ORGANIZATION OF AFRICAN UNITY
Scientific Technical and Research Commission

Joint Project 31 Semi-Arid Food Grain Research and Development

SAFGRAD

International Institute of Tropical Agriculture

IITA

FINAL REPORT
RESIDENT RESEARCH
PHASE II

Funded by :
USAID : United States Agency for International Development
IDRC : International Development Research Center, Canada

IITA/SAFGRAD
B.P. 1783
Ouagadougou
Burkina Faso

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ORANIZATION OF AFRICAN UNITY

SCIENTIFIC TECHNICAL AND RESEARCH COMMISSION
Joint Project 31 Semi-Arid Food Grain Research and Development

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ABBREVIATIONS

CIMMYT	- International Maize and Wheat Improvement Centre.
DSA	- Direction des Services Agricoles.
EEC	- European Economic Community.
FSU	- Farming Systems Unit.
HYVT	- High Yielding Variety Technology.
ICRISAT	- International Crops Research Institute for the Semi-Arid Tropics.
IDRC	- International Development Centre.
IITA	- International Institute of Tropical Agriculture.
INERA	- Institut d'Etudes et de Recherches Agricoles.
IRAT	- Institut de Recherche Agronomique Tropicale.
ISP	- Institut Supérieur Polytechnique.
NARS	- National Agricultural Research Systems.
OAU	- Organization of African Unity.
ORD	- Organisme Régional de Développement.
SAFGRAD	- Semi-Arid Food Grain Research and Development.
SAT	- Semi-Arid Tropics.
STRC	- Scientific, Technical and Research Commission.
USAID	- United States Agency for International Development.
WASAT	- West African Semi-Arid Tropics.

PREFACE:

This report highlights results of resident research in the second phase of the IITA/SAFGRAD Project from 1985 to 1987. During this period, the project underwent important philosophical and structural re-orientation. Following favourable mid-term and end-of-project evaluations the IITA component was extended into a second phase of 5 years beginning in September, 1986. During Phase II, Network activities will receive major emphasis while resident research will be terminated after 18 months. The primary thrust of SAFGRAD II will be to increase the efficiency and effectiveness of National Agricultural Research Systems (NARS) by developing the capacity and initiative or national scientists to direct cowpea and maize collaborative research networks which IITA accepted to establish, initially in West and Central Africa.

DECLARATION

Mention of a particular pesticide or any other chemical in this report does not imply endorsement or discrimination against any product by IITA/SAFGRAD.

ACKNOWLEDGEMENTS

The IITA/SAFGRAD Project is greatly indebted to the Government of Burkina Faso for its support of project activities. In particular, the Project is immensely grateful to the Ministry of Higher Education and Scientific Research, for providing land and other facilities at the Kamboinse, Saria, Farako-Ba, Vallee du Kou, and Gampela stations and to the Ministry of Agriculture for allocation of land at Loumbila, Pobe (Fajiba), and Gorom-Gorom. The collaborative support of the Director of the "Institut National d'Etudes et de Recherches Agricoles (INERA), the Directors of the "Direction des Services Agricoles (DSA), and the Station Directors have been crucial for the successful execution of SAFGRAD activities in Burkina Faso.

The cooperation of CIMMYT, IRAT, ICRISAT FSU and ISP (University of Ouagadougou) as well as that of many ORD Directors, ACPO's, U.S. Peace Corps and USAID/BF is acknowledged and deeply appreciated.

The active participation of national maize and cowpea programs of SAFGRAD member countries has been a key element in developing and improving the Regional Maize and Cowpea Networks under the auspices of SAFGRAD. The support of various national governments and the mutual collaboration with national researchers is gratefully acknowledged.

The support of the OAU/STRC SAFGRAD Coordination Office in Ouagadougou, in general, and the interest and encouragement of the International Coordinator and the Director of Research of SAFGRAD, in particular, have greatly facilitated our work.

The IITA/SAFGRAD Team in Burkina Faso succeeded in the attainment of project objectives, thanks to the continuous administrative and technical backstopping provided by the authorities at IITA headquarters, Ibadan, Nigeria.

These achievements would not have been possible without the financial assistance of the U.S. Agency for International Development (USAID) and the International Development Research Centre (IDRC) of Canada, to whom we are deeply grateful.

Joseph B. Suh
Entomologist/
Project Leader

OUAGADOUGOU
January, 1988

1. INTRODUCTION

The Semi-Arid Food Grain Research and Development (SAFGRAD) Project was launched in 1977 by the Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC) and the US Agency for International Development (USAID). The project, often referred to as OAU/STRC Joint Project 31, serves a total of 26 African countries. It is organized by the OAU/STRC Coordination Office in Ouagadougou headed by the SAFGRAD International Coordinator. The Project's ultimate objective is to improve the production of maize, sorghum, millet and cowpea. The International Institute of Tropical Agriculture (IITA) accepted responsibility for undertaking regionally oriented research and training activities for maize and cowpea. Our goal has been to develop and promote maize and cowpea varieties, in addition to determining the cultural practices, for maize and cowpea production, that are compatible with small-scale farming systems in the semi-arid tropics (SAT).

This report summarises the Project's resident research activities, highlighting results obtained between 1985, when the Phase I final draft report was prepared, and 1987, the cropping season of which was the last for the Project's resident research. Readers seeking more detailed information are kindly referred to the IITA/SAFGRAD Final Report (Phase I) as well as the Project's Annual Reports published in English and French since 1979.

2. STAFFING

The IITA/SAFGRAD Project became fully operational by June, 1979, with the arrival of four, USAID-funded scientists in Ouagadougou. These included a maize breeder, a maize agronomist, a cowpea agronomist (soil fertility specialist), and an entomologist. Under a separate bilateral agreement between the Government of Burkina Faso and IDRC of Canada, an IITA cowpea breeder had been based in Ouagadougou since 1977 to develop the National Cowpea Improvement Program. In addition to his national program responsibilities, the cowpea breeder provided technical support to USAID/SAFGRAD scientists. The IDRC/IITA Cowpea Breeding Program assumed a fully regional orientation, within the IITA/SAFGRAD Project, in 1983. Thus, from the start, the five IITA scientists have worked as two teams: (a) a maize team, consisting of a breeder, an agronomist and an entomologist (25%); and (b) a cowpea team, also consisting of a breeder, an agronomist, and an entomologist (75%). Recently IITA was asked to assume responsibility for

the soil and water management research previously contracted to ICRISAT/SAFGRAD. Consequently, in April, 1985, a sixth IITA/SAFGRAD scientist was added to the team which now comprises the following:

Name and designation of Staff	Supporting agency
Dr. V.D. Aggarwal, Cowpea Breeder	(IDRC)
Dr. N. Muleba, Cowpea Agronomist	(USAID)
Dr. A.O. Diallo, Maize Breeder	(USAID)
Dr. M.S. Rodriguez, Maize Agronomist	(USAID)
Dr. N.R. Hulugalle, Soil & Water Management Agronomist	(USAID)
Dr. J.B. Suh, Entomologist and Project Leader	(USAID)

All the IITA/SAFGRAD scientists are based at the Kamboinse National Agriculture Research Station (INERA) situated 14 km north of Ouagadougou.

A high degree of continuity among senior IITA/SAFGRAD staff has contributed greatly to attainment of the Project's goals.

The IITA/SAFGRAD Project employs in both its USAID and IDRC funded components the following local, permanent support staff:

1 Assistant Administrator, 1 Accountant, 1 Cashier, 1 Storekeeper, 1 Office Clerk, 1 Technician (B.Sc.), 15 observers, 1 Mechanic and 2 assistants, 4 secretaries, 4 drivers, 2 tractor operators, 18 labourers, and 4 watchmen. The casual labour force was highly variable, reaching a total of about 300 labourers in all research stations at the peak of the rainy season.

The Project has greatly benefited from close cooperation with the U.S. Peace Corps. A total of 10 volunteers have worked for the IITA/SAFGRAD Project, either as research assistants, or as assistants in the management of the research farm.

3. OVERALL OBJECTIVES AND STRATEGY

The major objectives of the IITA/SAFGRAD Project have been:

a) To assist and strengthen national maize and cowpea programs in the African semi-arid tropics.

b) To develop improved maize and cowpea varieties and agronomic management practices capable of giving higher and more stable economic yields in semi-arid environments.

c) To organize and promote systematic regional testing of available genetic materials and technologies in the SAT.

d) To assist in the training and manpower development of African nationals at all levels.

The strategies adopted for achieving these objectives include:

a) Resident research, i.e. research conducted directly by IITA/SAFGRAD staff at different locations in Burkina Faso.

b) Regional research conducted by IITA/SAFGRAD staff, in collaboration with national program scientists in the 26 member countries of SAFGRAD.

c) Support and assistance to national programs through: consulting visits, technical advice, encouragement and motivation, organization of annual maize and cowpea workshops, and organization of annual maize and cowpea monitoring tours.

d) Training of national program scientists in Burkina Faso and at IITA headquarters at Ibadan, Nigeria.

Mid-term and end-of-project evaluations of the SAFGRAD (Phase I) Project as a whole, and in particular, the IITA component, concluded that implementation has produced numerous positive results consistent with and contributing to, the achievement of project goals. The end-of-project evaluation team recommended extending the project into a second phase for five years. The major preoccupation for SAFGRAD II will be to increase the efficiency and effectiveness of agricultural research by developing the capacity and initiative of national scientists to assume increasing decision making roles in cowpea and maize collaborative research networks.

The International Institute of Tropical Agriculture (IITA) accepted the implementation responsibility for establishing the cowpea and maize collaborative research networks, initially in West and Central Africa. Under this arrangement, IITA accepted to:

a) Continue the resident research undertaken during Phase I during the first 18 months, beginning September, 1986.

b) Assume leadership in creating the collaborative research networks for cowpea and maize by appointing coordinators for each network. Management of these networks must, however ensure that national program researchers play an increasing leadership role in network planning, monitoring and coordination, such that the National Agricultural Research Systems (NARS) will in time, assume full leadership over networking, with IITA only in a supporting role.

c) Assist in the establishment of a Steering (Advisory) Committee (for each network), whose major responsibility will be to coordinate, provide leadership and direction for the network by setting up agendas for annual meetings, monitoring tours and workshops as well as allocate research responsibility among participating member countries.

4. PHYSICAL ENVIRONMENT: SOILS AND CLIMATE

The semi-arid tropics (SAT) of West Africa can be separated into three major ecologies: the Sahel, the Sudan, and the Northern Guinea savannas, all of which are characterized by a monomodal rainfall distribution. There is ample variability among different authors as to the terminologies and parameters used to define these ecologies. For our purposes, the following limits have been defined.

Savanna	Annual rainfall (mm)	Length of rainy season (months)
Sahel	300-600	2-3
Sudan	600-900	3-4
Northern Guinea	900-1200	4-5

One major characteristics of the West African SAT is the variability in the amount and distribution of the annual rainfall. Thus, this classification scheme should not be interpreted too rigidly. All three ecological areas are represented in Burkina Faso. Research sites selected in these ecologies have

permitted IITA/SAFGRAD to conduct regionally oriented resident research with potential applicability to much of the West African SAT.

The main resident research sites selected, and the area cropped by IITA/SAFGRAD are outlined below. The reader is also referred to the map (Fig.1) for the location of these research sites.

a) Northern Guinea Savanna:

(i) Farako-Ba Research Station (INERA), located 12 km SW of Bobo-Dioulasso; weakly ferrallitic soils (Eutrustox, Haplustalfs, Ustorthents, and Palenstalfs); mean annual rainfall, 1100 mm; area, 17 hectares.

(ii) Vallee du Kou Sub-Station (INERA), located 20 km NE of Bobo-Dioulasso; ferruginous, tropical soils and hydromorphic soils "peu humifiés" (Ustorthents and Troppaquepts); mean annual rainfall, 1100 mm; area, 1 hecture; irrigation facilities are available.

b) Sudan Savanna:

(i) Kamboinse Research Station (INERA), located 14 km NE of Ouagadougou; ferruginous, tropical, hydromorphic and some ferrallitic soils (Palenstalfs, Plinthustalfs and ustochrepts); mean annual rainfall, 800 mm; area, 30 hectares.

(ii) Saria Research Station (INERA), located about 90 km West of Ouagadougou; ferruginous, tropical, hydromorphic and ferrallitic soils (Haplustalfs, Plinthustalfs, Ustochrepts, and Eutrustox); area, 3.5 hectares.

(iii) Loumbila (Ministry of Agriculture), located 15 km North of Ouagadougou; mostly ferruginous, tropical soils (Hapludalfs, Plinthustalfs, Ustorthents and Haplustalfs); mean annual rainfall, 800 mm;limited irrigation facilities are available; area 3 hectares.

(iv) Gampela (ISP), located about 20 km East of Ouagadougou; mostly ferruginous, tropical soils; mean annual rainfall, 700 mm; area, 6 hectares.

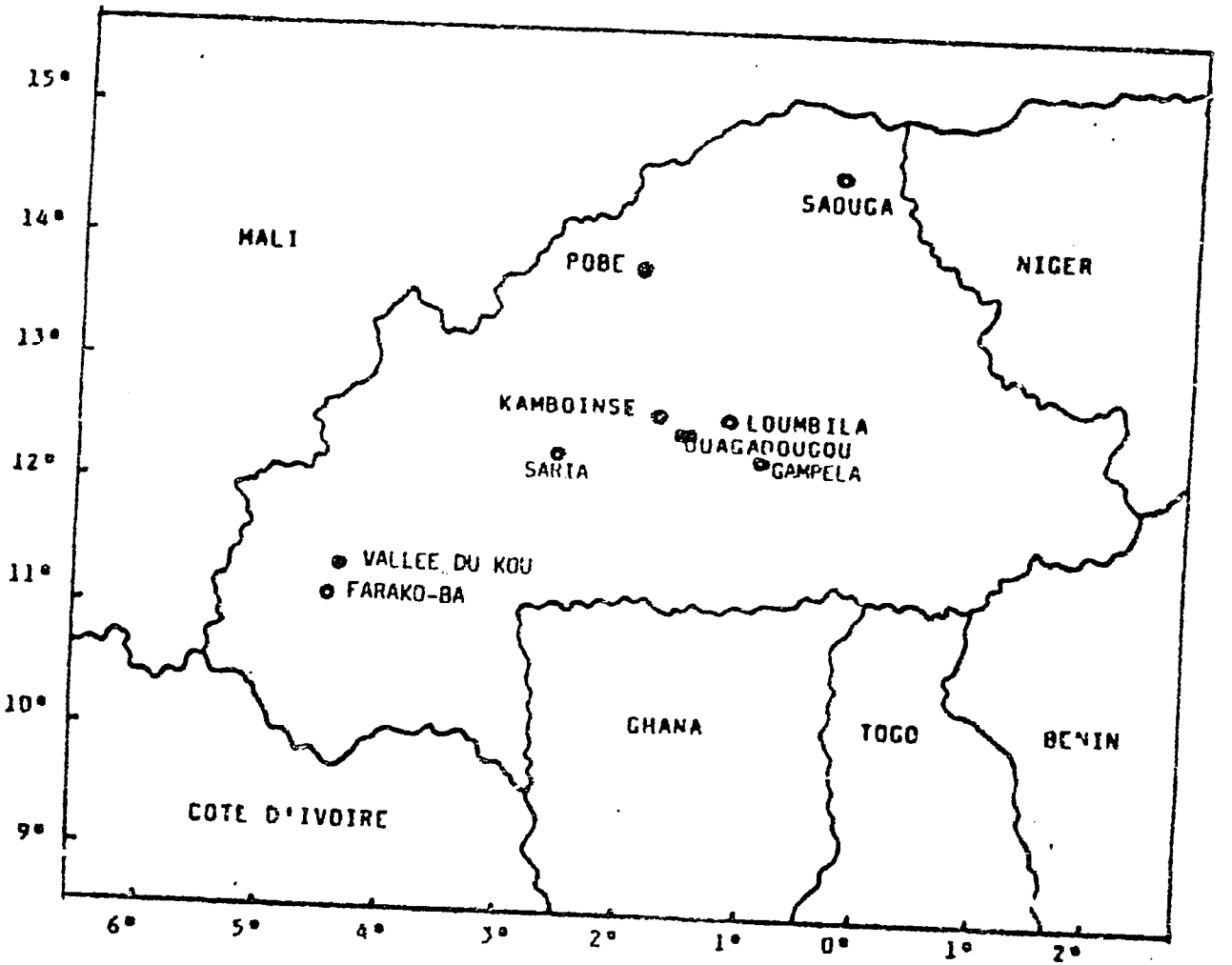

Fig. 1. MAP OF BURKINA FASO SHOWING MAIN RESEARCH SITES OF IITA/SAFGRAD
(PRINCIPALES LOCALITES POUR LA RECHERCHE A L'IITA/SAFGRAD)

c) Sahel Savanna:

(i) Saouga, Gorom-Gorom (Ministry of Agriculture), located about 300 km North of Ouagadougou; mean annual rainfall, 400 mm.

(ii) Pobe (Ministry of Agriculture), located about 200 km North of Ouagadougou; mostly ferruginous, tropical soils (Haplargids and Cambiorthids); mean annual rainfall, 450 mm; area, 7 hectares.

In addition to the above sites, some verificative research and demonstration trials are conducted in farmers' fields.

Cowpea research is conducted in the three major ecologies, but maize work has been confined to the sudan and northern Guinea savannas.

5. PHYSICAL FACILITIES DEVELOPMENT

Although the Project operates at the eight sites given in the previous section, only at Kamboinse and Loumbila have there been major developments of physical research facilities by IITA/SAFGRAD.

5.1 Kamboinse

The four USAID-funded scientists were accommodated in the office of the IDRC cowpea Breeder until a building with six offices was built by the SAFGRAD Project in the second half of 1979. By 1980, the Project had also built:

(i) A small cold-room for short term seed storage.

(ii) Two work sheds and three working rooms for seed handling, trial preparation, and harvest processing.

(iii) A screenhouse for cowpea breeding and entomology work.

(iv) An entomology laboratory with the financial support of IDRC (National Cowpea Program and Grain Storage Projects).

An existing building was renovated and enlarged to provide office space for technical support staff, trainees and Peace Corps volunteers.

A total of 17 hectares (seven in 1979 and 10 in 1980) were cleared and developed by the Project. With the assistance of the farm office at IITA headquarters, roads, drainage ways, and contour terraces were laid out on the land assigned to the Project.

A second screenhouse was built in 1981. The agronomy laboratory was finished in 1982, although water supply installations were not completed until 1983.

Essential farm machinery (including two tractors) was bought in 1980. To date, no storage facilities have been constructed at Kamboinse by IITA/SAFGRAD. The Project has, however, been using storage space belonging to Burkina National Program (INERA and Ministry of Agriculture).

5.2 Loumbila

Given very limited irrigation facilities at Kamboinse, the host Government agreed to give the Project ten hectares of irrigated land at Loumbila, where the Project carried out most of its dry season work. Two more hectares of land were made available to the Project by the ORD at Loumbila. It has not been possible, however, to properly irrigate more than three to four hectares in any one year, due to a limited supply of water.

IITA/SAFGRAD built a fence, a farm store, a work room, and a shed in addition to improving the irrigation channel and roads during 1980-81. Unfortunately, and in spite of these substantial investments in irrigation facilities by the Project, the Ministry of Rural Development decided to take back most of the land at Loumbila from the Project in 1984. Since then, most of our off-season breeding activities have been shifted to the Vallee du Kou sub-station(about 400 km south-west of Ouagadougou).

5.3 Other Sites

As a result of land limitations at Kamboinse, the Project cropped up to eight hectares at the Saria research station in 1979 and 1980. To facilitate operations there, the Project renovated an old house to serve as a field laboratory as well as a store. With the development of facilities at Loumbila

in 1980-81, activities at Saria were reduced substantially; the house was also returned to the national program.

6. RESIDENT RESEARCH IN BURKINA FASO

6.1. MAIZE BREEDING

6.1.1. Objectives

Drought stress is one of the major factors affecting the stability of maize yields in the Sudan Savanna zone of Africa. Breeding for drought resistance and drought escape, therefore, became major components of the maize genetic improvement program from 1984. For the northern Guinea savanna zone, early and intermediate maturing, streak resistant varieties are required.

In other words, through resident research, regional and international cooperation, the SAFGRAD/IITA Maize Breeding Program aims at developing and/or identifying four different types of varieties, namely: (1) early, drought resistant varieties, in collaboration with the maize agronomist; (2) extra-early varieties (for drought escape) which mature in less than 82 days after planting; (3) early varieties (82-95 days to maturity); and (4) intermediate (96-110 days to maturity), streak resistant varieties.

In addition, identification of good materials, for relay cropping with cowpea in collaboration with the cowpea agronomist, was another, but less important, objective of the program.

6.1.2. Research Results

These results cover the period, 1984-1987. The results of previous were reported in the IITA/SAFGRAD Final Report, Phase I.

a) Breeding for drought resistance

Agronomic research work done since 1979 has shown a very marked response of maize to tied ridges on the ferruginous, tropical soils common in the Sudan savanna. By growing sets of varieties, using both simple and tied ridges, their performance under two drought stress conditions can be evaluated. Given the lack

of irrigation facilities, tied and simple ridges were used to simulate two levels of stress conditions in both population improvement and varietal evaluation trials.

b) Population improvement

In 1982, Pool 16 (early, white dent, tropical pool developed by CIMMYT) was identified as resistant to drought stress compared to other materials. In 1983, a recurrent selection, using full sib families, was undertaken to improve this pool for drought resistance. Two cycles of selection have been achieved and seven experimental varieties were developed. New drought resistant versions of this pool (pool 16 DR C1 and pool 16 DR C2), with moderate resistance to maize streak virus, were developed.

A trend of improvement from cycle to cycle was observed. A mean of 7% progress was recorded from cycle to cycle under more drought stress conditions compared to a mean of 5% under medium stress conditions and a mean of 4.7% under less stress conditions.

At six locations in four SAFGRAD member countries, pool 16 DR C2 outyielded pool 16 DR C0 and SAFITA-2 by 8.7% and 7.7%, respectively. Pool 16 DR C2 yielded higher than SAFITA-2 by 28.9%, 15.5%, and 14.4% under three decreasing levels of drought stress designated as more, medium and less stress conditions, respectively.

Experimental varieties developed with 10 full sib families did not perform better than the respective cycles.

c) Varietal evaluation

From 1984 to 1987, more than 70 early maize materials, including local and improved, from CIMMYT, IITA and national programs of SAFGRAD member countries were evaluated under two stress levels at Kamboinse (Burkina Faso). In some cases, highly significant variety x stress level interactions were obtained.

Five materials (Temp x Tropical No. 42, SAFITA-104, Capinopolis 8245, pool 16, and JFS) performed better than others under drought stress conditions, whereas four varieties (local Kamboinse, Composite BD, Kito, and Synthetic C)

were found to be susceptible to drought.

Among the five materials resistant to drought, three (Temp. x Trop. 42, SAFITA-104, and Capinopolis 8245) have sub-tropical genetic backgrounds. It seems that sources of drought resistance should be sought in temperate and sub-tropical germplasm.

6.1.3. Breeding for extra-early (drought escape) varieties

During the 1984 dry season, early and extra-early germplasm collected from Colombia, CIMMYT, India and Burkina Faso were grown for observation and seed increase. Out of 80 materials collected, 48 were selected and evaluated.

Across locations, two varieties, Bursanga tollo or Kamandaogo tollo (local yellow variety) and GUA 314 (white Colombian variety) flowered, on the average, at 42-43 days after planting (7 days earlier than the local check) with mean yields of 2.4 and 2.5 t/ha, respectively. Because of the narrow genetic base of these varieties, bad looking grain type and colour, and susceptibility to lodging, it was decided to cross them with other existing good, early white and yellow improved varieties, to develop composites combining extra-earliness and other useful agronomic characters.

During the dry season of 1985-1986, 40 early white varieties were crossed with GUA 314 and advanced to F_2 while 58 early yellow varieties were crossed with Kamandaogo tollo and advanced to F_2, during 1986 growing season. The best F_2 white and yellow crosses were evaluated in two trials at Kamboinse. Sixteen crosses reached the black layer stage at 72-78 days after planting, with an average yield of 3.5 t/ha.

The best 10 crosses were included in Regional Uniform Extra-Early Variety Trial (RUVT-3) for testing in SAFGRAD member countries. In six countries, two yellow crosses (DMRESR-y x JFS x Tollo and Pool 29 x K. Tollo) flowered at 42-43 days after planting and yielded 2.1 t/ha. Also two white crosses (Pool 27 x GUA 314 and TZESR-W x GUA 314) flowered at 44-45 days after planting and yielded 2.1 - 2.2 t/ha.

During the dry season of 1986-1987 (October-December), the yellow crosses were back-crossed to the earliest yellow recurrent parent (Kamandaogo Tollo)

while the white crosses were back-crossed to the earliest white recurrent parent (GUA 314). During the same growing season (February to May, 1987), the best yellow and white back-crosses were recombined and the following composites were developed and tested in the 1987 rainy season at three locations in Burkina Faso:

TZEE-Y (Tropical Zea Extra-early Yellow), TZEEW-1 (Tropical Zea Extra-early white One), TZEEW-2 (Tropical Zea Extra-early white Two), and TZEEW-3 (Tropical Zea Extra-early white Three). These composites matured in 75-80 days after planting with 3 t/ha grain yield potential.

6.1.4. Breeding for early maturity

In 1984, the need to develop new early yellow flint population using local and improved germplasm was felt. Therefore 36 improved varieties of various origins (CIMMYT, IITA, national programs of SAFGRAD member countries) were crossed with Jaune Flint de Saria (JFS), a local improved variety well adapted in the Sudan savanna of Burkina Faso, in order to combine yield, earliness, resistance to lodging, and resistance to foliar diseases. In the 1985 dry season, these crosses were advanced to F_2 and then tested in the rainy season at three locations. The best yellow crosses plus local Raytiri (a good local variety) were diallel crossed to make a new population, TZEF-Y (Tropical Zea, Early Flint, Yellow). TZEF-Y was included in Regional Variety Trial (RUVT-1) in 1987 and was also tested at two locations in Burkina Faso (Karboinse and Farako-Bâ). At Kamboinse, TZEF-Y (with 44 days to 50% silking) yielded 3.5 t/ha which compared favourably with 2.8 t/ha produced by JFS, the local check. At Farako-Bâ, TZEF-Y and the local check yielded 3.8 and 2.7 t/ha, respectively, the yields being significantly different from one another. In five countries, TZEF-Y averaged 2.9 t/ha, with 45 days to 50% silking.

In collaboration with IITA and CIMMYT, three early varieties were developed at Kamboinse: Kamboinse (1) 84 TZESR-W, Kamboinse (1) 8433, and Kamboinse 8546.

Two varieties developed earlier were tested in 1987 regional trials (RUVT-1); they averaged 3.0 and 2.8 t/ha, respectively in five SAFGRAD member countries. Two other early materials (Capinopolis 8245 and Sids 8245) were identified and tested; both of them showed good performance in SAFGRAD member

countries. Two local varieties (Local Koudougou and Local Raytiri) performed very well in the Sudan savanna of Burkina Faso. These results are in agreement with those obtained by the SAFGRAD/IITA maize agronomist. However, these varieties are susceptible to foliar diseases.

In collaboration with the national program of Burkina Faso, TZESR-W, and EV84 30 SR were found to be adapted in the ORD of Koudougou where these two materials are being considered for formal release.

The new population, TZEF-Y, with a broad genetic base, population 45 (from CIMMYT), TZESR-W, and pool 16 DR can be recommended for the Sudan savanna where maize diseases are not very important.

Local Koudougou and local Raytiri are very well adapted in this environment and should be given a high priority by breeders of Burkina Faso National Program.

6.1.5. Breeding for intermediate or late maturity

These varieties are intended for the northern Guinea savanna zone where maize streak virus is the major constraint to maize production. In collaboration with CIMMYT and IITA/Ibadan, three varieties (Ilonga 8032, Across 8149, and EV 8322 SR) were identified in 1984 and have been tested in Regional Uniform Intermediate Variety Trial (RUVT-2) (see section on Regional Program). Our 1984 data were in agreement with those obtained by the national program of Burkina Faso in respect of EV 8322 SR, which, after further, detailed evaluation by the national program, has now been released in Burkina Faso under the name "SR-22".

In 1985, two other varieties, namely Ikenne 81 TZSR-Y-1 and EV 8428 SR BC4, were identified as good yellow germplasm for the northern Guinea savanna. Also, in collaboration with IITA/Ibadan, two varieties (Farako-Ba 85TZSR-Y-1 and Farako-Bâ 85TZSR-W-1) were developed. An experimental, intermediate yellow variety (Loumbila (1) 84TZUT-Y) was also developed and tested.

6.1.6. Evaluation of materials for relay cropping with cowpea

In 1985, two experiments, namely EVT-ESR (including early, streak resistant varieties) and RUVT-1 (including varieties in SAFGRAD Regional Trials) were conducted at Farako-Ba, in collaboration with the Cowpea Agronomist, to determine the effect of maize cultivars on relay-cropped cowpea and to identify maize cultivars that exert the least depressing effect on the yield of cowpeas. EV8431 SR was identified as a high yielding, early yellow variety which only slightly depresses the yield of relay cropped cowpeas.

6.2. MAIZE AGRONOMY

6.2.1. Objectives

a) To assess the relative importance of the different soil, climatic, and management factors affecting maize production in the northern Guinea and Sudan savanna zones.

b) To establish suitable management practices for the production of maize under low and high management conditions.

c) To participate in the formulation and execution of a maize improvement program, designed for the growing conditions in the semi-arid tropics (SAT), with particular emphasis on increasing the tolerance of maize to drought.

6.2.2. Research results

The research findings presented in IITA/SAFGRAD Final Report Phase I were for the most part further confirmed in trials conducted from 1985 to 1987. Consequently, only some additional results, as well as any necessary clarifications of those earlier findings, are presented in this report.

a) Genotype x fertility level interactions.

The performance of 12 local and improved varieties was evaluated for three years under low and high levels of nitrogen and phosphorus. Results showed that local varieties are not necessarily better adapted to low P and/or low N conditions than improved varieties. For example, several improved IITA/SAFGRAD varieties and the hybrid, IRAT-178, performed better than the local varieties

under low P, and to a lesser extent, under low N conditions. There were significant interactions between varieties and N level and between varieties and P level, i.e., the relative performance of varieties was affected by the N and/or P fertility levels. The variety, SAFITA-2, showed a consistently good performance under low P, whereas SAFITA-2, and TZE-4 were among the best performers under low N.

b) Maize-cotton intercropping in the Sudan savanna.

A maize-cotton intercropping system was developed and tested for six years with good results in the Sudan savanna. It involved simultaneous early planting (June 15-25) of an early, non-leafy maize variety (82 days to maturity) and a cotton variety adapted to the zone. Each crop was planted at about 42,000 plants/ha, at two plants/hill,in alternating hills along the row. Absolute maize and cotton yields were each shown to be a function mainly of rainfall pattern and amount, date of planting, and soil fertility levels. Relative yields (in relation to monocropping), however, were usually around 75% for each crop, resulting in a L.E.R. of about 1.5. The association often gave yields of 2 t/ha of maize and 1.5 t/ha of cotton. The inclusion of cotton, a cash crop, in the system appears to be a means of intensifying the use of fertilizer, an almost essential requirement for increasing maize productivity. The use of tied ridges was apparently a pre-requisite for the success of the association under the predominant Sudan savanna soils. An additional advantage of the association is the possibility of using the cotton stalks as wood for cooking purposes.

c) Maize-cowpea rotation and relay-cropping systems.

Maize yields were consistently lower under continuous maize crop than when maize followed cowpea crop in a rotation. The increase in yield of maize grown in such a rotation with cowpea was as high as 1200 kg/ha.

Relay-cropping of cowpeas and maize did not significantly reduce yields of maize in the relay. However, the yield of monocropped maize in the year immediately after that of the maize-cowpea relay crop was either depressed or unaffected. Therefore, the production of cowpea as a relay crop with maize did not result in increase in yield of the succeeding monocrop of maize; this contrasts with significant increases in yield of maize monocrop grown

immediately after a monocrop of cowpea.

d) Surface management systems.

When compared with traditional flat cultivation and planting, tied-earthing up by hand, or with the donkey ridge-tier, increased yields of mono-cropped sorghum and maize, as well as the productivity of a maize/cotton association. Likewise, digging small ditches between rows increased yields of mono-cropped maize and sorghum. These ditches can be dug either with a hand-hoe or with the oval wheel of a donkey and oxen traction implement developed by ICRISAT's Socio-economics program in Burkina Faso. The main advantage of such ditches is that they are separated by hard ground whereas newly made tied ridges consist of loose soil and, therefore, are more easily destroyed when there is water overflow in the furrows or when large amounts of runoff water enters the farm from the outside. Although tied ridges could hold more rain water than the ditches, they do not allow runoff water from outside the plot to enter the basins while ditches, by contrast, allow entry of run-off water into the farm or plot.

e) Residual tillage effects.

There seems to be a carry-over effect of tillage, but only in the absence of tied-ridges. Soil tillage by hand-hoe, oxen and tractor gave an average yield increase of 39%, in the second year, over zero-tillage.

f) Residual effects and duration of tied-ridges.

There was no maize yield advantage, in most cases, of pre-planting hand cultivation with complete tied-ridge renovation over direct planting on old tied ridges in plots where there had not been systematic removal of crop residues.

Nevertheless, direct planting on old tied ridges, without previous tillage, can result in depressed maize growth if, during the first weeks of the crop, weather and soil conditions are such that there is excess moisture in the upper soil layer. Such a negative effect is more pronounced under very low fertility conditions, or when sub-surface termite activity results in severe damage to maize roots.

In an average year, the basin capacity of tied ridges is reduced by about 50% by rainfall under Kamboinse station conditions. Farmers planting on old tied ridges would need far less labour for raising and maintaining the existing tied ridges than is required to make new ones. Our results have shown that even without any maintenance at all, old tied ridges in the year immediately after that in which they were first established increased maize yields by about 1 t/ha compared to those of maize grown under the conventional flat cultivation and planting.

g) Effect of maize crop residues

The application of 4 or more t/ha of maize residue dry matter always gave large yield increases due, at least in part, to improved water infiltration. Such yield increases were present even under tied ridges, indicating that maize residues, not only improve water infiltration, but are beneficial in other respects, such as e.g., reducing evaporation and lowering soil temperatures.

h) Residual Furadan effects.

Significant maize yield increases of around 0.5 t/ha were obtained in the second year after the application of Furadan 5 G at the rate of 1.5 kg a.i./ha, although there was no residual Furadan effect on cowpea yields.

i) Residual N fertilizer effects.

Sorghum, maize, and cotton responded differently to residual N fertilizer. There were significant residual N fertilizer effects on sorghum and cotton yields. Thus, appropriate crop rotations are a tool for more efficient recovery of applied fertilizer N.

j) Residual P fertilizer effects.

Consistent residual P effects on maize yields were measured every year from 1980, when the initial and the only P application (69 kg P_2O_5/ha) was supplied, to 1987 when the study was terminated.

k) Soil cultivation (scarification)

On crust-forming, dense soils, breaking the soil crust, even in the absence of weeds, improved water infiltration and soil aeration. Maize yield increases were very small, however, if the cultivations were shallow (1-2 cm); higher yields were obtained with deeper cultivations, 4-6 cm. These cultivations should be performed when the soil is not dry, e.g. after a 15-20 mm rain, and should inflict minimal damage to the root system. However, inter-row ditches and tied ridges are much more effective than cultivations in increasing yields in such soils.

l) Plants per hill.

Experiments in the Sudan savanna showed that in some, but not necessarily all, years having four plants per hill resulted in lower maize yields than one to two plants per hill (at the same plant density/ha).

6.2.3. Improvement of the animal traction ridge-tiers

(In collaboration with the Farm Manager)

Major limitations of the ridge-tiers initially developed by the tied-ridging with animal power (TRAP) sub-project were the relatively large weight of the ridge-tiers and the need for proper adjustments of the cable and latch mechanisms.

Several modifications have been introduced in respect of: blade thickness and size; nature and size of the frame; a stabilizer to facilitate lifting of the implements; and a new tripping mechanism (for the donkey ridge-tier). The latest donkey ridge-tier has 3 mm thick blades, which are 10 cm wide at the outer edge, widening to 39 cm at the axel. The blade height was increased to 20 cm. Total weight of the ridge tier with the old latch system is 8.5 kg compared to 8.0 kg with the new tripping system. Tube rather than angled iron was used for the frame.

In the case of the ox ridge-tier, blade widths at the axel and the outer edge were reduced from 55 to 46 cm and from 20 to 12 cm, respectively. The total tier width was reduced from 65 to 55 cm. The original blade height (20 cm) was maintained. Total weight of the ox model is 14 kg.

Production costs are not yet available but they should be below those of the earlier models. It should be noted that the new ridge-tiers have not been widely tested and their limitations are unknown. It is thought, however, that being lighter, they should be more efficient and easier to operate than the original versions.

6.3. MAIZE ENTOMOLOGY

6.3.1. Objectives

a) To explore the potential for use of host plant resistance in the suppression of the major insect pests of the crop (termites and *Cicadulina* spp., maize streak virus vector).

b) To identify and evaluate insecticides for maize insect pest suppression, taking into consideration safety and cost of available materials.

c) To develop and test integrated insect pest management (IPM) systems, for increased and sustained grain yield, which are affordable, compatible with local farming practices, and environmentally safe.

6.3.2. Research results

6.3.2.1. Maize resistance to termites

Preliminary trials were conducted at Kamboinse and Farako-Ba to assess performance of early (82-95 days maturity) and intermediate (96-110 days maturity) maize varieties for resistance to termites.

Kamboinse trials. Twelve local and improved early varieties were evaluated in 1985 and 1986 at Kamboinse (Sudan savanna) at two planting dates, two weeks apart, under natural field infestation; the results are summarised as follows:

(i) Incidence of early root lodging (at 60-70 days after planting), caused primarily by wind and, to a lesser extent, by termites was low and similar among varieties. However, considerably higher lodging due largely to termite root damage, occurred at or close to harvest, the incidence being significantly lower in Perennial x Normal (F4), TZESR-W and TZE-4 than in SAFITA-104, Local Koudougou,

and Population 31 SR Early. The incidence of lodging was also significantly lower in later than earlier planted maize.

(ii) Incidence of termite infestation of roots and stems of standing maize crop was modest and similar among varieties. Marked varietal difference emerged in respect of injury on stems, cobs and grain of lodged maize in 1985 (higher damage occurred in Population 31 SR Early, Population 30 SR Early, SAFITA-2, SAFITA-104 than in Perennial x Normal (F4), TZESR-W, TZESR-Y); in 1986, varietal differences were observed only in respect of damage on stems, the varieties sustaining greater and lesser damage being the same as those recorded in 1985.

It should be noted that above results showed only that termite feeding activity intensified with plant senescence, hence observed damage (lodging incidence and injury to roots, stems, cobs and grain) was invariably higher in earlier than later maturing cultivars; early varieties are thus, not necessarily more susceptible to termite infestation than later maturing ones.

(iii) Grain yields were satisfactory, but some varieties (Koudougou, Raytiri, and JFS) yielded significantly higher than others. Yields were similar between planting dates. However, highly significant variety x planting date interactions underlined the advantage of earliness as a drought escape mechanism; thus, earlier maturing varieties successfully produced a crop in contrast to later maturing varieties which succumbed to drought stress.

(iv) Insecticide application (Furadan 5G at 2.5 kg a.i./ha) significantly decreased lodging and termite damage (on roots, stems, cobs and grains) resulting in marked grain yield increase (14 and 35 per cent, respectively, in 1985 and 1986). Insecticide use also markedly reduced incidence of streak, armyworm (Mythimnia sp.) and lepidopterous borers.

Farako-Bâ trials. Twelve intermediate (96-110^{+} days maturity) varieties were planted at Farako-Bâ (northern Guinea savanna) on two planting dates to observe their performance under field termite infestation. The following results were obtained:

(i) Incidence of early root lodging was moderate, with marked differences among varieties. Incidence of lodging was significantly higher in Tuxpeno DR, EV 8435 SR, EV 8449 SR, and TZSR-Y than in Kamboinse 83 (2) TZUT (W), Across 83 TZUT (W), IRAT 178, Massayomba, or SAFITA-102.

(ii) Termite damage on roots of standing maize crop was mild but there were significant varietal differences (infestations were higher in TZSR-Y, EV 8449 SR, and Tuxpeno DR than in Across 83 TZUT (W), Kamboinse 83 (2) TZUT (W), IRAT 178, or Poza Rica 7882). Damage on stem of standing crop, as well as that on stem, cob and grain of lodged maize was negligible.

(iii) Grain yields were moderate (2.5 to 3.5 t/ha), yields being considerably lower for Tuxpeno DR, ATK 82 ZR, and Poza Rica 7882 than for Across 83 TZUT (W), Massayomba, Kamboinse 83 (2) TZUT (W), and EV 8449 SR. Yields were similar for both planting dates, but variety x planting date interactions were signficant.

(iv) Insecticide use (Furadan 5G at 3 kg a.i./ha) reduced lodging, and termite incidence on roots and stems of standing maize crops. However, yield increase due to insectide protection was negligible (8.5%).

6.3.2.2. Insecticidal control of maize insect pests.

The efficacy of systematic insecticides for maize insect pest suppression was assessed. Two granular (5G) systemic compounds, carbofuran (Furadan^R) and fonofos (Dyfonate^R) were applied at three doses (0,1, and 2 kg a.i./ha) at planting, and at 30 and 60 days after planting (DAP) to control termites and other insect pests in two early maize varieties: Jaune Flint de Saria (JFS) and SAFITA-104, at Gampela. The following results were obtained.

(i) Stand establishment improved significantly with increase in insecticide dose (scores of 3.5, 4.5 and 4.1 at 0,1, and 2 kg a.i./ha respectively, on a scale of 1 to 5, where 1 = poor, 3 = moderate, 5 = good stand establishment). Differences between varieties and between insecticides were negligible. Insecticide dose also caused considerable reduction in root lodging at harvest, although the differences were statistically insignificant.

(ii) Incidence of termite damage on stems of standing crop was signficantly higher in SAFITA-104 (7 per cent) than in Jaune Flint de Saria (3 per cent), and markedly reduced by insecticide dose (8,6, and 1 per cent at 0,1, and 2 kg a.i./ha). However, armyworm and lepidopterous borer infestations, termite

damage on roots of standing crop, as well as damage on roots, stems, cobs, and grains of lodged maize were low and similar between varieties and insecticides, regardless of dose.

(iii) Grain yields were moderate and comparable between varieties (JFS: 3.5 t/ha; SAFITA-104: 3.6 t/ha) and insecticides (carbofuran: 3.5 t/ha; fonofos: 3.6 t/ha), with marked differences between insecticide doses (3,4, and 3.5 t/ha respectively at 0, 1 and 2 kg a.i./ha).

6.3.2.3. Evaluation of three chemical insecticide compounds as seed treatments for improved stand establishment as well as reduced insect pest incidence in maize.

Cabosulfan (Marshal^R) at 1,2, and 3 kg/100 kg seed, carbofuran (Furadan^R) and fonofos (Dyfonate^R) both at 1 kg a.i./ha were applied at planting on four local and improved early maize varieties: Jaune Flint de Saria (JFS), SAFITA-104, SAFITA-2, and TZESR-W, at Kamboinse; each treatment was supplemented by a single application of carbofuran (0, or 0.5 kg a.i./ha) at 30 to 35 DAP. The results were as follows:

(i) Plant establishment was good and was clearly improved by insecticide protection in all varieties. Incidence of root lodging was significantly lower early in the season than towards harvest; it was also consistently lowest in TZESR-W compared to the other varieties.

(ii) Grain yields were low (400 to 1200 kg/ha), presumably because of severe drought stress, as well as soil and nutrient problems, during the season. Nevertheless, significant varietal differences emerged: TZESR-W produced the highest yield (1.2 t/ha), followed by Jaune Flint de Saria (JFS) and SAFITA-104 (1.0 t/ha) while SAFITA-2 yielded least (0.4 t/ha). These preliminary data indicate that insecticide protection of maize conferred little advantage in terms of reduced pest incidence and increased grain yield. To what extent this might have been influenced by drought, soil and nutrient problems, needs to be verified.

6.4 COWPEA BREEDING

6.4.1. Introduction

The cowpea breeding program continued to be funded by the International Development Research Centre (IDRC) of Canada until the end of Resident Research activities in the IITA/SAFGRAD Project.

6.4.2. Objectives

The major objectives remained the same as in previous years, but the work focussed on resistance to drought and Striga and on combining these traits with resistance to important insect pests and diseases in cowpea varieties with desirable seed quality, high and stable yields.

6.4.3. Research results

6.4.3.1. Drought resistance

In addition to varieties identified earlier, and reported in the Final Report, Phase I, several new ones were developed and tested in Burkina Faso and other places in the region. The most promising ones included KVx 257-K21-3, KVx 268-K03-3, KVx 250-K27-18, KVx 60-P04-1, KVx 61-1, KVx 65-114, and KVx 61-74, the last three being also resistant to Striga, particularly in Mali and Burkina Faso. Three other varieties, tested only in Burkina Faso and found to be promising, were: KVx 249-P37-IN, KVx 396-4, and IT83S-796.

Also several new crosses were initiated in 1986 to incorporate resistance to bacterial blight and pod brown blotch in preferred seed types. KVx 257-K21-3 and KVx 250-K27-18 were used as donor parents. F_2 of these crosses were screened at Kamboinse and Pobe and single plant selections were made, based on adaptability, good podding, desirable seed type, and resistance to diseases.

A study was also carried out in 1986 to determine the plant characters that are useful in selecting varieties adapted to dry areas. The varieties which produced high dry matter, particularly when conditions were drier, seemed to produce better grain yields, suggesting that vigorous plant growth, together with inherent ability to recover once drought stress is over, is a useful character. In addition, the number of pods per plant was positively and

significantly correlated with yield, indicating the importance of relatively late maturing varieties. Early maturity, which was generally associated with less vigorous plant growth, did not seem to be a desirable trait.

6.4.3.2. Striga resistance

The problem of Striga the importance of Striga resistant varieties, and the progress made in breeding for resistance to Striga were discussed in the earlier report. This work was continued in 1986 and 1987, the major objectives being to complete on-going work and to confirm results of previous work. The results were as follows:

a) Varieties resistant to more than one strain of Striga

In an effort to identify varieties that are resistant to more than one Striga strain, Dr. Parker and Ms. Poliniaszek, in a collaborative study in England, tested several cowpea varieties for resistance to different strains of Striga. Their data revealed that IT82D-849 (which was earlier identified as being resistant to Striga in Burkina Faso), and B 301 (which they obtained from Botswana where it was found to be resistant to Alectra vogelli, another cowpea parasite) were resistant to Striga strains from Mali, Burkina Faso, and Niger. However, in one experiment, IT82D-849 was found to be slightly susceptible to the Burkina strain, a finding that needs confirmation, while B 301 maintained its resistance to all strains. B 301 was also found to be resistant to Striga at Kamboinse in the 1987 dry season.

To test the resistance of IT82D-849 and B 301 to other Striga strains in Africa, they were included in the 1987 Regional Cowpea Striga Trial sent to several countries in the region where Striga is a problem. (B 301 is a small smooth seeded variety of about 70 days to maturity, while IT82D-849 matures in about 65 days and has smooth, cream coloured, medium sized grains). Results obtained from Burkina Faso showed both varieties to be resistant. Preliminary observations made in Mali, Niger and Nigeria also indicated that the two varieties were free of any Striga infestation.

Because of its spreading growth habit, considered as a desirable character in dry areas, B 301 has already been crossed with other promising varieties

adapted in the region, while awaiting confirmation of the resistance of the two varieties in other countries. The varieties crossed with B 301 included: SUVITA-2, TN88-63, TVx 3236, and some of the newly developed Striga resistant varieties, namely KVx 61-74, KVx 65-114 and KVx 30-166-3G. F_2 plants of these crosses were planted in the 1987 dry season and selections made. Approximately 25 F_3 plants in each cross were selected and their seeds have been sent to the Weed Research Division, Long Ashton Research Station, Bristol, England, to screen for resistance to the different strains of Striga.

b) Other sources of resistance to Striga.

To identify new sources of resistance to Striga, a large number of germplasm lines from IITA which showed high levels of resistance were identified, but when their pedigree was checked, they were found to have originated from SUVITA-2. In contrast, a few lines, e.g. IT81D-994 and IT82D-849, which did not originate from SUVITA-2 also showed good levels of resistance; when their origin was verified, both of them had VITA-3 (TVu 1190) as a common parent, suggesting that it is probably resistant to Striga. However, when VITA-3 was screened for Striga resistance at Kamboinse, it was found to be susceptible. So, although the source of resistance in IT81D-994 and IT82D-849 is not known at the moment, the two varieties appear to represent new sources of resistance to Striga; IT82D-849 is particularly interesting because it appears to be resistant to more than one strain of Striga.

c) Inheritance of resistance to Striga.

Studies conducted using 58-57 in 1986 and B 301 in 1987 showed that resistance in them, like that in SUVITA-2, is controlled by a single dominant gene. This conclusion, however, is applicable only to the Striga strain that occurs in Burkina Faso.

d) Studies of yield loss due to Striga.

Six cowpea varieties of various plant types and maturities were each planted in a Striga-infested or Striga-free plot at Kamboinse. Five of them are susceptible while the remaining variety, SUVITA-2, is resistant to Striga. Of the susceptible varieties, two are early maturing and have an erect to semi-

erect plant growth while two are of medium maturity and have spreading plant habit; the fifth is a local, late, photosensitive variety with crawling growth habit. Results obtained showed an average yield reduction of 30%. The resistant variety (SUVITA-2), which was completely resistant, suffered no yield loss, whereas yields in the susceptible varieties were significantly reduced (by up to 26-56%), irrespective of their maturity period or plant type. The local variety suffered the highest yield loss, probably because it stayed longer in the field in the vegetative phase. Among the yield components studied, none seemed to be solely responsible for the yield loss, but the number of pods per plant was the most affected.

e) Development of resistant varieties

Use of resistant varieties is the most convenient, and perhaps, the simplest way to control Striga. Since resistance is controlled by a single dominant gene, it should be easy to manipulate. Considerable progress was made in combining this resistance with other desirable traits in cowpea, such as high yield, wide adaptation, resistance to diseases (bacterial blight and pod brown blotch), resistance to insect pests (aphids and bruchids), and resistance to drought. These materials were at different stages of development and testing when the project was terminated. Some of the encouraging results are reported here.

i) Combining Striga resistance with high yield and wide adaptation.

The materials studied here originated from crosses of SUVITA-2 with KN-1, TVu 2027, TVx 3236, and several promising varieties received from IITA/Ibadan, Nigeria, such as IT82D-716, IT82E-18, IT82D-652, IT82D-847, IT82D-889 and TVx 4659-13C-1K. In the early generation materials (F_2-F_5), only plants that combined resistance to Striga with high levels of resistance to diseases (bacterial blight and pod brown blotch), uniformity of seed, suitable plant type and maturity, and high yield were selected. Yield evaluation of the selected materials (from 1984 until the end of the project in 1987) was done in Burkina Faso and other countries where Striga is a serious problem.

Results have been very encouraging. Varieties that combined good levels of resistance to Striga with other desirable traits were identified, the most

promising being KVx 61-74, KVx 65-114, KVx 61-1, KVx 61-2, KVx 68-31-3, and KVx 183-1. In trials in Burkina Faso and Mali, all of these varieties combined good levels of resistance to Striga with good seed quality, disease resistance, high yield, and good adaptation to Sudan and Sahel savanna areas of these countries. Except KVx 183-1, which originated from a cross of SUVITA-2 with IT82D-716, all of the above varieties originated from crosses of SUVITA-2 with TVx 3236. Also, in spite of susceptibility of SUVITA-2 to Striga in Nigeria, some of the breeding lines derived from it have shown remarkable levels of resistance to the parasite in that country. For example, results received from the cowpea breeder of IAR, Samaru, showed that KVx 30-183-3G and KVx 61-2 were completely free from Striga in 1985 at Bakura, a heavily infested site in northern Nigeria. Two other lines, KVx 30-403-1G and KVx 100-8, also appeared promising. The results from the 1985 regional trial at Maradi in Niger have also shown that SUVITA-2 was resistant while KVx 30-166-3G, and KVx 100-2 were less affected. At Kamboinse, the drought tolerant and dual purpose varieties (KVx 30-305-3G, KVx 30-309-6G and KVx 30-470-3G) also showed good levels of Striga resistance in 1986.

In addition, a total of 30 F_5 and F_6 single plant selections, combining Striga and bruchid resistance, were evaluated for yield and other characters in the 1986 crop season. They were found to be segregating for resistance to diseases and Striga. Again single plant selections were made, and 30 such plants, that combined resistance to Striga and diseases with good seed quality, were tested for bruchid resistance. Out of these, five plants, originating from crosses of IT82D-716 with KVx 30-G467-5-10K (KVx 164) and with KVx 30-G246-2-5K (KVx 291), were found to have high levels of resistance to bruchids. They were multiplied in the 1987 dry season, and then evaluated for yield, resistance to Striga, and other characters in the rainy season. The results obtained showed KVx 291-47-224 and KVx 164-65-5 to be promising since they had combined resistance to Striga, bruchids, and the two main diseases (bacterial blight and pod brown blotch).

ii) Combining Striga, aphid and bruchid resistance.

The materials evaluated in this category included selections made from crosses of promising aphid resistant varieties (KVx 145-27-4 and KVx 146-44-1)

and varieties with combined resistance to bruchids and Striga (KVx 30-G172-1-6K and KVx 30-G246-2-5K). One hundred and fifty five single plants from 18 F_3 families were first screened for aphid resistance in the screenhouse and a total of 22 plants combining good seed quality with aphid resistance were selected and evaluated for Striga resistance in the field. Single plants were selected and were further evaluated in the dry season in a Striga infested plot; they were also evaluated for bruchid resistance in the laboratory. Six plants that combined resistance to aphids, bruchids and Striga were selected. They were further multiplied in the 1987 dry season, and then yield evaluated. KVx 295-2-124-51 was the most outstanding variety; it produced the highest grain yield (1489 kg/ha) and combined resistance to aphids, and Striga with acceptable seed characteristics.

6.5 COWPEA AGRONOMY

6.5.1. Objectives

a) To determine factors limiting cowpea yield in the African semi-arid-tropics.

b) To determine the response of cowpeas to various management factors (time of planting, plant density, soil fertility, land preparation, soil type, etc), over the range of environments in the semi-arid zone.

c) To investigate maize-cowpea relay cropping systems.

d) To improve yields in intercropped sorghum and millet for Sahel and Sudan savannas.

e) To study the characteristics of daylength sensitive cultivars and to determine those agronomic practices best suited for their production.

f) To assist the cowpea breeding program in identifying cultivars with low nutrient and water requirements, and to assess fertility levels and crop mixtures under which cultivar testing should take place.

6.5.2. Research results

6.5.2.1. Northern Guinea savann.

a) Management of pure-stand cowpea

Mid-July is the optimum planting date for cowpeas in the northern Guinea savanna. It enables cowpeas to develop with very few disease problems, facilitating pod maturity at the end of September or early October, under full sun-shine with a minimum of rainfall, both of which are crucial for good grain quality (less seed rot). By contrast, early planting (late June to early July) subjects cowpeas to several foliage, stem and pod diseases, a situation which can be exploited in screening cultivars for resistance to these diseases.

The optimum plant population is 67,000 plants per hectare, which corresponds to an inter-row spacing of 75 cm and an intra-row spacing of 20 cm. Daylength sensitive cowpeas can tolerate this plant population but they still give good yields at 1/3 the density, provided that the rains do not terminate early (i.e., by mid-September).

The daylength neutral cultivars best adapted to monocropping are KN-1, TVx 3236, and TVx 1999-01F. The best daylength sensitive cultivars are Kaya local and Kamboinse local rouge.

The number of insecticide sprays needed for good insect control was reduced from seven to two or three. Two sprays (the first at 50% flower bud formation and the second at 50% pod formation) are crucial to obtain 0.5 to 2.0 t/ha, depending on the amount of rainfall. An additional spray may be required, if attack by aphids occurs before flower bud formation.

Zero-tillage with in situ mulch is as good as conventional tillage in ensuring high cowpea grain yield. In addition, it does not expose the soil to slashing rains, run-off and erosion, and direct sun-shine, all of which are harmful to the soil. The seedbed preparation method (tied ridges) has no positive effect on cowpea grain yield in this environment, irrespective of the date tied ridging is effected.

Daylength neutral cowpea responds positively to single or triple superphosphate fertilizer (25-50 kg of P_2O_5/ha). We have not obtained a yield response to the local, low solubility phosphate rock fertilizer (Burkina phosphate),

even at rates of 100-200 kg/ha of P_2O_5. Studies on residual effects of phosphatic fertilizer have shown that, when compared to Burkina phosphate, soluble sources have a strong residual effect. In a cowpea-maize rotation, for example, cowpeas fertilized with 100 kg P_2C_5/ha of Burkina phosphate required the addition to maize, of between 25 and 50 kg soluble P_2O_5/ha to obtain maize yields of 3 t/ha in the following year. In contrast, cowpeas which received 50 or 100 kg P_2O_5 as a soluble source, required the addition to maize, of only 25 or 0 kg P_2O_5/ha, respectively, to produce equivalent grain yields.

Liming at levels varying from 500 to 1500 kg/ha of finely ground agricultural lime had no effect on cowpea seed yield.

Cowpea, whether or not fertilized with phosphatic fertilizers, is equal to, or better than, the cover crop, Crotalaria retusa, and is definitely better than sorghum as the preceding crop to maize. It should, therefore, be considered in rotation in pure-stand cropping with maize.

b) Mixed cropping

There were differences in competitive ability between cowpea cultivars intercropped with sorghum, when both crops were planted simultaneously. Such intercropping of the most suitable cowpea cultivars with the sorghum cultivar, Framida, produced a sorghum yield of 2.4-2.9 t/ha and a cowpea yield of 0.50-0.7 t/ha. Cowpea grain quality was poor, however, due to pod maturation during late August and early September when rainfall was high.

There were also differences in competitive ability between soybean cultivars intercropped with sorghum, when both crops were planted simultaneously. Seed yield of sorghum cultivar Framida varied from 1.5 to 2.5 t/ha while that of soybean cultivars varied from 0.5 to 0.9 t/ha. Unlike cowpea, soybean grain yield was of very good quality because of the longer growth cycle of soybean as compared to that of cowpea. Thus, soybean planted in mid-June, ripens in late September or early October under good sun-shine. When soybean is planted two weeks after sorghum, there was little or no increase in sorghum grain yield; in contrast, there was a dramatic reduction of soybean yield by 50% or more compared to yield of soybean planted simultaneously with sorghum.

Maize-cowpea relay cropping systems have been developed. Daylength sensitive cowpeas should be planted under maize in mid-July, approximately one month after the normal planting date for maize in the northern Guinea savanna. At this planting date, cowpeas have no detrimental effect on maize growth and yield. Early (90 days), less leafy, high yielding maize cultivars, such as SAFITA-2, are better adapted to relay cropping than other cultivars. The maize crop should be fertilized with 80-100 kg/ha N and 40-50 kg/ha P_2O_5 from soluble sources. Cowpeas may need 2-3 insecticide applications. Maize yields from 3 to 4 t/ha and cowpea yields from 0.5 to 1.5 t/ha were consistently obtained during the past five years. In terms of soil conservation and resource utilization efficiency, maize-cowpea relay cropping appears to be the best system of production for the northern Guinea savanna.

c) Recommendations

Recommendation of pure-stand cowpea cropping requires cautious appraisal. Since mid-July, the optimum date of planting, corresponds with the period of protracted rainfall, land preparation by conventional tillage could be affected by problems, such as possible delay of tillage by several days (because of excessive wetness of the soil) or tilling the land during dry spells in late June or early-July, thereby exposing tilled land to slashing rains, run-off and erosion. Zero-tillage, with in situ mulch and appropriate weed control, seems, therefore, to be the best recommendation. It would, however, require the provision of herbicides and credit facilities to farmers. In the absence of this package, maize-cowpea relay cropping may be recommended to farmers; not only does it produce high grain yields of both crops, it also constitutes good soil conservation measures.

6.5.2.2. Sudan savanna.

a) Management of pure-stand cowpea

Date of planting, optimum plant population, protection against insect pests, and appropriate phosphatic fertilizer levels (excluding the rock phosphate, Burkina phospahte) follow the same management practices as those previously discussed for the northern Guinea savanna. However, in the Sudan savanna, unlike in the Guinea savanna the less soluble Burkina phosphate, has

a positive direct, as well as residual, effect on cowpea and the succeeding sorghum crop. This effect is, however, relatively smaller than that of superphosphate, at the same P_2O_5 levels.

The cowpea cultivars best adapted in this agro-ecology are TVx 3236 and Kaokin local. Cultivar KVx 396-4 is very promising; it combines heat and drought tolerance with good disease and Striga resistances, high and stable yield, and good seed quality. it is likely that it will be released soon after further testing.

Soil tillage, tied ridges, and in situ mulch (from natural fallow or crop residues) reduce rain-water run-off and increase soil water infiltration. As a result, there is a larger soil water reserve, reduced risk of drought stress and lower yield loss during protracted dry spells. In addition, because of its heat insulating capacity, mulch may reduce soil water evaporation. It also increases biological activity, such as burrowing by termites and earthworms, thereby improving soil porosity and water infiltration. The practice of mulching appears to be crucial to agricultural production in the semi-arid tropics. It requires, however, the use of chemical herbicides.

Crop residue removal for forage and other domestic uses has a detrimental effect on soil productivity because it adversely affects both physical and chemical properties of the soil.

Striga gesnerioides can cause total grain yield loss in heavily infested fields. This is particularly true for daylength sensitive cultivars sown earlier than mid-July. Thus Striga is the main cause of severe grain yield losses in early sown cowpea in the Sudan savanna just as diseases (less of a problem in Sudan savanna) severely reduce yields in early sown cowpea in the Northern Guinea savanna. The use of resistant (e.g., SUVITA-2, and 58-57), or tolerant (TN88-63) cultivars is recommended in heavily infested fields. In moderately infested fields, the destruction of Striga before it flowers may reduce Striga infestation in subsequent years.

b) Mixed cropping.

Results obtained with sorghum-cowpea intercropping and maize-cowpea relay cropping are similar to those obtained in the northern Guinea savanna. Under severe drought stress, however, a total grain yield loss of both crops may occur in sorghum-cowpea intercropping, although sole crop cowpea may produce some grain yield.

Cowpea grain quality can be improved, to the detriment of grain yield, by sowing cowpea later than sorghum; this results in maximum cowpea grain yield of only about 0.5 t/ha, whereas sorghum grain yield is only slightly increased. In maize-cowpea relay cropping systems, a total cowpea grain yield loss may occur, if the month of September is dry.

c) Recommendations.

Pure-stand cowpea production based on zero-tillage, with in situ mulch and herbicide application, is the best recommendation for farmers who desire high and stable yields. Conventional tillage with tied ridges can also be used. But severe food yield losses occur if August is dry and hot or if excessive rains in the crop season result in waterlogging. Opening tied ridges can reduce grain yield losses under waterlogged conditions.

Cereal cowpea mixed cropping may be used but complete failure of both crops or severe cowpea grain yield losses are expected during dry years.

6.5.2.3. Sahel savanna.

a) Management of pure-stand cowpeas.

Results obtained in the Sudan savanna are also applicable in the Sahel savanna. In the Sahel, however, no cowpea yield response to tied ridges has been shown; the use of wind-break and mulch becomes even more critical for soil conservation and prevention of severe grain yield losses during dry years.

The best adapted cultivars are SUVITA-2, TN88-63, 58-57 and Mougne. KVx 396-4 is also very promising.

b) Mixed cropping

Millet-cowpea intercropping has no bright future in the Sahel because it does not ensure the minimum, but valuable, cowpea grain yield obtained from sole crop cowpea during bad years. Complete loss of intercropped cowpea occurs even in moderately dry years. Indeed, farmers are already abandoning this cropping system. They practise it, however, whenever the cropping season appears to be rainy.

6.6. COWPEA ENTOMOLOGY

6.6.1. Objectives

The objective is to develop and test integrated pest management (IPM) systems for cowpea insect pest control which are affordable, environmentally safe, and compatible with small-scale farming practices in the semi-arid tropics, using the following strategies:

a) Pest surveys and yield loss assessment.

b) Host plant resistance studies, in collaboration with the breeder, to develop resistant varieties for the major insect pests of cowpea.

c) Evaluation of chemical insecticides for insect pest suppression in cowpea taking into consideration the costs, and safety/selectivity of available materials.

d) Cereal-cowpea intercropping studies, in collaboration with the agronomist, to assess practical cultural control options.

e) Exploring the potential role of parasites, predators, and pathogens for insect pest suppression in peasant small holdings.

6.6.2. Research results

6.6.2.1. Insect pest surveys and yield loss assessment.

Surveillance was initiated to determine the relative abundance and distribution of three major cowpea pests (aphids, flower thrips and *Maruca*

pod borer) in the three agro-ecologies of Burkina Faso, in attempts to establish the relation between yield loss and insect pest incidence. The following results were obtained.

(i) Aphids: Yellow pan traps were used to observe aphid phenology. Flight activity followed a south to north progression, starting in the northern Guinea savanna in June/July and moving northward to the Sahel savanna by August/September, presumably with the aid of prevailing S-N trade winds. In the Sudan savanna, where population densities were heaviest, flights were sustained from July to September/October. Higher population densities occurred in the Sahel than in the northern Guinea savanna. Preliminary yield loss estimates of up to 33 per cent, obtained at Kamboinse in 1986, were associated with the moderately high aphid incidence experienced during that season.

(ii) Flower thrips: Incidence was lower at Farako-Bâ (northern Guinea savanna) than at Kamboinse and Pobe (Sudan and Sahel savannas, respectively); but estimated yield reductions of 28,20 and 9 per cent were obtained at Pobe, Farako-Ba and Kamboinse in 1986. Combined yield loss estimates for both thrips and aphids in 1985 were between 89-93 per cent.

(iii) Maruca pod borer: Infestations were low and varied greatly between years and locations. In general, larval densities increased from north (Sahel) to south (northern Guinea savanna). However, yield reduction estimates, even at the same location, were highly variable, but were invariably highes' n the Sudan savanna (Kamboinse). Despite considerably higher incidence in northern Guinea savanna, yield decreases remained low, probably due to adequate compensation under the more favourable growing conditions in the south.

6.6.2.2. Cowpea host plant resistance

Twenty three advanced accessions developed by the Breeding Program in crosses incorporating aphid and flower thrips resistance (e.g., TVu 36 and TVx 3236, respectively) into local materials, with desirable seed and agronomic characters (Local Gorom or SUVITA-2 and KN-1 or VITA-7), were first evaluated for aphid resistance in the screenhouse at the seedling and reproductive growth phases. Fifteen promising selections were later assessed in field trials at

Kamboinse, Loumbila, Pobe and Farako-Ba under natural or artificial infestation (Kamboinse and Loumbila only) using the spreader row technique. Highlights of the results are as follows:

(i) Under field conditions, nine accessions (KVx 146-27-6, KVx 146-44-1, KVx 145-99-1, KVx 146-27-4, KVx 165-14-1, KVx 165-14-2, KVx 146-13-3, KVx 165-36-1, KVx 146-21-3) suffered consistently low aphid infestations which were not significantly affected by insecticide application to suppress aphids.

(ii) The above nine selections produced between 1.5 to 2.0 t/ha grain yield under both rain-fed and irrigated conditions at Kamboinse. In contrast to significant yield increases in susceptible cultivars associated with insecticide suppression of aphids, grain production in the above varieties was similar, regardless of whether or not insecticide sprays were applied.

6.6.2.3. Evaluation of chemical insecticides for insect pest suppression in cowpea.

Seven insecticides were assessed singly and in mixtures as foliar sprays (two or three applications) for cowpea insect pests control. The results obtained are summarised as follows:

(i) The pyrethroids deltamethrin (Decis^R), cypermethrin (Cymbush^R), and cyhalothrin (Karate^R) alone, but especially in mixtures with dimethoate (Rogor^R, Systoate^R, Thimul^R), a systemic organophosphate, satisfactorily suppressed aphids and flower thrips, enhanced flower production and increased grain yield; the effective mixtures included: Karate + Dimethoate ED^R, Cymbush Super ED^R, and deltamethrin + dimethoate.

(ii) In general, three applications gave better insect pest control and higher grain yield than two applications.

(iii) Pod and seed damage, primarily by Maruca pod borer, were significantly reduced by chemical control, thereby assuring farmers of high quality produce and optimum return to investment.

6.6.2.4. Cultural control of cowpea insect pests: Cereal-cowpea row-intercropping studies.

Cowpeas were row-intercropped with millet, sorghum, and maize at Pobe, Kamboinse and Farako-Ba,respectively, to determine the effectiveness of low to medium input technologies (resistant varieties, minimal pesticide protection, modified inter-row planting, etc.) in improving chronic, low productivity of traditional mixed cropping systems. Between two and five rows of cowpea were alternated with two or three rows of cereal, to facilitate insecticide application on cowpeas. Three cowpea varieties, namely TVx 3236 (moderately thrips resistant), KN-1, and Local Gorom or SUVITA-2 (both susceptible to flower thrips) were used in the trial. There were three insecticide treatments: no protection (no spray); minimum protection (2 sprays of deltamethrin + dimethoate mixture - 12.5 + 400 g a.i./ha applied at 30-35 and 45-55 days after planting - DAP); and full protection (four applications of the same mixture applied at 20, 30, 45 and 60 DAP). The following results were obtained:

(i) Two insecticide sprays were as effective as four in suppressing aphids and flower thrips, as well as in enhancing flower and seed production.

(ii) Flower thrips incidence was invariably significantly lower in TVx 3236 than in KN-1 and Local Gorom (SUVITA-2). Conversely, flower production was markedly lower in Local Gorom (SUVITA-2) and KN-1 than in TVx 3236.

(iii) Effect of intercropping on aphid and thrips infestations, as well as on flower production, was negligible. However, significant interaction between insecticide application and intercropping improved flower production in pure and intercropped cowpea.

(iv) Grain yield was considerably reduced in intercropped cowpea compared to the pure crop. Grain production was significantly higher in TVx 3236 than in KN-1 and Local Gorom (SUVITA-2). Interactions of intercropping x insecticide protection x cowpea variety were invariably significant and explained increased grain yields, in all systems, due to pest protection; this was more applicable in the moderately thrips resistant (TVx 3236) variety than in susceptible (KN-1, Local Gorom) varieties.

Cereal grain yield was modest (under 2 t/ha), presumably because of droughty growing conditions, and were often lower in mixtures with cowpea than in the pure crop. Grain production was similar among the different cereal-cowpea associations and the positive LERS obtained probably reflected the stability of these cropping systems.

6.7 SOIL-WATER MANAGEMENT

6.7.1. Objectives

In general, the objective of the soil-water management program has been to develop and define crop and soil management systems capable of optimizing the available soil and water resources in the Alfisols of the Sudan savanna of the West African semi-arid tropics (WASAT). More specifically, the program has had two major research thrusts:

a) Characterization of tied ridges, in terms of soil physical, chemical, and hydrological properties; and quantification of responses of the major crops of the West African Sudan savanna to tied-ridges, in terms of water use, crop and root growth, and yield.

b) Development of a minimum or zero tillage system, which would alternate with periods of grass or leguminous leys, for the West African Sudan savanna. Emphasis was on minimizing herbicide use.

6.7.2. Research results

a) Tied ridges: In general, program objectives were achieved, although responses of groundnut (*Arachis hypogea*) and sorghum (*Sorghum bicolor*) to tied ridges were not studied.

b) Only the first phase of development of a minimum tillage system was completed, i.e., identification of appropriate cover crops for the West African Sudan savanna.

6.7.2.1. Tied ridges.

Tied ridges (ridges with earth bunds placed at right angles at intervals of 1-2 m) caused large yield increases in many crops of the West African semi-arid tropics. This is primarily due to reduction of water runoff, increased infiltration and, consequently, greater water storage compared with either open ridging or flat planting. Except during rain-free periods, differences in profile water content to a depth of 0.75 m were of the order of 24-25 mm. Tied ridging also resulted in superior soil physical properties. Surface clay contents on ridges and furrows of tied ridged plots were 36% and 121% greater than those within and between plant rows, respectively, of flat-planted plots. Surface bulk density within plant rows of flat-planted plots was 8-15% greater than that on ridge slopes of tied-ridged plots. Daily maximum soil temperature, at a depth of 30 mm in dry soils, was highest and lowest in ridge slopes and furrows of tied-ridged plots, respectively. Soil temperatures in flat-planted plots were intermediate to those of ridges and furrows. Response patterns were similar in wet soils, although maximum soil temperatures observed were lower. Soil water retention was increased by tied ridging, and was greater in furrows. Soil chemical properties of tied ridges were superior to those of open ridges. Compared to open ridging, tied ridging resulted in greater levels of soil OM, exchangeable Ca, Mg, K, and total CEC.

Depth of rooting and subsoil root densities of cowpea (Vigna unguiculata), maize (Zea mays), millet (Pennisetum americanum) and cotton (Gossypium hirsutum) under tied ridging were superior to those under either open ridging or flat planting in dry years, although cowpea root growth was reduced by tied ridging in wet years, due to a high frequency of transient waterlogging. All crops under tied ridging were less likely to suffer from drought stress during rain-free periods. Yields of maize, millet and cotton were increased with tied ridging in all years, whereas in years of above-average rainfall, tied ridging did not significantly increase grain yields of cowpea and bambara groundnut (Vigna subterranea). Disadvantages of tied ridging are crop losses in wet years, in crops sensitive to waterlogging, instability of ridges in sandy soils, loss of water through deep drainage, and high labour requirement. Loss of water can be minimized by intercropping shallow-rooted crops, such as maize and cowpea,

with deep rooted companion crops. The labour constraint can be alleviated by mechanising construction of tied ridges. It is concluded, therefore, that tied ridges result in significant increases in soil and water conservation (accompanied by significant yield increases) in the Sudan savanna of West Africa.

6.7.2.2. Minimum tillage systems.

In relation to maize monoculture, sowing of Macroptilium artropurpureum and M. lathyroides, as cover crops under a minimum tillage system, where cover crop residue was retained as in situ mulch, resulted in reduction of topsoil loss; increases in: soil OM, C,C/N, exchangeable K, infiltration rate, soil matric potential and proportion of macropores (pore radius > 14.3/mm); and decreases in: soil temperature and proportion of micropores (pore radius < 2/mm). These changes resulted in large increases in subsoil root growth, grain and dry matter yields of the succeeding maize crop. (No herbicides were used at any time. Maize seeds were sown in 0.20 m wide strip which was cultivated to a depth of 5 cm within the row). significant improvements in soil properties, and in maize root growth and yields occurred with Psophocarpus palustris, Lablab purpureus, and Echinochloa colona. Where either a bare fallow or Cajanus cajan preceded a maize crop, soil degradation, and consequently, large yield decreases occurred. Soil ameliorative ability of the cover crop was primarily related to the rapidity of formation of ground cover and subsoil root density. It is concluded, therefore, that among the cover crops studied, M. artropurpureum and M. lathyroides are the most appropriate for the Alfisols of the West African Sudan savanna.

7. REGIONAL ACTIVITIES

7.1. REGIONAL TESTING

7.1.1. Maize Breeding

7.1.1.1. Objectives

The objectives of the regional testing are mainly to provide germplasm to national program scientists of SAFGRAD member countries. Every year, IITA/SAFGRAD maize breeding program organizes and coordinates regional uniform trials, namely RUVT-1 (early maturing varieties); RUVT-2 (intermediate maturing varieties);

and, since 1986, RUVT-3 (extra-early maturing varities). Varieties were nominated by national programs of SAFGRAD member countries, IITA/SAFGRAD Resident Research Program and International Agricultural Research Centres (CIMMYT and IITA). National programs of Senegal, Ghana, Cote d'Ivoire, Burkina Faso and Togo were the main contributors to this regional testing. In 1986 and 1987, 151 sets, comprising RUVT-1, RUVT-2, and RUVT-3, were sent to 19 and 16 countries, respectively.

More than 36 extra-early, early and intermediate varieties were tested for three years in SAFGRAD member countries of West and Central Africa.

7.1.1.2. Results

(a) Sudan savanna zone

In the Sudan savanna zone, four varieties, namely Capinopolis 8245, EV8431 SR, GUSAU 81 Pool 16, and M.G. 82 TZESR-W performed well in eight countries over a 3-year period (Table 1). However, EV 8431 SR, GUSAU 81 Pool 16, and M.G. 82 TZESR-W were unstable and not adapted to poor environments. Capinopolis 8245 is susceptible to maize diseases when the pressures are very high. Two other varieties: Jaune Dente de Bambey (from Senegal) and Compuesto selection precoz (from CIMMYT) appeared stable and adapted to less favourable environments. Also, it should be noted that Capinopolis 8245 and GUSAU 81 Pool 16 are susceptible to maize streak virus.

(b) Northern Guinea savanna

Over a period of several years, four varieties have performed well in the northern Guinea savanna in eight SAFGRAD member countries. Table 2 lists these varieties and countries in which they have been tested. However, several of the varieties (Across 83 TZUT-W, Kamboinse (2) 83TZUT-W, and EV 8422 SR) were unstable and unadapted to poor environments. In contrast, EV8449 SR is stable and well adapted to poor environments. TZUT-W is a good promising material but is susceptible to ear rot.

Table 1. The performance of promising early maturing maize varieties in various countries

Maize variety			Performance of varieties in[a]:							
Name	Colour & texture	Source	Benin	Ghana	Burkina Faso	Mali	Cameroun	Senegal	Togo	Cote d' Ivoire
Capinopolis 8245	Yellow	CIMMYT	-	+	+	+	+	+	+	+
EV8431 SR	Yellow Flint	CIMMYT	+	-	+	+	+	+	+	-
M.G. 82 TZESR-W	White Flint	IITA, Ibadan	-	+	+	-	+	-	+	+
GUSAU-81	White Dent	IITA, Ibadan	+	-	+	+	-	+	+	-

a: + = outstanding; - = not outstanding

Table 2. The performance of medium and late maturing maize varieties in various countries

Maize variety				Performance of varieties in[a]:								
Name	Colour & texture	Maturity type	Source	Senegal	Gambia	Togo	Mali	Burkina Faso	Cape Verde	Benin	Ghana	Cote d'Ivoire
Kamboinse TZUT-W	White dent	Medium	IITA/ SAFGRAD	+	+	+	+	+	+	-	-	-
Across 83 TZUT-W	White dent	Medium	IITA, Ibadan	+	-	+	+	+	+	+	-	-
EV 8449 SR	White dent	Medium	CIMMYT	+	-	-	+	+	+	-	-	+
EV 8422 SR	White dent	Late	CIMMYT	+	-	+	+	+	-	-	+	+

a: + = outstanding; - = not outstanding

7.1.2. Cowpea Breeding

The major activity consisted of two regional variety trials: one on drought, the Regional Cowpea Drought Trial (RCDT), and the other on *Striga*, the Regional Cowpea *Striga* Trial (RCST). Highlights of the results are as follows:

a) Regional Cowpea Drought Trial (RCDT)

Twenty six trials were sent to 19 countries in 1986 while 18 trials were despatched to 10 countries in 1987. Most of the varieties identified earlier (e.g., KVx 305-3G, KVx 30-470-3G, SUVITA-2, TN88-63) maintained their superiority, but several new ones were identified by various countries. They included: KVx 250-K27-18 (in Burkina Faso and Niger); KVx 61-1 (in Nigeria), KVx 268-K03-3 (in several countries); and KVx 61-74 (in Mali, Burkina Faso, and Niger).

b) Regional cowpea *Striga* trial (RCST)

This trial was sent only to those countries where *Striga* is a serious problem. Eleven sets were sent to eight countries in 1986 while 13 sets were sent to six countries in 1987. KVx 61-1 was the outstanding variety in 1986; it was followed by KVx 61-74 and 58-31-3. These varieties also maintained their superiority in 1987. In addition, KVx 183-1 (in Burkina Faso) and KVx 100-2 (in Niger and Nigeria) were identified as promising varieties. The most important observation made in 1987 was that two varieties (B 301 and IT82D-849 that were considered to be resistant to more than one strain of *Striga*, were found to be free of *Striga* infestation in Mali, Burkina Faso, Niger, and Nigeria, thus creating the possibility of developing *Striga* resistant varieties, particularly for Niger and Nigeria, where SUVITA-2 and 58-57 (identified earlier) are not completely resistant.

7.1.3. Cowpea Agronomy

In 1986, 16 sets of agronomic trials were distributed to six national programs in West and Central Africa as follows:

(i) Nine sets of sorghum/Cowpea Intercropping Trial to Central African Republic, Tchad, Gambia, and Guinea Conakry.

(ii) Two sets of Cowpea Management Trial to Gambia.

(iii) Five sets of Maize/Cowpea Relay Cropping Trial to Gambia, Guinea Conakry, and Togo.

In 1987, 26 agronomic trials were requested by nine national programs in West and Central Africa as follows:

(i) Ten sets of Sorghum/Cowpea Intercropping Trial requested by Cameroon, Gambia, Ghana, Guinea Conakry, Nigeria and Togo.

(ii) Ten sets of Millet/Cowpea Intercropping Trial requested by Gambia, Mali, Nigeria, Senegal and Tchad.

(iii) Six sets of Maize/Cowpea Relay Cropping Trial requested by Guinea Conakry, Nigeria, Tchad, and Togo.

Results from Guinea Conakry were reported in that country's 1986 Annual Report. The rest of the results are given below:

a) Maize/cowpea relay cropping

An early maize cultivar (90 days to maturity) was planted at 0.75 m x 0.25m spacing (two seeds per hole, seedlings being thinned to one per hill at 15 days after sowing). Cowpeas were sown at four weeks after maize in solid rows, alternating with those of maize, at a spacing of 75 x 20 cm. Two seeds were sown per hole and seedlings thinned to one per hill at 15 days after sowing. The maize sowing dates were 8 June, 30 June, and 8 July, 1985 at Broukou (Togo), Urp (Benin), and Sapu (Gambia), respectively. Maize plants received NPK (52.5:55:30 at Broukou, 57:49.5:00 at Urp, and 60:22.5:00 at Sapu) at sowing and N (22.5 kg/ha at Broukou, 49.5 kg/ha at Urp and 22.5 kg/ha at Sapu) one month after sowing. Cowpea plants received two or three insecticide treatments at critical growth stages.

As observed in previous years in Burkina Faso and other countries, cowpea cultivars had no significant effect on maize flowering and maturity periods, ear size and plant heights, and grain yield. Maize grain yields are shown on Table 3.

Table 3. Effect of cowpea on maize grain yield in relay cropping experiments at Broukou (Togo), Urp (Benin), and Sapu (Gambia) in 1985.

Cowpea cultivar	Maize grain yield (t/ha) at:		
	Broukou (Gambia)	Urp (Benin)	Sapu (Gambia)
(i) Daylength-sensitive			
Logofrousso Local	5.02	2.49	3.39
Kaya Local	5.30	2.40	3.29
Kamboinse Local rouge	5.17	2.89	3.37
Local check	4.38	2.80	3.51
(ii) Daylength-insensitive			
KN-1	5.26	2.92	3.55
TVx 3236	4.50	2.39	3.71
SUVITA-2	4.63	2.68	3.48
TN 88-63	4.96	2.55	3.43
(iii) Maize pure-stand	4.53	2.58	3.51
L.S.D. ((%)	NS	NS	NS
C.V. (%)	9.9	15.1	10.1

Cowpea cultivars significantly differred in flowering and maturity dates as shown on Table 4. Table 5 shows that Kaya Local outyielded all the other cultivars at Urp (Benin) and Sapu (Gambia) thereby confirming its better adaptation in maize-cowpea relay cropping observed in Burkina Faso. The prevalence of virus diseases at Broukou (Togo) prevented cowpea cultivars from expressing their yield potential in relay cropping with maize.

As observed in previous years in Burkina Faso and other West African countries, cowpea cultivars sown one month after maize had no detrimental effect on maize grain yield. Cowpea performance under maize depended, however, on environmental conditions, namely amount and distribution of rainfall, disease incidence and severity, and crop management practices. These results are in agreement with those of previous years. They suggest that maize-cowpea relay cropping system can be successfully extended to northern Guinea savanna zones in other West African countries.

b) Sorghum-Cowpea Intercropping

Sorghum-cowpea intercropping trials were conducted at Oronkua/Diebougou, Burkina Faso; Tilli-Bolgatanga, Ghana; Bordo/Kankan, Guinea-Conakry; Maroua, Cameroon; and Broukou/Kara and Atekou/Kante, Togo in 1987. The objectives consisted of testing three cowpea cultivars: TVx 3236, KN-1 and a farmers' local cowpea, under two insecticide treatments: No insecticide application; and, two sprays at flower bud formation and onset of pod fill, to control flower thrips and other insect pests. TVx 3236 and KN-1 are daylength-neutral cultivars: the first has moderate level of resistance or tolerance to flower thrips while the second is susceptible. Experiments conducted in the Sudan Savanna at Kamboinse (Burkina Faso) from 1981 to 1985 have shown TVx 3236 to give up to 300 kg/ha of seed yield without insecticide protection in inter-cropping. Whereas the same cultivar in pure-stand cropping would give 0 kg/ha as does KN-1 in both pure-stand and inter-croppings when insecticides are not applied to suppress flower thrips.

The sorghum cultivar Framida, was sown early in the crop season at all locations, except at Tilli/Bolgatanga, Ghana, and Maroua, Cameroon, using 1.25m x 0.25m spacings. Seedlings were thinned to one plant per hill within three weeks after sowing. Sorghum plants received NPK fertilizer at sowing and additional N fertilizer as side dressing one month after sowing. Cowpea was sown

Table 4. Flowering and maturity periods of cowpea in relay cropping experiments with maize at Broukou (Togo), and Urp (Benin), in 1985.

Cowpea cultivar	Cowpea flowering and maturity periods (days after sowing) at[a]:			
	Broukou (Togo)		Urp (Benin	
	Flowering period	Maturity period	Fowering period	Maturity period
(i) Daylength-sensitive				
Logofrousso Local	98 a	129 a	69 a	91 a
Kaya Local	85 c	103 b	59 b	85 b
Kamboinse L. Rouge	75 d	97 b	57 b	84 bc
Local check	90 b	107 b	107 b	93 a
(ii) Daylength-insensitive				
KN-1	62 e	85 b	55 c	82 bc
TVx 3236	56 f	86 b	54 c	84 bc
SUVITA-2	57 f	87 b	54 c	83 bc
TN 88-63	62 e	88b	49 d	81 c
L.S.D. (5%)	4	24	1	3
C.V. (%)	3	16.9	1.6	2

a: Means followed by the same letter are not statistically different (P = 0.05).

Table 5. Grain yield of cowpea in relay cropping experiments with maize at Broukou (Togo), Urp (Benin), and Sapu (Gambia) in 1986.

Cowpea cultivar	Cowpea grain yield (kg/ha) at[a]:		
	Broukou (Togo)	Urp (Benin)	Sapu (Gambia)
(i) Daylength-sensitive			
Logofrousso Local	24 a	132 bc	266 b
Kaya Local	58 a	344 a	476 a
Kamboinse Local Rouge	21 a	185 bc	246 b
Local Check	83 a	164 bc	103 c
(ii) Daylength-insensitive			
KN-1	114 a	100 c	87 c
TVx 3236	173 a	207 bc	83 c
SUVITA-2	34 a	160 bc	203 bc
TN 88-63	8 a	102 c	253 b
L.S.D. (5%)	NS	140	127
C.V. (%)	95	51	40

a: Means followed by the same letter are not statistically different (P = 0.05%).

two to three weeks after sorghum in solid rows 1.25m x 0.20m apart, alternating with sorghum. Two seeds were sown and seedlings thinned to one plant per hill two weeks after sowing.

Rainfall started late -- i.e. early July -- and ended early -- i.e., late September at Tilli/Bolgatanga, Ghana; and, Maroua, Cameroon. Excessive rains were recorded at Bordo/Kankan, Guinea-Conakry, in August and early September. In other locations rainfall was fairly well distributed.

Sorghum seed yields were high at Oronkua/Diebougou, Burkina Faso and Broukou/Kara, Togo; intermediate at Maroua, Cameroon, Atekou/Kante, Togo; very low at Bordo/Kankan; and, nil at Tilli/Bolgatanga, Ghana (Table 6). Late sowing caused by late establishment of rainfall and the early cessation of rains were responsible for failure of the sorghum crop at Tilli/Bolgatanga and the low (sorghum) yields at Maroua, Cameroon. On the other hand heavy rainfall and the ensuing water logging, drastically reduced sorghum seed yield at Bordo/Kankan, while a severe sorghum foliar disease reduced sorghum yield at Atekou/Kante, Togo.

Intercropped cowpea reduced sorghum seed yield only at Oronkua/Diebougou, Burkina Faso and Maroua, Cameroon (Table 6). Cowpea cultivars, with the exception of local cultivars did not appear to compete differently with sorghum at all locations.

Cowpea seed yield was: nil at Broukou/Kara, Togo; very low at Atekou/Kante, Togo (0.0 to 3.5 Q/ha); Bordo/Kankan, Guinea-Conakry (0.8 to 5.3 Q/ha) and Tilli/Bolgatanga, Ghana (0.0 to 8.5 Q/ha); intermediate at Oronkua/ Diebougou, Burkina Faso(1.7 to 10.0 Q/ha); and high (0.9 to 16.3 Q/ha) at Maroua, Cameroon (Table 6). High viral and fungal disease as well as pod sucking bug pressures and high rainfall were responsible for the low cowpea seed yield at Broukou and Atekou (Togo). Similarly, water logging at Bordo/Kankan, Guinea-Conakry reduced cowpea seed yield (Table 6).

Intercropping cowpea with sorghum reduced cowpea seed yields significantly at all locations (Table 6). Similarly omission of insecticide application significantly reduced seed yield in both pure and the inter-cropped cowpea at all locations. At Tilli/Bolgatanga (Ghana) and Atekou/Kante (Togo) which are located closely together in a similar ecological zone, cowpea seed yield dropped to 0.0 Q/ha when the crop was not sprayed. This contrasted with locations such as Oronkua/Diebougou (Burkina Faso) and Maroua (Cameroon) where good yields 0.0 to 3.5 Q/ha) in inter-cropping and (3.6 to 9.0 Q/ha) pure-stand were obtained without

Table 6 Sorghum and cowpea seed yields as affected by insecticide sprayings and intercropping at Oronkua/Diebougou, Burkina Faso ; Tilli/Bolgatanga, Ghana ; Bordo/Kankan, Guinea-Conakry ; Maroua, Cameroon; and Broukou/Kara and Atekou/Kante, Togo in 1987.

Treatments	SEED YIELD																	
	Oronkua/Diebougou (Burkina Faso)			Tilli/Bolgatanga (Ghana)			Bordo/Kankan (Guinea-Conakry)			Maroua (Cameroun)			Broukou/Kara (Togo)			Atekou/Kante (Togo)		
	Sorghum[&]	Cowpea[&]	LER[£] (%)	Sorghum	Cowpea	LER (%)	Sorghum	Cowpea	LER (%)	Sorghum	Cowpea	LER (%)	Sorghum	Cowpea	LER (%)	Sorghum	Cowpea	LER (%)
	Q/ha																	
a) No insecticide spraying																		
1) Intercrop treatments																		
TVx 3236	20.7 b	3.5 cd	1.11	0	0.0 c	N/A	3.1 a	1.3 de	0.73	10.5 c	3.0 ef	1.39	22.8 a	0.0	N/A	8.2 a	0.1 c	N/A
KN-1	19.7 b	2.0 d	0.89	0	0.0 c	N/A	4.1 a	1.0 de	0.79	9.5 c	3.2 ef	1.40	20.2 a	0.0	N/A	9.0 a	0.0 c	N/A
Local	19.7 b	1.7 d	0.85	0	0.0 c	N/A	4.1 a	2.0 cd	1.04	10.7 c	0.9 f	0.82	18.8 a	0.5	N/A	9.4 a	0.0 c	N/A
2) Pure-Crop Treatments																		
Sorghum : Framida	31.3 a	-	1.00	0	-	N/A	7.8 a	-	1.00	18.7 a	-	1.00	26.4 a	-	N/A	9.8 a	-	N/A
TVx 3236	-	7.7 ab	(1.00)	-	0.0 c	N/A	-	4.4 ab	(1.13)	-	9.0 bc	(2.50)	-	0.3	N/A	-	0.4 b	N/A
KN-1	-	7.1 abc	(0.92)	-	0.0 c	N/A	-	4.2 ab	(1.08)	-	8.2 c	(2.28)	-	0.0	N/A	-	0.0 c	N/A
Local	-	7.7 ab	1.00	-	0.0 c	N/A	-	3.9abc	1.00	-	3.6def	1.00	-	0.0	N/A	-	0.0 c	N/A
b) Insecticide spraying§																		
1) Inter-crop Treatments																		
TVx 3236	21.6 b	2.9 d	1.05	0	5.0 b	N/A	3.6 a	1.6 de	0.76	12.9 bc	6.7 cd	1.24	19.0 a	0.1	N/A	8.4 a	1.7 b	N/A
KN-1	21.1 b	5.2bcd	1.31	0	4.4 b	N/A	4.5 a	0.8 de	0.73	13.6 bc	4.5 de	1.10	20.4 a	0.0	N/A	9.5 a	1.4 bc	N/A
Local	14.6 d	2.6 d	0.79	0	5.4 b	N/A	3.1 a	1.3 de	0.64	17.1 ab	4.8 de	1.31	18.6 a	0.6	N/A	9.1 a	0.0 c	N/A
2) Pure-Crop Treatments																		
TVx 3236	-	10.0 a	(1.23)	-	8.5 a	N/A	-	2.6bcd	(0.49)	-	16.3 a	(1.33)	-	0.0	N/A	-	3.5 a	N/A
Local	-	8.1 ab	1.00	-	7.9 a	N/A	-	5.3 a	1.00	-	12.1 b	1.00	-	0.5	N/A	-	0.0 c	N/A
L.S.D. (5 %)	3.2	3.6	-	-	2.5	-	NS	1.9	-	4.4	3.2	-	NS	NS	-	NS	1.5	-
C.V. (%)	10	47	-	-	26	-	46	51	-	22	34	-	20	167	-	28	67	-

§ Two insecticide sprays at flower bud formation and pod formation.
& Means followed by the same letter are not statistically different at 5 % probability level.
£ LER = land equivalent ratio was computed using the yield of the pure crop local cowpea variety under each spray regime.

insecticide protection.

The high pressure of pod sucking bugs, observed at Atekou/Kante, could have contributed to the drastic seed yield drop.

TVx 3236 yielded higher than KN-1 without insecticide application whether in pure-stand or intercropped plots; the yield difference was, however, not significant. Local cultivars yielded either equally or significantly less than TVx 3236 (Table 6).

With insecticide application, intercrop yields of the three cultivars were similar at all locations (Table 6 . In pure-stand plots TVx 3236 produced significantly higher yields than the local cultivars at Maroua (Cameroon) and Atekou/Kante (Togo) and was outyielded by the local variety at Bordo/Kankan (Guinea). Pure-stand yields of both cultivars did not differ significantly at other locations.

Yield advantages in intercropping (LER greater than 1) were observed under both spraying regimes at Oronkua/Diebougou, Burkina Faso, and Maroua, Cameroon, where adverse environmental conditions for the growth/development of both cowpea and sorghum crops were lower.

From experimental results, cowpea performance without insecticide protection appeared to depend on the locality; intercropping did not enhance seed yield on plots that were not chemically protected against insect pests; similarly the cultivars TVx 3236 and the local cowpea had no significant yield advantage over KN-1 in those plots. Therefore, wide spread testing should be conducted over several years in each country to identify locations which require less insecticide protection than others in order to make appropriate recommendations to farmers.

c) Management of pure-stand cowpea

The experiment was a factorial in randomized block, replicated four times. The factors were: three sowing dates (early, intermediate and late) and two seed-bed preparation methods (planting on flat and on tied ridges). Spacing was 0.75m between rows and 0.20m within the row. Ridges were made and tied every 1.5m before sowing. Two seeds were sown per hole and seedlings thinned to one per hill at two weeks after sowing. In Benin, the experiment was conducted at Urp in shallow, sandy-clay loam Alfisol. The plots were fertilized with 60 kg

of P_2O_5/ha from a soluble source. The three sowing dates were: 1 June, 1 July, and 1 August, 1985. Cowpea plants were sprayed three times for the first two sowing dates and twice for the last sowing date. In Gambia, the experiment was conducted at Sapu in deep, loamy Alfisol, the plots being fertilized as in Benin. The three sowing dates were 17 July, 4 August, and 20 August, 1985. The plants were sprayed twice, regardless of sowing date.

Grain yields at both locations are shown on Table 7. At Urp (Benin), late sowing significantly reduced grain yield compared to early and intermediate sowing dates; the grain yields of the latter two sowing dates did not differ significantly from each other. Cowpea cultivars and seedbed preparation methods did not significantly affect grain yield.

At Sapu, Gambia, the intermediate sowing date, compared to the early sowing date, depressed grain yield significantly. In most cases, sowing cowpea on tied ridges resulted in higher yields which, in some cases were significantly higher than those of cowpea grown on flat seedbeds.

From the above results, it appears that inadequate soil water infiltration rate was not a problem at Urp (Benin) while it was probably a constraint to cowpea production at Sapu (Gambia).

7.1.4 Cowpea Entomology

7.1.4.1. Objectives.

The objectives of the regional program are to foster collaboration and information exchange with the national programs and to elicit their interest in Entomology and Crop Protection Research. One regional entomology trial on minimum insecticide protection was conducted during the period.

7.1.4.2. Results

Owing to lack of entries from national collaborators, the trial was modified to assess the performance of four cowpea varieties of differing maturity periods: extra early (IT82E-60), medium (TVx 3236, IT82D-716) and late, photosensitive (local cultivars) on three planting dates, with minimal insecticide protection (two sprays of deltamethrin + dimethoate, 12.5 + 400 g a.i./ha at flower bud formation and at podding, using a knapsack sprayer). Thirty sets of the trial were distributed, upon request, to 16 national programs in in West, Central and Eastern Africa in 1985 and 1986, five of which (Burkina Faso, Gambia, Ghana, Niger, Togo) returned results. The results are summarised below.

Table 7. Effect of dates of sowing, seedbed preparation methods and cultivars on grain yield of cowpea at Urp (Benin) and Sapu, (Gambia) in 1986.

(i) Urp, Benin

Cultivars	Grain yield (kg/ha) of cowpea sown on[a]:					
	1 June		1 July		1 August	
	Flat seedbed	Tied ridges	Flat seedbed	Tied ridges	Flat seedbed	Tied ridges
TVx 3236	1968ab	1567abc	1826abc	2000a	836f	1041def
Local cultivar (daylength-sensitive)	1779abc	1408cde	1465bcd	1503abcd	911ef	762f
L.S.D. (5%)	524					
C.V. (%)	26.6					

(ii) Sapu, Gambia

Cultivars	Grain yield (kg/ha) of cowpea sown on[a]:					
	17 July		4 August		20 August	
	Flat seedbed	Tied ridges	Flat seedbed	Tied ridges	Flat seedbed	Tied ridges
TVx 3236	242a	256a	93c	202ab	145bc	213ab
Local cultivar (daylength-sensitive)	102c	244a	133bc	120bc	131bc	209ab
L.S.D. (5%)	95					
C.V. (%)	39.4					

a: Means followed by the same letter are not statistically different (P = 0.05).

Flower thrips incidence was lower on TVx 3236 and IT82D-716 (both moderately thrips resistant) than on IT82E-60 or local varieties. Maruca pod borer and pod sucking bug infestations were invariably low and were presumably suppressed by insecticide application.

TVx 3236 averaged 1 ton of grain per hectare in various locations and up to 2.5 t/ha in Farako-Bâ (northern Guinea savanna); IT82D-716 produced about 0.7 t/ha while IT82E-60 and local varieties yielded around 0.5t/ha (Table 8). Average grain yields varied from 0.3 t/ha in the Sahel savanna to 0.5-1.5 t/ha in the Sudan and northern Guinea savannas.

In general, grain yield declined steadily with late planting. Thus, late planting resulted in substantial yield reductions in TVx 3236 and IT82D-716, while grain yields of IT82E-60 and local cultivars were not significantly affected by planting date, although late planting of local cultivars resulted in crop failures in areas where premature cessation of rains occurred (Table 8).

In 1987, the trial was reconstituted to evaluate 10 cowpea entries (eight improved varieties of varying maturity periods, with multiple resistance to insect pests, diseases, drought, and Striga; and, two local late, photosensitive cultivars). Twelve sets were despatched upon request to eight national programs in West and Central Africa; the results reported below were received from Cameroon, Gambia, Ghana, Guinea Conakry, Niger and Nigeria.

Insect pest infestation was in general low. Incidence of Flower thrips on cowpea racemes and flowers, as well as Maruca Pod Borer and Pod Sucking Bugs on flowers and pods was mild. Insect pest population densities differed significantly among varieties but this appeared to be related more to a variety's ability to flower and set pods (adaptability) than inherent resistance to various pest species. Flower production was low in most trial locations except Nyankpala (Ghana) and Maroua (Cameroon) presumably because of harsh conditions during the growing season. High flowering varieties included IT82E-32, KVx 165-14-1, IT84S-2246-4 and TVx 3236 while some local varieties, IT81D-994 and KVx 30-G172-1-6K produced only few flowers.

Grain yields appear in Table 9. Seed production was low (0.2 to 0.3 t/ha) at Kankan (Guinea), Pobe and Farako-Bâ (Burkina Faso); moderate (0.4 to 0.5 t/ha) at Maradi (Niger) and Kano (Nigeria); and promising (0.6 to 0.7 t/ha) in Kamboinse (Burkina Faso), Maroua (Cameroon) and Nyankpala (Ghana). Under minimum insecticide

Table 8 . Grain yield (kg/ha) of 4 cowpea varieties at three planting dates under minimum insecticide protection,[1/] in 5 Sahelian locations.

Location	TVx 3236	IT82D-716	IT82E-760	Local checks	Mean
I SITES					
Pobe (BF)[2/]	421	279	456	61	305
Kamboinse (BF)[2/]	504	334	326	408	393
Farako-Bâ (BF)[2/]	2480	1349	802	907	1384
Nyankpala (GH)[3/]	1014	750	708	659	783
Sadore (NI)[4/]	485	207	211	339	310
Means	981	584	501	475	635
II PLANTING DATES					
1	1225	714	540	578	764
2	1074	613	538	464	672
3	643	424	424	382	469
Means	981	584	501	475	635

Comparisons	LSD (5%)	C.V. (%)
Varieties	142.6	22.3
Site	351.2	22.3
Planting Date	185.0	42.8
Variety x Site	334.3	22.3
Variety x Planting Date	203.9	42.8

2/ Burkina Faso

3/ Ghana

4/ Niger

1/ Two sprays of deltamethrin and dimethoate (12.5 + 400 g a.i./ha), at flower bud formation and podding, - 30 to 35 and 45 to 55 days after planting respectively, using a knapsack sprayer.

Table 9. Grain yields (kg/ha) of 10 improved and local cowpea varieties under minimum insecticide protection[1/] in 9 Semi-Arid locations of West and Central Africa, 1987.

Varieties	Farako-Bâ Burkina	Kamboinse Burkina	Pobe Burkina	Maroua Cameroon	Nyankpala Ghana	Kankan[2/] Guinea	Yundum Gambia	Maradi Niger	Kano Nigeria	Variety Means
IT84S-2246-4	608	1083	224	850	859	514	755	358	456	634
KVx 165-14-1	544	1037	271	780	859	395	805	345	512	616
KVx 3236	66	873	248	928	732	215	767	365	361	506
KN-1	272	614	140	939	905	366	-	294	374	488
IT82E-32	262	532	199	941	940	354	-	229	468	478
Local-1	144	162	412	630	767	464	395	694	370	449
IT84S-2231-15	624	733	76	556	357	210	288	182	425	383
KVx-30-G172-1-6K	128	220	234	718	378	128	-	486	445	342
Local-2	208	191	129	0	902	241	142	498	325	293
IT81D-994	176	377	184	475	626	173	-	1	1	252
Mean	303	582	212	682	739	296	525	345	373	444
LSD (5%)	N.S	556	122	244	273	140	133	171	102	172
C.V. (%)	-	66	40	25	25	33	17	34	19	40

1/ Two sprays of dimethoate + deltamethrin (400 + 12.5 g a.i./ha) at flower bud formation and podding - 30 to 35 and 45 to 55 days after planting respectively using knapsack sprayer.

2/ Three sprays of Parathion.

protection, IT84S-2246-4 (Aphid, Flower thrips, Bruchid resistant) yielded over 0.5t grain per hectare across various locations while KN-1, IT82E-32, KVx 30-G172-1-6K and local varieties produced between 0.3 and 0.5t/ha. An average grain yield of 0.3 t/ha across test sites by IT81D-994 (Bruchid resistant, late maturing) was ascribed, inter alia, to low plant densities caused by poor germination.

These results show that judicious use of insecticides (minimum protection i.e. two insecticide sprays) effectively complimented moderate levels of pest insect resistance particularly in adapted cowpea varieties in assuring a grain yield of 0.5 t/ha.

7.2. ANNUAL WORKSHOPS

Favourable mid-term and the end-of-project evaluation for SAFGRAD I, particularly its IITA component, recommended an extension of the Project for five additional years. The major objective in SAFGRAD II is to increase the efficiency and effectiveness of agricultural research in SAFGRAD member countries by developing the capacity and initiative of African scientists working in respective national programs. In this respect, it was necessary to organize collaborative research networks in which African national program scientists will play greater, decision-making roles.

Consequently the Directors of Agricultural Research (Council of Research Directors) in the 26 SAFGRAD member countries met in Ouagadougou, Burkina Faso, from February 23-27, 1987 to review achievements of SAFGRAD I and set directions for SAFGRAD II. The council of Research Directors decided to initiate, organize and coordinate research networks for cowpea, maize, millet, and sorghum. In fulfilment of that directive, SAFGRAD, in collaboration with IITA, organised a workshop of national program scientists working on cowpea and maize in the 18 SAFGRAD member countries of West and Central Africa from March 23-27, 1987 at Ouagadougou, Burkina Faso. The ultimate objective of the workshop, therefore, was to launch the collaborative research networks for cowpea and maize for Central and West Africa. The workshop was designed to enable national program scientists to identify and deliberate upon the major, common constraints affecting maize and cowpea production in the sub-region. The scientists elected Steering Committees to propose and elaborate details of Maize and Cowpea Research Networks in the region. Thirty nine national program researchers (19 cowpea scientists and 20 maize scientists) from 17 national agricultural research systems (NARSs) and several representatives of regional and international organizations (involved in cowpea and maize research and production in the region) participated in the workshop.

7.3. MONITORING TOURS

No monitoring tours were undertaken in 1986 and 1987 due to budgetary constraints.

7.4. VISITS TO NATIONAL PROGRAMS

No visits to national programs were carried out in 1986 owing to severe fiscal restrictions. However, during the 1987 cropping season, the network coordinators visited 10 national programs, as part of their network activities. The Cowpea Network Coordinator visited Mali, Mauritania, Niger, Nigeria, Senegal, Togo and Guinea Conakry. The Maize Network Coordinator paid two visits (the first at the beginning of the season and the second towards its end) to Mali, Guinea-Conakry, and the Central African Republic; he also visited Togo and Benin in addition to making several trips within Burkina Faso.

The objectives of these visits were to acquaint the network coordinators with the production realities in various national programs so that they would understand better the problems and constraints encountered in achieving network research objectives. The coordinators also discussed, with researchers and research administrators, the objectives and advantages of collaborative research networks and the roles of national programs in network activities. Other relevant issues, discussed with national program officials included training of technical staff, supplemental budget proposals in support of network activities, and assistance with provision of small research materials.

8. TRAINING

Most of the training activities under the project (in-service, degree related, special courses, etc.) were eliminated in SAFGRAD Phase II in compliance with the recommendations of the Design Team. However, in 1986, two Burkinabe students completed thesis research projects for the B.Sc. degree ("Ingenieur Agronome") in maize and cowpea breeding programs of the project. In addition, three researchers from Burkina national program participated in the following IITA Group Training Courses in 1987: Statistics in Agricultural Experimentation, Maize Pathology, and Maize Research and Production; their participation was sponsored by USAID, FAO and IITA.

9. PROBLEMS AND DIFFICULTIES ENCOUNTERED IN ACHIEVING OBJECTIVES

9.1. RESIDENT RESEARCH

The problems encountered in executing resident research during Phase I of the project were clearly stated in the final report for that phase (see pp. 35 to 36). Since the same difficulties were experienced during Phase II, only a summary of these constraints is given below:

a) Inadequate technical and administrative support staff.
b) A general shortage of land for research activities.
c) Inadequate availability of land with irrigation facilities.
d) Inadequate physical and other research facilities, including:

(i) Lack of proper fencing.
(ii) Insufficient storage and handling facilities, particularly for fertilizers and pesticides.

(iii) Inadequate cold room facilities.
(iv) Insufficient working space - laboratories, offices, and processing sheds.

(vi) Lack of library facilities at Kamboinse Station.

(vii) Budgetary strictures limiting procurement of equipment for certain specific and indepth studies in such areas as soil fertility, crop nutrition, and crop physiology.

e) Combining the administrative/coordinating functions of the Project or Team Leader with the scientific responsibilities for resident research and regional activities results in ineffectual and unsatisfactory performance on both front A full-time Project Leader, with minimum research responsibility, is required for the Project. The present arrangement may work satisfactorily, only if an experienced and competent professional administrator is recruited to assist the Project Leader in managing the Project.

f) In-service training at Kamboinse needs improvement, especially with regard to provision of more office/laboratory space, training materials (books, manuals), and adequate transportation.

10. RECOMMENDATIONS FOR FUTURE RESEARCH EFFORTS

10.1. MAIZE BREEDING

(a) Sudan savanna

(i) Continuation of work already initiated to improve drought resistance in 16 SR; development of drought resistant pool by combining materials already identified as drought resistant (Temp x Trop. No. 42, SAFITA-104, Pool 16, JFS, and Capinopolis 8245).

(ii) Improvement of the new yellow flint, early Population TZEF-Y and two local varieties (Koudougou and Raytiri).

(iii) Improvement of the extra-early populations: TZEE-Y, TZEEW-1, TZEEW-2, TZEEW-3, DMRESR-Y x JFS x K. Tollo, Pool 29 x K. Tollo, and Pool 27 x GUA 314 BC1.

(iv) Continued evaluation of populations (45, 31, Pool 16 SR, and TZESR-W), as well as continued coordination of international trials (EVT 16A ELVT-20).

(b) Northern Guinea savanna

Continued evaluation of TZSR-Y-1, DMRESR-W, Populations 22 and 28, and TZUT-W; further testing of EVTSE-W, EVTISR-Y and ELVT 18B.

10.2 MAIZE AGRONOMY

Although some progress was accomplished in the last three years, the recommendations presented in the IITA/SAFGRAD Final Report Phase I are still valid. Thus, it is recommended that:

a) At the national program level, more priority should be given to research in the northern Guinea than in the Sudan savanna zone; it should be noted that IITA/SAFGRAD Project put more emphasis on the latter.

b) Within the northern Guinea savanna, research effort should focus on the following:

(i) Methods of land preparation and cultivation (with and without crop residues).

(ii) Nitrogen and phosphorus fertilization (rates, sources, timing, residual effects).

(iii) Surface management (to ameliorate the adverse effects of drought stress, or excess moisture during parts of the growing season).

(iv) Planting dates.

(v) Crop rotation and crop associations (including relay-cropping).

(iv) Control of weeds, including that of the parasitic weed, Striga spp.

(vii) Control of insect pests.

(viii) Development and testing of streak resistant genotypes.

c) In the Sudan savanna zone, research priorities should include the following:

(i) Methods of land preparation and cultivation.

(ii) Surface management.

(iii) Nitrogen and phosphorus fertilization.

(iv) Planting dates.

(v) Crop rotation and crop associations.

(vi) Termite control.

(vii) Crop management of extra-early maize varieties.

d) Agronomists should work closely with agricultural economists in order to have a better understanding of the cost/benefit ratios of new or improved technologies.

e) More attention should be given to problems of stand-establishment and to the effect of cultural practices on seed germination.

10.3. MAIZE ENTOMOLOGY

Termites are major insect pests of maize in the semi-arid tropics. At the present time, the high costs and potential hazards of insecticides put chemical control beyond the reach of most low income peasant farmers in the region. Host plant resistance offers the only realistic basis for the development of affordable and cost effective integrated pest management (IPM) for maize pests. The following should receive further attention:

a) Development of an effective methodology for rapid evaluation of maize varieties for termite resistance; this is an imperative that requires time and resources (human, financial, equipment).

b) Strengthening collaboration with institutions working on termites (ICIPE, TDRI, CSIRO, etc.) to facilitate exchange of information and ideas on the subject.

c) Control of storage insect pests to enable farmers to obtain optimum returns from investments in improved varieties and technologies.

d) Stepping up training and material assistance to NARSs to enable each of them to acquire human and material resources for the establishment of effective crop protection services.

10.4 COWPEA BREEDING

a) Striga resistance

Emphasis should be placed on confirmation of resistance to more than one strain of Striga in B 301 and IT82D-849 and their subsequent use as sources of resistance to develop Striga resistant varieties for Mali, Burkina Faso, Niger, Nigeria and other countries. Striga resistance should be combined with resistance to insect-pests, diseases, and drought in back-grounds of desirable seed quality, wide ecological adaptation and high yield. Resistance to Striga should also be incorporated in promising and well adapted photosensitive varieties. A formal long term agreement with the Weed Research Group at Long Ashton Research Station is recommended; Long Ashton would be required to screen breeding materials for resistance to different strains of Striga and to conduct some basic research on mechanisms of resistance, screening techniques, and biochemistry and physiology of cowpea Striga parasitism.

b) Drought resistance

The work on drought resistance needs to be strengthened to identify and develop new drought tolerant, dual purpose varieties that are specifically suitable for the cereal based cropping systems in the Sudan and Sahel savannas of West Africa. It is strongly recommended that a long term collaboration, be established with a research institute, or university, specializing in this type of work. Possibilities should be explored for the use of tissue culture techniques in developing stress tolerant materials.

To accomplish the above two broad objectives, permanent facilities with good insfrastructure and support staff should be established at a suitable location in the semi-arid areas of West Africa. This will require, at least, the services of an experienced plant breeder.

10.5. COWPEA AGRONOMY

10.5.1 Northern Guinea and Sudan savanna

a) Management of monocrop cowpeas - there is need for further studies on:

(i) The seasonal and residual effects N, P, and and lime applications

(ii) The residual effects of soluble (superphosphates) and low solubility (rock phosphates) phosphatic fertilizers in rotations involving cowpea and maize, sorghum or millet.

(iii) In situ mulch and crop residue management studies.

b) Mixed cropping research including studies on:

(i) Sorghum-soybean intercropping.

(ii) Row-spacing, plant density and dates of planting cowpeas in sorghum-cowpea intercropping systems.

(iii) Effect of mixed cropping systems on soil productivity.

10.5.2. Sahel savanna

The following studies should be continued:

a) Studies similar to those mentioned above should be carried out, except that millet will replace sorghum in cowpea-cereal intercropping studies. Maize-cowpea relay cropping studies are not relevant in the Sahel.

b) Evaluation of cowpeas for drought and intense heat tolerance, under rainfed conditions.

c) Effect of windbreaks on cowpea productivity.

10.6. COWPEA ENTOMOLOGY

The following are recommended:

a) Host plant resistance studies particularly on early insect pests (aphid, Flower Thrips).

b) Evaluation of potential role of parasites, predators and pathogens in the management of cowpea insect pests.

c) Identification and evaluation of chemical insecticides, for minimal and judicious use, paying special attention to safety and selectivity.

d) Close collaboration with the national programs in the region to enhance exchange of information and ideas.

e) Training of national program scientists to ensure their active and full participation in the newly established cowpea and maize collaborative research networks for West and Central Africa.

10.7. SOIL-WATER MANAGEMENT

The following studies are recommended:

a) Quantification of responses of local and improved varieties of groundnut and sorghum, as well as improved varieties of millet, to tied ridges.

b) Responses of intercropping systems to tied ridges.

c) Evaluation of the tied ridging system at on-farm level; effort should be made to explain the differences between yields obtained at research stations and those attainable in farmers' fields.

d) Characterization of rock and earth bunds, 'holes', and other systems of soil and water conservation in terms of soil physical, chemical and hydrological properties.

e) Long term evaluation of minimum or zero-tillage systems with respect to length of cropping and fallow periods, changes in soil properties over time, economic viability, etc.

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