 1986, then rose 56 percent from 1986 to 1987. Price fluctuations exist in efficiently operating markets and make production decisions difficult by increasing the risk associated with marketing or procurement of cotton. However, price stabilization is not necessarily the answer as illustrated by a comparison between three commodities, sugar, coffee and cocoa, that have experienced dramatic price interventions over the study period (Table 4.1).

Cotton is an annual agricultural crop whose production is subject to yield uncertainty created, largely, by the weather and insect pests. Consequently, the presence of a futures market with large trade participation in New York results in an immediate flow of fundamental information to the market where supply and demand interact through the price mechanism.

Table 4.1: Comparison of Volatility in Commodity Prices

Cotton	Period			
	1960-69	1970-79	1980-88	1980-94 ¹
5-Year, Centered Moving Average (US cents/kg)	71.3	143.1	165.1	160.5
Mean Residual (US cents/kg)	2.8	18.4	23.6	20.4
Cotton - Mean Residual (percent) ²	3.9	12.9	14.3	12.7
Sugar - Mean Residual (percent) ²	24.1	32.6	31.0	23.8
Coffee - Mean Residual (percent) ²	7.5	12.9	8.0	9.4
Cocoa - Mean Residual (percent) ²	15.7	14.9	7.4	6.9
30 Commodity Average - Mean Residual (percent)	7.5	15.2	11.6	11.6 ³

¹ ICAC Personal Communication

² Average difference between actual price and moving averages

³ Only includes 23 commodities due to changed definitions or non-availability of data

Source: ICAC (1989)

Risk Management against Price Volatility

International cotton price volatility is summarized in Table 4.2. Price volatility is important for the farmer because it may lead to fluctuations in income, for the textile industry as it endangers the stability of cotton supply, its basic raw material, and for the national economies of cotton exporting countries since it may lead to large fluctuations in foreign exchange revenues. However, at present, developing countries make very little use of risk management instruments. The main reasons for this are government interventions that reduce the incentive to hedge (by setting minimum or fixed prices and thus adsorbing the price risk) and the lack of technical knowledge in using risk management instruments. Another reason could be the cost of hedging.

The recent marketing liberalization efforts in many cotton producing developing countries are likely to expose participants to market forces and make hedging instruments such as futures and options trading attractive in reducing inter-temporal price volatility. However, even

¹ ICAC Personal Communication

without liberalization, there is scope for using hedging instruments. In most cases where government interventions prevail, the government effectively internalizes (assumes) the cotton price risk. For example, the private trade and parastatals in Northern India, the governments in China and Uzbekistan and cotton parastatals in Turkey and the Francophone African (FPA) countries could make good use of hedging instruments in reducing cotton price volatility, conditional on the development of futures markets that aren't characterized by the high degree of basis risk associated with hedging non-US growths on the NYCE. This is possible since mechanisms are in place that enable procurement of cotton supplies from farmers at an assured price. The use of forward sales by FPA countries for reducing price volatility provides only limited coverage.

Table 4.2: Cotton Price Volatility

Cotton Type	Period	Average Monthly	Standard	Coefficient of
		Export Price	Deviation	Variation ^a
		US Cents	US Cents	%
Central Asian	Aug 85 - Jan 93	66.12	14.05	21.2
Punjab SG 1505	Aug 88 - Jun 93	69.10	11.77	17.2
Chinese 329	May 85 - Jan 93	70.14	14.30	20.4
Turkish Izmirant	Jan 85 - Apr 92	74.99	14.59	19.5
FPA	May 85 - Jan 93	66.64	12.78	19.2

Source: Varangis et al., July 1994

a: Ratio of standard deviation to the mean

By hedging, market participants can increase the predictability of future cash flows, lock-in profit margins (basis loss excluded), and reduce the price uncertainty of investment projects. However, cotton futures cannot be used for hedging long term price fluctuations, and these instruments can only be used on a year-to-year basis. Where available, futures and options provide the most efficient way for dealing with short-term (mainly intra-year) price uncertainty. In addition, futures and options can add to the flexibility of selling decisions, for example, by giving flexibility to buyers to "call-in" their purchasing price.

Institutional Preconditions for Risk Management through Hedging

This section is not an endorsement of hedging as a means of risk management for farmers in all countries or even for farmers in individual countries. Hedging may or may not be appropriate depending on a number of factors, including the development of instruments (institutional, legal, regulatory) that are precursors to hedging. However, Turkey has established a Futures Exchange in Izmir and other countries are considering similar action so the preconditions for hedging and the risks involved are discussed.

The preconditions for effective hedging include the presence of an institution that is willing to assume the risk that includes both the basis and production risk and the requirement that the institution is able to finance margin requirements generated by changes in the futures market. In addition, a legal, binding contract system must be in place to ensure that the farmer actually delivers the cotton at the contracted price.

In order to hedge, the credit worthy institution (parastatal, cooperative, marketing board, or merchant) must have sufficient volume. The minimum size contract of 50,000 pounds (100 bales) of lint with lot sizes in multiples of 50,000 pounds, would be required to enable a foreign institution to open an account with a clearing member of the New York Cotton Exchange (NYCE). The NYCE handles a particular type of cotton, Memphis 1 1/16 inch, Strict Low Middling although the rules permit contract delivery for small differences in cotton quality parameters based on established, prevailing market price differences.

Price differentials are very volatile between cotton varieties grown in different regions under different climatic conditions. The differences result from a multitude of factors, including different cotton fiber quality parameters due to the variety of cotton, differences in fiber quality (length, micronaire, strength, and grade) caused by weather conditions, and the supply/demand in different types and grades of cotton. This so-called “basis-risk” precludes the hedging of a large part of the cotton that is grown worldwide, including some regions of the United States.

The institution carrying out hedging must not only be willing to assume this “basis risk” but must assume production risk as well. Institutions that hedge generally assume price risk previously held by farmers. Production risk assumes that the amount of cotton contracted will actually be produced and delivered to the institution. In the United States, basis risk is absorbed by the merchant or cooperative sector while production risk is generally avoided by contracting with farmers for a specific number of bales rather than a specific number of acres. In sections of the country where production uncertainty is great, hedging becomes very risky, in which case, individual farmers may use the options market for hedging to avoid both margin maintenance and production uncertainty. This procedure involves the purchase of a “put” which gives the hedger the option of a sale at a specific so-called “strike-price” for a premium paid to the seller of the option. This obviously involves more funds the more distant the month selected for the options strategy (the so-called time value) and the more volatile the supply/demand situation (the volatility) since options premia depend both on time and price volatility at the time of purchase.

Even systems of foreign sales are not without risk when the selling price is not based on the guaranteed delivery of a specific quantity of cotton at a contract price. A case in point is the Egyptian export sales during 1994/95 which were made in anticipation of a large crop that failed to materialize. In the interim period, farmers were able to sell cotton freely to any market participant and when world prices increased dramatically, export sellers were forced to cover purchases at much higher prices than anticipated.

Large international merchants who are willing to assume basis and price risk hedge some foreign growths. However, hedging of most growths is precluded by the above factors. Basis price volatility is fairly well behaved for a few countries (e.g. Mexico and West Africa) but extreme for many others (Egypt, Uzbekistan, China, Pakistan and India). At present, hedging is possible for the Mexican and West African crops, mainly due to the presence of a new pilot program in Mexico and institutions such as COPACO in West Africa. The Mexican program involves the use of options to guarantee a minimum floor price for cotton growers, defined as the strike-price of the option bought less the premium paid but its effectiveness is limited by the recent financial crisis in Mexico. Existing parastatals with assured supplies and willingness to assume basis price risk, could use hedging.

Country Case Studies

Thigpen et al. (1994)² investigated the risk reduction possibilities for cotton from Pakistan, Turkey, China, Uzbekistan and FPA countries, using portfolio analysis to determine the benefits to be gained from using futures contracts to hedge cotton price risk. Simulated ex-ante cross-hedges demonstrated that in each case, hedging effectively reduced price risk. In most cases, the risk reduction benefits from ex-ante hedges were around 50 percent, meaning that NY cotton futures contracts could remove 50 percent of the intra-year cotton price volatility.

² Thigpen, E. et al., “*The Use of New York Cotton Futures Contracts to Hedge Cotton Price Risk in Developing Countries*”, Policy Research Working Paper 1328, The World Bank, July 1994

In FPA countries, one of which is Mali, price risk was historically absorbed entirely by the government through the establishment of a price stabilization mechanism. Recent reforms focusing mainly on the producer pricing arrangement, the phased reduction and elimination of input subsidies, the institutional marketing system, and the taxation of cotton, have in effect shifted some of the cotton price risk from government to farmers and the marketing organizations. At present the governments of FPA countries hedge about 25 percent of the risk by using forward contracts. This still leaves a significant part of the risk unhedged.

Satyanarayan et al. (1993)³ recommend for these countries a combination of domestic cash/forward and international futures/options markets as the most transparent and efficient (lowest cost) way of risk sharing and short-run price stabilization. Domestic forward markets would transfer the risk of the farmers to intermediaries, banks and private exporters. Because the latter handle large volumes, they can pool risks of a large number of farmers and hedge it in the international markets by using cotton futures/options markets.

The use of futures/options would supplement and, in part, replace the current use of forward contracts. With market liberalization, forward sales are likely to diminish because of counterpart risk, since private exporters, particularly newly established ones, are perceived by foreign traders as being a greater risk than parastatals. To a certain extent, the use of futures contracts, forward sales and stabilization funds, substitute for and complement each other. However, futures and forward sales remove mainly intra-year price volatility while stabilization funds are more useful for the reduction of inter-year price volatility.

Effective provision of short term price stability through futures/options requires the removal of impediments to transparent price formation, so that prices at each marketing stage reflect an appropriate relationship to final demand for the product and to provide incentives for market participants to hedge price risks. Well defined product quality standards, marketing and processing agents and transportation and storage systems operating competitively, and freedom for all participants to sell products in domestic or export markets are necessary to achieve these goals. Under these conditions, domestic marketing and the allocation of production resources would be efficient. The creation of domestic spot markets for cotton could be a first step towards this end by providing opportunities for price discovery, crop financing and risk sharing.

A liberalization program was started in Egypt in 1993/94 but the government continues to carry part of the price risk faced by farmers by maintaining a guaranteed floor price, based on a cost-plus formula which takes account of the world supply and demand, international prices, domestic and international stocks and the need to reduce price uncertainty in domestic markets. Varangis et al. (1993)⁴ found that the New York futures market does not provide an appropriate mechanism for hedging the price risk in Egyptian cottons (extra-long staple and long staple) under the present administered prices. The spot market, currently being established, followed by a forward market, may provide the best interim mechanism. While the spot market will bring transparency, the forward market could provide a hedging instrument for Egyptian cottons.

In examining whether a futures exchange can be established in Egypt for Egyptian cottons, Varangis et al. found the following obstacles: (a) lack of a well-established physical mar-

³ Satyanarayan, S. et al., "*Hedging Cotton Price Risk in Francophone African Countries*", Policy Research Working Paper 1233, The World Bank, December 1993

⁴ Varangis, P. et al., "*Risk Management Prospects for Egyptian Cotton*", Policy Research Working Paper 1077, The World Bank, January 1993.

ket; (b) the existence of heavy government intervention in domestic commercialization and exports; and (c) in all likelihood, lack of adequate liquidity for establishment of futures contracts.

Price and Income Stabilization

The Ismailia Workshop on Cotton Production Prospects participants suggested that low, stable prices may offset the benefits of higher, volatile prices. Price and cotton grower income stabilization may be especially important in the transitional period of liberalizing cotton production and trade. Floor price and stabilization funds could be considered as measures to avoid drastic fluctuations in prices and incomes to ensure regularity of supply to the textile industry. These funds could be initiated by governments and joined by cooperatives and the private sector.

Since cotton growers have shown significant positive responses to price incentives, floor prices should be announced sufficiently far in advance of planting the crop to help farmers in making decisions with regard to resource allocation and utilization.

Price Incentives for Producing Higher Quality Seed cotton

Price Premia for Higher Quality

The payment of premia for various fiber attributes varies between domestic and world markets. Theoretically, the value of cotton lint is determined by the supply and demand factors for cotton suitable for spinning certain types of yarn. For example, SJV type cotton is typically utilized for spinning combed 40 to 60 count yarns. The combination of strength, length, trash content and fineness determines premia which decrease or increase, depending on the supply of this type of cotton and the demand for this type of yarn. It is difficult to substitute other types of cotton as only certain areas and certain cotton varieties are used for this laydown. For example DPL 90 is an Acala type cotton that was developed for California but was rejected because it cannot be used in these laydown due to its tendency to be coarse, resulting in an excessively high micronaire value.

The U.S. loan premia and discounts are market driven but the premia established by the USDA only apply when cotton is placed under the Commodity Credit Corporation loan in time of depressed prices. In these circumstances there is little reason to redeem cotton from the loan at prices less than the government established premia for quality parameters, based on three year moving average market prices. Procedures prevailing in the study countries are described below.

When the market price differences signal the need for an improvement in fiber quality, the premium usually results in shifting production to appropriate varieties or the breeding of varieties that possess the necessary fiber attributes. However, supply/demand factors can easily erode the premium for an attribute that is easily attainable. Thus the premium for grade is largely immaterial in most spinning applications since cotton can be overcleaned, a procedure easily attainable with modern ginning technology. On the other hand, strength can generally only be improved at the expense of yield within a specific variety.

World cotton quality continues to improve as indicated by such traditional measurements as length, strength, and fineness. Other factors such as "stickiness" and short fiber content are very important. However, it is almost impossible to accurately measure the former and current measurement technology results in the use of the proxy "uniformity" for the latter. Contamination is also a major factor that defies a set of premia and in extreme cases, hand sorting and re-baling may be required.

Finally, the evaluation in spinning technology as well as increased demand for certain type fabrics (denim, knits, etc.) results in changing premia for specific fiber attributes.

Quality Premia in Study Countries

Quality premia can be of large significance for small exporting countries, for whom cotton is a major foreign exchange earner. A case in point is Tanzania which has traditionally received a premium for roller ginned cotton, based on staple length, of 6 US cents per lb. for 1 1/8" cotton, 4 US cents for 1 3/32" cotton and 2 US cents per lb for 1 1/16" cotton. They have also received a premium for hand picked cotton but this has recently been withdrawn.

The channeling down of these premia to the farmgate price could provide farmers with incentives to produce higher quality cotton. Similarly, a consistent price differentiation for quality differences along the marketing chain would induce all agents involved in the chain to use quality preserving methods of picking, storage, packing, transportation and ginning. The technical factors determining lint quality were outlined in Chapter 2. Chapter 5 discusses the regulatory aspects of cotton classification. This section describes the classification procedures in the study countries and the extent to which quality affects producer prices.

In Mexico and India, no formal price differentiation for grade exists. In **Mexico** quality differences in terms of moisture, dirt and other minor impurities do not get translated into price differences. The country report stated that this is largely due to the overall lack of power of producers vis à vis ginners who determine seed cotton prices. In **India** where price differentiations are based on varieties, the quality of cotton is judged by a subjective visual inspection and price offers are made by intermediaries at the village level or by buyers at the market place.

Table 4.3: Pakistan - Grade Pricing (92/93) for Seed Cotton

Grade	Premia/Discount (Rs. Per 40 kg)
Super	+15
One	+10
Two	+5
Three	0
Four	-12
Five	-24

Source: Pakistan Country Report

In **Pakistan**, on the other hand, the Pakistan Cotton Standards Institute has established grades and standards of seed cotton and cotton lint that are currently applied on a limited scale, pending formalization of the system (Table 4.3). The grades are based on two main characteristics, non-lint content and the degree of reflectance. Grading is done by the ginners. The Pakistan country study team reports that the differentials that were announced for quality are not really working. This is due in part to the fact that the existing system of seed cotton marketing is based on weight. In addition, the majority of producers market their seed cotton through intermediaries, so-called *arthis*, and only about five percent, mainly large producers, deal direct with the ginner to benefit from premia for their quality. Moreover, ginners, who have an upper hand over farmers in price determination due to their financing relationship and the farmers' need to sell at harvest, do not always use the announced premia and discounts. Ginners have their own standards, depending on what they expect to get from the textile mills or exporters. For more accurate compensation, the team maintains that in addition to the grading program, the lint cotton support price policy should be replaced by spot rate announcements on the basis of grade and staple.

In all other countries, namely **Uzbekistan, Brazil, Egypt, China, Tanzania, and Mali** there is a formal classification system and premia for higher quality/grade cotton that is respected by the procuring central agency. In **Uzbekistan**, cotton types (upland and barbadense)

and industrial grade (each type of cotton is divided in four grades) plus moisture and trash content determine the government-fixed price, for the quota percentage bought by the state. In **China**, seed cotton, like lint, is divided into 7 classes and a sub-standard class. Each class, in turn, is divided in to three grades. There are pre-determined premia associated with each grade and class. The sub-standard cotton has two grades, for which the price difference is determined locally. The examination of seed cotton for quality, staple length, moisture content, trash content and GOT is done at ginneries operated by the Cotton and Jute Company, an agency of the Ministry of Internal Trade, who also make the payment.

Due to high domestic demand for high-grade cotton, **Brazil** exports low grade cotton (grade 7 and below) and receives prices that are between 10 and 15 percent below those prevailing in the international market for average quality. However, the Brazil country study reports that the low return to cotton production has had a negative impact on the quality of Brazilian cotton. Among fiber quality attributes, grade has been most seriously affected due to increasing levels of impurity. Hand picking by inexperienced, temporary labor is considered as one of the main reasons for contamination. The report also recommends that the storage, ginning, classification and transportation practices be revised to improve the quality of Brazilian cotton. Classification of lint is an official and obligatory process delegated by the Ministry of Agriculture to the States. Classification is carried out by Bolsa de Mercadorias and Futuros in São Paulo and Paranaense de Clasificação de Produtos (CLASPAR) in Paraná. In Pernambuco the task is performed in Campina Grande. In other states it is the responsibility of state administrative bodies. According to the report, lint classification is done well in São Paulo and Paraná but is just tolerable, in other states. Classification parameters are visual (color, brilliance, leaf and other foreign matters, and gin preparation). In addition, grade boxes are provided for the major commercial types in a manner similar to the method employed in the U.S. before grade was separated into leaf and color in 1994. While big, export-oriented companies and cooperatives in Paraná have introduced HVI, its widespread use has been hampered by high investment costs, lack of qualified personnel and interest.

In **Egypt**, each variety is classified into several grades on the basis of fiber quality ranging from Good (G) to Fully Good (FG). Prices for grades within each variety are determined by the Ministry of Economy and Foreign Trade who also take GOT into account. Historically, the grade of seed cotton was established in a two-step procedure in which agents of the Cotton Arbitration and Testing General Organization (CATGO) and seller and buyer representatives are involved. Farmers were paid 80 percent of their account after the first evaluation at the collection center and the balance was given after the final evaluation at the ginnery. Recent liberalization enables any licensed ginner to perform the evaluation.

In **Tanzania**, cotton is purchased from farmers in two grades: White Clean Cotton (AR) and Dull Stained Cotton (BR). (Fig. 4.11) The rest is discarded and has no grade. Due to lack of storage and a deteriorating ginning sector since the late 1970s, purchases of BR cotton from farmers have not been guaranteed. Failure to sell BR cotton discouraged farmers from grading. After hand picking, farmers grade their cotton before delivering it to the society store. Grade inspection at the buying post is done by primary society committee members on duty. However, inspection of cotton in the society store has become unsatisfactory and supervision has been weak. Stained cotton has been mixed with AR grade, resulting in lowering of the AR grade delivered to ginneries. Besides processing problems, causes for the apparent malfunctioning of the grading system include competition at the society level, corruption, fear of the electorate and a general lack of appreciation of the importance of quality. Clearly, market liberalization may ini-

tiate the institution of a more reliable system, given the importance of the maintenance of quality for Tanzanian exports.

In **Mali**, the seed cotton produced is divided into three quality types which are priced differently. The first choice/quality received 85 CFAF/kg, the second choice got 75 CFAF/kg and the third 45 CFAF/kg from 1985/86 to 1993/94, prior to the price increase following the devaluation of the CFA Franc. Producers that are organized into village associations and big individual producers who transport their seed cotton directly to the factory are paid on the basis of their cotton's fiber grade (industrial classification). The main criteria which determine this grade are color and trash. On the other hand, in villages that are not organized into village associations the seed cotton is classified by the CMDT buying agents.

There is an interesting contradiction between the Egyptian and Tanzanian reports regarding the value of premium for early delivery. The Egyptian team reports that in 1989/90, the Government introduced a premium for early delivery of cotton, but it was abandoned in 1991/92 because farmers tended to pick cotton prematurely with adverse impacts on both the yield and quality of cotton. The Tanzanian team, on the other hand, advocates the reinstatement of the bonus of 5-10 TSh/kg of the early 1980s for early delivery, i.e. if sold in the first four weeks after the opening of the marketing season. They maintain, that the bonus would contribute to quality improvement since grading and selling would be done very fast and less foreign matter would be picked up in the poor storage at the homestead.

Yield Trends and Profitability

Yield per unit area has a direct impact on farmer returns from cotton cultivation. The application of adequate fertilizers, sustainable crop protection, the presence of high yielding varieties and appropriate agronomic practices have emerged as the most important factors in improving yields. In **India**, low cotton profitability is caused to a large extent by low yields which are below the world average, despite a near doubling in the 1980s. This is a core problem faced by the cotton sector (Fig. 4.17) and is caused by the lack of high yielding varieties/hybrids for rain-fed areas, poor agronomic practices, lack of mechanization and poor usage of inputs in rain-fed areas. In **Tanzania**, yields are erratic and barely sufficient to cover production costs (Fig. 4.21). Poor agricultural extension services leading to non-adoption of recommended crop protection packages, low fertilizer use and a faulty seed multiplication program have been responsible for the non-realization of the yield potential of the varieties grown there.

In **China**, the average lint yield reached the 800 kg/ha level in the mid-eighties. Since then, the yield has fluctuated between 900 and 650 kg/ha, mainly due to pyrethroid resistance (Figs. 4.13 - 4.15). There has been a negative trend in the Yellow River Region (the region of pyrethroid resistance), while in the Yangtze River Region, with the exception of Sichuan, yields have remained relatively constant since the early 1980s. It should be kept in mind that the area harvested in the Yellow River Region was well below the area planted for 1993/94. Thus, if the yield figures were calculated using data on planted area, the actual extent of damage caused by pyrethroid resistance in this region would be more evident. In Xinjiang, on the other hand, the yield doubled between 1983/84 and 1991/92, then declined.

Since the late 1970s, cotton yields in **Brazil** have also shown an upward trend. The highest seed cotton yield was 1,137 kg/ha in 1991 while the lowest was 370 kg/ha recorded in 1976 (Fig. 4.12). The upward yield trend may be explained by the shift of production from the low-yielding cotton areas in the Northeast to the higher-yielding areas in Mato Grosso, Mato

Grosso do Sul, and Goiás. In **Uzbekistan**, the yield declined in the first half of the 1980s, increased in 1985 and decreased again in the following years. The expansion of cotton acreage was unsustainable, prevented crop rotation, and contributed to land exhaustion and the spread of wilt. The occasional increases in yield in the same period are likely to be the result of favorable weather conditions as was the case in 1994/95. The general decline in yield is identified by the Uzbekistan country study team as one of the most important threats facing the cotton sub-sector.

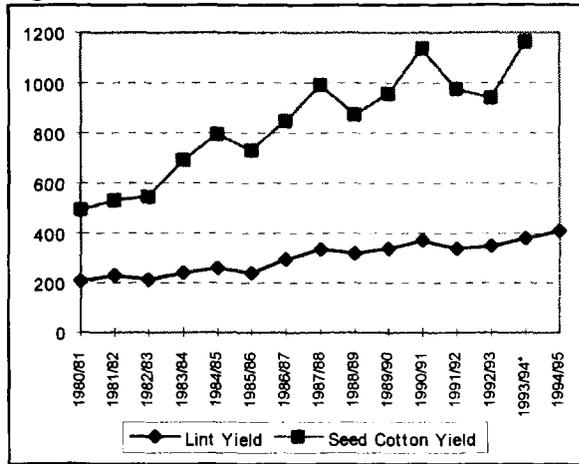
Lint cotton yields in **Egypt** declined from 1011 kg/ha in 1980/81 to 683 kg/ha in 1989/90 (Fig. 4.16). The main causes for the declining productivity were both economic and technical. Because of the low producer price, cotton was planted late in favor of additional berseem clover cuts. Similarly, given the low returns on cotton, fertilizer was used on other crops. Cotton was left unharvested when the cost of picking exceeded the returns to cotton for late picking. Economic inefficiency at the farm level was also probably compounded by government pesticide applications that were, in large part, cost ineffective, and excessive plant populations that resulted in extensive labor for thinning and created excessive vegetative growth. The lack of integration of plant breeders with market needs resulted in planting seed being 5 to 6 years or more removed from foundation seed, causing a dramatic decrease in yield. The increase in the early 1990s can be attributed to better production practices resulting from increased producer prices. However, yields declined again in 1994/95.

Mexico's cotton yields are among the highest in the world due to irrigation. Between the 1950s and 1980s, they increased by almost 200 percent. However, from 1980 to 1992, yields showed a tendency to decrease, reaching 771 kg/ha (lint), a level similar to those prevalent between 1965-1969 (Fig. 4.19). The main reason for this decline is the decrease in input use resulting from increasing input prices. However, there is great diversity in cotton yields among regions which masks country-wide yield comparisons.

Counter-examples are provided by Pakistan and Mali. In **Pakistan**, lint yield increased from around 300 kg/ha in the early 60s to 559 kg/ha in late 80s and peaked at 768 kg/ha in 1991/92 (Fig. 4.20). The increase was due to better plant protection measures, higher yielding varieties, higher use of fertilizer and better agronomic practices. The decline between 1991 and 1993 was largely caused by the leaf curl virus (L.C.V.) in Punjab but *Helicoverpa* damage and adverse weather contributed. *Helicoverpa* also influenced 1994 yields which were already depressed by large shifts from newer, high yielding varieties with a high GOT that were L.C.V. susceptible to older, lower yielding L.C.V. tolerant varieties. In **Mali**, yields have increased by 500 percent since 1960 as a result of the development of high yielding varieties with a high GOT in combination with improved production technology, effectively extended to the farmer, appropriate equipment suitable for small-holder production developed by CFDT and CMDT, input availability with applications at recommended rates, including effective crop protection. The stable, high yield level (Fig. 4.18) is also indicative of a successful CMDT seed program.

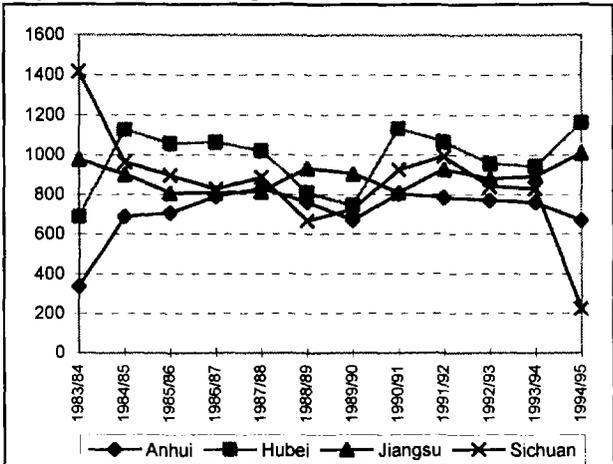
SEED COTTON AND LINT YIELDS (Kg/Ha)
(1994/95 yields are estimates)

Fig. 4.12: Brazil - Lint and Seed Cotton Yields



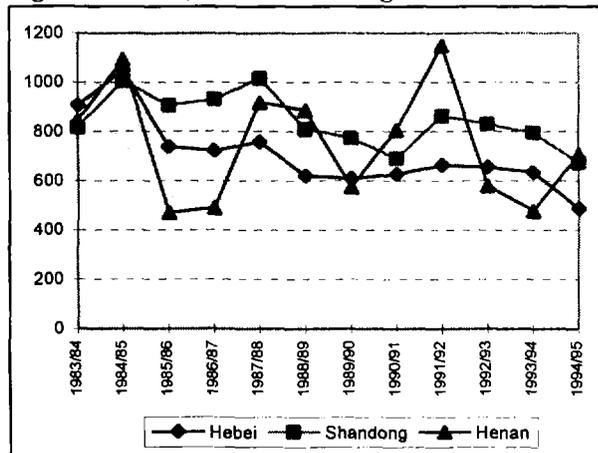
Source: Brazil Country Report and Bolsa de Mercadorias & Futros.
* estimated

Fig. 4.15: China, Yangtze River - Lint Yields



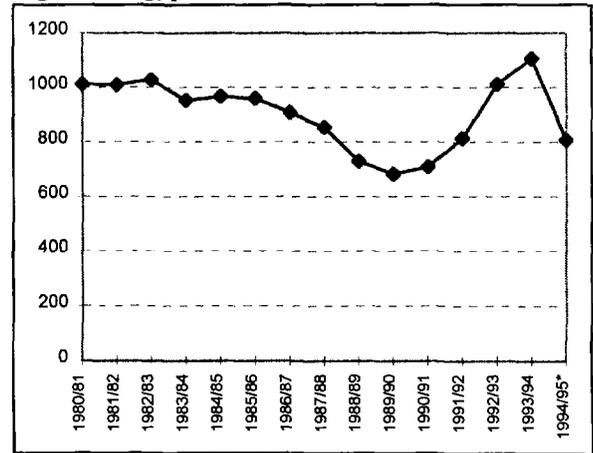
Source: China State Statistics Bureau. (1993/94 yields are estimates.)

Fig. 4.13: China, Yellow River Region - Lint Yields



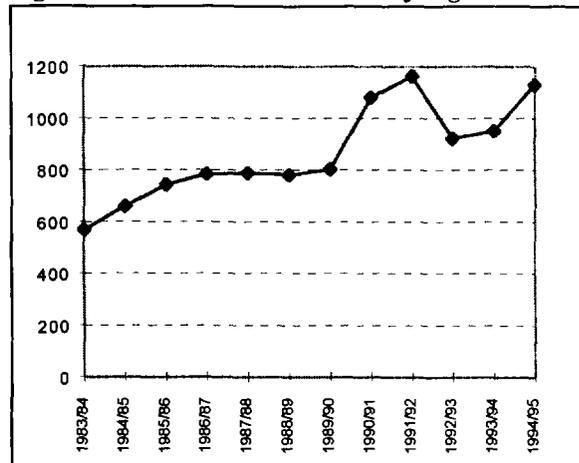
Source: China State Statistics Bureau. (1993/94 estimates.)

Fig. 4.16: Egypt - Lint Yields



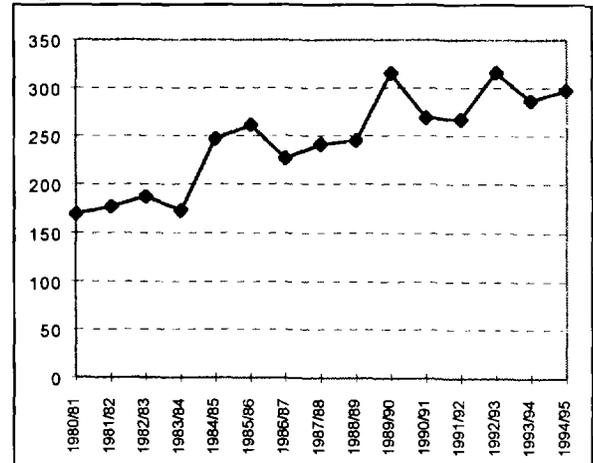
Source: ICAC

Fig. 4.14: China - Lint Yields in Xinjiang



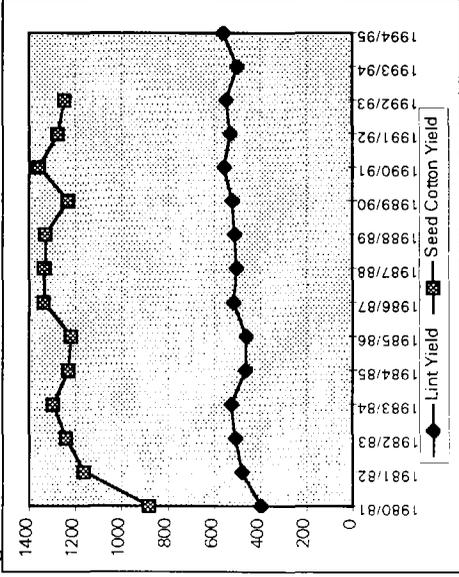
Source: China State Statistics Bureau (Data for 1993/94 and 1994/95 are estimates).

Fig. 4.17: India - Lint Yields



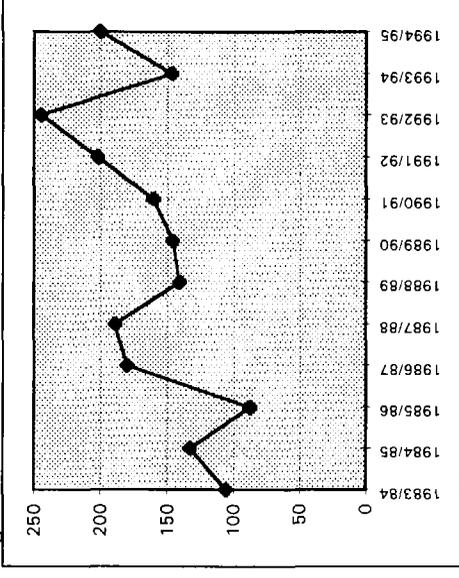
Source: ICAC

Fig. 4.18: Mali - Lint and Seed Cotton Yields



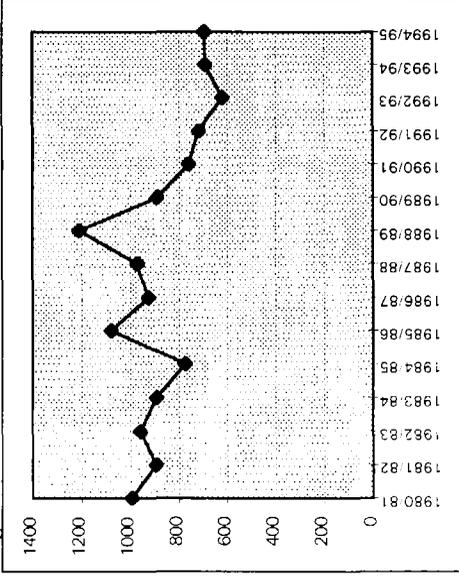
Source: ICAC and Mali Country Report

Fig. 4.21: Tanzania - Lint Yields



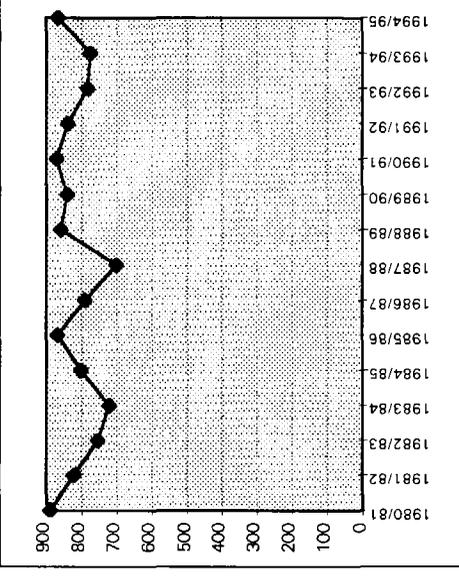
Source: ICAC

Fig. 4.19: Mexico - Lint Yields



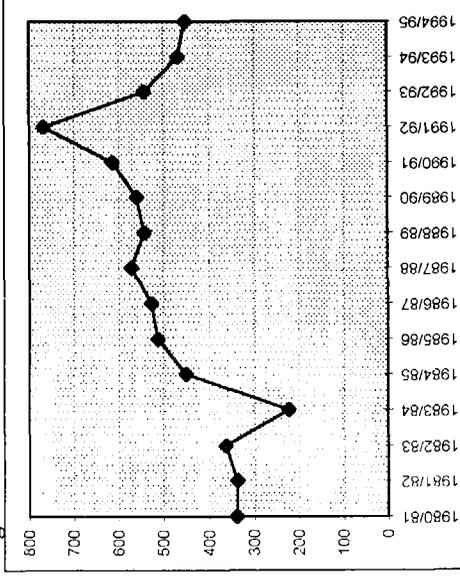
Source: ICAC

Fig. 4.22: Uzbekistan - Lint Yields



Source: ICAC

Fig. 4.20: Pakistan - Lint Yields

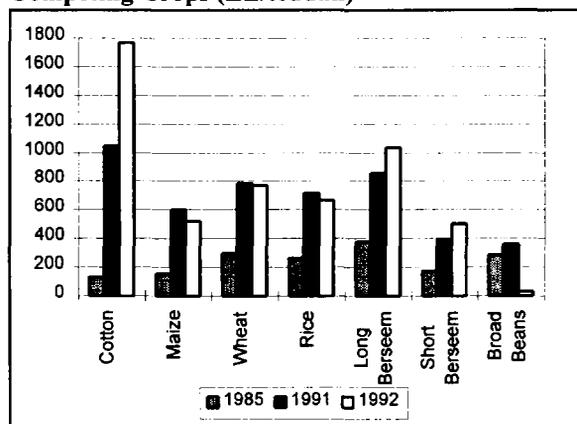


Source: ICAC

Financial Costs and Returns

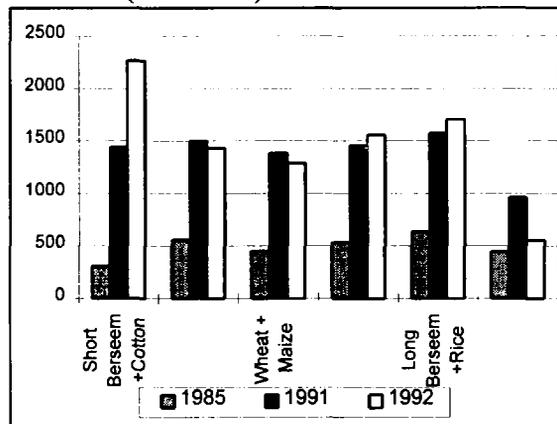
Financial returns are a crucial element in a farmer's choice to grow cotton as a mono-crop or in rotation with other crops. Besides yield and farmgate prices, costs of production are the major determinant of producer return. In this respect, input prices assume considerable significance. For instance, the levels of fertilizers and pesticides are influenced by prices, thus exerting an impact on both production costs and yield levels.

Fig. 4.23: Egypt - Net Revenue to Cotton and Competing Crops (LE/feddan)



Source: World Bank

Fig. 4.24: Egypt - Net Revenue from Competing Rotations (LE/feddan)



Source: World Bank

It is impossible to compare the behavior of returns to cotton production over time in the study countries because of lack of time series. In **Uzbekistan** the objective of the state is to set the producer price for the state-procured quota in a way that permits collective farms a minimum profit rate of 25 percent on expenditure. However, this level has not been attained since the early 1980s and in 1992, the rate of return was between 13 and 14 percent. The increase in the price of agri-chemicals led to a decrease in the use of pesticides, while, surprisingly, the use of fertilizers increased (from 4.0 to 4.8 percent) pushing up their share in the total cost of production (Fig. 4.35). In **Egypt**, on the other hand, the returns for cotton were significantly higher in 1991/92 and 1992/93, than in 1985/86, both as a mono-crop and in rotation with short berseem, due to both a rapid increase in the procurement price for cotton (Fig. 4.23-4.24) and increases in yield. The extensive controls on production and prices made cotton a financially unattractive crop compared to other crops that were gradually liberalized following the 1986 Agricultural Reform Program. In 1990, the last year data were available, cotton ranked third in terms of return to water (Fig 4.31). The increase in the procurement price for cotton relative to competing crops has obviously improved this ranking.

Table 4.4: Pakistan - Output/Input Ratio and Gross Revenue (1992/93 Market Prices and Yields, Punjab)

Crop/Rotation	Output-Input Ratio	Gross Revenue per	
		Day of Crop Rotation	Acre Inch of Water Use
Cotton	1.35	28.61	403.89
Basmati Paddy	1.05	20.91	80.09
Irri Paddy	1	18.31	62.19
Cotton & Wheat	1.27	24.85	316.34
Cotton & Sunflower	1.31	28.62	281.82
Sugarcane	1.17	19.1	171.02

Source: Pakistan Country Report

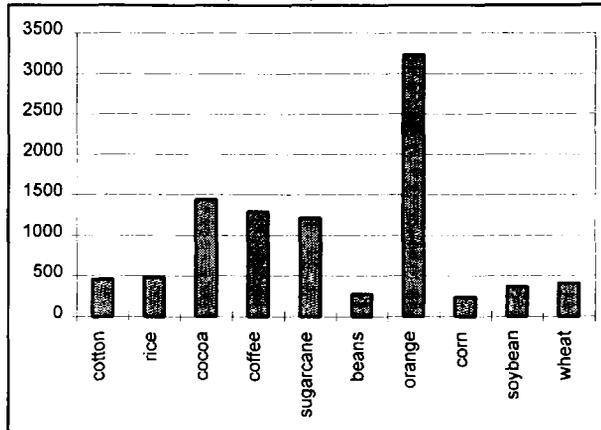
Cotton is also more remunerative in Pakistan than competing crops such as sugarcane, maize and rice, as indicated by output/input ratio, return per day of crop duration and per acre inch of water used. Gross returns to water from sugarcane are less than half those of cotton, underscoring the probable misallocation of water. Sugar producer prices are supported by import duties (Table 4.4). The study team maintains that sugarcane is not likely to maintain its area if the government subsidy (10-15 percent import duty on C.I.F. value) is withdrawn.

In **Brazil**, over the past 15 years, the average gross income for cotton growers has ranked lower than for orange, sugarcane, coffee, cocoa and rice (Fig. 4.25). (Naturally, in the absence of production cost figures, these data do not say much about relative profitability of cotton.) Production costs differ between states. For example, returns are higher in Paraná where cooperative supply of inputs and farmer land ownership exists than in São Paulo where absentee ownership results in high land rent and cooperatives do not exist.

In the Northern Region of **India** (Fig. 4.32), the cotton/wheat rotation and higher yields make cotton a fairly remunerative crop. In rain-fed regions, however, yields are lower and returns are generally poor, especially, in locations where cotton is a mono-crop. Higher cotton prices would motivate farmers to use inputs more efficiently which would result in better yields and improve farm economics.

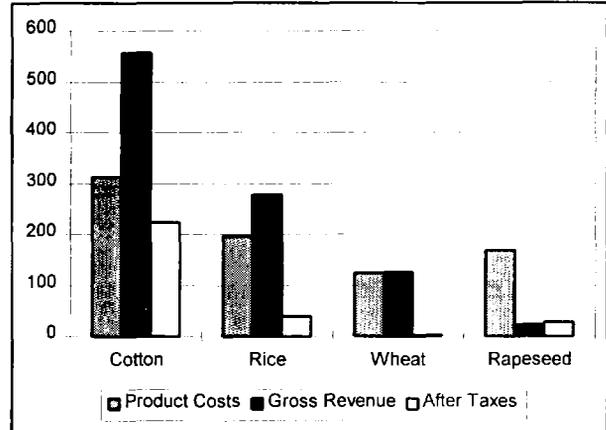
In **Mexico**, the combination of low producer prices and increasing input prices due to market liberalization of inputs led to low returns and decreased production in the early 1990s. Between 1990 and 1991, fertilizer costs rose by 326 percent, in 1991 water costs doubled and fuel costs went up by 14 percent.

Fig. 4.25: Brazil - Average Gross Income from Cotton in Brazil over 15 Years (US\$/Ha)



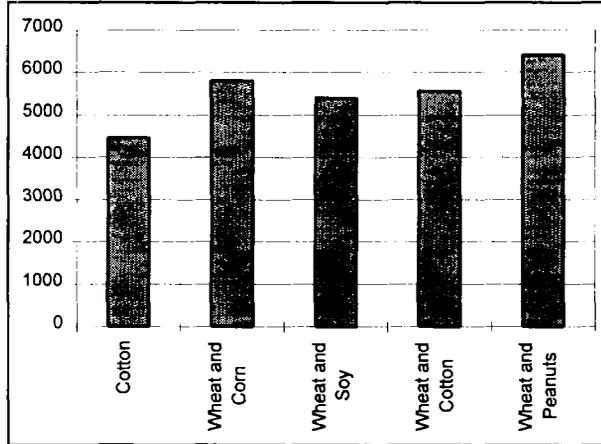
Source: Brazil Country Report

Fig. 4.28: China - Returns to Cotton and Competing Crops in Hanchuan County, Hubei (Y/mu) (1993 Prices)



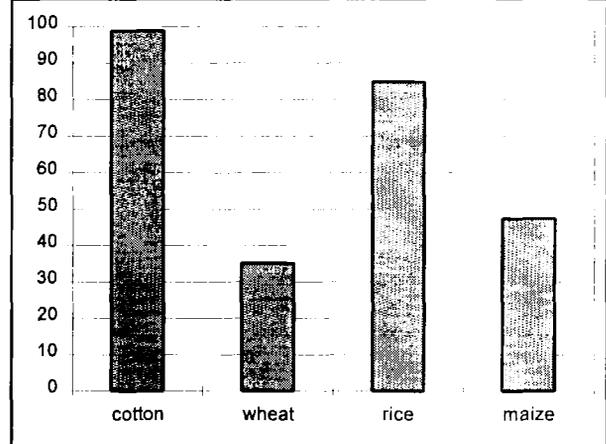
Source: World Bank

Fig. 4.26: China - Gross Financial Returns to Different Crop Rotations in Shandong (1993 Prices)



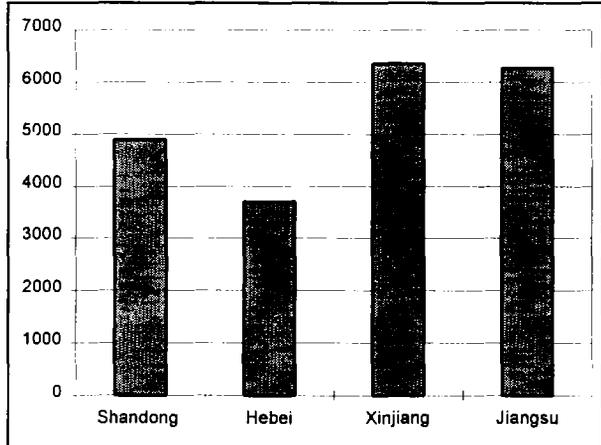
Source: World Bank, Based on Price : 6 Y/Kg and 1991 yields

Fig. 4.29: China - Net Revenue (Y/mu) (1986-1990)



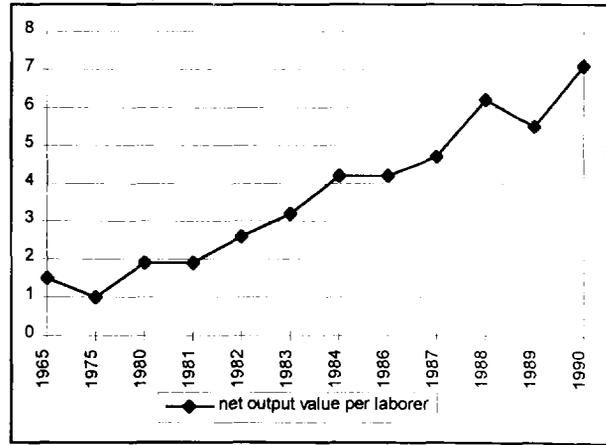
Source: World Bank

Fig. 4.27: China - Gross Financial Returns to Cotton across Provinces and Xinjiang (Y/Ha) (1993 Prices)



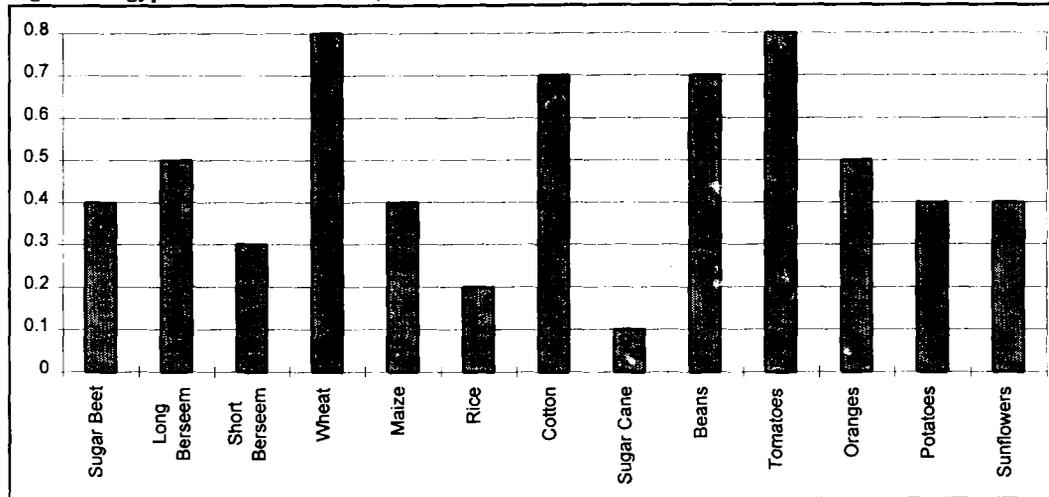
Source: World Bank. Based on Price : 6 Y/Kg and 1991 yields

Fig. 4.30: China - Return to Labor on Cotton Farms (Y/laborer/day)



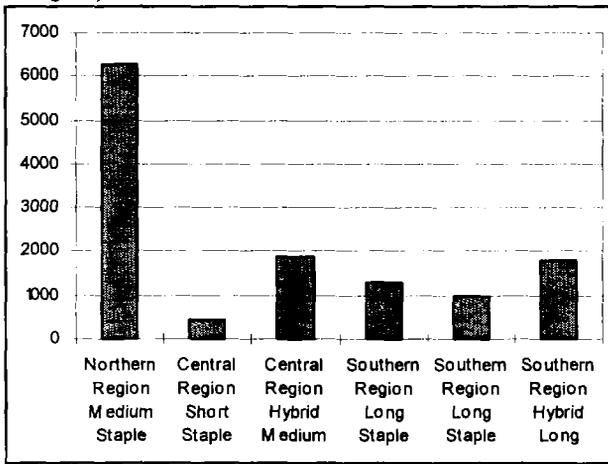
Source: China Country Report

Fig. 4.31: Egypt - Return on Water (Value Added in LE/m³ of Water) (1991 Prices)



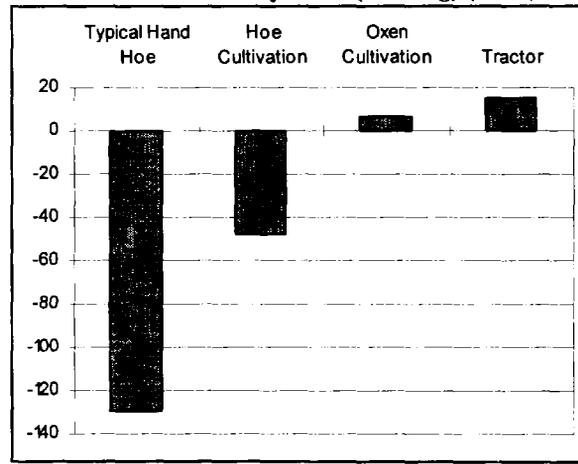
Source: World Bank

Fig 4.32: India - Profit from Cotton Cultivation Rs/QTL)



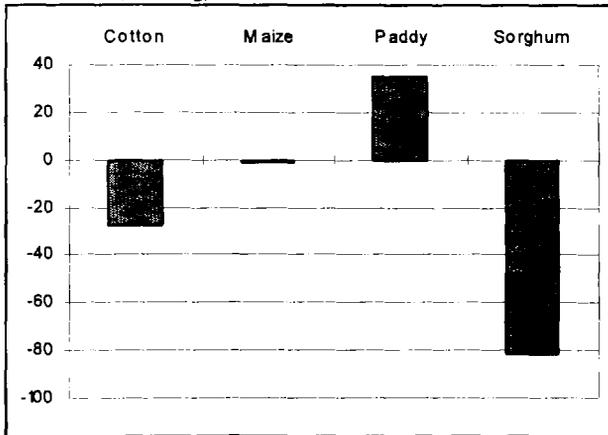
1990/91 Prices in the Northern Region, 1992/93 Prices in the others
Source: India Country Report

Fig. 4.34: Tanzania - Return to Cotton under Different Cultivation Systems (TSh/Kg) (92/93)



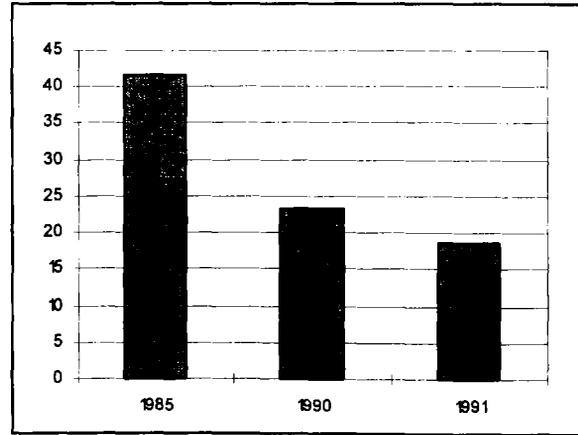
Source: Tanzania Country Report

Fig. 4.33: Tanzania - Financial Net Output Value in 1992/93 (TSh/Kg)



Source: Tanzania Country Report

Fig. 4.35: Uzbekistan - Rate of Return to Cotton Production as Percentage of Expenditure



Source: ICAC

Table 4.5: Cotton Crop Budgets for Six Study Countries (in Percentage)

Country	Egypt (1990/91)	India (1992/93)			Mexico (1994)			Pakistan (1993/94)		Tanzania (1993/94)		Uzbekistan (1991)
	<i>Irrigated</i>	Northern Hybrid Medium Staple <i>Irrigated</i>	Central Medium Staple <i>Irrigated</i>	Southern Long Staple <i>Irrigated</i>	S. Luis Potosi <i>Rainfed</i>	La Laguna <i>Irrigated</i>	Caborca <i>Irrigated</i>	Large Intensive Farms <i>Irrigated</i>	Small Family Farms <i>Irrigated</i>	Manual Cultiva. <i>Rainfed</i>	Animal Traction <i>Rainfed</i>	<i>Irrigated</i>
Inputs					22.6	30.1	22.6	14.8	15.5	54.5	42.3	
Seeds	1.0	8.8	7.1	3.1	4.8	1.9	1.8	2.0	2.7	0.0	0.0	1.7
Fertilizers	16.0	12.2	26.4	4.1	0.0	5.6	6.3	5.1	5.4	7.7	3.2	6.0
Pesticides	4.2	11.4	8.4	23.2	17.8	20.0	15.0	7.8	7.4	46.8	39.0	N.A.**
Insecticides					17.8	15.9	12.1	7.8	7.4	46.8	39.0	
Herbicides					0.0	4.1	2.4	0.0	0.0	0.0	0.0	
others	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	
Labor	48.8	56.5	37.8	19.6	53.5	29.5	19.9	8.5	9.9	0.0	0.0	68.7
Machine/Equip	18.4*				0.0	0.0	0.0	19.4	7.1	16.6	7.3	
Irrigation	0.0	0.0	1.6	7.8	0.0	4.0	21.6	4.5	6.2	0.0	0.0	
Harvesting	N.A.				17.3	23.2	16.7	9.7	9.5	14.1	8.8	
Other	Land Rent 12	Overheads 11.1 : 42.2 18.7			6.6	13.1	19.2	43.0	51.8	14.7	41.6	23.6***
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

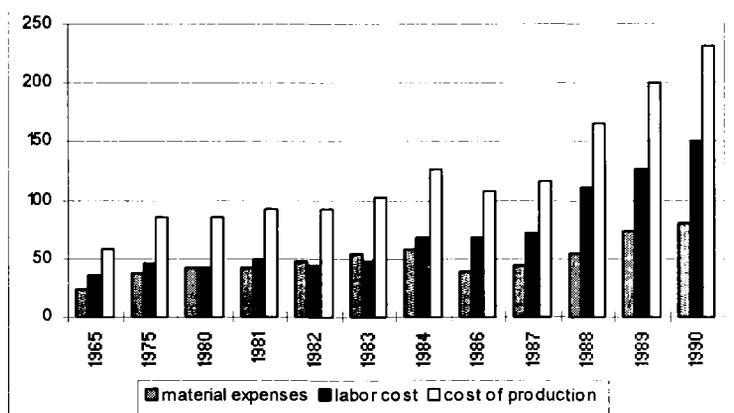
Source: India Country report, World Bank, French Ministry of Cooperation et al. (1995)

* Includes animals for traction

** The total quantity of insecticides on cotton decreased from 65,186 tons in 1975 to 30,083 in 1985 in 1990, and then to 2,586 in 1991. In recent years it is believed to have decreased further if not reached zero as a result of severe foreign exchange shortages. Thus the share of pesticides (insecticides) in the total production costs may very well be equal to 0.

*** Includes Depreciation

Fig. 4.36: China - Cost of Production Structure (Y/100 kg)

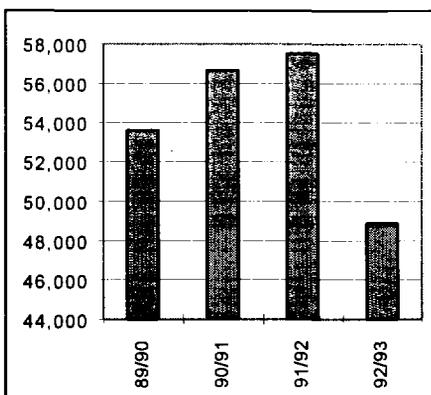


Source: China Country Report

(Fig. 4.36). Compared to 1980, in 1990, the output value of cotton increased 1.5 times and the after-tax net income increased by 122 percent, representing an annual increase of 12.2 percent. Country-wide Figures, which are misleading due to provincial yield differences, indicate that cotton (as a single crop or multi-cropped depending on the region) was financially the most attractive crop in China. In terms of regions, it is in the autonomous region of Xinjiang where cotton achieves its highest gross return (Fig. 4.27). Cotton is also profitable in the Yangtze River Region. As an example, in Hanchuan County, Hubei net returns to cotton are higher than rice, wheat and rapeseed (Fig. 4.28). However, cotton's profitability has eroded in much of the Yellow River areas due to decreases in yield. In Shandong the cotton and wheat rotation ranked third in terms of gross returns before the recent increases in cotton prices (Fig. 4.26).

In **Tanzania**, a survey carried out by the study team showed that the financial net output value was negative along with other crops like maize and sorghum. This is due both to low producer prices and the dramatic increase in the prices of pesticides, fertilizers and other production inputs following their liberalization. Between 1986/87 and 1988/89, the cost of cotton inputs increased by 475 percent while the producer price only increased by 70 percent over the same period. As a result, the use of fertiliser on cotton became minimal, especially among smallholder farmers. For instance, in the Mwanza Region only about 10 percent of farmers fertilise their crops and use farmyard manure as a supplement at less than half the recommended rate. Similarly, due to the high cost of batteries and chemicals, farmers often apply pesticides at an average of 2 to 3 sprayings below the recommended 6 to 8 sprayings, leaving cotton exposed to pest outbreaks. Production cost break-downs differ according to cultivation technique (Fig. 4.33).

Fig 4.37: Mali: Net Returns (CFAF/ha)



Source: Mali Country Study

In **Mali**, the growers' continued preference to cotton over competing crops can be explained by a) efficient extension, input distribution and general service provision, b) income security as a result of the procurement by CMDT of the entire crop, c) food security due to increased cereal yields as a side benefit from increased input use for cotton, and d) higher incomes due to productivity gains in cotton (Fig. 4.37). The 1993 devaluation of the CFA Franc increased cotton grower returns by 36 to 44 percent after adjustments were made for the higher costs of imported inputs while not significantly improving the returns from competing crops.

In **China**, an analysis of cost and return data of cotton lint and by-products and labor productivity shows that in the 1980s, the net income per unit area rose gradually. The price of chemical fertilizers, pesticides and plastic film for agricultural use has also increased in recent years. However, the proportion of material costs to the overall cost of production has tended to decrease due to more rapidly increasing labor costs

Labor Availability and Mechanization

In the majority of the countries cotton is entirely or to a large extent hand picked. In **Pakistan** almost all cotton pickers are female; in **Egypt** most picking is done by children and cleaning by women while in **Brazil** the labor force is composed of 80 percent children and adolescents and 20 percent adults (both men and women). In **Egypt** hand-picking is important in maintaining the quality of the fine and superfine varieties for which Egypt has an international reputation. Similarly, in **Mali**, exclusively manual picking is considered a quality guarantee. Labor availability is not a problem as the seasonal exodus of farm labor occurs only after the cotton harvest and is compensated by the arrival of migrants from other regions of Mali who are attracted to the richness of the cotton zone. However, the lack of training of the migrants in picking cotton has a negative effect on seed cotton quality. Similarly, in **Brazil's** Northeast where most pickers are unskilled, seasonal laborers (as opposed to resident peasants) who are paid on a weight basis, cotton quality is harmed by the high trash content. In addition, the high ratio of child and adolescent involvement in picking is considered a negative factor on quality.

Exhibit 4.1 : Tanzania - Production Schedule for Cotton, Maize and Rice in WCGA

Activity	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Field preparation	----- +++++++ ~~~~~											
Planting	----- +++++++ ~~~~~											
Pest control, including weeding	----- +++++ +++++ ~~~~~											
Harvesting & grading	----- +++++++ ~~~~~											
Marketing	----- +++++++ ~~~~~											
Uprooting stems & burning	----- +++++ ~~~~~											

----- Cotton +++++ Paddy ~~~~~ Maize

Source: Tanzania Country Report

Exhibit 4.2: Pakistan - Competition between Crops for Labor and Management Time

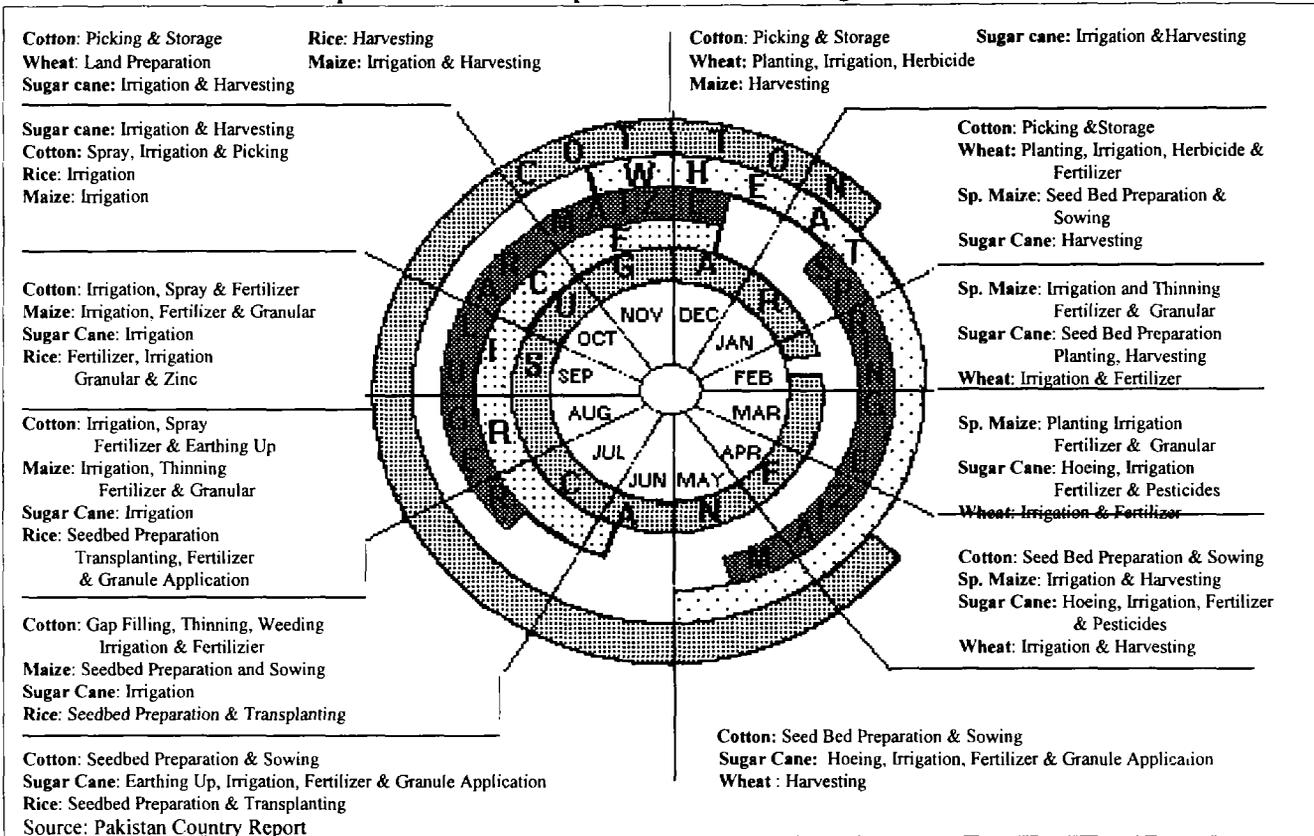
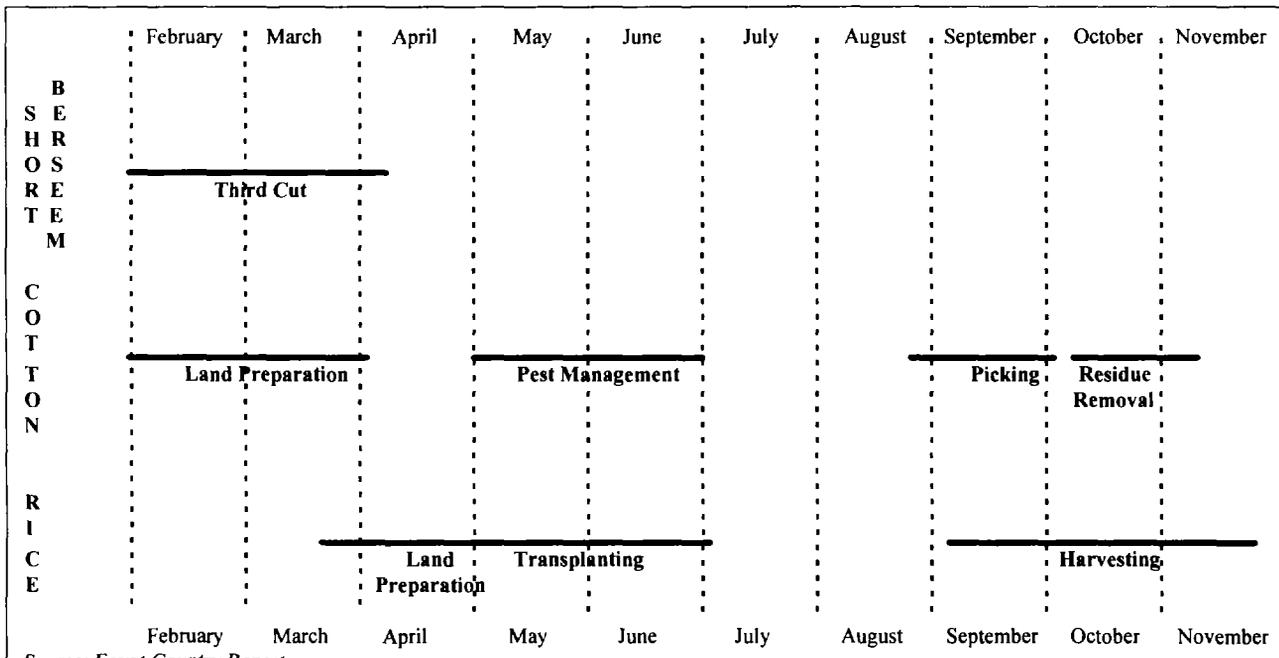


Exhibit 4.3: Egypt - Annual Labor Requirement for Cotton and Other Crops



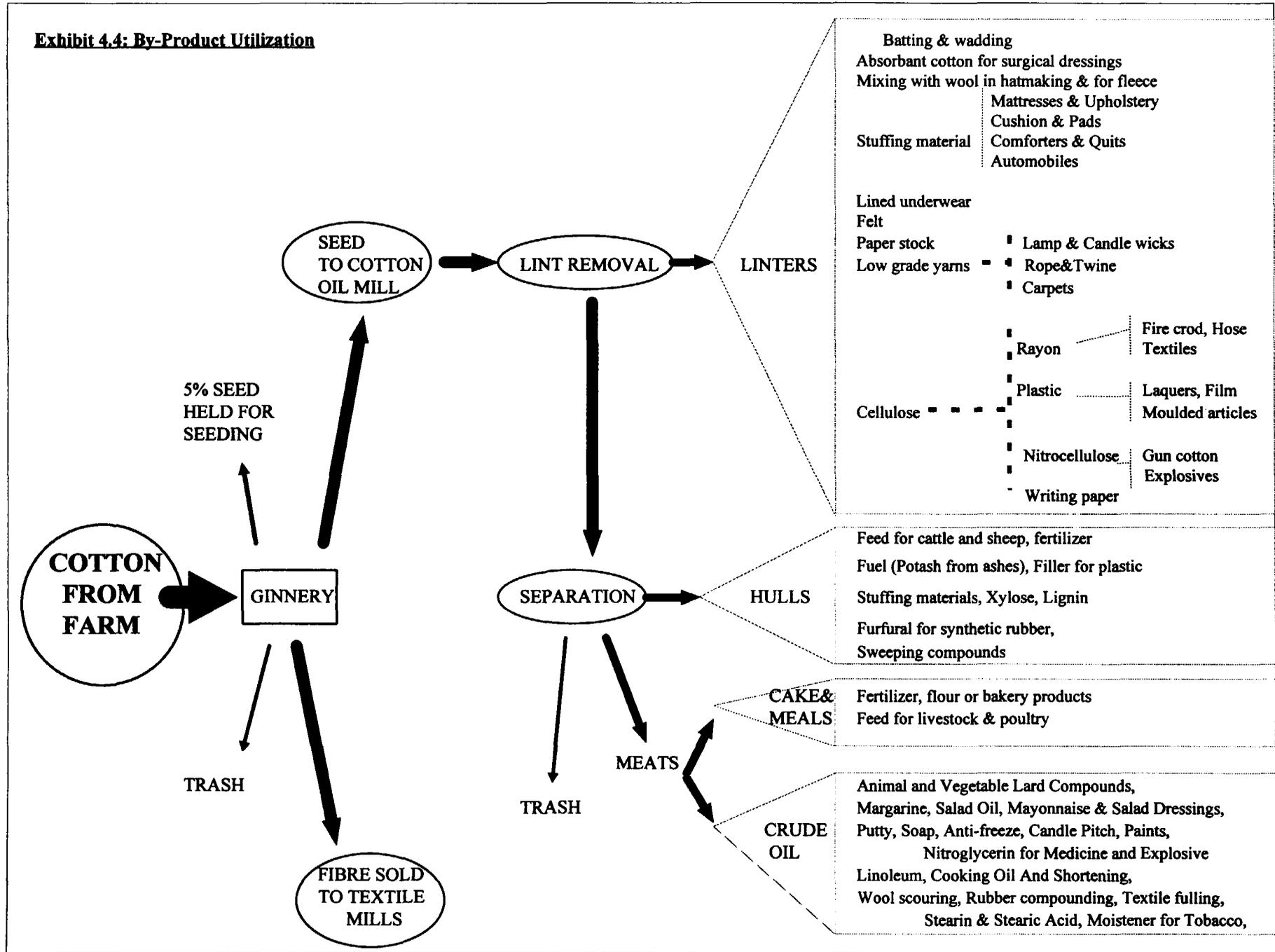
Non-availability and cost of labor are constraints to cotton production in a number of countries. The main causes for labor shortage are the overlap of tasks for other crops (Pakistan, Tanzania, Egypt), migration to big cities (Brazil) and other local employment opportunities (Mexico, China, Egypt). The **Tanzania, Pakistan, and Egypt** reports provide excellent illustrations of competition for labor among crops (Exhibits 4.1, 4.2 and 4.3, respectively). The importance of labor cost in **China** is illustrated by its increasing percentage of total cotton production cost and the fact that the location of cotton production is shifting from areas close to urban centers to poor rural regions. Mechanization is becoming more and more desirable in many countries. In **Mexico**, harvesting machinery is becoming common in the states of Sonora, Sinaloa and Baja California. In **Brazil**, cotton cultivation is moving into areas with low population density such as Mato Grosso, Mato Grosso do Sul and Goiás. Extensive large-scale production, practiced under conditions of labor shortage for picking, necessitates mechanical harvesting. However, given the increased trash content and higher rate of delivery of machine-picked seed cotton, a need is created for high capacity gins with ancillary seed cotton and lint cleaners.

In **Uzbekistan** the mechanical capacity in the cotton sub-sector is 80 percent. The utilization of this capacity largely depends on the presence of idle labor in different regions and weather at harvest time. For example in Termez where labor is scarce, the rate of mechanization is high, whereas in Bukhara and Ferghana where the population density is high, the mechanical capacity is less fully utilized. The country report also mentions that the existing 30,000 units of picking machines should be enough to completely mechanize the picking activity. However other factors such as lack of spare parts, high machinery cost, fuel shortages, lack of maintenance and the availability of cheap labor impede full utilization of mechanical capacity.

By-Product Utilization

Seed cotton by-products can be used in the production of a large number of goods as illustrated in Exhibit 4.4. In a number of countries, a significant percentage of cottonseed (85 percent in **Pakistan**, 55-60 percent in **Uzbekistan** and 17.5 percent in **China** and **Mexico**) is used to produce oil, by crushing or solvent extraction. In Pakistan, cottonseed oil accounts for over 85 percent of the country's edible oil consumption. Similarly, in **Egypt** cottonseed provides about 79 percent of the total edible oil produced and 20 percent of oil consumed in the country. Uzbekistan exports cottonseed to foreign oil extraction industries. In **India**, on the other hand, cottonseed oil is insignificant. The lack of organized trading facilities for cottonseed is an important factor affecting production economics. Cottonseed cake, which is obtained in the process of crushing for oil, is very rich in protein and is used in all study countries as stockfeed (only ruminants can digest cellulose and tolerate gossypol present in cottonseed) and with careful processing, as human food. China has developed varieties with very little (< 2 percent) or no gossypol which yield high quality protein for human food. Pakistan exports part of its cake production. In the majority of countries, cotton stalks are used as a major source of fuel, to a lesser extent construction and fencing elements, and as organic fertilizers. Cotton stalks can also play a major role in Integrated Pest Management. For example, in Mexico, like in Sudan and Zimbabwe, it is compulsory by law to chop and burn stalks and stubble of cotton after harvest to kill insects before hibernation begins. This helps reduce next season's bollworm population. Similarly, in Egypt cotton stalks are usually burnt to reduce the overwintering bollworm population.

Exhibit 4.4: By-Product Utilization



Ownership of the seed cotton by-products is important in determining the economic benefits farmers receive. In **Mexico** where ginners are hired by farmers to process their seed cotton, the value of cottonseed is used to pay for the ginning charge. In **Pakistan** farmers derive additional revenue from selling the stalks whose value is usually equivalent to the cost of cutting (Rs 166-200/ha). In **Brazil**, on the other hand, small and medium producers who are not associated with cooperatives, sell their seed cotton to ginning plants which sell the by-products to oil and fodder factories, and the furniture and fabric industry. The country report emphasizes that to increase the income of the farmers, the big problem is not increasing the potential of by-product production but the transfer of the revenue derived from their sale. This observation may or may not be valid depending on whether or not ginning charges are adjusted for lint by-product value. In **Mali**, where the cotton sub-sector is vertically integrated and managed by CMDT in a general rural development framework, cotton cake is returned by CMDT to farmers as stock feed.

Increased mechanization will lead to an increase in ginnery waste. Disposal of this material can be a problem. Traditionally, it has been burned in the USA but this is no longer permitted for environmental reasons. Ginnery waste consists mainly of leaf particles, twigs and remains of the boll walls. It can be used as a soil conditioner by merely spreading it on the soil. However, this may also spread weed seeds and any plant pathogens that are present in the plant remains. Composting would remove the weed and disease problem but would require a fair amount of labor. Composting with poultry litter makes excellent compost but again, labor could be a problem. Some research has been conducted in the USA, India and Pakistan on converting ginnery waste to produce bio-gas. This approach requires further investigation.

Motes comprise undeveloped seeds and consist mainly of short fibers. They can be utilized in upholstery or for the production of low grade fabrics.

Marketing⁵

Marketing of Seed cotton and Payment of the Producer

In countries where procurement is done through parastatals, at least part of the payment is made at the time of the collection. In **China**, the price of cotton is paid in cash by the purchasing unit. Farmers receive an advance down payment in the spring season which is then deducted from the final balance. However, script payments have existed in some years. In **Egypt**, prior to liberalization, farmers were paid in two installments (80 percent-20 percent): part of it on delivery to the collection centers and the rest after cotton was delivered to ginneries and graded. The reports from China and Egypt do not mention any delays in payments to the producers. In **Uzbekistan**, for the part of the quota that is procured by the state (currently about two thirds of the production), primary advanced payments are made after the seed cotton is taken to the procurement centers of the ginneries. The final settlement is in July-August of the following year after complete seed cotton processing to cotton fiber is completed. Under high inflationary conditions, as has been prevalent in Uzbekistan, this delayed payment of the second installment has contributed greatly to the decreasing profitability of cotton over the past two years. In **Mali**, where all seed cotton is procured by CMDT, about 80 percent of the primary collection is done by Village Associations (AVs). Classical AVs who collect and store the seed cotton at the village level until CMDT's buying agents arrive, purchase for cash, paying producers immediately after assessing the quality. Advanced AVs, on the other hand, carry out the marketing themselves. Their members receive payment, including the rebates, after the quality control at the ginnery. Large growers bring their seed cotton directly to the ginnery where they receive pay-

⁵ A schematic outline of the marketing organization in each study country is given in the annex to this chapter.

ment. Finally, in villages that are not organized in village associations, seed cotton is collected and purchased directly by CMDT collection agents. Farmers also receive a bonus based on the export selling price.

Until the onset of liberalization, cotton purchases in Tanzania were organized by regional cooperative unions except in Tabora, Kigoma, Singida and Iringa where TCLSB did all the purchasing. Societies contracted by the unions were charged with paying cash to farmers at collection points immediately after grade inspection and weighing. However, payments have been seriously delayed due to liquidity problems of the unions. After the transition to liberal marketing has been completed, private buyers holding buying licenses will also be able to purchase seed cotton. The Tanzania study team calls for a rigorous enforcement of regulations governing buyers licenses in order to protect farmers against unscrupulous buyers and to instill honesty in the buyers in general.

In India, Pakistan, and Mexico seed cotton is sold in the open market to private buyers. In Mexico, the sales process begins with the supply by the producers of a given number of bales and ends with the delivery of the produce, and the agreement of the parties on classification, penalties, weight and tare. Payment is made with a letter of credit or through some other agreed-on form. In case of a credit loan, the settlement is accomplished by a joint or separate check. In other cases the price is paid directly, to the seller's account. In **India**, payments in regulated markets, existing in nine major producing areas, are usually within a week (state-wise variation occurs) while no patterns exist in the unregulated markets⁶. It is estimated that about 80 percent of seed cotton passes through the regulated markets although an estimated 80 percent of this has been sold by the grower at the village level to an intermediary who pays cash and brings the produce to the market. In **Pakistan**, the farmer receives the payment for his seed cotton from the 'arthis' or the ginner to whom he sells his cotton. All the money ultimately comes from commercial banks which advance loans to ginneries for buying seed cotton, or from the buyer textile mills, the Cotton Export Corporation, or exporters who have to make payment to the ginner for the lint sale. Any blocking in this channel adversely affects the timely payment of growers. As an example, glut in the international yarn market affects the sale of lint locally and the payment to growers at the other end of the chain. In **Brazil**, cotton growers either sell directly to ginneries or utilize the government loan program.

Marketing Margins and Farmer's Share

Cotton is the raw material for yarn and apparel. The process from the harvesting of seed cotton to the production and marketing of the end material is a lengthy one, in which each step increases the value added. The price of the end product thus reflects the costs of processing, transportation, storage, handling and traders' profits. In perfectly competitive markets the share the farmer gets from the price of the end product, be it apparel, yarn or lint depends not only on the efficiency of the marketing and processing system but also on the distance of the farm from market, domestic or international. In the US, where there is minimum price distortion and an efficient marketing system, the ratio of the lint equivalent farmgate price in the domestic lint price is about 0.80 (Table 4.6). In contrast, in Mali, long distances contribute to the high transportation cost and thus, relatively low farmer share (about 0.52 in 1991/92.)

⁶ In the areas with regulated markets it is obligatory that produce is brought to such markets for sale and business is transacted according to certain by-laws. The legislation has been enacted to ensure fair prices and timely payment to the farmer.

Box 4.1: Marketing Margins in US Denim Industry

The example of the US denim industry is illustrated in Table 4.6. The farmgate price of cotton lint (i.e. the lint equivalent of the farmgate price for seed cotton) makes up only 8.8 percent of the retail price of denim dungarees. The shares of ginning, marketing and milling are 1.1, 0.9 and 18.4 percent, respectively. The technological progress towards more efficiency made in these fields since 1976, the date of these data, reduced these shares in favor of the farmers.

Table 4.6: Components of Farm-Retail Spread for Cotton Denim Dungarees in the US, 1976

Component	Cost per lb. of cotton used ¹ (US \$)	Cost per pair produced ² (US \$)	Proportion of Retail Value (%)
Lint Equiv. Farmgate Price	0.53	1.14	8.8
Ginning	0.067	0.143	1.1
Marketing to textile mills	0.055	0.118	0.9
Warehousing services	(0.011)	(0.024)	
Compression	(0.008)	(0.017)	
Transportation	(0.017)	(0.036)	
All other ³	(0.019)	(0.041)	
Lint Price on Mill Floor (Farmer's Share = 0.82))	0.652	2.401	18.54
Textile mill processing and finishing	1.114	2.384	18.4
Apparel manufacturing	1.740	3.724	28.8
Wholesaling-retailing	2.542	5.440	42
Total farm-retail spread	5.518	11.809	91.2

Source: USDA, "Cotton and Wool Situation," Economic Research Service, February 1977

¹ Reflects the estimated cost or value added to one pound of cotton used in the manufacture of denim dungarees at each stage. ² Reflects the estimated cost of value added to a pair of denim dungarees containing 2.14 pounds of cotton at each stage between the farmgate and the retail shelf. ³ Includes buying and selling expenses, cotton insurance, financing, and overhead expenses of marketing firms.

Marketing Margins and Farmers' Shares in Study Countries¹

Of the nine study countries, India, Brazil, China and Egypt use most of their cotton in their textile industry and Pakistan produces yarn, while Tanzania, Mali and Uzbekistan export the majority of their produce. Mexico has become essentially trade neutral due to both declining cotton production and increasing domestic cotton consumption.

Table 4.7 and Fig. 4.38 illustrate marketing margins and the development of the farmer's share in the domestic lint price of Brazil. Table 4.9 presents a breakdown of marketing costs and revenues in two regions of Mexico.

Table 4.7: Brazil - Cost Break-Down of Marketing Operations

	US\$/15 kg
São Paulo Cash Price for Lint	24.14
- Freight to São Paulo	0.30
- Lint Cotton Classification	0.10
+ Revenue from Seed Sales	2.90
- Ginning Costs	3.50
- Brokerage Percentage (1.0 %)	0.24
- Transportation Costs (0.2 %)	0.05
- Storage Insurance and Interest (1 month)	2.54
- Trade Margin (5.0 %)	1.20
= Lint Equivalent Farmgate Price	20.81
* GOT (0.34)	
= Farmgate Seed Cotton Price	7.07
(Farmgate Price / Domestic Lint Price = 0.86)	

Source: Brazil Country Report

* The year of the data was not identified but is probably 1993

Figs. 4.38 and 4.39 illustrate the changes in the farmer's share in the domestic lint prices in Egypt, where domestic spinning mills have enjoyed significant price subsidies on lint. However, this ratio has declined dramatically the past two years due to market liberalization. The farmer's

¹ A Section on the Calculation of Farmer's Share is presented in the Annex 2 to this Chapter.

share in the export price has increased since 1990 as illustrated in Fig. 4.42. Similarly, in **Pakistan** (Fig. 4.44) the domestic lint prices have been kept at a low level through the minimum export price and the benchmark price systems. However, this level has increased the past two years as Pakistan prices have responded to the difficulties encountered due to the leaf curl virus and pests.

Table 4.8 outlines the cost break-down of the **Tanzanian** marketing board from 1985-1993. Fig. 4.43 shows the development of the farmgate and export prices of lint and the farmer's share since 1981/82. The table and figures show that the farmer's share was held through fixed farmgate prices at about 80 percent until 1985/86 when world lint prices plummeted but since producer prices had been fixed in advance, the farmer's share was 165 percent of the export price and the marketing board incurred losses. Continued losses, mainly due to inefficiency and alleged corruption, led the board to decrease the farmer's share by not increasing the producer's price as much as the inflation level. In 1992/93 the share was 44 percent, a relatively low ratio.²

Table 4.8: Tanzania - Breakdown of Marketing Costs and Revenues (TShs/kg)

	1985/6	1986/7	1987/8	1988/9	1989/0	1990/1	1991/2	1992/3
A) Costs	70.73	147.61	209.11	255.48	316.94	390.02	400.42	358.94
Farmgate price/kg of seed cotton	13.00	16.90	19.10	22.35	28.00	41.00	70.00	60.00
per kg of lint ^a	38.81	50.45	57.01	66.72	83.58	122.39	205.88	176.47
Society levy	1.19	2.62	5.22	8.66	11.64	15.22	13.85	15.00
Union Costs ^b	3.88	60.75	80.57	111.04	142.06	198.51	89.43	69.93
Ginning Costs	5.25	8.89	14.81	24.83	35.93	53.90	53.00	53.00
Board Forwarding costs							30.00	33.72
Agency fees	21.30	24.90	51.50	44.23	43.73	58.15	8.26	10.82
B) Revenues	59.45	71.21	100.28	180.2	236.79	330.70	354.66	416.82
Lint Export Price in TShs / kg	51.6	59.16	85.26	173.03	239.25	325.36	331.2	399.75
% Export sales	75	72	73	85	75	72	82	93
a) Export Earnings in TShs/kg.	38.70	42.60	62.24	147.08	179.44	234.26	271.58	371.77
Local Sales Price	52.25	81.35	123.50	175.50	206.20	323.70	382	439
% Local sales	25	28	27	15	25	28	18	7
b) Local Earnings TShs/kg.	13.06	22.78	33.35	26.34	51.55	90.64	68.76	30.73
c) Income from seed/kg of lint	7.69	5.83	4.69	6.78	5.80	5.80	14.32	14.32
Profit (Loss)	(11.28)	(76.40)	(108.83)	(75.28)	(80.15)	(59.32)	(45.76)	57.88
% farmgate price / export price	75	85	67	39	35	51	62	44
% farmgate price/local sales price	74	62	46	38	41	38	54	40

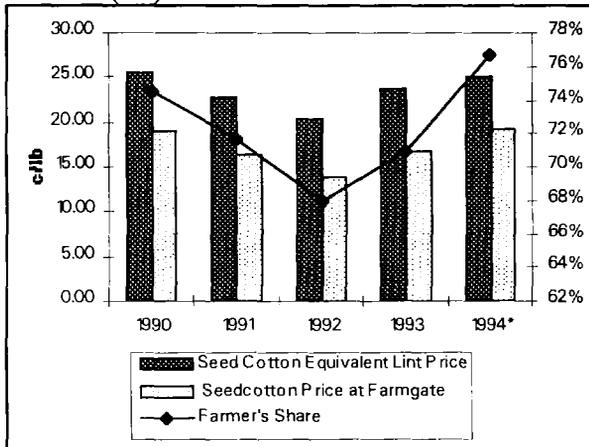
Source: Tanzania Country Report

^a Conversion factor (GOT): 0.335

^b Includes Society levy, District Council Cess, Handling, Crop Transport, Crop Insurance, Finance Costs, Union Levy, Cash Insurance and Transport, Storage and Fumigation, Bags and Twine and Miscellaneous Expenses.

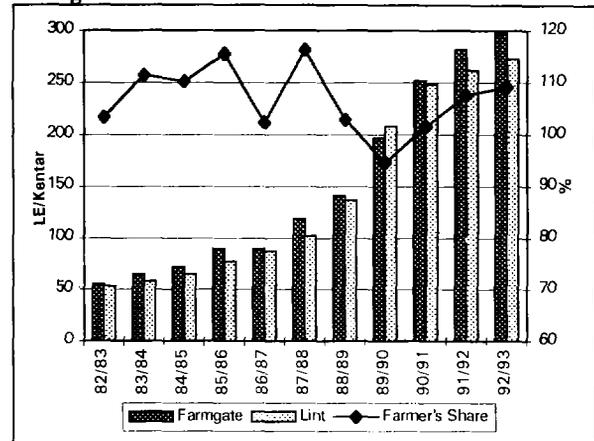
²The data used in Table 4.8 and Fig. 4.45 were taken from two different tables in the Tanzania Country Report that used different exchange rate series. That is the reason for the divergence in the farmer's shares. The series used to calculate the farmer's share in Table 4.8 probably reflect the market rate while the other series used in the Fig. reflects the overvalued official rate. Thus, the former, smaller farmer's share series is more likely to reflect the true share that the farmer received.

Fig. 4.38: Brazil - Paraná: Farmgate Seed Cotton vs. Domestic Lint Price (c/lb)



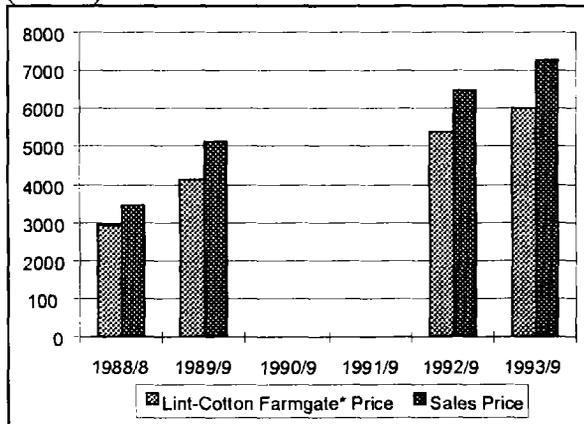
* Average of the first five months of 1994.
Source: Parana State Department of Agriculture

Fig. 4.41: Egypt - Giza 75 Qibli (LS) Lint Equiv. Farmgate vs. Domestic Lint Prices



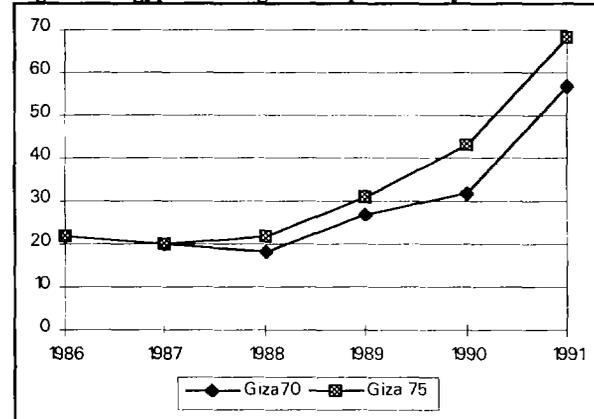
Source: Egypt Country Report

Fig. 4.39: China - Lint Cotton Purchase vs. Sales Price (Yuan/T)



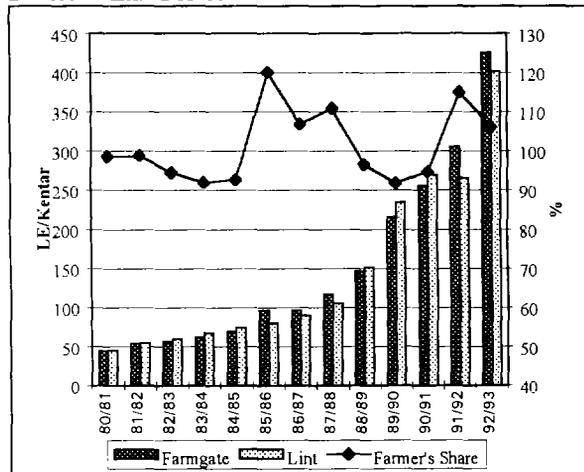
*In China is farmers are paid on the basis of lint.
Source: Ministry of Internal Trade

Fig. 4.42: Egypt - Farmgate / Export Parity Price



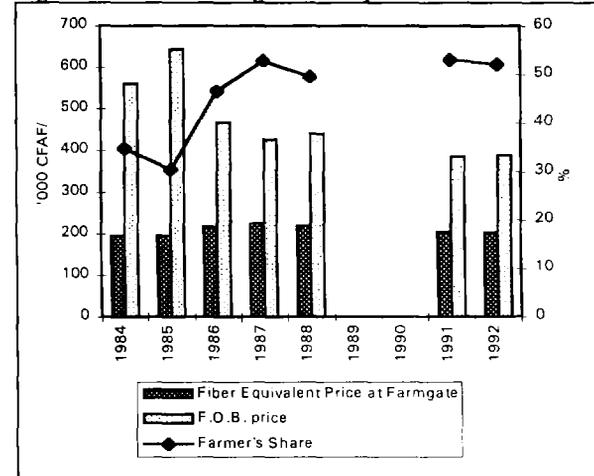
Source: Egypt Country Report

Fig. 4.40: Egypt - Giza 70 (ELS) Lint Equiv. Farmgate vs. Domestic Lint Prices



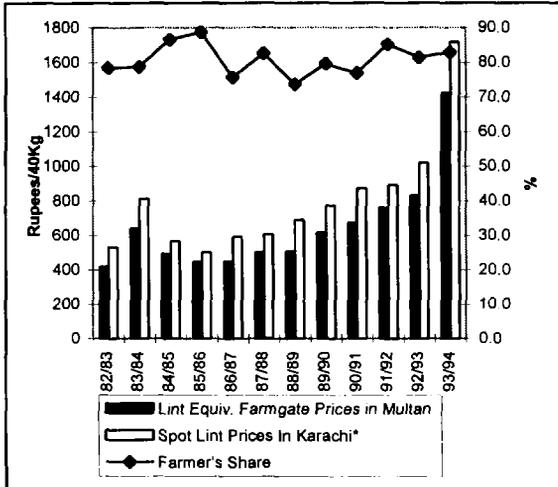
Source: Egypt Country Report

Fig. 4.43 : Mali - Farmgate vs. Export Prices



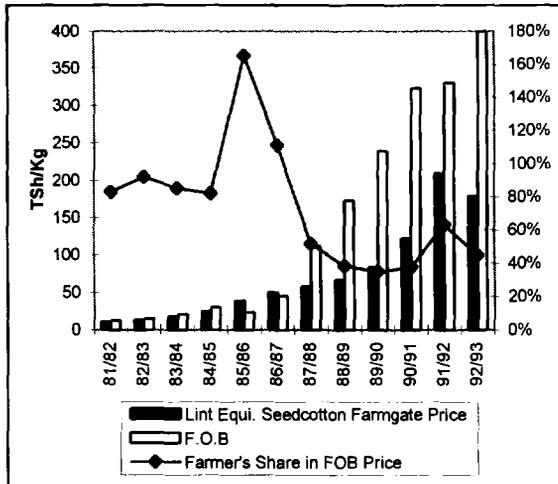
Source: Mali Country Report

Fig. 4.44: Pakistan - Lint Equivalent Farmgate Price vs. Domestic Lint Price



Source: ICAC

Fig. 4.45: Tanzania - Lint Equiv. Farmgate vs. F.O.B. Price



Source: Tanzania Country Report

Table 4.9: Mexico - Breakdown of Marketing Costs and Revenues (1994) (US cents/lb) in terms of Lint Cotton

	Region	La Laguna	Cabo rca
	Definition		
<i>A) Costs</i>			
1.	Production Cost at Farmgate (unpackaged)	86.01	76.43
2.	Primary Transportation and Marketing Costs	3.11	0.89
3.	Ginning Cost	7.08	7.05
4.	Classification and Storage	0.25	
5.	Total Cost at Export Port (F.O.B.)	96.45	84.46
<i>B) Revenues</i>			
6.	Lint Sale	52.91	57.24
7.	Subsidy	24.27	23.29
8.	Sale of By-Products	7.08	7.05
9.	Total Revenue	84.26	87.58
10.	9.-5. <i>C) Profit (Loss)</i>		3.12
11.	Farmgate Equiv. Lint Price		
12.	6.-3.-2. without Subsidy	42.72	49.21
13.	12.+7. with Subsidy	66.99	72.50
<i>D) Farmer's Share</i>			
14.	Reference World Price	50.95	50.95
15.	Ratio with Subsidy	1.31	1.42
16.	Ratio without Subsidy	0.84	0.97

Table 4.10 outlines the cost items of the CMDT marketing operations in Mali. The farmer's share of 52 percent seems low compared to the US ratio of 80 percent. However, this can be partly explained by the fact that while the producer price is relatively low, the CMDT provides other agricultural development services, some of which also figure as cost items in the table (items 9-12). Fig. 4.43 shows that the farmer's share was between 30 and 40 percent in the late 1980s.

Table 4.10: Mali - Marketing Costs (CFA/ ton)

	1990/91	1991/92
1. Overheads	8,679	8,320
2. (Farmgate Price for Seed cotton)	(84,894)	(85,058)
Lint Equivalent^a	204,324	202,420
3. Market charges	6,908	7,213
4. Collection costs	15,784	15,588
5. Maintenance of trucks	546	355
6. Municipal taxes	156	159
7. Remuneration by State endowment	2,339	2,339
8. Interest and other borrowings	1,844	2,575
9. Quota for research	2,626	2,706
10. Quota for monitoring	15,757	13,886
11. Support by CFDT	3,259	3,222
12. Crop protection	2,667	2,637
CMDT cost price	277,116	272,916
OHVN cost price	278,474	268,668
Delivery price to ginnery	277,263	272,892
13. Technical. Indust. Director.	2,359	2,466
14. Ginning cost	53,807	56,290
15. Fiber insurance	741	614
16. Financial costs	7,828	11,536
17. Stock handling	2,957	3,298
Price on ginnery floor	344,954	347,095
18. Cost (ginnery—alongside quay)	25,987	24,526
19. Transit-Abidjan/Dakar	14,045	14,466
FOB cost price	384,985	388,088
20. Freight/Insurance	34,410	35,442
21. COPACO's Commission	1,788	1,930
22. SOSEA's charges	982	1,725
CIF cost price	422,165	427,186
Farmgate Price/F.O.B Price	0.53	0.52

^a The conversion factor from the seed cotton price to the lint price is equal to the GOT, namely 0.42.

Source: Mali Country report

Credit

The cost and availability of credit are important issues in all stages of cotton production, processing and marketing. Most of the country studies report lack of credit as a major impediment to increased cotton production. At the production level, farmers need credit to purchase inputs (seed, pesticides, fertilizers), to pay temporary workers (planting, weeding, picking), to invest in machinery and for subsistence until the sale of the produce. Availability of affordable credit gives the farmer leverage at harvest time to wait until he can sell his cotton at a higher price. Credit may also be necessary for the transportation of seed cotton to the ginnery, which may be carried out by the farmer, a trader or the ginner himself. The trader usually pays the farmer an advance and has to

sustain this and transportation costs until the seed cotton is sold to the ginnery. Ginners may need short term credit to cover operating costs (labor, power, maintenance and in most countries the purchase of seed cotton) until they sell lint cotton (or receive their fee for ginning). Longer term credit may be needed for capital investment. Agents involved in marketing (from the ginnery to the mill or point of export) incur costs of transportation, handling and various government levies.

In **Brazil**, formal credit has not only been insufficiently available, but also their nominal rates have been very high due to the high inflation rate. The processing and industrial sectors are not eligible to receive marketing credits. They prefer to acquire lint in the foreign market, which offers a 180-day term and interests rates of 6 percent per year. The attractive credit terms for imported cotton have forced Brazilian producers to accept lower prices.

In China there is a state-controlled credit system that includes an early advancement of a part of the payment for the seed cotton to be procured and credit for the purchase of inputs. In Egypt, loans to farmers were administered by the Principal Bank for the Development of Agricultural Credit (PBDAC) (with its 17 affiliated Banks for Development and Agricultural Credit) that has an extensive outreach of credit servicing centers in rural areas, including about 800 village banks and 4,300 agencies. Informal credit played only a minor role in agriculture, mainly because of the near-monopoly of PBDAC on the supply of key inputs. PBDAC gave farmers loans for "strategic" crops at an annual rate of 10 per cent compared to 16-18 per cent annual rate of interest charged for other loans. The eligible loan limit for cotton growers was raised from LE 250 in 1992 to LE 313 per feddan, implying a cash subsidy of LE 12-16 per feddan. Market liberalization has resulted in PBDAC gradually shifting its lending to farmers since 1991 from loans in kind (seeds, fertilizers, pesticides) to cash loans. Short term production credit is currently available from the cooperatives due to liberalization.

In **India**, credit is available to farmers in the form of short term crop loans (to purchase inputs) or medium and long term loans (usually meant to create assets). Short term credit is largely provided by the co-operative institution while public sector commercial banks and co-operative land development banks provide medium/long term credit. The informal sector also provides credit but no estimates are available on how significant it is. The quantity of short term credit available to a farmer depends upon the area he owns and the scale of finance determined by the state Directorate of Agriculture in the district. This scale of finance is based on cost of production. Credit is given partly in cash and partly in kind (in terms of fixed quantity of seeds, fertilizer, pesticides etc.) and is repayable from the proceeds of the sale of the output. Nevertheless, typically, no post harvest credit is available to the farmer to enable him to hold stocks at times of low prices. Thus, he is forced to sell immediately, not necessarily to his advantage.

In Mali, short term input and medium term equipment credit is supplied to producers by BNDA (National Bank for Agricultural Development) (CMDT is not engaged in providing credit). Village associations receive special credits at 9 percent. Medium term credit rates vary from 9 percent (for the special equipment programs for Village Associations) to 13 percent. For all other actors in the sector, the minimum interest rate is 15 percent (discount rate + 4 points + taxes). These are considered excessively high by those involved.

In **Mexico** where the majority of cotton growers are large farmers, credit is available from the private sector at competitive rates that reflect the risky nature of cotton in Mexico. The private banking system has some necessary conditions: at least a 2:1 relationship between guarantees and loan. There exists a low priority for agricultural loans in comparison with non-farm industry. Due to apparent commercial risk and the high inflation rate, lending rates are in the 40 percent range.

With NAFTA, a change in this situation may occur soon. Cotton producers, who take such credits with high cost, are large producers and cover these costs by increasing the price of their seed cotton. Special credit is available from the public sector for two types of producers: the producers with potential for entering the market and those farmers whose capital endowment is too small or not viable. The institutions involved are BANRURAL for the former and the "Solidarity Program" for the latter. "Credit on the promise to pay" is the new way to get credit without guarantees to the lender. To promote investment in the cases when farmers cannot provide capital or guarantees, the Government operates a Fund that helps with minority risk capital⁹. Defaulted loans are restructured using public funds and the process continues. Finally, informal credit can be obtained from ginners through negotiations before planting to cover production and transportation costs.

Farmers in **Pakistan** obtain development loans from the Agricultural Development Bank of Pakistan (ADBP) to pay for of tractors, tubewells and other agricultural machinery. Production loans to cover the costs of seeds, fertilizers, pesticides and implements can be obtained from commercial and cooperative banks. The total credit issued by Government institutions comes to about Rs. 675.5 per hectare for both capital input and production purposes, a very small amount compared to the total cost of Rs. 15,500 per hectare for the production component alone, indicating that the formal credit supply is grossly deficient. Furthermore, the procedure for getting loans is complicated and lengthy so informal credit has become very important in cotton production and marketing. This is channeled through the so-called *arthis* or commission agents from ginners who in turn receive credit from banks, subject to State Bank regulations. Ginner interest in this credit system is to assure continued supply of seed cotton to their factories. Credit supplied to farmers by *arthis*' is both in kind (seed, fertilizer and pesticides) and in cash. Farmers receiving credit from an *arthis* are bound to sell their produce through the same commission agent. During this process farmers have to pay heavy commission and may not get the maximum price.

The credit system in **Tanzania** used to be intimately related to the provision of inputs. Unions normally obtained credit from both the Tanzania Cotton Marketing Board (TCMB) and Co-operative and Rural Development Bank (CRDB) as seasonal input financing. TCMB imported chemical pesticides and distributed them to the unions on credit, recovering the cost through sales of lint. The unions also distributed the inputs on credit to member Primary Co-operative Societies (PCS) who, in turn, gave them on credit to farmers. Credit was recovered during the seed cotton marketing by deducting the amount owed by the farmers from the proceeds of crop. Under this system, however, credit recovery from PCS did not work efficiently, leading to large unpaid debt accumulation with the unions who, in turn failed to settle the debts with the banks. The near collapse of the credit and input system led to the non-utilisation of fertilisers in some cotton producing areas for as long as two years, causing severe soil degradation. In addressing the question of credit for the supply of inputs under the liberalised system, in April 1994 the Government enacted the Agricultural Inputs Trust Fund Act which paved the way for the establishment and operation of an agricultural inputs trust fund to give low interest loans to farmers and suppliers for the procurement and distribution of inputs. However, the placement and operation of this fund may take time.

Since 1992/93 financial year interest rates were liberalized. The Bank of Tanzania (BOT) fixes the minimum rate but the maximum is open. This fact, and the policy tightening the operations of financial institutions making them operate more on commercial lines, has already

⁹ Investment and Capitalization Trust Fund for the Rural Sector. (FOCIR).

limited the availability of credit. Interest rates have also gone higher to 40 percent in order to attract more deposits by the banks. Hence, in the short term, availability of finance to the already constrained unions will be a problem.

Due to difficulties in obtaining credit for production activities, farmers resort to other forms of informal credit, especially in the WCGA. As reported by the Farming Systems Project in Mwanza, informal groups exist in villages which give loans to their members while charging interest. The use of this credit is only for financing short-term businesses. Hence, its use in agricultural activities, which are long-term investments, is limited, but may be promoted. The most practical credit is the traditional pooling up of resources to till the soil of, or pick cotton for, one farmer. During the tilling season farmers with ploughs and oxen may be invited by other farmers to till their land in return for a food banquet or drink. This provides compensation to farmers in lieu of payment for services.

The Banking system in Uzbekistan was reformed in 1991 by transferring credit allocation from the Cabinet of Ministers to commercial banks. Currently, the Republican Joint Stock Commercial Agro-Industrial Bank (Agroprombank) and its regional branches are the main banks extending credits to the agriculture sector. Inflation has led to high interest rates. Agroprombank lends at an interest rate of 55 percent. There are other commercial banks participating in agricultural credit, however, their interest rates are significantly higher. The high inflation rate leads to higher demand for credits, but the worsening of the financial situation of the kolkhozes and sovkhoses makes timely repayment impossible. Of special concern is the decrease in long-term credits given that have negatively affected capital investments.

Storage

The possession of adequate storage facilities may permit farmers to store the crop after harvest, pending rises in price¹⁰. In Pakistan, only a few growers with covered well ventilated godowns, often keep their seed cotton, hoping for better prices in the future. The majority of farmers are afraid of seed cotton heating up if it is stacked in a heap for long, especially in the open. In regions of Mexico where the climate is characterized by high humidity, farmers have to sell their cotton during the harvest time when the prices may be low and may incur losses as a result. Ginners, on the other hand, possess their own storage within the premises which may be rustic structures with good natural ventilation or may have air conditioning to dry the product.

In Tanzania, at one time, an early delivery bonus induced farmers to bring their cotton to the collection point in the first four weeks of the marketing season. However, the bonus was abolished in the early 1980s after it became impossible to implement due to processing problems and stockpiles of more than a year's crop in the societies, in addition to failure by unions to complete crop financing arrangements on time. The Tanzania country study team recommended that, as seed cotton marketing is now liberalized and new ginneries built, reintroduction of the early delivery bonus should be reconsidered as one of quality improvement measures.

Lint storage may occur along the marketing channel to benefit from later higher prices or as a strategic reserve. In **India**, where the government is committed to providing a steady and cheap supply of lint to the textile mills, hoarding of cotton at times of increasing prices is controlled. For this purpose, stock levels of the mills are regulated up to a certain number of months' consumption while the trader's stocks are regulated through the selective line of credit

¹⁰ The technical aspects of optimal duration and conditions of storage are discussed in Chapter 2.

whereby traders have to maintain higher margins against their seed cotton requirement. Cotton is stored mainly as lint with stocks of about 20 percent of the total demand. The major stock operators are CCI, Marketing Federations, Traders and Mills. The CCI used to purchase and stock cotton under government directives for buffer stocking and meeting requirements of government owned textile mills but since 1988-89 these roles no longer apply.

*Ginning*¹¹

Ownership of Ginning Plants

From the viewpoint of economic efficiency, the function and ownership of ginneries is very important. This varies across the countries studied. In **China**, ginneries are enterprises controlled by the Cotton and Jute Company, part of the Supply and Marketing Cooperative under the Ministry of Internal Trade. In **Tanzania**, the majority of ginneries are owned by quasi-private regional cooperative unions. Egypt is a country in transition. Previously all 68 ginneries were owned by public holding companies, but 17 ginneries are now leased to a private company. On the other hand, in **India** and **Pakistan** ginning is controlled entirely by the private sector. In India, more than 80 percent of all gins are in private hands (although ginning costs are regulated by the government) while the rest are in the cooperative sector. In Pakistan, ginning factories are privately owned, generally by private family companies.

Ginning Costs

The share of ginning cost in the overall production cost of lint varies among countries. In **Mali** ginning costs were reduced significantly between 1989 and 1992. In 1991 and 1992 they constituted about 15-16 percent of the fiber price on the mill floor. Similarly, in **Tanzania**, in the 1993/94 season ginning costs made up 16.6 percent of the total cost of lint production. In **Brazil**, ginning costs make up about 14.5 percent of the lint price in Paraná State¹². In **India**, in 1991/92, the ginning rate could be as low as 40-50 Rs. and as high as 175-178 Rs. per 170 kg. Ginning rates are regulated and do not provide adequate margins for modernization, which has led to poor infrastructure and storage facilities. These are also factors contributing to poor quality. In **Pakistan**, during the 1993/94 season, ginning operations cost about Rs. 160 per bale. In **Egypt**, the average ginning expenses were estimated at LE 27/kentar in 1990/91 and LE 43/kentar in 1992/93. In **Mexico**, cotton farmers hire a ginnery to gin their seed cotton and retain ownership of lint cotton and cottonseed. Table 4.9 suggests that the value of cotton by-products covers the ginning fees. Thus, these by-products, including cottonseed, may be left to the ginner as payment for ginning. Nevertheless, ginning fees vary significantly across regions.

Table 4.11: Itemized Cost Breakdown for Ginning Operations

%	Tanzania (1993/94)	India ³ (1985/86)	Pakistan (1993/94)	Mali (1992/93)
Power	29	10	40	30
Staff	41 ¹	77 ²	13	19
Packing Material	6	5	34 ⁴	31
Repair and Maintenance	21 ⁵	2	4	NA

Source: Country Reports of India, Mali, Pakistan and Tanzania

¹ Includes salaries, wages, night out allowance, uniforms and staff welfare, entertainment and medical expenses

² Wages, salaries and other overheads. ³ Double roller gin with a capacity of 20 gin stands

⁴ Cost of new wrapping material (hessian and hoop). ⁵ Includes ginnery rehabilitation fund fees and service charges

¹¹ Technical issues concerning ginning are discussed in Chapter 2.

¹² The Brazil country study does not specify the year of these data.

An itemized cost breakdown of ginning operations is available for Tanzania, India, Pakistan and Mali. The high share of the power costs in Tanzania, Pakistan and Mali, and that of staff costs in Tanzania and India are striking (Table 4.11).

Method of Payment of Ginning Fees

The method of payment for ginning influences the approach of the ginner toward lint quality. If ginneries function only to separate the lint from the seed and are paid on the basis of the quantity of seed cotton ginned, quality and GOT are generally disregarded. However, if they are paid on the basis of the value of the lint produced, quality and GOT become critical and the system of cotton classing dictates the extent of seed cotton and lint cleaning. Thus with the system of classing used prior to the introduction of HVI, lint price was determined by staple length, color and trash content. The tendency was to increase lint cleaning to attain higher grades, even though the loss of weight due to the extra cleaning usually offset the gains from the higher price. HVI instrumentation has facilitated increased dialogue between producers and spinners, leading to greater emphasis on fiber uniformity and resulting in reduced lint cleaning.

In Uzbekistan ginneries are paid on the basis of lint grade but farms are paid on the basis of seed cotton grade. In order to enhance the grade of lint, ginneries may use an excessive amount of cleaning but emphasis is on seed cotton cleaning rather than lint cleaning.

Transportation

In countries where transportation costs are relatively high in the overall marketing cost breakdown, the farmer's share of the price of the end product is reduced. High transportation costs may be a result of long distances between the farm, the ginneries and the textile mills or the point of export. In **India**, cotton must be transported long distances to the three textile cities (so-called texcities) of Ahmedabad in the Central Indian state of Gujarat, Bombay in the Central Indian state of Maharashtra and Coimbatore in the Southern state of Tamil Nadu. In **Mali**, transportation charges represent about 18 percent of the price of the fiber arriving at a European port (C.I.F. price), while transit accounts for more than 50 percent of these charges. In **Tanzania**, the average distance from the ginneries to the buying post is 44 km, although some societies in a few ginneries zones are as far as 200 km away. The high costs and low availability of spare parts, and poor road conditions increase the transportation costs. In addition, a levy is collected from unions for rural road maintenance (Table 4.7). However, the levy in most councils is used for activities other than road maintenance. On the other hand, it is widely maintained that the level of this levy is very low compared to the level of outlay required for road maintenance. In certain cases the levy is paid late or not paid at all by the unions. In **Brazil**, where all transportation is by road, the compensation the producer receives for his produce is heavily influenced by the distance. Producers in remote areas that lack feeder roads are at a special disadvantage in the rainy season. The shift of production to Mato Grosso, Mato Grosso do Sul, and Goiás will require the construction of new transportation facilities. Similarly, in **China**, transportation costs will affect the distribution of the expanded production in Xinjiang province.

The market structure governing the transportation sector has an effect on the efficiency and cost of transportation. In **Mali**, where two road carriers' unions control the transportation sector, it is very difficult for individual truckers to enter the market and make profits despite the liberalization of transport costs in 1990. In **Tanzania**, it may be more efficient if farmers were encouraged to deliver their crop directly to ginneries if they are in their neighbourhood. Farmers could be paid more to deliver their crop directly to the ginneries in the same zone. Advantages

such a system include better utilisation of farmers' idle time, speedy delivery to ginneries, more effective quality inspections by cotton and extension officers, and less demand for new lorries and maintenance of existing ones. Rural development in terms of rural roads construction should then be addressed properly by the Government and resources mobilised from all crops instead of overtaxing cotton.

An important issue that arises as marketing and transportation activities are liberalized is the situation of small farmers in remote areas. Will it be profitable for private traders to collect cotton in such areas? Even if it is, will the price that the producer receives be sufficiently remunerative to encourage continued cotton planting?

International Comparative Advantage in Cotton Production

Domestic Resource Cost¹ (DRC) ratios are available only for four countries, namely **Egypt, India, Pakistan and Tanzania** (Table 4.10). In all four countries, cotton, as a monocrop or in rotation, is competitive. In Egypt, the 1991 World Bank DRC estimate for cotton as a monocrop is 0.6. In rotation with short berseem clover the DRC ratio is 0.7. Together with the wheat/maize rotation, the cotton/short berseem rotation ranks highest among alternative rotations. (Table 4.12) The DRC is likely to have improved since 1991 due to the increased cotton yields and higher farmgate price.

Table 4.12: Tanzania, Pakistan and India - DRC Ratios

Country	DRC
Tanzania (92/93)	
Rice	0.44
Cotton	0.59
Maize	1.37
Sorghum	-4.57
Pakistan (90/91)	
Cotton	0.23-0.25
Rice	0.56-0.92
Sugar Cane	1.35-1.20
India	
North* & Central** (MS)	0.91
South** (LS)	0.58

* 1990/91 data. ** 1992/93 data

Source: Tanzania, Pakistan and India Country Reports

Table 4.13: Egypt - DRC Ratios for 1991

Rotation	DRC
Cotton +	0.6
Short Berseem	<u>1.0</u>
Total	<u>0.7</u>
Wheat +	0.6
Maize	<u>0.8</u>
Total	<u>0.7</u>
Wheat +	0.6
Rice	<u>1.0</u>
Total	<u>0.8</u>
Long Berseem +	0.7
Maize	<u>0.8</u>
Total	<u>0.8</u>

Source: Egypt Country Report

¹ Domestic Resource Cost (DRC) is used in estimating the cost in the domestic currency required to earn a unit of foreign exchange. It is defined as the ratio of *the present worth of domestic currency cost of realizing foreign exchange savings over the present worth of net foreign exchange saving.*

Annex 4.1

**Charts Illustrating the Marketing Chain
by Country**

ANNEX 4.1

CHARTS ILLUSTRATING THE MARKETING CHAIN

Exhibit A4.1.1: Brazil Marketing Chain

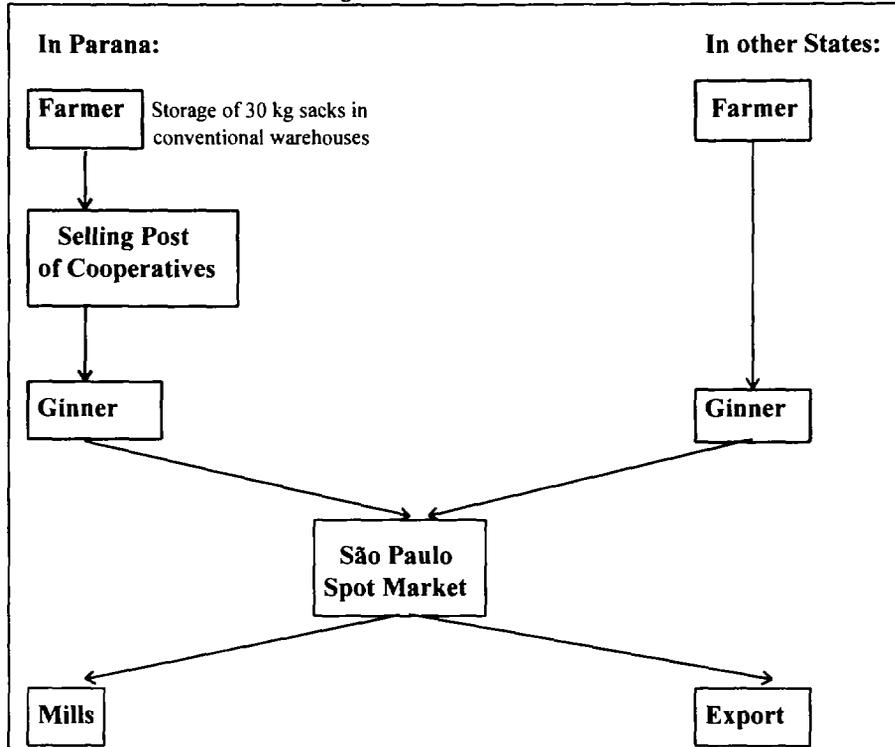


Exhibit A4.1.2: China Marketing Chain

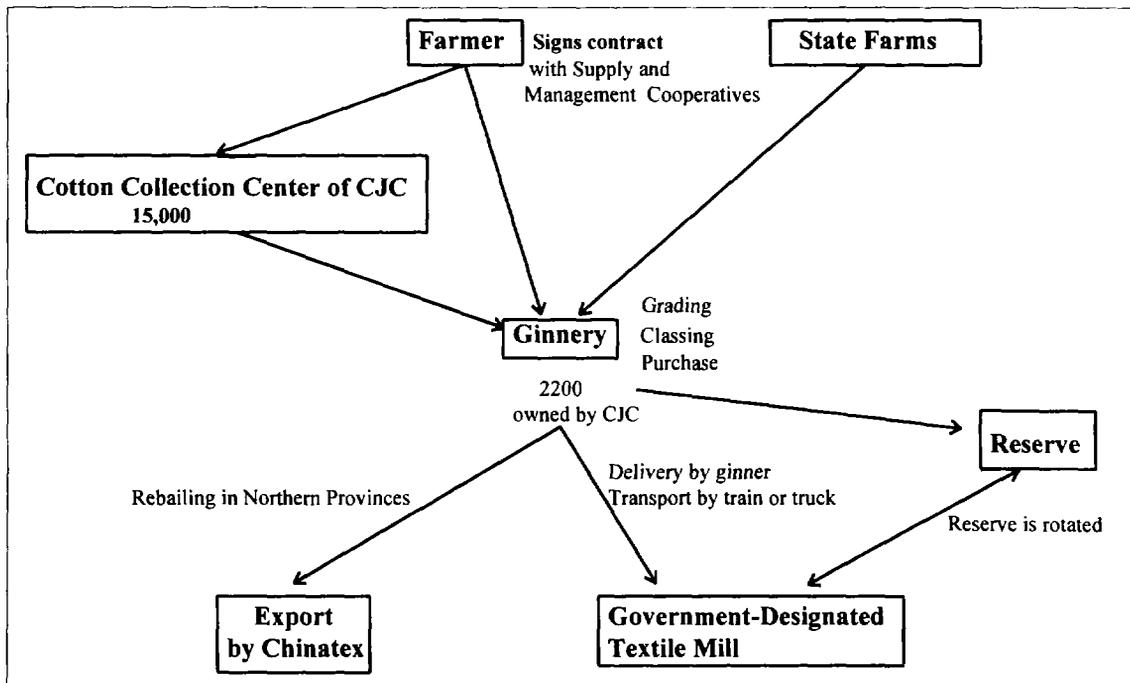


Exhibit A4.1.3: Egypt Marketing Chain

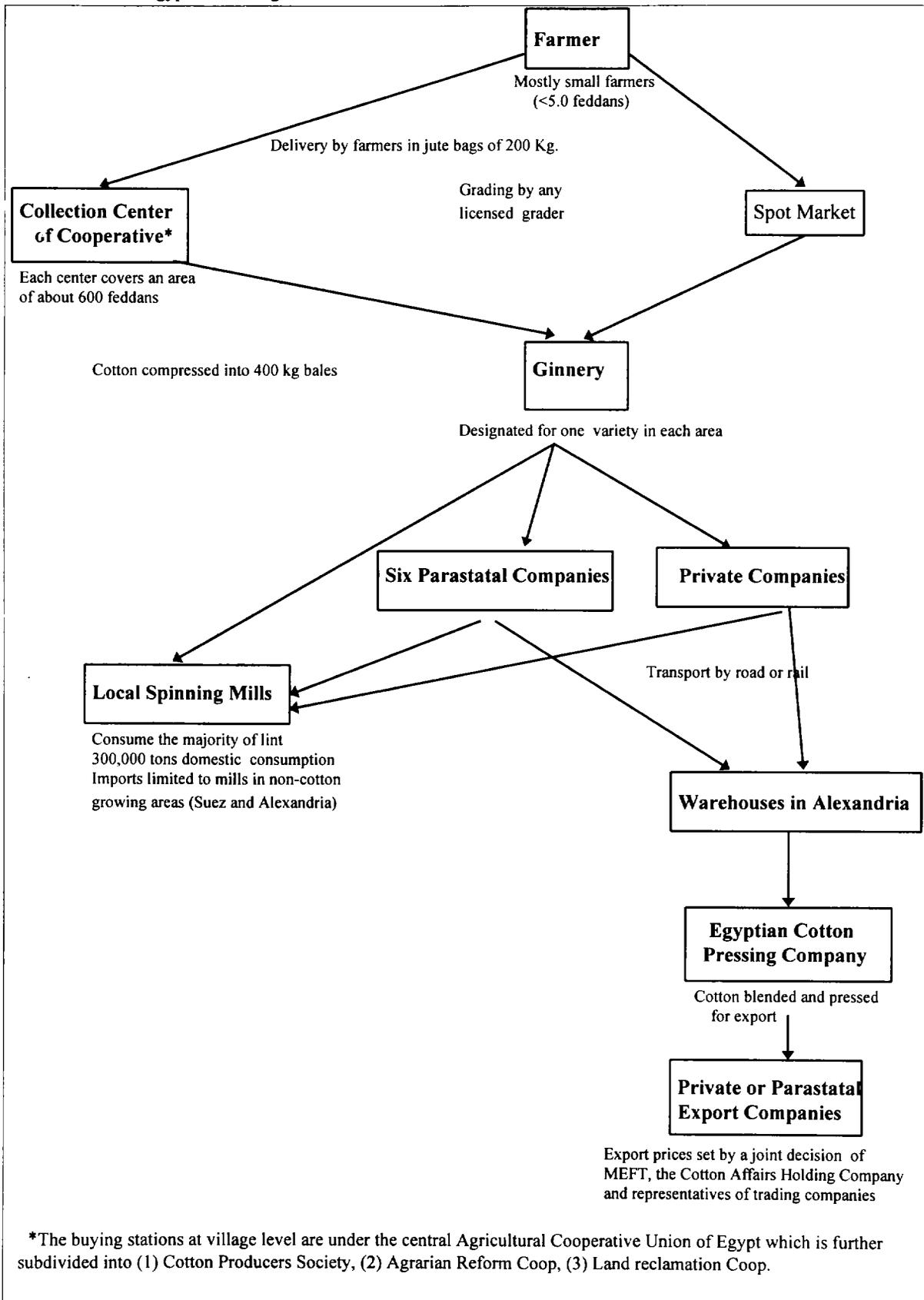


Exhibit A4.1.4: India Marketing Chain

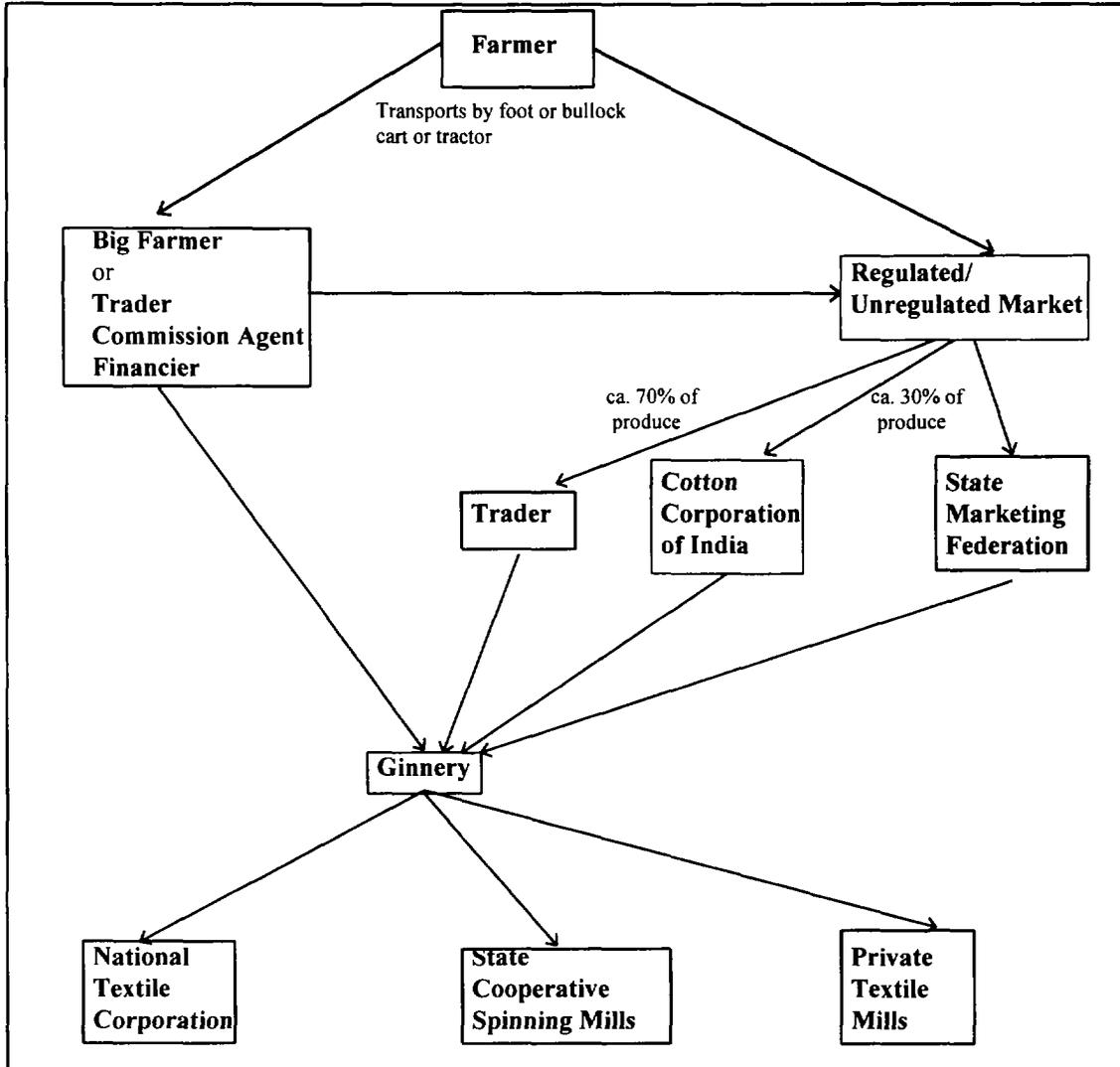


Exhibit A4.1.5 : Mali Marketing Chain

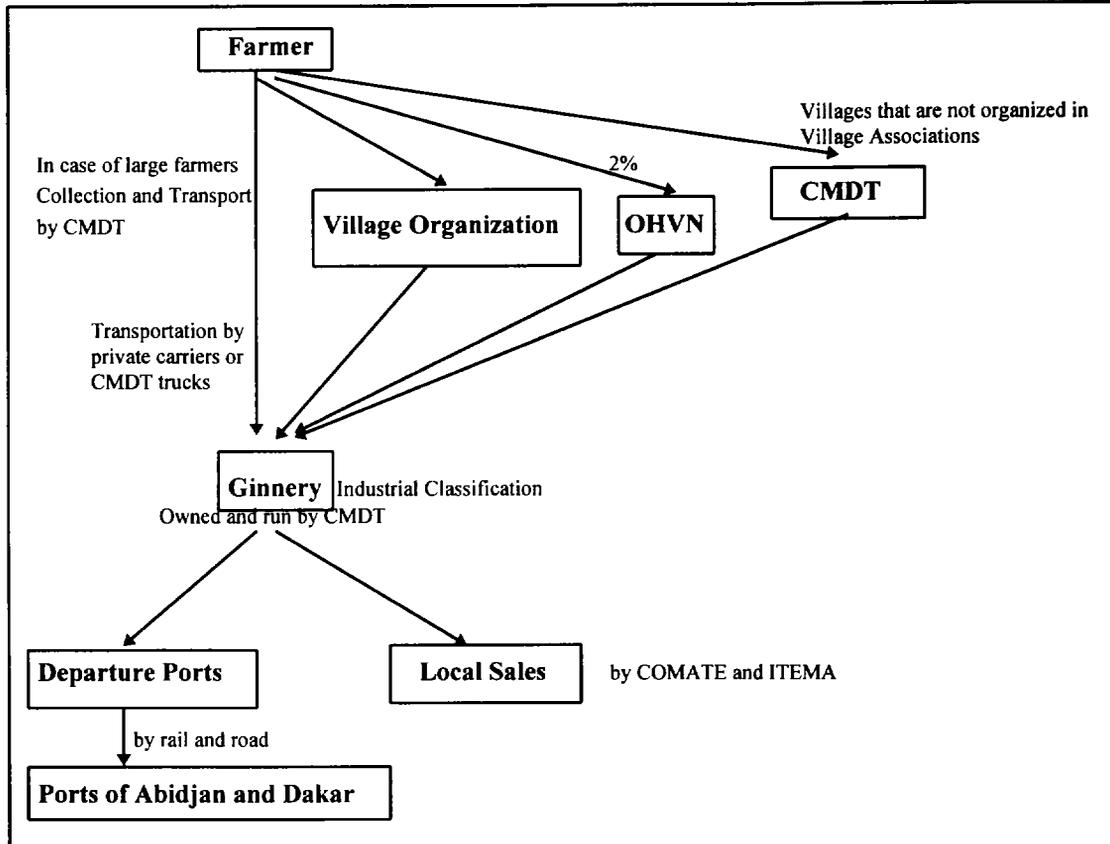


Exhibit A4.1.6 : Mexico Marketing Chain

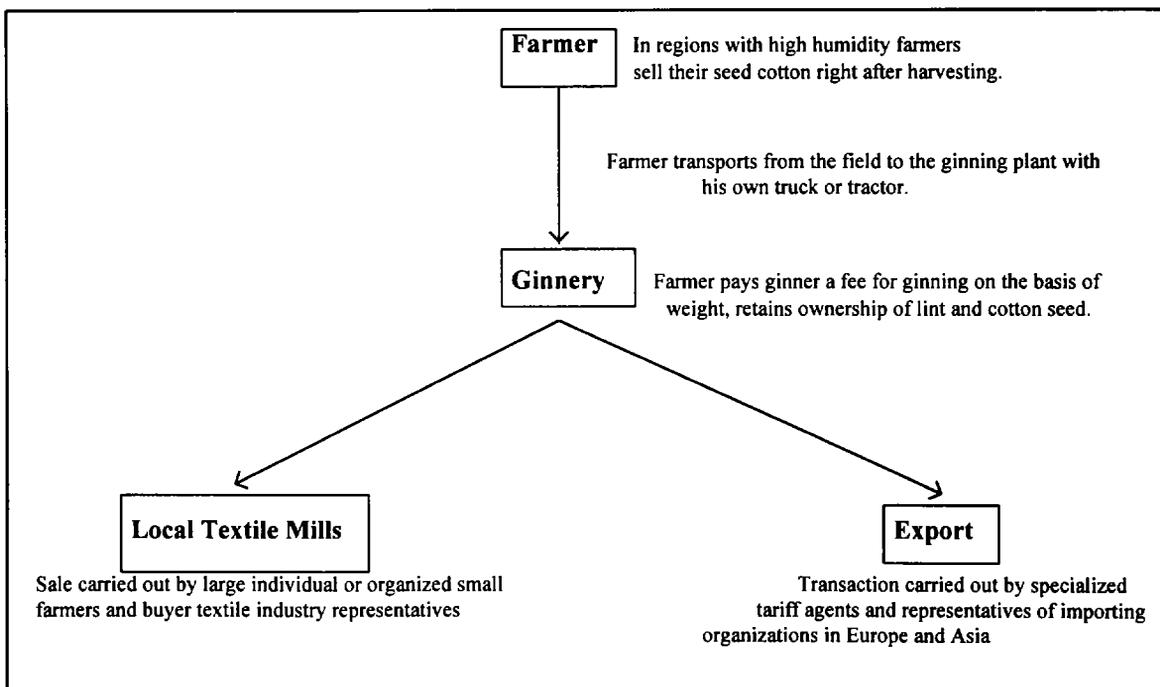


Exhibit A4.1.7: Pakistan Marketing Chain

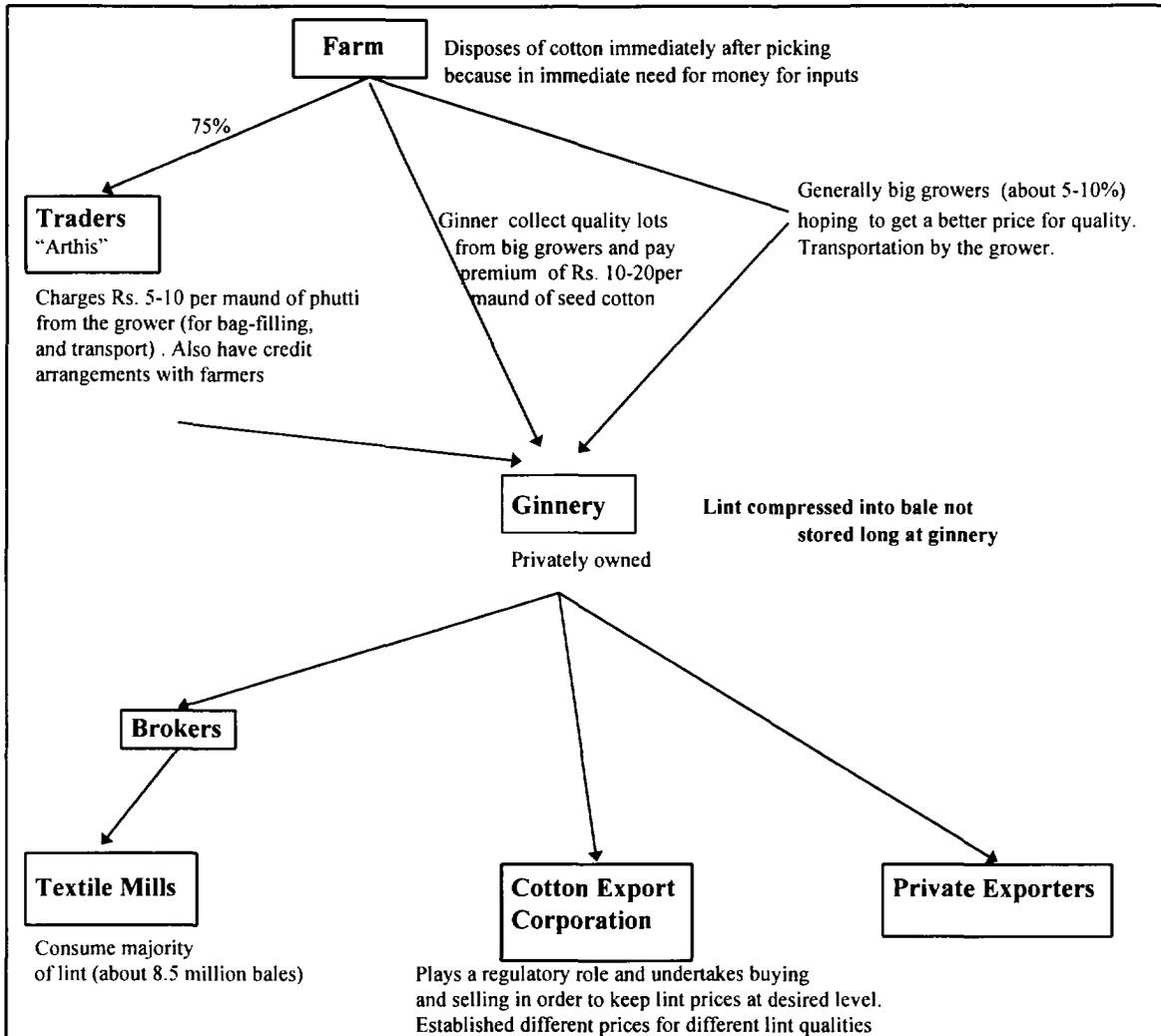


Exhibit A4.1.8 : Tanzania Marketing Chain

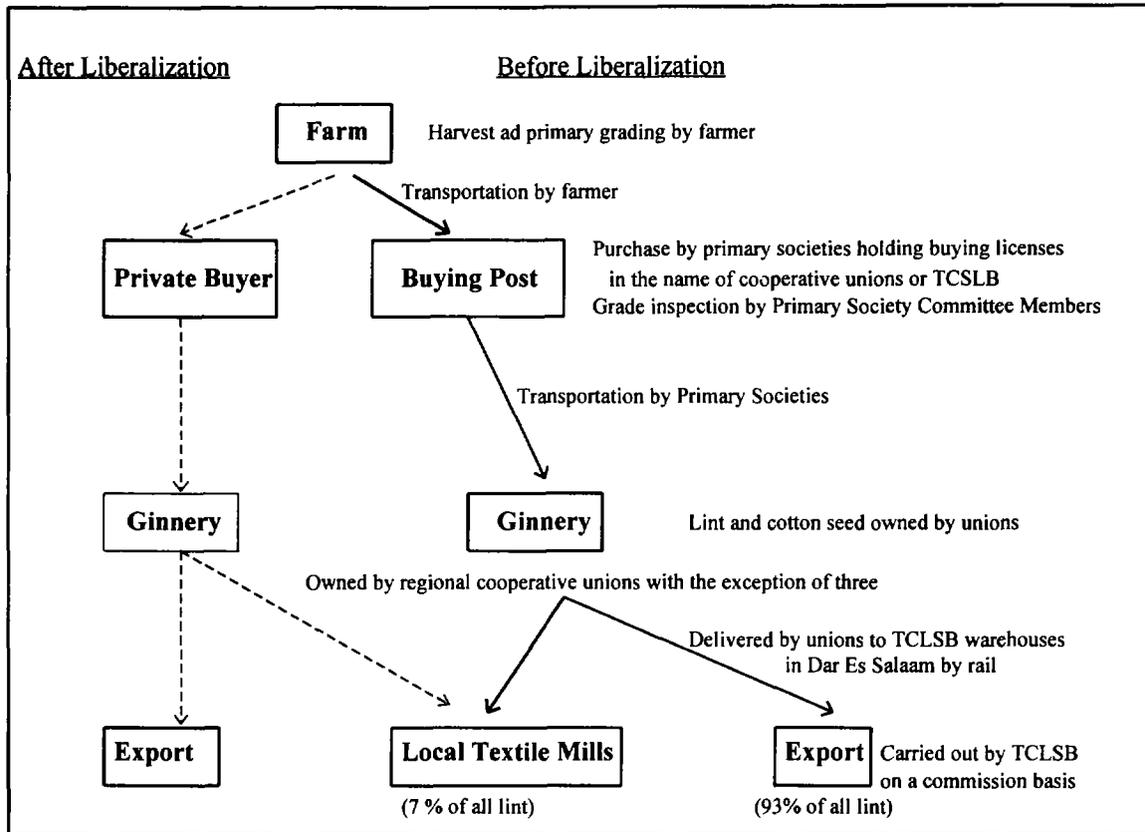
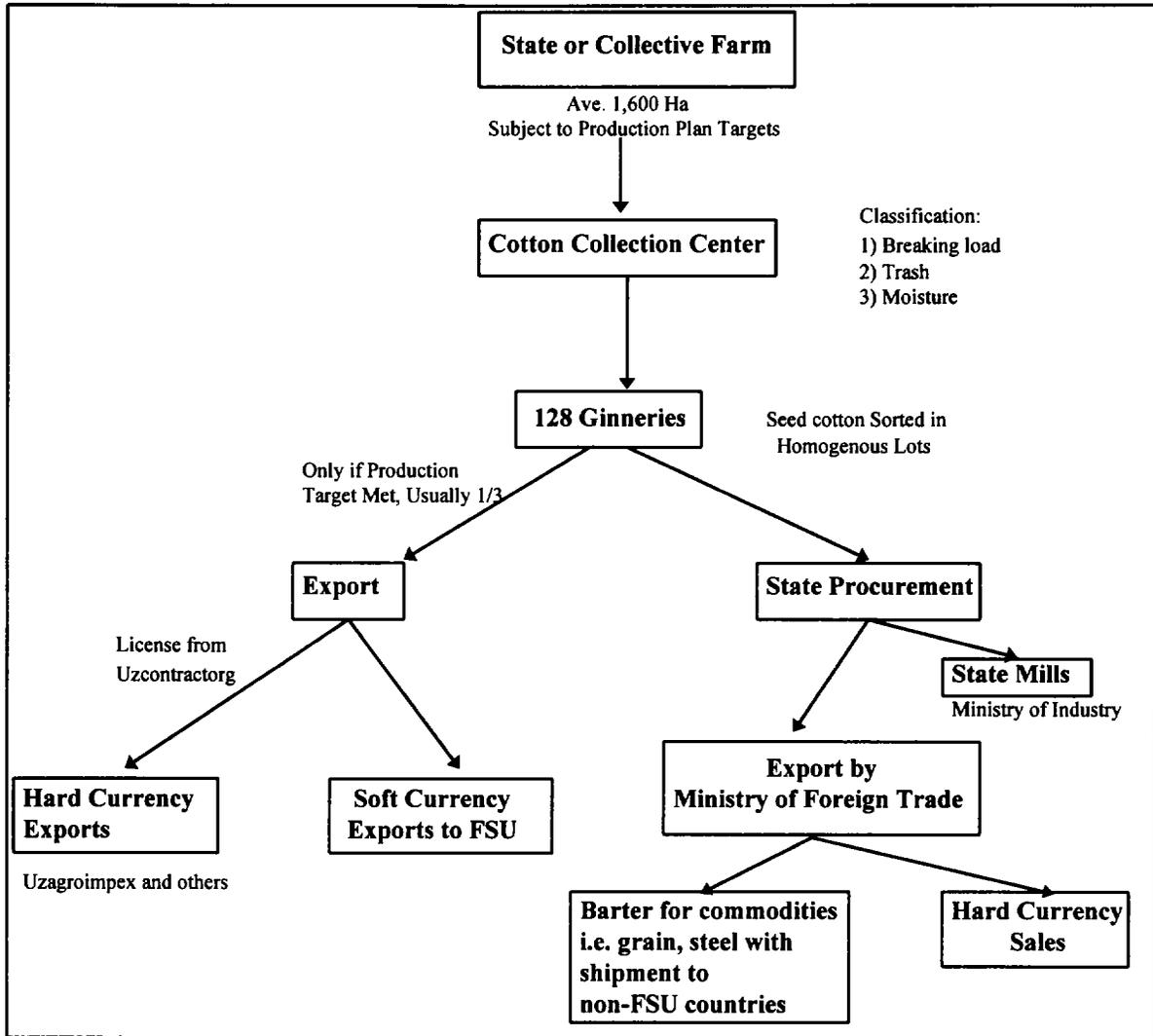


Exhibit A4.1.9: Uzbekistan Marketing Chain



Annex 4.2

The Calculation of the Farmers' Share

ANNEX 4.2

THE CALCULATION OF THE FARMERS' SHARE

It is important to note that the farmgate price can be quoted either in terms of seed cotton or lint. Given that the weight of lint obtained from a unit of seed cotton is roughly 1/3 units (2/3 units being cotton seed) depending on the GOT¹, the farmgate price for one unit of lint (= lint equivalent) is about three times the seed cotton farmgate price (i.e. seed cotton price / GOT). This distinction between seed cotton price and its lint equivalent is also important in the presentation of the farmer's share. In the US where there is minimum price distortion and an efficient marketing system, the ratio of the lint equivalent farmgate price to the domestic lint price is about 0.80 (Table 4.6). Expressed in terms of seed cotton this would be about 0.27 which is equal to 0.80 multiplied by the GOT of 0.33 (assumed GOT). Thus, caution must be exercised as to what price is quoted in order to avoid misinterpretations.

Table A4.2.1: Method of Calculating the Farmgate Price Back from the Export Price (Export Parity Price)

=	CIF Price
-	Shipment, Insurance etc. Costs

=	FOB Price in Exporting Country
-	Lint Marketing Costs (Transportation Storage, Handling, etc.)
-	Trader's Profit (if applicable)

=	Lint Price at Ginnery
+	Value of Cotton Seed
-	Ginning Costs
-	Seed cotton Marketing Costs (Storage, Transportation, Handling etc.)
-	Trader's Profit (if applicable)

=	Farmgate Price per unit Lint (Lint Equivalent)
x	GOT

=	Farmgate Price per unit Seed cotton

Ideally lint equivalent farmgate price is used to calculate the producer's share in the end product (which may be lint, yarn or apparel) as a percentage of the export price. In other words, any costs beyond the farmgate are considered as part of the marketing costs and are deducted from the producer's price in case he has to incur them. In some countries, the farmers' cotton is collected by collectives or parastatal agencies from the village. In these cases the farmer does not incur any transportation costs and the producer price is the same as the farmgate price. In other countries however, the farmer has to transport his seed cotton to a collection center, the ginnery or the market and incur a certain transportation cost, which may be substantial depending on the distance, opportunity cost related to the time spent away from the farm and the means of transportation used. In these cases this marketing cost should be deducted from the price the farmer is paid at the delivery point to arrive at the farmgate price. It is not always possible to obtain a complete set of data. Generally, the available data consist of a "producer price" (in terms of seed cotton or lint equivalent), the location of which is not identified. However, for re-

¹ Ranges form 28% to 44% depending on variety, purity of seed cotton and ginning efficiency.

liable cross-country comparisons, the use of the same “producer price”, or at least identification of the farmgate price or producer price at ginnery is important since transportation costs may be quite significant.

Another important point in the calculation of the farmer’s share is whether the prices taken are annual averages or are taken at a certain time in the year. Depending on the season and the supply situation the price ratios may differ, making interpretation difficult.

CHAPTER 5

SUPPORT SERVICES

Governments and/or quasi government institutions play a central role in performing the following essential functions for the industry of practically all cotton producing countries:

1. Compilation and dissemination of information for market participants through registration of sales, estimates of production and prices paid;
2. Maintaining quality standards and keeping business dealings in good order;
3. Registration of chemicals consistent with sustainable production;
4. Support for research on cotton and active involvement in extending the results of research to the farmers; and
5. Providing a focus of the interests of cotton and presenting these interests to society as a whole in an effective manner.

Over the last four years, many countries have reduced or planned reduction of the role of government in economic decision making in the cotton industry. However, despite these changes, the provision of support services and the regulation of certain aspects of the industry remains an important function of the government.

Research

The governments of most cotton producing countries are involved in agricultural research on cotton through their Ministries of Agriculture (Chaudhry, 1995). This applies to all the countries in the study. This is an important function because of the social and economic role of cotton as a source of employment and of foreign exchange earnings. It is also important to have a source of information, based on relevant research that is independent of commercial interests, on such matters as the most appropriate pesticide to use in specific circumstances.

Regardless of whether cotton research is conducted by the government or by private organizations, at least partial funding by the farmers strengthens the research and renders it more responsive to farmers' needs. In so doing, it improves the practical implementation of recommendations based on the results of the research. Funding could come from the growers in the form of a levy on the crop or from all sectors of the industry including the growers, the ginners and the textile mills. The advantages of grower involvement in research have been demonstrated in countries such as Australia, Mali, the USA and Zimbabwe.

The amount of private research reported in the study countries is very limited. Brazil has a cooperative in Paraná which has a contract with CIRAD CA to provide technical support in variety development while Algodoeira São Miguel S/A in Angicos, Rio Grande do Norte had a breeding program up to 1990 on the improvement of arboreal moco cotton. In Egypt, most research is government funded but certain agro-chemical companies have their own research farms for testing and promoting new products. The CMDT in Mali is a public limited company which

supports adaptive research and obtains most of its funding from trading in cotton. In Pakistan, the agro chemical companies conduct a limited amount of research on pesticide resistance.

Brazil

Cotton research in Brazil was initiated independently in different states but was consolidated in São Paulo in 1924 at the Agronomic Institute of Campinas (IAC) when genetics, chemistry, agricultural technology, bacteriology and cultural practice sections were established. The objective of producing cotton with fiber characteristics desired by the textile industry was adopted. Plant breeding gained high priority, the first release of seed to farmers being in 1927.

Two agencies administer cotton research, EMBRAPA and the Cooperative System for Agricultural and Cattle Raising Research (SCPA). There is some private funding of specific research projects, particularly those concerned with genetic improvement. EMBRAPA coordinates technological research through the National Centre for Cotton Research (CNPA).

Cotton improvement is almost exclusively conducted by the Public Sector through the Agronomic Institute of Campinas in São Paulo serving the Meridian Region, working exclusively on Upland (herbaceous or annual) cotton and the National Center for Cotton Research in Campina Grande serving the Sententrional Region and working on the improvement of both moco (arboreal or perennial) and Upland cotton. The exceptions are Algodoeira São Miguel S/A which worked on the improvement of moco cotton in Angicos, Rio Grande do Norte from 1920 to 1990 and also developed improved Acala del Cerro in Juazeiro, Bahia. In Paraná, the Organization of Paraná Cooperatives (OCEPAR) has a cooperative agreement with CIRAD CA who provide technicians to assist with variety improvement.

The general objectives of cotton improvement in both regions is higher yields, resistance to the main pests and diseases and fiber characteristics which are desired by the textile industry. Since the boll weevil, *Anthonomus grandis* (Boh.) emerged as a major problem, early maturity has become a key selection criterion.

China

In the early 1950s, an Academy (Research Institute) of Agricultural Sciences was set up in each major administrative region. Over fifty experiment farms (stations) with cotton as the main crop were established in the cotton producing provinces, autonomous regions, municipalities, and counties to conduct scientific cotton research. In August 1957, the Cotton Research Institute (CRI) of the Chinese Academy of Agricultural Sciences (CAAS) was founded in Anyang with a nation-wide scope. Since 1958, cotton research institutes and cash crop research institutes focusing on cotton have been established in the cotton producing provinces of Liaoning, Hebei, Sanxi, Shanxi, Shandong, Henan, Jiangsu, Hubei, Hunan, Anhui, Sichuan and the Xingjiang Autonomous Region. Agricultural schools and colleges and prefectural institutes of agriculture are engaged in scientific cotton research. In addition, demonstration farms and extension stations have been established in the cotton producing counties. All these organizations form a relatively comprehensive system of cotton research, covering the whole country.

Funds for research come mainly from national and prefectural administrations or from local projects or programs. In addition, the Ministry of Agriculture and provincial governments have basic research, applied research and transfer of technology projects for the conversion of

scientific achievements into productive forces. Research funding, is general limited although funding for specific projects or programs is usually adequately but to varying degrees.

Egypt

There are several institutions in the Ministries of Agriculture, Economy, Industry, Supply, Scientific Research and Irrigation, and in the Faculties of Agriculture of universities involved in cotton research. However, a major part of the research is done in the Agricultural Research Centre (ARC) in the Ministry of Agriculture and Land Resources (MALR), involving mainly the Cotton Research Institute (CRI), the Plant Protection Research Institute (PPRI), the Plant Pathology (Disease) Research Institute (PDRI) and more recently, the Agricultural Genetic Engineering Research Institute (AGERI).

ARC was established in 1971 and now manages 16 research institutes, 6 Central Laboratories and 37 research stations located in different regions of the country. One of the serious problems is the lack of effective coordination in the work of many of the agencies involved in research on various aspects of the cotton industry.

CRI is engaged in maintaining the high standards of both yield and quality of existing varieties and developing new varieties. It includes a breeding program, a variety maintenance program and research on agronomic practices. The CRI Technology Department has well equipped fiber and spinning test facilities to support the cotton improvement program. It also tests, on behalf of MALR, samples of cotton produced by farmers in order to check on the maintenance of fiber quality and GOT. The CRI collaborates with PPRI and PDRI in controlling cotton pests and in breeding cottons resistant to major diseases. Since most of the cotton research is done in CRI, PPRI and PDRI with other institutions at the periphery, most funding and resources come from the government without private sector involvement.

India

Under the 1966 reorganization, the Indian Council for Agricultural Research (ICAR) took responsibility for all agricultural research in India. Research on all crops, including cotton, is coordinated through 42 Research Institutes, four National Bureaux, 22 Research Centres and nine Project Directorates.

The Central Institute for Cotton Research (CICR) in Nagpur is the main center for cotton production research and the Central Institute for Research on Cotton Technology in Bombay for research on cotton fiber and processing. Research is also conducted by other research stations, agricultural universities and a few privately funded research organizations in various states.

The entire cotton research program in India is conducted under the All India Coordinated Cotton Improvement Project (AICCIP). Research at various centers is conducted under sub-projects of the parent AICCIP and coordinated by the coordinator at the CICR, Coimbatore through zonal coordinators in each of the three production zones.

AICCIP is a project of ICAR and receives about 75 percent of its funding from this source, the balance coming from the states where cotton research is under way. The CICR, Nagpur and its sub stations obtain funding from the Central Planning Commission.

Mali

The Rural Economy Institute (I.E.R), along with other specialized institutes, plays a major role in agronomic research. The institute is responsible for coordinating cotton research and has recently been converted to an Administrative and Public Establishment, giving it a large degree of autonomy. An agreement links the IER to the CMDT for the purpose of conducting cotton research activities. There is also logistical support from CIRAD CA in computerizing cotton research and fiber quality assessment.

The IER is organized into Regional Agronomic Research Centres (CRRA) in the regional capitals with research stations and sub-stations in certain districts. The two main cotton research centers are based at the Sikasso CRRA and the Ntarla stations. Research disciplines are determined by the Department of Agronomic Research while the Department of Production Systems is in charge with respect to the study and experimentation of the technological packages being developed. The disciplines include the fields of Selection and Variety Improvement (genetic unit); Agronomy, Cultivation Techniques and Entomology. The research objectives are defined by the National Commission for the Agronomic Research which holds meetings every two years under the chairmanship of the Minister of Agriculture.

The Research Stations participate in Rural Polytechnical Institute (I.P.R) training, and collaborate in regional cotton research in francophone West Africa and with other specialized institutes such as KIT (the Netherlands), IFDC (Togo), CIRAD-CA (France) and others. The Agricultural Planning and Rural Economy Department conducts research on the production costs of cotton, millet-sorghum, corn, rice, tobacco and peanut. These studies include the different production factors and served as the basis for fixing the producer price before they were liberalized. The processing research capabilities of the Textile Industry Higher Education School (ESITEX), a sub-regional center created by ECOWAS, have not been exploited.

Cotton research to develop new varieties and production technology is financed by the Government of Mali, either from the National Budget or through external financing, while the cotton sub-sector administers the adaptive research stations and sub-stations through the CMDT.

Mexico

Since 1939, cotton research has been the responsibility of Ministry of Agriculture with funding from the Federal Government. The Agriculture Experimental Stations conduct agricultural research under the supervision of the Department of the Agriculture Secretariat. Currently, the National Institute of Forestry, Agriculture and Animal Husbandry Research, (INIFAP) of the Ministry of Agriculture and Water Resources is the responsible agency for agricultural research and coordinates all cotton research. It maintains a regular relationship with USDA institutions.

Cotton Experimental Stations are located in Mexicali, Baja California; Valle del Yaqui Sonora, Culiacan y Valle del Fuerte Sinaloa; Delicias and Juarez Chihuahua, La Laguna, Torreón, Coahuila; Rio Bravo, Tamaulipas; Apatzingan, Michoacán and Rosario Izapa, Chiapas. Research is focused on developing cultural practices which are adapted to the different ecological areas of Mexico and disciplines include Plant Breeding, Agronomy, Irrigation, Soil Fertility and Fertilizers and Crop Protection. A fiber laboratory provides fiber testing facilities to support the plant breeding program. Biological control of pests and diseases has a high priority. Market research to keep abreast of the supply and demand situation is carried out by the Federal Government, farmers organizations and private entrepreneurs.

Cotton research includes the disciplines of plant breeding, diseases and pest control, soils and fertilizers. However, since 1982, it has suffered because research on food crops has received priority. The uncertainty of international cotton prices has also had a negative impact.

Mexico has not embarked on any projects involving genetic engineering but it is possible that the development of transgenic varieties in the USA will have an influence on the varieties grown there in future.

Pakistan

Cotton research in Pakistan is handled at the federal level by the Pakistan Central Cotton Committee (PCCC) which comes under the Federal Ministry of Food, Agriculture and Livestock and at the provincial level by the Provincial Departments of Agriculture. The PCCC has two multi-disciplinary institutes, one at Multan in the Punjab and the other at Sakrand in Sindh. These mono-crop, multi-disciplinary Research Institutes include the disciplines of Plant Breeding, Cytogenetics, Agronomy, Physiology, Entomology, Pathology and Fiber Technology. In addition, the PCCC conducts research at the Provincial research centers at Sahiwal and Bahawalpur in the Punjab and has Research centers at Ghotki and Mirpur Khas in Sindh.

In the Punjab Province, the main Department of Agriculture research centers are at Faisalabad, Sahiwal, Multan, Bahawalpur and Rahimyar Khan. They have their major breeding research centers at Faisalabad and Multan, the research capabilities of which have been strengthened through the addition of research officers in the disciplines of Agronomy and Entomology. The Agronomy, Entomology, Pathology and Virology Sections of the Department also undertake cotton research activities on specific cotton problems. The Department of Agriculture has a Director of Research in cotton who controls the research centers technically and administratively. In Sindh Province the main Department of Agriculture cotton research center is located at Tandojam and in the same manner as Punjab, the research capability of the center has been strengthened through the addition of an Agronomist and an Entomologist.

The Atomic Energy Commission has established Nuclear Institutes for Agriculture and Biology (NIAB) at Faisalabad in the Punjab and at Tandojam in Sindh to work on mutation breeding and on nutritional/physiological studies involving radio-active material. In addition, Universities of Agriculture at Faisalabad and at Tandojam include studies on cotton in all disciplines but their research programs are more or less incidental to teaching.

There is no research activity in the field of ginning although there is a growing feeling that the country should establish a Ginning Research Institute to conduct research and to provide guidance and training in the selection, maintenance and adjustment of ginning machinery to attain desired grades while preserving intrinsic fiber quality. The Cotton Export Corporation (CEC) has apparently started activities in this direction. Similarly, research on optimum utilization of by-products, including stalks, linters, motes and ginnery waste is lacking. The possibilities of wider utilization of cottonseed flour for human food also require further study.

The Directorate of Marketing under PCCC undertakes limited research in market information. This activity needs to be strengthened to provide up to date information and market trends on demand in order to facilitate a market oriented production policy.

The only private sector research is in pesticide resistance. However, this is incidental to promotional activities. Cotton research activities by private organizations which are established

and partially funded by the farmers could make research activities more responsive to farmers needs. However, at present, farmers are not prepared to undertake any such investment even though the government is in favor of inducing private research.

Effective coordination of research on cotton at the Federal and Provincial levels is lacking although the PCCC coordinates cotton research projects which they fund nationally through the Agricultural Research Sub-Committee. The PCCC could perform this function effectively if given a mandate. Currently it does cooperate with international agencies to provide linkages with research programs in foreign countries.

The PCCC provides funds for the main research Institutes at Multan and Sakrand and a major portion of the funding for research stations at Faisalabad, Sahiwal and Bahawalpur Centers in Punjab and Ghotki, Tandojam and Mirpur Kas Centers in Sindh. It supplements the cotton research of the Provincial Departments of Agriculture by providing funds under special schemes. The projects receiving this funding are generally of short duration and are periodically replaced by new projects as the need arises.

Tanzania

Cotton research in Tanzania is administered by the Department of Research and Training in the Ministry of Agriculture which is headed by a Commissioner for Research and Training. The research program is co-ordinated by a national co-ordinator for cotton who reports on technical matters to an Assistant Commissioner for Crop Research.

There are two nucleus research institutes, Ukiriguru Zonal Research and Training Centre in Mwanza catering for the Western Cotton Growing Area (WCGA), and Ilonga Zonal Research and Training Centre in Kilosa, catering for the Eastern Cotton Growing Area (ECGA). The location of the sites for the institutes was based on the differences in ecological conditions in the two cotton growing areas.

Ukiriguru is the main co-ordinating station and has most of the laboratory facilities for research on cotton while only one section of the Institute at Ilonga deals with cotton research, utilising the support laboratory facilities which service research on cereals and legumes. The cotton co-ordinator, normally stationed at Ukiriguru, supervises the national cotton research program and is responsible for compiling reports and reviews on cotton research and development for presentation at the annual Research Co-ordinating Committee meetings and to the Ministry.

The six main research disciplines on cotton are Plant Breeding, Entomology, Pathology, Soils and Agronomy, Farm Economics and Extension. The last, only recently introduced, deals with the interrelation of farming practices in the entire farming system. Each of the disciplines is headed by a head of department who is responsible to the institute's director through the cotton research co-ordinator. Each discipline has its own research objectives but in practice, they adopt a multi-disciplinary approach to research. The co-ordinator rationalises research programs to address key problems through a collective effort, thus utilising limited resources in terms of funds and personnel more effectively.

Since the dissolution of the Tanzania Agricultural Research Organisation (TARO) and the incorporation of all agricultural research into the Ministry of Agriculture, there have been two constraints to agricultural research. Firstly, the declining real term financial resource allocation to agricultural research and, secondly, the concern on the part of the scientists that minis-

terial bureaucracy may prevent the effective use of the limited funds made available. Over the past six years, the financial allocation to cotton research has been inconsistent and has declined steadily. Consequently, inadequate provision has been made for field equipment and machinery, transportation, laboratory supplies and scientific literature, contributing to a lack of incentives on the part of the scientists and supporting technical staff.

At Ukiriguru inadequate capital and recurrent funds have reduced the quality and scope of cotton research, while lack of transport has limited the capability of the research agronomists and field staff to carry out field experimentation. Thus for the WCGA the number of locations for field trials has been reduced from 42 to 28. In addition, the fibre laboratory is virtually non operational because of a lack of spare parts for the fibre testing and air-conditioning equipment. This has caused delays in the development and release of new varieties which cannot be adequately field tested while the absence of adequate fibre quality evaluation could result in undesirable changes occurring in some fibre properties.

Cotton marketing in Tanzania is being liberalised and consideration should be given to involving cotton producers, ginners and the textile industry in contributing towards cotton research in order to supplement the limited government funds. This should also result in improved linkages between the various sectors of the cotton sub-sector with close attention being paid to the direction and output of research, resulting from the financial contribution of the end users of the research results. It is envisaged that the Tanzania Cotton Lint and Seeds Board (TCLSB), as overall overseer of the cotton industry on behalf of the Government, would continue to coordinate the raising of funds for research from these sources until an appropriate body is in place.

Uzbekistan

Uzbekistan is a major cotton research center in Central Asia and most of the research institutes have the status of 'Central Asian Institutes,' having had the status of 'All-Union' before the break-up of the Soviet Union. The institutes form a broad network for specialized research and development and include the Research Institute of Cotton Growing (the former SoyuzNIKHI); the Research Institute of Breeding and Seed Production; the Research Institute of Plant Protection; the Research Institute of Economy of Agriculture; the Biological Research and Production Association of the Academy of Science of the Republic of Uzbekistan (the former Institute of Experimental Biology); the Research Institute of Irrigation and Land Improvement (the former SANIIRI); the Research Institute of Mechanization and Electrification of Agriculture (the former SAIME); the Research and Industrial Association of Cotton Industry (the former TsNIIKhProm) and the Institute of Genetics (formerly the Institute of Pathology):

In addition, numerous departments in academic higher educational establishments and researchers and scientists of the institutions of the Academy of Science and the Ministry of Agriculture are involved in cotton production research. The Andidjan Research Institute of Cotton Growing, the Tashkent State Agricultural University, the Tashkent Agricultural Institute of Engineers of Irrigation and Land Improvement, the Samarkand Agricultural Institute, Research Institute of Chemistry and Technologies of Cotton Cellulose, the Institute of Chemistry of Vegetable Substances and the Institute of Chemistry of the Academy of Science occupy a very important place in this sphere. Funding of research is dependent on the administrations of these research organizations.

Coordination of research work of the specialized research institutes of agriculture is the responsibility of the Academy of Agricultural Sciences. The other research organizations are

generally subordinate to various administrative establishments (Academy of Science of the Republic of Uzbekistan, Ministry of Higher Education, Ministry of Agriculture, Ministry of Land Improvement and Water Supply and so on). The State Committee on Science and Technology is responsible for overall coordination of research activities. There are also special departments in the Government and Parliament involved in this activity.¹

Research in the field of genetics and cotton breeding has been effective and their work has made significant contributions to the development of the cotton sub sector but research on other problems associated with cotton production has not been commensurate with the costs and number of people involved. The links with foreign researchers is periodic and weak. Currently there are no joint international programs and even those that existed under the FSU have broken down. The establishment of links with foreign cotton growing countries is considered to be of prime importance in seeking solutions to current practical problems facing the science of cotton growing and in developing advanced technology for the production, processing and marketing of cotton. The World Bank/CFC cotton study could contribute to the establishment of these links.

Extension

Brazil

There are twenty seven formal Extension Units in Brazil, one for each state, which act independently under the State Government. Their effectiveness and activity vary from state to state. Until 1991, Extension was coordinated by EMBRATER which came under the Federal Government and was responsible for allocating resources to State units. This organization was disbanded in 1991 and the function of distributing resources fell to EMBRAPA. This was not successful so the function of coordination of extension returned to the Ministry of Agriculture.

Part of the funding came from an International loan but part came from a levy of 2.0 percent on sales of produce. However, in 1992, there was a sharp decline in the funding from these contracts and government organizations that counted on these resources were left short of funds.

Informal Extension organized by Universities, Municipalities, non-government agencies and agro-chemical merchants has been more effective than formal Extension. In particular, traders have an extensive staff of technicians supporting this activity. In Paraná, the OCPER is active in extension and in seed production, procurement and distribution of inputs and marketing.

China

Agricultural technical extension in China involves a comprehensive course in which agricultural techniques are extended through adaptive trials, demonstration, training, guidance, and advisory services to agricultural producers during the growth of crops and before and after harvest. The extension system includes agro-technical extension agencies, agricultural research units, relevant schools, mass sci-tech organizations, and peasant technicians. In the major cotton producing counties, prefectures and provinces, cotton production offices are responsible for implementing the cotton growing policies, extension of research findings and advanced techniques, and the organization of technical training. Technical extension agencies have been established at the national, provincial, prefectural, county and township levels and are classified according to

¹ Dourbek Akhmedov. Personal communication

their specialization into seed distribution stations, soil and fertilizer stations, crop protection stations, etc.

During the process of reform, supply and marketing cooperatives at all levels have changed from being management oriented to being service oriented. Consequently all types of crop advisory services are being established and a new approach to developing an organization of comprehensive agricultural services is being sought. Cotton research societies in villages are gradually evolving into technical economic entities for self development and self-service and are a new force in the extension system.

Most of the cotton technical peasant technicians are graduates from agricultural colleges and schools and are qualified cotton experts with a relatively high education level. After taking a special technical course, they are examined by a higher authority and given a professional title.

Funds to state agricultural technical extension agencies are appropriated by the financial unit of the government. Agricultural technical extension agencies, research units, schools and colleges, and technicians who are involved in the transfer of technology, technical services or technical contracts may collect fees for their service but in general, technical information and extension are free of charge. To increase the funds allocated to the technical extension system, the government makes a provision for collecting the cotton technical improvement fee of 0.5 Yuan for every 50 kilograms of grade 1-4 cotton sold. This money is used mainly in the extension of new technology and personnel training.

Recently, the state has implemented important projects to promote technical progress and the training of cotton farmers. A special project was approved to support the CRI of the CAAS, in its experiment on double-cropping in the Henan and Shandong Provinces in order to promote the wheat-cotton double-cropping system and to augment the production and economic returns. Yields of cotton and wheat reached 1,050 and 4,500 kilograms per hectare, respectively, providing a good demonstration effect.

In the Seventh Five Year Plan, the state established a number of counties as Quality Cotton Production Bases and a sound seed multiplication system. Cotton seed farms, cotton propagation areas, quality cotton ginneries and seed treatment workshops were established. Ten million yuan were allocated to sci-technical research units, high schools, and colleges rendering technical services. The counties designated as quality cotton production bases achieved better economic returns than the neighboring counties. The quality cotton production bases provide superior seed multiplication bases and high yield demonstration areas. Furthermore, in the implementation of the 'Bumper Harvest Program', efforts were concentrated on the extension of advanced practical techniques, such as the promotion of new cotton varieties including the high yield, high quality and wilt resistant 'Zhongmiansuo 12', short season cultural techniques in different ecological areas, and integrated disease and insect control. The shared efforts of the concerned units have led to remarkable achievements.

A cotton journal publishing office was organized in the CRI, to accelerate the extension of new research results and techniques. This compiles and issues 'Acta Gossypium Science', 'The China Cottons' and 'The Cotton Technological Express'. The cotton producing provinces such as Shanxi, Sichuan, and Jiangxi, publish provincial cotton journals. These periodicals provide cotton farmers with the latest information on cotton growing techniques.

Egypt

The transfer of technology in Egypt is coordinated by the Cotton Technical Support Committee (CTSC) in MALR which provides an integrated management framework to ensure sustainable links between researchers, extension workers and farmers. The CTSC screens extension packages and other information from the ARC, the National Agricultural Research Program (NARP) and regional universities, and disseminates it through the Central Administration for Agricultural Extension Services (CAAES), the Central Administration for Pest Management (CAPM) and the General Administrations of Applied Extension Services (GAAES) in the Governorates. The CTSC uses feed-back from on-farm research involving researchers, extension agents and farmers, to improve the transfer of technology to cotton growers. CTSC monitors and reviews training programs for extension agents at the district level and holds weekly meetings during the cotton season to coordinate the functions of research and extension services.

The Agricultural Extension and Rural Development Institute (AERDI) which falls under the NARP is responsible for developing extension programs and material for dissemination to farmers. It organizes the training of extension specialists and collaborates on training programs for extension agents. Training centers for extension agents are spread throughout the country.

The CAAES has three General Directorates at the headquarters in Giza, to administer Communication and Extension Methods, Program Planning, Monitoring and Follow-Up. In addition, there are three GAAES, distributed regionally in Upper, Middle and Lower Egypt which operate through a Director General of Agriculture supported by Directors of Extension, Plant Protection and Monitoring in each Governorate. There are specialist Cotton Extension Agents (CEA) who supervise an area of 76 hectares (180 feddans) or about 200-250 farm families. Four CEAs are supervised in turn by one Inspector of Cotton. At the top of this team is a Deputy Director for the cotton subsector, who is responsible for an area of 1,260 hectares (3,000 feddans) and four Inspectors of Cotton. The total strength of the field staff in the Governorates responsible for cotton alone is about 7,000.

The regional (specialized) agricultural research stations coordinate their work plans with the Governorate extension services. Interdisciplinary teams of Subject Matter Specialists (SMS), provided by the research stations, support the extension staff in field trials and demonstrations and train the extension field staff at the District Training Centers. Extension workers organize demonstrations and outreach, launching national campaigns during the cotton season and using the written and audio-visual media at the regional level. However, it must be emphasized that grower involvement and participation in training and demonstration is, at best, limited.

India

Each State Department of Agriculture in India has one common agricultural extension organization for all crops grown in the state. For this purpose, the States are divided into Divisions or Zones which consist of Districts. The Districts are subdivided into Sub-Divisions and the Sub-Divisions into Circles. The Circle consists of a group of villages.

Extension is under the guidance of the Director of Agriculture who usually has an officer who is directly responsible for extension, with Divisional Agricultural Officers and District Agricultural Officers (DAO) or Principal Agricultural Officers (PAO) at the Divisional and District levels, respectively. At the grassroots level, each Village Level Extension Worker (VLEW) is responsible for 800 families in the rainfed areas and 500 families in the irrigated areas. The

VLEWs work through contact farmers in each village. The VLEWs are supervised by Agricultural Extension Officers (AEO) at the Circle level with one AEO for eight VLEWs.

The Training and Visit (T&V) system is used in training farmers and Extension Workers. AEOs and VLEWs receive training at regular intervals from Subject Matter Specialists (SMS) on specific topical issues which must then be passed on to the Contact Farmers and through them, to the farmers. At the same time, there is a feed back from the VLEWs to the SMSs on practical problems being encountered in the field. VLEWs also receive weekly training from their AEOs.

State Departments use the media, extension aids and publications in their extension programs. Periodical publications cover general agricultural issues, specific crop problems and, in some states, topical issues of the month. The efficacy of these publications is limited by the level of literacy among the farmers and lack of understanding of the technical information provided. The budget for these publications is often inadequate.

Mali

Extension is among the oldest services of the *Compagnie Malienne pour le Développement des Textiles (CMDT)* whose functions include extension, seed and other input supply and distribution, and marketing. The hierarchical structure of the service is administered by the DTDR at the central level with five regional directorates represented by divisions supervising Zones, Sectors and Basic Sectors which are groups of villages.

At the village level, there are two kinds of zones, the Rural Expansion Zones with basic sectors (SB) with classical monitoring methods and the Zones of Expansion and Rural Animation (ZAER) comprising a number of Advanced Village Associations (AV). The village associations and their technical teams have no legal status but they are the main actors in rural development at the village level. The ZAER carry out their own monitoring up to agricultural credit. The monitoring rate varies in different locations from one agent per 175 producers to one agent to 357 producers. The average rate for the CMDT is one agent for 198 producers. Most of the agents received their initial training at the professional training school. They receive additional in-service training from the CMDT through seminars and training periods abroad.

The training of growers is divided into practical modules and carried out in collective, seasonal training sessions with the participation of the growers themselves. They may be held in the field of a grower, in the workshop of a craftsman or in seasonal centers. Functional literacy sessions (35-45 days) are more advanced and give the producers managerial skills. The importance of management in the AV requires the development of modules for training in secretarial skills.

Extension is increasingly supported by the rural radio station and by the Rural Animation Division of the national television station which give more synergy to the monitoring action, emphasizing the importance of the communication with the rural population. A monthly liaison bulletin called *Jekabaara* allows inter-village exchanges.

Evaluation index cards help evaluate the modules and the various sessions. The efficiency of training can be assessed at the technical level through the correct implementation of agricultural techniques and at the theoretical level from the willingness of producers to be involved in the management of their business.

Mexico

The Secretariat of Agriculture established the National Extension Service in 1954 with the goal of aiding farmers in using the results of research to get better yields and incomes. Instructors from the experimental stations and personnel from the Extension Service itself, train new officers. The area allocated per extension agent depends on the type of roads, the dispersion of farms, land tenureship, irrigated or rainfed lands and the level of technology.

Initial successes of the Extension Service declined and modifications were introduced in the 1970s. The Secretariat of Agriculture decentralized its activities and Districts of Rural Development were established. The government is transferring responsibility for extension to private enterprises but Federal policies stimulate farmer initiatives. In a first stage, extension costs are shared by the government and the farmers at the rate of 80 percent to 20 percent, respectively. Costs are being transferred in 20 percent steps until the farmers bear the full cost.

Fragmentary information about the results of the program show that it is too early to judge its viability. The official policy to reduce inflation makes it difficult to finance technical assistance. The government has established a Farm Income Support Program, PROCAMPO, to assist farmers during the transition period as the increasing proportion of the costs are transferred to them. This program is intended to phase out in 2005.

Pakistan

In the Extension Wing of the Agriculture Department of each province, there is one Field Assistant (Diploma holder) in each Union Council, one graduate (B.Sc. Agri.) Agricultural Officer in each Markaz, one Extra Assistant Director of Agriculture (EADA) in each Tehsil and one Deputy Director of Agriculture in each District. On top is the Director General (Extension) with Directors in various ecological zones.

In both Punjab and Sindh, the major cotton producing provinces of Pakistan, the T & V system has been adopted in its typical shape as introduced by Daniel Benor in 1977 and revised by him in 1984. The components of the system are Adaptive Research, On-the-Job Training, Agricultural Extension and Monitoring and Evaluation.

Overall, there are eight Adaptive Research Stations in the Punjab and five in Sindh province. Every Adaptive Research Station is manned by experts in the fields of Agronomy, Entomology, Agricultural Engineering, Economics and Farm Management. These experts have a close liaison with Research Institutes for the latest crop production technology and conduct tests to establish its suitability under local agro-climatic conditions. After making necessary modifications, they prepare fortnightly messages for growers of that area.

For on-the-job training of Agricultural Officers and Field Assistants, a training wing has been organized with DDA (Training), EADA (Training) and Agricultural Officers (Training) at divisional, district and sub-divisional levels respectively. Responsibility of DDA (Training) is to prepare fortnightly messages in consultation with Adaptive Research experts. EADA (Training) conducts sub-divisional level fortnightly training sessions for field staff, whereas Agricultural Officer (Training) is responsible for conducting Markaz level fortnightly training programs.

Field assistants have an agricultural diploma and are responsible for 500 to 1,100 families, depending on the population density. All officers higher up in the extension hierarchy are graduates in agriculture. There are six to eight field assistants in a Markaz with an Agricultural

Officer in charge. Three to four Markaz form a sub-division with an EADA (Extension) in charge and three to four sub-divisions form a District with a DDA in charge. Finally, a region comprises 10 to 14 districts and has a Director of Agriculture. The system is administered by the Provincial Director General of Agriculture. Monitoring and evaluation are the responsibility of an Evaluation Cell attached directly to the Secretary for Agriculture.

Training halls at district and sub-divisional level are equipped with Audio-Visual aids such as over-head projectors, slide projectors, flip charts, VCRs and television sets. After receiving training covering the message for the next two weeks (fortnight), Field Assistants (FAs) and Agricultural Officers (AOs) conduct training of Contact Farmers selected from farm families at an average ratio of 1:8. There are 64 Contact Farmers per Field Assistant. Demonstration plots are the most important means for transmitting technology to the farmers and are laid out by extension staff throughout the area.

Field Assistants visit all their 64 contact farmers at least once every fortnight. The Agricultural Officers visit all their Field Assistants at least once a fortnight and all the contact farmers over a maximum of four months. In addition to supervising the Field Assistants, they also have their own Contact Farmers.

The private sector, particularly pesticide and fertilizer companies, provide a complementary role in educating the farmers while promoting their products.

Tanzania

Since independence, agricultural extension in Tanzania has undergone several functional changes, first under the central Government, and then under commodity authorities. In 1983 the system reverted to the government but the commodity authorities like Tanzania Cotton Marketing Board (TCMB) continued to offer their own extension services. This resulted in several problems, including duplication and overlapping in the dissemination of extension information, poor personnel utilization, lack of operational and investment funding, lack of training, weak linkages between research and other commodity-related institutions, low staff motivation, weak and fragmented organizational structure.

In 1988 the Ministry of Agriculture, through a donor-support programme, started to revitalize the research and extension activities for agriculture. At present, the Ministry is implementing the National Agricultural and Livestock Extension Rehabilitation Project (NALERP) to rehabilitate the extension services. This includes merging crop and livestock extension services whereby under the T&V system, the village extension worker (VEW) can disseminate technology and other services to groups of farmers.

The project, which has now covered all cotton growing areas, aims at providing essential physical infrastructure, logistical support and extension packages. Other provisions include monitoring and evaluation, workers' training and effective linkage with other institutions.

The main extension methods used include working through individual Contact Farmers, demonstration plots and field days. For cotton growing areas, particularly Shinyanga and Mwanza, the extension message has put emphasis on intensification, use of organic manure, crop rotation², livestock and mechanization.

² Recommended rotation crops are legumes (groundnuts, cowpeas, sunhemp) and cassava.

The Assistant Commissioner for Extension Services (ACES) is the head of extension service. ACES is assisted by an extension methodologist, an education and publicity officer, a financial controller, a monitoring and evaluation officer and a transport officer. ACES is responsible to CALD who holds the overall responsibility for extension.

NALERP is in its third year and has had quite an impact on extension services to farmers. By early 1993 the project covered 13 Regions and 57 Districts. The average ratio of VEW to farmers is around 1:450, with variations from 1:399 to about 1:750 compared to a ratio of between 1:800 and 1:2,000 prior to this project. The project has a total of 4,436 VEWs, each VEW in WCGA being responsible for 48 Contact Farmers, each responsible for 10 other farmers. Effectively, therefore, each VEW provides extension services for an average of about 480 farmers/households. The effect of this in the Mwanza Region has been a significant increase in cotton yields. However, these results should be regarded with some caution as they represent only a small portion of the project area.

NALERP provides various training methodologies which are applied among farmers by the Farmers Education and Publicity Unit (FEPU). This unit is directly funded by NALERP and is charged with the development and co-ordination of farmer training programmes, providing support to extension through mass media such as radio, magazines, and the preparation of various types of educational material and programmes, including visual aids such as slide and video shows. FEPU also operates through a training unit at Ukiriguru in the WCGA and Msolwa Farmers Training Centre in the ECGA. Limited funds and inadequate personnel and facilities are major bottlenecks.

Uzbekistan

An institutional system for extension was in existence in Uzbekistan before economic reform commenced and remains substantially unchanged. However, its efficacy has deteriorated due to financial constraints in the government budget. Changes are taking place in the institutional system but currently it is in a transitional stage and lacks stability.

The State Committee for Science and Technology (SCST), the Administration of Information and Dissemination of the Achievements of Science and Advanced Experience at the Ministry of Agriculture and the Academy of Agricultural Sciences (AAS) are the three institutions occupying key positions in the extension system of Scientific and Technology Progress (STP). There are corresponding departments at the local (regional and district) bodies of management of agriculture. There is a pilot farm in every administrative region where the advanced achievements of science are tested and demonstrated. Exchange of experience between regions, rural districts, farms, and even between structural units within farms form an important component of the system.

Cotton-growing is the leading branch of agriculture in Uzbekistan so the whole system of personnel training and improvement of qualification in agriculture is primarily focused on meeting the needs of cotton-production. The significant difference in the size, organization and technical advancement between the two types of farm, large State and Collective farms (kolkhoz and sovkhoz) and small, individual farms determines the systems of personnel training and qualification required for the improvement of agriculture.

Large scale farms are very traditional and have a relatively adequate form of training, involving Higher Agricultural Educational Establishments, Technical and Vocational Educa-

tional Establishments and Vocational Training and Qualification Improvement which, until recently, was carried out at special workshops or at corresponding academic departments of Higher Agricultural Educational Establishments.

The Tashkent State Agrarian University, the Samarkand Agricultural Institute and the Andidjan Institute of Cotton-Growing which are all under the Ministry of Agriculture and the Tashkent Institute of Irrigation and Mechanization of Agriculture which is under the Ministry of Land Improvement and Water Supply are all Higher Agricultural Educational Establishments (HEEs). Almost all the HEEs train agronomists, agricultural engineers and managerial staff (economists, book-keepers etc.) who acquire higher education specializing not only in cotton-growing but also in other branches of agriculture.

There is a broad network of senior technical colleges and junior technical colleges or vocational schools in Uzbekistan. There are 40 Agricultural Senior Technical Colleges (ASTC) which provide specialist training in all areas of agriculture. Most of them function as both training and agricultural enterprises (sovkhos-technikum). Reorganization is planned to reduce the number of ASTCs to 25-28. In addition, there are Rural Junior Technical Colleges (SPTU) in practically every rural district. Diverse professional agricultural training is provided for 35 thousand specialists in 25 agricultural specializations annually.

Vocational training is a form of apprenticeship in which an inexperienced worker is attached to a more experienced worker who has specialized education and practical labor skills. This form of training has been broadly applied in such tasks as irrigating cotton, agricultural machine operation etc. However, it has not proved satisfactory because of the lack of clear and systematic control.

Most of the specialist workshops have closed down because of financial constraints. In 1992, the same lot befell the School of Agro-Business of the Ministry of Agriculture, the school having been mainly specialized in improving the qualifications of managerial staff of the farms.

Currently, all large farms are staffed with agronomists, economists and book-keepers with advanced specialized education and qualified engineers, technicians and other professionals to operate and maintain agricultural machinery and equipment. There is no lack of 'qualified' personnel in the agricultural sector but the quality of training and the level of their professional competence often leaves much to be desired.

Training of individual farmers is more complex because of the diversity of their operations, the relatively small number of farms and the lack of training establishments. Cotton growing doesn't form a major part of their activity. In November, 1993, there were only 8,026 independent farmers who accounted for only 10,000 ha of the total of 1.6 million ha of cotton. There is only one permanent two-year workshop for training individual farmers at the Tashkent Institute of Irrigation and Mechanization of Agriculture which turns out approximately 100 farmers per year. In addition, there are short courses for individual farmers at the Tashkent Agrarian University.

The gap between training and real practical production is the main shortcoming of the system of personnel training.

Transportation Infrastructure

Little is reported in the country reports about the transportation infrastructure handling seed cotton and cotton lint. In most countries, farmers are responsible for delivering seed cotton to the ginnery or to a collection point or purchasing center. The distance of the purchasing point from the farm and the condition of the road system can have a significant influence on the cost of production and on the cotton hectareage. As an example, China has numerous small ginneries and has considered consolidating the ginning infrastructure by replacing some of these ginneries with larger, centrally located ginneries. However, this would result in many farmers being more remote from the ginneries and could have a negative effect on their decision to plant cotton.

The major cotton producing areas of Brazil have been in the south east and north east which are in close proximity to major industrial areas and so transportation has not been a problem. However, the development of the western areas of Mato Grosso, Mato Grosso Sul and Goiás will necessitate upgrading the transportation infrastructure to move the crop from this more remote area to the major markets. Similarly, the major cotton producing provinces of China have been in the Yellow River and Yangtze River Valleys which are in reasonable proximity to the industrial areas of the south and east of China. However, the major area of expansion in cotton production is in western China and this could lead to serious transportation problems because of the remoteness of the area.

Uzbekistan is landlocked and is totally dependent on the railway system to transport cotton lint. All shipments require negotiation with neighboring countries which can cause serious problems since virtually all Uzbek cotton is destined for export.

Of the other countries, Tanzania has had major transportation problems both in getting seed cotton to the ginneries and in moving baled lint. A great deal of expenditure has gone into upgrading the road and transport system, with support from the Government of the Netherlands.

The provision of an adequate transportation infrastructure is essential for the economic well being of any country. Whatever the method of transportation may be, road, rail or waterway, independently or in combination, it cuts across all aspects of rural and urban development and so generally, the provision and maintenance of a transportation network is a function of government while the transportation itself may be associated with public or private enterprises.

Regulatory Functions

Regardless of the approach taken towards privatization of the cotton industry, government involvement is essential in certain regulatory functions to ensure orderly production and marketing of the supply and quality of product required for an efficient textile industry.

Production Information

Reliable information on the area and varieties planted to cotton with a regular update on the condition of the crop as the season progresses is required to facilitate:

1. National planning for the sub-sector;
2. Orderly marketing through a progressive update throughout the year of the national and world supply and stock situation relative to demand;

3. Financial analysis of farming operations would benefit from regular inclusion of data on the prices of inputs, the quantities used and the price of outputs with the production information.

Where marketing boards exist, they have normally been responsible for compiling and disseminating this information. The privatization of marketing boards does not remove the need for a continuation of this function. Governments restructuring their cotton sub-sectors need to ensure that the flow of production and marketing information continues uninterrupted.

Quality Control

Cotton Classing

Farmers in most cotton producing countries are paid on the basis of seed cotton quality. The classification of seed cotton as opposed to lint presents many problems and often, the seed cotton is graded on the basis of color and trash without taking intrinsic fiber quality into account. In many instances this can result in farmers not being paid a fair price for seed cotton because the seed cotton grades are based on expected lint grades without taking account of possible price differentials resulting from differences in fiber properties. If quality control parameters, combined with rewards for preserving fiber quality, are not in place, ginneries have little incentive to preserve fiber attributes. Excessive cleaning can then enhance lint grades at the expense of quality. For example the final cotton in Uzbekistan depends, to a degree, on the extensiveness of seed cotton cleaning. Furthermore, prices may be depressed when either larger cotton production or higher quality than expected, results in a shortage of fund allocation for cotton procurement. Finally, even though seed cotton grading may exist, the farmer may be selling to a middleman who does not pay premiums for higher quality.

To a degree, all of the above conditions exist in the study countries. Uzbekistan ginneries generally produce a higher percentage of higher grades than the percentage of these grades that are procured. Both China and Tanzania have experienced shortages of funds and this has probably resulted in down grading of seed cotton procured. The lack of payment for cleaner seed cotton in Brazil, Pakistan and India has resulted in inferior cotton lint quality. The allocation of cotton to state mills in Egypt has resulted in ginneries failing to preserve fiber quality.

HVI classing has received attention due both to its use in the US for determining the market value of cotton and its extensive use by spinning mills to relate fiber quality to yarn quality. This has revolutionized cotton marketing by facilitating changes in marketing from the emphasis on the grade, determined by color and trash content, and staple in establishing the price to the introduction of premiums and discounts for micronaire and strength and the separation of grade into its components of color and trash. Mills worldwide use the information on fiber attributes to determine the worth of cotton in the spinning process. The use of HVI is necessary in the USA because of the large number of varieties grown under different agronomic and climatic conditions and the marketing system that does not identify the variety and region of growth, especially in the Southwest, Delta and Southeast. However, HVI equipment is difficult to maintain and calibrate. The USA has an extensive network for calibrating HVI lines to ensure that they give comparable data and when necessary, HVI equipment can be repaired with minimum delay. This situation does not necessarily apply in other countries, particularly the smaller producers.

In general the cotton variety and the climatic condition under which it was grown determine its spinning value. Consequently, many countries where varieties are identified in the

bale, fail to significantly classify cotton. This is the case in India where the Cotton Transportation Act prohibits not only the mixing of cotton from different varieties at the ginnery but also the mixing of the ginned bales. Differentials in cotton quality are reflected by differences between the support prices for different varieties. In Pakistan the Pakistan Cotton Standards Institute (PCSI) has established standards that are only applied on a limited basis. However, cotton with low maturity is identified by micronaire and sold at a large discount. The ginning, the number of lint cleanings and marketing of cotton fiber is based on utilization for medium or coarse count yarns and is usually determined by the international price differentials for these two general cotton types.

The system of cotton classification developed by the Soviet Union and still being used in Uzbekistan is based on the relationships between fiber properties and their heritability. Fiber length and fineness are closely correlated and determined by the variety while fiber maturity is strongly influenced by environmental factors. Thus within a variety, the Micronaire value is indicative of maturity. Furthermore, fiber bundle strength is also determined by the variety but its expression is influenced by maturity. Thus provided the fiber is undamaged, within a variety, the micronaire value is also indicative of bundle strength. The Soviet Union developed tables for each variety, giving estimates of maturity and strength from the Micronaire value. This system is not fully understood in international trading and is being replaced by HVI classification.

The Mexican classing system is similar to the system utilized in the United States before HVI was introduced, with most fiber attributes, except micronaire, determined manually. However, smallholders are still paid on color and trash grades, determined by visual inspection at the ginneries. The system used in Brazil is not clear, but formal grading systems are in place in the other five countries where state or parastatal agencies are responsible for classification. In Egypt, the Cotton Arbitration and Testing General Organization (CATGO) determines grades with payments made for quality differences. The state-run ginning sectors grade and class seed cotton on delivery and make payment in China and Uzbekistan. However, in Uzbekistan cotton classing is moving towards the HVI system and a separate Government agency will control the cotton grading standards. Parastatals grade the cotton in both Mali and Tanzania.

Quality determination and control systems are essential elements of economic efficiency. Orderly marketing is based on having internationally understood quality standards for cotton lint. The Cotton Futures Act of 1914 provided permanent authority for the US Department of Agriculture (USDA) to establish cotton standards. All European trading associations signed the Universal Standards Agreement following conferences held between August and November 1923. Under the provisions of this agreement, the Associations made the Official Cotton Standards of the United States for Grades of Upland Cotton the basis of all contracts in which grades were specified for the purchase and sale of cotton (Gillham and Bell, 1993). Countries such as Pakistan sell their cotton by type but the types are related to the universal cotton standards.

The Universal Standards Agreement includes the following provisions for US cotton:

- the grade and staple designation used in the official US standards to be used in any shipment in interstate or foreign commerce in which cotton was described by grade and staple;
- authority of the US Secretary for Agriculture to establish standards for the classification of cotton on the basis of which its quality or value could be judged or determined for commercial purposes;
- the establishment of a classing service for the public on a fee basis;

- the licensing of qualified classers, not in the employ of the government, to determine the quality of cotton according to the official standards;
- machinery for the arbitration of disputes involving cotton quality.

Associations from a number of countries other than Europe are signatories of the agreement, including India, Japan, Poland, Indonesia, Korea, Malaysia and the Philippines. Conferences are held in Memphis, Tennessee every three years to review and amend the standards. The classing service of the USDA has ten classing offices in the major cotton producing areas and conducts HVI tests on every bale.

Classification is one of the most important aspects of cotton marketing because it establishes the spinning utility and hence the market value of the cotton. Spinners rely on accurate grading and classing information to facilitate the purchase of the appropriate quality of cotton required for the efficient manufacture of the type of yarn required by their customers. Grading and classification are necessary to establish the relationship between the true market value of the cotton and the price paid to the grower. In order to ensure that the farmer is paid the market value of the lint cotton and to ensure that ginneries preserve fiber quality, standards need to be established and monitored by an independent organization that is not directly involved in growing and ginning cotton. The farmer can only be rewarded for producing high cotton quality if premiums and discounts are paid for fiber attributes that are independently determined by agencies that have no vested interest in the value of the cotton.

The regulatory function of the government may take the form of providing a cotton classification service similar to that in the USA which may be a free service or may operate on a pay for service basis. Where cotton is sold by growers as seed cotton, the government should establish the seed cotton grades with indicative price differentials from a standard grade. These grades should be based on the quality of lint that is expected with standard ginning procedures that achieve an acceptable grade while preserving intrinsic lint quality.

Varieties

Spinning mill efficiency depends on having long runs of uniform cotton to ensure trouble free operation with a minimum of machine adjustment to compensate for variability in the raw material. Advances in spinning technology, particularly higher operating speeds and developments in open end spinning, have accentuated the need for greater uniformity. In the past, most of the smaller cotton producing countries and many of the large producers have met this requirement through single variety ginneries and single variety production areas. Countries such as Greece, Tanzania, Uganda, Zimbabwe, the francophone countries of West Africa and in the USA, the San Joaquin Valley of California built their reputations and found their market niches on the basis of being single variety areas. Egypt has nine clearly demarcated single variety areas and the Cotton Control Act (1949) in Pakistan regulates the growing of varieties in various regions. The Meridian region of Brazil is essentially a single variety area while Uzbekistan ginned its varieties separately, storing the seed cotton in single variety, single grade lots to ensure long runs of regular cotton. The countries gained recognition for the consistency of their cotton and enjoyed premium prices and a regular market while buyers could return to the same producers year after year for their raw material and expect consistency in fiber quality.

In the 1960s, Breeders' Rights legislation in the USA brought about changes in California which permitted free access for private breeders to the cottonseed market in the San Joaquin Valley. Today, with trade agreements such as GATT and NAFTA coming into play, the cotton

industries of most countries are being privatized. Countries which previously maintained their market share by ensuring consistency in quality through a single variety policy, are having to open the cottonseed market to the private sector. The resultant production of more than one variety could lead to loss of consistency through variety mixing. The Pakistan report states that variety zoning is promulgated every year under the Cotton Control Act but that in practice, there are hardly any areas where only one variety is recommended. It suggests that multiple varieties could provide some degree of insurance against catastrophic crop losses resulting from an increase in the susceptibility of a particular variety to some form of adversity such as leaf curl virus. Ginneries in Pakistan are all in the private sector, making the implementation of single variety ginneries impractical unless there are concurrent changes in the system of varietal zoning (Ahmad & Ali, 1994).

Different countries have approached the problem of maintaining quality standards in different ways. In California, the State enacted legislation to ensure that any new variety undergoes rigorous testing before being registered to ensure that it complies with the quality standards of the region. The Pakistan report suggests that the concept of single variety ginneries is not practicable when they are all in the private sector. This is not necessarily true. The Egyptian report recommends that single variety status which is so important to the maintenance of their reputation for quality should be maintained by government decree but suggests that this could be replaced through a cooperative approach between the growers and the ginners. Variety mixing is prohibited in India at any stage of production, ginning and transportation. Bales of cotton of different varieties are only brought together after delivery to the spinning mills. This practice explains the absence of a grading system in India. However, due to the large area under cotton and the number of farmers involved, the implementation of this regulation is lax and of doubtful effect. In Greece, promotional activities are used to persuade farmers to grow only those varieties that comply with traditional high quality standards. Uzbekistan maintains quality standards by having single variety stacks of seed cotton of similar grade while in China, seed cotton is sorted according to quality characteristics before being placed in stacks.

Liberalization of marketing in Tanzania and Uganda has permitted free movement of seed cotton across variety demarcation lines and has contributed to the problem of mixed varieties. Tanzania has rules and regulations regarding single variety areas but mixing has occurred because of non observance and non enforcement of these rules and because of the collapse of the seed multiplication program while the problem in Uganda has been exacerbated by a collapse of the seed multiplication program, leading to distribution of gin run seed over a number of years and seed of one variety being distributed in the other variety zone because of a shortage of seed. The Tanzania report recommends (i) enforcement of the existing rules and regulations; (ii) seed multiplication under the supervision of the Tanzania Cotton Lint and Seed Board until the seed sector is privatized and (iii) the introduction of seed certification while Uganda is trying to restore its reputation as a producer of consistent, high quality cotton by reintroducing the two single variety zones, preventing the movement of seed cotton between zones and resuscitating its seed multiplication program.

Several alternatives are possible to achieve the consistency in quality which was previously enjoyed as a result of single variety policies. The approaches in California and Greece ensure that all varieties in a given area produce lint that meets the same quality standards. A third alternative is that proposed by Egypt of maintaining single variety status through cooperative action between the growers and the ginners. In all cases, varieties must be treated on an area-wide and not a farm by farm basis, particularly where smallholder cotton production is involved.

The major cotton producing countries have a sufficiently large number of bales to give them flexibility in selecting regular running lots on the basis of HVI instrumentation. This flexibility is not enjoyed by minor cotton producing countries which must necessarily, therefore, maintain regularity by careful selection of varieties to comply with specified quality standards and by regulating where they are grown and ginned.

Recommendations on the most suitable, adapted varieties which meet market objectives requires variety registration, based on independent research free of commercial interests. In the absence of regulation of single variety areas, means are needed, particularly with smallholder cotton, to ensure that the regularity of quality required by the textile industry is achieved.

Seed Certification

Seed certification programs should be designed to ensure that sufficient healthy, high quality, genetically pure planting seed is available in a timely manner to meet grower needs, that the benefits of the variety improvement and maintenance program are passed on to the growers as rapidly as possible and that the spinners get the quality and uniformity of lint they require. This normally involves contract growers who follow the necessary procedures to ensure that the seed they produce is genetically pure and of high quality. This entails inspection by qualified inspectors on at least three occasions during the season. The first inspection during the seedling stage is to ensure that the seed crop is adequately isolated from all other cotton and that the land preparation, planting, weed control and thinning are satisfactory. The second inspection is normally at the start of flowering and is intended to establish varietal purity by roguing out any off-type plants. The third inspection is at the start of picking to ensure that the crop has been looked after and is healthy and free of seed borne diseases, noxious weeds and insect pests. Picking, packing, transportation, storage and ginning are supervised by the certifying authority to ensure that there is no mechanical mixing of varieties and that seed quality is maintained. Finally, seed certification requires germination tests, preferably under a normal and cool temperature regime, to test for viability and vigor. Details of the variety, the stage of multiplication and the germination test results are normally printed on the seed label.

Seed certification may be carried out by a government agency or by private seed companies. In India and Pakistan, seed can only be certified by the government but seed producers may carry out all the requirements for seed certification without the involvement of the government seed certifying authority, in which case seed is labeled as 'Truthfully Labeled Seed.'

Regardless of whether seed certification is in the hands of government or private agencies, an independent Seed Certifying Agency, with no vested interest in seed multiplication, should set seed quality standards based on international guidelines, and monitor any private seed companies to ensure that all certified seed meets the specified quality standards.

Pesticide Use and Deregulation of the Pesticide Market

One of the features of privatization of pesticide distribution is that as soon as pesticides become readily available, there is an assumption by many growers that they must use a chemical to control pests, irrespective of the size of the pest population and in some cases, wrongly identifying beneficial species as pests. Thus they tend to overuse chemicals, thinking that more insecticide will automatically result in higher yields. This assumption is also made by banks and other agencies who provide credit to growers. Insecticides can only protect a good potential yield. If the plants do not grow properly due to poor soil, lack of moisture, unsuitable tempera-

ture conditions or any other agronomic cause, insect control will not increase yields. Unfortunately, where there is no regulation of pesticide use, excessive applications lead to the establishment of resistant pest populations. The same concerns apply to transgenic Bt cotton varieties.

Protective clothing is generally not worn when handling pesticides because hot temperatures during the main cotton growing period make it most uncomfortable and it is usually not available because of lack of finance to purchase this clothing. Nonetheless, farmers have very easy access to some of the most hazardous pesticides. As many of the older pesticides are no longer covered by patents, there are more sources of highly toxic chemicals, such as methyl parathion, which the growers tend to choose because they are cheap and quick acting. Hence the growing concern about the increase in reported (and probably far larger number of unreported) cases of poisoning, and in many cases deaths, due to operator contamination.

Deregulation has generally also led to an increase in the number of small companies selling pesticides. Although in India, there is legislation to control pesticides, there are situations where there is no effective control at the farmer level. For example, almost every other shop in the Patnan Bazaar in Guntur, Andhra Pradesh, sells pesticides. Throughout India, there are over 86,000 dealers. The sales staff at these establishments are inadequately trained to give sound advice on the most appropriate pesticide to use against a particular pest. These shops are, in turn, supplied by a large number of local formulators. The quality of an initial product may have been checked prior to registration, but subsequent quality control is often impossible due to the lack of laboratories and trained analytical chemists. A similar situation is developing in China.

Box 5.1: Examples of Pesticides Regulation

Australia:	Pyrethroids restricted to one generation of bollworm;
Zimbabwe:	Pyrethroids restricted to the main flowering period;
Zimbabwe:	Pyrethroid selection restricted to brands that don't cause resurgence of mites.
Zimbabwe:	Acaricide rotation counteracts acaricide resistance.
Arkansas:	Boll weevil eradication involves: <ul style="list-style-type: none"> · Field mapping and systematic trapping to detect and delimit populations; · Mandatory participation following grower referendum; · Judicious use of control measures in response to existing pest conditions and environmental conditions; · Insecticide treatments on infested areas only.
South America:	Joint program between Argentina, Brazil and Paraguay to control/eradicate boll weevil (CFC).

When resistance to pyrethroids was detected in Australia, the growers, agrochemical industry and Government immediately collaborated to use an insecticide resistance management program that has enabled growers to continue the use of pyrethroids for a further 10 years. Similarly in Zimbabwe, the number of insecticides has always been limited, the use of pyrethroids has always been restricted to the peak flowering period and when a resistance problem was detected with red spider mites and the organophosphate dimethoate in the 1960s, an acaricide rotation scheme was quickly implemented and remains effective. However, where a large number of different insecticides have been used within one area and resistance occurs, it is no longer possible to develop a satisfactory pesticide management policy. Similarly, if transgenic Bt cotton varieties are grown without consideration for other aspects of IPM, resistance will de-

velop in Lepidopterous species to *Bacillus thuringiensis*. These varieties should be handled in the same manner as insecticides in an insecticide resistance management program, being considered only as part of an overall IPM program. Box 5.1 lists examples of regulation of pesticides.

Exhibit 5.1: Pyrethroid Resistance Management in Australia

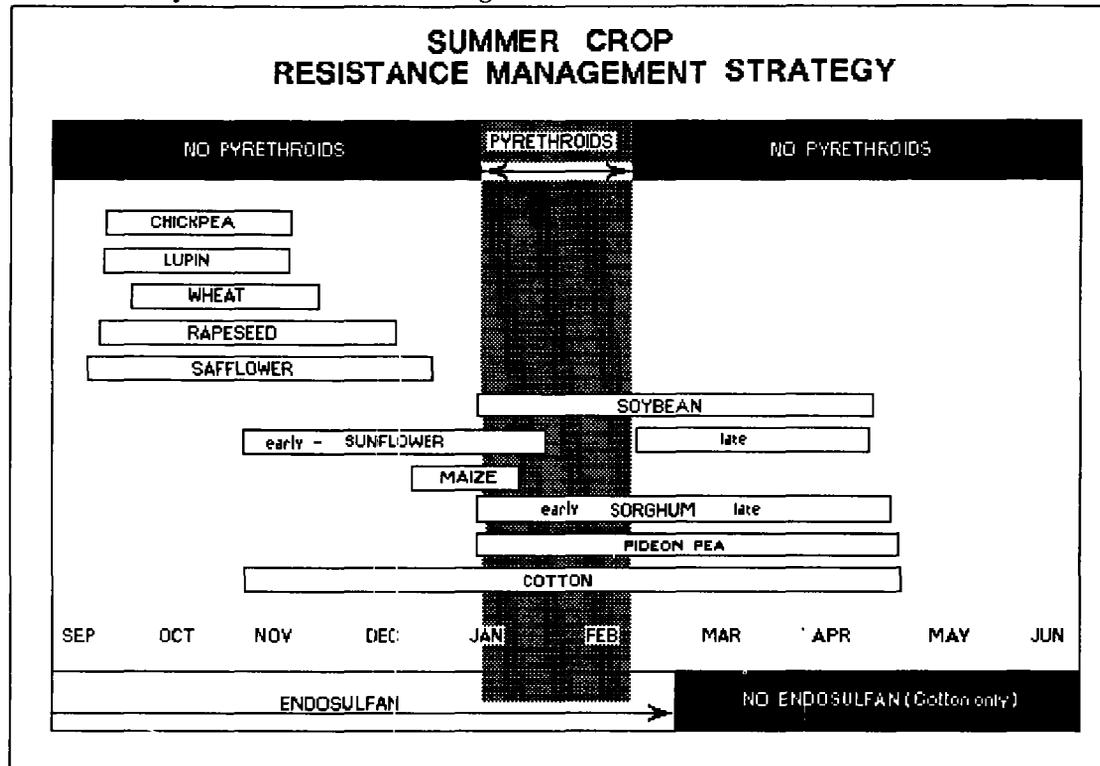
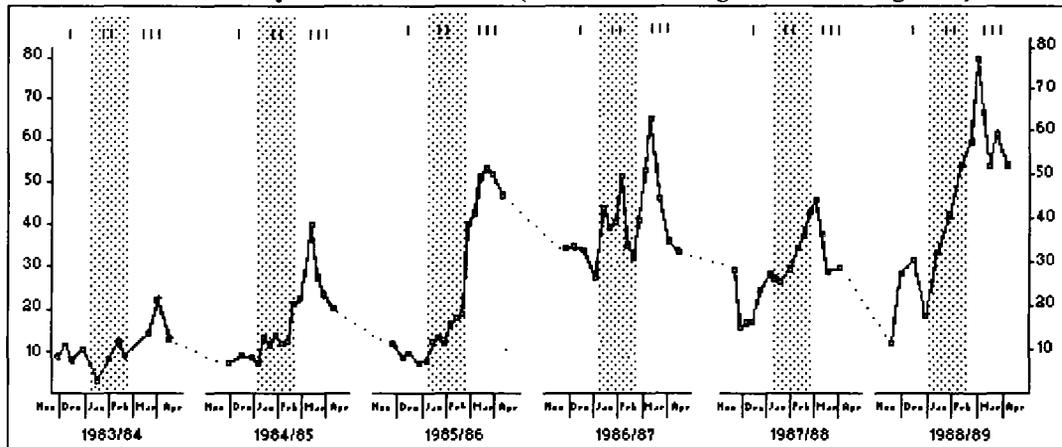


Exhibit 5.2: Namoi/Gwyder - Fenvalerate (Percent Surviving Discriminating Dose)



Weekly pyrethroid resistance in *Helicoverpa armigera* from the Namoi and Gwyder Valleys of Northern New South Wales for the first six seasons of the Resistance Management Strategy (Stages I, II and III).

It is clear, therefore, that pesticides cannot be treated like soap powders. Free market competition without adequate regulation will NOT be beneficial. There is an urgent need to control hazardous pesticides to avoid health risks, if necessary, through a system of licencing of applicators. Furthermore, sound advice on the most appropriate strategy to control pests is often

not available and independent research is essential to provide advice on how to integrate minimal use of selected pesticides, including transgenic Bt cotton varieties, into an IPM program.

Exhibit 5.1 illustrates the Australian pyrethroid resistance management strategy which involves the pyrethroid window, the only period during the season when pyrethroids can be used on any crop. This is Stage II in Exhibit 5.2. No pyrethroid is permitted on any host plant of *Helicoverpa armigera* during Stages I and III. There is also a restriction on the use of endosulphan on cotton only during Stage III. Exhibit 5.2 demonstrates that despite this strategy, there has been a progressive increase in the level of resistance over the six years covered by these data. However, the life of the pyrethroids has been extended by at least containing the rate of increase in resistance. Clearly this strategy requires area wide compliance by all users of pyrethroids.

The commercial view is to sell a chemical as extensively as possible to recoup the heavy investment required to develop new products. Reputable companies may take a long-term view if patent life can be extended but this does not apply to small formulators of the many chemicals available. Chemicals are over used if they are extensively and easily available at relatively low cost. Training of individual operators of pesticide applicators seems an insurmountable task, but clearly, greater emphasis could be placed on training. This is not a new concept. In the 1970s, Chlordimeform was withdrawn from the market and when it was reintroduced, it could only be used by licensed applicators. Similarly, the new herbicide Clomazone (Command) can only be applied by qualified personnel (Crumby and Taylor, 1995).

In the absence of effective pesticide regulation, the implementation of more ecologically acceptable technology such as the conservation or dispersal of biological control agents and use of pheromones, becomes extremely difficult. Thus deregulation harbours the risk of gross overuse of pesticides, environmental damage, selection for resistance and increased health problems associated with pesticide poisoning.

The regulatory function of the Government with regard to IPM should include:

1. Pesticide resistance management, including transgenic cotton;
2. Area wide approaches in the use of pesticides and pheromones (Note: the area may be regional, national or international);
3. Registration of all pesticides, based on toxicity and efficacy against specific target pests;
4. Monitoring the quality of inputs, including pesticides, equipment and pheromones;
5. Production of bioagents where appropriate.

An information system such as an IPM related Electronic Mail network would greatly enhance the sharing of knowledge and experiences in IPM among cotton producing countries.

CHAPTER 6

SYNTHESIS OF COUNTRY STUDY FINDINGS AND WORKSHOP RECOMMENDATIONS

The challenges as seen by the teams conducting the study in the nine study countries differ widely from the importance of political stability in Brazil, the emerging empowerment of the farmers in Mali, the impact of a high interest rates in Mexico, protection from natural disasters in China to the impact of changes in marketing in China, Egypt, Tanzania and Uzbekistan. However, the common thread in all the reports is the relationship between price and yield. When prices rise to make cotton more competitive with alternative crops, yields rise because growers apply available production technology more intensively. The workshop participants and the study teams highlighted two factors as crucial to the prospects for cotton over the decade to 2005. The first would be some form of price stabilization or means either to establish a minimum price in advance of planting to bolster grower confidence or to develop instruments to minimize risk. The second factor highlighted was the proportion of the fiber market value in the farmgate price, taking account of the GOT and the costs of transportation, ginning, storage, classification and handling. A strong case was also made for a levy on all commercial and industrial crops to enable their sub-sectors to contribute towards the cost of research and extension.

The key issues and recommendations made by each of the study teams are summarized below. Implementation of the recommendations would require a variety of interventions, ranging from the policy level to changes in the area of research. This discussion is followed by a summation of the discussion at the Workshop on topics relating to i) variety improvement, ii) seed supply, iii) fiber laboratories, iv) agronomy, v) irrigation, vi) crop protection, vii) ginning, viii) economies and policy and, ix) regulatory functions.

Key Issues and Recommendations from Country Studies

Brazil:

The most serious problems identified for **Brazil** were not confined to the cotton sector but relate to inflation, urban migration, lack of housing, unemployment and/or hunger. Although technical challenges are no less relevant, they depend very much on socio-economic conditions.

Key Issues:

Variety Improvement and Seed Supply

- There is no legislation to protect intellectual property rights, so the private sector has not become involved in the development of new varieties.
- Cotton improvement is essentially confined to the IAC in São Paulo for all states, including the State of Paraná, IAC 20 became the only variety for eight consecutive years for the whole of the Meridien Region and part of the Setentrional Region, despite considerable agro-ecological differences.

- The multiplication and distribution of seed is organized by state government agencies in all states except Paraná, where it is in the hands of the cooperatives. However, with the exception of the big producers of Mato Grosso and Goiás who do not utilize official resources, States other than Paraná and São Paulo do not have any systematic program for control and distribution of seed, seed being supplied from Paraná and São Paulo. This involves long distances and high transportation cost, and seed seldom reaching these States on time.

Crop Protection

- The boll weevil, *Anthonomus grandis*, has become a major pest throughout Brazil.
- There are a number of IPM projects but the extension and implementation of new technology is hampered, particularly in poor areas, by illiteracy and low agricultural expertise.

Irrigation

- Irrigated production accounts for a very small proportion of the cotton crop. Nevertheless, even in the Setentrional Region where irrigated cotton production is likely to expand, water use efficiency is poor and there are problems with drainage and salinity.

Cotton Ginning

- Most ginneries are old, inefficient and incapable of handling machine picked cotton.

Economics and Policy

- High input costs result from high import duties and the high cost of road transportation over long distances, with high insurance costs and poor road conditions, consequently, producers use fertilizer and other inputs below levels recommended by research.
- Currently the low level of mechanization requires intensive manual labor but costs are high and the labor force is very motile because of competition for labor from other regions (e.g. for sugarcane, coffee and orange production). The constant movement of labor limits training, leading to bad picking which causes quality degradation with a high level of trash and contamination, particularly with polypropylene from the picking sacks.
- Producer prices have been low while production costs, input, labor and credit, are high.
- There has been a decline in the demand by the textile industry for domestic cotton because taxes along the marketing chain have reduced the competitiveness of domestic cotton. Favorable interest rates are offered for imported cotton and import duties have been removed.
- The rural insurance program has not worked effectively.

Study Team Recommendations:

Variety Improvement and Seed Supply

- Develop breeders rights legislation to facilitate the controlled importation of improved varieties to raise productivity in the Meridian Region.
- Improve the yield and quality potential of local cotton varieties through adaptation of new varieties specific to different ecological zones and to irrigated production in Setentrional.
- Develop the capability to utilize biotechnology in plant improvement through training and by equipping appropriate laboratories.
- Develop a more aggressive program for seed production in all states, including the incorporation of 5,000 ha of irrigated cotton specifically for seed production in the Setentrional re-

gion in the States of Paraíba, Pernambuco, Ceará, Rio Grande do Norte and Piauí, following the diversion of the São Francisco River.

Crop Protection

- Develop an area wide IPM approach to control of the boll weevil, avoiding strategies that may lead to a resurgence of other pests such as bollworm and late season sucking pests.
- Intensify the development and implementation of IPM, monitoring insect activity in all areas, particularly when cotton is grown under irrigation.

Irrigation

- Develop irrigation production technology for the Setentrional Region, if it is shown to be environmentally and economically justifiable, with 5,000 ha set aside for seed production.

Cotton Ginning

- Upgrade ginneries for mechanical picking, particularly in the western expansion areas.
- Provide training to improve the performance of cotton ginnery operators and supervisors.

Economics and Policy

- Rationalize duties on imported agro-chemicals and ensure that credit is available to enable growers to utilize fertilizers and other inputs efficiently and economically to enhance the competitiveness of cotton production.
- Modify the law governing short term employment to permit longer term employment, leading to more effective training.
- Market failures that prevent premiums for higher quality lint being reflected in producer prices for seed cotton should be corrected.
- The trading of cotton should be strengthened through use of futures markets and rationalizing the taxes and duties on imports and exports.
- Greater integration of production and processing should be encouraged.

China:

China has economic and technical constraints to expanded cotton production. The cotton acreage is likely to decrease in Southern China as labor migrates from rural areas to cities or shifts to the developing rural industry and village enterprises. In Northern China, high production costs and declining yields are leading to reduced profits. As a consequence, the inputs devoted to cotton cultivation are declining and the maintenance of historical areas planted to cotton is in doubt. Additionally, with reforms taking place in the textile industry, attention needs to be paid to quality if profitability is to be maintained. Finally, the present cotton purchase system benefits neither the cotton farmers nor the consumers. China was moving towards a market economy in cotton but as a result of declining production, the government has once again tightened controls on marketing. The study team suggests that the present purchasing system could be reformed by setting up a stock reserve system and a risk fund system for raw cotton.

Technically, the Yellow River Valley suffers from periodic droughts while the Yangtze River Valley suffers from periodic floods. Poor basic field layout provides little protection against these natural disasters. Pyrethroid resistance is causing serious aphid, *Aphis gossypii*, and bollworm, *Helicoverpa armigera* problems in Northern China. The incidence of *Fusarium* and *Verticillium* wilts also shows an upward trend. Farmers have poor technical education, and

the technical service system needs strengthening. There has been little increase in fertilizer usage because of a shortfall in supply which is only about 85 percent of demand.

Key Issues:

Variety Improvement and Seed Supply

- Crop losses occur because of early termination of the cotton season to make way for wheat planting in the east and because of early frost.
- Pyrethroid resistance in bollworm, *Helicoverpa armigera* is causing serious crop losses, particularly in the Yellow River Valley
- The quality of much of the seed used by farmers is low and inadequate seed multiplication leads to varietal deterioration.

Agronomy

- Some cotton growing areas have a poor basic field layout with little protection against erosion, flooding or drought.
- The double cropping (relay cropping) system is very tight, requiring an overlap between cotton and wheat at the beginning of the cotton season and early termination of the cotton crop to make way for wheat at the end of the cotton season.
- Double cropping provides a continuous source of host plants for bollworm, *Helicoverpa armigera* and precludes soil disturbance between the wheat and the cotton crops, thus preventing destruction of bollworm pupae in the soil.
- The fertility and organic matter content of many soils are declining in both the Yellow and Yangtze River Valleys.

Irrigation

- Irrigated cotton in the northwest has a particularly low coefficient of water-use efficiency.
- In the Yellow River Valley, dry winter and spring conditions often prevent timely planting without irrigation and summer rains often cause waterlogging of low lying areas.
- Excessive pumping of ground water in some areas is leading to a water shortage, receding water table and even sink holes.

Crop Protection

- Pyrethroid resistance is leading to serious bollworm (*Helicoverpa armigera*) damage in cotton producing areas of Northern China.
- The incidence of *Fusarium* and *Verticillium* wilts is showing an upward trend.
- The extent of nematode damage and its link to wilt diseases is not fully understood.
- Weed control is heavily labor dependent.

Economics and Policy

- In Southern China, the cotton acreage is likely to decrease as labor migrates from rural areas to cities or shifts to the developing rural industry while in Northern China, the production cost is high and the yield is decreasing, leading to lower returns for the farmers.
- In the Northwest, limitations in water supply and transportation impose restrictions on further area expansion under cotton.

- Liberalization of the agricultural input marketing has caused input prices to increase rapidly and increased demand for labor in the newly emerging non-agricultural industries has driven labor costs up, increasing production costs and reducing the return on cotton.
- Cotton remains the only crop whose pricing and marketing is under state control, making it less remunerative in comparison to food crops and isolating growers from the market.

Study Team Recommendations:

Variety Improvement and Seed Supply

- Early maturing varieties with high yield and quality potential are required to fit into the double cropping system in the east and the short season in the northwest.
- Host plant resistance to bollworm, *Helicoverpa armigera* should be actively pursued.
- Seed multiplication and quality control should continue to be developed through expansion of the seed bases in the Quality Cotton Producing County program.
- Biotechnology capabilities should be developed to enhance breeding for insect resistance and herbicide tolerance.

Agronomy

- Field layouts need to be developed to provide protection against erosion and flooding.
- The double cropping system should be further developed to promote early crop set in order to accelerate maturity and achieve a pre-frost cotton harvest above 80%.
- Soil deterioration and restoration of fertility need to be addressed, particularly in lower yielding areas.
- Soil and petiole analysis capacity needs to be strengthened to identify nutrient deficiencies and rationalize fertilizer use.

Irrigation

- Enlarge the northwest inland irrigated cotton area and improve the techniques of growing cotton on saline-alkali fields to compensate for declining production in the east.
- Develop drainage systems to mitigate against flooding and waterlogging.
- Develop efficient irrigation techniques to optimize the water utilization efficiency.

Crop Protection

- Develop Integrated Pest Management (IPM) strategies, including resistant varieties, cultural practices, appropriate use of pesticides and biological control to counteract pyrethroid resistance and reduce damage to the crop.
- Investigate the extent of nematode damage and develop techniques, including host plant resistance, to control wilt diseases and nematodes.
- Develop appropriate technology for the introduction of herbicides, paying particular attention to herbicide resistance and the environment.

Economics and Policy

- Government should consider setting a minimum price annually before the season to foster grower confidence to avoid large price fluctuations. A stock manipulating and risk fund system should also be considered for seed cotton to reduce price volatility.
- Irrigation methods and scheduling should maximize water use efficiency.

- In the short run, the procurement price for cotton should be increased to give the producer a higher proportion of the market value of the lint, taking account of the GOT and the transportation, ginning, storage and handling costs in order to offset rising production costs.
- Ultimately, cotton marketing should be liberalized as with other crops.

Egypt:

The performance and contribution to the national economy of the cotton sub-sector in **Egypt** has been declining for some time. This overall deterioration has three interrelated aspects: (i) falling production and productivity, (ii) falling exports, and (iii) deterioration of the spinning and weaving industry. Central to these problems is the deterioration in the competitiveness of cotton because of declining yields, deterioration of grades and reduced cotton area.

A combination of factors, including poor quality seed, inappropriate agronomic practices and inadequate extension services have contributed to reduced yields. The seed problem arises from inadequate breeding and seed multiplication, coupled with the high seeding rate and resulting in insufficient delinted planting seed being available. The agronomic practices adversely affecting the yield level include the high seed rate leading to the need for excessive thinning, poor crop protection, late planting, and intercropping. The extension services are inadequate in terms of training of field staff and lack of effective coordination with researchers and farmers in the field. Cotton grades have deteriorated as a result of narrow, government regulated price differences between grades.

The public sector in Egypt has had a monopoly on marketing and distribution of cotton. In addition, they have exerted direct controls on planted area, output delivery, prices of inputs and outputs (cottonseed and lint). This has been exacerbated since the mid-1980s when the government introduced its economic reform program in the agriculture sector but maintained control of cotton production. At the farm level, the asymmetrical policy of the government made cotton even less profitable and productive than its competitors. This continued until 1993 when reforms were extended to the cotton sub-sector and the government began to gradually dismantle its controls and liberalize its regulatory framework to encourage greater participation by the private sector in the production, distribution and processing of cotton.

Key Issues:

Variety Improvement and Seed Supply

- Inadequate breeding and seed multiplication have contributed to declining yields and quality.
- Reliance is placed on ELS and LS cotton which is spun well below its spinning potential in domestic spinning mills.
- Varietal deterioration has become a serious problem for maintaining the quality premiums traditionally enjoyed by Egyptian ELS and LS varieties in world markets.
- The genetic base of cotton in Egypt is somewhat narrow.
- Variety mixing occurs during seed multiplication.
- Seeding rates are excessive because of unreliable seed quality.

Agronomy

- Yield levels are adversely affected by current agronomic practices, including high seed rates, excessive thinning, poor crop protection, late planting and intercropping.

Irrigation

- High water tables and high salinity are of particular concern in the rice-growing areas of the Delta. This has resulted in a substantial drop in yields in certain areas. Recent monitoring of data on cotton yields has shown that they start to fall when the water table depth averages less than 90 cm during the growing season.

Crop Protection

- Yields are adversely affected by poor insect control.
- Pheromones are being used against pink bollworm but are only effective if applied on an area wide basis. Indiscriminate use of pesticides disrupts the effectiveness of the pheromone and leads to continuing problems with late season sucking pests.
- Deregulation of pesticide marketing could result in indiscriminate use of pesticides to the detriment of other IPM strategies

Economics and Policy

- In 1993, the government embarked on a five year economic reform program for the cotton sub-sector, to remove in stages its controls on production and prices of cotton, to privatize the ginning industry, and to liberalize the trade in cotton, cottonseed, etc. for both domestic and foreign markets. Implementation of this program is underway. A number of transitional problem have emerged as part of the adjustment process.

Study Team Recommendations:**Variety Improvement and Seed Supply**

- Varieties are needed that are tolerant to waterlogging and salinity; tolerant to drought and heat; resistant to insect pests and herbicides; high yielding without loss of quality; have a shorter growing period.
- Medium staple cotton varieties should be studied for possible production in Upper Egypt.
- Ginning companies should be allowed to undertake breeding and development of varieties, including the supply of Foundation Seed.
- Farmer cooperatives should be encouraged to develop their own links with breeders, ginneries, seed distributors, etc.
- The government should withdraw its present controls on assignment of areas and delivery of planting seed and encourage self-regulation of the variety-zone system by growers, under the supervision of the MALR. The Government Extension Services and research system could perform a monitoring role to prevent varietal mixing and pest dispersal.
- The production of high quality, acid delinted, gravity graded seed should be developed to cover planting seed requirements.

Agronomy

- Develop improved agronomic practices, in particular the reduction of seeding rates as high quality seed becomes available.
- Develop short season production technology for LS and ELS cotton varieties to parallel the development of shorter season varieties.

Irrigation

- The government still subsidizes irrigation water and drainage but should gradually recover at least the Operation and Maintenance (O&M). Placing a commercial value on water should lead to more efficient water utilization, and mitigation of waterlogging and salinity.

Crop Protection

- Develop and promote IPM strategies for implementation by farmers.
- Develop varieties with high tolerance to insect pests and herbicides.
- Maintain an effective institutional framework to register and regulate pesticides.

Ginning

- The private sector should be encouraged to take over the existing gins, within the framework of government monitoring to prevent varietal mixing and pest dispersal.

Economics and Policy

- Policies need to be further modified to ensure farmgate price, reflect the world market price with some provision for price stabilization to protect the industry from large fluctuations in world market prices.

India:

The key constraints being faced by the cotton sub-sector in **India** are low profitability and high risk. Contributing factors include policies designed to protect the textile industry, most of which is in the handloom, cottage industry type sector, lack of high yielding varieties/hybrids for rainfed production, poor agronomic practices, lack of mechanization and poor usage of inputs in rainfed areas. Rainfed cotton yields in India are particularly sensitive to the reliability of the monsoon, leading to the high risk and reluctance to increase input usage.

Key Issues:**Variety Improvement and Seed Supply**

- Rainfed production areas are poorly served in the development of adapted high yielding, pest resistant varieties/hybrids.
- Varieties are mixed due to the multiplicity of varieties, lack of implementation of the Cotton Control Act and inadequate variety maintenance and seed multiplication.
- The quality of planting seed is unreliable.

Agronomy

- Inadequate plant populations in rainfed areas due to poor quality seed, lack of certified seed and inadequate soil preparation, leading to leading to poor germination;
- Poor soil conservation due to poor land preparation;
- Inadequate use of fertilizers in rainfed areas due to risk of wastage caused by erratic rainfall.
- Inadequate crop rotation in rainfed areas.
- Excessive use of fertilizers and irrigation in some areas, leading to excessive vegetative growth and poor pest control.

Irrigation

- Inadequate supplementary irrigation in the Central and Southern zones to reduce risk and increase yields.
- Irrigation is not related to crop water requirements.

Crop Protection

- Inadequate use of pesticides especially in rainfed areas because of non availability of appropriate pesticides and risk of wastage due to erratic distribution of rain.
- Absence of area based implementation of IPM.
- Unregulated distribution of pesticides contributing to the development of pesticide resistance and resurgence of secondary pests.
- Ineffective pest control because of spurious pesticides and poor application technology.

Ginning

- Low grades due to poorly maintained ginning facilities, leading to a high trash content.

Economics and Policy

- Low yields, caused mainly by poor quality seed and pest problems, low farm gate prices, high crop production risk, and lack of efficient marketing of the full product range. and difficulty in transferring technology from the scientific to the farm sectors are all are all challenges relative to the economics of production.
- Cotton fiber and yarn export policies result in low farmgate prices and inefficiencies in the textile sector.
- Cotton grading standards do not enable cotton to be priced according to spinning value.

Study Team Recommendations:**Variety Improvement and Seed Supply**

- Intensify breeding drought tolerant varieties for rainfed conditions, paying particular attention to the possible role of Asiatic cotton;
- Implement the Cotton Control Act to limit the number of varieties in any one zone and to prevent variety mixing and pest infestation, but use price signals rather than physical measures to limit varieties;
- Establish seed processing facilities to ensure adequate availability of high quality, certified, acid delinted seed, but make the state seed corporations independent of government controls in terms of pricing and distribution of seed;

Agronomy

- Improve the standard of land preparation, taking account of conservation principles, through the development of better equipment
- Make greater use of foliar fertilizers and establish facilities for soil and petiole analysis so that fertilizer applications can be based on crop needs as the season progresses, taking into account the crop condition and climatic factors.
- Reduce risk and increase yield through application of better agronomic practices, paying particular attention to rotations in rainfed areas.

- Rationalize the use of fertilizers and irrigation with the aid of soil and petiole analysis, plant monitoring (Plant Mapping) and careful use of plant growth regulators.

Irrigation

- Develop supplementary irrigation for rainfed areas in southern and central zones.
- Develop irrigation scheduling based on crop water needs for fully irrigated cotton.

Crop Protection

- Ensure that appropriate pesticides are readily available and monitor plant growth as well as insect activity as a basis for management decisions on crop protection
- Development and area wide approach to IPM, including insect monitoring, biological control and timely, efficient application of pesticides where needed.
- Regulate pesticides to ensure that farmers receive reliable products and register only those based on sound research findings;
- Set up laboratories to test and monitor pesticides to identify spurious products.
- Investigate the feasibility and economic justification for setting up laboratories for the production of biological control agents.

Ginning

- Establish standards for ginneries to maintain grade quality;
- Modernize outdated ginneries that are causing quality problems;

Economics and Policy

- Improve extension to transfer of technology.
- Provide funds to credit institutions to support farmers in the purchase of inputs
- Provide autonomy to the state seed corporation in terms of crop sequence, pricing and distribution of seeds.
- Support commercialization of byproducts by setting up a special cell in the Center for Research on Cotton Technology (CIRCUIT) for this purpose.
- Rationalize the export policy by allowing exports to take place with a small, variable export duty to encourage value added exports and to initially protect the textile sector from sudden price increases.
- Establish quality and grade standards and set up the necessary infrastructure to measure and grade cotton at the seed cotton and lint stages, and to subsequently involve CCI and cooperative federations in paying higher prices for better quality cotton.
- The Ginning and Processing Act should be modified progressively to remove price fixation,

Mali:

The **Malian** agricultural sector faces a number of institutional challenges which affect the cotton sub-sector. The move to empower the rural population has been paralleled by the efforts of CMDT to redefine its relations with the farmers and to delegate some of its functions to farmer organizations. In addition, the division of power between the state and the CMDT needs to be clarified. The CMDT has played an ambiguous role as a profit seeking trading company on the one hand and as an organization charged with a rural development mission on the other.

On the economic front, despite the positive effects of devaluation of the CFA franc on profitability and international competitiveness, the sector still needs to find ways to cut costs. The most likely cost reductions are in transportation and energy. The study emphasizes the need for further integration of the cotton sub-sector with the textile industry to fully exploit the domestic and sub-regional market potential. Risk management has emerged as an important issue.

The most important environmental problem is soil degradation in the heart of the cotton zone. The study team recommends that beside the ongoing natural resource management program, the use of Tilemsi Natural Phosphate ((PNT) a high quality rock phosphate) and organic manure be promoted, in addition to incorporation of crop residues.

Finally the need for quality maintenance to preserve Mali's market share has been highlighted. The quality of Malian cotton has been deteriorating for the past few years due to rapid expansion in the cotton area relative to the availability of labor, inadequate storage at the village level and insufficient ginning capacity. To reverse the trend in cotton quality and meet international spinner requirements, Mali will have to focus on variety development, seed multiplication and dissemination, agronomy and processing.

Key Issues:

Variety Improvement and Seed Supply

- Emphasis in the variety improvement program has been on improving yield and GOT while maintaining quality, with little attention to byproducts.
- The slow rate of multiplication extends the period for the distribution of improved varieties.

Agronomy

- The intensification of production on the best cultivable lands in the absence of land fallow practices causes degradation of the soils and environment in the heart of the cotton zone, leading to reduced yields and increased risks for grower;
- The unavoidable increase in production costs can only be supported by a commensurate increase in productivity.

Ginning

- The requirements of the international market are not being served in terms of preservation of intrinsic fiber quality during ginning.
- Current production exceeds the ginning capacity.

Economics and Policy

- The quality/price ratio of Malian cotton is not sufficiently competitive in the world market.
- The internal textile market is narrow.
- Transport, energy and monitoring are the major cost items.
- Better risk management for small producers is needed.
- The relationship and division of labor between the State and CMDT is not clear, leading to uncertainties with regard to the funding and provision of services. This issue assumes particular importance when the cotton sub-sector is in recession as was the case before the devaluation of the CFA Franc in 1994.
- Cotton farmers have started claiming a higher level of economic and political empowerment, that is commensurate with their role in the economy.

Study Team Recommendations:**Variety Improvement and Seed Supply**

- Place emphasis on quality to improve the quality/price ratio in order to increase the competitiveness of Malian cotton by developing varieties that meet international market requirements for both rotor and ring spinning.
- Improve the value of cotton byproducts of oil, protein and linters while improving fiber quality and GOT.
- Improve the capacity to multiply and disseminate new varieties.

Agronomy

- Develop cultivation techniques which can be adopted by the growers, and which insure the restoration, maintenance or improvement of the soil fertility, a *sine qua non* condition for the sustainability of cotton growing.
- The sub-sector must play a direct role in the promotion of PNT rock phosphate and organic matter, use of crop residues to restore soil fertility and the rearing of cattle to ensure supplies of organic fertilizers.

Ginning

- The existing ginneries need to be modernized in order to improve of quality and to reduce processing costs.
- Increase ginning capacity to match the cotton production and optimize the ginning period.

Economics and Policy

- Quality should be improved through better cultivation methods, use of appropriate methods of marketing and transportation and the modernization of the cotton ginning industry.
- Production and marketing costs should be decreased e.g., through easing of the monitoring system, avoidance of waste and increased productivity.
- For better risk management the state can help find new market outlets, improve storage possibilities and encourage diversification into other crops, such as cereals, fruits and vegetables, and cattle-rearing.
- The solution to the dissatisfaction of the farmers with the current system exceeds simple budget measures. It requires some actions combining:
 - 1) the redefinition of the strategy for extension and training;
 - 2) broadening the transfer of functions the CMDT and the State to farmer cooperatives,
 - 3) setting up a policy partnership that, in the long run, will enable farmers individually or organized in Economic Interest Groups to invest in CMDT and cotton ginning factories.
 - 4) clarification of the roles of: the State, the Decentralized Territorial Collectives, the Regional Chambers of Agriculture, Trade Unions and Farmers' Organizations.

Mexico:

The main constraint to cotton production in Mexico in the recent past was considered to be the low price relative to competing crops, resulting from policies supporting the price of maize and beans. However, when this was corrected in 1994, other inefficiencies became apparent. Mexico is capable of achieving high yields but their attainment is hampered by delays in the

availability of inputs of seed, fertilizers and agro-chemicals. A number of institutions in the countryside are still adjusting to the move to a more market oriented economy.

Interest rates in Mexico have reflected a period of uncertainty with real interest rates as high as 30 percent in some banks. Moreover, the small size of the market is not conducive to the formation of a local cotton exchange to enable farmers to use trading devices to provide risk protection. Opportunities exist for local cotton brokers to become active in hedging and other risk management strategies on the New York Cotton Exchange.

Key Issues:

Variety Improvement and Seed supply

- Almost total reliance is placed on US seed suppliers and breeders although US varieties are not necessarily superior to locally developed and adapted varieties, either in yield or quality.

Agronomy

- Lack of timeliness in the supply of seeds, chemicals, and pesticides.
- The cotton harvest depends on the availability of manual labor at harvest time and shortage of labor may depress yields.
- The cost of labor is expected to increase along with competition from non farming activities.

Crop Protection

- Farmers are not made sufficiently aware of interactions between different chemical products or their impact on health and environmental aspects.

Ginning

- The technology applied in cotton production and ginning is good but some of the ginnery machinery is obsolete and may not preserve fiber quality.
- Ginneries are not equipped to handle mechanically picked cotton.

Economics and Policy

- Labor is in short supply so labor costs are high.
- Fertilizer use has decreased as a result of high interest rates and the removal of subsidies for fertilizers obtained through FERTIMEX.
- The open economy of Mexico will have to compete in markets where advanced marketing methods are commonplace.
- Based on current trends, it is likely that the textile industry will continue to enter the international market for part of its spinning needs due both to the close proximity to the US and the expanding denim industry that utilizes coarser cotton than that produced in Mexico.
- The organization and training of individuals in the industry may be deficient, adversely affecting the competitiveness of the Mexican cotton in the international market.
- The returns to farmers need to be increased to make cotton more competitive by obtaining higher values for byproducts

Study Team Recommendations:**Variety Improvement and Seed supply**

- Intensify research to identify the regional adaptation of foreign varieties in comparison with locally bred varieties;
- Develop timeliness in supply of quality seed of locally developed varieties;
- Monitor the quality of all planting seed.

Agronomy

- Ensure timely availability of inputs and optimize fertilizers application rates and timing. Increase the use of plant growth regulators.
- Consider mechanization in most areas as a solution to the problem of labor shortages and cost of picking.

Irrigation

- Any new irrigation schemes should include improvements in water use efficiency.

Crop Protection

- The regulatory role of the government in registering pesticides and regulating their use, taking account of toxicity, should continue.
- Special attention should be given to the development and adoption of integrated pest management strategies.

Ginning

- The preservation of fiber quality requires well maintained ginning equipment and efficient storage facilities, ginning process and administration.
- Any expansion in mechanical picking will necessitate upgrading existing ginneries or installation of new ginneries which incorporate the equipment to handle this type of cotton.
- Methods of baling and bale wrapping materials must be appropriate for the needs of the domestic and international markets.

Economics and Policy

- In areas where there is insufficient labor, picking should be fully mechanized.
- Cotton policy should be incorporated into the agricultural program as a priority item. A finance policy should be developed to aid cotton's agricultural credit, such as the use of warehouse receipts as collateral for loans.
- Cotton should be included in the commodity market to be operated in Mexico.
- Technologies for cotton byproduct processing and utilization should be investigated for the production of human food and animal feed products. These actions could translate into better returns for the cotton producer.

Pakistan:

In **Pakistan**, seed cotton prices have been maintained below the prevailing world prices to subsidize the textile sector and by the export policies. Sugarcane has competed strongly with cotton and hence the area planted to cotton is strongly influenced by the relative returns on the two crops. Lower cotton yields in the past two years have resulted in a decrease in area.

Technical issues include the damage caused by leaf curl virus and inefficient insect pest control. The leaf curl virus problem should be resolved through breeding while farmer education is needed in plant protection, including selective use of pesticides, appropriate timing of pesticide applications, management of pesticide resistance, use of appropriate spray machinery and plant management. Improvements in ginnery operation and cotton grading are necessary to preserve intrinsic fiber properties to meet the needs of the spinners.

Key Issues:

Variety Improvement and Seed Supply

- Leaf curl virus susceptibility of recently released varieties has resulted in major crop losses.
- The quality, particularly strength and uniformity of current varieties, is deficient for modern textile mills.
- The quality of seed distributed by the informal seed sector is variable and contributes to the problems being experienced with fiber uniformity.

Agronomy

- Irregular plant stands caused by poor land leveling, poor seed quality and poor weed control are constraining yields.

Irrigation

- The area planted to cotton is constrained by the available irrigation water, both from canals and tubewells.

Crop Protection:

- Inefficient control of insect pests, in particular whitefly which transmits the leaf curl virus.
- Indiscriminate use of pesticides is causing pesticide resistance in bollworm and whitefly populations, resurgence of secondary pests and reduction of beneficial insects.
- Under-dosing arising from rising pesticide costs and inadequate extension exacerbates the problem of resurgence of pests.
- Defective spray nozzles and spray pumps result in inefficient spray application.

Ginning:

- Current ginning machinery, mostly copied from imported Continental machines does not adequately preserve intrinsic fiber characters or achieve the grades required by the spinners.
- There is no ginning research to support equipping and training in the ginning sector.

Economic and Policy Issues

- Rising production costs threaten the competitiveness of Pakistan cotton in the world market.
- All inputs such as tractor, fertilizer, pesticide, diesel etc. are available at international prices but seed cotton is purchased below the world price, the benefit going to the textile sector, placing capital equipment such as tractors and their accessories, tube-wells and other such inputs beyond the reach of smallholders.
- Sugarcane production has been protected by a duty on imported sugar leading to a substitution of cotton by sugarcane.
- Credit for farmers is limited.

- Labor costs are rising and availability is likely to decline.
- Cotton quality needs to be enhanced.
- Losses caused by poor grading and ginning are estimated at about 5 million rupees annually.

Study Team Recommendations:

Variety Improvement and Seed Supply

- The solution to the leaf curl virus problem rests with the development of resistant varieties. The possible role of genetic engineering in this endeavor should be considered and if feasible, biotechnology capability should be developed;
- Intensify selection pressure for improved fiber quality, particularly strength, noting the limitations in the use of HVI instrumentation for this purpose;
- Develop quality control regulations to facilitate the supply of quality seed to the growers and revise the seed law to protect intellectual property rights to promote the private seed sector.

Agronomy:

- Studies should be oriented to the development of sustainable cropping systems for cotton, in particular, greater attention is needed in land preparation, the supply of quality seed, the use of fertilizers and weed control to enhance the yield and uniformity of the crop.

Irrigation

- Improve water use efficiency with currently available water through land leveling and improved irrigation scheduling.

Crop Protection:

- Strengthen research on IPM, including pesticide resistance management and plant management to enable growers to control pests in a sustainable, economically viable system.
- Strengthen the education of the farmers in plant protection;
- Monitor the quality and calibration of spraying equipment and the quality of pesticides being used by the growers
- Investigate the cost and sources of pesticides.

Ginning:

- Modernize the ginning industry to increase the GOT and preserve intrinsic fiber quality.
- The establishment of a Ginning Research Institute to provide necessary knowledge regarding the steps to be taken and machinery requirement to achieve the desired quality of ginning and to provide a training platform for the ginners, should be pursued.

Note: The Asian Development Bank has agreed to finance this project with the proviso that the private sector share should be 49.0 percent so that the Institute can become self sustainable and responsive to the needs of the ginning industry.

Economic and Policy Issues

- The local manufacture of appropriate, cost effective equipment should be investigated.
- The efficiency of the textile sector needs to be enhanced.
- Credit against collateral of crops in the field should be considered.

- Cooperative farming should be considered as a means of enhancing the management and economic viability of small holdings.
- Mechanical picking experiments are necessary to prepare for labor shortages.
- Incentives should be introduced for quality. The present incentives framed by CEC should be reviewed from this perspective. It is also necessary that the entire production is identified for quality for each bale or lot ginned by a ginning factory and each lot should bear a tag for staple characters and grade on the basis of samples tested by an institution appointed for this purpose. This grading and classification system should be followed for the entire ginned cotton crop, whether destined for local consumption or export.

Tanzania:

The outlook for **Tanzanian** cotton which has a reputation for being clean as it is hand-picked and roller-ginned, is good. Cotton production in Tanzania is on average only 0.35 percent of world production, and its exports are only 0.82 percent of world exports but since the world production of roller-ginned cotton, is only 15 percent of the total, Tanzania is a major producer in this market. The premium for roller-ginned cotton at present is about 6 US cts/lb. for staple length I: 1 1/8", 4 US cts/lb for staple length II: 1 3/32" and 2 US cts/lb for staple length III: 1 1/16". In the past another premium of 7 cts/kg was achieved due to the cleanliness of hand-picked cotton. This premium has been lost but could be regained if corrections are instituted in handling cotton. Another 2 cts/kg premium would also be achievable if cotton could be delivered to the market in the third quarter of the year. The challenge for Tanzania, therefore, is to maintain the unique features of its cotton in the world market.

Key Issues:

Variety Improvement and Seed Supply

- The quality and purity of planting seed has deteriorated because of failure to observe by-laws and regulations governing cotton production;
- Uncontrolled movement of seed cotton between variety zones is causing mixed varieties and could contribute to the spread of diseases such as *Fusarium* wilt and the dispersion of insect pests such as pink bollworm, *Pectinophora gossypiella*;
- Lack of funds and weak management of seed multiplication have hampered the rapid dispersion of new, high yielding varieties to production areas;
- Limited research facilities have hampered the development of new high yielding varieties.

Agronomy

- The scale of operation is limited by the available implements - mainly hand hoes.
- Field operations are often delayed by competition for labor and equipment.
- Soils have become exhausted through prolonged cultivation without added fertilizers, mainly because of non-availability of fertilizer and/or its high cost, compounded by late procurement and delivery to farmers when it is available.

Crop Protection

- Rising costs and untimely or non-availability of chemicals and spray equipment, including batteries for hand held ULV sprayers, adversely effect crop protection.

- Prior to 1988 Fusarium wilt disease, *Fusarium oxysporium* f.sp. *vasinfectum*, was confined to the lakeshore areas but now it has spread to drier areas of Shinyanga. The incidence of this disease is often associated with root knot nematode, *Meloidogyne acrita*.
- The surveillance of pests and diseases has been hampered by limitations in research.
- The economic importance of nematodes is not clearly understood.
- Seed dressings to control bacterial blight, *Xanthomonas malvacearum*, are often not applied.
- Protective clothing is often not worn by those handling toxic agro-chemical.

Ginning

- Poor processing facilities at rundown ginneries lead to backlogs in ginning, creating storage problems and delay in the acceptance of deliveries by farmers.
- Antiquated gins give a low GOT and produce poor quality lint, leading to a loss of premiums in the international market.

Economic and Policy Issues

- Inputs are restricted by limitations in credit and in timeliness of availability.
- Lower returns from cotton compared with competing crops, such as paddy and maize, have reduced production of cotton. Prices for paddy and maize are higher and their marketing is smooth as the pricing is based on market forces. Due to shortage of food, farmers have tended to give priority to paddy and maize, in preference to cotton. Producer prices for cotton are still low and have actually declined in real terms.
- The buying season is often protracted by liquidity problems of the buying bodies and unions/TCMB, and delayed credits from banks. Crops are collected on credit but society level storage is limited so seed cotton is kept in poor storage in homesteads. The situation is compounded by poor and inadequate feeder road haulage of cotton and inputs.
- Delayed ginning leads to delayed lint sales, tying up money spent by Unions to pay farmers seed cotton and resulting in liquidity problems.
- There is little processing of lint and by-products and poor performance of the textile and oil milling industries. These industries which are mainly under the public sector, have been undercapitalized and mismanaged.

Study Team Recommendations:

Variety Improvement and Seed Supply

- The by-laws and regulations governing cotton production and handling should be enforced to prevent unrestricted movement of seed cotton.
- Annual dissemination of breeder seed to ensure the integrity of zonally designated varieties.
- Establish seed certification to monitor seed production and quality and restore the seed multiplication program to ensure that planting seed is genetically pure and of high quality.
- Existing facilities at Ukiriguru Research Station need to be updated, the air conditioning plant restored and the fiber and spinning test laboratories equipped with modern equipment.

Agronomy

- Encourage the use of ox-drawn implements for cultivation and weeding to facilitate timely field operations.

- Develop more intensive production practices and rational seeding rates to reduce labor requirements, particularly for such operations as thinning.
- Develop cultural practices that incorporate the use of fertilizers and manure in conjunction with appropriate crop rotations, to restore soil fertility, particularly in the WCGA.

Crop Protection

- Research into IPM should be undertaken to reduce the number of sprays required through the incorporation of biological and cultural control measures with chemical controls.
- Successful IPM will depend, in part, on timely availability of chemicals and equipment, including batteries.
- Restore regular surveillance of pests and diseases.
- Determine the economic justification for additional work on nematode control eg. through host plant resistance breeding and/or soil treatment.
- Ensure that the seed processing equipment is in good working order, that the appropriate chemicals are available and that the operators understand the importance of wearing protective clothing when handling toxic products.

Ginning

- A long term strategy is needed to replace run-down ginneries and for the modernization of ginneries to maintain quality and reduce costs
- Private investment in ginneries should be encouraged, particularly in areas where there is a high demand for ginning capacity.
- Cotton ginneries should be self-sustaining.
- Amendments to the Cooperative Act are needed to permit unions to enter into joint ventures with private companies or individuals.

Economic and Policy Issues

- Timeliness in the availability of credit and inputs needs to be assured.
- Constraints in marketing (such as delayed payments, limited village and ginnery storage and poor ginning capacity) need to be resolved. The liberalization of marketing and government withdrawal from controlling the producer price is an important start.
- The buying season should be opened early, and premium payment for early sales and properly graded cotton should be given. This would instill competition among producers. It is important that TACOCA and other buying agencies should pay farmers at least 60 percent of the export price of cotton. Moreover, farmers and other actors in the industry should consider contributing to a price stabilization fund to cushion farmers against fluctuations in cotton prices in the world market.
- The textile sector needs rehabilitation and capitalization, together with divestiture by the government. A deliberate export drive should be initiated to promote value-added cotton exports.

Uzbekistan:

Cotton growing in Uzbekistan faces numerous problems, the most important being declining yield and quality. Approximately 25.0 percent of all farms produce less than 2,000 kg/ha seed cotton and 12.5 percent less than 1,500 kg/ha. The reduction in yield has adversely effected

exports, economic efficiency, labor productivity, profitability and competitiveness of the cotton sub-sector. The cotton area has been reduced from 2.1 million ha in 1988 to 1.5 million ha in 1994 and is expected to decline to 1.4 million ha by 2003 as marginal areas go out of production.

First grade seed cotton accounted for only 31.8 percent of the total in 1992, and the Ginning Outturn (GOT) was only 30.7 percent. Most of the seed cotton produced was low quality which gave low cotton fiber output and reduced profitability on the world market. Recently, all the main indicators of efficiency have been declining; investment returns have declined as have labor productivity and profitability despite increases in the base cost of cotton.

Key Issues:

Variety Improvement and Seed supply

- Declining yield and quality leading to financial losses.
- Varieties that tend to be deficient in various attributes, including GOT, tolerance to wilt diseases and insect pests;
- Cottonseed for planting is not delinted or graded and lacks quality control, leading to variable viability and vigor;
- Varieties are becoming mixed because of the excessive number of varieties, leading to individual ginneries processing planting seed of more than one variety.
- The plant breeding program is supported by reliable fiber tests but the methods are slow, severely limiting the fiber data available for use in selecting for quality.

Agronomy

- New forms of farming, based on individual peasant farms, are being developed but appropriate technology and equipment for small-scale operation on areas of 10-20 ha. is lacking.
- The fertility of the irrigated land has been declining and salination is increasing.
- Inadequate field management is leading to lack of timeliness in field operations, depressing yield and quality.
- Cotton quality is jeopardized by poor defoliation and deficiencies in harvesting and storing seed cotton.
- Current production technology is wasteful of labor, water and energy.

Irrigation

- The most important factors limiting cotton production are the shortage of water resources and the problem of preserving the Aral Sea. This precludes large scale development of irrigation in the vast areas of undeveloped lands.
- The preservation of the area of the irrigated land requires continual development of new land for irrigation to replace degraded land.
- The consumption of water is excessive and the area of saline soil has been increasing due, in part, to the inadequacies of the collector and drainage network, wasteful irrigation technology and inadequacies in the irrigation network.

Crop Protection

- Weeds, insect pests and diseases cause periodic crop losses but the use of herbicides and other chemicals has declined since 1990 because of financial constraints.

- The incidence of nematodes is most pronounced on sandy soils of Surkhan Dar'ya. Root knot nematode is reported to be widespread in this region, causing serious crop losses.
- The environmental hazards of excessive use of pesticides for crop protection have contributed to the problems of contamination of the waters remaining in the Aral Sea.
- Environmental hazards are exacerbated by inefficient application technology.

Economic and Policy Issues

- Declining yield and quality, coupled with the planned decrease in the area planted to cotton, have led to lower production, negatively affecting labor productivity, profitability of cotton production, the competitiveness of the cotton sector and export earnings for cotton.
- Over supply of labor leads to under-employment / low labor productivity.
- Old forms of management and farming that are still in place are to a large extent responsible for the low levels of returns on investment, labor productivity and rate of profitability.
- The transition from a centrally planned to a market oriented economy is creating problems with marketing and developing quality standards.
- The intrinsic quality of cotton is not being preserved during harvesting, storage and ginning.

Study Team Recommendations:

Variety Improvement and Seed Supply

- Develop the breeding program with the objective of producing high yielding, high quality, wilt-resistant, early ripening varieties of cotton for the various ecological zones with a high drought tolerance. As a secondary requirement, they should have a high oil content.
- Develop seed production and certification facilities, incorporating delinting, grading and seed treatment and supported by appropriate quality controls which meet international standards.
- Prevent variety mixing and limit the number of cotton varieties by adapting specific varieties with the properties desired by the textile industry for different ecological zones.
- Enhance the fiber and spinning test facilities which support the plant breeding programs to facilitate adequate testing of breeding material for selection purposes.

Agronomy

- Actively attract foreign capital through joint ventures and implementation of joint projects in such fields as improvement of agricultural machinery and equipment appropriate for the new forms of farming, to accelerate the up-grading and restructuring of the cotton sub-sector.
- Ameliorate soil fertility through the introduction of appropriate crop rotations, increased use of organic fertilizers and by undertaking drainage and anti-erosion measures.
- Ensure timely, well executed field operations, incorporating integrated weed management.
- Enhance short season production technology to facilitate defoliation under favorable soil and climatic conditions.
- Enhance mechanized field operations.

Irrigation

- Optimize the use of available water through the introduction of efficient on farm water management and upgrading the irrigation network.

- Develop methods of soil salinity control such as the use of gypsum, crop rotations, green manures and drainage.
- Expand the area of land under salt tolerant and salt absorbing crops such as sorgo and lucerne (alfalfa).

Crop Protection

- Herbicides need to be introduced as one component of integrated weed management.
- Effective crop rotations and seed treatments are needed to aid in the control of plant pathogens and nematodes.
- The biological control systems that have been developed, including both the rearing and dispersal of bio-agents, need to be refined to ensure economic viability.
- The hazards associated with chemical control need to be minimized through the use of less toxic and ecologically safer products and refinements of the application technology.

Economic and Policy Issues

- The decline in area planted to cotton needs to be offset by increased yields arising from improved production technology. At the same time, the narrow specialization in cotton should be replaced by a diversification into other crops.
- Employment in the cotton sector should be optimized.
- Old forms of farming and management should be replaced and farm workers should be trained in agronomy, farm economics, farm management and in the operation of agricultural equipment to raise the standards of production and increase labor productivity.
- The move away from the centrally planned economic system to one based on the market should be continued and implemented consistently.
- The intrinsic quality of cotton needs to be preserved through improvements in harvesting, handling, storage and ginning.

Workshop Summaries

The following provides a summation of the main points discussed and of the consensus that emerged among the Workshop Participants.

Variety Improvement

While it is recognized that varieties should be developed to meet local growing conditions, more focus is needed on collaboration among plant breeders and international exchange of germplasm. Specific recommendations were;

1. The development of new varieties is a lengthy process, taking an average of about ten years. There is a need to develop techniques to shorten this process. The development of haploid plants through tissue culture is one option that should be explored.
2. There is a need to understand how yield is inherited, how many genes are involved and where they are located, taking account of the relationships between yield and quality.
3. Currently, there is a great deal of emphasis on genetic engineering in cotton, the research in this field concentrating on insect pest resistance and resistance to certain herbicides. Biotechnology should also be used to induce characters such as tolerance to salinity, faster seedling growth, resistance to leaf curl virus etc. However, biotechnology should not be re-

garded as a replacement for conventional breeding methods and breeders should determine the pros and cons of transgenic cotton before embarking on extensive breeding programs and before releasing transgenic cotton varieties for commercial production.

4. India has recorded steady expansion in the area planted to hybrid cotton varieties. However, there is a need to develop better male sterility systems to avoid the demerits of cytoplasmic and genetic male sterility systems.
5. More attention should be paid to breeding for specific local conditions, including abiotic and biotic stresses.
6. A need was recognized to try new gene combinations and to break undesirable linkages. The possible role of biotechnology in this endeavor was recognized.
7. It was recognized that some degree of farmer preference should be permitted in the selection of varieties and that varieties are often needed to fit into specific ecological niches, such as areas of high salinity or where a wilt disease is present in the soil. However, caution is necessary, particularly in small holder production, to prevent mixing of varieties that differ in fiber properties in order to meet the quality requirements of the spinners.

Seed Supply

1. Identification of varieties is an important issue in seed production programs but is difficult with cotton, thus emphasizing the importance of variety maintenance programs to ensure reliable sources of pure breeder and foundation seed.
2. The breeder's role in the seed production was highlighted, particularly with regard to the production of pre-basic and basic seed. Ideally, commercial seed should go through no more than four generations, starting with Breeder Seed, before being replaced.
3. High seeding rates in some countries are a waste of resources and place serious limitations on the development of efficient, economically viable seed multiplication programs. Adaptation of available methods of lowering seed rates without limiting yield should be explored.
4. The production and availability of adequate quantities of certified seed is a problem in all the study countries. There is a need to develop reliable, country specific strategies, involving the private sector in seed production and supply.

Fiber Laboratories

The needs of the spinning industry were presented in a paper by Mr. Sebastian Otto, Chairman of the Spinners' Committee of the International Textile Manufacturers Federation, at a special session of the workshop. Recognizing that cotton is produced almost entirely for the textile industry, the workshop noted the need for:

1. Breeding programs to take account of the fiber quality requirements of the textile industry;
2. Efficient, accurate and repeatable testing methods to assess the real value and spinnability of the fiber. Expansion in the use of HVI systems were noted with a caution regarding the limitations of this equipment in producing reliable fiber strength measurements for use in plant breeding programs;
3. The need for a rapid, reliable method for small scale spinning tests to replace the Shirley Small Scale Spinning System which is no longer available.

Agronomy

Importance of Quality Seeds

The primary problem facing farmers each season is obtaining a uniform, healthy, vigorous plant stand. A number of factors can contribute to poor stands but the primary cause is poor seed quality. The quality of lint varies according to position of the bolls on the plant. Similarly, the quality of seed varies according to the position on the plant. The conditions needed to produce good quality planting seed are the same as those required to produce quality fiber. The production of quality seed requires close attention to the following factors:

- a) In hand picked crops, seed cotton for the production of planting seed should be selected by harvesting only clean, undamaged bolls from the middle of the plant, avoiding the first bolls which are often damaged by rain or boll rot and the last pickings which are often immature;
- b) Large seed cotton stacks should be avoided to facilitate adequate ventilation and so prevent seed deterioration resulting from temperature increases caused by high humidity;
- c) Extended periods of storage should be avoided;
- d) Ginning should be as gentle as possible so as to prevent damage to the seed coat;
- e) Seed should be delinted and gravity separated to remove light, immature seed and heavy, deteriorated seed to ensure good, even germination and vigorous seedlings.

Land Preparation and Fertilization

- a) In rain-fed conditions, it is important to practice early land preparation to permit early rains to infiltrate the soil. Plowing should be at the end of the season but this is not always practical in semi-arid conditions because of the non-availability of adapted equipment and the risk of wind erosion, particularly in the presence of cattle. When soil preparation is not possible before the dry season, it should be carried out as soon as possible after the first rains.
- b) Limited tillage was discussed and could play an increasingly important role. This would require the development of specially adapted equipment and would depend on the use of herbicides. Effective equipment may be too heavy for draft animals.
- c) In irrigated conditions, the first irrigation is for soil preparation so soil moisture at the time of plowing is no problem. However, working soil that is too wet will result in compaction.
- d) Soil compaction is a possible limitation to cotton production and various measures are available to alleviate this problem. However, their application in smallholder production would require specially adapted equipment.

The non-availability of adapted equipment is one of the main bottlenecks for smallholder farmers in the semi arid tropics. Some countries have made great progress in overcoming this problem and could contribute to the solution of the problem in others. The technology exists and requires dissemination, followed by local adaptation.

Seed-Bed Preparation

- a) Seed bed preparation is critical and should be carefully carried out to ensure good contact between the seed and the soil.
- b) Various methods are used in seedbed preparation but the primary goal should be to facilitate rapid, even germination and crop establishment, and to permit uninhibited root penetration.

Make the Young Plant Fit and Ready for Production.

This should be the farmer's motto and calls for timely land preparation and planting, using high quality seed in order to ensure good conditions for vigorous seedling development. This calls for particular attention to the following:

- a) Good root penetration is essential. Cotton is deep rooted and is sensitive to the water status of the soil. Large scale growers periodically use ripping or chisel plows to break up hard pan to facilitate root development, rain infiltration and drainage. Adapted equipment may not be available for smallholders but appropriate rotations with graminaceous and leguminous crops contributes to maintaining the soil in good condition.
- b) In short season rain-fed and irrigated areas, the incorporation of fertilizers, including phosphate (P), potassium (K) and at least a part of the nitrogen (N), is recommended at or before sowing to encourage seedling development. The best solution would be to apply the fertilizer at the time of planting but hand application is time consuming and comes at a time when farmers have many other tasks to perform. The development and adaptation of small equipment should not present insurmountable difficulties but this may be easier than to change the attitudes of farmers and extension agents on the timing of fertilizer applications.
- c) Uniform, vigorous crop development depends on timeliness in all field operations. Cotton is very sensitive to competition from weeds during the early stages of development. Excessive cotton plants can compete in the same way as weeds. Thus thinning and weeding operations must be carried out in a timely manner. Timeliness is often not achieved because of competition for labor with food crops. The introduction of herbicides, at least on part of the farm, could help resolve weed control problems while high quality seed planted at low seeding rates would help resolve the thinning problem.
- d) The rate of nitrogen applied before sowing should depend on the N status in the soil, particularly with rainfed cotton. Excessive N in the presence of abundant soil moisture during the early stages of crop development can result in excessive vegetative growth, leading later on to problems with crop protection.

Water and Soil Management

Anti-erosion projects are not sufficiently frequent and in many cases, deal only with erosion problems at the village or regional level, without addressing the issue of increased water penetration at the field level. Various practices have been developed to conserve water and minimize erosion hazards under rainfed conditions and should be applied to prevent erosion at both the area and farm level. The following practices may have application in certain situations:

- a) Plowing at the end of the rainy season minimizes moisture losses through evaporation and permits infiltration by the first rains, thus permitting early land preparation, early planting, and strong seedling development;
- b) Run-off can be minimized through tied ridging and/or potholing;
- c) Light cultivation of crusting soils after rain can open the soil for easier penetration of the next rainfall.

These practices are not applicable under all circumstances or on all soils. They require the development of special equipment, particularly for smallholders.

In irrigated areas, water management issues also have to be addressed to make better use of available resources and to reduce the problems related to poor water management such as water losses in the feeder canal systems, salinity, waterlogging etc.

- a) All efforts should be made to reduce the use of flood irrigation which is wasteful of water and detrimental to young seedlings, creating stress conditions and suffocation which frequently result in plant losses;
- b) Row or furrow irrigation is quicker and more economical than flood irrigation, and allows better drainage during the seedling stage.

Drainage is a critical issue both at the regional and farm levels in both irrigated and rain-fed production of cotton to prevent an excessive rise in the water table and to minimize the risk of salinity. Drainage systems should be designed in a way that prevents soil erosion.

- a) Field techniques are available to assess the volume of soil that is exploited by the crop roots. Water applications in excess of the crop water requirements will create problems.

Plant Development and Fruit Set

Earliness may come from plant breeding but most earliness results from a good early crop set which keeps the plant from becoming overly vegetative and contributes to minimizing the exposure of the crop to insect pest attack late in the season. The target should be to set a bottom crop as early as possible to assure early maturity. However, the use of chemicals to control early season pests can lead to increased insect activity. Thus technology must be developed to protect the early crop without conflicting with sound IPM practices such as systemic insecticidal seed dressings. Other important practices are;

- a) Fertilizer applications should be balanced, taking into account the need not only for NPK but also for sulphur, boron and other minor elements. Over-feeding the plants doesn't lead to better production. Excessive N leads to an imbalance between vegetative growth and fruit development, causing rank growth which makes the plant more attractive to insect pests and more susceptible to boll rots.
- b) Good early boll set will help to contain vegetative growth, making the plant easier to manage and leading to an earlier crop. Early crop set can be encouraged by careful use of plant growth regulators and boron, but it can be set back by thrip or jassid damage to seedling.
- c) Observation of sound crop production practices, starting from high quality seed and going through timely weeding and thinning, careful use of fertilizers and growth regulators and, where applicable, irrigation will help to shorten the season. Plant growth regulators are an important management tool but their introduction requires local adaptation.
- d) Simple plant mapping techniques have been developed to monitor plant development as an aid in managing fertilizers and plant growth regulators. However, their application in small-holder production may be limited and would probably entail an area wide approach.
- e) Earliness is determined by climate, variety, cropping practices and management.

Many problems of pesticide resistance and quality loss could be avoided through better crop understanding. Early sowing of good quality seed, adapted fertilization practices, early fruit set, early cut-out and early and frequent picking would result in good yields of quality cotton which would be easy to market for the benefit of the farmer and the industry.

Seed Cotton and Lint

Cotton is produced for the spinning mills, so quality is important. With hand picked crops, pick frequently to minimize losses due to weathering and to avoid stickiness. With mechanical picking, ensure effective defoliation, correct settings of the picker and monitor the seed cotton for moisture during storage. Seed cotton that is stored on the farm for any length of time before delivery to the ginnery, should be dry and protected from the elements and from contamination.

Irrigation

1. In the nine study countries, 61 percent of the area and 80 percent of the production of cotton is irrigated compared with 53 percent and 80 percent, respectively, for the world. Irrigation is a major factor affecting sustainability with the potential to increase production or to degrade the environment and reduce production.
2. Salinity and/or water table problems are inevitable with irrigation in a desert or semi arid environment, making drainage mandatory for sustainable production. These threats appear to be contained in all countries except Uzbekistan. The cause of rising water tables varies among countries - seepage from main canals or on farm channels, or over irrigation of fields. Thus, solutions vary from lining of canals to improved on farm water management. Recycling saline drainage water for irrigation must be judicious to avoid accelerating salinization.
3. Brazil, China and Pakistan have the potential to increase the supply of irrigation water. Uzbekistan needs to reduce consumption for ecological reasons. All countries can effectively increase their supply by using existing supplies more efficiently. Old canal systems were designed before modern knowledge of crop water requirements, and when cropping intensity was half current levels. Design of new systems should be based on crop water requirements and economic rates of return on all investments. Farmers should be involved in the management of irrigation systems through water users associations.
4. Most countries described irrigation practices in terms of frequency of irrigation and/or number of irrigations per season and the volume of water used per season. None related these values to crop water requirements as estimated by energy balance. Consequently, the various aspects of irrigation efficiency and risk of salinity or rising water tables could not be evaluated, nor compared country by country.
5. Supply driven irrigation systems carry the risk of over irrigation early in the season, when supply exceeds demand, and under irrigation mid season, when supply is less than demand.
6. Irrigation scheduling, i.e., the use of objective criteria for decision making, does not require the use of hi-tech hardware or software. Simple rules of thumb can be devised to take into account crop water requirements. For "turn" systems, these can be used to determine whether irrigation can be deferred until the next "turn" and if not, to determine the volume of water to apply. Techniques are needed for small holdings to meter specific volumes of water onto fields. Scheduling is more flexible with well water, which is best suited for supplementary irrigation of rainfed crops.
7. Water pricing is a sensitive issue, but is essential if farmers are to have an incentive for better water management, both to conserve water and to reduce negative side effects. One proposal is for farmers to pay for water on a volume basis. The World Bank is committed to

eventually pricing water, but is feeling the way cautiously. Several countries are taking steps towards recovering costs, while another indicated it will not. Pressure for water pricing will come as future demand for water increases in other sections of the economy.

Crop Protection

Over the last few decades, over-dependence on chemical control of cotton pests (including insects, pathogens, weeds, etc.) has led to many adverse effects, notably changes in pest and insect status, an increase in sticky cotton, development of resistance, environmental pollution and health problems. Some health problems were due to defoliant sprays. An increase in certain pests has been associated with changes in cropping practices; for example, more bollworms where wheat or sunflowers are grown, and more *Fusarium* and *Verticillium* wilt where there is an inadequate crop rotation. Outbreaks of leaf curl virus in Pakistan have been mainly due to growing a susceptible variety, but increased vegetable production has contributed to an increased incidence of whitefly.

These problems have led to a greater awareness of the need for integrated pest management (IPM) or in more practical terms - integrated crop management. Key feature of IPM programs require:

- a) An institutional structure to coordinate organizations, including agribusiness;
- b) Training of farmers;
- c) Certified acid delinted seed of pest and disease resistant variety;
- d) Better choice of chemicals (more selective, less hazardous);
- e) More efficient applicators (nozzle selection, very low volume);
- f) Better time of applications (avoid early season sprays, improve action (economic) thresholds, use of seed treatments, lure and kill techniques;
- g) Avoidance of excess fertilizer (imbalance of N);
- h) Cropping systems and habitat management to conserve natural enemies;
- i) Efficient disposal of crop residue and observance of closed season;
- j) Pest and disease surveillance to collect and analyze data in a timely manner for on-line decision making and providing advice to farmers;
- k) Continuous information flow, including radio and television, to provide advice to farmers;
- l) Pesticide resistance management (including transgenic cottons); and
- m) Area wide treatment e.g., pheromone applications.

Ginning

There was very little discussion of ginning and the only point raised concerned the possible role of cage ginning in improving the regularity of cotton to the point where it could overcome the problem of mixed varieties. It is doubtful if cage ginning would contribute to improving the regularity of lint from varietal mixtures unless they were fairly similar to start with. It could give greater length uniformity, but would have no impact on such characteristics as fiber strength, elongation or intrinsic fineness.

Economics and Policy

Production Economics:

- The profitability of cotton needs to be considered in the context of its profitability relative to that of competing crops, and also the relative profitability of the cotton crop rotation compared with the other crop rotations.
- In calculating economic benefits of cotton production, the value of all byproducts oilseeds, feed cakes and stalks should be considered, in addition the value of the lint..
- Price and income stabilization of cotton growers can be an important issue in the transitional period of liberalizing cotton production and trade. Floor price and stabilization funds could be considered as transitory measures to avoid large fluctuations in prices and incomes and to ensure regularity of supply to the textile industry.
- Floor prices should be announced in advance of planting the crop in order to help farmers make decisions on resource allocation.
- International competitiveness as measured by DRC ratios should be considered by policy makers when determining investment alternatives.
- Lack of market information is a major constraint in the current marketing system of cotton in many countries. Improvement in information flow should be addressed for countries moving towards market liberalization.
- Crop forecasting is important for market development and often needs attention in developing countries.
- Credit is vital for cotton producers, traders; and exporters, to help finance heavy infrastructure costs related to production, ginning, storing and marketing.
- Premiums for higher quality lint in the international market should be reflected in farmgate prices to encourage quality lint production. The classification of seed cotton at the ginnery should be based not only on color and grade of seed cotton, but also on fiber characteristics.

Government Price Intervention:

- Participants noted that the textile ministry within the government of India determines cotton policies. In the last two years, there has been a policy of liberalization but, it was also noted, that higher farm prices would lead to increases in yield per hectare because farmers would be willing to apply more inputs. In many cases, prices of inputs are still subsidized to partially compensate for policies which decrease output prices. This distortion needs to be corrected.
- Participants noted that the trend is to allow greater autonomy to producers. However, questions regarding cotton policies included social implications. If cotton prices are demand driven, could textile industries in developing countries be competitive? The answer to this question is linked to protectionist policies of competing textile industries in other countries

Cotton Quality:

- Some reports indicate that cotton does not meet the quality standards desired by mills. Pakistan is a case in point. Further, it was noted that the difference in international quotes for cotton from the San Joaquin Valley of California in the United States of America (SJV cotton is typically the highest quoted in the upland category because of inherent quality characteristics, including strength, fineness, grade, color and uniformity) and the Cotlook B Index™ (an

indicator of prices for coarse-count cotton) declined from more than 30 US cents per pound in 1986/87 to 13 cents in 1993/94 and to 8 cents during the first three months of 1994/95. This might indicate that the structure of demand for cotton in the world is shifting toward coarse-count cottons, placing a lower premium on traditional standards of cotton quality. However, the premium increase in the mid to late 1994/95 season reflected the shortage of SJV cotton.

- Participants noted that the textile industry has shown little enthusiasm for paying premiums for improved quality. However, there are price differentials between varieties and areas of growth, based on quality differences and the end use of the cotton. Thus there are price differentials between California SJV cotton and Memphis cotton and between Memphis cotton and Texas cotton, based on quality. Similarly Tanzania, Uganda and Zimbabwe enjoyed premiums because of the quality and regularity of their cotton. The price differential does not necessarily off-set differences in yield between the high quality and other cotton varieties
- It was noted that enforcing single-variety regions is a better way to achieve desired quality characteristics, given that ecological concerns are met and that reasonable yields will be achieved. It was also stated that regulations are important and necessary in countries where farmers do not receive accurate price signals. Furthermore, because cotton markets span the world, it is impossible for price signals from spinners on different continents to reach producers selling in small, isolated and fragmented markets.
- A participant noted that spinners will pay for quality characteristics that improve the product they are producing, but that different qualities are needed depending on the product being made. Newer spinning machinery is capable of making higher-quality textile products than was possible with older systems in the past, from the same quality cotton.
- Some participants noted that regulations are not sufficient signals for quality and that policies should encourage market competition to ensure accurate communication of price signals.

Parastatals

- Parastatals were created originally to market agricultural inputs, outputs and services, but over time many became involved in the entire production chain. Parastatals have been particularly important in Africa, and in the cotton sectors of two study countries, Tanzania and Mali. Parastatals have been both criticized and praised. In a 1990 World Bank study, (Knudson) parastatals were found to create tremendous distortions in incentives, operate inefficiently and drain national treasuries. These costs occur because of the influence of parastatals on commodity and input prices, and problems in their design and management. However, parastatals have also been praised for stabilizing prices, providing inputs and information to farmers, fostering regional economic development and for providing an organized chain of services supporting the cotton sector. The country reports for Mali and Tanzania suggest reduced roles for parastatals in those countries.
- In some countries, parastatals were created originally to control foreign exchange earnings from the cotton sector, but as economies have been liberalized and exchange rates freed, need for parastatals declines. Also, parastatals have sometimes been created as a means of extending government control and to create employment. Overall, the performance of parastatals has been disappointing.
- In deciding whether the role of parastatals in an economy is justified, the state of economic development must be considered. In some cases, greater government organization of markets is needed and parastatals may be appropriate, even though their role may be re-defined. In other cases, governments should act more as a regulator and observer of market conditions.

Some parastatals created decades ago no longer serve their original purpose. For instance, government corporations intended originally to serve the interests of cotton producers may now serve primarily the interests of the textile industry, because of a shift in political power.

- Participants from Brazil noted the success of the privately owned farmers' cooperative in the state of Paraná. The cooperative is involved in several crops in addition to cotton and provides numerous services, including finance, technical assistance, ginning and spinning facilities for cotton, and cooperative purchasing of inputs. The Organization of Cooperatives of Paraná State (OCEPAR) accounts for one-third of all cotton produced in Brazil.

Inputs Policy

Timely availability of inputs coupled with changing prices and alternative sources of supply are issues as input markets are liberalized.

a) Water

- Expansion of irrigation facilities may be sensible in (e.g. China, Pakistan, India, Brazil), but overall scope of irrigation area expansion seems limited.
- International focus is on increasing water resource management. Productivity gains will focus on irrigation use efficiency.
- Responsible and more efficient water use should increase as government subsidies decline, shifting focus to on-farm water management issues.
- Development of water markets will be a challenge of the future.
- Environmental concerns must be integrated into irrigation development decisions.

b) Credit

- Most developing countries recognize lack of credit as a constraint to cotton productivity but most countries also recognize mis-allocation of formal credit. Credit access of smallholders is a problem. Government subsidized credit has prevented the development of alternative credit institutions, costs have been high and loan defaults have also been high. Access to credit for all scales of producer must be improved.
- Subsidies on interest rates are being phased out in most countries but access to credit remains an issue in several countries.

c) Seed

- The roles of public sector/parastatals and the private sector need to be redefined.
- For seed supplies and development, maintaining quality is critical.
- Breeding new varieties should generally be an option for public sector development.
- Government policies must encourage greater availability of certified seed to producers.
- Low percentage of certified seed is a constraint in several countries (e.g. 10 percent in India and 30 percent in Pakistan).
- A combination of public and private sector participation in seed production was thought by most participants to be appropriate.

Research

1. There is an increased role for the private sector in cotton research in areas such as seed production and adaptive research.

2. To encourage the private sector to share research findings, actions such as the sharing of pre-basic and basic seed with the private sector, should be enhanced. Provision of funds should include establishing competitive and matching grant systems from the funds/taxes/levy levied on the commodity.
3. The group called for collation of research efforts and networking on specific, common areas such as IPM, stickiness and quality upgrading required by the spinners. Funding for such specific networking should primarily be from the main stake holders i.e. spinners, ginners and producers. There is a role for the ICAAC in assisting expansion of the exchange of information among cotton producing countries.

Extension

1. Increased farmer participation is essential at all levels of extension. If Integrated Crop Management principals, including IPM, are to be implemented at the farm level, the message should be based initially on farmer considerations and their environment (bottom up);
2. Farmer education and training programs need strengthening. They should be demand driven and not routine;
3. Research-Extension linkages are weak and need further strengthening by incorporating formal, organized feed back from the farmers, ginners and the spinners.

Transportation and Storage

Road construction and maintenance are generally regarded as government functions and although they are critical to the cotton industry, they are also critical to all other activities. Discussion at the workshop on this topic, therefore, was limited.

The method of storage is influenced by the climate. Traditionally, seed cotton awaiting ginning in the USA, Israel and Australia where the ginning season is restricted, has been stored in cotton wagons but these have largely been replaced by modules. Seed cotton storage in other countries may be loose in large stacks in the open (e.g. China and Uzbekistan), in some kind of container in stacks in the open (e.g. Tanzania (bags), Uganda (cloth squares) and Zimbabwe (jute woolpacks)) or it may be stored loose or in a container under cover. Deterioration during extended period of storage has the potential to be serious.

The main points raised were:

- Poor road conditions have contributed to the drop in production in Tanzania;
- The expansion in production in the middle west of Brazil and in the northwest of China could result in serious problems with the transportation of bales of ginned cotton lint and could increase shipping costs significantly;
- In Mali, the maintenance of rural roads in the cotton producing area is one of the functions performed by the CMDT;
- The transfer of seed cotton to modules could ease the storage problem and improve ginning efficiency under some circumstances.
- The problem of deterioration in storage is one of management rather than method or length of storage. Seed cotton with a high moisture or trash content is likely to deteriorate rapidly and should be ginned first. All other seed cotton should be monitored regularly and ventilated or ginned immediately if there is any significant rise in temperature.

Contamination

- The method of handling cotton from the field into storage and during transportation reflect the potential for contamination.
- Grading of hand picked seed cotton and removal of potential for contamination begins in the field and is a reflection of the level of training of the pickers.
- The practice of picking cotton early in the morning, even when it is wet with dew and then laying it out in the sun to dry, leaves it exposed to possible contamination.
- In discussing the use of cotton bale wrapping, the importance of using cotton wrapping was stressed. In India, export bales are wrapped according to specifications while less stringent packaging requirements are observed for delivery to domestic customers.
- Some storage of seed cotton is inevitable and some ginners regard it as necessary to improve the quality of ginning. However, this can expose the seed cotton to contamination.

Production Information

- Production information is required by the ICAC and other organizations to monitor the supply and demand situation as an aid to orderly marketing. It is required by the cotton producing countries to monitor performance and facilitate planning for the sub sector.
- The information should include not only area planted and projected production but also information on the prices of inputs and outputs to aid in financial analysis.

Regulatory Functions

There are several regulatory functions which have traditionally been performed by the government and have been delegated to parastatal marketing organizations in countries where they exist. In many countries, parastatals are being disbanded and their functions taken over by private enterprise. However, certain regulatory functions should remain in the hands of government, including the compilation and dissemination of production information, quality control, the registration of varieties, seed certification and the registration and regulation of pesticides.

Quality Control

- Any experienced marketing organization is able to assess the quality of cotton. Increasingly, this is being achieved with HVI instrumentation. However, an independent body is necessary to set and monitor the standards and to act as arbitrator in the event of a dispute. Similarly, any private or public organization can establish an adequate seed laboratory but in the same way as cotton classification, seed certification requires an independent body to set and monitor standards. Both these functions should fall to the government.
- The possibility of using selective ginning¹ could replace the single variety zone. It is unlikely that this would be achieved because of differences in fiber properties between varieties other than fiber length.
- Both India and Pakistan have legislation on single variety areas but with the large number of farmers and lack of certified seed, the implementation of the decree is doubtful.

¹ The cage gin was developed in the USA to selectively remove longer fibers first, leaving a small amount of shorter fiber for removal on a conventional saw gin. So far, the principle has not found favor commercially because the price differential for the higher quality lint does not offset the losses on the low quality lint.

- The delegation from Tanzania pointed out that the mixing of varieties was not necessarily the result of market liberalization but was the result of several causes, including:
 - (a) Non observance of rules and regulations governing cotton growing and marketing; and
 - (b) The collapse of the seed multiplication and distribution system.
- To ensure that this is corrected, it has been recommended that:
 - (a) The government enforces the existing rules and regulations;
 - (b) The TCLSB should take over the seed multiplication role at least for the supervision of production and distribution if not production altogether;
 - (c) The long term objective is to have private enterprise involved in this function;
 - (d) Introduce seed certification.

Pesticide Use and Deregulation of Pesticide Markets

Deregulation of pesticides has created problems with uncontrolled distribution in China, India and Pakistan, leading to the development of pyrethroid resistance in *Helicoverpa armigera*. The government needs to be involved to protect the farming community and the environment and in facilitating the implementation of IPM strategies.

- The government must maintain an effective institutional framework for the registration and regulation of pesticides.
- The government should monitor the quality of pesticides being marketed;
- Research organizations should provide information which is independent of commercial bias on the most appropriate pesticides to use in specific situations.

CHAPTER 7

CONCLUSIONS

In supporting the Cotton Production Prospects Study, the Common Fund for Commodities was looking to the study and workshop to develop a global strategy for cotton. This strategy was to determine the main problems to be solved, taking into consideration the structural conditions of the cotton industry. The study was intended to point the way to solving the problems through changes in research, production technology, institutional arrangements and marketing.

A global strategy for cotton would provide the basis for an organized and systematic approach by development organizations to assist countries exploit the potential in their cotton sub-sectors. Consequently, the study was undertaken to be a guide for both national and international efforts. In the case of The Common Fund, it was intended to provide a basis for other cotton commodity development projects which it might assist.

The study has revealed certain technical issues which are common to all countries such as seed production, the procurement, distribution and utilization of fertilizers and other agricultural chemicals, the development of IPM strategies and improvements in irrigation practices. Varieties should be treated on an area wide basis to take account of the needs of the textile industry for regularity of quality and necessary provisions are needed to ensure regularity of supply. Regulation of pesticides is an important issue to restrict the use of the more toxic products and to reduce the likelihood of resistance developing in target insect pests. IPM and unrestricted distribution of pesticides may be incompatible and need to be looked at on an area wide basis. The area may overlap political boundaries as in the case of the CFC supported Boll Weevil Eradication Project in Latin America.

When it comes to mechanization, the needs of each country depend on the scale of production and the status of the farming community. China and other countries have developed small tractors with appropriate equipment for smallholders but many developing countries are short of fuel and do not have the workshop facilities to maintain this type of equipment. Thus smallholders require specially adapted and generally animal drawn equipment. They can only use equipment designed for large scale production if they have consolidated areas of land under cotton and can treat the whole area as a single unit. Appropriate technology is needed to suit the scale of production. The CMDT in Mali has made significant contributions in this regard.

The policies of the study countries differ widely, depending on their market orientation. Thus in Uzbekistan, Mali and Tanzania, production is geared to export of raw cotton while in Brazil, China, India and Pakistan, it is geared to the domestic mills, the main exports being value added products. Mexico occupies a unique position because of its proximity to the USA, with large quantities of Texas cotton being utilized by the Mexican textile industry.

There is ever increasing pressure for governments to liberalize price and trade restrictions and to increasingly devolve responsibility to the industry for its own development and provision of services such as research and extension. In such cases, the sequencing of privatization of the industry is crucial so as not to unduly disrupt production, quality and technology gen-

eration and dissemination. Parastatal marketing organizations are not necessarily inefficient and in some countries, government research and extension services have performed adequately and have the advantage of being independent of commercial interests. Nonetheless, there is no doubt that financial support from the industry provides an opportunity to enhance the quality of research and extension, not only by providing additional funding but also by strengthening the links between research and extension and the industry they serve.

The study report is meant to benefit, in particular, the cotton producing countries in the study. The findings, problems and objective needs in the report can be used as a basis by these countries for their own cotton research and development programs, e.g., through policy reforms or other measures. This could include investment projects which introduce new technologies and processes, with a view to enhancing the competitiveness of cotton through productivity and quality improvements. These measures should be devised in such a way that the investment projects would be conducive in attracting private investors or loans from bilateral and multilateral sources. Due regard should be given to health and environmental aspects, while special emphasis should be given to ensure that the main benefits accrue to the cotton growers, in particular the small holders.

The report should also provide bilateral donors and multilateral development or financing agencies with guidelines when considering assistance for cotton development projects. For the International Cotton Advisory Committee in particular, it will provide valuable material in drawing up a long-term strategy for the commodity.

The country study reports have been summarized in the synthesized report to give the main highlights. In so doing, the authors have attempted to provide the necessary guidelines for future development. However, the country reports themselves contain a great deal of additional detail on projects which the study teams consider to be of importance to the future of cotton. Any government or donor organization considering a cotton sub-sector improvement project in any of these countries should study the relevant country report. There is no provision to publish them in full for broad distribution but they will be available on request from the World Bank.

The findings of the study need not be confined to the nine countries participating in this particular Cotton Prospect Study but could have application in all cotton producing countries, by serving to identify common problems. Through joint efforts, projects aimed at solving common problems which require financing by bilateral or multilateral donors, could be proposed. Two such projects are already being supported by the CFC, the boll weevil eradication project in Argentina, Paraguay and Brazil referred to above and a study on stickiness and sucking pests involving Israel, Egypt, Ethiopia and Zimbabwe.

The workshop is a good example of cross-boundary, international cooperation which should continue. Effective international cooperation needs a network for exchange of information, ideas and experiences among the national research and other relevant institutions. To a large degree, this is being provided by ICAC. One of the main functions of their Technical Information Section is to monitor research in various countries and to develop and facilitate communication among researchers. They contributed to the establishment of a research network in Latin America and collaborated with CIRAD CA in developing similar networks in Sub Saharan Africa and in the Mediterranean and Middle East, they have staged a regional meeting for South and Southeast Asia and were one of the main instigators of the highly successful First World Cotton Science Congress in Australia in 1994. The provision of a newsletter by the ICAC could be achieved with their existing facilities if researchers would submit information on activities in

their regions to the Head of the Technical Information Section on a regular basis. This could lead to the development of an Electronic Mail Network such as that suggested for the exchange of information on IPM. Regional networks of this type could aid in planning crop production and protection strategies during the cotton season.

However, not only information and ideas should be exchanged. Other and more concrete forms of cooperation can be set up among the producing countries such as exchange of germ-plasm or joint efforts in managing and controlling pest and other cotton diseases. The initiatives of the ICAC, CIRAD CA, the FAO and others in promoting regional cooperation through the establishment of regional networks and the staging of regional meetings should be encouraged and taken into consideration in developing cotton improvement programs. The World Cotton Research Conference might also become a permanent feature every four to five years, leading to cooperative research initiatives.

Two issues stand out as crucial to the prospects of cotton for the decade to 2005. The first is that as the transition to more open market economies occurs, the mechanism must be put in place to facilitate the flow of price signals not only from the world cotton market but also from the domestic and world wholesale/retail sectors of textiles back to the cotton production sector. The second which is coincident with or a precondition for the transition to open cotton/textile economies, is the development of instruments that will provide the means for minimizing risk in conjunction with the move to more open cotton/textile economies, to enable private institutions to take over the functions of parastatals in a more efficient manner.

The flow of price signals without distortion is important if private institutions are to assume the roles previously held by government entities. Exhibit 3.1 and 3.2 on pages 141 and 142 illustrate the textile marketing flow and the failure of price signals to flow through the textile industry. The failure of international cotton price signals to be transmitted is obvious. They can only be put in place by removing input subsidies, modifying exchange rate policies, and disbanding inefficient parastatal marketing institutions that have not only subsidized inputs but also fixed farm prices. However, price distortions in the entire cotton/textile industry must be addressed. Liberalization of textiles in countries with small industries is likely to have an adverse impact if they are competing with the textile industries of countries that continue with textile subsidies. Liberalization of the cotton production and marketing sectors could result in non-profitability for a textile industry that was operating with subsidies. This must be done in the light of the global circumstances surrounding subsidized textile industries.

Risk management can be defined in several ways but typically involves both price and production uncertainty. Developing countries do not have access to a Futures Market to manage price risk or to initiate a crop insurance program that insures against production risk. Cotton merchants typically assume the role of providing insurance against basis risk while speculators in Futures Markets generally provide the overall insurance against price risk. Spot or cash markets must be established together with contract sanctity. Well defined procedures with supporting instruments can then be developed for forward contracting. Governments should look at methods of insuring against production uncertainty that do not distort market signals. Instruments are not limited to contracts and spot and forward markets but include the collection and dissemination of accurate, timely and unbiased market information to market participants.

The study teams were asked to prepare Problem Trees in which the core problem facing the cotton industry was identified along with the causes of this core problem. These were then arranged in the form of a hierarchy, giving a diagrammatic illustration of the cause and effect

relationships of the subsidiary problems contributing to the core problem. Exhibit 7.1 gives a generalized, schematic outline of major problem categories with broad, general cause and effect relationships. However, this is not exhaustive but is indicative of the major problem areas that may require attention. They can be broken down still further, using the same cause and effect relationship to identify fundamental problems that need attention, in order of priority, in order to solve the core problem. Individual countries have provided sub-sets of problems without necessarily identifying problems in all of these categories.

Once the Problem Tree is complete, the objectives can be analyzed to describe the future situation that would be achieved by solving the problems and to identify potential alternatives for their solution. Objectives Trees can then developed by relating all the negative conditions of the Problem Tree into positive conditions that are desirable and realistically achievable. The completeness of the diagram can be verified by examining the means and end relationships.

Most of the country reports contain detailed Problem and Objective Trees which can be revised with new objectives added if they appear to be relevant and necessary to achieve the stated objective at the next higher level, or deleted if they do not seem to be expedient or necessary in preparing Project Planning Matrices. There was considerable variation in the detail provided by different countries but clearly, the teams went to a great deal of effort in carrying out these exercises. Although it has not been possible to publish the contributions of each country for various reasons, it is strongly recommended that individuals or organizations interested in exploring the possibilities of investing in the cotton industry, either of one of the study countries or of other cotton producing countries, should study the problem and objective trees in detail. They are contained in the country study reports which are available on request from the Agriculture and Natural Resources Department of the World Bank.

The teams were also asked to break the objectives in the Objective Tree down into Short, Medium and Long Term objectives and to prepare corresponding short, medium and long term matrices in the form of Project Planning Matrices. This should provide a summary of why a project is considered necessary (Overall Goal and Purpose), what the project would be expected to achieve (Results), what actions would be necessary for the project to achieve these results (Activities), which external factors would be essential for the success of the project (Assumptions), how success could be assessed (Objectively Verifiable Indicators), where to find the data necessary for this assessment (Means of Verification) and what it would cost in input and finance. The Results and Activities were broken down into Technological, Institutional and Policy components. The Assumptions are conditions which must exist for the project to succeed but which are not directly under its control while the Objectively Verifiable Indicators define the performance standards to be reached in order to achieve the objective by focusing on the important characteristics of an objective and providing the basis for monitoring and evaluation.

The study Cotton Production Prospects for the Next Decade was initially conceived as a study of the technologies which are being developed or may be necessary to ensure expanded production of cotton to meet the expected increase in demand in a sustainable agricultural system. Studies of policy matters were added because of their impact on the development and implementation of new technologies. However, it did not attempt to make an in depth study of the linkages between cotton production and the textile industry, or the implications of changes in policy which are being implemented, particularly regarding privatization of marketing, for the marketing chain and the spinning industry.

It is clear from the study that cotton is an important commodity in each of the nine countries in the study, providing employment opportunities and generating cash flow in the rural sector and providing the country with foreign exchange earnings either for raw cotton exports or for value added products. Where applicable, the textile industries are major employers and generators of foreign exchange earnings. However, it is equally clear that each of the nine countries has its own objectives which may be the production and export of raw cotton, the production and export of cotton yarn, the provision of raw material for an industrial complex or the support for an informal spinning and weaving industry. These industries rely on regularity of supply and quality to survive and are not able to absorb wide fluctuations in raw material prices without having a ripple effect right down to the consumer.

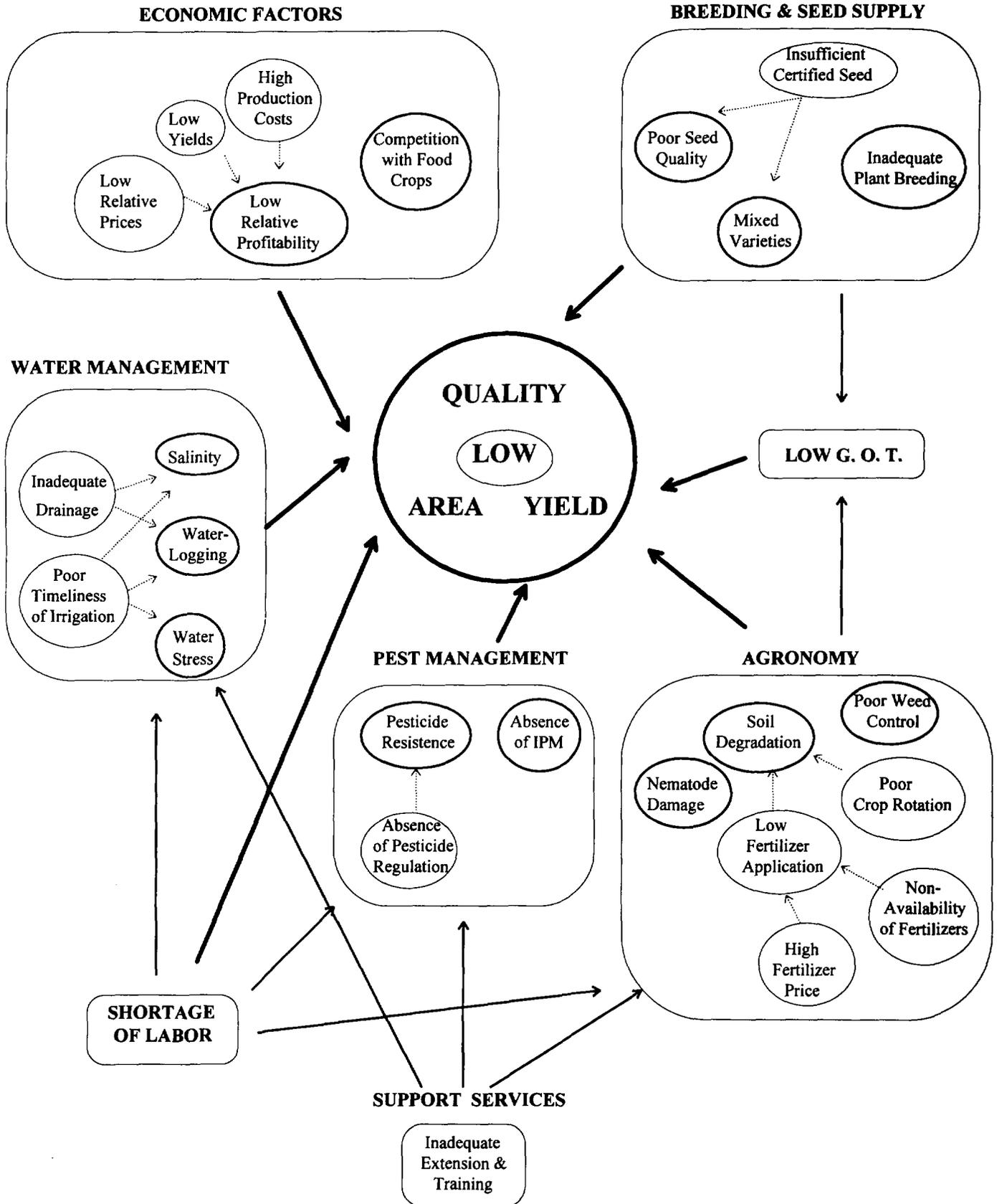
The policy section of this study is more descriptive than analytical and does not attempt to completely evaluate agricultural policy either in terms of the policies of individual countries or for key policies common to most countries. Evaluation is generally partial and is in terms of inefficiencies or the absence of price linkages both for inputs and output and the taxation of farmers to support other policies. It does not go in sufficient depth into the impact of linkages between research, extension, the producer, the ginner and the market on production efficiency.

Many countries use price support mechanisms for farmgate cotton prices and in general indicate that this policy is likely to continue. No attempt has been made to examine the trade-off between price stabilization and the return as measured by the level of prices. The analysis suggested by Newbery and Stiglitz (1981) could be used to calculate the benefits of the current pricing system. The cost of price stabilization should be examined not only from the viewpoint of the farmer but also for government expenditures and the impact on all parties in the cotton/textile complex. There are alternatives for price risk management that could be more efficient and less costly in dealing with cotton price risks. These alternatives can be market based and are not limited to the establishment of commodity exchanges or forward contracts. However, the necessary instruments (institutional, legal, and regulatory) must be developed in order for governments to make the necessary changes in policy for alternative price risk management arrangements to work.

Production risk, especially in rain-fed areas, is another issue that was not addressed and is left for future studies. The question of crop insurance, the program currently in place in the United States, either by the government or private insurers, is also left for future study.

Cotton is an industrial crop whose fiber is the basic raw material for the textile industry. Textile policy and linkages between the cotton and textile complex must be determined in much more detail than were possible in this study. They are touched on in this report in order to ascertain the full implications of the impact of policy changes. Clearly, there are several issues that need to be addressed in follow up studies.

EXHIBIT 7.1: PROBLEMS IN COTTON PRODUCTION



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GLOSSARY

Acaricide	Pesticide for the control of spider mites
Acid Delinting	Treatment of ginned cottonseed by wet or dry process with sulfuric or hydrochloric acid to remove the linters and fuzz when preparing planting seed.
American Egyptian USA from Cotton	Varieties of the species <i>Gossypium barbadense</i> developed in the Egyptian lines. See Pima
Apparent Consumption	Domestic mill consumption of cotton plus the fiber equivalent of imports of cotton manufactures minus exports of cotton manufacturers.
Arboreous cotton	Long staple, semi-perennial tree cotton, known as moco-serido, originally from the Brazilian semi-arid region
<i>Bacillus thuringiensis</i>	A bacillus which produces an endotoxin that disturbs the metabolism of Lepidopterous larvae when ingested, leading to death.
Bio Pesticides	Pesticides produced from disease organisms that attack insect pests such as <i>Bacillus thuringiensis</i>
Biological Control	Control of insect pests by their natural enemies.
Boll Weevil	<i>Anthonomus grandis</i> , a weevil found in North and South America that develops in the cotton boll, feeding on the developing seeds.
Bollworm	Several species of Lepidoptera that feed on cotton bolls.
Botanical Pesticides	Plant products such as extracts of the Neame Tree that have insecticidal properties.
<i>Bracon herbator</i>	A parasitic wasp that parasitizes the larvae of various Lepidoptera.
Canvas	Strong, firm, compact fabric usually made of cotton, jute, flax or hemp in plain or double-end plain weave of single or plied yarn. The mass ranges from 200 to 2,000 g/m ² .
Carded Yarn	Yarns made from fibers that have been carded to remove short fibers and impurities and to form a web during the manufacturing process.
Cerrado	Savanna soil
Chemical Control	Control of insect pests through the use of chemical pesticides.
<i>Chrysopa cornea</i>	Gold eye lace wing that is predatory on the eggs and young stages of insect pests such as aphids.
Combed Yarn	Yarns made from fibers that have been combed after carding to remove additional short fibers and impurities during the manufacturing process to make yarns smoother and more regular.
Cotton Bale	A package of compressed cotton lint after ginning, tied with wire or metal bands and wrapped in cotton, jute or polypropylene. Bales vary in weight in different countries but the universal density bale weighs 220 to 225 kg, has a density of 448 kg/m ³ and measures nominally 1.400 X 0.53 X 0.69 m.
Cotton Bolls	The fruit of the cotton plant. Usually divided into three to five segments, locs or locules.

Cotton Bollworm	Also known as American bollworm. The larval stage of <i>Heliothis armigera</i> or <i>H. zea</i> (America), a major pest of cotton and a wide range of alternative host plants in most cotton producing countries. Larvae feed on buds, flowers and bolls.
Cotton Gin	A machine used for separating the cotton fiber from the seed
Cotton Ginning	The process of separating the cotton fiber from the seed.
Cotton Lint	Cotton fiber that develops as an extension of cells in the walls of developing cottonseed.
Cottonseed	The seed of the cotton plant
Cultural Control	Control of cotton pests through cultural means such as manipulation of the planting date to escape insect attack.
Defoliant	A chemical used to accelerate leaf shedding to facilitate less trashy seed cotton picks, particularly when mechanically harvested.
Denim	Warp faced heavy cotton twill made from yarn-dyed warp and undyed weft or filling yarns.
Desi Cotton	Old World cotton of the species <i>Gossypium arboreum</i> and <i>G. herbaceum</i> , grown mainly in South Asian countries.
Economic Action Level	The level of insect infestation in a crop at which control measures are necessary to prevent economic losses.
Economic Threshold	The level of insect infestation in a crop above which economic losses will occur.
Egyptian Cotton	Long Staple and Extra Long Staple cotton varieties of the species <i>Gossypium barbadense</i> developed in Egypt.
ELS Cotton	Extra Long Staple cotton. Staple length 1 3/8" or above.
Endotoxin	A toxin that requires ingestion to become toxic.
Fiber Fineness	The outside perimeter or outside diameter of the fiber.
Fiber Maturity	The degree of wall thickening of the fiber.
Fine Filter Cotton	LS and ELS cotton produced from <i>Gossypium barbadense</i> varieties in the Central Asian Republics.
Fineness/Maturity Tester	An instrument which measure the resistance of a plug of cotton to airflow at (FMT) two different pressures to differentiate between fineness and maturity.
Flower Terminator	Chemicals that terminate flowering and hasten opening of bolls nearing maturity.
Genetic Engineering	The transfer of genetic characters between species to enhance the performance of the recipient species in some specific characteristic.
Glands	Structures that look like black spots in the seeds and above ground portions of the cotton plant.
Gossypol	A substance that is toxic to non-ruminant animals and is one of the main constituents of the glands
Herbaceous cotton	Medium staple, annual cotton
Herbicide	A chemical developed to control unwanted vegetation eg. weeds.
Hulls	The outer shell of cottonseed
HVI Test Line	High volume instrument test lines for rapid assessment of fiber length, uniformity, micronaire, strength, elongation, color and trash content.
Hybrid Variety	A variety in which the planting seed is the first or second generation following a cross between two breeding lines.

IPM	Integrated Pest Management is a system of pest management that incorporates all aspects of pest control, including cultural practices, biological control, natural control, pheromones and discriminate chemical control.
Interplanting	A second crops planted between the rows of the primary crop such as mung beans planted between rows of cotton.
Interspecific Hybrid	A hybrid between lines or varieties of different species.
Intraspecific Hybrid	A hybrid between lines or varieties of the same species.
Leafworm	Lepidoptera larvae that feed on the foliage of the plant.
Lepidoptera	Butterflies and moths.
Linters	The short fibers remaining on cottonseed after ginning
LS Cotton	Long Staple cotton. Staple length 1 1/8" to 1 5/16".
Machine Delinting	Mechanical removal of linters from the surface of cottonseed.
Male Sterile	Plants that have been bred to produce sterile male flower components.
Micronaire	An instrument for measuring the resistance offered by a plug of cotton to airflow. This is influenced by a combination of fineness and maturity
Mites	Minute pests related to spiders that feed on the underside of leaves.
Motes	Undeveloped seeds
Muslin	Plain weave cotton fabric.
Mutation Breeding	Breeding systems in which chemicals or radiation are used to create mutations in the genetic system.
Natural Control	Control of insect pests exerted by natural phenomena such as winter freeze, rainfall etc.
Nematicide	Pesticide for the control of nematodes.
Nematode	Microscopic wormlike creatures that attack the roots of plants. Some species cause galls (root knots) while others restrict root development, in both cases leading to loss of yield and quality.
Neps	Small clusters of fiber which is usually immature, often attached to a seedcoat fragment (seedcoat nep).
New World Cotton	Varieties of cotton of the species <i>Gossypium hirsutum</i> and <i>G. barbadense</i> which had their center of origin in the New World.
Non Cellulosic Fiber	Man-made, organic, synthetic polymer base fiber eg. Polyester (introduced 1941).
Oil Expeller	Screw press for pressing oil from vegetable oil seeds.
Oil Expression	Pressing oil from the seed of vegetable oil crops, including cotton.
Old World Cotton	Varieties of cotton of the species <i>Gossypium herbaceum</i> and <i>G. arboreum</i> which had their center of origin in the Old World.
Pesticide	Chemicals for controlling pests.
Photosynthetic efficiency	A measure of the ability of the plant to utilize available sunlight for photosynthesis.
Pima	Cotton varieties developed in the USA from importations of seed from Egypt
Plant Growth and Regulator	A chemical substance that influences the development of the plant regulates the length of the branches and main stem (eg. PIX™) or accelerates boll opening (eg. PREP™).
Polyester	Man-made, synthetic polymer base fiber introduced in 1941 and utilized in filament (continuous) or staple form.

Polypropylene	Man-made, synthetic polymer based fiber widely used for packaging. Contamination of cotton lint with this material can cause serious problems during textile manufacture.
Potholing	The practice of making holes at intervals through the field to reduce run-off and increase water infiltration.
Pyrethroid	Botanical pesticides extracted from the daisy species <i>Pyrethrum</i> .
Relay Cropping	The practice of sowing a second crop between the first crop shortly before the first crop is ready for harvesting.
Restorer	A mechanism for restoring the fertility of male sterile progeny of a hybrid between a normal parent and a male sterile parent line.
Seed Cotton	The product of the cotton boll consisting of the seeds with the fiber attached before ginning.
Selective Pesticides	Pesticides that are specific for one or a limited range of target pests.
Stelometer	An instrument for assessing fiber bundle strength.
Structural Elasticity	Percent change in an economic variable (eg. quantity or area) associated with a one percent change in another variable (eg. price or income) with other variables held constant.
Synthetic Cellulosic Rayon Fiber	Man-made, organic, natural polymer base, cellulose basefiber eg. (introduced 1890).
Synthetic Pyrethroid	Synthetically manufactured pyrethrins which generally have greater persistence than the natural product.
Systemic Pesticides	Insecticides that are absorbed into the vascular system of the plant and are then ingested by insects when they feed.
<i>Trichogramma</i> spp.	Small parasitic wasps that can be artificially reared on the wheat moth and then released to reinforce the wild population as a biological control measure against Lepidoptera.
Tied Ridges	A system in which the crop is planted on ridges with ties at regular intervals joining adjacent ridges to create a series of small dams to minimize run-off and facilitate water infiltration.
Trap Crop	An alternative host plant to particular pest species planted to siphon the pest off the main crop plants.
Upland Cotton	Varieties of the species <i>Gossypium hirsutum</i> .
Whitefly	<i>Bemesia</i> spp. that feed by sucking from the foliage of cotton plants and secrete honeydew which causes stickiness in cotton lint.
Yarn Count	Measure of the fineness of yarn expressed as mass per unit of length (gms/km) (direct system) in denier or tex or as length per unit mass (indirect system) in N_e the number of 840 yard hanks per pound.

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