FINAL REPORT

CFC/ICAC/21FT

Assessment of the impact and main dynamics of cotton diseases affecting in particular small-scale production systems in Southern and Eastern Africa

May 2003

EXECUTIVE SUMMARY

Cotton yields are generally very low in the Southern and Eastern African region. Cotton diseases contribute to some extent to these low yields. The effect of cotton diseases on yield and fibre quality is usually overlooked or underestimated. There also exists a misconception among farmers and even extension officers that it is possible to "live with" cotton diseases. One of the reasons for this is that it is commonly seen in cotton infected with a certain disease that plants still bear bolls, but what the uninformed do not know is that these infected plants are seriously reducing yield and that infection has a negative effect on fibre quality. Fibre characteristics like length, strength and sometimes colour are affected by these diseases. Cotton is susceptible to a variety of plant pathogens and many of the most important cotton diseases like bacterial blight, Fusarium- and Verticillium wilt, Alternaria leaf spot and various boll rots are widely distributed in the cotton-growing areas of the Southern and Eastern African region. Not only do cotton diseases reduce yield and affect fibre quality, they can also adversely affect seed quality. Both bacterial blight and Fusarium wilt diseases are seed-borne. If seed multiplication blocks get infected with the pathogen of one or both of these diseases, serious yield losses can be expected during the following season. Whenever one is talking about yield and fibre quality losses, the question is usually asked how these losses relate to income earned by the farmer. Little published data is available on the quantification of the economic importance of cotton diseases.

Due to the constraints (eg. lack of trained/experienced cotton plant pathologists) highlighted during the SEACF meetings held in Malawi 1999 and Zimbabwe 2000, very little work has been done on issues like epidemiology and yield loss assessment (economic importance) in the region. Research in the field of cotton pathology in the regions has been focused mainly on resistance breeding to these diseases. This Fast Track proposal originates from the recommendation of the Consultative Committee when reviewing a proposal from the Southern and Eastern African Cotton Forum (SEACF), which is an informal network of cotton research organizations/institutes focusing on production research. The SEACF works under the auspices of the ICAC, but membership is open to all cotton producing countries in the region. There is no membership fee. The chairmanship is currently with South Africa. In reviewing the submitted proposal, the Consultative Committee recommended that a study be conducted in the framework of the Fast Track procedure, possibly followed by a regional workshop, in order to determine the nature, scale and economic significance of cotton diseases in the Southern and Eastern African region. The countries currently proposed to be included in the study are Ethiopia, South Africa, Sudan, Tanzania, Uganda and Zimbabwe. Sudan and Ethiopia have been added on the recommendation from the Consultative Committee.

The principal objective of the project was to determine the status of cotton diseases in the region, with reference to distribution, incidence and economic importance (to determine whether cotton diseases really have an effect on yield). The project also attempted to survey related issues like the extent and quality of cotton pathology research in the region, variety information, seed quality and multiplication structures and current disease management strategies. The outcome of the project

would be used as a basis to determine whether the region is in need of future cotton pathology research projects. The project was executed as a survey by means of a questionnaire that was emailed during July 2002 to all national-coordinators in each participating country. Only one questionnaire had to be completed for each country. The questionnaires were returned to the project-executing agency (SEACF) during August 2002. Results were analysed and summarized by the project-executing agency.

The survey results clearly indicated that different diseases are of economic importance in the participating countries. Although the whole spectrum of known cotton diseases was covered in the survey, only bacterial blight, Verticillium wilt and Fusarium wilt are considered as serious threats to cotton production. In many cases, respondents were not able to obtain complete data sets with regard to the size of production areas affected by the diseases and yield loss observed. Consequently, yield losses could not be quantified for many of the surveyed diseases in some of the participating countries. Complete data could only be obtained for South Africa and to a lesser extent Uganda. Cotton in South Africa is subjected to very aggressive pathogens and heavy inoculum pressures. A total national yield loss due to cotton diseases could be calculated for South Africa and was determined as 7%. This number can probably be used as an estimate for the region.

The following conclusions were drawn from the survey:

- The data obtained from this survey is not sufficient to determine the real effect of cotton diseases on yield and fibre quality.
- Survey data should be updated on an on-going basis through:
    - Standardizing survey protocols in the region
    - Standardizing parameters for incidence, yield loss determination and area affected
- Variety development should be addressed and the region should engage in a germplasm exchange program and standardize on resistance evaluation protocols.
- Management of foundation and certified seed should be addressed in some of the countries in the region.
- Seed quality (infection of seed by seed-borne diseases) should be addressed.
- Correct identification of cotton pathogens and relevant strains should receive serious attention. Cotton pathologists should standardize on protocols.
- Current cotton disease management strategies are not effective and should be revised
- Farmers are not always aware of the seriousness of cotton diseases. It has been established that linkages between researcher, extension officers and farmers are not adequate and should receive attention.

The project culminated in a workshop that was held in Kampala, Uganda during 11-12 September 2002. The workshop was attended by the general co-ordinator of the project, all national co-ordinators, as well as staff from ICAC, CFC and the National Resources Institute, UK. All national co-ordinators also had the opportunity to present a paper on the status of cotton diseases and cotton pathology research in their country. During the workshop, the survey results were presented

to the participating countries and discussed. Although the data collected through this survey were not complete, the indications are there that cotton diseases have a serious effect on yield. The threat of cotton diseases should be addressed through research programs that concentrate on integrated disease management strategies that will focus on the improvement of yields in the region. These programs should have a strong element of technology transfer between researcher, extension officers and farmers.

FINAL REPORT

Assessment of the Impact and Main Dynamics of Cotton Diseases Affecting in Particular Small Scale Production Systems in Eastern and Southern Africa

INTRODUCTION

In many of the cotton-growing countries in the Southern and Eastern African region, cotton is a smallholder crop where the producers own land from 0.5 to 10 ha in size. In these countries, cotton is a very important agricultural export earner. Cotton is usually grown in rotation with other crops. As a land opening crop, it promotes food production by improving yields in subsequent crops by leaving well-prepared land for cereals such as millet, sorghum, sesame, groundnuts and peas. However, the production per hectare is very low and averages between 200 kg and 600 kg seed cotton per hectare (FAOSTAT Agriculture database, FAO). From this data, it can be seen that low cotton yields are common in the Southern and Eastern African region. Over the past 10 years production remained more or less constant in South Africa, Sudan and Ethiopia, steadily increased in Zimbabwe, and was very variable in Tanzania and Uganda. The data for the average yield (kg/ha) clearly show that there is a slight improvement in the average yield per hectare in Zimbabwe, Uganda and South Africa. In Tanzania, there was a steady decline since 1996. Average yields remained more or less constant in Ethiopia and Sudan. In general, low production probably could be attributed to inadequate application of fertilizers, poor land cultivation, poor pest management practices, the fact that production is almost entirely dependent on rainfall and lastly the occurrence of cotton diseases.

Although many factors can contribute to the problem of low yield, in many cases the effect of diseases on cotton yield and quality is either overlooked or underestimated. Plant diseases are among the major factors that reduce cotton yield and adversely affect fibre quality in the Southern and Eastern African region and this results in a loss of income. There also exists a misconception among farmers and even extension officers that it is possible to “live with” cotton diseases. One of the reasons for this is that it is commonly seen in cotton infected with a certain disease that plants still bear bolls, but what the uninformed do not know, is that these infected plants are seriously reducing yield and have a negative effect on fibre quality. Cotton is susceptible to a variety of plant pathogens and many of the most important cotton diseases like bacterial blight, Fusarium- and Verticillium wilt, Alternaria leaf spot and various boll rots are widely distributed in the cotton-growing areas of the Southern and Eastern African region. Fibre characteristics like length, strength and sometimes colour are affected by these diseases. Not only do cotton diseases reduce yield and affect fibre quality, they can also adversely affect seed quality. Both bacterial blight and Fusarium wilt are seed-borne. If seed multiplication blocks get infected with the pathogen of one or both of these diseases, serious yield losses can be expected during the following season. Whenever people talk about yield and fibre quality losses, the question is usually asked how these losses relate to income earned by the farmer. Published data on the incidence and economic importance of cotton

diseases in the SEA are either outdated or not available. Some data were available for South Africa, Zimbabwe and Tanzania. The most recent data available for Zimbabwe (1983/84) indicated that in the middleveld region, where the variety G501, that had some resistance to Verticillium wilt, was grown, 78% of the crop was infected with Verticillium wilt. In the lowveld region where a susceptible variety, K602, was grown under dry land conditions, the disease was kept at bay by the higher prevalent temperatures of the region. However, under irrigated conditions in the lowveld area 22% of the crop was affected. In Tanzania, it was found that there is a dramatic increase in the incidence of Fusarium wilt. Surveys conducted since 1969 indicate that there is an average increase of 8% in the incidence of Fusarium wilt in the cotton crop. It was found in a survey during the 1998/99 cotton season in South Africa that 37% of the ~ 99 000 ha cotton harvested, was infected with *Verticillium dahliae*, the pathogen of Verticillium wilt. In South Africa, Verticillium wilt was always considered as a problem only under irrigated conditions, but it has since been found that the disease is just as serious and common in rain fed cotton. It has also been established that the disease is rapidly spreading throughout the small-scale communities. Losses due to infection in infested fields can vary between 30% and 70%; 100% yield losses are seldom observed. Research conducted by the ARC indicated that under irrigated conditions yield would be reduced by 12 kg/ha for each percentage of plants infected with Verticillium wilt and by 4 kg/ha for dry-land conditions. Some of the varieties currently grown in South Africa have resistance to bacterial blight, but losses up to 46% have been recorded in susceptible varieties. In South Africa, in the Makhatini Flats area, boll rots annually cause yield reductions of 5-12% per hectare. Although comprehensive data are not available for all diseases in all of the collaborating countries, it could be assumed that the figures for the percentage loss per ha that have been calculated for South Africa would be applicable for the other countries as well. From this data, it can clearly be seen that the occurrence of cotton diseases does indeed have a serious effect on yield. If only one boll per plant can be saved, it will cause a dramatic increase in yield and will result in a higher income for the farmer.

The principal objective of the project was to determine the status of cotton diseases in the region, with reference to distribution and incidence (economic importance). The project also attempted to survey related issues like the extent and quality of cotton pathology research in the region, variety information, seed quality and multiplication structures and current disease management strategies.

SURVEY PROCEDURE

Participating countries This project was executed in Southern and Eastern Africa. Ethiopia, Sudan, Uganda, Tanzania, Zimbabwe and South Africa participated in this project. The project was executed under the management of the Southern and Eastern African Cotton Forum (SEACF) and the chairman of SEACF acted as the general co-ordinator of the project. A national co-ordinator was assigned for each participating country. Details of the respondents are summarized in Table 1.

Format of the survey The survey was conducted by means of a questionnaire (Annex A) that was emailed to the national co-ordinator of each participating country. Only one questionnaire had to be completed by each country. Data were supposed to be as recent as possible, preferably for the 2001/2002 season.

Elements of the survey The survey consisted of several sections that were used to collect the data. The survey consisted of the following sections:

1. Determination of the level of cotton pathology expertise available in the Southern and Eastern African cotton region.
2. Typical prevailing environmental conditions in each cotton production region for each country were surveyed. These factors usually correlate closely with disease occurrence and incidence:
    a. Average rainfall in each production area
    b. Minimum and maximum temperatures in each production area
    c. Dominant soil types in each production area.
3. Production statistics were surveyed in an effort to calculate national disease incidence and effect on yield. The following data were collected:
    a. Total area under cotton production during 2001/2002 season
    b. Number and names of cotton production regions and hectares under cotton production.
    c. Number of producers per region and average size of farms
4. Dominant diseases present in each region during the 2001/2002 season.
5. The following variety information was surveyed:
    a. Names of varieties
    b. Genetic stability of varieties
    c. Known disease resistance of varieties
    d. Breeding activities
    e. Procedures for resistance evaluation
6. Current seed source and seed multiplication schemes in each country were surveyed to determine if there are possible problems with seed quality.
    a. Seed source
    b. Seed multiplication structures
    c. Seed marketing structures

d. Presence of seed-borne diseases in seed multiplication areas
e. Treatment of seed before distribution/planting

7. Incidence and economic importance of these diseases. The following diseases were included in the survey:
    a. Seedling disease
    b. Bacterial blight
    c. Verticillium wilt
    d. Fusarium wilt
    e. Nematodes
    f. Alternaria leaf spot
    g. Wet-weather blight
    h. False mildew
    i. Boll rot
    j. Virus diseases
    k. Other

    Incidence and economic importance (yield losses) were been calculated by using the data provided in the production statistics section of the survey. If all the relevant data were not available, estimates were calculated by using the yield loss factors previously determined by the ARC-Institute of Industrial Crops in South Africa. Respondents were also asked to indicate which symptoms of each disease were prevalent and if any strain/race characterization of the relevant pathogens had been done.
8. Current disease management strategies and short-comings in these strategies were surveyed. This section of the questionnaire dealt with:
    a. Problems/short-comings with current disease management practices
    b. Optimum methods to control diseases
9. Available basic resources for cotton pathology research were also surveyed:
    a. Number of cotton pathologists
    b. Access to microbiology/plant pathology laboratories
    c. Access to greenhouse facilities
    d. Access to facilities for infection studies
10. Future research needs.

RESULTS

Level of expertise From the data summarized in Table 1 it can clearly be seen that most of the cotton pathologists in the region have on average more than 10 years of experience and are in possession of post-graduate qualifications. Each country has at least one trained pathologist and a research technician.

Environmental conditions in cotton production areas The average annual rainfall, minimum and maximum temperatures during the cotton season and soil types for each country are summarized in Table 2 to 7.

Ethiopia In most regions average rainfall ranged from 350 to 800 mm (Table 2). In the Gambella region, rainfall ranges from 1400 to 1600 mm. Minimum temperatures range from 12 to 20 °C and maximum temperatures from 30 to 42 °C. Soil types are predominantly fluvisol, vertisol and alluvial.

South Africa Average rainfall is approximately 600 mm, except in the Orange River area where average rainfall is 200 mm per year. Minimum and maximum temperatures range from 10-14 °C to 27-30 °C respectively. Soils in the cotton production areas range from sandy to heavy black clays (Table 3).

Sudan Environmental data are summarized in Table 4. Average rainfall ranges from 150-800 mm and minimum and maximum temperatures from 18-20 °C to 30-40 °C respectively. Soil types are predominantly vertisol, except in the Tokar region where soil type is a loamy soil.

Tanzania Climatic data could only be obtained for the Western cotton-growing region (Table 5). Average rainfall is 900 mm and minimum and maximum temperatures are 17 °C and 29 °C respectively. Soil type in the Western cotton-growing region is sandy and calcerous, while loam soil is predominantly present in the Eastern cotton-growing region.

Uganda The data for Uganda is summarized in Table 6. Average rainfall ranges from 1200-1400 mm. Minimum and maximum temperatures range from 15-20 °C to 25-30 °C respectively. Soil types ranges from sandy clay loams to grey clay soils.

Zimbabwe Average rainfall ranges from 567-877 mm (Table 7). Minimum and maximum temperatures range from 13-22 °C to 26-31 °C respectively. Soil types are predominantly fersialitic and siallitic.

Cotton production statistics Cotton production statistics collected during the survey are presented in Table 8 to 13.

Ethiopia The total area under production in Ethiopia was 93844 ha during the 2001/2002 season. Cotton is produced in 10 different production areas (Table 8) and the total number of producers was 199516. The average size of a farm for small-scale farmers is approximately 0.25 ha. Sizes of commercial farms range from 500 to 3000 ha. Bacterial blight, Verticillium wilt and Fusarium wilt were reported as the most important diseases.

South Africa The production statistics for South Africa are summarized in Table 9. Cotton is produced in six different areas and 31556 ha of cotton were produced during the 2001/2002

season. Cotton was produced by 4060 farmers. The average size of farms for small-scale farming is 2 ha and for commercial farming 11-156 ha. Bacterial blight, Verticillium wilt, Alternaria leaf spot and false mildew were reported as the most serious diseases during the 2001/2002 season.

Sudan Cotton is produced in 12 different regions and 125 191 ha of cotton were produced by 8334 farmers during the 2001/2002 season (Table 10). The average size of farms is 2 ha. Bacterial blight has been reported as the most important disease in all of the cotton growing regions.

Tanzania Cotton is grown in two regions (Table 11). A total number of 420000 ha of cotton were produced. No other production statistics could be obtained. Bacterial blight, Fusarium wilt, Alternaria leaf spot and seedling disease were reported as the most important diseases during the 2001/2002 season.

Uganda The data for Uganda are presented in Table 12. Cotton is produced in six different regions and 101175 ha were produced during the 2001/2002 season. The total number of producers was 183700 and the average size of a farm is 0.5 ha. Bacterial blight was reported as serious in all production areas, except in the South Eastern region where Fusarium wilt caused serious yield losses.

Zimbabwe Cotton is produced in 10 different regions. A total of 362170 ha cotton were produced by 281800 farmers (Table 13). The average size for small-scale farming is 1.2 ha. Bacterial blight and Verticillium wilt was reported as major diseases. Isolated cases of boll rot also occurred.

Variety information Details of the various varieties grown during the 2001/2002 season in the participating countries are summarized in Table 14 to 19.

Ethiopia Five varieties were grown in Ethiopia (Table 14). Only the varieties Arba, Albar 637 and Reger-36 are considered to be genetically stable/uniform. Reger-36 is planted by only one commercial farmer. Arba has resistance to certain diseases. Local, a local variety that is of a mixed type has good disease and stress tolerance. Albar 637 is susceptible to bacterial blight.

South Africa Data are summarized in Table 15. Six varieties were grown in South Africa and all, except Tetra, are genetically stable and uniform. All varieties, except Tetra and DP655BR and Acala OR3, are resistant to bacterial blight. Only Acala OR3 is tolerant to Verticillium wilt.

Sudan Five varieties were grown in Sudan during the 2001/2002 season (Table 16). All varieties are genetically stable and uniform, but are susceptible to bacterial blight. Barakat 90, Barac 67B and Albar (57)12 are resistant to Fusarium wilt.

Tanzania Five varieties were grown in Tanzania during the 2001/2002 season. All varieties are considered genetically stable and uniform (Table 17). UK 77 and UK 91 are resistant to Fusarium wilt. UK 91, IL 85 and ALAI 90 are resistant to bacterial blight.

Uganda Data for Uganda are presented in Table 18. Four varieties were grown during the 2001/2002 season and all were considered genetically stable and uniform. All varieties have good resistance to bacterial blight, but are susceptible to both Verticillium and Fusarium wilts.

Zimbabwe Four varieties were grown in Zimbabwe (Table 19). All varieties are genetically stable and uniform and have resistance to bacterial blight. Verticillium wilt tolerance is poor in all varieties.

Involvement in breeding activities The data are summarized in Table 20. All participating countries, except Ethiopia, are involved with breeding activities. All countries are sourcing resistant germplasm on an on-going basis and except for Ethiopia, are characterizing phenotypes. All countries, except Sudan and Ethiopia, are optimising selection techniques and study pathogen variation. On-going breeding activities are summarized in Table 21. All participating countries are involved with field and greenhouse screening and selection activities.

Seed sources and seed multiplication structures Data for the 2001/2002 season are summarized in Table 22.

Ethiopia Seed is sourced from ginneries, local markets and home preparation. No formal institution is involved or responsible for maintaining seed quality through foundation seed production and no formal seed multiplication schemes/structures are in place. The presence/absence of seed-borne diseases in seed could not be confirmed. Due to the cost involved with acid delinting, fuzzy seed is widely used in Ethiopia. Seed is not chemically treated before planting.

South Africa The Agricultural Research Council and private seed companies are both responsible for maintaining foundation seed of their varieties. Seed multiplication schemes are run by the private seed companies. Marketing of seed is done by the private seed companies. Bacterial blight is prevalent in the areas where seed is multiplied and seed blocks are subjected to strict screening for bacterial blight prior to harvesting. Only acid delinted seed is planted in South Africa and all seed is treated with fungicides before marketing.

Sudan Varieties are maintained, multiplied and marketed by the state-owned seed production units. Bacterial blight is prevalent in the areas where cotton is grown for seed production. Only fuzzy seed is available in Sudan. Seed is treated with insecticides prior to marketing.

Tanzania Seed is sources from the ginneries. Seed is produced by contracted farmers and is marketed by the ginneries. Both bacterial blight and Fusarium wilt occur in the areas where the seed is produced. Only fuzzy seed is available in Tanzania. Seed is treated with fungicides before distribution to farmers.

Uganda Foundation seed of the varieties is maintained by National Agricultural Research Organization (NARO) and certified seed is produced under the supervision of Cotton Development Organization (CDO) and Uganda Cotton Ginners & Exporters Association (UCGEA). Seed is marketed by CDO and UCGEA. Bacterial blight and Fusarium wilt is prevalent in the seed production area. Ninety percent of all seed planted in Uganda is fuzzy seed and 10% is machine delinted. Seed is chemically treated with fungicides before distribution to farmers.

Zimbabwe Foundation seed of the varieties is maintained by the Cotton Research Institute and seed multiplication is done by contracted farmers under the supervision of a private marketing

company that is also handling the marketing of the seed. All seed planted in Zimbabwe is acid delinted. Seed is also treated with fungicides and insecticides before marketing.

Symptoms and identification of cotton diseases Data are summarized in Table 23 to 32.

Seedling disease Seed decay was only observed in South Africa (Table 23). Damping off and seedling blight were observed in all the participating countries during 2001/2002. In all countries, except Sudan, infection was confirmed with microbiological tests. Only visual identification was done in Sudan and the respondent was unsure of an accurate identification. Various pathogens were involved with seedling disease, but the most common was *Rhizoctonia solani*, *Fusarium* spp., *Pythium* sp., *Colletotrichum* sp. and *Macrophomina* sp.

Bacterial blight Cotyledon blight was observed in Tanzania, Uganda and Sudan. Angular leaf spot and boll rot were common in all participating countries (Table 24). Black arm was observed in all countries, except in Tanzania. Microbiological confirmation of infection was done in Tanzania, Uganda, South Africa and Ethiopia. Various races have been identified. Races 6, 7, 10 and 18 are common. Non-characterised hyper-virulent races have been identified in Uganda, South Africa and Sudan.

Verticillium wilt Data are presented in Table 25. Verticillium wilt has not yet been found in Sudan. Wilting of cotton plants was only observed in Tanzania and South Africa. Wilting and subsequent death of plants were observed in Zimbabwe, South Africa and Ethiopia. Chlorosis and necrosis of interveinal leaf tissue have been observed in all participating countries, except in Sudan. Discoloration of vascular tissue in stems and petioles was common in all countries. Infection with Verticillium wilt was confirmed with microbiological techniques in all countries. Only South Africa has performed strain differentiation. A defoliating strain of *Verticillium dahliae* occurs in South Africa.

Fusarium wilt Wilting was only observed in South Africa. Wilting and subsequent death of plants was observed in all participating countries, except in Ethiopia (Table 26). Chlorosis and necrosis of interveinal leaf tissue have been observed in all participating countries, except in Sudan. Discoloration of vascular tissue in stems and petioles was common in all countries. Infection with Fusarium wilt was confirmed with microbiological techniques in all countries. Only Tanzania and Ethiopia have performed strain differentiation. Strain 1 occurs in both Tanzania and Ethiopia.

Nematodes Various nematode species occur commonly on cotton grown in all participating countries (Table 27). *Meloidogyne* spp. were frequently found in association with soil-borne diseases like Verticillium and Fusarium wilts and except for Sudan, was present in all participating countries. *Pratylenchus* spp. occurred in all participating countries. *Paratrichodorus* sp. was present in South Africa. In all cases, nematode infection was confirmed with laboratory tests.

Alternaria leaf spot Data are summarized in Table 28. Alternaria leaf spot has not yet been found in Sudan. Lesions on cotyledons were observed in Zimbabwe, Tanzania and Uganda. Seedling blight was reported only in Uganda. Leaf spot was prevalent in all participating countries. Boll rot was only observed in Zimbabwe and South Africa. Stem canker was reported only in South Africa. Infection with *Alternaria* spp. has been confirmed with microbiological tests in only Tanzania, South Africa and Ethiopia. *A. macrospora* was identified in Zimbabwe, Tanzania, South Africa and

Ethiopia. *A. alternata* was identified in South Africa and Sudan and infection with *A. gossyppi* was confirmed only in South Africa.

Wet-weather blight Wet-weather blight does not occur in Sudan and no data could be obtained for Zimbabwe (Table 29). Leaf spot symptoms were common in the other participating countries. Only Tanzania, South Africa and Ethiopia confirmed infection with microbiological tests.

False mildew False mildew did not occur in Sudan. White, mouldy, angular lesions were observed in all the participating countries, except Sudan where false mildew has not been found yet (Table 30). Symptoms on bolls were reported in Uganda, Ethiopia and South Africa. Infection with false mildew was confirmed with microbiological tests in all participating countries where the disease occurred.

Boll rot (other than bacterial blight boll rot) Boll rot did not occur in Sudan. Various boll rots were observed in the other participating countries (Table 31). Alternaria and Colletortrichum boll rots were the most common boll rots observed. Infection with all boll rots was confirmed with microbiological tests in all countries.

Virus diseases Data are presented in Table 32. Various virus disease-like symptoms were observed in Tanzania, Uganda, Sudan and Ethiopia. Cotton mosaic virus has been reported in South Africa. Except in South Africa, infection with cotton virus diseases was not confirmed with laboratory tests.

Cotton diseases incidences and yield losses Data are presented in Table 33 to 42. Due to incomplete data sets, total yield loss due to infection with cotton diseases could only be determined for South Africa. During 2001/2002 cotton diseases caused an estimated national yield loss of 7% (13538088 kg seed cotton).

Seedling disease No data were obtained for Ethiopia, Sudan, Uganda and Zimbabwe. No serious outbreaks of seedling disease have occurred for the past five years in Zimbabwe and the disease is currently not considered as important. In Sudan, seedling disease is caused by the bacterial blight pathogen, *Xanthomonas campestris* pv. *malvacearum* and outbreaks of this disease is dependant on certain climatic conditions. Seedling disease was reported in one of the two cotton production areas in Tanzania with an average incidence of 12.5%. An incidence of 10% was reported in the survey area in South Africa. This resulted in a 10% yield loss in the survey areas. This translated to a national disease incidence of 4%. The national yield loss was 0.004%, which translated to a national loss of 7384 kg seed cotton (Table 33).

Bacterial blight Data are summarized in Table 34. No data were available for Sudan due to the planting of resistant varieties. Bacterial blight occurred in very high incidences in all the other participating countries. Incidence was 25% in Ethiopia, Tanzania and South Africa. The incidence was 22 % in Zimbabwe and as high as 51% in Uganda. Bacterial blight caused an estimated national yield loss of 2.4% (2584436 kg seed cotton) in South Africa, 3018556 kg seed cotton in Uganda and 109935 kg seed cotton in Zimbabwe.

Verticillium wilt Verticillium wilt does not occur in Sudan and is not considered as an important disease in Tanzania. No data were available for Ethiopia. Verticillium wilt incidence was 30% in the surveyed area in South Africa, 10 % in Uganda and 22% in Zimbabwe (Table 35). Forty

percent of the total cotton production area in South Africa is infested with Verticillium wilt and this resulted in a national seed cotton yield loss of 6645694 kg. In Zimbabwe Verticillium wilt caused a national seed cotton yield loss of 616111 kg.

Fusarium wilt Fusarium wilt occurred in all the participating countries (Table 36). In Zimbabwe, it occurred in only three isolated cases and no data could be obtained. Incidences in the survey areas were as low as 5% in Ethiopia and South Africa and as high as 54 and 60% in Uganda and Sudan respectively. Fusarium wilt caused national yield losses of 55381 kg seed cotton in Sudan, 1384520 kg seed cotton in Tanzania and 2489828 kg seed cotton in Uganda.

Nematodes The data for nematode incidences in all the participating countries are summarized in Table 37. No data could be obtained for Sudan and nematodes are not considered as important in Zimbabwe. In South Africa, 15% of the total cotton production area is affected by nematodes and this caused a national seed cotton yield loss of 2492135 kg. The incidence of nematodes in the surveyed area in Tanzania was 59% and 31 % in Uganda.

Alternaria leaf spot Alternaria leaf spot does not occur in Sudan and no data could be obtained for Tanzania and Zimbabwe. Due to variety resistance, Alternaria leaf spot is not considered as an important disease in Zimbabwe. Alternaria leaf spot occurred widely throughout the production areas of South Africa, but caused only a national yield loss of 0.008% (1477 kg seed cotton).

Wet-weather blight The data for wet-weather blight is summarized in Table 39. Wet-weather blight does not occur in Sudan and no data could be obtained for Zimbabwe, and Tanzania. Uganda reported a 30% yield loss in the survey area. Incidence of wet-weather blight in the survey area in South Africa was 25%, but caused only a national yield loss of 0.0004% (692 kg seed cotton). In Ethiopia, the disease caused a national yield loss of 0.0001% (185 kg seed cotton).

False mildew Data for false mildew are presented in Table 40. False mildew does not occur in Sudan and no data could be obtained for Uganda and Zimbabwe. In South Africa, false mildew affected 0.6% of the total production area and the incidence was 25% in the survey area. This resulted in a national yield loss of 0.004% (692 kg seed cotton). In Sudan a national yield loss of 0.001% (184 kg seed cotton) occurred.

Boll rot (other than bacterial blight boll rot) Boll rot does not occur in Sudan and was not seen in Tanzania, Uganda and Zimbabwe. In Ethiopia, the incidence was 3% in the survey area. In South Africa, boll rot incidence was 15% in the survey area and 15% of the total cotton production area was affected by boll rots (Table 41). This resulted in a national yield loss of 0.45% (8307120 kg).

Virus diseases The data for virus diseases is summarized in Table 42. No data was obtained for Sudan and virus diseases have not been seen in Tanzania, Uganda and Zimbabwe. Virus diseases affected 0.1% of the total cotton production area in South Africa and the incidence of virus diseases was 15% in the survey area. This resulted in a national yield loss of 0.0002 % (277 kg seed cotton).

Disease management strategies Data are summarized in Table 43 to 52.

Seedling disease All countries except Ethiopia are applying a fungicide seed treatment before distributing seed to farmers. Several cultural practices like sanitation, crop rotation, delayed sowing date and removal of infested crop residues are also used. Tanzania, Sudan and Ethiopia did not consider the current control measures available to be effective.

Bacterial blight Zimbabwe, Tanzania, Uganda and Sudan are using chemical control for bacterial blight. All countries, except Sudan and Ethiopia have resistant varieties. Cultural practices like burning of infested crop residues and closed seasons are followed by Uganda, South Africa, Sudan and Ethiopia. All countries except Uganda and Zimbabwe considered current available control practices effective.

Verticillium wilt Zimbabwe, Uganda and South Africa are planting tolerant varieties. All countries are applying cultural practices like roughing, burning of infected crop residues and crop rotation for the control of Verticillium wilt. All countries considered current control practices as not effective.

Fusarium wilt Tanzania, Uganda and Sudan are planting tolerant varieties. Cultural practices like sanitation and crop rotation are widely used to control Fusarium wilt in all the participating countries. Only Sudan considered the available control strategies to be effective to control Fusarium wilt.

Nematodes Tanzania and South Africa are the only countries that are using chemicals to control nematode infestation. Uganda, South Africa and Sudan are planting varieties with tolerance to nematodes. Tanzania, Uganda and South Africa are also using cultural practices like crop rotation to control nematodes. Only Sudan is considering the current control practices to be effective.

Alternaria leaf spot Tanzania is the only country that is using chemicals to control Alternaria leaf spot. Zimbabwe and Uganda have varieties that are resistant to Alternaria leaf spot. Cultural practices to control the disease are widely used in all participating countries. Zimbabwe and Uganda consider current control practices as effective.

Wet-weather blight Tanzania is the only country that is using chemicals to control wet-weather blight. Only Uganda considers the current control practices effective to control the disease.

False mildew Tanzania and Uganda are using cultural practices like uprooting and burning of infected plants, proper spacing and early planting to control the disease. Only Uganda considers current control practices effective to control false mildew.

Boll rot Zimbabwe, Tanzania and Uganda are using chemicals to control the disease. Cultural practices like uprooting and burning of infected plants, proper spacing and chemical control of cotton stainers that disseminate *Nematospora* sp. are widely used by all participating countries.

Virus diseases Only Sudan is currently growing varieties that have resistance to cotton virus diseases.

General comments on cotton disease management strategies The data are summarized in Table 53. IPM, resistance, sanitation and quarantine are management strategies that are currently used in the participating countries. A lack of resistant varieties and containment of soil-borne diseases were identified as major shortcomings in current disease management strategies. A lack of awareness of the importance of cotton diseases among farmers and extension has also been

identified as a shortcoming. Seed quality needs to be addressed and this could only be done through seed certification schemes. Seed certification cannot be implemented if seed production structures are not formalized or regulated by the different countries.

DISCUSSION AND CONCLUSION

Although each country has at least one trained cotton pathologist, there is a definite need to train more scientists to ensure continuity. Most cotton pathologists are senior scientists and there are no back-up scientists should they decide to resign/retire. This can have serious effects on research on cotton pathology in the region.

The data collected on variety information indicated clearly that many of the newer varieties that are grown in the Southern and Eastern African region have good resistance or tolerance levels to the major diseases. Older varieties are, however, still in use in some countries and they generally have none or poor disease resistance. This poses a serious threat to genotypic and phenotypic uniformity and stability is a problem in many varieties and should be addressed in the future. Due to the lack of regulated or organized seed multiplication structures and susceptibility to seed-borne diseases like bacterial blight, seed quality is affected in many of the participating countries. If contaminated seed is distributed to farmers, the cotton crop is already at a disadvantage from germination. Early infection (through contaminated seed) can have serious effects on seed cotton yield and fibre quality.

Sufficient data could not be obtained through the survey for some of the participating countries to calculate or estimate the economic importance of cotton diseases (yield loss). Complete data could only be obtained for South Africa and to a lesser extent Uganda. It was also established that respondents used different protocols/parameters to determine disease incidence. In many cases, the size of the area affected by a particular disease could not be obtained and consequently the percentage of the total production area affected by a particular disease could not be determined. These problems, together with the incompleteness of the data, made it almost impossible to analyse and compare the data sets between the different countries. For most diseases, it is very difficult to calculate yield loss, because cotton plants adjoining diseased plants have the ability to compensate for losses incurred by diseased plants. Yield loss parameters, which accommodate a compensating factor, has been calculated for South Africa. In some cases, yield loss caused by certain diseases in some of the participating countries could be estimated using the yield loss parameters for South African conditions. The survey data clearly indicated that the participating countries have different priorities regarding cotton diseases. According to the survey data collected, bacterial blight is the most important disease occurring in Ethiopia. In South Africa, many of the diseases occur in high incidences and result in serious yield losses. Verticillium wilt is without doubt the most serious disease, followed by bacterial blight, boll rot and false mildew. Only Fusarium wilt is currently a problem in Sudan and the incidence is very high. Although bacterial blight occurs in Sudan, it was

not seen during 2001/2002 due to the planting of resistant varieties. This, however, does not mean that it cannot become serious in the future. In Tanzania disease incidence was generally high - bacterial blight, Fusarium wilt, nematodes, Alternaria leaf spot and false mildew are important diseases. It was clear from the data obtained from Uganda that bacterial blight is a serious problem, followed by Fusarium wilt and nematodes. In Zimbabwe, Verticillium wilt and bacterial blight were the most important diseases. It can be concluded from the survey that bacterial blight, Verticillium wilt and Fusarium wilt are the most important diseases occurring in the Southern and Eastern African cotton producing region.

The following conclusions were drawn from the survey:

- The data obtained from this survey are not sufficient to determine the real effect of cotton diseases on yield and fibre quality.
- Survey data should be updated on an on-going basis by:
    - Standardizing survey protocols in the region
    - Standardizing parameter incidence, yield loss determination and area affected
- Variety development should be addressed and the region should engage in a germplasm exchange program and standardize on resistance evaluation protocols.
- Management of foundation and certified seed should be addressed in some of the countries in the region.
- Seed quality (infection of seed by seed-borne diseases) should be addressed.
- Correct identification of cotton pathogens and relevant strains should receive serious attention. Cotton pathologists should standardize on protocols.
- Current cotton disease management-strategies are not effective and should be revised.
- Farmers are not always aware of the seriousness of cotton diseases. It has been established that linkages between researcher, extension officers and farmers are not adequate and should receive attention.

Although the data collected through this survey were not complete, the indications are there that cotton diseases have a serious effect on yield. The threat of cotton diseases should be addressed through research programs that concentrate on integrated disease management strategies that will focus on the improvement of yields in the region. These programs should have a strong element of technology transfer between researcher, extension officers and farmers.

Some of the problems identified by this project can be addressed through training and others through certain basic research initiatives. Three main objectives have been identified for the proposed project.

i) The implementation of standardized techniques to identify cotton pathogens and relevant races/strains, evaluate resistance and to assess yield and fibre quality losses. This objective should be the first objective of the project to be achieved. Most of the techniques are well established techniques that do not need any development and cotton

pathologists can acquire the skills necessary to implement and perform these skills in their relevant countries through in-service training sessions.

ii) Strengthening of the local knowledge of cotton diseases by the implementation of management strategies. This objectives will concentrate primarily on genetic resistance to cotton diseases and will entitle germplasm exchange programmes in the region, screening techniques for disease resistance and the development of new varieties. Here also, the skills for implementing evaluation techniques can be acquired through in-service training. Although the development of new varieties is considered as a long-term activity, it can successfully be initiated under a new project. It takes approximated six to eight years to develop a new variety, but if such a breeding programme is initiated in conjunction with the germplasm exchange programme, it is possible to advance a breeding programme by a few generations. If a breeder can obtain for example segregating breeding lines from another country, these can be incorporated his breeding programme and he can do advanced selections specific for his country's needs from those lines.

iii) Improving yield and fibre quality through the awareness of the effect of cotton diseases on yield, training in and the implementation of disease management strategies. This objective will focus primarily on cultural practices like sanitation, crop rotation and quarantine of affected areas, as well as seed quality. The possibilities for implementing seed certification in the region will also be explored. Training will concentrated on technology transfer from researchers to extension officers to farmers. Farmer training will be implemented by sending farmers to farmer field schools and on-farm demonstration trials. Photographic guides to aid in the identification of diseases will also be published.

OUTCOME OF THE WORKSHOP

A workshop to present and discuss the survey results was held on 11 September 2002 in the Equatoria Hotel, Kampala Uganda. The workshop was attended by all the national co-ordinators from the countries that participated in the project, as well as by representatives from the Common Fund for Commodities (CFC), International Cotton Advisory Committee and the Natural Resources Institute of the UK. Each national co-ordinator got the opportunity to present a paper on the situation and views on the major cotton diseases that occur in their respective countries. The survey results were officially presented and discussed. The results of this project clearly showed that there is a lack of the understanding of cotton disease loss-assessment in the SEA region. Very few statistics on yield loss could be gathered with the survey that was conducted in the relevant countries during July/August 2003. Discussions during the workshop lead to the conclusion that there is a lot of uncertainty about the protocols to be used to determine incidence of cotton diseases and assess yield losses. It was also extensively discussed that different diseases are of importance and are considered as research priority in the different countries. The survey results have

established that bacterial blight is a common economic threat to cotton production in all the participating countries and then also that either Fusarium or Verticillium wilt are of economic importance.

The need for future collaborative research projects for the region has been emphasized. It has been recommended during the workshop that a new project on cotton diseases with the emphases on bacterial blight and either Fusarium or Verticillium will be initiated for the region. This main objective of such a project should concentrate on developing technologies, with reference to cotton disease control, in an effort to increase yield and fibre quality. This should be achieved by strengthening of regional knowledge in cotton plant pathology and transfer of improved knowledge to farmers. Cotton pathology areas that need to be improved are the standardization of research protocols throughout the region. In addition, the acquired and improved knowledge should be disseminated to extension officers and the farmers. The project will concentrate on yield loss assessment; disease management strategies and technology transfer to farmers through the concept of farmer field schools and master farmers. It was recommended that Ethiopia, Sudan, Uganda, Tanzania, Zimbabwe, South Africa and Zambia should participate in the project.

The ICAC and CFC recommended that a full proposal should be developed for the proposed project and that it should be submitted through the ICAC to the CFC to be considered for funding. It was also recommended that the project proposal should be developed under the structure of the Southern and Eastern African Cotton Forum (SEACF), which is administered from the Agricultural Research Council – Institute for Industrial Crops in South Africa. The project proposal should be developed in collaboration with the proposed collaborating countries, which should deliver certain inputs for the development of the project proposal.

FUTURE PROSPECTS

The proposed project aims to strengthen the capacity of cotton pathologists and extension officers in the Southern and Eastern African region by training in basic plant pathology techniques like standardization of techniques like disease identification on basis of symptoms, pathogen confirmation, resistance evaluation and loss assessment. The project will also aim to improve yield and fibre quality by making cotton producers more aware of the effect of cotton diseases and the benefit of implementing cotton disease management strategies. Although it is not proposed that this project will be executed in all the cotton growing countries in the region, all of these countries will benefit from this project.

This project would provide a strong base to:

- Strengthen local expertise by standardization of research protocols.
- Create awareness of the presence and economic impact of cotton diseases on yield and sustainable income

- Start developing research methodologies and training for participating countries.
    - Varieties with disease resistance
    - Higher quality seed
- Disease management and control will ensure better yields and fibre qualities
- Sustainable cotton production will be ensured.
- Sustainable use agricultural soils will be ensured.
- An increase in yield and fibre quality will ensure a larger income for the farmer, which will lead to the upliftment of the people.

An increase in cotton production in the region will ensure a sustainable income for the farmers.

Table 1. Details of respondents of the cotton diseases survey in Southern and Eastern Africa during August 2002.

Country	Respondent	Years of experience	Address
Ethiopia	Dr Geremew Terefe Mr Desta Gebre Banje	19 (Plant pathology)	IRA Melke Were Research Centre PO Box 2003 Addis Ababa **ETHIOPIA** Tel: 251-1-611222 Fax: 251-1-611222 Email WARC@TELECOM.NET.ET
South Africa	Ms A Swanepoel	16 (Plant pathology)	Agricultural Research Council Institute for Industrial Crops Private Bag X 82075 Rustenburg 0300 SOUTH AFRICA Tel: 27-14-5363150 Fax: 27-14-5363113 Email annette@nitk1.agric.za
Sudan	Dr AM Mustafa	7 (Breeding)	Agricultural Research Corporation Wad Medani PO Box 126 SUDAN Email a_m_mustafa@yahoo.com
Tanzania	Dr T Kibani	18 (Plant pathology)	ARI-Ukiriguru Box 1433 Mwanza TANZANIA Tel 255-68-550215 Fax 255-68-550214 UKIRIGURU@AFRICAONLINE.CO.TZ
Uganda	Dr L Serunjogi Dr B Akello	30 (Breeding) 8 (Plant pathology)	National Agricultural Research Organization Serere Agricultural and Animal Production Research PO Soroti UGANDA Tel 256-45-61192 Fax 256-45614444 Email ddgr@infocom.co.ug corsu@infocom.co.ug
Zimbabwe	Mr Rob Jarvis[1] Mr N Mapope[2]	29 (Breeding) 2 (Plant pathology)	[1]Quton Seed Company 100 Prince Edward Street, Milton Park, Harare, Zimbabwe Tel 263-4-707636 Fax 263-4-707636 Email quton@cottco.co.zw [2]Cotton Research Institute Private Bag 765 Kadoma ZIMBABWE Tel 263-68-24331 Fax 263-68-24229 Email ZIMCOTT@AFRICAONLINE.CO.ZW

Table 2. Climatic and soil type data for the cotton production regions in Ethiopia.

Region	Average rainfall (mm)	Temperature (°C)		Soil type
		Min	Max	
Upper Awash Basin	500 - 700	16	33	Fluvisol, Vertisol
Middle Awash Basin	450-500	18	41	Fluvisol, Vertisol
Lower Awash Basin	350-400	20	42	Vertisol, Fluvisol
Gambella	1400-1600	18	35	Vertisol
Metema	800	17	39	Light alluvial Vertisol
Arbaminch	>700	16	32	Vertisol, Fluvisol
Gondar	>750	12	30	Vertisol, Light alluvial
Humera	600 - 800	13	40	Vertisol, Light alluvial
Bilaten	750 - 900	15	34	Alluvial, Vertisol
South Omo	500 - 800	16	42	Vertisol, Alluvial

Table 3. Climatic and soil type data for the cotton production regions in South Africa.

Region	Average rainfall (mm)	Temperature (°C)		Soil type
		Min	Max	
Northern region	600	12	29	Calcerous black clay Sandy clay loam Black clay alluvial
North west region	600	11	27	Black clay, Sandy clay Red sandy clay loam
Mpumalanga region	600	12	28	Sandy clay loam Sandy clay Dark clay
KwaZulu Natal region	550	14	30	Calcerous black clay
Northern Cape region				Sandy alluvial
Orange river region	200	10	28	Claypan alluvial

Table 4. Climatic and soil type data for the cotton production regions in Sudan.

Region	Average rainfall (mm)	Temperature (°C)		Soil type
		Min	Max	
Nuba Mounties	600	20	37	Vertisols
Blue Nile	500	20	35	Vertisols
Rahad	350	20	35	Vertisols
Gezira	300	20	35	Vertisols
Suki	450	20	30	Vertisols
White Nile	500	20	30	Vertisols
Blue Nile	500	20	30	Vertisols
Damazine	500	20	30	Vertisols
New Halfa	150	25	37	Vertisols
Gadarif	500	20	30	Vertisols
Upper Nile	800	18	30	Vertisols
Tokar	-	28	40	Loamy Soil

Table 5. Climatic and soil type data for the cotton production regions in Tanzania.

Region	Average rainfall (mm)	Temperature (°C)		Soil type
		Min	Max	
Western cotton growing area	900	17	29	Sandy, Calcareous
Eastern cotton growing area	NA	NA	NA	Loam

Table 6. Climatic and soil type data for the cotton production regions in Uganda.

Region	Average rainfall (mm)	Temperature (°C)		Soil type
		Min	Max	
Western	1400	17.5	25	Grey sandy clay loams Clay loams
Mid western	1400	17.5	27.5	Dark red clay loams
South eastern	1200	15	30	Shallow loamy sands
North eastern	1300	17.5	30	Grey brown sands Brown sandy loams
Northern	1400	17.5	30	Grey clays Sandy clays
West Nile	1200	20	30	Sandy grey loams Reddish-brown sandy clay loams

Table 7. Climatic and soil type data for the cotton production regions in Zimbabwe.

Region	Average rainfall (mm)	Temperature (°C)		Soil type
		Min	Max	
Gokwe	758	16.3	27.5	Siallitic
Chinhoyi	803	16	28	Fersialitic
Kadoma	732	16	29	Fersialitic
Bindura	877	13	27	Fersialitic
Glendale	827	14	26	Fersialitic
Mutare	750	15	26	Paraferallitic
Sanyati	732	16	29	Siallitic
Muzarabani	705	22	34	Colluvial soils
Lowveld	567	18	31	Vertisols

Table 8. Cotton production statistics for Ethiopia for 2001/2002.

Region	Area (ha)	Nr. of producers	Average size of farm (ha)	Major diseases reported
Upper Awash	470	1	470	Verticillium wilt
Middle Awash	12500	8	1563	None reported
Lower Awash	10000	5	2000	Fusarium wilt
Arbaminch	20000	50000	0.40	Verticillium wilt
Gambella	2000	4	500	Boll rot
Metema	21732	87000	0.25	Bacterial blight
Humera	7652	100	77	None reported
Gondar area	15990	62396	0.26	None reported
Bilaten area	500	1	500	None reported
South Omo	3000	1	3000	None reported
Total	93844	199516		

Table 9. Cotton production statistics for South Africa for 2001/2002.

Region	Area (ha)	Nr. of producers	Average size of farm (ha)	Major diseases reported
Northern	15586	100	156	Bacterial blight Verticillium Alternaria
North west	2971	50	59	Bacterial blight Alternaria leaf spot
Mpumalanga	4322	400	11	Bacterial blight Verticillium False mildew Boll rot
KwaZulu Natal	7463	3300	2	Boll rot Bacterial blight False mildew Verticillium
Northern Cape	195	10	20	Bacterial blight Verticillium wilt
Orange river	1019	200	5	Verticillium wilt
Total	**31556**	**4060**		

Table 10. Cotton production statistics for Sudan for 2001/2002.

Region	Area (ha)	Nr. of producers	Average size of farm (ha)	Major diseases reported
Nuba Mounties	-	-	-	Bacterial blight
Blue Nile	5384	1282	4	Bacterial blight
Gezira	79899	38047	2	Bacterial blight
New Halfa	16059	7654	2	Bacterial blight
Rahad	8400	4000	2	Bacterial blight
Tokar	-	-	-	-
Upper Nile	3780	1800	2	-
White Nile	6003	2858	2	Bacterial blight
Damazine	-	-	-	Bacterial blight
Gadarif	-	-	-	Bacterial blight
Suki	5670	2700	2	Bacterial blight
Nuba/MTS	-	-	-	
Total	**125191**	**8334**		

Table 11. Cotton production statistics for Tanzania for 2001/2002.

Region	Area (ha)	Nr. of producers	Average size of farm (ha)	Major diseases reported
WCGA	419160[a]	NA	2-5	Fusarium wilt Bacterial blight Alternaria Seedling disease
ECGA	840[a]	NA	2-5	Bacterial blight
Total	**420000**			

[a] Exact data could not be obtained from respondent. Data estimated based on percentages obtained from the Tanzanian Cotton Lint and Seed Board.

Table 12. Cotton production statistics for Uganda for 2001/2002.

Region	Area[a] (ha)	Nr. of producers	Average size of farm (ha)[a]	Major diseases reported
Western	-	5300	-	Bacterial blight
Mid western	-	3700	-	Bacterial blight
South eastern	-	19000	-	Fusarium wilt
North eastern	-	71000	-	Bacterial blight
Northern	-	80000	-	Bacterial blight
West Nile	-	4700	-	Bacterial blight
Total	**101175**	**183700**		

[a] Data could not be obtained from respondent.

Table 13. Cotton production statistics for Zimbabwe for 2001/2002.

Region	Area (ha)	Nr. of producers	Average size of farm (ha)	Major diseases reported
Gokwe	62781	50000	1.26	None reported
Kadoma	27638	23000	1.20	Verticillium wilt Bacterial blight *Alternaria* - isolated cases
Bindura	67609	57000	1.19	Verticillium wilt Bacterial blight - isolated cases
Glendale	11500	7000	1.64	Verticillium wilt Bacterial blight - isolated cases
Mutare	14798	12000	1.23	Verticillium wilt in some areas
Sanyati	54012	49000	1.10	None reported
Muzarabani	51702	47000	1.10	Boll rots in some areas Verticillium wilt - isolated cases
Chinhoyi	37910	33300	1.14	Verticillium wilt Bacterial blight - isolated cases
Banket	7069	2000	3.53	Verticillium wilt
Lowveld	27151	1500	18.10	Verticillium wilt
Total	**36217**	**28180**		

Table 14. Variety information for Ethiopia for 2001/2002.

Variety	Genetic stability / uniformity	Known disease resistance
Deltapine 90	Yes/Mixed	None
Acala SJ2	No	Wilt susceptible
Arba	Yes	Tolerant
Local	No (mixed type)	Disease & stress tolerant
Reger-36	Yes	Not studied
Albar 637	Yes	Bacterial blight - susceptible

Table 15. Variety information for South Africa for 2001/2002.

Variety	Genetic stability / uniformity	Known disease reactions
DeltaOpal	Yes	Bacterial blight resistant Verticillium wilt moderate
NuOpal	Yes	Bacterial blight resistant
DP 5690 RR	Yes	Bacterial blight susceptible
Acala OR3	Yes	Verticillium tolerant Bacterial blight susceptible
Tetra	No	Bacterial blight susceptible Verticillium wilt low
DP 655BR	Yes	Not tested yet

Table 16. Variety information for Sudan for 2001/2002.

Variety	Genetic stability / uniformity	Known disease reactions
Barakat 90	Yes	Bacterial blight – susceptible Fusarium wilt – resistant
Barac 67B	Yes	Bacterial blight – susceptible Fusarium wilt – resistant
Albar (57)12	Yes	Bacterial blight – susceptible Fusarium wilt – resistant
Acrain	Yes	Bacterial blight - susceptible

Table 17. Variety information for Tanzania for 2001/2002.

Variety	Genetic stability / uniformity	Known disease reactions
UK 77	Yes	Fusarium wilt – tolerant
UK 82	Yes	Fusarium wilt - susceptible
UK 91	Yes	Fusarium wilt – tolerant
IL 85	Yes	Bacterial blight – resistant
ALAI 90	Yes	Bacterial blight - resistant

Table 18. Variety information for Uganda for 2001/2002.

Variety	Genetic stability / uniformity	Known disease reactions
BPA 2000	Yes	Bacterial blight – good
BPA 99	Yes	Bacterial blight – good Verticillium wilt susceptible Fusarium susceptible
BPA 97	Yes	Bacterial blight – good Verticillium wilt susceptible Fusarium susceptible
BPA 95	Yes	Bacterial blight – good Verticillium wilt susceptible Fusarium susceptible

Table 19. Variety information for Zimbabwe for 2001/2002.

Variety	Genetic stability / uniformity	Known disease reactions
SZ 9314	Yes	Verticillium wilt - poor Bacterial blight – fair to good
BC 853	Yes	Verticillium - fair to good Bacterial blight - good
LS 9219	Yes	Bacterial blight - good Verticillium wilt - poor
FQ 902	Yes	Bacterial blight - good Verticillium wilt - poor

Table 20. Involvement of participating countries in breeding activities during 2001/2002.

Activity	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Involved in breeding	X	X	X	X	X	
Collection of resistance sources	X	X	X	X	X	X
Characterization of phenotypes	X	X	X	X	X	
Optimisation of selection techniques	X	X	X	X		
Study pathogen variation	X	X	X	X		

Table 21. Breeding activities in each participating country during 2001/2002.

Activity	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Field – natural infection	X	X	X	X	X	
Field – artificial infection	X	X	X	X	X	
Green house – artificial infection	X	X	X	X		
Use of representative pathotypes	X	X	X	X	X	

Table 22. Current seed sources and seed multiplication structures in the participating countries during 2001/2002.

	Ethiopia	**South Africa**	**Sudan**	**Tanzania**	**Uganda**	**Zimbabwe**
Seed source	• Ginneries • Local markets • Home preparation • WERER	• ARC *Foundation seed* • Seed companies *Foundation* *Certified seed*	State seed production units	Farmers through ginneries	• NARO *Foundation seed* • CDO & UCGEA *Certified seed*	Cotton Research Institute
Seed multiplication structures	Non organized	Seed companies	Seed production units	Contracted farmers	CDO and UCGEA through contracted farmers	Quton marketing company through contracted farmers
Seed marketing	• No existing structures • WERER	Seed companies	Seed production units	Ginneries	• CDO • UCGEA	Quton marketing company
Presence of seed-borne diseases in seed multiplication areas	Unsure	Bacterial blight	Bacterial blight	• Bacterial blight • Fusarium wilt	• Bacterial blight • Fusarium wilt	None observed
Fuzzy/acid delinted seed	• Fuzzy seed *small scale farmers* • Acid delinted seed *commercial farmers*	Acid delinted seed	Fuzzy seed	Fuzzy seed	• Machine delinted (10%) • Fuzzy seed (90%)	Acid delinted
Seed treatment	None	Vitavax @ 250 g/kg seed	• Gaucho + Roxor • Roxor/Apron	• Cuprous oxide (45%) • Bronopol (10%)	• Bronocot 12% @ 1kg/200kg for machine delinted seed or 1kg/150 kg for fuzzy seed	• Vitavax @ 250g/kg seed • Cruiser

Table 23. Symptoms observed and identification of seedling diseases in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Seed decay				X		
Damping off	X	X	X	X		X
Seedling blight	X	X	X	X	X	X
Identification						
Visual		X	X	X	X	X
Microbiological	X	X	X	X		X
Unsure					X	
Pathogen[a]	*Rhizoctonia* *Colletotrichum* *Fusarium* *Sclerotium*	*Rhizoctonia* *Fusarium* *Ascochyta* *Xanthomonas*	*Rhizoctonia* *Pythium* *Fusarium* *Macrophomina* *Sclerotium*	*Rhizoctonia* *Pythium* *Fusarium* *Macrophomina* *Sclerotium*		*Colletotrichum* *Rhizoctonia* *Pythium* *Fusarium* *Macrophomina* *Sclerotium* *Thielaviopsis*

[a] Listed in order of importance.

Table 24. Symptoms observed and identification of bacterial blight in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Cotyledon blight		X	X		X	
Angular leaf spot	X	X	X	X	X	X
Black arm/canker	X		X	X	X	X
Boll rot	X	X	X	X	X	X
Identification						
Visual		X	X	X	X	X
Microbiological	X	X	X	X		X
Unsure				X		
Races identified[a]	6, 7, 10	7, 10	6, 7, 10, 18, HV[a]	1, 2, 6, 7, 8, 10, 12, 18, HV	20, HV	None

[a] According to the race identification system endorsed by the Cotton Disease Council.

[a] HV: Uncharacterised hyper-virulent strains that occur in Africa.

Table 25. Symptoms observed and identification of Verticillium wilt in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Wilting		X		X	Does not occur	
Wilting & death	X			X		X
Chlorosis of leaf	X		X	X		X
Chlorosis & necrosis	X		X	X		
Vascular discolouration	X	X	X	X		X
Visual		X	X	X	Does not occur	X
Microbiological	X	X	X	X		X
Unsure	?	No	?	Yes		No
Races identified[a]			?	Defoliating		

[a] According to the disease reaction on differential host range.

Table 26. Symptoms observed and identification of Fusarium wilt in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Wilting				X		
Wilting & death	X	X	X	X		X
Chlorosis of leaf	X		X	X		X
Chlorosis & necrosis	X	X	X	X		
Vascular discolouration	X	X	X	X	X	X
Identification						
Visual		X	X	X	X	X
Microbiological	X	X	X	X	X	X
Strain ID	No	Yes	?	No	Yes	No
Strains	-	1	?	?	-	1

[a] According to the disease reaction on differential host range.

Table 27. Symptoms observed and identification of nematodes in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Meloidogyne incognita	X	X	X	X		X
Meloidogyne acronea			X			
Pratylencuhs spp.	X	X	X	X	X	
Heterodera spp.						X
Rotylenchulus spp.		X	X	X		X
Xiphinema spp.		X		X		
Longidorus spp.				X		
Paratrichodorus spp.				X		
Dorylaimus spp.						x
Aphelenchus sp.		X				
Tylenchus sp.		X				
Identification						
Visual		X	X	X		X
Root isolation	X	X	X	X	X	X
Soil isolation	X	X		X	X	

Table 28. Symptoms observed and identification of Alternaria leaf spot in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Cotyledon lesions	X	X	X		Does not occur	
Post-emergence damping off						X
Seedling blight		X				X
Leaf spot	X	X	X	X		X
Stem lesions/canker				X		
Boll lesions	X			X		
Identification						
Visual		X	X	X	Does not occur	X
Microbiological	X	X	X	X		X
Alternaria spp. ID	*A. macrospora*	*A. macrospora*	?	*A. macrospora* *A.alternata* *A. gossyppii*		*A. macrospora* *A.alternata* *A. gossyppii*

Table 29. Symptoms observed and identification of wet-weather blight in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Cotyledon lesions		X			Does not occur	
Leaf spot		X	X	X		X
Stem lesions/canker		X		X		
Identification						
Visual		X	X	X	Does not occur	X
Microbiological		X		X		X

Table 30. Symptoms observed and identification of false mildew in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Water-soaked lesions on cotyledon					Does not occur	
White, mouldy angular lesions	X	X	X	X		X
White/grey mould on bolls			X	X		X
Identification						
Visual	X	X	X	X	Does not occur	X
Microbiological		X		X		X

Table 31. Symptoms observed and identification of boll rot in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Alternaria alternata	X	X	X	X	Does not occur	
Ascochyta gossypii			X	X		X
Colletotrichum spp.	X	X		X		X
Fusarium moniliforme	X		X	X		X
Phytophthora sp.			X			
Rhizoctonia solani			X	X		X
Myrothecium roridum						
Phoma sp.	X					
Alternaria macrospora	X			X		
Botrytis sp.	X			X		
Rhizopus sp.	X			X		
Nematospora sp.			X			
Visual		X	X	X	Does not occur	X
Microbiological	X	X	X	X		X

Table 32. Symptoms observed and identification of virus diseases in the participating countries during 2001/2002.

Symptom	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Cotton mosaic	-			X		
Cotton anthocyanosis	-					X
Cotton blue disease	-					X
Cotton leaf crumple	-					
Cotton leaf curl	-				X	X
Cotton yellow vein	-					X
Unsure		X	X			
Identification						
Visual (symptoms)	-	-	-	X	X	X
Serological/EM/ DNA	-	-	-	X		

Table 33. Incidence and yield loss data for seedling diseases in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	No data	4	No data	-	No data	Not NB
% Incidence in survey area		10		12.5		
% Yield loss in survey area		1		-		
% National yield loss		0.004		-		
National yield loss (kg seed cotton)[a]		7384		-		

[a] Calculated using yield loss factors for South Africa.

Table 34. Incidence and yield loss data for bacterial blight in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	12	Not seen	-	5	0.45
% Incidence in survey area	25	25	due to	25	51	22
% Yield loss in survey area	-	20	planting of	-	20	1.13
% National yield loss	-	2.4	resistant	-	0.5	0.02
National yield loss (kg seed cotton)[a]	-	2584436	varieties	-	3018556	109935

[a] Calculated using yield loss factors for South Africa.

Table 35. Incidence and yield loss data for Verticillium wilt in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	No data	40	Does not	Not NB	-	5
% Incidence in survey area		30	occur		10	22
% Yield loss in survey area		30			1	30
% National yield loss		3.6			0	0.33
National yield loss (kg seed cotton)[a]		6645694			-	616111

[a] Calculated using yield loss factors for South Africa.

Table 36. Incidence and yield loss data for Fusarium wilt in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	0.003	1	50	50	Only 3
% Incidence in survey area	5	5	60	30	54	isolated case
% Yield loss in survey area	-	5	5	5	5	
% National yield loss	-	0.00001	0.03	0.75	1.35	
National yield loss (kg seed cotton)[a]	-	15	55381	1384520	2489828	

[a] Calculated using yield loss factors for South Africa.

Table 37. Incidence and yield loss data for nematodes in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	15	No data	-	-	Not NB
% Incidence in survey area	5	60		59	31	
% Yield loss in survey area	-	15		-	-	
% National yield loss	-	1.35		-	-	
National yield loss (kg seed cotton)[a]	-	2492135		-	-	

[a] Calculated using yield loss factors for South Africa.

Table 38. Incidence and yield loss data for Alternaria leaf spot in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	100	Does not	-	No data	Not NB
% Incidence in survey area	2	80	occur	70		
% Yield loss in survey area	-	0.001		-		
% National yield loss	-	0.0008		-		
National yield loss (kg seed cotton)[a]	-	1476		-		

[a] Calculated using yield loss factors for South Africa.

Table 39. Incidence and yield loss data for wet-weather blight in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	2	0.6	Does not	No data	-	No data
% Incidence in survey area	2	25	occur		-	
% Yield loss in survey area	0.25	0.25			30	
% National yield loss	0.0001	0.0004			-	
National yield loss (kg seed cotton)[a]	184.6026	692.26			-	

[a] Calculated using yield loss factors for South Africa.

Table 40. Incidence and yield loss data for false mildew in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	1.5	Does not	-	No data	No data
% Incidence in survey area	2	25	occur	45		
% Yield loss in survey area	-	0.5		-		
% National yield loss	-	0.0019		-		
National yield loss (kg seed cotton)[a]	-	3461		-		

[a] Calculated using yield loss factors for South Africa.

Table 41. Incidence and yield loss data for boll rot in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	15	Does not	No data	No data	No data
% Incidence in survey area	3	15	occur			
% Yield loss in survey area	-	20				
% National yield loss	-	0.45				
National yield loss (kg seed cotton)[a]	-	8307120				

[a] Calculated using yield loss factors for South Africa.

Table 42. Incidence and yield loss data for virus diseases in the participating countries during 2001/2002.

	Ethiopia	South Africa	Sudan	Tanzania	Uganda	Zimbabwe
% Total production area affected	-	0.1	No data	Not seen	Not seen	Not seen
% Incidence in survey area	0.5	15				
% Yield loss in survey area	-	1				
% National yield loss	-	0.0002				
National yield loss (kg seed cotton)[a]	-	277				

[a] Calculated using yield loss factors for South Africa.

Table 43. Current control measures for seedling diseases in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical	X	X	X	X	X	
Genetic						
Biological						
Cultural	X	X	X	X	X	
None						X
No need						
Control effective	Yes	No	Yes	Yes	No	No

Table 44. Current control measures for bacterial blight in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical	X	X	X		X	
Genetic	X	X	X	X		
Biological						
Cultural			X	X	X	X
None						
No need						
Control effective	Yes	No	Yes	No	No	No

Table 45. Current control measures for Verticillium wilt in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical					Does not occur	
Genetic	X		X	X		
Biological						
Cultural	X		X	X		X
None		X				
No need						
Control effective						No

Table 46. Current control measures for Fusarium wilt in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical						
Genetic		X	X		X	
Biological						
Cultural	X	X	X	X	X	X
None						
No need						
Control effective	No	No	No	No	Yes	No

Table 47. Current control measures for nematodes in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical		X		X		
Genetic			X	X	X	
Biological				X		
Cultural		X	X	X		
None	X					X
No need						
Control effective		No	No	No	Yes	No

Table 48. Current control measures for Alternaria leaf spot in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical		X			Does not occur	
Genetic	X		X			
Biological						
Cultural	X	X	X			
None				X		**X**
No need						
Control effective	Yes	No	Yes	No		**No**

Table 49. Current control measures for wet-weather blight in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical	Does not occur	X			Does not occur	
Genetic						
Biological						
Cultural		X				
None				X		X
No need			X			
Control effective		No	Yes	No		No

Table 50. Current control measures for false mildew in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical					Does not occur	
Genetic						
Biological						
Cultural		X	X			
None	X			X		X
No need						
Control effective	?	No	Yes	No		No

Table 51. Current control measures for boll rot in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical	X	X	X		Does not occur	
Genetic	X	X				
Biological						
Cultural	X	X	X	X		
None						X
No need						
Control effective	Yes	No	Yes	No		No

Table 52. Current control measures for virus diseases in the participating countries during 2001/2002.

Control measure	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Chemical	Not reported	Not reported	Not reported			
Genetic					X	
Biological						
Cultural						
None				X		X
No need						
Control effective						

Table 53. General comments on cotton disease management in the participating countries.

	Zimbabwe	Tanzania	Uganda	South Africa	Sudan	Ethiopia
Short-comings with disease management	• Lack of resistant material • Cannot prevent Verticillium spread	• Inadequate resources	• Lack of trained staff & resources • Seed smuggling	• Lack of resistant varietys • Lack of awareness among farmers • Inadequate researcher-extension-farmer links	• Relaxation of control measures by farmers	• Lack of research facilities • Limited resources and funds • Lack of training
Current methods used to control cotton diseases	• Contain diseases • Avoid spreading of • new diseases • MAR lines	• Integrated pest control (IPM)	• Quarantine regulations • Seed & plant protection acts & enforce	• IPM • Resistance • Sanitation	• Resistant varieties	• Cultural and genetic