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IITA/SAFGRAD
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Mario Rodriguez
Maize Agronomist &
Project Leader

Ouagadougou
May 31, 1986

1. INTRODUCTION

The Semi-Arid Food Grain Research and Development Project (SAFGRAD) was launched in 1977 by the Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC) and the U.S. Agency for International Development (USAID). The Project, 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 and headed by the SAFGRAD International Coordinator. SAFGRAD target crops are maize, sorghum, millet, cowpea and groundnuts. The International Institute of Tropical Agriculture (IITA) was given the responsibility for undertaking regionally oriented research and training activities for maize and cowpeas.

The USAID-funded IITA/SAFGRAD team moved to Ouagadougou in 1979. Our goal was to establish a regionally oriented research and development program to develop and promote improved maize and cowpea varieties in addition to cultural practices compatible with small-scale farming systems in the semi-arid tropics (SAT). During the past seven years, IITA/SAFGRAD scientists have developed or introduced new improved varieties of maize and cowpeas as well as improved management practices in the SAT. This report presents a summary of project activities and the most salient research activities and results. For more detailed information, the reader is kindly referred to the IITA/SAFGRAD Annual Reports published yearly since 1979, both in English and French.

2. STAFFING

The IITA/SAFGRAD project became fully operational by June, 1979, with the arrival of four USAID-funded scientists. Among them were a maize breeder (and Project Leader) a maize agronomist, a cowpea agronomist (soil fertility specialist) and an entomologist. Under a separate agreement (Host Government/ IDRC of Canada), an IITA cowpea breeder had been based in Ouagadougou since 1979 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 project took on 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 position, previously contracted under ICRISAT/ SAFGRAD. Thus, in April, 1985, a sixth IITA/SAFGRAD scientist was added to our team.

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

IITA/SAFGRAD has had a high degree of senior staff continuity, which has contributed to the achievement of project goals. Following is a list of staff members currently employed:

Dr. V.D. Aggarwal, cowpea breeder.	(IDRC)
Dr. N. Muleba, cowpea agronomist.	(USAID)
Dr. J. Suh, entomologist.	(USAID)
Dr. A.O. Diallo, maize breeder.	(USAID)
Dr. N. Hulugalle, soil & water management agronomist	(USAID)
Dr. M. Rodriguez, maize agronomist and Project Leader	(USAID)

Including both the USAID and IDRC components, the IITA/SAFGRAD project employs the following local permanent support staff:

1 assistant Administrator, 1 accountant, 1 cashier, 1 storekeeper, 1 office clerk, 1 technician (B.S.), 15 observers, 1 mechanic and 2 assistants, 4 secretaries, 4 drivers, 2 tractor operators, 18 laborers, and 5 watchmen. The casual labor force is highly variable, reaching a total of about 300 laborers at the peak of the rainy season (Kamboinse and other research sites).

The project has greatly benefited from cooperation given by the U.S. Peace Corps. A total of ten volunteers have worked for IITA/SAFGRAD either directly in research or in station farm management activities.

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 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 strategy followed to achieve these objectives includes:

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

b) Regional research conducted by and in collaboration with national programs in 26 SAFGRAD member countries.

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

d) Training in Burkina and at IITA headquarters (Ibadan, Nigeria).

4. PHYSICAL ENVIRONMENT: SOILS AND CLIMATE

The 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, we have defined the following limits:

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 characteristic of the West African SAT is variability in total annual rainfall and its distribution. Thus, this classification scheme should not be interpreted rigidly. All three of these 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 during 1985 are outlined below. The reader is also referred to a map of these research sites on the following page.

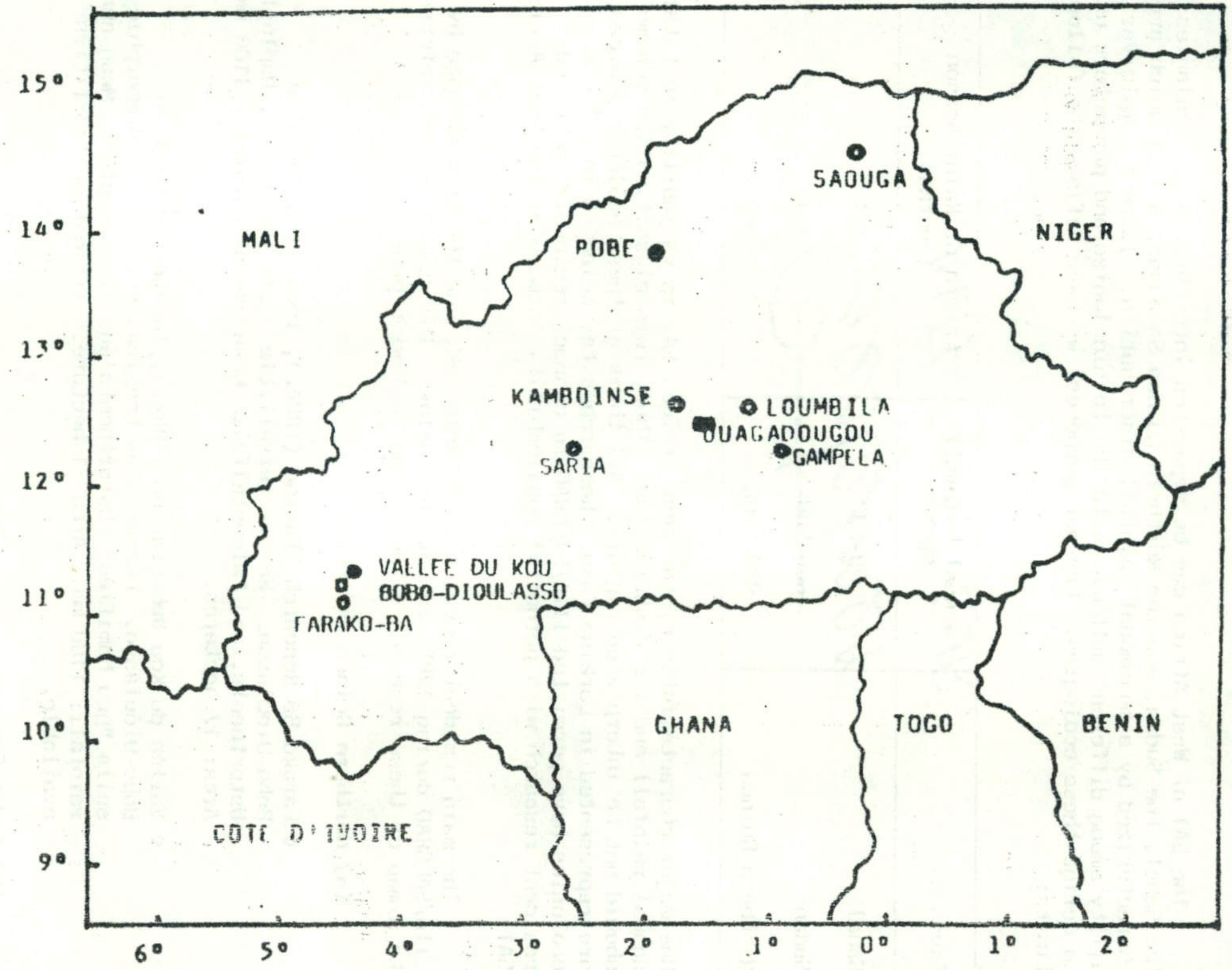
(a) Northern Guinea Savanna:

- Farako-Bâ Research Station (IBRAZ), located 12 km SW of Bobo-Dioulasso. Weakly ferrallitic soils (Eutrustox, Haplustalfs, Ustorthents, and Palenstalfs). Mean annual rainfall: 1100 mm. Area: 17 hectares.

- Vallée du Kou Sub-station (IBRAZ), located 20 km NE of Bobo-Dioulasso. Ferruginous tropical soils and hydromorphic soils "peu humifiés" (Ustorthents and Tropaquepts). Mean annual rainfall: 1100 mm. Area: 1 hectare. Irrigation facilities are available.

(b) Sudan Savanna:

- Kamboinse Research Station (IBRAZ), 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.



MAIN RESEARCH SITES OF IITA/SAFGRAD IN BURKINA FASO

◊ Saria Research Station (IBRAZ), located about 90 km west of Ouagadougou. Ferruginous tropical hydromorphic and ferrallitic soils (Haplustalfs, Plinthustalfs, Ustochrepts, and Eutrustox). Area: 3.5 hectares.

◊ 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.

◊ Gampela (ISP), located about 20 km east of Ouagadougou. Mostly ferruginous tropical soils. Mean annual rainfall: 700 mm. Area: 6 hectares.

(c) Sahel Savanna:

◊ Saouga, Gorom-Gorom (Ministry of Agriculture), located about 300 km north of Ouagadougou. Mean annual rainfall: 400 mm.

◊ Pobé (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 type trials are conducted in farmers' fields.

Cowpea work is conducted in the three major ecologies, but maize work has dealt only with the Sudan and Northern Guinea Savannas.

The project hired a soils specialist to characterize soils where IITA/SAFGRAD conducts its research in Burkina Faso. During a four-week consultancy in March of 1985, 57 soil profiles were described in detail. Soils were classified according to the USDA Soil Taxonomy, FAO-UNESCO and the French classification systems.

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 any major physical developments of 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:

◊ A small cold room for short term seed storage.

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

◊ A screenhouse for cowpea breeding and entomology work.

◊ 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 ten 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 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 used storage space belonging to Burkinabè National Programs (IBRAZ).

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 the bulk of its dry-season work. Two more hectares of land were lent by the ORD at Loumbila. It was never possible however, to properly irrigate more than three to four hectares during the dry season due to a limited supply of water.

IITA/SAFGRAD built a fence, a farm store, work room, and shed in addition to improving the irrigation channel and roads during 1980-81. Unfortunately, and in spite of the large development investment by the project, the Ministry of Rural Development decided to retire most of the land at Loumbila from the SAFGRAD Project in 1984. Since then, the bulk of our off-season breeding activities have been shifted to the Vallée 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 during 1979 and 1980. To facilitate operations there, the project renovated an old house for work space as well as storage. With the development of facilities at Loumbila, activities at Saria were reduced to a minimum and the house was returned to the national program.

6. RESIDENT RESEARCH (BURKINA FASO)

6.1 MAIZE BREEDING

6.1.1 Objectives:

Maize genetic improvement had three major objectives which dictated its research activities, namely the development of:

a) Early (90 days to maturity) high yielding varieties for the Sudan Savanna Zone.

b) Intermediate (105-110 day) high yielding varieties designed for the Northern Guinea Savanna Zone. These varieties could also be grown on lower slopes or hydromorphic soils of the Sudan Savanna.

c) Drought resistant varieties. Risk of drought stress is one of the major factors affecting yield stability in the SAT. Improving maize resistance to drought should enhance the well-being of small farmers in the region.

Some testing of QPM materials developed by CIMMYT has been carried out to identify the best populations/varieties for the Sudan Savanna.

6.1.2 Research results

a) Genetic improvement

TZESR-Y. This is an early streak resistant population developed at IITA/Ibadan. Two cycles of full-sib family selections were completed in 1984 at Kamboinse.

Pool 16. This early white dent CIMMYT pool has performed well in SAFGRADs' Regional Uniform Variety Trial (RUVT). The first cycle of selection was completed in 1982 and sent to IITA/Ibadan for further improvement and resistance to streak. Maize streak virus is a serious disease in Africa and is becoming more and more important in the Northern Guinea Savanna of West Africa. At Kamboinse, one selection cycle was completed in 1985 to incorporate drought resistance into this population.

TZUT-Y. This is a temperate x tropical intermediate maturity population which combines the efficient plant type of U.S. corn belt varieties with the disease tolerance/resistance of tropical germplasm. Since 1982, 305 S1 lines of this population have been combined twice at Kamboinse. In 1984, the first selection cycle of this new population was completed.

One selection cycle of TZE-3, TZE-4, and TZPB was carried out at SAFGRAD.

Through International Progeny Testing Trials (IPTT's), the Maize Breeding Program participated in the improvement of TZSR-Y, TZSR-W, TZUT-W and TZESR-W (IITA populations); and Pop 33, Pop 70 and Pop 46 (CIMMYT populations).

210 local varieties from Burkina were collected and evaluated.

b) Varietal development.

The following varieties were developed and tested:

24 experimental varieties from IITA's early maturing populations (TZE 7, TZE 8, TZE 9, TZE 12, TZE 14, TZE 15, TZE 16, TZE 17).

Four varieties from Pool 16 (CIMMYT Germplasm).

Four varieties from TZESR-Y (IITA Germplasm).

In addition, 72 crosses between tropical and temperate maize were advanced to F_4 and tested.

Of the above 104 varieties/crosses, six varieties (two intermediate and four early) showed good performance in the Regional Testing Program and some were adopted by national programs. The varieties developed by IITA/SAFGRAD which have shown the best performance are:

Early: Temp. x Trop. Nº 42, Temp x Trop. Nº 3, SAFITA-2 and SAFITA 104.

Intermediate: SAFITA-102 and Temp. x Trop. Nº 27.

Controlled irrigation studies permitted identification of the best performing genotypes under drought stress. These were Pool 16 and Jaune Flint de Saria. A field methodology for identifying the best families under drought stress has been developed. In 1985, experimental varieties were developed and tested using this methodology.

The program also developed a quality protein maize variety from QPM Pool 34 which was sent for regional testing and evaluation. It performed well in both Burkina and Cape Verde.

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 growing conditions in the SAT, with particular emphasis on increasing maize drought resistance.

To accomplish these objectives, the program conducted more than 240 field trials between 1979 and 1985 under both low and high management conditions. These and other available research results (Section 6.2.2), together with the experience gained by the maize agronomist, have permitted the establishment of a broad data base of agronomic factors limiting maize production in the region. Based on research conducted by IITA/SAFGRAD's Maize Agronomy Program, management alternatives to production are presented in sections 6.2.3 and 6.2.4.

6.2.2 Agronomic factors affecting maize production in the West African Northern Guinea and Sudan Savannas.

In the predominant soil types of the West African Savannas (ferruginous tropical soils or Alfisols and Inceptisols), soil fertility, soil compaction, and the risk of drought stress are the main agronomic factors affecting maize production. To this list, other factors of lesser importance or of a more localized nature may be added such as termites, maize streak virus, weeds (including Striga), soil acidity and lodging.

a) Soil fertility. Nitrogen and phosphorus deficiencies are most prevalent.

b) Soil compaction. This problem is mainly a function of:

◊ Mineralogy: high contents of quartz and kaolinite with low contents of amorphous iron and aluminum oxides.

◊ Low organic matter.

◊ Crop residue removal.

◊ Lack of tillage.

◊ Impact from intense rainfall.

c) Drought stress. The risk of drought stress is often high due to:

◊ Erratic rainfall distribution patterns. Dry periods of one week or longer are common but unpredictable during the growing season. In addition, rains may be established late or cease earlier than expected.

◊ Surface sealing and/or surface crusting. The consequences are lower infiltration rates and increased runoff losses.

◊ Soil or subsoil compaction. As a result, percolation and infiltration rates decrease.

6.2.3 Agronomic solutions to major limiting factors.

6.2.3.1 Soil fertility

a) Nitrogen. Grain yield response to nitrogen fertilizer was strongly dependent on the amount of rainfall received. Responses were found with up to 100 kg N/ha in the Sudan Savanna and up to 150 kg N/ha in the Northern Guinea Savanna. Recommendations to farmers should, however, take into account soil type and management history, removal of crop residues, rainfall in the preceding year, economic and other risk factors.

Timing of Nitrogen application. Experiments in the Sudan Savanna with ferruginous tropical soils showed no consistent difference in grain yield between one total and several split nitrogen applications. On ferrallitic soils in the Northern Guinea Savanna, split nitrogen applications generally produced better yield than one single nitrogen application at or soon after planting.

Legume-maize crop rotations. Maize grain yield was higher when maize followed cowpeas or groundnuts than when under continuous maize. However, the grain yield differences were small or modest (150 to 700 kg/ha) and could not be attributed solely to increased nitrogen fixation by the legume, implying that other factors were involved in the positive rotation effect.

b) Phosphorus. Phosphorus deficiencies are widespread in Burkina and are a greater factor limiting yield than nitrogen. Deficiencies can be corrected, however, with moderate amounts of fertilizer application. Grain yield responses were found with up to 50-75 kg soluble P_2O_5/ha. In addition, marked residual effects of phosphorus on grain yield were measured several years after its initial application.

Use of local phosphatic rock. Experiments with the local phosphatic rock (Burkina phosphate) indicated its effectiveness in increasing grain yield during the first two years of application was very minor due to its low solubility.

6.2.3.2 Soil compaction.

Soil compaction affects maize growth and yield in at least two ways: 1) reduced root growth, with its related effects on water uptake and mineral nutrition, and 2) reduced water infiltration. Tillage and crop residue management were shown to reduce the negative effects of soil compaction on yield.

a) Soil tillage. In the absence of tied ridges, soil preparation by tractor, oxen, donkey, or hand-hoe always gave higher maize grain yields than zero-tillage. Generally, grain yield is positively correlated with depth of soil tillage. As such, tillage methods can be ranked as tractor > oxen > donkey = hand-hoe.

b) Residues. Crop residues help in maintaining soil organic matter and promote a higher level of biological activity. In particular, termite activity at or near the soil surface was found to be greatly enhanced by the presence of crop residues. As a result, infiltration rates and soil aeration are improved. When residues are kept as a mulch, there is an additional positive effect on maintaining lower soil temperatures and minimizing evaporative losses. Marked effects on maize grain yield were obtained only when the amount of residue was at least 3-4 tons of dry matter/ha. The amount of residue required was less when tied ridges were used. Under traditional (hand-hoeing) soil preparation methods, the systematic removal of crop residues leads to such low infiltration rates that grain yield response to fertilizer applications was very small or non-existent.

6.2.3.3 Drought stress

Alone or in combination, the following practices reduce the risk of drought stress.

a) Soil tillage. Tractor, oxen, donkey and hand-hoe tillage methods improve infiltration and soil water storage. Deep tillage was generally better than shallow tillage. The effect of soil tillage was only temporary and was not enough to ensure improved soil water infiltration rates throughout the growing season.

b) Tied ridges. **Evaluation of tied ridges in the Sudan Savanna of Burkina Faso was introduced by the IITA/SAFGRAD Maize Agronomy Program in 1979. Since then, tied ridges have been very effective in increasing infiltration and decreasing runoff losses. This is particularly true in those soils which have low infiltration rates due to surface sealing, crusting or compact subsoil layers. The yield response to tied ridges has been more consistent in the Sudan than in the Northern Guinea Savanna.**

Tied ridges can be established at or before planting, or at the time of earthing (hilling) up. If farmers don't have the means to make tied ridges before planting, they may plant on the flat. Later, when plants reach a minimum height of about 25 cm and when labor is less of a constraint, they can earth up and tie their ridges. Long term trials have also shown that it is profitable for farmers to plant directly on old tied ridges, without any prior soil preparation except weeding. The latter is a more viable option in the Sudan than in the Northern Guinea Savanna because the longer dry season lessens the problem of weed control.

Tests conducted directly by the Maize Agronomy Program and by other research agencies showed a yield response to tied ridges at most locations (maize and other crops) in Burkina Faso. However, no yield response was found in the weakly ferrallitic soils at Farako-Bâ. These soils were typical forest zone soils, however, which are not common in the West African Savanna. At Saria, only on poorly or inperfectly drained lower slope soils were there negative effects in most years of tied ridging on maize growth and yield.

The grain yield increase obtained on-station using tied ridges can be as high as 2000 kg/ha when soil fertility is not a yield limiting factor. Yield increases of 1 ton/ha are common. On-farm tests have given yield increases of up to 500 kg/ha. The labor cost of making tied ridges by hand was estimated at 27 man-days/ha or 10.800 CFA/ha (opportunity cost of labor at 50 CFA/hour). At a maize price of 90 CFA/kg, such labor costs equal 120 kg maize/ha, which is only a fraction of the potential yield increase.

c) Shallow ditches. Digging shallow ditches or small holes between the maize rows also increased soil water retention and decreased runoff. Experiments have shown large yield increases due to digging holes approximately 40 cm long x 20 cm wide x 10 cm deep. Such yield increases were usually smaller than those obtained by making tied ridges, due to the larger volume of water contained by the latter. If the farmer plants on the flat, he can dig small holes between rows any time after planting; whereas tied ridges can be established only after the plants reach a minimum height, usually 25 or more days after planting.

It has been concluded that the risk of drought stress can be reduced by any sort of small hole,catchment, basin, or terrain irregularity that slows down water runoff and conserves rainfall.

d) Cultivations (scarifications) for breaking a sealed soil surface or crust. Crusting and/or surface sealing are soil characteristics frequently encountered in Burkina Faso. The results are poorer soil aeration and reduced water infiltration leading to a greater risk of drought stress. Even in the absence of weeds, cultivations after planting led to improved grain yields. In general, the greater the number of cultivations, the higher the yield. It was also shown that cultivations were not as effective as either digging small holes or as ridge tying in increasing maize yields. Moreover, cultivations can cause root prunning and/or exposure of moist soil to dessication, leading to increased drought stress and possibly reductions in yield.

e) Planting of maize on lower slope and hydromorphic soils. There was a very marked toposequence effect on maize grain yield. Yields were lowest on plateau soils and increased toward lower slopes and hydromorphic soils. The difference in grain yield was on the order of two to five fold, even when improved soil and water management practices such as tillage, tied ridges and fertilizer were used.

f) Use of residues as a mulch. The effect of crop residues has already been discussed under soil compaction (Section 6.2.3.2). Although farmers need crop residues for fuel, fodder and construction material, the current practice of systematic crop removal from the field is counter-productive in the long run and is one of the major factors responsible for the current degradation of the soil resource base.

g) Use of varieties whose maturity fits the length of the growing cycle. Under "average" rainfall conditions, varieties of the following maturities should be used in simple maize monocropping systems:

Sudan Savanna: early varieties (82-95 days). Northern Guinea Savanna: intermediate maturity varieties (96-110 days).

There is a demonstrated need to develop extra-early maize varieties (less than 82 days to maturity) to be used in the Sudan Svanna in those years when maize can not be planted as soon as it should or has to be replanted when the remaining part of the growing season is too short for planting an early variety.

h) Appropriate planting dates. When rainfall conditions permit, it appears that the optimum planting dates for maize are June 15-30 in the Sudan Savanna and June 1-20 in the Northern Guinea Savanna. Nevertheless, given the high variability in the rainfall distribution pattern from year to year and the erratic occurrence of dry spells during the growing season, there were years when the highest maize grain yields were obtained when the planting date was earlier or later than the average optimum given above.

6.2.4 Results of other agronomic studies.

a) Planting depth. In experiments where there was overplanting and thinning to one plant/hill, deep planting (8-10 cm depth) gave the same grain yield as shallow planting (3-5 cm). Nevertheless, deep planting reduced field germination and could lead to decreased stands and lower yields under farmers' conditions, where overplanting and thinning don't normaly occur.

b) Seedbed. Experiments in the Sudan and Northern Guinea Savannas showed no differences in maize grain yield between planting on the flat and planting on simple (non-tied) ridges.

c) Earthing up. When planting on the flat, there was no effect of simple earthing up (without ridge tying) on maize grain yield.

d) Plants/hill. Experiments in the Sudan Savanna showedthat at the same plant density, there were no grain yield differences between one or two plants per hill. When the number of plants/hill increased to 3 or 4, grain yields decreased.

e) Seed size. There is a direct effect of seed size on field germination and seedling vigor, but its effect on yield has not been consistent over the years. A small seed size leads to lower field germination rates and can result in lower maize grain yields.

f) Plant density. The optimum plant density for maximum grain yield changes with soil fertility, planting date and number of days to maturity. When soil fertility is not a major limiting factor and the planting date is appropriate, optimum densities are similar to those found in more humid zones: Intermediate varieties: 50,000 to 65,000 plants/ha. Early varieties: 65,000 to 90,000 plants/ha. These optimum densities can be reduced by 20-30% with only a small (less than 10%) effect on grain yield. By using densities which are 20-30% below those which give the highest grain yields, the small farmer can decrease his/her planting and harvesting costs. Sub-optimal densities can also reduce the risk of crop failure if grain filling occurs during a very severe drought.

Optimum densities decrease as soil fertility becomes a yield limiting factor. Under very low fertility, the optimum density for intermediate maturity varieties is about 25,000 plants/ha. The effect of planting date on stand density becomes very important when most of the grain filling period occurs under conditions of very low soil moisture. In this case, the optimum density should be drastically reduced from 50-65,000 to 20-25,000 plants/ha.

g) Thinning date. Results showed no effect of thinning between 12 and 25 days after planting on maize grain yield. Although thinning is not a practice normally followed by the maize farmer, overplanting and thinning late (20 days after planting) can increase a researchers' chance of obtaining desired stands and higher within-plot uniformity.

h) Spatial arrangement. There were no differences in maize grain yield between row spacings of 37.5 cm and 75 cm. At a row spacing of 112.5 cm, yields were the same as at 75 cm with a density of 40,000 plants/ha, but lower yields were obtained when the density was increased to 67,000 plants/ha.

i) Potassium fertilizer. Short term studies showed no grain yield increase due to the application of potassium fertilizers.

j) Zinc deficiencies. In some years, zinc deficiency symptoms have been observed in the Sudan Savanna, but no grain yield response to zinc application was found. Foliar sprays of zinc sulfate were effective in correcting the deficiency symptoms.

k) Effect of Furadan (Carbofuran). Soil applications of Furadan 5G at or after planting and/or during the crop cycle often gave grain yield increases, sometimes as high as 1 ton/ha. The positive effect of Furadan is due mostly to termite control in the Sudan Savanna, whereas it helps control termites, stem borers, maize streak virus and some soil insects in the Northern Guinea Savanna.

l) Local varieties. Most if not all of the early (82-95 day) local varieties in the Sudan Savanna showed good yield potential (4-5 ton/ha) when properly managed. Some had good agronomic characteristics while others were too susceptible to lodging. Although foliar diseases are not a major problem in the Sudan Savanna, all local varieties appear to be highly susceptible to them.

m) Genotype x management interactions. Many trials were conducted to compare varieties under low fertility and/or drought stress. In general, local varieties did not perform better than improved varieties of the same maturity.

6.2.5 Development of a ridge-tier for animal traction.

Although tied ridges can be made by hand and still be economically profitable, a mechanical device adapted to animal traction has made tied ridging even more attractive. Two versions of such a device have been developed by the IITA/SAFGRAD Maize Agronomy Program (Fig.2); one designed for donkey and the second for oxen traction. The donkey model has shovels which are 16 cm wide at the outer edge, widening to 40 cm at the center. It weighs 11 kg and costs about 14,000 CFA to produce. The same parameters for the oxen model are 20 cm, 55 cm, 17 kg, and roughly 16,000 CFA. In 1985, more than 130 units of both ridge-tiers were built and widely distributed to farmers and cooperators in Burkina. Evaluation of these tests has not yet been completed, and additional design improvements are underway.

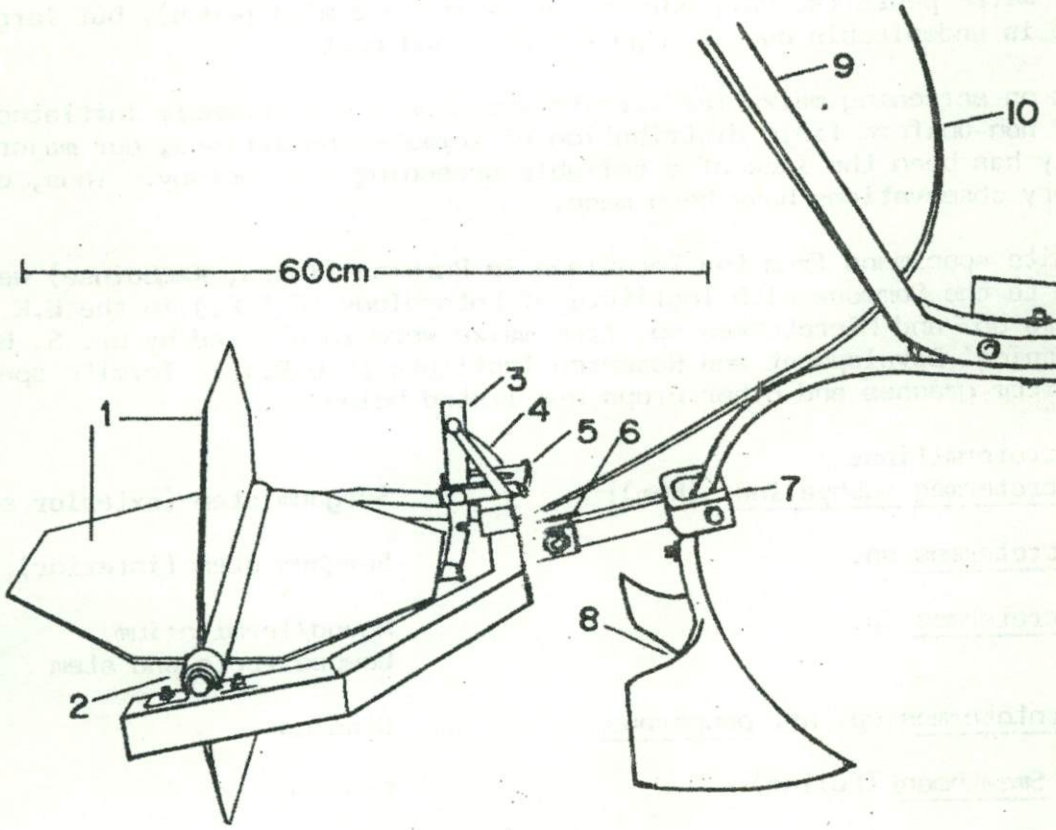
6.3 MAIZE ENTOMOLOGY

6.3.1 Objectives

a) Identify principal insect pests and estimate associated yield losses to maize in the West African SAT.

b) Identify and evaluate chemical insecticides for pest suppression with emphasis on availability, cost and safety.

c) Develop and test integrated pest management (IPM) systems which are economically sound, ecologically balanced, and agronomically feasible for increased stable maize production.



(1) Shovels

(2) Axel Bearing (Pipe)

(3) Latch Lever

(4) Rubber Band (Inner Tube Strip)

(5) Latch Adjuster (for correct angle and to compensate for wear in bearings, shovels and latch).

(6) Shovel angle Adjusting Bolt

(7) Coupler

(8) 30cm Ridger that allows soil to flow over the top.

(9) Handles of "houe Manga" (FAO donkey weeder)

(10) Bicycle cable to Brake Lever

Fig. 2 The IITA/SAFGRAD Trap ridge-tier (Donkey Version)

6.3.2 Research results.

Millipedes, armyworms (Mythimnia sp), stem borers (Sesamia, Eldana), Cicadulina leafhoppers (streak virus vector) and termites were identified as the most important insect pests of maize in the West African SAT. Termites are the most serious pest because they attack all plant parts at all growth stages.

Furadan (Carbofuran) 5G (1-3kg a.i./ha) effectively controls termites and other maize pests (streak, borers, armyworms and millipedes), but large scale use is undesirable due to high toxicity and cost.

Work on screening maize for termite resistance was recently initiated. Given the non-uniform field distribution of termite populations, our major difficulty has been the lack of a reliable screening methodology. Thus, only preliminary observations have been made.

Termite specimens from two locations in Burkina (Kassa, Kamboinse) were forwarded to the Commonwealth Institute of Entomology (C.I.E.) in the U.K.. Macrotermes sp. and Microtermes sp. from maize were identified by Dr. S. Bacchus at the Tropical Development and Research Institute (T.D.R.I). Termite species obtained from grasses and other crops are listed below:

◊ Macrotermitinae	
Macrotermes subhyalinus (Ram):	Sorghum stem (exterior surface)
Macrotermes sp.	Sorghum stem (interior)
Microtermes sp.	Mound/Termitarium Cowpea roots and stem
Odontotermes sp. nr. pauperans	Grasses
O. Smeathmani (Fuller)	Grasses
O. Magdalenae (Grasse Noirot)	Termitarium
◊ Nasutermitinae	
Trinervitermes togoensis (Sjostedt)	Grasses
T. (sp. ?) 'oeconomus	Roots of bushes
Trinervitermes sp.	Grasses

6.4 COWPEA BREEDING

6.4.1 Introduction

Funded by the International Development Research Center (IDRC) of Canada, the Cowpea Improvement Program was started in 1977 as a bilateral project between IITA and the Government of Burkina Faso. It continued to be a bilateral project until 1983, at which time the national program separated.

IDRC agreed to continue funding IITA/SAFGRAD's cowpea breeding activities. A summary of the work carried out from 1979 to date is described in this report.

6.4.2 Objectives

Main program objectives are to identify and/or develop cowpea varieties adapted to agroclimatic zones of the African SAT which possess desirable seed qualities and stable yields in addition to resistance to important insect pests, diseases, Striga and drought.

6.4.3 Research results.

6.4.3.1 Insect resistance.

Insects are the major constraint to cowpea production in the West African SAT. Among the most economically important are aphids, flower thrips, pod sucking bugs, Maruca, and the storage weevil (Callosobruchus maculatus). Considerable progress has been made in identifying sources of resistance to aphids and bruchids and incorporating these materials into the breeding program.

a) Aphids.

Aphids are a serious pest attacking cowpeas at all stages of plant growth. Plants in the seedling stage are particularly vulnerable. The Entomology Program identified a new aphid biotype (K) as well as sources for its resistance (i.e. TVu 36). Our major achievement is that this resistance was incorporated successfully into KN-1, a variety which has been released in Burkina. KVx 165-14-1 was produced using TVu 36 as the resistant donor parent. It is slightly early in maturity and has a yield potential of about 2 ton/ha, comparable to that of KN-1. In addition, new varieties have also been developed which combine aphid resistance to other desirable traits such as seed quality, early maturity, high yield etc. (i.e. KVx 145-27-6, KVx 146-27-4, KVx 146-44-1). These varieties produced yields of 1468, 1798 and 2438 kg/ha respectively, in a trial conducted at Kamboinse in 1985. Work is also in progress to combine aphid resistance with Striga and drought resistance.

b) Bruchid resistance

A bruchid resistant IITA variety (TVu 2027) has been crossed with varieties adapted to semi-arid areas. Many promising selections have been identified between TVu 2027 x SUVITA-2 (see section combining Striga and bruchid resistance). These selections, however, were slightly late in maturity (75-80 days) and susceptible to disease. F_3 and F_4 progeny were crossed with IT82D-716 and screened for Striga resistance in the field in 1985. A total of 65 F_3 and 44 F_4 single plants were selected which combined early maturity, disease resistance, and good seed quality. These plants are currently being evaluated for bruchid resistance in the laboratory.

Bruchid resistance has also been incorporated into photosensitive varieties, which continue to be popular with the small farmer. The varieties which show the most promise are KVx 30-400-6K, KVx 30-4K, and KVx 30-301-2K. In addition, a large collection of bruchid resistant varieties from IITA/Ibadan have been evaluated in Burkina. The varieties with the best performance are IT82D-716, IT81D-988, IT81D-994 and IT82D-713.

6.4.3.2 Drought resistance.

The two varieties which have performed consistantly well over the last several years and again in 1985 under drought conditions are SUVITA-2 and TN 88-63. Variety 58-57 has also given promising results. SUVITA-2 is a local variety from Gorom-Gorom in the Sahel of Burkina; while 58-57 is an introduction from Senegal, where it is widely grown. These varieties have been crossed with many others in an attempt to develop more drought tolerant genotypes. Varieties originating from these crosses produced high, stable yields uner the severe drought conditions of 1984. The best varieties (KVx 30-309-6G, KVx 30-305-3G, and KVx 30-470-3G) produced average yields of 924, 992, and 1033 kg/ha respectively across 14 locations in nine West African countries, as compared to yields of 800 and 793 kg/ha for SUVITA-2 and TN 88-63.

6.4.3.3 Striga resistance

Striga is a plant parasite commonly known as witchweed. The species which parasitizes cowpeas in Africa and is thus economically important is Striga gesnerioides (Willd) Vatke. Although Striga occurs in many West African countries, the most seriously infested areas are localized in Nigeria, Niger, Burkina Faso and Mali. Susceptible cowpea plants succumb easily to this parasite. Fields may be so infested that farmers cannot produce a crop. Moreover, viable Striga seeds may persist in the soil for as long as 20 years. They are stimulated to germinate by chemicals exuded from the cowpea host. The most feasible way to overcome this problem is through the development of Striga resistant varieties. With this as an objective, IITA initiated a breeding program for Striga resistance in an artificially infested cowpea plot at the Kamboinse station.

a) Identification of resistant varieties.

In 1981, a collection of 50 elite cowpea lines was screened for Striga resistance. Two varieties (SUVITA-2 and 58-57) were found to be resistant. In 1982, both field and screenhouse experiments verified that SUVITA-2 and 58-57 had high levels of resistance to Striga. SUVITA-2 was selected as a donor parent because of its good seed quality and adaptation to dry areas. In addition to SUVITA-2 and 58-57, advanced generation materials (i.e. SUVITA-2 x 2027, a bruchid resistant variety) were evaluated at several locations in Burkina as well as in Niger, Nigeria, and Mali. We observed high levels of Striga resistance in Burkina, moderate resistance in Niger and Mali and high susceptibility in Nigeria. This suggested the presence of different strains or biotypes of Striga gesnerioides in these countries.

b) Striga biotypes.

To verify the existence of different Striga biotypes, a collaborative experiment was conducted in 1984 with Parker at the Weed Research Organization (WRO) in Oxford, England. The experiment was conducted on cowpea using Striga seeds from Burkina Faso, Niger, and Nigeria. In terms of either the number of Striga emerged or its vigor, SUVITA-2 and 58-57 were shown to be resistant to the Burkina (Kamboinse) biotype, yetthey were susceptible to biotypes from Niger (Maradi) and Nigeria (Kano). In another experiment, Parker confirmed resistance of SUVITA-2 to the Kamboinse strain and high susceptibility of 58-57 to the Maradi strain. SUVITA-2, however, showed only mild resistance to the Maradi strain and 58-57 was mildly susceptible to the Kamboinse strain.

c) Inheritance of resistance.

Preliminary results show that resistance to Striga is controlled by a single dominant gene.

d) Breeding for resistance to Striga.

Germplasm evaluation. To find new sources of resistance, 136 lines from IITA/Ibadan were screened in 1984. Only a few of them were found to be free from susceptibility to Striga. These selections were re-evaluated in 1985, along with 150 new entries.

Combining Striga resistance with high yield and wider adaptation. The yields of twenty F_5 SUVITA-2 x KN-1 families were evaluated at Kamboinse in 1984. Due to a high infestation of bacterial blight, only four individual plants were selected for their combined resistance to Striga and bacterial blight. Results of 1985 yield tests are still being evaluated.

In another trial, 28 F_5 families from SUVITA-2 x TVx 3236 were evaluated at Kamboinse in 1984. Nine bulk populations were selected based on resistance to Striga and disease, uniformity of seed and plant type, maturity, and yield. An especially promising selection (KVx 61-74) showed zero Striga infestation and produced an average yield of 881 kg/ha under severe drought conditions. These tests were conducted again in 1985.

A series of new crosses were made between SUVITA-2 and 16 promising IITA/Ibadan lines, one of which was a bruchid and multiple disease resistant variety (IT82D-716). F_2's of these crosses were evaluated in 1984 at Kamboinse. Ten F_2 families were rejected due to their susceptibility to Striga, bacterial blight, pod blotch and their overall poor plant type. Of the remaining six families, a total of nine single plants were selected. They originated from crosses between SUVITA-2 and IT82E-18, IT82D-716, IT82D-652, IT82D-847, IT82D-889 or TVx 4659-13C-1K. A preliminary yield trial was planted during the 1985 cropping season.

Combining Striga and Bruchid resistance. In the past few years, several highly promising bruchid and Striga resistant lines have been developed (i.e. KVx 30-G172-1-6K, KVx 30-G246-2-5K, KVx 30-G467-5-10K, KVx 30-183-5K, KVx 30-G20-1-2K). However, they have shown some susceptibility to pod blotch and bacterial blight and are slightly late in maturity. They have since been crossed with IT82D-716 to incorporate multiple disease and bruchid resistance. F_3 progenies of these materials were screened for Striga, disease, maturity, yield and bruchid resistance in 1985.

Combining *Striga*, Bruchid and Aphid resistance. The *Striga* and bruchid resistant varieties mentioned above were crossed to newly developed aphid resistant lines (KVx 146-44-1, KVx 145-27-4 and KVx 146-13-3). The F_2 material was evaluated in the field for bruchid resistance. In addition, new crosses are planned between aphid (KVx 146-49-3 and KVx 165-14-1) and bruchid resistant material expected to be selected from the crosses of IT82D-716 with bruchid and *Striga* resistant varieties as discussed above.

Combining *Striga* and drought tolerance. F_5 materials originating from crosses between SUVITA-2 and drought tolerant varieties (2-13-4 and 3-4-13 (Brazil); TN 88-63 (Niger); Mougne (Senegal); IT82E-32 and TVx3236 (IITA) were evaluated in a *Striga* infested plot to select for *Striga* resistance at Kamboinse and drought tolerance at both Kamboinse and Pobe. It is hoped that varieties will be identified which combine *Striga* resistance with tolerance to drought.

6.5 COWPEA AGRONOMY (Including intercropping studies with maize and other cereals).

6.5.1 Objectives.

a) To determine factors limiting cowpea yield in the African SAT.

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 cowpea yields in intercropped sorghum and millet for the Sahel and Sudan Savannas.

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

f) To assist the cowpea breeding program in identifying those 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 Savanna.

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 sunshine with a minimum of rainfall, both of which are crucial for good grain quality (less seed rot). Early planting (late June to early July) can subject cowpeas to several foliage, stem and pod diseases; a situation which can be useful to the cowpea breeder in creating disease epidemics to screen for cultivar resistance.

The optimum plant population is 67,000 plants per hectare, which corresponds to a row spacing of 0.75m by 0.20m spacing within the row. Daylength sensitive cowpeas can tolerate this plant population but still give good yields at 1/3 the density, providing rains don't terminate early (i.e. by mid-September).

The daylength sensitive cultivars best adapted to monocropping are KN-1, TVx 3236, and TVx 1999-10F. 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 sprayings (the first at 50% flower bud 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 spraying may be required if aphids attack before flower bud formation.

Daylength insensitive cowpeas respond positively to single or triple superphosphate fertilizers (25-50 kg/ha of P_2O_5/ha). We have not obtained a yield response to the local low solubility phosphatic rock fertilizer (Burkina phosphate), even at rates of 100-200 kg/ha of P_2O_5. Studies on the residual effects of phosphate fertilizers 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_2O_5/ha 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 yields.

b) Mixed cropping.

There was a difference in competitive ability related to sorghum P nutrition among cowpea cultivars intercropped with sorghum, when both crops were planted simultaneously. The proper choice of cowpea cultivars intercropped with sorghum cv. 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.

Maize-cowpea relay cropping systems have been developed. Daylength sensitive cowpeas should be planted under maize in mid-July, approximately 1 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 day), less leafy, high yielding maize cultivars such as SAFITA-2 are better adapted to relay cropping than are 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 have been repeatedly observed during the past 5 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.

6.5.2.2 Sudan Savanna.

a) Management of pure stand cowpeas.

Date of planting, plant population, protection against insect pests, and phosphatic fertilizer levels (excluding Burkina phosphate which is currently under investigation) follow the same management practices as those previously discussed for the Northern Guinea Savanna.

The cowpea cultivars best adapted to the Sudan Savanna are TVx 3236 and Kaokin Local.

Soil tillage, tied ridges and in situ mulch from natural fallow or crop residues reduce rainwater runoff 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 property, mulch may reduce soil temperatures and minimize soil water evaporation. It also increases biological activity and the action of burrowing by termites and earthworms, which improves 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 or other domestic uses has a detrimental effect on soil productivity. This refers to soil physical as well as chemical properties.

Striga gesnerioides can cause total yield loss in heavily infested fields. The use of resistant (i.e. SUVITA-2 or 58-57) or tolerant (TN 88-63) cultivars is recommended under these conditions. In moderately infested fields, the elimination of Striga before it flowers may reduce yield losses and Striga infestations during 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 yield loss of both crops may occur in sorghum-cowpea intercropping, whereas in pure stand cropping, some cowpea yield may still be obtained. In maize-cowpea relay cropping systems, a total cowpea loss may occur if the month of September is dry.

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 best adapted cultivars are SUVITA-2, TN-88-63, TVx 3236, 58-57 and Mougne.

b) Mixed cropping. Millet-cowpea intercropping studies are underway.

6.6 COWPEA ENTOMOLOGY

6.6.1 Objectives.

a) Identify major insect pests and assess associated yield losses of cowpeas in the SAT of West Africa.

b) Identify and evaluate chemical insecticides for pest suppression, taking into consideration availability, safety and cost.

c) Determine the critical plant growth stages at which protection from insect damage is necessary.

d) Develop and test integrated pest management systems which are economically viable, environmentally safe and agronomically acceptable for increased and stable cowpea production.

6.6.2 Research results.

The major field pests of cowpeas are aphids, thrips, Maruca and Hemipteran pod bugs; while the principal storage pest is the cowpea seed weevil (Callosobruchus maculatus, Bruchidae).

The Pyrethroids, Decamethrin (Decis) and Cypermethrin (Cymbush) at 12-15g a.i./ha in combination with Dimethoate (a systemic organophosphate) at 400-500g a.i./ha are effective against the above insect pest spectrum. These insecticides are available at reasonable cost and are less toxic than Monocrotophos, Carbaryl, Endosulfan, etc.

The reproductive phase in cowpea (flower bud initiation and podding) is the most vulnerable growth stage for insect pest damage. Two treatments (Decis or Cymbush + Dimethoate or Endosulfan at 30-35 and 45-55 DAP) are recommended for minimum protection against insect pests. In the event of an early aphid infestation (2 to 3 weeks after planting), one application of Dimethoate is effective. The use of aphid resistant varieties is the best long term solution.

Aphids infest cowpeas at all growth stages: seedling, pre-flowering, flowering and post-flowering. Our studies showed that aphid resistance at the seedling stage is not always maintained throughout later stages of development. Thus it is important that evaluation for aphid resistance be repeated at the reproductive phase, notably at raceme or floral bud production.

Discovery of a third aphid biotype (biotype K) in Burkina (Biotypes A and B were found in Nigeria). Sources of resistance to all three biotypes were identified in IITA/Ibadan lines TVu 36, TVu 2896, and TVu 3000, and are being used as sources of resistance in the Cowpea Breeding Program.

Low to moderate levels of resistance were confirmed for flower thrips in TVu 1509, TVu 2780 and TVx 3236; and for the pod borer Maruca testulalis in TVu 946 and Local Kamboinse. As is true for both aphids and storage weevils, the mechanism of resistance is antibiosis.

Economic thresholds for flower thrips on cowpeas were determined by manipulating the density of thrips at varying concentrations of the insecticide Monocrotophos. A strong favorable crop response (increased flower and grain production) was obtained at low thrips density levels.

When cowpeas and sorghum were intercropped, minimum insecticide protection (two treatments at floral budding and podding) and the use of a thrips resistant variety (TVx 3236) ensured cowpea yields of at least 500 kg/ha. Intercropping alone was ineffective in reducing population levels of thrips or Maruca, while pod bugs were adequately suppressed. Results were complicated by inconsistancies in yield due to drought.

An analysis of local market grain samples revealed that storage losses caused by the cowpea seed weevil were in the range of 9 to 40%. Samples from farmers' stores indicated much higher losses. Pod infestations and grain damage increased from 47% and 16% in January, to over 90% and 50% in September, respectively.

6.7 SOIL-WATER MANAGEMENT

The IITA/SAFGRAD Soil Water Management Program was initiated in May, 1985.

6.7.1 Objectives

The program's primary objective is optimization of the available soil and water resources in the African SAT through appropriate soil and crop management systems.

6.7.2 Research results.

Most of the research in 1985 was concentrated at the Kamboinse research station and on-farm trials in the Sudan Savanna. Initial results have emphasized the need for more in-depth studies of the soil-root-plant system, particularly with respect to the sub-soils of the West African Savanna. A soil water management laboratory and staff training program were established in 1985.

The practice of tied ridging has resulted in striking yield increases. Quantitative verification was made in 1985 of previous qualitative observations attributing yield increases to an increase in water storage. It was evident, however,that maximal use was not being made of the increase in water storage which occurred with tied ridging. For example, although the increase in water storage due to tied ridging in the surface 0.75 m of soil profile was on the order of 30 mm 48 DAP, only 50% of this increase was potentially available to the crop. This was due to shallow root growth caused by high soil compaction. High subsoil bulk density (about 1.65 Mg m^{-3}) is a characteristic feature of Savanna soils in the West African tropics.

When maize was intercropped with a foreage (i.e. Stylosanthes hamata var. verano, a deeper rooting pattern occurred with the intercropped than the monocropped maize. As a result, the depth of water extraction was greater with the intercrop. Yields were similar in both instances, however.

Another approach toward increasing porosity and improving root extension and proliferation in the subsoil is through the use of crop rotations, where deep-rooted crops are followed by shallow rooted-crops. The latter crop is thought to utilize the root pores created by the former crop to extend its root system into the sub-soil. Cotton has shown the ability to extend its root system into the sub-soil in on-going maize cotton association trials of the Maize Agronomy Program. There was no evidence from a newly established maize-pigeonpea alleycrop that pigeonpea had a deeper rooting system than maize. Nonetheless, survival over the dry season suggests that this may have indeed occurred. Further investigations will be carried out this season.

Although on-station trials have emphasized the use of tied ridges, co-operative trials with the socio-economics program of ICRISAT have studied other methods of water conservation. "Digettes", or low rock barriers (20-30 cm high) constructed on the contours of the land are known to trap water and reduce runoff. The effects of digettes and their possible interaction with tied ridges on soil water storage were studied at two researcher-managed locations in Burkina. Neither location indicated a beneficial effect of digettes on soil water storage except immediately adjacent to the digette, although plant growth was observed to improve. At one location, overall water storage was increased by tied ridging.

7. REGIONAL ACTIVITIES

7.1 REGIONAL TESTING

7.1.1 Maize Breeding

7.1.1.1 Objectives

a) Provide elite maize germplasm to research workers in the African SAT for testing and use in their national programs.

b) Provide national scientists an opportunity to have their elite materials systematically evaluated over a wide range of environments.

c) Develop varieties possessing tolerance to problems in semi-arid areas for wider adaptation and stability.

e) Evaluate regional variation in diseases and insect pests of maize.

d) Enhance the exchange of germplasm between national programs.

7.1.1.2 Results

Two Regional Uniform Variety Trials (RUVT), one early (RUVT-1) and one intermediate (RUVT-2) have been prepared and coordinated by IITA/SAFGRAD. The different RUVT entries were nominated by national programs, the IITA/SAFGRAD resident program, and other international organizations (CIMMYT-IITA). In addition, the program also prepared and coordinated four different Regional Family Testing Trials (RFTT) from 1980-1982. The RFTT's are composed of families generated by the IITA/SAFGRAD Population Improvement Program of early and intermediate maturity populations. From 1979 to 1985, 192 sets of RUVT-1, 171 sets of RUVT-2 and 23 sets of RFTT were sent to national programs of SAFGRAD member countries as is shown below.

Distribution of regional trials by the IITA/SAFGRAD Maize Breeding Program.

Year		RFTT'S	RUVT-1	RUVT-2
1979	Sets	-	10	9
	Countries	-	10	9
1980	Sets	12	23	24
	Countries	4	14	13
1981	Sets	8	25	22
	Countries	4	17	17
1982	Sets	3	20	18
	Countries	3	20	18
1983	Sets	-	50	35
	Countries	-	24	24
1984	Sets	-	27	26
	Countries	-	17	15
1985	Sets	-	37	37
	Countries	-	18	16

A total of 44 varieties have been tested in RUVT-1 and 42 varieties in RUVT-2. Six national programs have been participating in the nomination of varieties for these trials (Burkina Faso, Senegal, Ivory Coast, Ghana, Tanzania and Togo). Based on reports presented at the last SAFGRAD/EEC Maize and Cowpea Workshop (Cotonou, 16-20 September, 1985), the following national programs are using varieties tested in RUVT's:

Togo: TZPB (IITA/Ibadan) was tested in RUVT-2 and is going to on-farm testing.

Ghana: SAFITA-2, developed by the IITA/SAFGRAD resident program from Pool 16 (CIMMYT germplasm) has already been released, and breeder seed was provided to the Ghana Seed Company. This variety serves the need for an early maturing white dent for the Guinea Savanna and Coastal Volta Regions. TZESR-W (IITA/ Ibadan) is included in the National Variety Trial for further evaluation.

Mali: SAFITA-2 (IITA/SAFGRAD) and TZE-4 (IITA/ Ibadan; further improved by IITA/SAFGRAD) are in the process of release. Golden Crystal and Composite C4 (Ghana) are in multi-location testing for possible release. TZPB, TZSR-Y-1 (IITA / Ibadan), SAFITA-2 and SAFITA-104 (IITA/SAFGRAD) are being used by the National Maize Breeding Program.

Burkina Faso: SAFITA-2 is used in a top cross program by IBRAZ/IRAT at Farako-Bâ. SAFITA-2 has been proposed for release in Burkina, having been found very promising by SAFGRAD's cowpea agronomist for relay cropping with cowpeas in the Northern Guinea Savanna.

Benin: Synthetic C (Senegal) will be tested in farmers' fields next year (1986).

Cameroon: SAFITA-2 and Elite x Mexican Composite (Ghana) are in the process of release.

7.1.2 Maize Agronomy

7.1.2.1 Objectives

The IITA/SAFGRAD Maize Agronomy Program first proposed regional trials in 1982 with the following general objectives:

a) To test at a regional level those cultural practices which have been proven successful in Burkina or other SAFGRAD member countries.

b) To evaluate the regional importance of other soil and crop management practices.

7.1.2.2 Results.

Regional Maize Agronomy Trials (REMAT) were proposed in 1982. Such trials were requested by the following countries, to which experimental plans and field books were sent.

a) REMAT-1 (Tied ridges trial): Ghana (1 set); Mali (3 sets).

b) REMAT-2 (Legume-maize rotation trial): Gambia (1 set); Somalia (1 set).

c) REMAT-3 (Nitrogen and phosphorus response and residual fertilizer effect trial): (1 set); Guinea (1 set).

Experiments conducted in Mali at Katibougou and Tietiguila (Sudan Savanna) on ferruginous tropical soils (red, red-brown, and leached) showed very significant maize yield responses to tied ridges, similar to those obtained in Burkina (Kamboinse). The yield response to tied ridges was present even without any fertilizer application at Katibougou, but only when fertilizer was applied at Tietiguila.

On fallowed soil at Nyankpala in the Northern Guinea Savanna of Ghana, there was no significant yield difference between the control and any treatment using tied ridges. Additionally, an experiment evaluating the response to N, P, and K showed that phosphorus was a greater yield limiting factor than nitrogen. No response to potassium was observed. Linear yield responses were found up to 120 and 75 kg/ha of N and P_2O_5, respectively (maximum rates used in the trial).

The response to N, P, and K was also evaluated at Bordo-Kankan, Guinea. Since the mean annual rainfall at this location is 1700 mm, it is considered semi-arid and results will not be presented here.

After 1982, only Gambia, Mali and Ghana reconducted regional trials. For reasons that will be discussed later, the maize agronomist was unable to fully analyze available results and encourage more extensive national program participation.

7.1.3 Maize Entomology

7.1.3.1 Objectives.

To stimulate collaboration and information exchange with national programs, thereby generating interest in entomology and crop protection research.

7.1.3.2 Results.

A regional trial on the survey of maize arthropod pests was conducted in 1981 and 1982.

In 1981, two maize varieties, TZE-4 and a local check were grown for observation at two planting dates in Gambia, Mali, Senegal and Burkina Faso. Results indicated that an early planting (two weeks before normal planting date) sustained higher borer damage (Gambia), higher aphid infestation (Mali, Burkina) and severe millipede attack (Senegal, Burkina). Maize planted at the normal planting time was infested by shootfly and armyworms (S. littoralis) (Senegal) and stem borers (Burkina Faso).

The trial was repeated in 1982 in Burkina, Gambia and Senegal using SAFITA-2 and local check varieties. Millipede injury was severe (80%) on the early crop in Senegal, but mild in Burkina and Gambia. Termite damage was heavier in Burkina (Kamboinse) on the second planting date. Termite incidence in Senegal was low. Armyworm attack was higher for the second planting at Kamboinse (var. SAFITA-2) but low in Senegal at both planting dates. Stem borer incidence was higher on a later planted local variety in Gambia (Yundum) compared to mild attacks in Burkina and Senegal. Low aphid and shootfly infestations occurred in Burkina (Kamboinse) and Gambia (Sapu, Yundum).

These results indicate that the principal pests of maize were termites and armyworms in Burkina, stem borers in Gambia and millipedes in Senegal.

7.1.4 Cowpea Breeding.

7.1.4. Objectives.

The first regional variety trials were sent to SAFGRAD member countries in 1980. Initially, there was only one trial. In 1983, regional trials were subdivided to include a) varieties suitable for dry areas and b) varieties resistant to Striga.

7.1.4.2 Results.

a) Regional Cowpea Trial for Drought (RCTD).

Among the varieties in the 1980-82 regional cowpea trials contributed by national, regional and international programs, SUVITA-2, TN 88-63 and 58-57 were the most promising at the drier sites, while KN-1 and TVx 1999-01F were best in wetter areas. TVx 3236 was found to be well adapted across all environments. Some of these varieties have either been released or are in the process of release in several of the SAFGRAD member countries. For example KN-1 has been released in Burkina, 58-57 in Senegal and TN 88-63 in Niger. SUVITA-2 and TVx 3236 will soon be released in Burkina Faso and Mali. Since 1983, new drought resistant cultivars (i.e. KVx 30-305-3G, KVx 470-3G) have been identified which in addition to high stable yields also possess rough, large white seeds preferred by people in semi-arid areas.

b) Regional Cowpea Striga Trial (RCST).

The first trial was planted at seven locations in four countries (Nigeria, Niger, Burkina Faso and Mali) in 1983. It contained 12 entries, 7 of which were promising F_5 selections identified at Kamboinse in 1981 from SUVITA-2 and TVu 2027 progeny. Two lines (TVx 30-166-3G and TVx 30-183-3G) were identified as most promising across all locations.

TVx 30-403-1G performed particularly well in Nigeria at Kano and Bakura. One kg of breeder's seed was supplied to the cowpea breeder at the Institute of Agricultural Research (IAR) in Samaru, Nigeria for multiplication and additional testing. The trial was repeated in 1984 using 12 varieties, three of which were checks (SUVITA-2, Mougne and Local). KVx 30-166-3G and KVx 30-183-3G were among the nine best varieties; the remaining 7 were new selections from SUIVITA-2, KVx 3236 and KN-1. The trial was sent to six locations in the same four countries. Three varieties, TVx 100-2, KVx 100-1 (SUVITA-2 x KN-1) and KVx 61-2 (SUVITA-2 x TVx 3236) were found to be promising. In 1985, a similar trial consisting of 15 entries was sent to 10 locations in 5 different countries.

7.1.5 Cowpea Agronomy.

Maize-cowpea relay cropping is being or has been tested in the following countries: Mali (1981, 1983); Senegal (1983); Gambia (1983, 1984, 1985); Ghana 1983, 1984); Togo (1983, 1984, 1985); Nigeria (1984, 1985); Cameroon (1985); and Benin (1985).

Cowpea management trials are being or have been tested in the following countries: Mali (1984, 1985); Senegal (1983); Gambia (1985); Benin (1985); and Cameroon (1985).

Maize-cowpea relay cropping is now in pre-extention testing stages in Burkina Faso (O.R.D. de Hauts Bassins) and Mali.

7.1.6 Cowpea Entomology.

7.1.6.1 Objectives

To foster collaboration and exchange of information with national programs and generate interest in entomology and crop protection research. Two entomology regional trials were conducted to this effect.

7.1.6.2 Results.

a) Standardized sampling procedures trial (1980-82).

Following the SAFGRAD Entomology Workshop (IITA/Ibadan, 1981) this study used uniform sampling techniques to determine the phenology, seasonal and geographical distribution of major cowpea insect pests in the African SAT. The objective was to develop management thresholds (economic thresholds, economic injury levels) and formulate appropriate IPM strategies for their suppression. Trials were sent to Benin, Burkina, Cameroon, Gambia, Ghana, Guinea (Conakry), Kenya, Mali, Mauritania, Senegal and Togo.

◊ Aphids, Maruca, thrips and Hemipteran pod bugs were important field pests in these countries. However, intensity varied with location and season. Other pests included leaf and flower feeding beetles and the storage weevil. This trial has been discontinued since 1983 due to logistical problems. However, the sampling techniques have been incorporated into pest survey and yield loss assessments as well as other resident research programs.

b) Minimum Insecticide Protection Trial.

In Burkina, Cameroon, and Senegal, thrips development on resistant and local varieties was assessed under a minimum protection scheme of two treatments of Decis (12-15g a.i./ha) at 35 and 50 DAP.

◊ In Burkina, Benin, Gambia, Ghana, Cameroon, Niger, Nigeria, Ethiopia, Kenya and Togo, thrips and Maruca populations were suppressed by minimum protection. Grain yields were 1-2 T/ha higher on resistant (TVu 1509, TVx 3236, TVu 2893) vs. local or susceptible varieties (VITA-4, VITA-5, VITA-7, ER-7). Local checks plus nine elite entries contributed by national programs and IITA/Ibadan were evaluated under minimum protection. One treatment consisted of Decis (15g a.i./ha) at 30-35 DAP and the second of Endosulfan (400g a.i./ha) at 45-55 DAP.

◊ Thrips, Maruca and pod bug populations were adequately suppressed on most varieties. Thrips populations were invariably lower on resistant varieties (TVx 3236) when compared to local or susceptible cultivars (Local Kamboinse, Mougne, KN-1). In general, local varieties produced higher grain yields (1 to 2 tons/ha) in their natural environments when compared with other entries. Across locations, local checks TN 88-63, TVx 1999, IAR 48 and SUVITA-2 produced yields of over 1 ton/ha; followed by TVx 3236, Mougne and KN-1 at 900-1000 kg/ha. Yields of IT82E-60 and Bambey-21 were moderate (600-800 kg/ha). Since there were no new entries from the national programs in 1985, the trial was modified to assess the performances of 4 varieties: IT82E-60 (early); TVx 3236 (medium maturity, thrips resistant); IT82D-716 (medium maturity, bruchid resistant); and a local check (late) at three dates of planting under minimum protection. Treatments consisted of two applications of Decis (12g a.i./ha) + Dimethoate (400g a.i./ha) at 30-35 and 40-45 DAP. Gambia, Ghana, Burkina, Benin, Ethiopia, Niger and Togo requested the trial, but results are not yet available.

7.2 ANNUAL WORKSHOPS

The first SAFGRAD Maize Workshop took place in Burkina (Ouagadougou) in 1979. In each of the following years, Annual Maize and Cowpea Workshops have been organized by IITA/SAFGRAD and the OAU/STRC Coordination Office. Starting in 1984, the annual workshop was held jointly between SAFGRAD and the IITA/EEC (European Economic Community) High Yielding Varieties Technology Project.

The annual workshop permits an evaluation of progress being made by national maize and cowpea programs, IITA/SAFGRAD and other participating institutions (EEC Project). It also plans for future research activities. In particular, the workshop serves as a very efficient tool in presenting and discussing results of the previous season, and in making arrangements for regional testing programs during the following season. If the workshop is held near March, as is usually the case, it provides national programs the opportunity to nominate their own entries for regional testing while at the same time give seed of the nominated entries to the IITA/SAFGRAD team which is responsible for assembling and dispatching regional trials.

The annual workshop promotes an exchange of information and a sense of friendship and common purpose among national scientists and SAFGRAD researchers. Thus, a major accomplishment of the IITA/SAFGRAD project has been the breaking of barriers between anglophone and francophone countries. As a result of these workshops and the annual monitoring tours (See Sec. 7.3), most of the leading maize and cowpea researchers in the African SAT have been able to interact more closely with eachother.

Funding allocated for the annual workshop limited participation to only two national scientists from each SAFGRAD member country; one for maize and another for cowpeas. This prevented a balanced representation of all the disciplines concerned. As a result,there has been an over-representation of plant breeders and not enough participation on behalf of agronomists, plant protection specialists, and other disciplines. To correct this problem, a study is underway to determine how to restructure the annual workshops. Details about the annual workshops are given below.

Year	Date	Location	Representation	
			Participants	Countries
1979:	February 20-23	Ouagadougou	42	20
1980:	February 12-15	Ouagadougou	63	19
1981:	February 23-27	IITA,Ibadan	46	20
1982:	February 28-March 2	Ouagadougou	47	15
1983:	April 25-27	Ouagadougou	55	19
1984:	March 5-9	IITA,Ibadan	70	26
1985:	September 16-20	Cotonou	80	20

7.3 MONITORING TOURS

Monitoring tours have been organized yearly by IITA/SAFGRAD since 1979. Excluding 1979 when there was a maize but no cowpea tour, separate maize and cowpea monitoring tours have taken place since 1980. Under the coordination of IITA/SAFGRAD scientists, monitoring tours are conducted during the growing season, bringing together national scientists from up to 6 countries (per crop) to visit national maize or cowpea programs in as many as 6 countries. Scientists from CIMMYT and IITA/Ibadan are also invited. The monitoring tours promote interaction among national programs in west, east and south African countries.

During monitoring tours, the relative performance of entries and/or management practices included in the regional testing are evaluated, as well as the performance of any other maize, cowpea or agronomic trial. In addition, the monitoring tours give both national scientists and IITA/SAFGRAD staff a unique opportunity to learn about the problems limiting maize and cowpea production in the SAT - be it edaphic, climatic, biotic, or management related.

The following lists provide details relevant to monitoring tours.

Maize Monitoring Tours

Year:	Countries visited	Number of Participants	
		SAFGRAD Countries	IITA/SAFGRAD & IITA/CIMMYT
1979 (Sept.)	Senegal, Mali, Burkina, Ivory Coast, Ghana, Benin	3 (Burkina, Mali Senegal)	3
1980 (Sept.)	Senegal, Burkina, Benin, Ghana, Cameroon	3 (Senegal, Ghana, Cameroon)	2
1981 (Sept.)	Senegal, Gambia, Mali, Burkina, Togo,	5 (Senegal, Mali, Burkina, Togo, Tanzania)	1
1982 (Sept.)	Senegal, Burkina, Ghana, Nigeria, Guinea-Bissau	5 (Ghana, C.A. Rep., Ethiopia, Somalia, Zimbabwe)	4
1983 (Feb.)	Botswana, Zimbabwe, Zambia, Kenya, Somalia, Ethiopia	3 (Nigeria, Senegal Benin)	2
1984 (Sept.)	Burkina, Nigeria, Ghana, Mali, Cameroon, Senegal	5 (Burkina, Nigeria, Ghana, Mali)	2
1985 (Sept.)	Guinea, Senegal, Burkina, Nigeria	---	2

Cowpea Monitoring Tours

Year:	Countries visited	Number of Participants	
		SAFGRAD Countries	IITA/SAFGRAD & IITA/CIMMYT
1980 Sept.)	Burkina, Niger, Benin, Nigeria, Cameroon	5 (Burkina, Benin, Niger, Nigeria, Botswana)	3
1981 (Sept.)	Senegal, Burkina, Gambia, Mali	5 (Burkina, Mali, Senegal, Somalia, Gambia)	3
1982 (Sept.)	Ghana, Burkina, Niger, Nigeria	3 (Burkina, Ethiopia, C.A. Republic)	3
1983 (Feb.)	Botswana, Zimbabwe, Zambia, Kenya, Somalia, Ethiopia	3 (Gambia, Burkina, Nigeria)	3
1984 (Sept.)	Benin, Burkina, Mali, Senegal	2 (Benin, Mali)	3
1985 (August)	Nigeria, Cameroon, C.A. Rep. Niger, Burkina	3 (Ghana, Nigeria)	3

7.4 VISITS TO NATIONAL PROGRAMS

In addition to the monitoring tours, IITA/SAFGRAD scientists have paid at least 25 visits to national programs in the following countries: Niger, Benin, Mali, Senegal, Gambia, Guinea, Nigeria, Togo, Ivory Coast, Ghana, Guinea-Bissau, and Mauritania.

8. TRAINING

8.1 IN-SERVICE TRAINING

Every year national researchers and technicians from SAFGRAD member countries come to Burkina (Kamboinse) for in-service training in one or more disciplines of their choice. Participants in this training program work closely with project scientists during the growing season for a period of 3 to 7 months in both field and laboratory activities.

The total number of trainees per discipline is given below.

Discipline	Number of trainees	Countries
Maize Breeding	4	Mali, Guinea, Burkina, Somalia
Maize Agronomy	4	Gambia, Guinea, Guinea-Bissau.
Maize Entomology	1	Burkina.
Cowpea Breeding	8	Zambia, Guinea, Mali, Botswana, Benin, Burkina.
Cowpea Agronomy	3	Gambia, Chad, Botswana.
Cowpea Entomology	11	Senegal, Gambia, Burkina, Guinea, Botswana.
Total	31	

8.2 DEGREE-RELATED TRAINING

Students working toward a B.S. degree ("Ingénieur Agronome") can do their research work (thesis) under the guidance of IITA/SAFGRAD scientists. To date, a total of nine students from the University of Ouagadougou and the Katibougou Polytechnic Rural Institute (Mali) have done, or are presently completing their research under IITA/SAFGRAD. Student breakdown by disciplines is as follows: Maize Breeding, 2; Maize Agronomy, 1; Cowpea Breeding, 1; Cowpea Agronomy,4; Cowpea Entomology, 1. These students have come from the following countries: Burkina, Chad, Zaire, and the Central African Republic. In addition, two students did part of their Ph.D. thesis research at IITA/SAFGRAD: one in Cowpea Entomology (from Niger) and the other in Soil Fertility (from Burkina).

8.3 OTHER TRAINING

At the request of the National Seed Service in Ouagadougou, and with the help of the Training Office at IITA/Ibadan, IITA/SAFGRAD conducted a maize and cowpea production training course at Kamboinse from March 15 to April 9, 1982. Five trainees from Benin and 15 from Burkina participated in the training course.

8.4 TRAINING COURSES AT IITA, IBADAN

IITA organizes production courses for both researchers and extension agents of national programs. The following SAFGRAD member countries have participated in training courses at IITA/Ibadan: Burkina, Mali, Senegal, Sierra Leone, Guinea and Togo. Under IITA/SAFGRAD funding, a total of 17 Africans have been trained via such production courses. In addition, two research trainees (one in a one month farming systems program and the other in a two month agricultural documentation program) were funded. Three SAFGRAD technicians attended a three week course in weed control at Ibadan in March, 1986.

9. PROBLEMS AND DIFFICULTIES ENCOUNTERED IN ACHIEVING OBJECTIVES.

9.1 RESIDENT RESEARCH

a) Inadequate technical and administrative support staff. Most of the projects' technicians do not even have a secondary education and few have formal training in agriculture. As a result, project scientists must spend a considerable amount of time supervising simple field and laboratory activities. More adequate budget provisions would allow the hiring of more qualified technicians, researchers, and administrative support staff.

b) Land limitations.

The initial agreement between SAFGRAD and the host government took into consideration only land requirements at the Kamboinse and Saria research stations. Considering the land limitations at Kamboinse, the distance to Saria and the lack of project facilities at the latter, IITA/SAFGRAD has been forced to look for land at other sites in the Sudan Savanna (Loumbila, Gampela), with logistic consequences that would be expected to follow. Necessary expansion of the research to cover the Sahel and Northern Guinea Savannas has further complicated logistics as the project has to negociate land allocations every year and operate at locations where it has not developed proper research facilities.

c) Lack of land with irrigation facilities.

Although the host government agreed to provide four hectares of irrigated land at Kamboinse, irrigation facilities are such that water is not available throughout the dry season. Moreover, IITA/SAFGRAD requires more than four hectares of irrigated land for its dry season work. This explains the projects' need to have obtained 12 hectares of irrigated land at Loumbila. Unfortunately, most of the land allocated to IITA/SAFGRAD at Loumbila was retired from the project in 1984. On the other hand, problems of limited water supply at Loumbila never permitted the irrigation of more than three hectares. IITA/SAFGRAD needs about 10 hectares of land with good irrigation facilities in order to properly carry out its research objectives.

d) Deficiencies in physical facilities.

◊ None of the sites/stations where the project operates are fenced. As a result, problems with thieves or animals entering the fields are a constant threat. This increases operation costs and makes the conduction of certain trials involving crop residues and mulch cropping with perennial legumes difficult.

◊ A general shortage of storage space for project property, with particular regard to fertilizers and pesticides (including a pesticide handling facility) exists.

◊ Inadequate cold room facilities.

◊ Insufficient work space: laboratories, offices and sheds.

e) Lack of all the necessary equipment for field and laboratory work in both Agronomy and Soil and Water Management.

f) Lack of a library at the Kamboinse station.

g) Budget limitations are a constraint to emphasizing research in soil fertility and plant nutrition.

9.2 REGIONAL ACTIVITIES

a) Resident research was conducted only in Burkina Faso, where conditions are representative of those prevalent in the West African SAT. As a result IITA/ SAFGRAD has more to offer West Africa in terms of varietal and technological development than to east and south African countries.

b) Heavy demands of the resident research program in Burkina conflict with the demands of regional activities. Thus, the IITA/SAFGRAD staff was unable to visit all of the national programs and interact more frequently with them on regional trial evaluation and information exchange. In some cases (i.e. Maize Agronomy Program), proper consideration for data analysis could not be provided.

c) Weaknesses in some national programs in terms of either qualified manpower or research supplies prevented the gathering of some data or resulted in data that was highly variable or unreliable.

d) Visa problems were often encountered by IITA/SAFGRAD staff visiting some SAFGRAD member countries.

e) Seed collection of varieties nominated by national programs presented a major difficulty due to quarantine regulations when the Annual Maize and Cowpea Workshop was held at IITA/Ibadan, or when the workshop was not held before the growing season began.

f) Late dispatch of regional trial results by some national programs prevented timely data analysis and their inclusion in annual reports.

9.3 GENERAL

a) The administrative and coordinating responsibilities of the Chief of Party or Project Leader cannot be properly executed if he/she has, in addition, the technical responsibilities of carrying out resident research and regional programs. It is not possible to do a good job on both fronts. A full-time Project Leader with no direct research responsibilities should be appointed for SAFGRAD Phase II.

b) The quality of in-service training at Kamboinse needs to be improved. There is a need for more office space, training materials (library, training manuals etc.) and transportation facilities.

10. RECOMMENDATIONS FOR FUTURE RESEARCH EFFORTS

10.1 MAIZE BREEDING

a) Continue work already initiated to improve drought resistance in maize. This major objective targets the Sudan Savanna Zone.

b) Development of extra-early maize varieties. Breeding work will continue on development of varieties maturing in less than 82 days which are adapted to the Sudan Savanna Zone.

c) Continue screening maize genotypes for resistance to termites, with the eventual development of methodologies for increasing termite resistance in maize (in collaboration with the Entomology and Agronomy Programs).

10.2 MAIZE AGRONOMY

a) Evaluation of the medium and long-term effects of both traditional and improved management practices on soil physical and chemical properties.

b) Testing and development of cropping systems involving legumes which could lead to a reduction in the need for chemical nitrogen fertilizers.

c) Evaluation of cropping systems involving associations with maize and non-leguminous crops which would result in more efficient utilization of available resources, reduced risk, and/or better soil conservation practices.

d) Continue the evaluation of genotype x management interactions, with emphasis on aspects of soil fertility and drought stress.

e) Continue development and testing of implements used for making tied ridges with animal traction.

f) Refine recommendations developed to date for maize production in the SAT.

g) Establish the proper management practices for growing new improved varieties in the SAT of West Africa.

10.3 MAIZE ENTOMOLOGY

a) Continue screening for maize resistance to termites (See sec. 10.1-c).

b) Evaluate insecticides for pest control in maize which are less costly and less dangerous than Furadan.

c) Investigate losses caused by maize storage pests.

d) Determine the role of natural enemies in maize pest suppression.

10.4 COWPEA BREEDING

No new research topics are envisioned for the future. Work on drought and Striga resistance needs to be strengthened. Facilities at Pobé (storage and office space, land, equipment, etc.) need to be improved for continued research on drought tolerance. Similarly, more land is required for Striga research at Kamboinse.

Collaboration with the Weed Research Organization (WRO) and Birbeck College (London). There are some aspects of research in determining cowpea resistance to Striga which require specialized laboratory techniques, such as an understanding of the physiological mechanisms of resistance itself. Such research cannot be carried out at Kamboinse or IITA/Ibadan. WRO and Birbeck College have shown interest in such an undertaking. The following collaborative studies are planned to further strengthen our knowledge of the mechanisms of cowpea resistance to Striga.

a) Determination of the resistance of cowpea varieties SUVITA-2 and 58-57 to a wide collection of S. gesnerioides biotypes available at WRO.

b) Determination of the range in genetic diversity of Striga by iso-enzyme analyses.

c) Determination of the mechanisms of resistance in SUVITA-2 and 58-57.

d) Evaluation of the wide range of herbicides available at WRO for their selectivity against Striga in cowpeas.

10.5 COWPEA AGRONOMY

10.5.1 Northern Guinea and Sudan Savanna.

a) Management of monocrop cowpeas.

◊ The seasonal and residual effects of N, P, Ca, and lime applications will be initiated.

◊ Studies on the residual effects of soluble and phosphatic rock fertilizers in crop rotations (i.e. cowpea, maize, sorghum, millet) will be continued.

◊ In situ mulch and crop residue management studies.

b) Mixed cropping.

◊ Sorghum-soybeans intercropping.

◊ Row spacing, plant density and dates of planting for cowpeas in sorghum-cowpea intercropping systems.

◊ Effect of mixed cropping systems on soil productivity.

10.5.2 Sahel Savanna

◊ Studies similar to those mentioned above will be carried out, except that millet will replace sorghum in cowpea intercropping. Maize-cowpea relay cropping studies will not be conducted.

◊ Evaluation of cowpeas for drought and high heat tolerance under rain-fed conditions.

◊ Effect of windbreaks on cowpea performance.

10.6 COWPEA ENTOMOLOGY

a) Studies on control of early cowpea pests (aphids and thrips) and cowpea storage pests (bruchids). Emphasis will be on pest identification, breeding for resistance, and control by selective insecticides.

b) Evaluation of the role of natural enemies (parasites, predators, and pathogens) on cowpea pests.

10.7 SOIL WATER MANAGEMENT

Development of management systems which result in root extension and proliferation in the subsoil have been given a high priority in IITA/SAFGRADs' Soil Water Management Program. It is felt that a long-term solution may be achieved only by appropriate manipulation of crop rotations and cropping systems. Mechanical manipulation of the soil with this objective in mind has met with little long-term success in the past.

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Aggarwal, V.D., and S.D. Haley. Breeding for drought and Striga resistance in cowpea. 21 p.

Aggarwal, V.D., and S.D. Haley. Varietal evaluation of cowpea to determine characters associated with adaptation to dry areas in Africa. 9 p.

Diallo, A.O., et M. Rodriguez. Comportement et sélection de certains genotypes de maïs dans des conditions naturelles de sècheresse. 34 p.

Muleba, N. Rainfall characteristics at selected sites in Burkina Faso. 14 p.

Muleba, N. Responses of cowpea to high soil temperature and drought. 30 p.

Rodriguez, M. Agronomic practices for reducing drought stress and improving maize grain yield in the Semi-Arid Tropics of West Africa. 29 p.

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