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REPUBLIC OF CAMEROON
MINISTRY OF HIGHER EDUCATION, COMPUTER SERVICES AND SCIENTIFIC RESEARCH
(MESIRES)
INSTITUTE OF AGRICULTURAL RESEARCH
(IRA)

National Cereals Research and Extension Project (NCRE)

Annual Report 1991

United States Agency for International Development
(USAID)
Institute of Agricultural Research
(IRA)
International Institute of Tropical Agriculture
(IITA)

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The team is particularly indebted to the Director of IRA, Dr. Jacob Ayuk-Takem, for his valuable professional guidance, able leadership, constant understanding, patience and intellectual stimulation. His counsel and suggestions have been invaluable.

Equally important has been the support received from all IRA Chiefs of Centers, Stations and Substations and from the scientific administrative and support staff. In particular we would like to acknowledge the important contribution of the national counterparts and technicians who have provided invaluable advice to the technical assistants. Some of the national counterparts and technicians have already taken over the role of the technical assistants. We expect that all of them will carry on the work started by this project. Without their cooperation and receptiveness this project could not have been a success.

The collaborative effort of ICRISAT with regard to the project's sorghum unit is greatly appreciated. The assistance received from CIMMYT and IRRI is also greatly appreciated. We would also like to acknowledge SAFGRAD, MIDEVIV, MIDENO, SODECOTON, WARDA, SODERIM, UNVDA SEMRY and the staff of the Karewa Experimental Farm.

We are thankful to IITA for its administrative and technical support and for its encouragement.

We would also like to express our deepest gratitude to the Government of the United States of America through its Agency for International Development (USAID) whose financial assistance has made this project possible. We cannot talk about the NCRE project and USAID-Cameroon without mentioning the dedication and support of Mission Director Mr. Jay Johnson and his close collaborators. To these people and to the entire USAID-Cameroon Mission we are deeply indebted.

Perhaps the greatest contributions to the success of the NCRE Project have come from the farmers of Cameroon. Without their cooperation and receptiveness, this project could not have been successful. To them we say thank you.

EXECUTIVE SUMMARY

Administration

The NCRE III contract was signed and put into action. A contract was signed with Winrock International for Long Term Training and purchasing. The activities of NCRE Project Administration centered around the arrival and installation of eight new staff. All completed project housing was occupied by staff and the Nkolbisson office/laboratory building was occupied. Six national counterparts left for degree training and six others returned from successful degree training in the USA to resume duties. Peace Corps Volunteers started doing Agroforestry work in collaboration with the NCRE staff in Northwest Province.

Highland Maize Breeding

Maize sown in 1991 at six locations, in the Adamaoua, West and Northwest Provinces include variety and hybrid trials, nurseries for population improvement and inbred line development, and isolated plots of breeder's seed. Synthetic-4 which was in its first year in the variety testing program had a four location mean yield of 117% of the widely grown control variety Coca. From our hybrid program 11 inbred lines were sent to the recently established Pioneer Agrogenetique Cameroun S.A. for further testing and potential use in commercial hybrids. We also took an important step toward the screening of breeding lines for maize streak virus resistance with the construction of two screenhouses and the initiation of artificial rearing of Cicadulina, the insect vector of the virus.

Lowland Maize Breeding

The Lowland Maize Breeding program performed a total of 243 trials in four agro-ecological zones. Almost 37 ha of lands was used in 16 locations. The program concentrated on evaluation of varieties, population improvement, line development, hybrid and synthetic veriety development and multiplication and maintenance of seed, one of the areas of study was evaluation of varieties in striga infested plots.

Rice Breeding Maroua

The 1991 cropping season was successfully conducted with two trials on breeding and two others on Agronomy. All the trials were harvested and data analyzed. Two top varieties gave promising results and can be grown alongside IR 46. They are ITA 212 and ITA 222. The best fertilizer combination should take into account all the elements (NPK) plus organic matter to improve the response of rice to fertilizer in SEMRY area.

Cereals Agronomy

During 1991, the researchers of this Unit participated in 7 national and international scientific meetings and workshops. Both counterparts (Mr. NGOUMOU and Mr. EBETE) left for graduate studies in USA. We organized 6 training field days for farmers and extension agents on maize and cowpea production and utilization, and conservation farming technologies. We also prepared 4 fiches techniques on maize and 3 scientific papers. A set of 18 on-farm experiments were conducted in 1991 in the sub-humid lowland savanna of North Cameroon. Research showed that a minimum tillage system could produce good maize yields if appropriate fertilization is used. Study conducted with multipurpose legume crops identified 4 legume species as very promising for improving sustainability of the cropping systems in the region. Research on Striga management confirm the value of Crotalaria, cowpea and cotton as trap crops as well as intercropping with legume, urea and organic by-products to alleviate Striga damage on maize and sorghum in the subhumid lowland savanna.

Sorghum Breeding

During the 1991 cropping season, the sorghum unit designed and implemented about 23 different experiments, tested over 250 new sorghum introductions and advanced over 300 crosses in different generations (F1 to F6). In general the results show that many accessions were selected based upon yield potential, resistance/tolerance to various pests and stress factors.

The evaluation of local germplasm helped identify some agronomically elite lines which may be used as parent in the crossing program. Approximately, twenty exotic lines were selected. These exotic lines performed significantly better than the check. They will be advanced to the preliminary yield trials for further testing and increase.

The multilocation variety yield trials tested approximately 30 to 40 lines over six locations in the sorghum grown region of the North Cameroon. Some lines were identified in each zone as being very promising in respect to yield potential, and yield stability. Early maturing varieties did yield better across locations, but some were attacked by grain mold and birds. Most of the late maturing varieties could not complete their cycle.

Pearl millet trials tested about 40 exotic lines and 10 local entries. Most introductions performed significantly better than the local varieties. The results suggested that further screening should be made within pearl millet local germplasm to identify agronomically elite lines. The seed of IKMV-201 an ICRISAT introduction was multiplied for further testing.

Bambui TLU

A survey of farmers maize stores, initiated in 1990, was completed in 1991. Potential quantitative losses in the mid-altitude zone (Ndop: 1200 m) were assessed at between 0.1 and 35% (mean=7%). Assessed qualitative losses ranged from 2% to 64% (mean=23%) damaged grains (by weight) in the last storage period (August). The average value of storage losses to the Ndop Plain farmer storing 2.5 tons of maize (shelled equivalent) was estimated at 15% (23,000 CFA).

New varieties tested included ATP, SYNTHETIC-3, EARLY WHITE and MSR (2nd season trial). Fertilizer was applied at a low level (100 kg 20-10-10) and most management decisions left to the farmer. The maize was intercropped with soybeans. In the 1st season, the new varieties outyielded the farmers' local varieties by : mean 0.5 t/ha (24%), but did not outyield the released varieties. With the exception of Early White, farmers assessed the new varieties as being superior to their local varieties. Specific characteristics of the new varieties (e.g., yellow color and flinty grains for the ATP variety) were of special interest to subsets of farmers, demonstrating the differences in preferred maize characteristics among farmers in the area. In the 2nd season trial, no new varieties yielded more than the local variety.

New high altitude maize varieties were tested on-farm for the third year in the Eastern Highlands of the NWP. After 2 years of promising results for the HAP variety; results that gave the TLU reason to hope that the 1st improved high altitude maize variety would be released in 1993; HAP performed poorly in 1991, yielding no better than the local variety. Most farmers ranked their local variety first in overall performance. A new maize disease in the area, Phaeasophora leaf spot, widely attacked all varieties in the trial, including the local.

The new mid-altitude maize varieties (ATP, SYNTHETIC POOL 3 and EARLY WHITE) performed well under bean and soybean intercrop, but were not significantly better than the LOCAL variety.

"Ankara" land preparation system (i.e., burying crop and weed residues and burning them under the soil) effectively neutralized up to 1.28 meq/100 g of exchangeable Al in the soil.

A rapid assessment of soil fertility status of the Western Highlands showed that exchangeable K was the strongest single factor influencing maize yields in the mid-altitude zone. In the high-altitude zone a complex interaction of Ca with other nutrients including Mg and P is a major factor influencing maize yield. The frequency of very strongly acid soils (pH < 5.0) is low in both zones.

Ekona TLU

Two major contrasts in 1991 provided a glimpse into the future of TLU, Ekona. The contrasts were (a) an absence of any Technical Assistant during the first half of 1991 following the departure of two long-term TLU Technical Assistant and (b) the near collapse of our working relationship with MINAGRI's village site extension staff following a withdrawal of cash incentives.

The National counterparts effectively managed the program as attested by the 1991 Midterm Report of activities, the current one being simply updated to include the second half of 1991. In response to the problems of village extension staff, Ekona TLU has not only received a commitment from Southwest delegation of agriculture to work with TLU, Ekona, but it has also been given direct access to village staff with whom it will mutually execute farm level projects in an institutionalized manner.

The effective use of Marshall ST 25 for egusi melon control and low dosage of Furadan for second season maize stem borer control have been convincingly demonstrated to farmers in South West Province but these products remain unavailable to them. Contrary to some breeders' and extensionists' assertions that 8017 and 8034 cassava can be eaten boiled, our findings show that they are unacceptable in that form to all the communities studied in 1991. Nitrogen derived from coppiced one year old fallows of leucaena and gliricidia were estimated at 105 and 75 kg/ha, respectively - enough to satisfy maize N requirements of 300 to 400 kg of 20-10-10.

In socioeconomic research, achievements in 1991 include the holding of focus village meetings with farmers in February and the convening of an annual workshop with over 80 participants from IRA, MINAGRI, Development projects staff and farmers in March. Farmers' mixed cropping system was found to have low individual plant populations and crop yields in the farmers' system but higher land and income equivalent ratios. A retention study by IRA maize minikit users revealed farmers' high appreciation for IRA maize. Consequently, 80% of the users kept seed to plant in a future season.

Maroua TLU

Two compound maize varieties, CM8704 and DMR ESRY, are ready for extension. Sorghum seed treatment with thioral along with Peanut varieties M416 and K3237-80, while not highest yielding, have certain grain characteristics (color, size, and taste) which are highly appreciated by farmers. All 28 widely dispersed tests were visited by IRA peanut researchers. One more year is needed in regional trials before advancement to minikit tests. A local sorghum variety "Gueling" purified by IRA/NCRE breeding performed very well in regional tests.

At the research village level, sorghum cowpea association gave LERs greater than 1.1 for the third straight year and a high marginal rate of return. Plowing increased sorghum grain yield in 14 farmer-managed tests in the four representative TLU villages.

Cowpea storage tests, conducted in collaboration with the Bean Cowpea CRSP were attended by hundreds of farmers and dozens of MINAGRI extension agents. One set of trials (sorghum and peanut) was visited by hundreds of farmers and filmed by CRTV. MINAGRI agents also attended several training sessions presented or coordinated by the Maroua TLU.

Impact of previous research on and extension of sorghum will be possible thanks to a survey of adoption of varieties in general and of S-35 in particular, published in 1991. Agricultural practices were closely followed in four representative villages for the third straight year providing important base line data. Other surveys initiated in 1991 include one on storage practices and another on forest/soil/fallow management.

Parasitic Striga weed and water availability were the focus of research which included cover crop screening for protection and study of water use by potential agroforestry species.

Nkolbisson TLU

A number of on-farm alley cropping with Calliandra are ready for cropping in 1992. Planted fallows with Mimosa and Sesbania were effective in suppressing weed growth and yielding high fixed nitrogen into the production system.

Improved cassava, maize and sweet potato varieties have consistently out performed local varieties for the last three years. These findings are being verified through collaborative regional on-farm testing in the Central and South Provinces.

Herbicide application appears to be profitable for farmers facing labor constraints. Marshall seed treatment is more effective in the transition than in the forest zone, since borer infestation occurs two weeks earlier in the transition than in the forest zone.

Economic Analysis

The Economics Analysis Unit (EAU) was not created until September. However, due to a planned overlap with the Nkolbisson TLU work plan, some EAU activities were started during the first half of the year. These included collaboration on two pilot research benefit-cost studies, statistical analysis for research targeting, and design of a nationwide resource management survey. During the final four months, main activities of the unit were: (a) data analysis related to technology retention and diffusion, (b) work on the resource management survey, (c) preparation and presentation of three papers, and (d) initiation of a Directorate support role in IRA's new Research, Development and Computers Division (DIRVA). Key activities postponed until 1992 are an IRA-wide priority setting study and finalization of research budgeting guidelines. On balance, the Economics Analysis Unit has made a promising start and the need for such a unit in IRA seems to be well-established.

Soil Agroforestry

Soils of the operational zone of the NCRE Project in North West Cameroon have been grouped into two classes A and B based on elevation, exchangeable cations, pH, phosphorus fixation and Al and Fe oxides. Preliminary results shows: a) good growth of Tephrosia and crotalaria in Babungo (1178m), b) good growth of Crotalaria and poor performance of Tephrosia at Mfonta (1200m), c) good growth of Tephrosia and poor performance of Crotalaria at Mbiyeh (2100m) and d) good growth of both species during season 1, March to August at Befang (600m) but poor performance of Tephrosia in season 2, September. Canavalia, Cajanus, Crotalaria, Dolichos, were suitable for Befang; Dolichos, Canavalia and Mucuna for Mfonta and Lupin pea for Mbiyeh. Calliandra and Leucaena show much promise for agroforestry. About 3t/ha starter manure is necessary to facilitate establishment of the species on impoverished soils. Nurseries have been established.

Grain Legumes

The main objectives of the 1991 cropping season have been: identification of high yielding and adapted varieties resistant to virus, striga, having good seed quality and potentials for both grain and fodder; evaluation of germplasm and varietal development; evaluation of lines under low insecticide treatment; and varietal purification.

To achieve these objectives appropriate trials have been conducted at Guiring Station, Maroua on cowpea (varietal trials, testing of local and introduced materials, crossing of selected entries, selection of best entries). Field and post harvest data have been collected on the materials and statistically analyzed.

The results of the analysis show that:

- High yielding varieties exist (grain upto 2400 kg/ha has been obtained)
- Dual purpose varieties exist (lines with both good grain and fodder yield have been identified).

- Virus resistant lines under natural infestation have been identified (several lines with zero or mild virus infestation have been observed).
- Varieties with good seed quality (big and white seed) have been identified.
- Varieties with good yield potentials have been identified under no insecticide application.

It should be noted that during the 1991 season, insect pressure was not too high at Guiring. Heavy infestation of Aphids has been observed early in the season but disappeared after heavy rains which were frequent this year. The low insect pressure may explain the non response of insecticide treatment and the good performance of many lines under zero insecticide treatment.

Plant Pathology

Ten experiments were planned by the Plant Pathology Section for the 1991 cropping season in few locations. Most of them were a continuation of experiments started on or before 1990. Rusts, blight, rots, antrachnose, phaeosphalria leaf spot were our main diseases. Maize and sorghum were our main crops. Few tolerant varieties Kasai, Coca, CMS 8501, CMS 8701 were resistant to the maize disease while Barlang, CS316, SC418 were our best resistant sorghum varieties.

Epidemiological studies on phaeosphaeria leaf spot (PLS) showed that the disease developed slower on EC573 than with any of our elite genotypes.

Two grasses were infected by rust fungi. Both causal agents were Puccinia sp; however, they were different from Puccinia polysora, the causal agent of lowland rust. More investigation is needed.

HighLand Cereals Entomology

The efficacy of one of the new stored grain insecticide (SOFAGRAIN) was tested on maize under two major storage methods (shelled grain and maize on cobs) and it was discovered that while untreated maize stores better on the cob, more protection is obtained with treated shelled grain than with treated maize cobs.

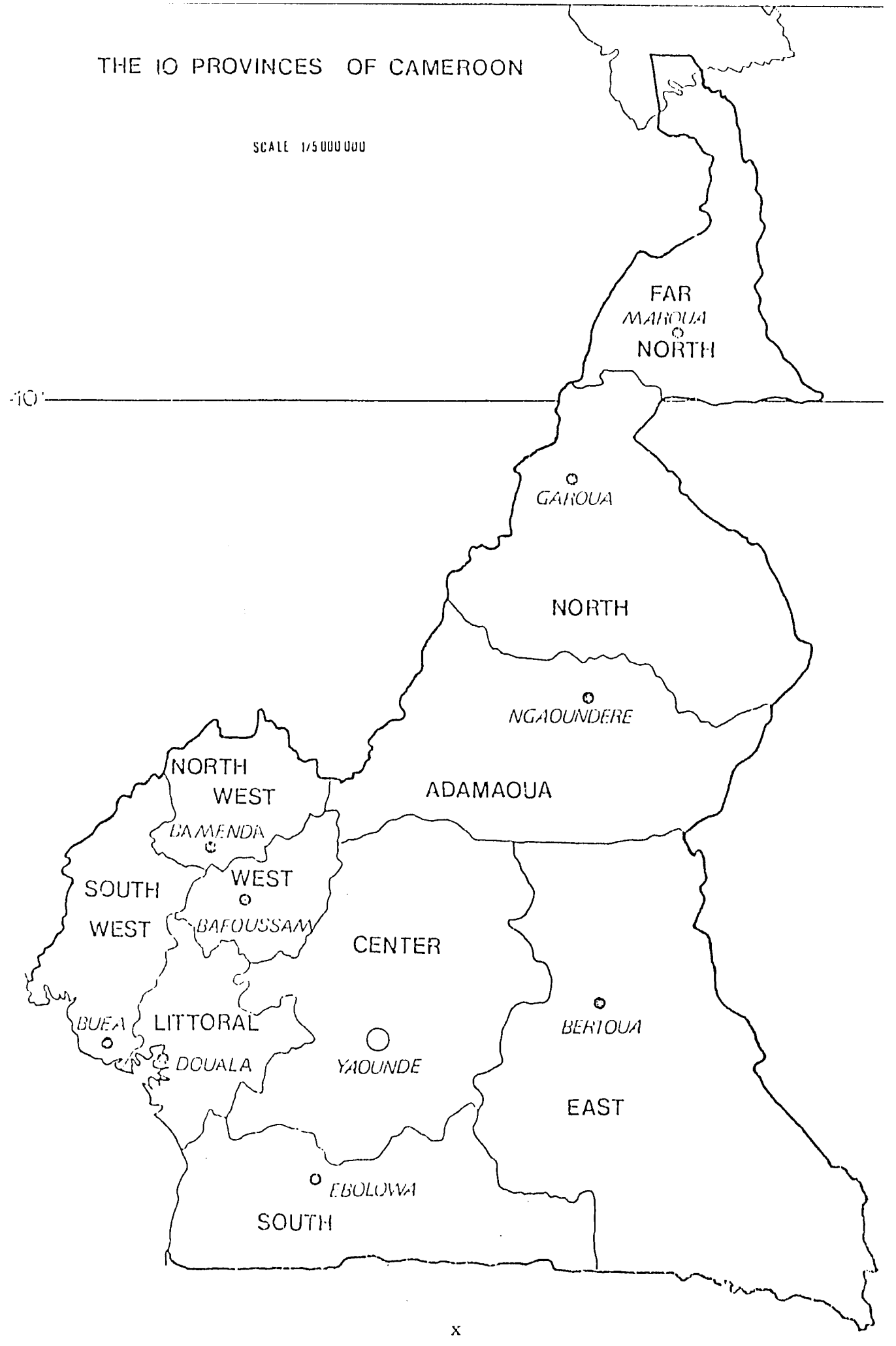
After confirming that hermetic storage of low moisture maize of about 12% in small plastic cans is effective in maintaining grain quality for over 12 months, further experiments were set up using bigger plastic containers and maize of varying moisture contents.

The experiment to identify sources of stored maize insect pest resistance in some 20 maize varieties grown and stored in three sites was terminated but screening of breeders' materials will continue. Farmers' questionnaires on the use of natural plant material materials for stored grain protection was finalized and the study will be identified next year.

Lowland Cereals Entomology

Both on-station and on-farm maize borer monitoring and chemical control trials have given more insight into the importance of borer to maize production in 3 agro-ecologies represented in the lowland forest. The on-farm trials showed 47% marketable fresh ear weight reduction due to borer attack in the forest zone.

Sesamia spp, Eldana saccharina and Musidia nigrivenella were the most abundant borer in all the locations sampled. Chilo spp was encountered early season at Ntui (transition zone) and at harvest in Mbalmayo (humid zone). Marshall seed treatment is more appropriate for borer control in the transition zone while carbofuran is recommended for the forest zone.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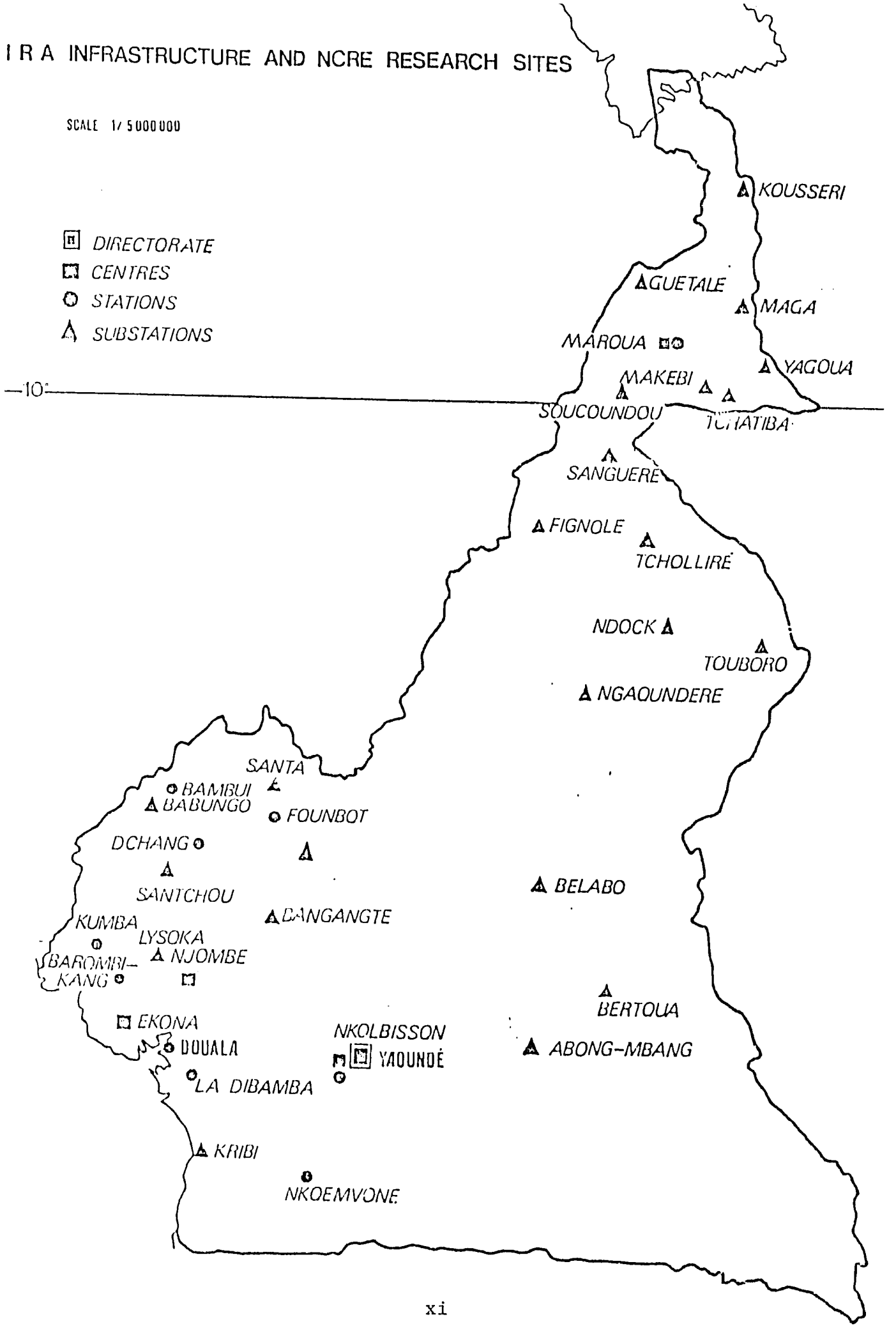
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NJOMBE
BAROMBI-KANG
BERTOUA
EKONA
NKOLBISSON
DOUALA
YAOUNDÉ
ABONG-MBANG
LA DIBAMBA
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DISTRIBUTION MAP
THE MAIN CEREAL PRODUCING AREAS IN CAMEROON

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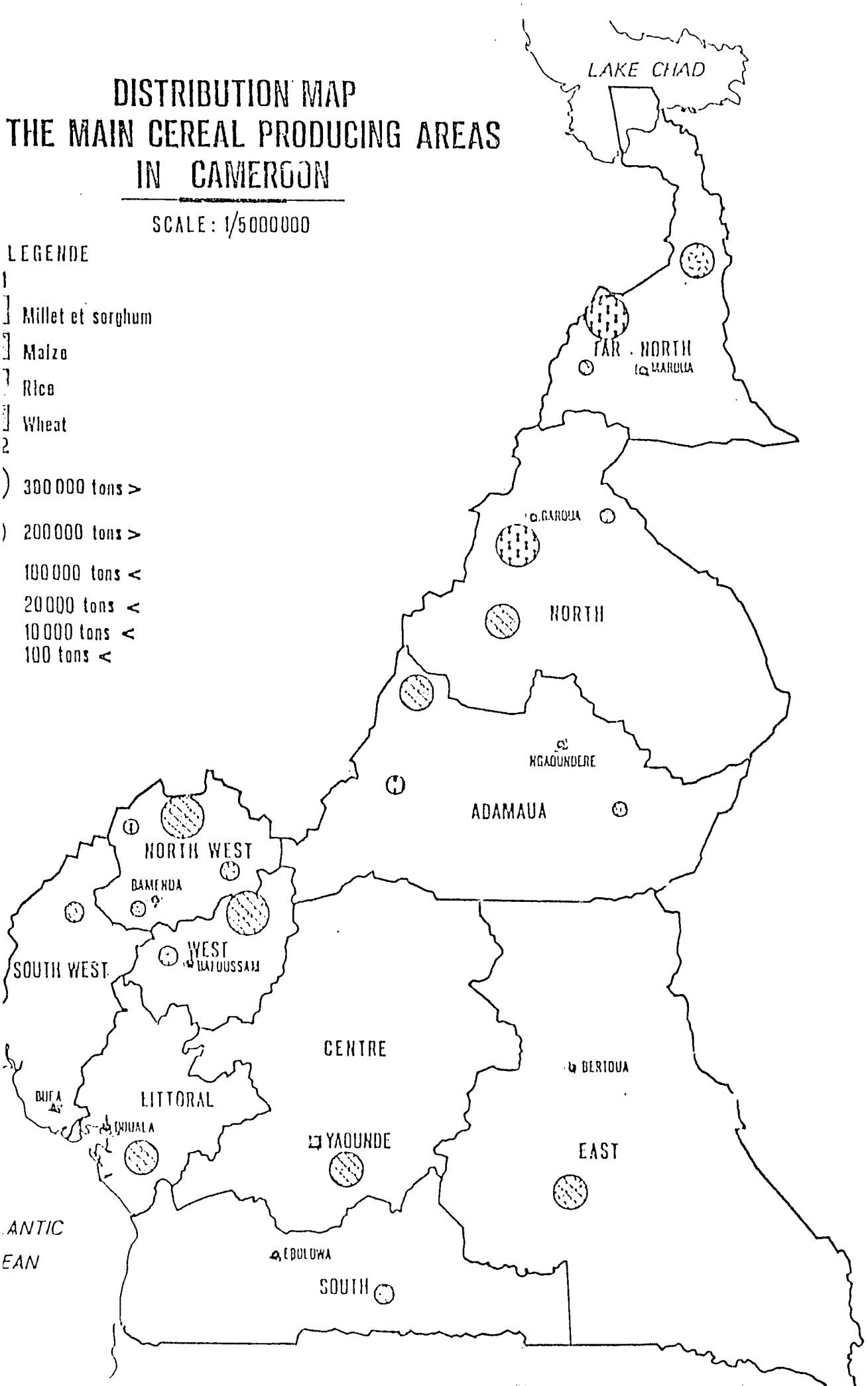

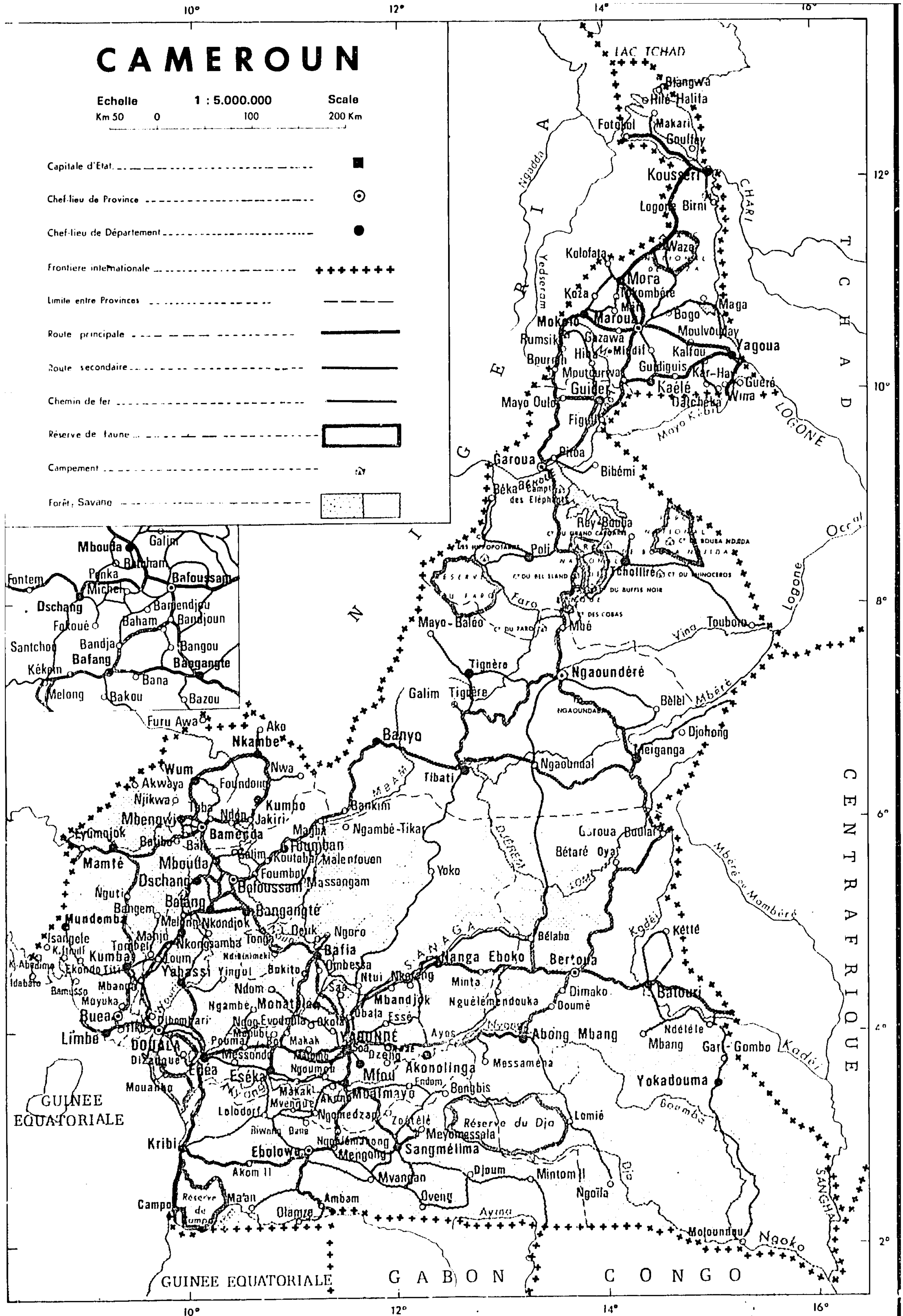

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1. ADMINISTRATION

1.1 INTRODUCTION

The NCRE Administration is responsible for all administrative coordination of the project. Primary activities are centered at Nkolbisson. Administrative staff at each NCRE location are supervised by the NCRE coordinator at that location.

The overall goal of project administration is to assist researchers in their achievement of project goals and objectives. The administration also maintains liaison among the sponsoring organizations; IRA, IITA and USAID. The project administration consists of the Chief of Party, Deputy Chief of Party and Administrative Officer. The Chief of Party is in charge of overall project coordination and staff productivity. The Deputy Chief of Party coordinates publications, counterpart training, and reports. The Administrative Officer is in charge of daily details of accounting, inventory and local staff supervision.

During the first 10 years of NCRE the administration concentrated on addition of programs and streamlining administrative procedures for an increasing number of technical staff. During the period 1991-1994 emphasis is placed on phasing out of expatriate staff and takeover of existing programs by IRA national researchers and administration.

1.2 SUMMARY OF PROGRAM ACTIVITIES

During this period administration has been concerned with the arrival and installation of new staff. Most have occupied USAID constructed housing at their respective locations. New staff arriving during this time were:

Dr. N. Beninati	Maize Breeder	Maize Breeding Bambui
Dr. R. Carsky	Systems Agronomist	TLU Maroua
Dr. J. Detongnon	Legume Specialist	Grain Legumes Maroua
Dr. H. Ezumah	Systems Agronomist	TLU Ekona
Dr. M. Moussie	Agricultural Economist	TLU Nkolbisson
Dr. O. Osiname	Systems Agronomist	TLU Bambui
Dr. C. Yamoah	Agroforester	Soils/Agroforestry Bambui
Mr. G. Servant	Administrative Officer	Nkolbisson

During 1991 the Chief of Party accompanied the ARDO (USAID/Yaounde) and the USAID Project Officer to visit all staff locations on two separate occasions.

All IRA national counterparts selected for degree training completed intensive English language training, TOEFL and GRE testing needed for university admission. A total of six were accepted for degree programs and left to start their training. Seven others were accepted and will start classes in 1992. Dr. Julius Takow, Dr. Edward Ngong-Nassah, Mr. Pascal Ngninbeyie, Mr. Celicard Zonkeng, Mr. Andre Djonnewa and Mr. Martin Nguegnim returned from successful degree programs in the USA and are now working in the cereals program of IRA. Three other IRA staff continued their studies in the US.

A contract was signed with Winrock International to handle graduate training and purchasing of project equipment and supplies. Purchase orders were sent to Winrock for bids. Several shipments of air freight were received during September and December.

Details were settled to coordinate the activities and technical support of Peace Corps volunteers associated with TLU Agroforestry research in the Northwest Province. Volunteers arrived and are living in villages in the TLU target zones and are supported by TLU staff in technical matters.

The first meeting of the Project Implementation Committee was held in Yaounde. It was chaired by the NCRE COP and was attended by representatives of MESIRES, IITA and USAID. Two cereals program staff meetings were held in Yaounde. These were attended by IRA cereals staff, NCRE Staff, IITA administrative staff and USAID representatives. They discussed the effect of the national political situation on NCRE activities as well as plans for the coming year. In general the political unrest caused some reduction in productivity but most planned work was accomplished.

The project expense reporting system was decentralized and administrative personnel at each location were trained in the use of the accounting software. Job descriptions for administrative personnel were reviewed and rewritten.

Staff housing was completed at Nkolbisson (2 units), Ekona (2 units), Bambui (2 units) and Maroua (3 units) and occupied by expatriate and national staff. An office-laboratory complex was completed and occupied at Nkolbisson and construction started on the office-laboratory building at Ekona. A seed storage facility was completed at Maroua.

There was active collaboration with other development agencies such as CAPP Project, ROTREP Project, Bean-Cowpeas CRSP, "Projet Garoua", CIRAD, University Center at Dschang, IITA Humid Forest Station and IRZ at Nkolbisson.

The year ended with a short awards ceremony for NCRE Nkolbisson employees who had completed 5 and 10 years service with the project. Safe driving awards were also given to those drivers who had completed 1991 without accidents.

1.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Planning and supervision of project performance.		
1.1 Publish reports of work to be done and work accomplished.	1.1 Publish Annual Work Plans, Semi-Annual Progress Reports and Annual Reports.	1.1 Annual work plan, 4 year work plan, semi-annual progress reports published.
1.2 Review work in progress	1.2 Regular field visits and meetings with counterparts.	1.2 COP visited all location with AID project officer.
1.3 Review work in progress with IRA and USAID officials	1.3 Present reports and regular field visits.	1.3 Numerous regular consultations. Meeting of Project Implementation Committee held in October.
1.4 Plan project actions involving IRA officials.	1.4 Daily consultation.	1.4 Constant daily meetings.
1.5 Consult with IITA and Winrock staff.	1.5 At least bi-monthly or yearly meetings. Arrange consultant visits.	1.5 COP met with IITA staff and DCOP with Winrock staff.
Operation 2: IRA Counterpart Training		
2.1 Determine short term training needs and plans.	2.1 Arrange IITA visits and course participation by counterparts	2.1 Five NCRE counterparts received short term training at IITA and ICIPE.
2.2 Determine long term training needs and plans.	2.2 Arrange in-country preparation for degree training. Liaise with Winrock and counterparts during university degree training.	2.2 Twelve persons completed English training, TOEFL and GRE testing. Six counterparts departed for studies and five returned from studies in USA. Seven more accepted to start studies in 1992.

Objectives	Activities	Accomplishments
Operation 3: Financial and Materials management.		
3.1 Researchers have adequate funds for research	3.1 All imprest accounts have sufficient cash on hand.	3.1 All accounts have maintained a cash surplus.
3.2 Expenditure of project funds properly documented.	3.2 Monthly expense reports filed as required.	3.2 Monthly expense reports filed with Ibadan within 30 days.
3.3 Needed equipment is ordered and received.	3.3 Purchase orders prepared and equipment distributed.	3.3 Purchase orders sent to Winrock and first shipments received and distributed.
3.4 Equipment use is properly documented.	3.4 Inventory and use records kept up to date.	3.4 Regular maintenance of inventory records.
Operation 4: Publication of results		
4.1 Publications available for researchers and farmers.	4.1 Farmer information leaflets and research bulletins available.	4.1 English and French versions of CICA 8 printed and ready for distribution.

1.4 VISITORS

During 1991 a total of 45 official visitors were received at the Nkolbisson offices. These included the Director General of IITA, Dr. L. Brader. Various representatives of national research organizations also visited during this period.

2.1 HIGHLAND MAIZE BREEDING

2.1.1 INTRODUCTION

The Highland Maize Breeding Unit is responsible for the development of varieties adapted to improved and current farming systems between 1000 and 2500 meters altitude. The target zones are found in the Northwest, West and Adamaoua Provinces and include a large range of soil types and farm sizes. The Western Highland, comprising the North West and West Provinces, cover less than 10% of the land area in Cameroon, but contains 25% of the population, and produces over 60% of the national maize crop.

The goal of the unit is to further develop a comprehensive breeding program which will continuously provide seed of new varieties to the seed multiplication and distribution organizations, well past 1994. Past work by this unit has emphasized the development of a germplasm base, which has been improved to the point of producing open-pollinated, hybrid and synthetic varieties. After confirmation by TLU, the best of these varieties will be available for foundation seed production.

While the unit has, in recent years, put an emphasis on selecting inbred lines for hybrids, we will gradually return the emphasis to population improvement. The proposed installation of a maize streak virus screening facility means an emphasis will be placed on developing virus resistant germplasm.

The rapid spread of varieties in farmer fields depends,in large part, on the ability of the seed production system to provide sufficient quantities of good quality seed, and of the extension system to disseminate the seed and the appropriate information on its use. The success of hybrids in Cameroon is likely, in the next four years, to depend on the success of the private seed industry in the country. The success of the streak screening nursery will depend on the ability of national scientists to learn the necessary techniques and to manage the facilities. Guidance for this will be provided by the TA with technical backstopping provided by IITA.

2.1.2 SUMMARY OF ACTIVITIES

Substantial advances were made in each of the three major components of the breeding program in 1991. Synthetic-4 which was in its first year in the variety testing program had a four location mean yield of 117% of the widely grown control variety Coca. From our hybrid program 11 inbred lines were sent to the recently established Pioneer Agrogenetique Cameroon S.A for further testing and potential use in commercial hybrids. Thirdly, our germplasm improvement program took an important step toward the screening of breeding lines for maize streak virus resistance with the construction of two screenhouses and the initiation of artificial rearing of Cicadulina, the insect vector of the virus.

Due to the arrival of the new TA breeder in the unit in late February, and the departure of the senior counterpart for Ph.D. studies in September, no major changes in the direction of the program were attempted this year. However, a reduction in the number of locations and plot sizes used for trials was necessitated by budget cuts and difficulties in obtaining sufficient labor.

Population improvement continued in three introduced source populations which serve as sources of inbred lines for hybrids and synthetic varieties. Two released varieties were converted to streak virus resistance by recombination of resistant lines that had been sent to IITA for screening. Promising new inbred lines for hybrid and synthetic formation were identified from multilocational test cross trials and others were under development through selfing and selection in the nurseries. Small programs to obtain locally adapted sweet corn and popcorn were continued.

Seven varieties were grown in isolated plots, breeder seed was selected, and selected bulks were obtained for foundation seed production and use by other researchers. We also collaborated with the seed multiplication program at Bambui station in the production of hundreds of kilograms of each of four released varieties.

Other activities included the sowing of trials for collaborators, the results of which will be obtained from the collaborators after their analyses. These include IITA international hybrid, inbred, and progeny testing trials; Pioneer International hybrid trials; and a joint study with IITA of the cyclic improvement of the Cameroonian open-pollinated populations. In addition to carrying out the latter study, the former NCRE TA breeder sowed most of our hybrid and variety trials in the mid-altitudes of Nigeria. Finally, although it was unsuccessful due to a severe disease infection, we provided an irrigated field and technical assistance to the Pioneer company to pilot test hybrid production of two of its highland inbreds.

2.1.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Develop Germplasm		
1.1. Improve source populations.	1.1 Progeny testing, screening and intermating.	1.1 Coca and Kasai inbreds screened for streak resistance at IITA and recombined at Nfonta. Selfing and line selection in populations EMSR, A_4, B_4, 43SR, 32 and 32xA_4.
1.2. Select inbreds for hybrids and synthetics.	1.2. Inbreed, testcross and select lines for hybrids or recombination.	1.2 27 inbreds selected from testcross trial results and sown in off-season nursery for preliminary hybrid formation.

Objectives	Activities	Accomplishments
Operation 2: Test varieties and hybrids		
2.1. Select best hybrids and inbreds for eventual release.	2.1. Preliminary and advanced hybrid trial at several locations.	2.1 Best inbreds from Advanced Hybrid Trials released to Pioneer Seed Company. Best hybrids selected from Preliminary trials now in off-season nursery for advanced trials in 1992. Best inbreds from hybrid trials in nursery for formation of synthetics.
2.2. Identify new varieties for eventual release.	2.2. Compare new varieties with old in multilocational national and international trials.	2.2 Synthetic 4 showing promise and proposed for on-farm testing.
Operation 3: Maintain breeder seed		
3.1. Grow breeder seed for purity and improvement.	3.1 Ear-to-row selection in open-pollinated varieties and selfing of inbreds.	3.1 Coca, ATP, Bacoa, Early White, Synthetic 4, HAP and Shaba advanced by ear-to-row selection.
3.2. Monitor foundation seed production.	3.2 Visit isolations, provide logistical assistance and advise.	3.2 Hundreds of kilograms of Kasai, Coca, Ekona White and Ekona Yellow produced.
3.3. Provide seed for collaborators.	3.3. Included in 3.1 and 3.2	3.3 see 3.1.1 and 3.2.1 Two hybrids under production in off-season nursery for testing by TLU.

2.1.4 RESEARCH FINDINGS

2.1.4. Germplasm Development

Population 32, Population 43 SR and EMSR were grown in 1991 to be improved as sources of new inbred lines for varietal and hybrid formation. 515 S_1 lines, 382 S_2 lines and 254 S_1 lines were selected from Population 32, Population 43 SR and EMSR, respectively. While these source populations possess important characteristics (e.g. good plant type and flinty white grain for Population 32, and earliness for EMSR) on which future progress can be based, budgetary constraints will limit the effort that can be made in their improvement.

Progress was made toward the testing of Maize Streak Virus resistant versions of the varieties Coca and Kasai with a first recombination of streak resistant lines made at Nfonta. Sixty-one and 186 streak resistant lines of Coca and Kasai, respectively, were obtained after screening at Ibadan and were intermated during the 1991 main season. A second recombination is being carried out in the off-season nursery at Foumbot.

New inbreds for synthetic and hybrid formation were identified in test cross trials and new and advanced inbreds were advanced and selected in the Foumbot and Nfonta nurseries. Twenty seven inbreds were selected from two test cross trials, sown in single row plots at Foumbot and Nfonta. From these and older inbreds, 298 preliminary hybrids are being produced in the off-season nursery for testing in 1992. Selfing was done in crosses involving the reciprocal source synthetics and East African introductions with segregating lines from S_1 to S_6 being advanced in the nurseries at Foumbot and Nfonta. At Foumbot, 549 S_2 lines were advanced to S_3, 12 S_3 lines were advanced to S_4, and 98 lines at S_5 or greater were advanced one generation. At Nfonta single crosses from Synthetic A_4 and Synthetic B_4 were selfed and 174 S_2 lines were selected. A small program in sweet corn conversion to mid altitude adaptation continued. MSR-sh, a very sweet type with poor germination, is undergoing a germination test of selected lines in the 1991 dry season. The MSR-su type has good germination but is less sweet. 200 lines of MSR-su were selfed and selected for minimum grain starch content, and subsequent selfing and recombination should improve the grain quality.

A small program of conversion of U.S. popcorn to mid altitude adaptation was advanced, with 10 lines and sister lines selected. A full diallel trial was carried out at Foumbot in 1991 to evaluate specific combining ability, and a second evaluation will be made in 1992.

2.1.4. Variety and Hybrid Testing

National Variety Trials (NVT) for 1991 included the Mid Altitude Early and Late, each sown at Foumbot (1000m), Nfonta (1300m), Babungo (1100m), Tibati (1000m) and Mbang Mbirni (1100m), and the High Altitude trial sown at Mbiyeh (2000m) and Upper farm (2000m). Plots for all trials consisted of 4, 5m rows with 80 cm between rows and 25 cm between plants. The central rows were harvested for yield samples. Two seed were sown per hill with thinning to 1 plant per hill.

The NVT Early was initiated in 1990 to test the earliness, yield and adaptation of Early White and Early MSR in comparison with the released varieties Bacoa and Kasai. In 1991, five sites were sown, but the location of the trial on poor soils at Tibati and Mbang Mbirni permitted analysis of data from only Foumbot, Nfonta and Babungo (Tables 1 and 2). Early White gave the best results ranking 1st, 2nd and 2nd for yield at Foumbot, Nfonta and Babungo, respectively. Its yields were significantly ($P < 0.05$) higher than those of Bacoa at Foumbot and Babungo. In addition, the mean days to silk indicate that Early White is six days earlier to flower than Bacoa and Kasai. Plant and grain characteristics of Early White are also good, especially a mean plant height of 221 cms, making it good for intercropping. The variety is presently in on-farm testing by the TLU and is being converted to a yellow grain type using Bacao as the source of yellow grain color.

Reliable data for the NVT-Late came from all of the five stations where it was sown, except Tibati (Tables 3 and 4). Entries in the trial for the first time in 1991 include the following: a new mixed grain color variety, Synthetic 4; the latest cycle of the Acid Tolerant Population, ATP-90; and the most recent cycle of the IITA population which is based on selections made in Cameroon, Babungo MSR 89. With the exception of the hybrid control ZS 206, Synthetic 4 ranked 1st for yield over the four locations, was significantly ($P<0.05$) higher yielding than Coca at Foumbot and significantly ($P<0.05$) higher yielding than Kasai in the combined Nfonta-Mbang Mbirni analysis. ATP-90 ranked highest for yield of all of the versions of ATP tested, and, ranking 2nd, was significantly higher yielding than Kasai at Nfonta. For the 2nd consecutive year Synthetic-3 was the highest yielding entry at Foumbot significantly ($P<0.05$) higher than ZS 206 and Coca. It is also worth noting that the yield of Shaba was 3rd over the four locations and that this yield was stable over location never ranking below 5th.

These yield results and the good agronomic and ear characteristics of the above mentioned varieties lead to the following conclusions:

1- Synthetic-4, though needing further testing in our trials, could be tested by the TLU in 1992.
2- ATP-90 needs further testing in comparison with Coca on soils with low available P, but it shows good potential for release.
3- Synthetic-3 should be further tested on farm in the Foumbot area and in other transitional altitude (approximately 1000m), high fertility areas.
4- Shaba should be made available to farmers in the West and Northwest Provinces and should not be restricted to the Adamawa Plateau.

Another interesting result of this trial was the non-significant ($P<0.05$) variety x location interaction for yield when a combined analysis was calculated using Nfonta and Mbang Mbirni data. It re-emphasizes the need for the Highland Maize Researchers to better understand the agro-ecological factors that affect the performance of our varieties. This will lead, not only to more efficient selection by the breeders, but to better targeting of varieties to farmers by the TLU.

Of the two NVT High Altitude trials only the one at Mbiyeh was harvested, and poor soils and early lodging in all plots contributed to poor yields at that site. At Upper farm cattle and sheep grazed on the maize, damaging all plots. Entries in the trial were the following: cycles 0,1 and 2 of the High Altitude Population (HAP); Pool 9 Synthetic, one parent of HAP; NDU Local; and Coca as a control at Upper Farm, and a farmers local variety as a control at Mbiyeh. The mean yield of the trial at Mbiyeh was 2.9 T/HA and there was no significant difference ($P<0.05$) between the yield of the entries nor of any of the other characteristics noted at the time of harvest. All entries in the trial at both locations were infected with Phaeosphaeria Leaf Spot (Phaeosphaeria maydis), a disease about which little information exists. Heavy infections with this disease were found in farmer's fields throughout the high altitudes of Cameroon (>1500m), in 1991. It appears that further breeding efforts for this area will have to include selection for resistance to Phaeosphaeria Leaf Spot. A better understanding of its epidemiology and effect on yield are required.

Hybrid trials for 1991 included two, 18 entry Advanced Trials sown at Foumbot, Nfonta, Babungo and Mbang Mbirni and four, 56 entry preliminary trials sown at Foumbot, Babungo and Mbang Mbirni. Plot size, spacing, thinning and harvest was the same as for the NVT's except that the Preliminary Hybrid Trials had two row plots with both rows harvested for yield determination. Good results were obtained from all trials with trial mean yields ranging from 7.8 T/HA for the Preliminary Hybrid 3 trial at Babungo to 12.0 T/HA for the Preliminary Hybrid 1 trial at Mbang Mbirni.

In the Advanced trials (Tables 5-8) two of the five hybrids recommended last year for pilot production, 88069 x 87036 and 88094 x M131, were again among the highest yielding. An outstanding mean yield of 10.19 T/HA for 88091 x 87036 in Advanced Hybrid Trial 2 was significantly ($P<0.05$) higher than any other entry in the trial and was 131% of the open-pollinated control, Synthetic-4. Based on these results and field observations of our trials by researchers of Pioneer Hybrid International the following inbreds were sent to Pioneer, Garoua where they are being multiplied: 87036, 88069, 89274, 87014, 88094, 89258, 88091, 89302, 88030, 89182, M131.

While the results of our trials indicated that this program has bred high yielding hybrids with good agronomic and grain characteristics, the adaptation of the inbred lines to commercial hybrid production needs to be tested. It is only through collaboration with seed producers that this unit will be able to adequately test these inbreds and determine which will be used to produce hybrids for Cameroonian maize producers.

Preliminary Hybrid Trial results (Tables 9-16) indicate that rapid progress in yield potential continues to be made through selection of new inbred lines. Whereas, in past years the control Variety ZS 206 was among the highest yielding hybrids in the trials, in 1991 at least 20 hybrids in each of the four trials ranked higher than ZS206. In the four trials a total of twenty-two hybrids had a mean yield significantly ($P<0.05$) greater than ZS 206, and all possessed a better score for ear rot. The following hybrids were retained for 1992 Advance Hybrid trials and are being made in the off-season nursery:

Trial 1:	M131 x 90323, 89293 x 90323, 89293 x 89365, Z28 x 89223, Z289 x 90323, Z28 x 90332, Z28 x 89365, 87366 x 90323, 88069 x 90323, 89302 x 90323, 89302 x 89343.
Trial 2:	89258 x 88098, 89258 x 90314, 89260 x 90323, 90113 x 89343, 90113 x 87036, 90117 x 90323, 90147 x 89365, 90156 x C70.
Trial 3:	90204 x 88094, 90219 x 88094, 90204 x 89293, 90201 x 88094, 90194 x 90323, 90194 x 90313, 90183 x 89365, 90183 x 89291, 90183 x 89242, 90183 x C70.
Trial 4:	90219 x 87036, 90220 x 88094, 90251 x 880904, 90251 x 88099, 90251 x 89223, 90276 x 89223, 89320 xz 90323, 89320 x 89365.

Table 1: Grain yields of the 4 entries in the National Variety Trial- Mid Altitude Early sown as a randomized complete block design in 4 replications at 3 locations in Cameroon in 1991.

ENTRY	FOUMBOT (T/HA)	Rank	NFONTA (T/HA)	Rank	BABUNGO (T/HA)	Rank	MEAN (T/HA)	%Bacoa
Kasai	7.1	3	6.3	1	8.6	1	7.3	130
Early White	7.7	1	5.8	2	7.7	2	7.1	126
EMSR	7.5	2	4.9	4	7.4	3	6.6	117
Control								
Bacoa	4.1	4	5.8	2	6.9	4	5.6	100
Trial Means	6.6		5.7		6.9		5.6	
S.E.	0.28		0.17		0.2		0.57[1]	
LSD	0.8		0.5		0.6		NS	
CV (%)	9		6		5		6	

1. Entry x location mean square used to calculate standard error and significance of entry.

Table 2: Characteristics[1] of the 4 entries in the National Variety Trial-Mid Altitude Early sown as a RCBD in 4 replications at 3 locations in Cameroon in 1991.

ENTRY	DS (Days)	PH (cm)	EH (cm)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)
Kasai	72	225	111	1.5	1.2	1.4	2.1
Early White	66	221	107	1.9	1.6	2.0	2.8
EMSR	67	231	113	2.1	1.8	2.2	2.7
Control							
Bacoa	72	250	135	1.9	1.8	2.1	2.1
Trial Means	69	232	116	1.9	1.6	1.9	2.4
S.E.[2]	0.3	6.2	5.1	0.2	0.2	0.12	0.18
LSD (.05)	0.6	17.5	14.3	NS	NS	0.4	NS
CV%	1	9	9	32	31	22	14

1. DS=Days to Silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect, EA=Ear Aspect, ER=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor.
2. Where entry x location interaction is significant, it is used to calculate the standard error, LSD and the significance of entry.

Table 3: Grain yields of the 11 entries in the National Variety Trial-Mid Altitude Late sown as a RCBD in 4 replications at 4 locations in Cameroon in 1991.

ENTRY	FOUMBOT		NFONTA		BABUNGO		MBANG		MEANS NF-MB[1]		MEANS All-LOC	
	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	%Coca
SYNTHETIC-4	7.5	4	7.1	6	7.5	2	8.4	1	7.8	2	7.6	117
SHABA	7.4	5	7.4	3	6.9	3	7.9	3	7.6	3	7.4	114
SYN 3	8.2	1	6.5	11	6.8	4	7.1	10	6.8	10	7.1	110
ATP 90	7.2	6	7.7	2	6.2	10	7.2	8	7.5	4	7.1	109
BAB MSR89	8.0	2	6.5	10	6.5	6	7.3	5	6.9	9	7.1	109
ATP89	6.2	9	7.4	4	6.7	5	7.3	6	7.3	5	6.9	106
KASAI	6.6	7	7.1	7	6.4	8	7.2	9	7.1	8	6.8	105
ATP EV89	6.2	10	7.1	8	6.4	7	7.5	4	7.3	7	6.8	104
FBT MSR87	7.5	3	6.7	9	6.0	11	6.7	11	6.7	11	6.8	104
Controls												
ZS 206[2]	6.4	8	8.5	1	7.7	1	8.2	2	8.4	1	7.7	118
COCA	5.1	11	7.3	5	6.3	9	7.3	7	7.3	6	6.5	100
Trial means	6.9		7.2		7.6		7.5		7.3		7.1	
S.E.	0.28		0.17		0.21		0.43		0.25		0.19[3]	
LSD (.05)	0.8		0.5		NS		NS		0.7		NS	
CV%	9		6		5		11		9		11	

1.Nfonta and Mbang combined location RCBD analysis showed no variety x location interaction.
2.Commercial hybrid.
3.Variety x location interaction used to calculate standard error, LSD and significance of variety.

Table 4: Characteristics of the 11 entries in the National Variety Trial- Mid Altitude Late sown as a RCBD in 4 replications at 4 locations in Cameroon in 1991.

ENTRY	DS	PH	EH	HC	PA	EA	ER
	(Days)	(cms)	(cms)	(1-5)	(1-5)	(1-5)	(1-5)
SYNTHETIC-4	74	264	133	1.3	1.7	1.6	2.1
SHABA	75	258	127	1.3	2.0	1.6	2.1
SYNTHETIC 3	75	257	129	1.7	1.6	1.6	2.0
ATP 90	74	256	139	1.4	2.1	1.4	1.6
BAB MSR89	74	251	132	1.4	2.4	1.7	2.3
ATP89	76	261	136	1.6	2.0	1.4	1.6
KASAI	74	236	122	1.2	2.0	1.9	2.6
ATP EV89	75	267	142	1.3	2.3	1.5	1.8
FBT MSR87	75	254	131	1.4	1.9	1.4	2.4
Controls							
ZS 206[2]	75	263	130	1.7	1.7	1.0	2.5
COCA	74	259	138	1.5	2.4	2.2	2.4
Trial Means	75	257	133	1.4	2.0	1.6	2.1
S.E.[3]	0.15	2.3	2.5	0.2	0.09	0.08	0.08
LSD (.05)	0.65	6.6	7.0	NS	0.25	0.21	0.22
CV%	2	6	12	31	29	32	24

1.DS=Days to Silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect, EA=Ear Aspect, ER=Ear Rot; for all 1 to 5 rating scale 1 is good, 5 is poor.

2. Commercial hybrid.

3.Where variety x location interaction is significant, it is used to calculate the standard error, LSD and the significance of variety.

Table 5: Grain yield of the 18 entries in the Advanced Hybrid 1 trial sown as a lattice in 4 replications at 4 locations in Cameroon in 1991.

ENTRY	FOUMBOT		NFONTA		BABUNGO		MBANG MBIRNI		MEANS[1]	
	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	%SYN
89274 X 89293	8.20	10	9.10	1	10.29	2	11.89	3	9.87	120
88069 X 88091	8.74	4	7.59	5	9.73	7	12.56	1	9.65	118
M131 X 88099	9.72	2	7.41	7	10.29	1	11.08	10	9.63	117
89223 X 89258	8.43	8	8.09	2	10.05	3	11.38	5	9.49	116
8534-7	9.88	1	7.29	10	9.91	5	10.50	15	9.39	115
89223 X 88099	8.65	5	7.98	3	8.89	8	11.24	7	9.19	112
88069 X 89207	9.45	3	6.51	18	9.74	6	10.81	11	9.13	111
87366 X C70	8.50	7	6.87	14	8.70	12	12.09	2	9.04	110
89274 X 89302	6.95	16	7.25	12	9.93	4	11.10	8	8.81	107
89223 X 89260	7.43	15	7.94	4	8.84	10	10.76	12	8.74	107
87366 X 89311	8.57	6	7.34	9	8.82	11	9.98	18	8.68	106
Z28 X 89293	7.72	13	7.59	6	8.58	14	10.65	14	8.63	105
87366 X 89243	7.95	11	6.82	15	8.19	17	11.32	17	8.53	104
88091 X C70	7.86	12	7.27	11	8.62	13	10.36	13	8.44	103
Z28 X 89242	8.38	9	6.71	16	7.95	18	10.71	16	8.44	103
87366 X 89199	7.67	14	7.15	13	8.54	15	10.38	4	8.63	105
Controls										
Synthetic-4[2]	6.78	17	6.58	17	8.36	16	11.09	9	8.20	100
ZS206[3]	6.45	18	7.19	8	8.84	9	11.86	6	8.57	104
Trial means	8.2		7.4		9.1		11.1		8.9	
S.E.	0.34		0.36		0.41		0.6		0.34[4]	
LSD (0.05)	1.0		1.0		1.2		NS		1.0	
CV%	7		8		8		10		9	

1.RCBD multilocational analysis.
2.Open-pollinated variety.

Table 6: Characteristics[1] of the 18 entries in the Advanced Hybrid 1 trial sown in 4 replications at 4 locations in Cameroon in 1991.

Entry	DS (Days)	PH (cm)	EH (cm)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)
89274 X 89293	72	255	141	1.4	1.8	1.7	2.3
88069 X 88091	74	262	131	2.3	1.6	1.4	1.9
M131 X 88099	72	258	138	1.6	1.8	2.0	2.3
89223 X 89258	72	250	130	1.3	1.5	1.5	1.6
8534-7	71	249	114	1.8	1.8	1.6	1.5
89223 X 88099	72	261	133	1.2	1.8	1.1	1.7
88069 X 89207	74	265	129	1.8	1.8	1.9	2.6
87366 X C70	75	240	118	1.5	1.4	1.3	1.6
89274 X 89302	70	228	120	1.2	1.3	2.4	2.4
89223 X 89260	71	244	129	1.1	1.4	1.6	1.4
87366 X 89311	74	247	119	1.5	1.9	1.4	1.9
Z28 X 89293	76	259	139	2.4	1.8	2.0	2.7
Z28 X 89242	75	257	131	1.1	1.6	1.8	2.6
87366 X 89243	75	261	126	1.6	1.9	1.1	1.5
88091 X C70	73	276	132	1.1	1.6	1.8	2.6
87366 X 89199	74	249	123	1.5	1.6	1.5	1.9
Controls							
ZS206[2]	72	273	136	2.4	2.0	1.6	2.8
Synthetic-4[3]	72	263	134	1.4	1.9	2.9	2.5
Trial means	74	256	129	1.5	1.6	1.6	2.0
S.E.[4]	0.68	3.6	2.7	0.17	0.2	0.11	0.11
LSD (0.05)	1.9	10.3	7.6	0.5	NS	0.3	0.3
CV%	2	6	8	29	32	27	22

1. DS=Days to Silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect, EA=Ear Aspect, ER=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor.
2. Commercial hybrid
3. Open-pollinated variety.
4. RCBD multilocational analysis where variety x location interaction is significant, it is used to calculate the standard error, LSD and the significance of variety.

Table 7: Grain yield of the 18 entries in the Advanced Hybrid 2 trial sown as a lattice in 4 replications at 4 locations in Cameroon in 1991.

ENTRY	FOUMBOT		NKOMTA		BAFUNGO		MBANG-MBIRNI		MEAN[1]	
	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	%SYN
88069 X 87036	9.01	3	8.60	1	11.13	1	12.02	1	10.19	131
88094 X M131	9.12	1	7.89	3	10.43	2	9.23	13	9.17	118
89182 X 88099	9.09	2	6.98	12	9.85	7	8.82	18	8.69	112
89277 X 89293	7.26	8	7.81	4	10.16	3	9.34	12	8.64	111
89258 X 89182	7.81	4	6.86	13	9.56	10	9.92	6	8.54	110
89258 X C70	7.54	5	7.02	11	9.26	14	10.28	5	8.52	110
89310 X 89293	6.80	14	8.07	2	10.16	4	8.96	16	8.49	109
89246 X C70	7.49	7	7.20	8	9.49	11	9.72	8	8.47	109
89302 X 89293	6.91	12	7.74	5	9.30	13	9.80	7	8.44	109
89258 X 89248	6.98	11	7.07	10	10.05	6	9.35	10	8.36	108
87014 X M131	7.53	6	6.57	17	10.09	5	9.07	15	8.31	107
89310 X C70	6.53	16	7.70	6	9.68	8	9.09	14	8.25	106
89302 X 88099	6.30	17	6.82	14	9.46	12	10.32	4	8.23	106
89260 X 88099	7.06	10	7.11	9	8.99	16	9.35	11	8.13	105
87366 X 89296	6.89	13	6.64	16	8.51	18	10.39	3	8.11	104
87366 X 88030	7.16	9	6.77	15	8.72	17	9.36	9	7.99	103
Controls										
ZS206[2]	6.06	18	7.22	7	9.65	9	11.67	2	8.65	111
Synthetic-4[3]	6.61	15	6.47	18	9.12	15	8.84	17	7.76	100
Trial means	7.3		7.2		9.6		9.7		8.5	
S.E.	0.35		0.3		0.38		0.68		0.33[4]	
LSD (0.05)	1.0		0.8		1.1		1.9		0.9	
CV%	10		8		8		14		11	

1.RCBD multilocational analysis.
2.Commercial hybrid.
3.Open-pollinated variety.
4.Variety x location interaction used to calculate standard error, LSD and significance of variety.

Table 8: Characteristics[1] of the 18 entries in the Advanced Hybrid 2 trial sown in 4 replications at 4 locations in Cameroon in 1991.

ENTRY	DS (Days)	PH (cm)	EH (cm)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)	
88069 X 87036		76	269	126	1.6	1.6	1.5	2.4
88094 X M131		75	261	131	1.5	2.1	1.4	2.4
89182 X 88099		73	251	129	2.2	2.3	1.8	2.1
89277 X 89293		76	259	141	1.4	1.8	2.2	2.8
89258 X 89182		71	244	119	1.3	1.6	1.6	1.8
89258 X C70		75	253	125	1.6	1.6	1.9	2.3
89310 X 89293		77	268	140	2.6	2.3	1.7	2.8
89246 X C70		78	277	138	1.3	2.4	1.4	2.0
89302 X 89293		75	241	121	1.4	1.4	1.6	2.3
89258 X 89248		76	265	126	1.9	1.9	2.0	2.1
87014 X M131		78	260	131	1.6	1.9	1.9	2.1
89310 X C70		79	263	130	1.3	1.9	1.7	2.4
89302 X 88099		76	239	128	1.7	1.7	1.9	1.6
89260 X 88099		71	253	139	2.3	2.1	2.0	1.9
87366 X 89296		75	241	130	2.8	1.6	1.7	1.9
87366 X 88030		75	261	129	1.1	2.1	2.0	2.1
Controls								
ZS206[2]		73	266	131	2.1	1.8	1.7	2.8
SYNTHETIC-4[3]		75	265	131	1.3	2.1	2.5	2.4
Trial Means		75	258	130	1.7	1.9	1.8	2.2
S.E.[4]		0.5	3.4	3.2	0.1	0.2	0.1	0.1
LSD (.05)		1.4	9.6	9.3	0.35	NS	0.3	0.34
CV%		3	5	10	29	31	24	22

1.DS=Days to Silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect, EA=Ear Aspect, ER=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor

2.Commercial hybrid

3.Open-pollinated variety.

4.RCBD multilocational analysis where variety x location interaction is significant, it is used to calculate the standard error, LSD and the significance of variety.

Table 9: Grain yield of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 1 trial sown as a lattice in 3 replications at 3 locations in Cameroon in 1991.

ENTRY	FOUMDOT		BABUNGO		MBANG MBIRNI		MEAN[1]	
	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	%SYN
88069 X 89274	10.2	6	9.2	15	14.5	2	11.3	123
88069 X 89365	11.8	1	8.5	37	13.3	8	11.2	121
88069 X 90323	10.0	7	10.0	1	13.3	9	11.1	120
88069 X 90332	10.0	8	9.4	10	13.7	5	11.0	120
88069 X 89343	11.3	2	8.9	19	12.6	21	10.9	119
M131 X 89274	8.5	26	10.0	2	13.9	4	10.8	117
89293 X 90323	9.8	10	9.4	8	13.0	13	10.7	117
M131 X C70	9.7	11	9.8	3	12.3	27	10.6	115
88069 X 90313	9.4	13	8.5	35	13.9	3	10.6	115
88069 X 90301	8.3	29	8.7	30	14.6	1	10.6	114
89293 X 89365	9.8	9	9.8	14	12.6	20	10.5	114
Z28 X 90301	10.3	5	8.9	23	11.9	38	10.4	112
88069 X 90314	9.3	14	9.6	5	12.1	33	10.3	112
Z28 X 89223	10.9	3	9.2	16	10.9	54	10.3	112
Z28 X 88094	10.6	4	7.2	55	12.9	15	10.2	111
89258 X M131	8.1	36	9.4	9	13.1	12	10.2	111
87366 X 90323	9.0	18	9.3	12	12.1	34	10.1	110
Z28 X 89274	8.1	35	9.6	4	12.7	19	10.1	110
M131 X 90323	8.6	23	8.9	22	12.8	17	10.1	109
Z28 X 87036	8.3	30	8.7	28	13.2	10	10.1	109
Controls								
ZS206[2]	6.1	54	8.7	31	13.5	7	9.4	103
SYNTHETIC-4[3]	8.0	38	7.8	50	11.9	40	9.2	100
ZS 206	5.5	55	7.9	47	13.0	14	8.8	96
Trial Mean	8.4		8.7		12.6		9.8	
S.E.	0.54		0.44		0.44		0.50[4]	
LSD (.05)	1.5		1.2		1.2		1.5	
CV%	11		9		6		9	

1.RCBD multilocational analysis.
2.Commercial hybrid sown as two entries.
3.Open-pollinated variety.
4.Variety x location interaction used to calculate standard error, LSD and significance of variety.

Table 10: Characteristics[1] of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 1 trial sown in 3 replications at 3 locations in Cameroon in 1991.

ENTRY	DS (Days)	PH (cms)	EH (cms)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)
88069 X 89274	71	271	138	2.0	2.4	1.7	2.2
88069 X 89365	72	258	122	2.3	1.4	1.8	2.1
88069 X 90323	72	262	126	2.3	1.9	1.8	1.9
88069 X 90332	73	264	126	2.0	1.6	1.9	2.1
88069 X 89343	71	263	129	1.9	1.7	2.1	2.4
M131 X 89274	69	259	135	1.6	1.8	2.1	2.1
89293 X 90323	71	265	133	1.8	1.3	1.8	1.9
M131 X C70	71	274	141	1.6	2.4	1.8	2.1
88069 X 90313	71	260	120	2.2	1.3	1.6	2.6
88069 X 90301	68	264	121	2.0	1.3	1.8	1.9
89293 X 89365	73	263	130	1.6	2.1	1.7	1.3
Z28 X 90301	68	261	142	1.9	2.6	1.7	2.1
88069 X 90314	69	250	116	1.6	1.1	2.1	2.6
Z28 X 89223	69	267	134	1.3	2.0	1.2	1.6
Z28 X 88094	71	272	128	2.0	2.3	1.3	2.8
89258 X M131	69	259	124	1.9	1.9	1.8	2.2
87366 X 90323	70	261	122	1.6	1.2	1.7	1.3
Z28 X 89274	69	252	131	1.7	1.6	1.9	2.8
M131 X 90323	72	267	131	1.7	2.2	1.9	2.0
Z28 X 87036	74	272	129	1.3	2.3	1.4	1.4
Controls							
ZS206[2]	68	266	132	2.2	2.0	1.6	2.7
SYNTHETIC-4[3]	69	262	130	1.6	2.0	2.9	2.6
ZS 206	69	264	125	2.2	2.0	1.7	2.8
Trial Mean	70	258	129	1.6	1.7	1.8	2.0
S.E.[4]	0.76	4.35	4.35	0.18	0.17	0.16	0.18
LSD (.05)	2.1	12.3	12.3	0.5	0.5	0.5	0.5
CV%	2	5	10	32	30	27	27

1. DS=Days to Silk, PH=Plant Height, EH=Ear Husk, HC=Husk Cover, PA=Plant Aspect, EA=Ear Aspect ER=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor.
2. Commercial hybrid sown as two entries.
3. Open-pollinated variety.
4. RCBD multilocational analysis where variety x location interaction is significant, it is used to calculate the standard error, LSD and the significance of variety.

Table 11: Grain yield of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 2 trial, sown as a lattice in 3 replications at 3 locations, in Cameroon in 1991.

ENTRY	FOUMBOT T/HA	FOUMBOT Rank	BABUNGO T/HA	BABUNGO Rank	MBANG MBIRNI T/HA	MBANG MBIRNI Rank	MEAN[1] T/HA	MEAN[1] %SYN
90113 X M131	9.0	14	8.4	17	13.2	2	10.2	114
90147 X 89365	10.4	1	8.7	10	11.5	27	10.2	114
89258 X 88094	9.4	7	9.0	5	12.1	8	10.2	114
90113 X 89343	9.2	11	8.9	7	12.2	7	10.1	113
90156 X 89291	9.8	3	7.7	35	12.4	5	10.0	112
89258 X 88098	9.5	6	8.5	14	12.0	10	10.0	112
89260 X 90323	8.4	26	9.6	2	11.8	13	10.0	112
89258 X 90314	8.6	23	9.6	1	11.6	21	9.9	112
90117 X M131	8.2	32	8.5	15	13.1	3	9.9	112
89258 X 89183	9.3	10	8.7	9	11.7	18	9.9	111
90117 X 90323	10.1	2	8.5	13	11.1	39	9.9	111
90113 X 87036	9.6	5	8.4	18	11.5	30	9.8	110
90113 X 90323	8.8	16	9.0	6	11.6	20	9.8	110
89258 X 87036	9.2	12	9.1	4	11.1	36	9.8	110
90156 X C70	8.7	19	8.6	12	11.8	14	9.7	109
89258 X 89274	8.3	29	9.3	3	11.4	31	9.7	108
89260 X 89246	7.9	41	8.5	16	12.4	6	9.6	108
90135 X 89365	8.8	17	8.0	28	11.9	12	9.6	107
90156 X 90313	9.8	4	7.4	43	11.5	25	9.6	107
90143 X 88094	8.5	25	7.9	31	11.8	15	9.4	105
Controls								
ZS206[2]	5.9	56	7.1	48	13.6	1	8.9	99
Synthetic-4[3]	7.7	45	7.7	34	11.1	38	8.8	100
ZS206	6.0	55	7.0	49	13.0	4	8.7	97
Trial Mean	8.3		8.0		11.4		9.2	
S.E.	0.38		0.48		0.34		0.43[4]	
LSD (.05)	1.1		1.4		1.0		1.1	
CV%	8		11		5		8	

1.RCBD multilocational analysis.
2.Commercial hybrid sown as two entries.
3.Open-pollinated variety.
4.Variety x location interaction used to calculate standard error, LSD and significance of variety.

Table 12: Characteristics[1] of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 2 trial, sown in 3 replications at 3 locations, in Cameroon in 1991.

ENTRY	DS (Days)	PH (cms)	EH (cms)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)
9113 X M131	73	274	139	1.4	2.1	1.7	2.4
90147 X 89365	72	271	138	1.0	1.8	1.1	1.2
89258 X 88094	69	269	139	2.6	2.3	1.4	2.1
90113 X 89343	72	270	139	1.2	2.0	1.4	1.9
90156 X 89291	67	259	136	2.2	2.1	1.8	1.9
89258 X 88098	69	265	133	1.4	2.2	1.4	1.9
89260 X 90323	68	256	131	1.4	1.3	1.9	1.7
89258 X 90314	69	261	139	1.7	1.6	2.0	2.0
90117 X M131	73	272	145	2.2	1.7	1.8	1.8
89258 X 89183	69	266	141	1.6	1.7	1.6	1.7
90117 X 90323	72	259	132	1.8	1.9	1.8	1.6
90113 X 87036	71	277	141	1.3	2.0	1.6	1.8
90113 X 90323	72	267	138	1.9	1.9	1.7	2.3
89258 X 87036	69	268	133	1.2	2.0	2.1	1.8
90156 X C70	72	266	135	1.1	2.0	1.7	1.4
89258 X 89274	67	261	136	1.6	1.7	2.1	1.8
89260 X 89246	70	266	140	1.8	1.8	1.2	1.3
90135 X 89365	74	268	128	1.1	2.0	1.0	1.2
90156 X 90313	70	252	129	1.3	1.4	2.1	1.9
90143 X 88094	68	268	132	2.7	1.6	1.6	1.9
Controls							
ZS206[2]	68	272	145	2.1	1.7	1.7	2.8
Synthetic-4[3]	68	269	136	1.4	2.1	2.6	2.6
ZS206	68	272	152	2.2	1.6	1.6	3.0
Trial Means	70	264	135	1.6	1.7	1.8	1.9
S.E.[4]	0.80	5.58	5.37	0.16	0.17	0.16	0.23
LSD (.05)	2.3	15.8	NS	0.5	0.5	0.5	0.6
CV%	3	4	9	31	29	27	25

1. DS=Days to Silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect, EA=Ear Aspect, ER=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor.
2. Commercial hybrid sown as two entries.
3. Open-pollinated variety.
4. RCBD multilocational analysis where variety x location interaction is significant, it is used to calculate the standard error, LSD and the significance of variety.

Table 13: Grain yield of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 3 trial, sown as a lattice in 3 replications at 3 locations, in Cameroon in 1991.

ENTRY	FOUMBOT		BABUNGO		MBANG MBIRNI		MEAN[1]	
	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	%SYN
90204 X 89293	8.4	28	8.8	9	13.6	3	10.3	111
90204 X 89365	10.6	1	8.4	18	11.7	16	10.2	110
90204 X 87036	9.1	11	9.0	4	12.2	7	10.1	109
90194 X 90313	9.7	4	8.4	19	12.1	9	10.1	108
90183 X 89365	10.0	3	8.6	15	11.3	23	10.0	107
90219 X 88094	9.2	8	7.8	32	12.5	4	9.9	106
90183 X 89293	8.5	23	8.7	11	12.3	5	9.8	106
90183 X 90332	9.4	6	7.8	34	12.1	8	9.8	105
90176 X 88094	8.5	24	8.8	10	12.0	12	9.8	105
90183 X 89242	9.1	12	8.5	17	11.7	17	9.7	105
90194 X 87036	8.9	18	8.3	20	12.0	11	9.7	105
90183 X 89291	9.6	5	7.5	39	11.9	14	9.7	104
90204 X 88094	8.5	25	9.4	1	11.1	26	9.7	104
90183 X C70	9.1	10	8.8	8	10.9	32	9.6	104
90194 X 89274	8.2	34	8.9	7	11.8	15	9.6	103
90210 X 89274	9.1	13	8.3	21	11.4	21	9.6	103
90204 X 88099	9.0	15	8.6	14	11.1	27	9.6	103
90194 X 89343	8.9	17	8.9	6	10.8	36	9.6	103
90219 X 88099	8.2	32	9.1	3	11.3	22	9.5	103
90194 X 88099	7.7	44	9.0	5	11.9	13	9.5	102
CONTROLS								
SYNTHETIC-4[2]	7.4	49	8.2	22	12.3	6	9.3	100
ZS206[3]	6.0	56	6.9	49	13.7	2	8.8	95
ZS206	6.5	53	5.7	56	14.1	1	8.8	95
Trial means	8.3		7.8		11.1		9.1	
S.E.	0.54		0.44		0.44		0.49[4]	
LSD (.05)	1.5		1.2		1.2		1.4	
CV%	7		11		6		9	

1.RCBD multilocational analysis.
2.Open-pollinated variety.
3.Commercial hybrid sown as two entries.
4.Variety x location interaction used to calculate standard error, LSD and significance of variety.

Table 14: Characteristics[1] of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 3 trial, sown in 3 replications at 3 locations, in Cameroon in 1991.

ENTRY	DS (Days)	PH (cms)	EH (cms)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)
90204 X 89293	71	265	138	2.8	2.2	1.6	2.4
90204 X 89365	70	260	131	1.8	1.3	1.7	2.2
90204 X 87036	69	264	128	1.8	1.6	2.2	2.1
90194 X 90313	72	257	124	2.3	1.6	1.7	2.0
90183 X 89365	70	280	133	2.0	1.6	1.7	2.2
90219 X 88094	68	285	137	1.4	1.9	1.2	1.4
90183 X 89293	70	281	139	2.1	2.0	1.8	1.9
90183 X 90332	71	286	137	1.1	1.6	1.6	1.6
90176 X 88094	67	282	141	1.2	1.8	1.2	1.3
90183 X 89242	70	268	139	1.3	1.8	1.8	2.1
90194 X 87036	70	278	130	2.2	1.8	1.9	1.8
90183 X 89291	69	283	149	2.1	2.1	1.3	2.0
90204 X 88094	69	266	130	2.6	1.6	1.7	2.0
90183 X C70	71	285	140	1.6	2.3	1.8	2.7
90194 X 89274	68	266	138	1.9	1.4	2.3	1.9
90210 X 89274	68	275	146	1.2	2.2	2.3	2.1
90204 X 88099	69	274	134	2.7	1.6	2.0	2.1
90194 X 89343	69	259	127	1.4	1.7	2.2	2.3
90219 X 88099	71	266	138	1.8	2.0	1.2	1.7
90194 X 88099	68	255	120	2.4	1.4	2.9	1.9
Controls							
SYNTHETIC-4[2]	70	265	136	1.6	2.1	2.6	2.3
ZS206[3]	68	275	135	2.0	1.8	1.6	2.7
ZS206	68	269	134	2.0	2.1	1.6	2.7
Trial means	70	266	133	1.7	1.7	1.9	2.1
S.E.[4]	0.58	4.38	3.69	0.17	0.18	0.16	0.21
LSD (.05)	1.7	12.4	10.4	0.5	0.5	0.5	0.6
CV%	2	5	8	31	32	26	23

1.DS=Days to silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect, ER=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor.
2.Open-pollinated variety.
3.Commercial hybrid sown as two entries.
4.RCBD multilocational analysis where variety x location interaction is significant, it is used to calculate the standard error, LSD and the significance of variety.

Table 15: Grain yield of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 4 trial, sown as a lattice in 3 replications at 3 locations, in Cameroon in 1991.

ENTRY	FOUMBOT		BABUNGO		MBANG MBIRNI		MEAN[1]	
	T/HA	Rank	T/HA	Rank	T/HA	Rank	T/HA	%SYN
90252 X 89291	9.9	1	8.5	31	11.3	7	9.9	118
90268 X 88094	8.8	12	9.6	7	11.3	6	9.9	118
90267 X 89223	9.1	6	9.7	5	10.9	18	9.9	118
90251 X 89223	9.2	4	9.3	10	11.0	13	9.9	118
90251 X 88098	8.9	10	9.5	8	11.0	12	9.8	117
90267 X 89293	8.2	30	9.2	12	11.9	2	9.8	117
89320 X C70	8.0	32	10.2	1	11.0	16	9.7	117
89320 X 89274	8.0	34	9.1	16	12.0	1	9.7	116
90220 X 88094	8.8	14	9.9	4	10.1	43	9.6	115
90220 X 89365	8.9	11	9.3	11	10.5	28	9.5	114
90267 X M131	8.9	9	8.9	23	10.8	21	9.5	114
89320 X 89365	9.4	3	8.2	38	10.8	20	9.5	113
89320 X 90323	8.0	33	8.5	33	11.9	3	9.5	113
90268 X 88098	8.6	19	8.9	20	10.8	22	9.4	113
90267 X C70	8.6	20	8.6	29	10.9	17	9.4	112
90251 X 88099	8.8	15	9.0	17	10.3	34	9.4	112
90250 X 89343	9.0	8	8.9	21	10.1	41	9.3	112
90267 X 88099	8.5	23	8.9	19	10.6	24	9.3	112
90268 X 89343	9.1	7	9.6	6	9.3	51	9.3	112
90219 X 87036	8.2	29	8.9	24	10.9	19	9.3	112
Controls								
ZS206[2]	6.0	56	7.9	45	11.4	5	8.4	101
Synthetic-4[3]	6.9	53	7.7	48	10.4	31	8.4	100
Trial means	8.1		8.6		10.5		9.1	
S.E.	0.78		0.57		0.51		0.4[4]	
LSD (.05)	0.9		1.6		1.4		1.1	
CV%	7		12		8		9	

Table 16: Characteristics[1] of the 20 highest yielding entries and controls in the 56 entry Preliminary Hybrid 4 trial sown in 3 replications at 3 locations in Cameroon in 1991.

ENTRY	DS (Days)	PH (cms)	EH (cms)	HC (1-5)	PA (1-5)	EA (1-5)	ER (1-5)
90252 X 89291	68	265	125	1.7	1.7	1.8	1.7
90268 X 88094	73	283	136	2.4	2.4	1.3	2.1
90267 X 89223	73	269	121	1.3	1.6	1.7	2.1
90251 X 89223	69	259	120	1.1	1.7	2.0	2.2
90251 X 88098	67	258	125	1.0	1.6	2.3	1.8
90267 X 89293	71	271	123	1.4	1.4	1.9	2.8
89320 X C70	72	282	136	1.6	1.8	1.3	1.8
89320 X 89274	73	274	138	1.4	2.2	2.3	2.3
90220 X 88094	71	280	136	1.3	1.7	1.3	1.9
90220 X 89365	71	258	132	1.6	1.8	1.8	2.1
90267 X H131	71	268	125	1.3	2.0	2.1	2.7
89320 X 89365	75	276	132	1.6	2.2	1.9	2.1
89320 X 90323	74	270	132	1.3	1.4	2.0	1.8
90268 X 88098	71	277	131	1.8	2.3	2.2	2.2
90267 X C70	75	276	135	1.3	2.2	1.8	2.4
90251 X 88099	68	255	133	1.4	1.2	2.1	1.3
90250 X 89343	70	266	131	1.0	1.9	2.2	2.2
90267 X 88099	71	258	125	1.4	1.8	2.1	2.0
90268 X 89343	71	276	128	1.2	2.0	2.0	2.3
90219 X 87036	73	281	137	1.2	2.0	1.7	1.9
Controls							
ZS206[2]	70	278	126	1.9	1.7	1.7	2.7
Synthetic-4[3]	72	270	131	1.3	2.1	2.9	2.9
Trial means	71	269	129	1.4	1.8	1.9	2.1
S.E.[4]	0.8	4.2	4.5	0.16	0.17	0.16	0.25
LSD (.05)	2.3	11.8	NS	0.4	0.5	0.4	0.7
CV%	2	5	10	34	31	25	24

1.DS=Days to Silk, PH=Plant Height, EH=Ear Height, HC=Husk Cover, PA=Plant Aspect,EA=Ear Rot; for all 1 to 5 rating scales 1 is good, 5 is poor.
2.Commercial hybrid.
3.Open-pollinated variety.
4.RCBD multilocational analysis where variety x location interaction is significant, it is used to calculate the standard error, LSD and significance of variety.

2.1.5 VISITORS

Dr. Alix Paez,Research Director, Pioneer, USA.
Dr. Osman Arikoglu, Regional Trial Coordinator, Pioneer, Egypt.
Dr. Mohamed Mostafa, Research Manager, Pioneer, Nigeria.
Dr. Sarvesh Paliwal, Production Manager,Pioneer,Cameroon.
Mr. Sunday Olojeday, Maize Entomology, IITA, Nigeria.

2.2 LOWLAND MAIZE BREEDING

2.2.1 INTRODUCTION

The lowland maize breeding unit covers the need of all areas in Cameroon that are less than 1000 meters above sea level in elevation. This include 9 provinces out of ten. The agro-ecological zone covers are:

i) The lowland humid forest;
ii) The lowland humid transitional zone;
iii) The guinea savanna zone (lowland moist savanna);
iv) The soudan savanna zone and the south sahel zone.

The main objective of the unit is to provide high yielding and stable varieties which are adapted to each of the agro-ecological zones, and are acceptable to farmers. To achieve this goal, the units work is divided into five main subgoals:

i) Evaluation and recommendation of varieties;
ii) population improvement,
iii) line development;
iv) hybrid and synthetic varieties development;
v) multiplication and maintenance of breeder and foundation seed.

In 1991 the lowland maize breeding unit carried out a total of 243 trials. This represented a 7% increase over the 1990 trials. One hundred and seventy eight (178) of these trials evaluated 2401 genotypes. This represented a 27% decrease in number of trials as compared to 1990 and about the same number of genotypes evaluated. The 1991 trial names and numbers tested are presented in Table 1.

Eighty two (82) out of 178 evaluation trials were done in 8 savanna locations while 96 trials were in 8 forest locations. 58% of the 178 trials had a coefficient of variation (C.V %) below 20%. About 30% of the 178 trials had a C.V between 20% and 30%, and finally 11% of the trials had their C.V % higher than 30% and were not included in means calculations. These percentages were not different from those obtained in 1990.

The 1991 testing locations (16 in total) and land area (37 ha) used is presented in Table 2. Land area used in 1991 was almost double that of 1990. This was due to the increase in second season trials.

Population improvement in 1991 used 4 schemes. Half-sib, mass selection, Full-sib selection and S_1 testcrosses selection. Just like in 1991, 12 populations were improved for agronomic characteristics. In addition, 15 new varieties were developed and advanced to F_2. Those varieties consisted of the best variety crosses developed in 1991 as well as varieties obtained by recombining lines from different heterotic groups.

Among the single cross hybrids tested, 16 had at least 15% yield superiority over the best open pollinated. However, only half of them were 20% better than the best open pollinated.

In 1991, 486 inbred lines were screened under artificial striga infestation. About 8% of them showed moderate tolerance for striga.

Finally, seed multiplication in 1991 used 8.5 ha of land. This represented a 15% increase.

2.2.2 PRODUCTION CONSTRAINTS

- Eratic rainfall after planting in savanna (20 days drought).
- Frequent breakdown of the vehicle No 771 AF
- Frequent breakdown of the irrigation pump during the off-season
- Timely availability of input such as fertilizer in savanna zone and financial support
- Poor storage facilities
- Termite damage in Maroua and Soucoundou
- Not enough research land
- Soil fertility (Zinc & Magnesium dificiency in Sanguere and acid soil in Nkolbisson and Ebolowa).

2.2.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Testing of Introductions and newly created maize varieties or hybrids		
1.1. To identify new germplasm.	1.1 Variety trial on 2 to 4 locations.	1.1 Identification of Suwan I white and 8321-18 x Exp_1 24 as potentially good open pollinated and hybrid, respectively.
1.2 To identify new trait donor source	1.2 Inbred lines evaluation planted	1.2 Initial screening of inbred line for striga, acid tolerant and borer resistance.
1.3 To collect data	1.3 Data collection	1.3 Data collected on 37 introduced trials and 141 NCRE trials.
Operation 2: Population Improvement		
2.1 To improve plant and ear aspect, disease resistance, stress tolerance	2.1 Half-sib recurrent selection.	2.1 Half-sib improvement of CMS 8501, CMS 8704, Ndock 8701, Syn E1 and Syn E2.

Objectives	Activities	Accomplishments
2.2 To develop new higher yielding and stable varieties.	2.2 S_3 recombination and variety crosses.	2.2 Formation of experimental varieties from recombination of lines from heterotic group.
2.3 To increase yield potential.	2.3 Same as 2.2	2.3 Formation of new experimental varieties from advancement to F_2 of selected variety crosses.
2.4 To develop drought tolerant varieties.	2.4 S_3 recombination of drought tolerant lines.	2.4 S_3 lines of drought tolerant population could not germinate.
2.3 Refinement of the 3 heterotic pools	2.3 Diallel recombination of lines and advancement from F1 to F2	2.3 Advancement to F_2 of 4 new synthetics developed from the heterotic pools.
Operation 3: Inbred line development		
3.1 Creation of new heterotic and trait donors inbred lines.	3.1 Selfing, selection and evaluation on artificial environments.	3.1 Selection through testcrosses of 15, 17 and 19 S_8 lines from NCRE group 1, group 2 and group 3. And evaluation of 486 under striga infestation.
3.2 Identification of new lines for heterotic pool improvement and variety crosses.	3.2 Combining ability studies and variety crosses.	3.2 Advancement of lines of 4 populations to the next generation and testcrosses of T2B lines with 1368, 9071, 5012.
3.3 Development and selection of hybrids which are at least 20% better than the best open pollinated.	3.3 Single and three-way crosses formation.	3.3 Single cross evaluation of hybrids obtained between highland and lowland inbred lines.
3.4 35 synthetic varieties development.	3.4 Diallel recombination among heterotic lines.	3.4 Creation and advancement to F_2 of 4 new synthetics.
Operation 4: Special Maize		
4.1 To create soft endosperm maize.	4.1 Backcross improvement.	4.1 Purification of already developed varieties for their soft endosperm.
4.2 To create variety adapted to intercropping.	4.2 Selection for erect leave and earliness.	4.2 None

Objectives	Activities	Accomplishments
4.3 To create acid tolerant and drought tolerant pool.	4.3 Screening of lines under artificial environment.	4.3 Variety crosses among acid tolerant population of Madagascar and NCRE-IRA lines.
4.4 Pop corn and sweet corn development.	4.4 Pop corn and sweet corn maintenance.	4.4 Introduction from IITA of 76 pop corn lines and white SU gene for sweet corn.
4.5 Maize for brewery.	4.5 QPM material.	4.5 Multiplication of E.V 8762 QPM & E.V 8766 SR QPM.
4.6 Maize for feed.	4.6 Evaluation of QPM on chickens with IRZ.	4.6 Same as 4.5.
Operation 5: National Varieties Trials		
5.1 To identify variety for release	5.1 Variety trials on 21 locations	5.1 Variety trials on 21 locations. Identification of Suwan I (white).
5.2 To collect data for program evaluation and scientific papers.	5.2 Same as 5.1	5.2 Data collected on all trials.
5.3 To test stability of new variety.	5.3 Same as 5.1 and across locations data analysis.	5.3 Same as 5.2
Operation 6: Multiplication and maintenance of breeder seed and foundation on seed.		
6.1 Production of better population.	6.1 Seed production in Half-sib.	6.1 5 varieties maintained by half-sib.
6.2 Production of seed to supply agronomist, TLU and seed companies.	6.2 Seed production in isolated randomating blocks.	6.2 Total of 4 tones of seed produced.
6.3 Population and lines maintenance.	6.3 Sibbing and chain-crosses of inbred lines.	6.3 Bulk-sibbing used to maintain all advanced lines.

2.2.4 RESEARCH FINDINGS

Due to space limitation data tables are not included. Detailed results are available upon request.

NATIONAL VARIETY TRIALS (N.V.T)

Objective : To identify a high yielding and stable varieties for release.

Material and Method : 2 sets of N.V.T were conducted. One early set, N.V.T(E/I) made of 14 entries. Seven of these entries were of intermediate maturity cycle and the seven others were early. The second set of N.V.T were a late set made of 18 entries. Five of these entries were hybrids. All N.V.T were planted at 53300 plants per hectare. Entries comprised 4 rows per plot and were replicated 4 times. RCBD were used in all the trials.

2.2.4.1 NATIONAL VARIETY TRIAL EARLY (N.V.T E/I)

N.V.T (E/I) IN FOREST

This trial was conducted in 7 locations during the first cropping season and in 3 during the second season. Grain yield ranged from 3.3 t/ha in Ebolowa to 5.0 t/ha at Foumbot. Coefficient of variation (C.V %) ranged from 20.3% obtained at Mile 17 to 32.8% in Ntui. The two best entries were of intermediate maturity cycle: CMS 8503 (5.4 t/ha) and BSR Syn I (5.0 t/ha). The best early white entry was CMS 9015 (Pool 16 DR) with 4.8 t/ha. The best yellow entry was CMS 8806 (4.8 t/ha). P_3 Kollo which was an introduction from Niger and which was supposed to be drought tolerant yielded the least (2.2 t/ha). Across 87 TZUT-W (3.5 t/ha) which was the 1990 best entry was disappointing. This was attributed to its poor germination. (13000 plant per hectare).

During the second season except for ACR 87 TZUT-W (3.5 t/ha) all the varieties yielded less than 3 t/ha. All intermediate maturing varieties also outyielded the early entries. Pool 16 DR (CMS 9015) was still the best early variety with 2.1 t/ha.

N.V.T (E/I) in Savanna

The N.V.T. (E/I) was conducted in 8 savanna locations. One of the site (IRZ Sanguere) was artificially infested with striga seeds. Results showed that grain yield ranged from 1.5 t/ha in striga infested field at IRA Sanguere to 7.0 t/ha on non- infested field in Sanguere. The coefficient of variation ranged from 14.7% at Mayo Galke to 33.5% under striga infestation at IRZ Sanguere. CMS 8503 (6.6 t/ha) and BSR Syn I (5.8 t/ha) which are of intermediate maturity cycle outyielded EV 8931 SR (5.8 t/ha) and CMS 9015 (5.5 t/ha). P_3 Kollo (4.5 t/ha) had a better performance in savanna, reaching 6.4 t/ha in Sanguere and Maroua. This was an indication of its dryer area adaptation. E.V 8931 SR which has the same genetic background as CMS 8802 was better than CMS 8806 by 0.2 t/ha. Most of the early trials were planted at 65000 plants per hectare. Syn E_2 (5.0 t/ha) was the best striga tolerant variety, with a 4.0 rating out of 9, for striga symptoms, and 89 striga plants per plot. The second best under striga was Syn E_1 with a 5.5 rating.

CONCLUSION FOR N.V.T. (E/I)

In both forest and savanna zones, the 2 top intermediate maturing varieties were CMS 8503 and BSR Syn I. In addition, Pool 16 DR (CMS 9015) remained the best early white variety while, CMS 8806 is still the yellow early entry to recommend. However, Syn E_2 and Syn E_1 need to be further tested for their potential as striga tolerant varieties.

2.2.4.1.2 NATIONAL VARIETY TRIAL LATE (N.V.T/L)

N.V.T. (I) in forest

This trial was evaluated in 7 forest locations during the first growing season and in 3 locations during the second season. Mean grain yields ranged from 4.2 t/ha obtained in Ebolowa to 7.5 t/ha in Yaounde. C.V. ranged from 12.4% obtained at Yoke to 32.6%. The best entries were 8321-18 Exp_1 42 and Pioneer yog 62 with 7.4 t/ha. However, these two hybrids yielded the same as the best open pollinated variety Suwan I (W) which is the white version of CMS 8704 (6.8 t/ha). The two pioneer varieties yog 62 and yog 66 yielded at least 10.0 t/ha in Foumbot. The lowest yield variety was TZB S.E (6.2 t/ha) which is a soft endosperm variety.

During the second season mean grain yield at the 3 locations were very low. This was attributed to an early drought that hit all the trials 2 weeks before flowering. The best hybrid was 8321-18 (3.8 t/ha) followed by Pionneer yog 67 (3.6 t/ha).

N.V.T. (L) in savanna

This trial was conducted in 8 savanna locations. At IRZ Sanguere, the trial was artificially infested with striga seed. The results showed that the mean grain yield ranged from 3.3 t/ha at Agri-Lagdo to 7.0 t/ha in Sanguere. C.V varied from 12.4% in Sanguere to 34.2% at Lagdo and IRA Sanguere under striga infestation. The five best varieties were hybrids. The best of them were 8321-18 x Exp_1 7-1 (7.0 t/ha). The best open pollinated variety was Suwan I (W) with 6.7 t/ha. Here again TZB SE 2.8 t/ha was the lowest yielding variety. This was partly attributed to its lowest plant stand (14400 plant per hectare). 8321-18 x Exp_1 7 and 8321-18 were the two best striga tolerant varieties with 3.7 and 4.7 striga symptom rating, respectively. However, CMS 8704 and 8321-18 x Exp_1 7-1 showed the least striga plants per maize plant (1.4). Maroua and Soucoundou who had more than average rainfall in 1991, revealed an average yield of 6.2 t/ha and 6.8 t/ha respectively.

CONCLUSION FOR N.V.T (LATE)

Hybrids were in general superior to open pollinated. But the observed differences were not significant. However, an 18% yield advantage was obtained between the best hybrid and the cultivated CMS 8501 in savanna zone.

Surprisingly, Suwan I (W) 6.7 t/ha, was the 1991 best open pollinated in both savanna and forest zone. CMS 8704 and TZUT as open pollinated, showed some potential as striga tolerant varieties.

2.2.4.1.3 NATIONAL HYBRIDS TRIALS (N.H.T)

Objective : To identify the best hybrid for release.

Materials and Methods

This trial comprised 17 hybrids and 1 open pollinated variety (CMS 8501). It was conducted in 8 locations (4 in forest and 4 in savanna). The trial also occupied 3 locations during the second season. Mean grain yield ranged from 4.3 t/ha in Touboro under striga infestation to 8.4 t/ha in Sanguere. C.V ranged from 11.2% in Ntui to 23.4% in Touboro.

In the forest zone, the best hybrid was 8321-18 x Exp_1 24 (8.1 t/ha) with 35% yield advantage over CMS 8501 (6.0 t/ha). In savanna, the best hybrid was 8321-18 x Exp_1 20 (7.1 t/ha) followed by 8321-18 x Exp_3 7 (7.0 t/ha) with 16% and 15% yield increase over CMS 8501 (5.1 t/ha) respectively. These yield advantages corresponded to 2.1 t/ha yield advantage in forest and 1.0 t/ha yield advantage in savanna zone. The overall mean showed 8321-18 Exp_1 24 (7.4 t/ha) having 21% yield advantage over CMS 8501 (6.1 t/ha). This corresponded to an 1.3 t/ha yield advantage.

During the second season, 13 hybrids exhibited more than 20% yield increase over the best open pollinated CMS 8501 (2.6 t/ha). Yields in general were very low (3.3 t/ha). This was attributed to early drought experienced in Ntui and in Ebolowa. This last location had acid soil. The two best entries were 8321-18 Exp_1 1 (4.0 t/ha) followed by 8321-18 Exp_1 24 (3.7 t/ha).

2.2.4.1.4 NCRE WHITE SINGLE CROSSES

Objective : To identfiy the best white single crosses to be included in N.H.T.

Materials and Methods

Three groups of these materials were evaluated in 1991. All groups were tested in 4 rows/plot and 4 replications. The design used was a RCBD. All agronomic practices used were the same as the one used in testing open pollinated. All groups also had CMS 8501 or Ndock 8701 as open pollinated check.

Group I (1368)

Materials here included, lines from the NCRE population crossed with IITA 1368 which is Tuxpeno derived line. This trial were evaluated in 4 locations during the normal growing season and 3 locations during the second season. Grain yield ranged from 6.5 t/ha in Ntui and Soucoundou to 8.3 t/ha in Yaounde. C.V. varied from 15.2% in Soucoundou to 17.4% in Sanguere. Two hybrids exhibited at least a 10% yield increase over the check Ndock 8701 (7.3 t/ha). These varieties were 1368 x NCRE 91-93 (8.5 t/ha) and 1368 x 58-88 (8.0 t/ha). The best hybrid had a 1.2 t/ha yield advantage over Pionneer yog 67.

Group II (9071)

Treatments consisted of 18 hybrids. Nine of them consisted of NCRE lines crossed to 9071, which is a temperate derived IITA line. Results revealed that 4 single crosses had at least 12% yield advantage over the open pollinated Ndock 8701 (7.8 t/ha). This corresponded to at least 0.9 t/ha yield increase. This trial was conducted in 2 locations during the normal growing season and 3 locations during the second season. The best single cross was NCRE 56-58 x 9071 (9.5 t/ha). This was followed by NCRE 46-48 x 9071 (9.3 t/ha). Both varieties had at least 19% yield increase over Ndock 8701. This represented at least 1.5 t/ha yield increase.

Group III (5012)

Material used in this trial consisted of 21 hybrids and 1 open pollinated CMS 8501. The hybrids were made of NCRE lines crossed with 5012 which is a sub-temperate derived IITA line. This trial was evaluated in 4 locations during the normal growing season and in 3 locations during the second season. All second season trials were hit by drought two weeks before flowering. Mean grain yield ranged from 3.8 t/ha at Ndock to 7.5 t/ha at Sanguere. C.V. varied from 20.7% obtained in Sanguere to 33.0% in Ndock. In forest locations, 5012 x 14-16 (7.2 t/ha) outyielded the other entries, while 5012 x 91-94 (6.5 t/ha) was the best entry in savanna. The overall mean grain yield not taking Ndock into account revealed 5012 x 77-79 (7.6 t/ha) as the best cross in this group. This variety had only 10% yield increase over the check CMS 8501 (6.9 t/ha).

2.2.4.1.5 SINGLE CROSSES AMONG HETEROTIC GROUP LINES

Objective : To obtain high yielding single crosses among lines from different heterotic groups.

Methods : Randomly selected lines from each group were randomly mated. The F_1 were evaluated in two sets. The advanced set and the new set. The advanced set included material previously selected in 1990. All F_1 were tested in single row plot, 3 replications. The design used was a RCBD.

2.2.4.1.6 ADVANCED SETS OF TESTER SINGLE CROSSES

The advanced set included 43 entries and 3 checks. Trial mean were 6.0 t/ha in Ntui and 7.3 t/ha in Sanguere. C.V. for both locations were under 20%. The 8 selected lines had their ear aspect under 2.0. The best single cross had a 18% yield advantage over CMS 8501. This corresponded to a 1.4 t/ha difference in yield. The two pioneer checks yog 62 (8.1 t/ha) and yog 66 (7.8 t/ha) were not that different from the open pollinated check CMS 8501.

2.2.4.1.7 NEW SET OF TESTER SINGLE CROSSES

New set of single crosses among lines from different heterotic group comprised 2 sub-sets. Both sub-sets had 40 entries. Data were obtained at Ntui and Sanguere. In the first sub-set, the 3 best entries outyielded CMS 8501 (7.9 t/ha) by at least 1.0 t/ha. In the second sub-set, the 2 best entries outyielded CMS 8501 (7.8 t/ha) by at least 1.2 t/ha. Most of the

selected single crosses from the first sub-set originated from crosses between group 3 and group 1. The second sub-set had its best hybrids from crosses between group 3 and group 2.

2.2.4.1.8 OTHER WHITE SINGLE CROSSES

Objective To measure if high yielding crosses are obtainable between lines from la posta population, Cameroon mid altitude lines and lowland lines. In addition, it was necessary to know in which heterotic group la posta lines belong.

Methods : About 18 laposta lines were randomly crossed to some advanced NCRE lines (Exp_2, Exp_3). In addition, random crosses were also made between laposta lines and NCRE lines of different heterotic group. Finally, the same type of crosses were repeated using mid-altitude lines here called highland material (HLM) with the same NCRE lowland lines.

All F_1 were tested in single row plot, 3 reps.

2.2.4.1.9 LAPOSTA HYBRIDS

Seventy-two single crosses were obtained from crosses between 18 laposta lines and NCRE lowland lines. These crosses were evaluated in two sets at two locations. In the first set that included 44 entries, 1.4 t/ha grain yield difference was obtained between Sanguere and Ntui evaluation. The 2 best crosses involved line 4 and 5 of laposta. These 2 hybrids yielded at least 1.2 t/ha over CMS 8501 (7.4 t/ha). This corresponded to at least 16% yield difference.

In the second set, trial means from the two locations were not that different. However, at least 1.0 t/ha yield differences were recorded between the two best hybrids and CMS 8501 (7.4 t/ha). This represented al least 14% superiority of hybrids over open pollinated.

2.2.4.1.10 HIGHLAND x LOWLAND HYBRIDS

A total of 53 crosses between mid-altitude lines and lowland lines were made in 1991. Those crosses were evaluated in two sets. The first set which included 30 entries were evaluated in one mid-altitude site (Foumbot) and 2 lowland sites (Ntui, Sanguere). The result showed that the performance of highland x lowland materials are better in Foumbot (8.9 t/ha and C.V. = 15%). In this site 6 out of 7 selected hybrids had their yield potential over 10.4 t/ha. The best crosses had 3.4 t/ha superiority over the check Ndock 8701. This high yielding crosse HLM 4 x gp 2 26 (11.2 t/ha) also yielded 10.8 t/ha in Sanguere and was in general 30% superior to the check.

The second set tested in two sites also revealed that the same HLM 4 crossed to NCRE gp 2. 8 yielded 10.9 t/ha in Sanguere, while HLM 5 crossed to the same NCRE gp 2 8 yielded 10.6 t/ha. This was an indication that mid altitude lines crossed to lowland lines will express their full potentiality either in mid altitude ecology or in savanna zone. In this second set, 24% yield superiority was recorded between the best hybrid and the open pollinated check CMS 8501. This represented a 3.0 t/ha difference.

2.2.4.1.11 NCRE SINGLE YELLOW CROSSES

Objective About 15 yellow inbreds lines were crossed to 3 IITA yellow lines: 4001, 9450 and 9848. Due to poor seed sets, only 18 F_1 which had enough seed were evaluated at 3 locations. Ntui, Sanguere and Foumbot in single row plots. The average trial means were high; 9.1 t/ha. Six single crosses yielded at least 10.0 t/ha and had at least 19% yield superiority over the open pollinated check CMS 8704 (8.4 t/ha). The best crosses had 48% yield increase over the check. This represented a 4.0 t/ha yield difference.

The second yellow hybrid trial consisted of 24 entries tested at two locations. Material consisted of Suwan I S_5 lines (CMS 8703) crossed to 9848, 9450 and 4001. Results showed that nine hybrids were better than CMS 8704 (7.8 t/ha). However, only one hybrid had 14% yield advantage over the open pollinated. This was 9450 x Suwan I. 179 (8.9 t/ha). This represented a 1.1 t/ha yield superiority.

2.2.4.1.12 EXPERIMENTAL VARIETY TRIAL (E.V.T)

The E.V.T. in 1991 was made of introduced trials from IITA, SAFGRAD and Pioneer.

Objective The objective of the E.V.T's was to identify new varieties that would enter the N.V.T or new traits donor source that could be used in the population improvement program.

2.2.4.1.13 E.V.T. ISR

This trial originated from IITA and comprised 10 entries tested at 2 locations. All entries were from an intermediate maturity cycle (100-110 days). The results revealed yield superiority in Sanguere (7.2 t/ha) as compared to Ntui (5.6 t/ha). This was partly attributed to higher planting density in Sanguere (70000 plant/ha) as compared to Ntui (53300 plants/ha). The best entry was E.V. 8744 SR BC6 (7.6 t/ha) which yielded 8.4 t/ha at Sanguere.

2.2.4.1.14 E.V.T. LSR-W

This trial is being conducted in 20 African countries. It originated from IITA and comprised two Cameroonian entries: CMS 8710 (Gusau x gene Pool), and Ndock 8701.

In Cameroon, this trial was planted in four locations. Grain yield ranged from 3.7 t/ha in Mayo Galke to 7.9 t/ha in Sanguere. C.V. varied from 7.3% in Sanguere to 23.4% in Mayo Galke. The best entry in 1991 was an hybrid from NCRE program: 8321-18 x Exp_3 13 1 (6.8 t/ha). The two best open pollinated were E.V 8722 SR BC6 (6.2 t/ha) and Gusau x gene Pool (CMS 8710) with 5.9 t/ha. The poorest entry in Cameroon was Okomasa (5.2 t/ha) proposed by the Ghana program. These results were similar to 1990 findings obtained in 15 African countries where the best entry was E.V 8722 SR (4.2 t/ha), followed by two Cameroonian varieties CMS 8710 (4.1 t/ha) and Ndock 8701 (3.9 t/ha).

2.2.4.1.15 E.V.T. LSR-Y

This trial was conducted in two locations and comprised 9 entries. The results showed that 8644-31 (5.5 t/ha) which is a hybrid outyielded other entries. The best yellow open pollinated was Suwan I-SR BC5 (5.5 t/ha) which is an improved version of CMS 8704 (4.5 t/ha).

2.2.4.1.16 R.U.V.T EXTRA-EARLY

This trial originated from SAFGRAD and comprised 9 extra-early varieties (less than 85 days). The check used was an early variety CMS 9015. This trial was conducted in 3 savanna locations. Mean grain yield ranged from 5.6 t/ha in Sanguere to 6.1 t/ha in Maroua. C.V. varied from 7.1% in Soucoundou to 16.3% in Maroua. Average yield was 5.9 t/ha. This was attributed to higher plant density used at planting (70000 plants/ha) and to early sidedressing (25 days after planting). Variety ranking was highly correlated to plant density at harvest. The best extra-early variety was TZEEW-SR-BC3 F_3 (6.8 t/ha) with 65000 plant per hectare harvested. The last variety was TZEE-Y (3.9 t/ha) with 50000 plants harvested per hectare. TZEE-Y (5.8 t/ha) which was previously selected had 1.0 t/ha less than the best variety.

2.2.4.1.17 R.U.V.T. EARLY

This trial also originated from the SAFGRAD program and had 14 entries. Those entries were supposed to have some tolerance to drought. This trial was planted at three savanna locations at 70000 plants per hectare. The results showed a very high correlation between plant density at harvest and yield. The average grain yield accross the 3 sites was 7.0t/ha with an average of 61400 plants harvested per hectare. Trial grain yield ranged from 6.8t/ha at Maroua to 7.1t/ha at Soucoundou. C.V varied from 10.2% at Soucoundou to 15.4% at Maroua. The best variety was FBC6(7.8t/ha) from Burkina-Faso program. This was followed by Maka-SR BC_3 F_3 C 7.5t/ha). TZE comp 3 x 4 (5.8t/ha) ranked last.

2.2.4.1.18 INTERNATIONAL WHITE HYBRID

This trial originated from IITA and consisted of 11 white hybrids and 3 open pollinated varieties. The trial was planted at 4 locations.

Mean grain yield varied from 5.3 t/ha in Mayo Galke to 6.9 t/ha in Sanguere. The C.V. ranged from 10.9% in Ntui to 14.4% in Mayo Galke. All hybrids outyielded the open pollinated varieties. The best hybrid was 8705-6 (6.6 t/ha) which is a three way cross. 8516-12 (5.8 t/ha) usually tested as check in NCRE trial was disappointing.

2.2.4.1.19 INTERNATIONAL YELLOW HYBRID

This trial consisted of 6 hybrids and 3 open pollinated checks. The trial was planted at 3 locations. C.V obtained in Yaounde (35.3%) was unacceptable. The best varieties were 8644-32 (7.2 t/ha) and 8644-31 (7.2 t/ha). These hybrids had Ku 1414 SR as one of the parents. These 2 hybrids had a 1.8 t/ha yield superiority over the check Across 85 TZ SR-4-1 (5.4 t/ha).

2.2.4.1.20 PIONEER ELITE HYBRID TRIAL

This trial was conducted at 4 sites in close collaboration with Pioneer seed company. It included 14 Pioneer hybrids and 2 NCRE hybrids. Results showed that mean grain yield varied from 4.4 t/ha obtained on acid soil in Yaounde to 8.4 t/ha in Sanguere. C.V ranged from 7.8% in Sanguere to 25.4% in Yaounde. The best entry 9130 IY (8.6 t/ha) yielded 9.7 t/ha in Sanguere and 10.1 t/ha in Ndock.

The 2 randomly selected NCRE checks were outyielded by 6 Pioneer hybrids including yog 67 which didn't perform that well when used as check in other NCRE trial. Seed requested was formulated for 9130 IY, 9129 IY and 124608 to be included in our advanced hybrid trial. Ear aspect of Pioneer hybrid was usually poorer than those from NCRE.

2.2.4.2 POPULATION IMPROVEMENT

2.2.4.2.1 OBJECTIVE

- To improve plant and ear aspect, disease resistance and stress tolerance of NCRE varieties.

- To increase yield potential of already released varieties.

2.2.4.2.2 METHODS

In 1991, breeding methods used in population improvement included:

- Variety crosses with a trait donor source.

- S_1 testcrosses and selection of outstanding families for recombination.

- S_8 inbred line recombination for F_2 heterotic Pools and experimental varieties development.

- Half-sib recombination to improve major release varieties

2.2.4.2.3 VARIETY CROSSES

The objective of this program was to increase the yield potential of already released varieties by inclusion of complementary genes. In addition, evaluation of the variety hybrids would allow for variety classification vis-à-vis the 3 heterotic pools.

2.2.4.2.4 E.V.T NCRE EARLY

This trial included 16 entries. Eight of these entries consisted of crosses of 4 composites with the 3 testers 1368, 5012 and 9071. The result revealed that in the 2 forest locations, 33% high parent heterosis was obtained from TZESR-SE x 9071 and Pool 16 DR

x 1368. Also, 9071 was efficient in improving Pool 16 DR (32% heterosis) and DMRESR-W (16%) in the 2 savanna locations, 5012 was the best tester for TZESR-SE (27% high parent heterosis), Pool 16 DR (37%) and DMR ESR-W (37%). Variety crosses obtained by crossing those 3 varieties with 5012 yielded 7.5 t/ha; 7.0 t/ha and 7.0 t/ha, respectively.

In general, TZUT-W (6.4 t/ha) which is an intermediate variety was better than all the variety crosses. Those varieties will be advanced to F_2 and F_3 and will be evaluated again as experimental varieties.

2.2.4.2.5 E.V.T. NCRE INTERMEDIATE

This trial included 17 entries. Nine entries consisted of crosses between 3 intermediate maturing varieties with the same 3 testers 1368, 9071, 5012. The results showed that in forest zone (2 locations), BSR Syn I x 1368 exhibited a 31% high parent heterosis, while CMS 8503 x 5012 and BSR Syn II x 9071 exhibited 16% and 15% high parent heterosis, respectively. In forest area 1368 and 9071 were efficient in improving the varieties.

In the two savanna locations, CMS 8503 x 5012 (8.4 t/ha) showed 20% high parent heterosis, BSR Syn I x 1368 (7.8 t/ha) exhibited a 40% heterosis and BSR Syn II x 5012 (7.7 t/ha) had a 24% heterosis. In this zone, it was noticed that varieties with forest adaptation were improved by 5012.

In general, CMS 8503 x 5012 (7.1 t/ha) was the best variety hybrid followed by CMS 8503 x 1368 (6.8 t/ha).

2.2.4.2.6 E.V.T. NCRE LATE

This trial included 31 entries and was tested at 4 locations. Entries included 14 crosses of NCRE late varieties with 1368, 5012 and 9071. Results revealed an overall 26% high parent heterosis for CMS 8507 x 9071 (7.3 t/ha), CMS 8701 x 9071 (7.9 t/ha) showed a 22% heterosis, Ndock 8701 x 9071 (8.5 t/ha) had a 33% heterosis. In Foumbot, CMS 8507 x 9071 yielded 11.5 t/ha.

In general, the high yielding variety was Ndock 8701 x 9071 (8.5 t/ha) followed by Suwan I (W) x 5012 (8.2 t/ha). It was also noticed that 5012 was efficient only in savanna zone while 9071 and 1368 would improve the performance of the varieties in forest zone.

2.2.4.2.7 ACID TOLERANT

The objective of this trial was to evaluate the potential of the 9 introduced acid tolerant populations from Madagascar and to classify them into the 3 heterotic pools.

The trial consisted of 35 entries made of 10 parents, 3 checks and 22 crosses tested in 1 acid site (Yaounde) and 3 non-acid soil.

On acid soil (Nkolbisson), the best parent was Hp 27 (2.9 t/ha), followed by Hp 374 (1.9 t/ha), Hp 04 (1.7 t/ha) and AF 1066 (1.7 t/ha). In crosses, Hp 33 x 1368 (5.2 t/ha). This represented a 371% yield increase over the parent Hp 33 (1.4 t/ha). Hp 374 x 1368

(0.5 t/ha) and Hp 53 x 1368 (4.5 t/ha) showed a 263% and 500% yield increase over their respective parents. In general, 1368 crossed to parents had 6 varieties among the 10 types crosses.

On nonacid soil, the best parent was AF 1066 (5.5 t/ha). Four parents had at least 5.0 t/ha mean grain yield. In crosses, Hp 05 x 9071 (8.0 t/ha) performed better than check CMS 8501 (6.2 t/ha). Low yielding parents in acid soil (Hp 05, Hp 53) generally combined well in crosses with 1368 and 9071 in non acid soil.

Hp 53, Hp 05 and Hp 374 will be retained as parent in backcrossing program for acid tolerance.

2.2.4.2.8 S_1 TESTCROSSES

Two populations were evaluated in 1991 using S_1 testcrosses method. They were TZE comp. 4 C_1 and TZL comp 3 Co. In each population 10 families were retained for experimental varieties formation.

TZL Comp 3 co

This trial consisted of 169 entries evaluated in 13 x 13 Lattice design with 4 replications. The selected ten top entries at both site Sanguere and Ntui were based on ear aspect remnant seed requested and others obtained from IITA will be recombined in 1992.

TZE Comp 4 C_1

This trial consisted of 5 sets of 40 entries each. The trial was made of early families and evaluated in Maroua. Just like in TZL comp 3 Co, the entries were issued from crossing S_1 lines of the IITA heterotic pool composite 4 C_1 with bulk pollen from the opposite pool.

From each pool, 2 families were retained primarily for their ear aspect. The result showed that the mean of 10 selected families were 8.0 t/ha for grain yield and 1.6 for ear aspect. The expected gain is 4% for grain yield and 12% for ear aspect.

2.2.4.2.9 BUSSEOLA TRIAL

This trial started in 1990. Lines originated from IITA and screened for Busseola tolerance, were advanced to S_1 in 1990 second season and to S_2 during the first season of 1991 under natural borer infestation. The 84 lines retained were evaluated during the second season at Ntui and at Minkomeyos. Selected lines will be recombined to form a borer tolerant pool. In addition they will advanced to S_3 for line extraction.

2.2.4.3 INBRED/TESTCROSSES

The objective of this program is to develop heterotic and trait donor inbred lines. Inbred lines will also serve in improving the open pollinated varieties as well as in developing high yielding hybrids and synthetic populations.

In 1991 a total of 1883 inbred lines developed from 21 populations were advanced to new generations. 3 of those populations (TZB SR, Suwan I SR and Crosses) were testcrossed to 1368, 9071, 5012 and TZUT for white, 4001, 9848 and 9450 for yellow. The trial was composed of 4 sets of testcrosses and evaluated at 2 sites. Twenty eight lines and 32 lines were selected in forest and savanna locations, respectively.

2.2.4.3.1 STRIGA RESEARCH

Objective :

1. To identify a variety or hybrid tolerant to striga that could be released.

2. To identify striga tolerant inbred lines that could be used as trait donor sources in the breeding program or that could be recombined to form a striga tolerant pool or variety.

Methods

Two sets each of an open pollinated trial and a hybrid trial were introduced from IITA. In 1991, these trials were evaluated under artifical infestation of striga. Each hill received an average of 2000 striga seeds. Striga symptoms rating (1-9) were done at 10 weeks and 12 weeks after planting. In addition, the number of striga plants per plot were evaluated at 8 weeks, 10 weeks and 12 weeks.

Furthermore, 486 inbreds lines were screened under artificially infested field conditions. These inbred lines were divided into 5 trials by their population of origin. Each trials was evaluated in single row plots and 3 replications.

Results

The striga hybrid trial included 14 entries tested at two infested sites at Sanguere (IRZ Sanguere and block Karite). Results showed that the best hybrid was 9022-13 STR which yielded 3.4 t/ha and had 3.9 out of 9 rating. This is in fact the new version of already known 8322-13. CMS 8710 which is open pollinated yielded 2.8 t/ha and had a 5.8 rating. The most susceptible line was the usual 8338-1 (0.6 t/ha) which rated 7.0 and had 146 striga plants in the 2 middle rows.

The open pollinated trial revealed that the best open pollinated was STR DT-SR which yielded 2.5 t/ha with a 5.1 rating. It was also noticed that varieties with TZB in their pedigree ranked among the best. CMS 8710 in the hybrid trial a 5.7 rating. It was also one with the fewest striga plants.

From the advanced testing (Table 35) 6 inbred lines were retained and will be recombined to form a striga pool.

2.2.5 VISITORS

1. Quincy Benbow, NCRE Project Officer (USAID)
2. Bruce Whitehouse, U.S University exchange student
3. Rudolphe Boum, a Cameroonian student in Germany
4. Dr. Alex Poez, Research Director, Pionner U.S.A
5. Dr. Mohamed Mostafa, Research Manager, Pionner, Nigeria
6. Dr. Sarvesh Paliwal, Production Manager, Pionner, Cameroon
7. Dr. S.K. Kim, maize breeder IITA
8. Dr. Awad, Striga specialist IITA
9. Dr. Winslow, maize program director, IITA
10. Mr. Rouanet CIRAD, France
11. Mr. Etienne Hainzelin, CIRAD, France
12. Many farmers seeking advise.

Table 1 : 1991 Trial names and number tested

I. INTRODUCTION

Trial name	Origine	Entries number	Reps	Number Tested Forest	Number Tested Savanna	Total
1. EVT LSR-W	IITA	12	4	1	3	4
2. EVT LSR-Y	IITA	9	4	1	2	3
3. EVT ISR	IITA	10	4	1	1	2
4. TZL comp 3 CO T.C	IITA	169	4	1	1	2
5. TZE comp 4 C1 T.C	IITA	200	4	-	5	5
6. International white hybrids	IITA	14	4	2	2	4
7. International yellow hybrids	IITA	9	4	2	1	3
8. Striga observational O.P.	IITA	12	3	-	2	2
9. Striga observational hybrid	IITA	-	3	-	2	2
10. R.U.V.T extra early	SAFGRAD	10	4	-	3	3
11. R.U.V.T early	SAFGRAD	14	4	-	3	3
12. Pionneer hybrids	U.S.A.	16	4	2	2	4
Total		473		10	27	37

II. NCRE/IRA Trial Evaluation

Trial names	Set	Entries	Reps	Number Tested Forest	Number Tested Savanna	Total
1. NVT (E/I)	-	15	4	10	7	17
2. NVT (I/L)	-	18	4	11	8	19
3. NHT	-	19	4	7	4	11
4. NCRE single crosses						
- group 1	1	17	4	4	2	6
- group II	1	23	4	4	1	5
- group III	1	22	4	6	3	9
5. NCRE single yellow		24	4	6	1	7
6. NCRE Test single crosses						
- advanced set	1	46	4	2	2	4
- New set	3	120	3	5	2	7
7. TZB Tester single crosses	6	240	3	6	-	6
8. SUWAN I SR Testcrosses	9	360	3	4	1	5
9. Crosses Testcrosses	4	160	3	4	4	8
10. Highland x lowland crosses	2	53	3	2	2	4
11. Laposta hybrids	2	82	3	2	2	4
12. Striga inbred screening						
- Yellow inbred	-	34	3	-	1	1
- TZMI inbred	-	21	3	-	1	1
- Laposta inbred	-	35	3	-	1	1
- Highland inbred	-	31	3	-	1	1
- Busseola inbred	-	59	3	-	1	1
- MIR inbred	-	66	3	-	1	1
- NCRE inbred	-	14	3	-	1	1
- Crosses inbred	-	226	3	-	1	1
13. Acid tolerant trial	-	35	3	2	2	4
14. EVT NCRE early	-	16	4	2	2	4
15. EVT NVRE international	-	80	4	2	2	4
16. EVT NCRE late	-	31	4	2	2	4
17. Busseola trial	-	84	3	3	-	3
18. IITA lines (TZUT)		60				
Total		1928		86	55	141

III. POPULATION IMPROVEMENT

Populations	Activities	Locations	Total
1. Syn E^1	Half-sib	Nkolbisson	1
2. SYN E^2	Half-sib	Nkolbisson	1
3. CMS 8501	Half-sib	Sanguere + Minkomeyos	2
4. DMR-ESR W	Mass selection	Minkomeyos	1
5. TZUT-W	Mass selection	Minkomeyos	1
6. CMS 8806	Half-sib	Sanguere	1
7. CMS 8704	Half-sib	Sanguere	1
8. Pool 16 DR (CMS 9013)	Mass selection	Sanguere	1
9. Mdock 8701	Half-sib	Sanguere	1
10. Pop corn	Mass selection	SOUCOUNDOU	1
11. Sweet corn	Mass selection	Nkolbisson	1
12. CMS 8701	Half-sib	SOUCOUNDOU	1
Total			13

IV INBRED/TESTCROSSES (NKOLBISSON)

Population Tester	Generation	entries	Activities	Location
1. Experiment I 8321-18	S10	7	Seed increase + three-way	Nkolbisson
Experiment II 8428-19	S10	4	Seed increase + three-way	"
Experiment II (both)	S10	4	Seed increase + three-way	"
2. MCRE group 1 (1368)	S9	13	Seed increase + single crosses	"
MCRE group 2 (9071)	S9	11	Seed increase + signle crosses	"
MCRE group 3 (5012)	S9	21	Seed increase + signle crosses	"
3. TZB group 1 (1368)	S5	111	Advanced to S6 + testcrosses	"
TZB group 2 (9071)	S5	68	Advanced to S6 + testcrosses	"
TZB group 3 (5012)	S5	61	Advanced to S6 + testcrosses	"
4. Suwan I group 1 (9848)	S5	90	Advanced to S6 + testcrosses	"
Suwan I group 2 (4001)	S5	60	Advanced to S6 + testcrosses	"
Suwan I group 3 (9450)	S5	47	Advanced to S6 + testcrosses	"
Suwan I group 4 (8425-8)	S5	83	Advanced to S6 + testcrosses	"
5. Crosses	S4	385	Advanced to S5 + testcrosses	"
6. MIR group 1	S5	7	Seed increase + single crosses	"
7. Variety crosses	S0	32	Advanced to F^2	"
8. Laposta line	S8	20	Testcrosses	"
9. Highland lines	S8	11	Testcrosses	"
TOTAL		1035		

Population Tested	Generation	entries	Activities	Location
10. Single yellow population				
group 1	S8	17	Seed increase + single crosses	Nkolbison
group 2	S8	13	Seed increase + single crosses	"
group 3	S8	10	Seed increase + single crosses	"
11. DMR-LSR W	S1	107	Advanced to S2	"
12. Pionneer	S1	43	Advanced to S2	"
13. Busseola	S3	84	Advanced to S4	"
14. Acid tolerant	S0	35	Variety crosses	"
15. Heterotic				
Pool 1	S0	91	Advanced to F^2	"
Pool 2	S0	33	Advanced to F^2	"
Pool 3	S0	83	Advanced to F^2	"
16. Syn I	S0	30	Advanced to F^2	"
Syn II	S0	24	Advanced to F^2	"
Syn III	S0	26	Advanced to F^2	"
Synh IV	S0	32	Advanced to F^2	"
17. Striga white Pool	S8	51	Reconbination	"
18. Striga yellow Pool	S8	14	Reconbination	
19. French derived inbred	S1	37	Advanced to S_2	
20. Pop 28 DMR-LSR-W	S2	107	Advanced to S_3	
21. IITA (TIUT)	S6	48	Single crosses	
Total : 39 plots of breeding nursery.		848		

V SEED INCREASE

Population	Total land area	Locations
1. CMS 8501	1.5 ha	Minkomeyos, Sanguere, Ndock
2. CMS 8704	3 ha	Ndock, Ntui, Sanguere
3. CMS 8806	2 ha	Ntui, Soucoundou
4. Ndock 8701	1 ha	Sanguere, Ntui
5. Pool 16 DR	1/4 ha	Sanguere
6. EV 8762 SR	1/4 ha	Ntui
7. TZPB SR	1/4 ha	Mayo Galke
8. BSR Syn I	-	Bertoua
9. BSR Syn II	-	Bertoua
10. Suwan I (W)	-	Nkolbisson
11. CMS 8503	-	Nkolbisson
12. CMS 8710	-	Nkolbisson
	8.5 ha	
Total seed multiplication plot : 18		

3.1 RICE BREEDING MAROUA

3.1.1 INTRODUCTION

The rice research unit in the Far North Province has the mandate to improve qualitatively and quantitatively the rice production by the farmers through breeding and agronomy. The task of the unit is therefore to provide advanced or improved lines suitable for the agro-ecological zones of KOUSSERI, MAGA and YAGOUA with high and stable yields, tolerant to diseases with good response to fertilizers. The main priority now is to improve the advanced lines already identified for grain qualities and to determine the best combination of fertilizer which would make rice production profitable for the farmers.

3.1.2 SUMMARY OF PROGRAM ACTIVITIES

During the 1991 cropping season, two experiments on breeding were carried out. The 1st to compare yield of IR 46 to that of some elite varieties and the 2nd on the segregating material which is undergoing it's 5th generation. There was one agronomic trial on improving phosphorus efficiency and another which studies the frequency of application of P_2O_5.

3.1.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Improve existing lines for grain quality by hybridization.		
1.1. To develop varieties suitable for the agro-ecological zone of SEMRY.	1.1 The farmers are growing under supervision of SEMRY monitors.	1.1 Segregating is undergoing it's 5th generation.
1.2 Select a suitable variety for farmers to grow alongside IR46	1.2 Selections for advanced yield and elite variety trial.	1.2 Some selections were made and promising results were obtained.
Operation 2 : Improving the Soil Fertility Level.		
2.1 To identify best fertilizer combination to optimize rice yield.	2.1 1st year data available on farmers field.	2.1 There's a need to improve soil fertility level with organic matter.

3.1.4 RESEARCH FINDINGS

Findings reported are mainly based on data collected on the advanced yield trial and on the fertilization trial.

Methodology

The cultural practices remained unchanged during the 1991 cropping season. The segregating materials were established in a single plot of 3 m x 5m with 25 cm 25 cm spacing. No protection against disease was utilized. 90-45-40 (N.P.K.) was applied in form of urea, triple superphosphate and nuriate of potash. The plots were weed free during all the cropping season and water level was well managed.

For the advanced yield trial, 7 varieties were compared to the check variety IR 46. The design was randomized complete block with 4 replications. Seedlings 35 days old were transplanted at a spacing of 25 cm x 15 cm with 2 - 3 seedlings per hill. The plot size was 5 m x 4 m. The optimum rate of fertilizer was used and split into two fractions (90-45-40); half at 21 days after transplanting half at panicle initiation.

The following observations were made.

- plant height at maturity
- panicle count/M^2
- Date of maturity
- paddy yield at 14 % moisture content.

For the agronomy trial, the methodology was almost the same as in the advanced yield trial, but 6 treatments were compared. The 6 treatments were as follows:

T_1 = 90-0-40

T_2 = 90-45-40 broadcast

T_3 = 90-45-40 band placement

T_4 = 90-0-40 + 3 T/ha organic matter

T_5 = 90-45-40 + 3 T/ha organic matter

T_6 = 90-45-40 + 3 T/ha organic matter band placement.

The organic matter was obtained from rice straw which we made decomposed during 4 months in a pit near the experimental site. The organic matter was applied at transplanting but the N.P.K. fertilizers were applied as previously stated.

Results :

Advanced Yield Trial.

Seven (7) medium duration varieties/advanced lines were tested against IR 46. Significant differences were obtained among the varieties. Two test varieties (IR 25 898 and Tox 3344) plus 5 varieties (advanced) were compared in terms of yield to IR 46 and some agronomic performances.

All the lines showed a considerable tolerance to lodging and leaf blast. Those which had the highest yield also had the longest cycle. The top two varieties were : CICA 8 and ITA 212. They also had the highest panicle count per square meter. Five varieties had yields up to 7 t/ha. CICA 8, ITA 212 and ITA 222 have shown for the past two cropping seasons considerable yield performance and tolerance to diseases . (see table 1)

For the next season, in addition to the routine screening, we will perform some palatability test to draw the final conclusion.

For the segregating population, this trial was initiated in 1988 to incorporate into existing and promising lines/varieties some characteristics desired by the consumers. This year was the fifth generation and we observed many of F-types within the population in such a way that it was not possible to take into consideration certain parameters.

This trial will continue for further purification of the lines.

For the agronomic trial, the treatments have shown a positive effect of straw yield, plant height, plant cycle and paddy yield. (Table 2, 3, 4, 5, 6))

Among all the treatments T_5 yielded the highest with an average of 8 t/ha; thus at Guirvidig (T_5) the highest yield was 8266 kg/ha compared to 8114 kg/ha at Yagoua (Y 20).

In these localities, the lowest grades were registered by the check treatment and this confirms earlier findings that there's a P_2O_5 deficiency in the soils of SEMRY. T_2 which differs from the check only with 45 units of P_2O_5/ha has almost doubled the yield of T_1 , but T_3 shows us also that it is not only necessary to bring Phosphorus but it is also important the way you apply it. This is why the band placement has an increase of almost 500 kg/ha over the broadcast application. T_4, T_5 and T_6 showed how the soil fertility level can be improved by using organic matter.

The trial will be continued in the next cropping season to confirm these results.
The trial on the effect of frequency of phosphate application on irrigated rice will undergo it's 3rd season this year. After this harvest we can begin some analysis.

TABLE I : ADVANCED YIELD TRIAL

VARIETIES	YIELD (T/HA)	CYCLE (DAYS)	PLANTS HEIGHT	NUMBER PANICLE	VERSE	PYRICU-LARIOSE
IR 25 898	6.69 B	144 F	87.5 A	358 B	1	1
CICA 8	7.28 AB	158 AB	87.5 A	431 AB	1	1
ITA 222	7.99 A	154 C	86.21 AB	479 AB	1	1
ITA 212	8.06 A	159 A	82.7 BC	540 A	1	1
HANG-HIEP	7.70 AB	157 B	82.5 BC	500 AB	1	1
CESADANE	7.23 AB	148 E	82.5 BC	416 B	1	1
TOX 3344	6.58 B	150 D	87.2 BC	385 B	1	1
IR 46 T	7.30 AB	148 E	81.0 C	405 B	1	1
Average	7.35	152	84	450		
C. V.	8 %	14 %	12 %	10.1 %		

TABLE II: PLANT HEIGHT (CM)

TREATMENTS	AVERAGE	PPDS 5%
T_5	85.38	A
T_6	84.00	AB
T_2	83.38	AB
T_3	82.75	B
T_4	82.63	C
T_1	77.38	

C. V. 3.5 % L.S.D. 2.439

TABLE III : PANICLE COUNT/M^2

TREATMENT	AVERAGE	PPDS 5%
T_5	376.00	A
T_6	348.25	AB
T_4	326.00	B
T_3	256.00	C
T_2	244.00	C
T_1	194.00	D

C.V. = 13.84 L.S.D = 33.97

TABLE IV: STRAW YIELD KG/HA

TREATMENTS	AVERAGE	PPDS 5 %
T_5	4384.50	A
T_6	3942.25	B
T_4	3557.50	C
T_3	3192.13	D
T_2	2922.75	E
T_1	2576.88	F

C.V. = 7.83 L.S.D. 226.64

TABLE V: G5 PADDY YIELD KG/HA (MAGA)

TREATMENTS	AVERAGE	PPDS 5 %	PPDS 1 %
T_5	8266.75	A	A
T_6	7766.00	B	AB
T_4	7687.00	B	BC
T_3	7459.00	BC	BC
T_2	7150.25	C	C
T_1	4343.75	D	D

C.V. 3.83 L.S.D. = 410.1984 L.S.D. 567.0962

TABLE VI : (Y 20) PADDY YIELD KG/HA (YAGOUA)

TREATMENTS	AVERAGE	PPDS 5%	PPDS 1 %
T_5	8114.50	A	A
T_6	7344.75	AB	AB
T_4	7089.50	BC	B
T_3	7037.75	BC	B
T_2	6633.50	C	B
T_1	4076.75	D	C

C.V. 6.53% L.S.D. = 661.059 L.S.D. 913.9008

3.1.5 VISITORS :

Mr. BENBOW of USAID and the NCRE Chief of Party from Yaounde. We were visited by farmers at our on-farm trial at Maga and Yagoua. Dr. Ekokule, entomologist from Maroua assessed insect problems on our trials at maga and Yagoua. Dr. Takow from Garoua also visited our trials and experimental sites at Maga and Yagoua.

3.2 RICE BREEDING DSCHANG

3.2.1 INTRODUCTION

The 1991 rice research activities were focused on varietal improvement through the development and maintenance of high and stable yielding rice varieties for release to the farmers, along with investigation aimed at determining the effect of management levels on cost of cultivation and yield performance of the promising rice cultivars. The trials were conducted at the main production sites of Mbo Plain in the West Province and Ndop Plain in the North West Province where the SODERIM and UNVDA projects are located. Prior to 1991, the rice research team based in Dschang (West Province) extended its activities to the Lagdo and Maga production zones in the North and Extreme North of Cameroon. From 1991, this team will limit its activities to the Southern rice production zones while a second rice research team based in Maroua (Extreme North Province), will cover the Northern rice production of Cameroon.

The major research goal remains the development of new, high and stable yielding agronomically improved rice varieties with better grain characteristics and with tolerance /resistance to the major diseases such as blast, sheath rot and glum discoloration diseases and to environmental stresses such as low temperatures prevailing during the cropping season. Thousands of lines have been introduced and widely tested and many were identified as breeding lines and few as promising for recommended and adopted varieties for cultivation in each production zone. Agronomic practices have been developed and can now be used by farmers on the released varieties.

The major shift in varietal improvement occured in 1988 with the initiation of a breeding program centered on the development of suitable high yielding varieties from local crosses. Many advanced progeny lines can now be tested for their yield performance in the target ecologies.

3.2.2 SUMMARY OF PROGRAM ACTIVITIES

The search of superior rice varieties for Ndop and Mbo plain continued in 1991 with more emphasis placed on selection of promising segregating genotypes from local crosses. Good selections of fixed lines identified from over 10,000 introductions in the rice growing areas and over 900 F_4 - F_5 segregating lines from local crosses were tested and advanced in various trials and generations in Ndop plain and Mbo plain. The main constraints considered when selecting high and stable yielding varieties are low temperature with associated diseases (sheath rot, glume discoloration) in Ndop plain situated at 1200 m above sea level, and diseases such as blast and leaf scald in Mbo plain (700 m). Varieties with long, slender and translucent grain type are favored during the screening. Such grain characteristics are prefered by local consumers.

Promising varieties with these attributes include TOX 3145, TOX 3344, TOX 3145-TOC 34-3-4, in Ndop plain, ITA 222 in Menchum valley and in Mbo plain. The research effort will be maintained in the breeding program and the number of trials will be kept at least the same as for 1991 in Mbo Plain and Ndop if appropriate funds are made available.

Even though two national Rice Researchers have been selected for further training, two others (one based in Garoua and one in Dschang) are back from USA and will continue on going activities with support of collaborators at the experimental sites.

3.2.3 ACCOMPLISHMENTS

SUB-GOAL	OUTPUTS	ACCOMPLISHMENTS
Operation 1:	Screen germplasm of local and exotic sources for release as variety or as donor in hybridization program, and select new lines from segregating populations.	
1.1 Promising selections for future yield testing or latter use in the breeding program.	1.1 57 new irrigated cold tolerant (IRETN) lines are tested in Ndop plain and 250 accessions (AURON + AURPSS are screened in Mbo plain under upland conditions.	1.1 Seven lines were selected out of 106 lines tested in the cold tolerant Nursery in Ndop (IRCTN, 1991), and 29 selections from AURON and 44 from AURPSS were made under upland conditions at Mbo plain.
1.2 development of new locally created lines.	1.2 868 F_4 - F_5 segregating lines from Ndop plain and Dschang undergo pedigree selections under irrigated conditions in Ndop plains and 59 F_4 - F_5 segregating populations are selected under upland conditions in Mbo plains.	1.2 Over 110 lines from F_4 - F_5 segr egating progenies and 18 segregating populations were selected for further evaluation under irrigated conditions in Ndop and upland conditions in Mbo plain respectively.
Operation 2:	Assess yield potential and test adaptability at different locations.	
2.1 Promising lines for breeding and for future use as variety per se.	2.1 58 irrigated in Ndop plain and 80 upland lines in Mbo plain tested in observational yield trials.	2.1 Twenty two irrigated in Ndop plain and eleven upland lines in Mbo plain were selected from observationa yield trials.
2.2 Selection for advanced yield and elite variety trial.	2.2 16 irrigated varieties in Ndop plain and 16 upland varieties in Mbo plain are compared in replicated variety trials.	2.1 Eight irrigated selections in Ndop and 5 upland selections in Mbo plain will be further evaluated in advanced yield trial 1992.

SUB-GOAL	OUTPUTS	ACCOMPLISHMENTS
2.3 Confirm adaptability and suitability of elite lines.	2.3 12 irrigated promising or recommended varieties for Ndop plain, Mbo plain, Lagdo and Maga are further tested in a national coordinated trial in Ndop plain.	2.3 The locally grown IR 7167-33-2-4 followed by Tox 3145-34-3-2 outyielded all other varieties.
Operation 3:	Assess the yield potential of elite varieties under farmers' conditions, and assess the farmers choice.	
3.1 Evaluate adaptability, yield potential of promising selections under farmers' managed conditions.	3.1 Two sets of 5 promising varieties are replicated in large plots in 10 farmers' fields under irrigated conditions in Ndop plain and in the Mentchum Valley.	3.1 A set of five varieties being evaluated in five farmers field in Ndop plain will be harvested by January 30th.
Operation 4:	Produce breeder's seed of recommeded and promising elite lines.	
4.1 Availability of pure genetic stock of elite lines and varieties.	4.1 Activities still to be carried out in Mbo plain irrigated conditions with the elite varieties from Mbo plain, Ndop plain.	4.1 Activity to be carried out in Mbo plain in early 1992.
Operation 5:	Determine the effect of management levels on the costs of cultivation and yield performances of selected rice cultivars.	
5.1 Evaluate varietal yield performances as affected by managemant levels.	5.1 The trial is being carried out under irrigated conditions in Ndop plain.	5.1 The trial is harvested and the data available.
5.2 Estimate the costs of production and benefit cost ratio at each management level.	5.2 The estimates will be available after harvest.	5.2 Estimates are not yet finished.

2.3.4. RESEARCH FINDINGS

The findings reported are based on results from Upland Rice experiments conducted at Mbo plain (West) and irrigated rice experiment conducted in Ndop plain (North West). In Mbo plain the irrigated experiments initially planned from 1991 (July - December) will be conducted in 1992 (January - June).

3.2.4. Methodology

The cultural practices adopted during 1991 were similar to that of previous years with a slight modification of some procedures due to budget constraints. The procedures for the trials reported were as follows: observational nurseries (ONs) were established in single plots of two to four rows of 5 meters long; observational yield trials (OYTs) were conducted in single plots of 2 to 3 meters x 5 meters. Test entries in ONs and OYTs were each planted in single plots and check entries were replicated after every ten entries which allowed for better comparisons. All replicated trials were conducetd in randomized complete block design (RCBD) with four replications, each plot size being 3m x 5m. Because of the budget limitation the early and medium duration varieties were grouped in one OYN under upland conditions and preliminary and advanced yield trials were put together under variety trial (VYT). Under irrigated conditions, seeds were raised on wet bed nurseries which were treated with Nitrogen fertilizer only, at the rate of 60 kg/ha (N). Twenty - one to twenty - five day - old - seedlings were transplanted at the rate of 1 - 3 seedlings per hill spaced 25 cm x 25 cm for F^1 plants and segregating population and 25 cm x 15 cm for other trial. Fertilizers were applied at 60 kgN, 40kg P_2O_5 and 40 kg K_2O per hectare. P_2O_5 and K_2O_5 were applied as basal and N in 3 equal splits at the vegetative phase. Hand weeding was done between 20 - 30 days after transplanting. No protection against insect pests and diseases was done.

Under rainfed upland conditions the seeds were drilled in rows 25 cm apart at the rate of 70 kg/ha. A complete fertilizer was applied at 60 kg N, 80 kg P_2O_5 and 40 kg K_2O. P_2O_5 and K_2O were applied as basal and N was applied in 3 splits at the vegetative stage. Weeding was done manually (permanent workers) and no pesticide was used.

At harvest two border rows were removed along all four sides of the yield plots. Weight and moisture content of grain were recorded and yield calculated in kilograms per hectare at 14 percent moisture content. Resistance to blast, brown spot, leaf scald, sheath rot, glume discoloration, tolerance to low temperature, time of 50% flowring, time of maturity, height and grain type were also recorded.

3.2.4. Results

3.2.4. Upland rice: mbo plain (700m)
3.2.4. Observational nurseries

New introductions screened in observational nurseries (ONSs) in 1991 were obtained through INGER-AFRICA. Two nurseries were tested:

AURPSS.

The entries in the African Upland Rice Preliminary Screening Set were tested against IRAT 79 as check variety and 44 entries with acceptable resistance/tolerance to diseases and good phenotypic acceptability were selected further evaluation in OYT in 1992.

AURON.

The lines in African Upland Rice Observational nursery were also tested against IRAT 79 as check. Twenty nine lines with acceptable resistance/tolerance to deseases and good grain qualities were selected for testing in OYT 1992.

OBSERVATIONAL YIELD TRIAL

Seventy entries were compared to two local checks (M_{35} and IRAT 10) in an observational yield nursery. In general the incidence of leaf and neck blast and leaf scald were moderate. Brown spot and glume discoloration had limited incidence. Twelve lines were selected for variety yield trial because of good yield, acceptable grain quality and good phenotypic acceptability scores (Table 2).

Table 1: Number of entries and selections from various INGER-AFRICA nurseries screened under rainfed upland conditions at Mbo plain during 1991 wet season.

Nursery	date of seedling	number of entries	number of selections
AFRICAN upland rice			
preliminary screening set (AURPSS) - 1991	16-5-91	150	44
AFRICAN upland rice observational nursery (AURON) - 1991	10-5-91	100	29
TOTAL		250	73

Table 2: Performance of the top twelve entries and the check variety early and medium duration observational yield trial conducted under upland conditions at Mbo plain 1991 wet season.

Entry	grain yield (kg/ha)	50% flower (days)	Reaction To (0-9) **				
			Leaf blast	Neck blast	Brown spot	Leaf scald	Grain type
WABIS 7	2850	92	3	3	1	3	L
B 36 22F-TB-14-2	2200	89	3	3	1	1	M
B 3622F-TB-14-4	2200	89	3	3	1	3	L
B Au-180-61-18	2150	82	3	3	1	3	M
UPL RI 7	2130	92	5	3	1	3	L
CNA 6650	2110	94	3	3	1	3	L
ROK 16	2110	94	3	3	1	3	L
ITA 162	2010	89	2	5	1	5	L
B 8906F-13-13-ST-37	2000	82	2	3	1	3	L
Tox 1768-3-1-1-101-1	1945	95	3	3	1	3	L
TGR 78	1835	92	3	3	1	3	L
ITA 186	1775	95	3	3	1	5	L
M 55	1565	92	2	3	1	5	ML
IRAT 10	783	70	3	3	1	5	SH
Mean of 70 entries	1354						

* Check varieties - Mean of 4 entries in replicated plot.
** Scoring for diseases based on standard evaluation system for rice, IRRI-1988
Grain type: long (L) ; Medium (M) ; Short (SH).

3.2.4. Variety yield trial african upland rice advance trial (aurat - 1991)

This trial is an international collaboration trial with INGER-AFRICA. Fifteen entries in this trial were tested against IRAT 79 as local check. Five varieties (Tox 1739-101-4-2, ITA 120, IRAT 147, TGR 78 and Wabis 675) gave higher yields than the local check (1481 kg/ha). All varieties had yields ranging from 225 kg/ha to 2191 kg/ha. All varieties had a moderate to high incidence of leaf scald and a low incidence of blast. There was an important infestation of weeds in this trial which to reduced the yields of the unadapted exotic germplasm (table 4).

Variety Yield Trial Duration (120-135 days)

Fourteen early duration varieties were tested against IRAT 10 as local check. As in previous years the highest yielding was UPL 41-7 with a yield of 2773 kg/ha followed closely by IRAT 104 and wabis 7 which yielded 2737 kg/ha and 2706 kg/ha respectively. The check variety which matures very early was damaged by birds and had the lowest yield, 832 kg/ha. Weed infertation was high in this trial and significanly reduced the yields (Table 3). All varieties showed a moderate resistance to Leaf and Neck blast, and a high resistance to glume discoloration. Five top yielding varieties will be tested in advanced yield trials early in 1992.

Table 3: Performance of entries in short duration variety yield t l conducted under upland conditions at Mbo plain during 1991 wet season.

Entry	grain yield (kg/ha)	plant height (cm)	50% flower (days)	Reaction To (0-9) **			
				Leaf blast	Neck blast	Leaf scald	brown spot
UPL 41-7	2.772		94	3	3	1	1
IRAT 104	2.737		99	2	3	5	1
Wabis 7	2.706		95	3	3	5	1
IRAT 216	2.440		89	3	3	3	1
IRAT 284	2.299		79	3	3	3	1
Wabis 560	2.202		96	3	3	3	1
ITA 321	1.975		95	3	3	3	1
ITA 301	1.633		93	2	3	5	1
ITA 120	1.604		69	2	3	3	1
IRAT 170	1.516		94	3	3	3	1
IDSA 10	1.366		74	3	3	3	1
ITA 135	1.300		91	3	3	3	1
IDSA	0.979		94	3	3	5	1
IRAT 112	0.946		73	3	3	5	1
IRAT 10*	0.832		72	2	3	5	1
Mean of 15 entries	1.820						
L.S.D. (5%)	0.732						
C.V. (%)	28						

* Check varieties - Mean of 4 entries in replicated plot.
** Scoring according to the standard Evaluation system of rice, IRRI, 1988.

Table 4: Performance of entries and the check variety in African upland rice advance trial conducted under upland conditions at Mbo plain during 1991 wet season. season.

Entry	grain yield (kg/ha)	plant height (cm)	50% flower (days)	Reactions To (0-9) **			
				Leaf blast	Neck blast	Leaf scald	brown spot
Tox 1739-101-4-2	2191		79	2	3	5	1
ITA 120	1954		76	2	5	5	1
IRAT 147	1856		83	2	3	5	1
TGR 78	1726		94	2	3	5	1
Wabis 675	1587		93	2	3	5	1
IRAT 79*	1481		88	2	3	5	1
ITA 143	1293		87	3	3	5	1
ITA 132	1234		85	2	3	5	1
Tox 1012-12-28	1171		83	3	3	5	1
IDSA 17 (IRAT 306)	1037		80	2	3	5	1
Tox 1010-2i-5-12-4	1012		83	2	3	5	1
ITA 130	964		93	3	3	5	1
IDSA 13 (IRAT 265)	746		76	2	3	5	1
IRAT 314 (7441)	409		74	2	3	5	1
TGR 94	225		74	2	3	5	1
Tox 1011-4-A2	173		73	2	3	5	1
Mean of 16 entries	1191						
L.S.D. (5%)	437						
C.V. (%)	50						

* Check varieties.
** Scoring for diseases based on standard evaluation system for rice, IRRI, 1988.
Evaluation system of rice, IRRI, 1988.

3.2.4. Irrigated Rice - Ndop Plain (1200 m)

The rice breeding program objectives in Ndop plain remained unchanged in 1991 and consisted of developing agronomically improved varieties with sturdy culm, lodging resistance, high tillering with good grain qualities and tolerance/resistance to low temperature, blast sheath rot and glume discoloration. Two observational nurseries, and three yield trials were conducted and segregating populations were evaluated.

3.2.4. Varietal Introduction Observational Nursery International Rice Cold Tolerant Nursery (irctn 1991)

This is an international collaborative trial with INGER-AFRICA and consisted of 106 entries that were sown in an observational nursery in Ndop plain. This site is subject to shallow flooding and low air/water temperature during the growing season. This environmental condition subjects the entries to low temperature stress from transplanting to harvest, with subseaquent diseases such as sheath rot, glume discoloration and spikelet sterility. Only seven entries had good acceptability scores and were selected for further testing in observational yield trials 1992.

3.2.4. Yield Trials of Promising/Varieties/Lines

In continuation with the testing of advanced lines/varieties selected in previous years, one observational nursery, one variety yield trial and one national coordinated variety trial were conducted during 1991.

Observational Yield Trial (oyt)

During 1991, 57 lines selected from F_4 - F_5 progenies of local crosses carryed out in Dschang and Ndop plain and screened in Ndop plain ecology were compared to Tainan V IR 7167-33-2-3 as local check in an observational yield trial. Yields of these entries ranged from 1943 kg/ha for TOC6N3 to 6216 kg/ha for TOC13N5. The two local checks were out yielded by over thirty entries which showed moderate to high incidence of sheath rot (1-3), leaf and Neck blast (2-5), good resistance to lodging (c) and a high tillering ability (3-5) (table 5). Twelve of these entries with yields above 4500 kg/ha will be tested in preliminary yield trial 1992.

Variety Yield Trial

Fourteen selections of medium duration (135-150 days) and late duration (above 150 days) were tested against two local checks IR7167-33-2-3 and Tainan V in a replicated variety trial. Five of the lines were selected from observational yield trial (OYT-1990), nine from advanced yield trial (AYT-1990) one from preliminary yield trial (PYT-1990) and one from head row selection (HRS-1990) (Table 6). The check variety IR7167-33-2-3 came second with an average yield of 5334 kg/ha. It was outyielded by Tox3145-3-3-2 which yielded 5554 kg/ha. This check was followed by IR2061-52[illegible] 6-9 (5116 kg/ha). Overall 5 varieties including IR7167-33-2-3 made over 5000 kg/ha. The advanced line Tox3145 IR-34-3-3-2 recently advanced from observational nursery 1990, has comparable grain qualities compared to Tox3145-34-3-2 now multiplied by UNVDA (long, slender and translucent grain). An advantage of Tox3145-3-3-2 over Tox3145-34-3-2 is a more homogeneous flowering.

National Coordinated Variety Trial

The results of the national coordinated variety trial are shown on table 7. Only two varieties had yields above 5000 kh/ha : IR7167-33-2-4 (5413 kh/ha) and Tox3145-34-3-2 (5201 kg/ha). These two are actually recommended for general cultivation in Ndop plain (UNVDA).

3.2.4. Breeding Programme

The breeding program was initiated in 1988 to incorporate desirable characteristics such as suitable agronomic traits good grain properties and resistance/tolerance to low temperature and blast into already identified improved varieties.

Table 5: Performance of the top eighteen entries in observational yield trial conducted under irrigated conditions at Ndop plain during 1991 wet season.

Entry	grain yield (kg/ha)	plant height (cm)	50% flower (days)	Reactions To (0-9) **			
				Leaf blast	Neck blast	Leaf scald	brown spot
TOC 13N5	6216	70	127	3	3	3	3
TOC 12N1	5784	88	129	3	3	1	1
TOC 9N12	5403	80	105	5	3	3	5
TOC 12N7	5118	82	117	3	3	3	3
TOC 12N6	5006	77	122	3	3	3	1
TOC 12N4	4954	80	117	3	3	5	1
TOC 12N3	4943	78	119	4	3	5	3
TOC 9N9	4928	85	106	3	3	3	3
TOC 11N3	4756	82	122	3	3	3	3
TOC 13N9	4729	70	124	3	3	3	3
TOC 11N4	4545	80	122	3	3	3	3
TOC 4N1	4545	80	113	3	3	5	3
TOC 12N2	4487	84	119	4	3	3	5
TOC 12N8	4478	72	124	2	3	3	3
TOC 5N1	4390	67	107	3	5	3	1
TOC 12N9	4370	72	125	3	3	3	3
TOC 9N8	4341	78	104	3	3	3	3
TOC 13N7	4182	77	126	3	1	1	3
IR 7167-33-2-3*	3624	84	120	5	3	3	1
TAINAN 5*	3326	88	121	2	1	1	1
Mean of 20 entries	4706						

* Check varieties.

** Scoring based on the IRRI standard evaluation systen for rice 1988.
TOC - tropical oryza Cameroon. Cameroon nonenclature for varieties developed in the country.

Table 6: Performance of entries in variety yield trial conducted under irrigated conditions at Ndop

Entry	grain yield (kg/ha)	plant height (cm)	50% flower (days)	Reactions To (0-9) **			
				Leaf blast	Neck blast	sheath rot	glume disc.
TOX 3145-34-3-3-2	5554	84	120	3	3	3	3
IR 7167-33-2-3	5334	86	110	5	3	1	1
IR 2061-522-6-9	5116	97	110	3	5	3	3
IR 15579-135-3	5090	98	111	3	1	1	1
TOX 3145-38-2-3	5015	77	118	3	3	3	3
B 2881 F-SR-62-5	4769	78	115	5	5	3	3
TOX 3145-34-3-3	4758	87	115	5	1	3	1
TOX 3145-15-2-1	4722	82	119	5	3	3	1
TOX 3145-34-3-3-1	4722	87	122	4	3	3	1
TOX 3344-34-3-2	4567	115	118	5	1	1	3
TOX 3145-34-2-3	4504	80	111	3	3	3	1
TOX 3145-34-3-1	4369	81	120	5	3	3	1
TOX 3145-34-3-3-3-1	4045	78	106	3	3	3	1
TOX 3145-34-3-4	3822	87	122	3	3	3	3
TAINAN V	3329	88	108	3	1	1	2
TOX 3144-2-4-1-1-4	2827	86	138	3	3	3	5
Mean of 16 entries	4533						
L.S.D. (5%)	376						
C.V. (%)	12.0						

* Check variety
** Scoring based on the IRRI standard evaluation system for rice, 1988.
Disc. Discooration.

Table 7: Performance of enties in national coordinated variety trial conducted under irrigated conditions at Ndop plain during 1991 wet season.

Entry	grain yield (kg/ha)	plant height (cm)	50% flower (days)	Reactions To (0-9) **			
				Leaf blast	Neck blast	sheath rot	glume disc.
IR 7167-33-2-4	5413	90	109	3	3	1	1
TOX 3145-34-3-2	5201	86	119	3	3	3	1
RNR 29692	4843	115	113	2	1	1	1
KAUSHUING SENYU	4721	86	111	2	3	3	3
BKN 7033-3-3-2-2-3	4703	83	115	3	3	3	1
B 2161-C-MR 57-1-3-1	4594	100	115	4	3	1	1
B 29838 -SR-51-1-2-3	4580	95	117	3	3	1	1
TOX 3344-34-3-2	4365	112	128	3	3	3	3
IR 7167-33-2-3*	4350	92	109	3	3	1	1
ITA 222	4342	67	119	2	3	3	3
CICA 8 4	4241	68	118	3	3	3	1
NANG NG HIEP 75.5	3926	70	116	3	3	5	1
IR 46	3884	87	116	3	3	5	3
CISADANE	3848	80	118	5	3	1	1
TOX 3344-3-4-1	3774	102	125	3	3	3	3
ITA 308	3582	68	117	3	3	3	3
ITA 212	3565	68	113	3	3	1	3
TAINAN V *	3124	86	111	3	1	0	1
Mean of 18 entries	4283						
L.S.D. (5%)	908						
C.V. (%)	14						

* Check variety

** Scoring based on the IRRI standard evaluation system for rice, 1988.

Segregating Population

A total of 868 F_4 -F_5 segregating lines from Ndop plain and Dschang were evaluated during 1991 season in Ndop. One hundred and fifty individual plant selections corresponding to one hundred and ten populations were made and advanced to the next generation. Thirty nine fixed populations were bulk harvested and will be promoted to observational yield trials in 1992.

Reference

IRA/NCRE Annual report, 1990 (Rice Breeding Unit).

TOC - tropical oryza Cameroon. Cameroon nomenclature for varieties developed in the country.

4. CEREALS AGRONOMY

4.1 INTRODUCTION

The NCRE Cereals Agronomy Research Unit has as primary responsibility to conduct agronomic research on maize in the three provinces of North Cameroon, and on sorghum in two provinces (North and Adamaoua). Since its creation in 1982, this Unit has devoted 70% of its research efforts to maize agronomy and 30% to sorghum Agronomy. In Northern Cameroon (6 to 13° latitude North, 160 000 kms²), the maize area under traditional and intensive cultivation is estimated to be around 70 000 hectares while the total area under sorghum production is estimated to be around 430 000 hectares.

The main goals of this research program are : a) to identify and alleviate the main agroclimatic and management constraints to cereals production in the major cereals - growing zones of the mandated area of Northern Cameroon ; b) to develop improved and adapted packages of agronomic practices for maize and sorghum and for sustainable cereals - based cropping systems. The researchers of this Unit conducted during the last 9 years more than 400 field trials at 8 different IRA antennas and on farm trials on maize and sorghum agronomy. The main research subjects during that time included : fertilization management, crop establishment, land preparation, plant population densities, planting dates, variety testing, weed management, intercropping and graded steps of improved technologies. A lot of progress regarding several research subjects has been accomplished. Many varieties and agronomic practices have been extended to the farmers by our team in cooperation with the development and extension agencies.

In recent years, soil degradation and Striga have become major constraints which constitute a threat to the sustainability of the cereals - based cropping systems. It was decided during NCRE phase III, to emphasize agronomic research aimed at developing appropriate conservation farming technologies and Striga Control on maize and sorghum particularly in the Subhumid lowland savanna of Northern Cameroon.

4.2 SUMMARY OF PROGRAM ACTIVITIES

A- The Researchers of the NCRE Cereals Agronomy Unit participated in the following activities in 1991:

The IRA/North Planning Meeting held at Maroua in January 1991; an agronomy Seminar on "low input technology" held at IITA and organized by SAFGRAD/IITA; the Workshop of the SAFGRAD networks held in March in Niger; the IRA/MINAGRI/SODECOTON Planning Meeting held at IRA/Garoua in March 1991 ; The Workshop of the SAFGRAD Agronomy Network held in May 1991 in Burkina Faso ; the Fifth International Symposium on Parasitic Weeds and the Second workshop of the Pan African Striga Network held in Kenya in June 1991.

We organized 6 different training field days on maize and cowpea production and utilization, conservation farming technologies, improved fallow management and alley cropping from September to December 1991 for different groups of farmers and extension agents of SODECOTON and Projet Nord Est Benoué. We organized one field day and one "maize and cowpea utilization" day for IRA/North researchers. Both counterparts left for long term training in the USA Mr. A EBETE for an M.Sc. degree at the University of MISSISSIPPI in August 1991 and Mr. T. NGOUMOU for a Ph. D. degree at Cornell University in December 1991.

B- The following technical papers and reports were prepared by our Unit and some were presented at different meeting.

We have prepared in French (then translated into English) 4 production guides "fiches techniques" for the maize varieties CMS-8501, TZPB-SR, CMS-8704, SHABA, CMS-8806, and CMS-9015. These varieties have been and are being extended to the farmers in the 3 provinces of Northern Cameroon. These "fiches techniques" were distributed to more than 200 farmers and extension agents.

We prepared a special report on our 1990 Striga research (30 pages). We have also written 3 technical papers which were presented at different workshops.

4.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: On-farm Tests and Demonstrations with Conservation Farming Technologies in the subhumid lowland savanna.		
1.1. To develop appropriate and profitable minimum tillage systems in farmers fields in the lowland subhumid savanna of North Cameroon.	1.1 On-farm tests (with 2 replications) involving fertilization and alley cropping with maize and cowpea under minimum tillage systems.	1.1. Twelve on-farm tests and demonstrations were conducted and harvested in 5 villages of the West and South East Benoue regions.
Operation 2: To develop agronomic practices for improved and sustainable maize and sorghum - based cropping systems in the lowland savanna.		
2.1. To identify appropriate crop rotations and improved fallow management systems in the lowland savanna of North Cameroon.	2.1 On-farm replicated experiments on crop rotation cereals/legume crops (grain and green manure).	2.1. Four experiments on crop rotation were conducted and harvested at Djalingo.

Objectives	Activities	Accomplishments
2.2. To evaluate the impact of several interplanted legume/cereals, and alley cropping systems in maize and sorghum yield in the lowland savanna.	2.2 On-station and on-farm replicated agronomic trials testing several intercropping patterns with and without alley cropping systems.	2.2. Five experiments on interplanted cereals/legumes and alley cropping were conducted and harvested at Djalingo.
Operation 3: To develop agronomic practices to alleviate Striga constraints on maize and sorghum in the lowland subhumid savanna of North Cameroon.		
3.1. To evaluate the differential impact of trap crops against Striga on maize and sorghum.	3.1 On-farm replicated experiments with 7 trap crops on maize and sorghum.	3.1. two trap crop experiments were conducted and harvested at Karité.
3.2. To evaluate different methods of Striga control on maize and sorghum.	3.2 On-farm replicated experiment with maize and sorghum.	3.2. Six experiments on Striga were conducted and harvested at Karité and Djalingo.
Operation 4: To help extend tested agronomic technologies to the extension agents and the farmers of the region.		
4.1. To communicate research results and provide technical assistance to the extension agents, farmers and other agricultural agencies	4.1 Preparation of production guides on maize and technical papers on our research results ; conduct training field days on production and utilisation.	4.1 Four production guides were prepared (in French and in English) related to 5 maize varieties being extended to the farmers. Three technical papers prepared and presented in regional scientific meetings. Five training days organized for farmers.
4.2. Provide improved varieties to extension agents and farmers.	4.2 Tests with newly available maize varieties.	4.2 More than 700 farmers tested 2 maize varieties used as "compound crop for hunger period".

4.4 RESEARCH FINDINGS

4.4.1 On-farm testing and demonstration with minimum tillage for sustainable cropping systems in the subhumid lowland savanna.

Response of maize to different N fertilizer rates under a minimum tillage system in farmers' fields in the subhumid lowland savanna of North Cameroon.

A set of on-farm trials involving N fertilization and minimum tillage was conducted during the 1991 cropping season. The main objectives of this experiment were : a) to determine the response of maize to different N fertilizer rates under a minimum tillage system in 13 farmers' fields located in the West and South East Benoué regions ; b) to evaluate the performance of the newly available maize variety CMS-8704 in different agroecological zones under farmers' conditions ; c) to introduce a system of alley cropping with pigeon peas hedgerows in farmers fields.

The ultimate goal of this research is to develop practical and appropriate conservation farming technologies in order to achieve and sustain relatively good and stable cereals yields in the lowland savanna. It was decided to intensify the on-farm trials with minimum tillage after the successful testing of this conservation technology on-station and in farmers' fields in previous years.

Regarding N fertilization, experiments conducted by our team in farmers' fields indicated that there is a differential response of N fertilizer under conventional tillage as compared to minimum tillage. The reasons of this observation are not completely understood. As the studies conducted by our team on N response to maize was conducted mainly under conventional tillage, there was a need to determine the N response under a minimum tillage in a multilocational experiment.

The minimum tillage system used in this experiment involved no land preparation with mechanical implements. Only a total herbicide (Paraquat 4 l/ha) was applied at planting time in combination with the pre-emergent herbicide used by the farmers (Primextra 3 l/ha). Animal traction with ridger was used once during the cropping season for earthling up of the soil after application of sidedress urea about one month after maize emergence. A mulch was made with the weed residues that were killed by the total herbicide at planting.

All the plots except the absolute check received the fertilizer rate recommended by SODECOTON and commonly used by the farmers' (84 N + 20 P_2O_5 + 15 K_2O + 6S kgs/ha). The treatments consisted of 4 rates of N (0, 12, 24, 48 kgs N/ha) which were applied as urea sidedress application about one month after planting.

Maize variety CMS-8704 a newly available yellow grain with high yield potential- was used as test crop. The tests were carried out in 13 sites located in 6 villages in the West and South Benoue regions. A RCBD was used with 2 replications per site (method - bloc disperses). Finally a system of alley cropping with pigeon peas as hedgerow was used in an effort to introduce this system to the farmers on an observational basis and get their feedback. Treatments and partial results are shown table 4.4.1.

TABLE 4.4.1 ON-FARM TESTING : RESPONSE OF MAIZE CMS-8704 TO DIFFERENT N RATES UNDER A MINIMUM TILLAGE SYSTEM IN 12 FARMERS' FIELDS LOCATE IN THE SUBHUMID LOWLAND SAVANNA OF NORTHERN CAMEROON (1991) (MAIZE GRAIN YIELD T/HA)

TREATMENTS	DJALINGO I	DJALINGO II	DJALINGO III	DJALINGO IV	SANGUERE I	SANGUERE II	WINDE	NGONG	ZOUAYE	LABOUN	RAINA I	RAINA II	AVERAGE
- Fert.	3.30	1.15	0.99	1.37	1.01	1.12	1.59	3.56	0.79	0.32	0.58	1.21	1.42
+ Fert.	4.54	2.74	3.09	4.42	1.93	1.69	3.52	4.71	2.51	0.89	2.33	2.51	2.91
+ Fe + 11 kg N/ha	5.04	3.55	4.13	5.03	2.27	2.21	4.11	5.86	3.16	1.28	2.96	2.89	3.56
+ Fe + 22 kg N/ha	5.49	3.75	4.24	5.98	2.66	2.64	4.60	6.38	4.18	1.95	3.47	3.11	4.04
+ Fe + 44 kg N/ha	5.75	3.84	5.22	6.48	3.17	3.56	5.19	7.0	5.65	2.43	4.51	3.90	4.73
Average	4.82	3.0	3.53	4.65	2.21	2.24	3.8	5.5	3.26	1.38	2.77	2.72	3.32

F_{TRT} = H.S.; C. V. = 8%.; $L.S.D._{TRT}$ = 0.158 T/HA.; F_{LOC} = N.S.; $F_{LOC \times TRT}$ = H.S.;

Note : These trials were conducted in farmers fields (1250 m^2 each one) located in the West and south East Benoue regions in cooperation with the development agents. Fe = Fertilizer rate recommended to the farmers by SODECOTON for maize (84 N + 20 P_2O_5 + 15 K_2O + 6 S) kg/ha.

It was found among other things that growth of maize variety CMS-8704 was relatively good in most locations. One trial was abandoned at Djalingo because of severe infestation of insects (Spodoptera spp) which significantly damaged the seedlings. In the sector of Tcholliré, the maize plants were negatively affected by a moderate incidence of Striga. In general maize grain yields can be considered relatively good. This variety seemed well adapted to this minimum tillage system in these different agroecological zones. Farmers appreciated it well and requested seeds of this variety.

This experiment demonstrated once more that a reasonable yield can be obtained in farmers' fields under a minimum tillage system in the lowland savanna of North Cameroon. The average grain yield of maize was 3.32 t/ha with the maximum yield 5.5 t/ha obtained at Ngong. The lowest yield (1.38 t/ha) was obtained at Laboun where serious damage of Striga occurred.

As expected, there was a significant response to the additior of N fertilizer. In general, maize grain yield increased steadily as N rates increased in all the locations. As compared to the second check (rates used by the farmers) an extra yield of up to 1.82 t/ha, (62 %) was recorded. On the average it was found that : one kg of N was associated with an extra grain yield of 54 kgs between the rates (0 12 kgs N/ha) with an extra yield of 40 kg of grain between the rates (11 - 22 kgs N/ha) and an extra yield of maize grain of 28.8 kg N/ha between the rates (22 44 kgs N/ha).

Maize grain yields varied significantly according to locations. However, the interaction of N treatment and locations was not significant which would imply the N responses did not vary significantly with location in this experiment.

Regarding the alley cropping, the pigeon peas growth was considered satisfactory when planted early in June. The mulch produced under the canopy helped smother weeds. Farmers reaction was, in most cases, positive and appreciated the fact that pigeon peas produce marketable grain and stakes that can be used for firewood. Pigeon peas recycle nutrients and fix N. Most farmers showed interest in testing this system if proper technical assistance is available to them.

4.4.2 Research on multipurpose legume species for sustainable cropping systems in the subhumid lowland savanna.

4.4.2a - Response of maize and sorghum to interplanted forage legume in the subhumid lowland savanna.

This long-term experiment which started in 1991 involved the use of 4 legume forage species : Canavalia ensiformis, Stylosanthes hamata, Calopogonium mucunoides and Cajanus cajan. Maize variety CMS-8704 and sorghum CS-95 were used as test crop in this study. The legume species were planted at the same time as maize and sorghum using a pattern of 2 rows of cereals for 1 row of legumes. The spacing between maize rows was 1 m. The experiment was carried out on a representative Alfisol and moderate amount of fertilizer was used. This system of interplanted fallow cereals/legumes was used in an effort to increase the economic value of the system and make it more attractive to the farmers.

The main objectives of this experiment were: a)to study the performance of maize and sorghum grain in interplanted fallow systems with forage legume species in a representative Alfisol of subhumid lowland savanna; b) to develop sustainable and profitable systems of cereals (for human consumption) and forage (for livestock) while improving soil properties on Alfisols of this region (integration crop/livestock).

Treatments and results are shown in table 4.4.2a :

TABLE : 4.4.2a RESPONSE OF MAIZE AND SORGHUM TO INTERPLANTED FORAGE LEGUMES ON YIELD OF MAIZE AND SORGHUM IN THE LOWLAND SAVANNA, DJALINGO 1991

TREATMENTS MAIZE OR SORGHUM	MAIZE CMS-8704 GRAIN YIELD T/HA	RGY%	SORGHUM CS-95 GRAIN YIELD/THA	RGY %
1) Interplanted with Calopogonium mucunoides	5.33	95	1.79	90
2) Interplanted with Stylosanthes hamata	5.50	98	1.85	93
3) Interplanted with Canavalia (Ensiformis)	5.27	94	1.69	85
4) Interplanted with pigeon peas (Cajanus cajan)	5.29	94	1.87	94
5) Mococrop	5.63	100	2.01	100
Average	5.40		1.84	

For Maize : F_{TR} = N.S. C.V. = 6% ; For Sorghum F_{TR} = N.S. C.V. = 17%

Maize growth was moderately affected by 2 long dry spells which occurred in June and July. However grain yield was relatively good. There were no significant differences among the treatments for maize as well as for sorghum. The average grain yield decrease with respect to the check (monocropping) was about 4% for maize, while in the case of sorghum it was 9%. Canavalia exhibited a relatively fast growth rate which could create a strong competition for the maize plants while Stylosanthes was relatively slow in the initial growth period. It seems that the pattern of interplanting used with wide interrow allowed for good light penetration and good growth of both crops. Observations made in the maize trial seem to indicate that a better time to plant these legume species would be about 2 3 weeks after planting maize. This relay system could reduce plant competition in case of severe dry spells or erratic rainfall patterns.

The observation made on this trial confirm that these legume species are well adapted to the agroclimatic conditions of the sudan guinea savanna as well as to interplanted fallow systems. A significant amount of biomass (high quality forage) was produced by each one of these legume species. When harvested about 45 days after harvesting maize, the average dry matter produced by theses legumes species are : a) for Calopogonium, was 3 t/ha ; b) for Stylosanthes 4.3 t/ha ; c) Canavalia 8.1 t/ha ; and d) pigeon peas 8.75 t/ha : It is also interesting to note that Calopogonium and Stylosanthes, leaves were looking dry at late November while Canavalia and pigeon peas stayed green longer. The beneficial effect of these multipurpose legume species included a) production of mulch which protects soil against erosion and favor infiltration ; b) recycling nutrient elements ; c) fixing N d) production of high quality forage; and e) smother weeds. The pigeon peas produce reasonable amounts of grain for human consumption. More research be conducted in 1992 to evaluate the carryover effects of these leguminous crops. Minimum tillage will be used in this experiment using the mulch produced by these legume species.

4.4.2 Response of Maize and Sorghum to Interplanted Grain Legume Species in the Subhumid Lowland Savanna.

This study which was initiated at Djalingo in 1991 was conducted on an Alfisol of the lowland savanna. It involved the use of cowpea, pigeon peas, a mixture of pigeon peas plus cowpea, Crotalaria (improved fallow) and monocrop. The planting patterns used were 2 rows of maize (or sorghum) with 1 row of legume species. The interrow spacing between maize was 1 meter. A moderate level of fertilizer was used. The test crops in this experiment were CMS-8704 and CS-95. They were planted at the same time with the legume crops. The main objective of this study was to evaluate the performance of maize grown in an interplanted system with grain legume crops in this agroecological zone.

There were significant differences among treatments. Contrary to the forage legume experiment, the monocropping treatments outyielded significantly the interplanted treatments. In the case of maize, yield reduction varied between 24% (1.4 t/ha) for the mixture of (cowpea and pigeon peas) and 2% for Crotalaria (0.12 t/ha). For sorghum, yield reduction varied between 23% (0.44 t/ha) to 11% (0.19 t/ha). This severe yield decrease could be partly attributed to the plant competition along with the dry spells during the first part of the

season. The association with Crotalaria exhibited less competition while the mixtures of pigeon peas plus cowpeas had the greatest competition causing greater yield loss. It is interesting to note the competition due to the grain yield was greater than that due to the legume forage crops used in the previous experiment.

table: 4.4.2b Response of maize and sorghum to interplanted grain legume crops in the lowland savanna, djalingo (1991).

TREATMENTS MAIZE OR SORGHUM	MAIZE CMS-8704 GRAIN YIELD T/HA	RGY %	SORGHUM CS-95 GRAIN YIELD T/HA	RGY %
1) Interplanted with pigeon peas	4.85	83	1.61	89
2) Interplanted with cowpea	5.29	90	1.34	74
3) Interplanted with Crotalaria	5.75	98	1.59	88
4) Interplanted Pigeon peas + cowpea	4.46	76	1.36	76
5) Monocrop.	5.87	100	1.80	100
Average	5.24		1.54	

For Maize : F_{TRT} = H.S. ; C.V. = 7.5% ; L.S.D. $_{TRT}$ = 0.58 T/HA
For Sorghum : F_{TRT} = H.S.; C.V. 9% L.S.D.$_{trt}$ = 0.25 t/ha

4.4.2 Effects of Different Sustainable Agronomic Technologies On Maize and Cotton performance in the Lowland Savanna.

This long term study which started in 1991 involved 2 trials (one hectare each one): one with maize and the other with cotton grown in a rotational pattern. The sustainable technologies tested on both crops were; a) the use of interplanted fallow (with Canavalia ensiformis) ; b) the use of alley cropping with pigeon peas as hedgerow ; c) a combination of both technologies ; d) a check (normal practice by the farmers). The test crops used in the experiment were 2 varieties of maize CMS-8806 (a medium cycle variety) and CMS-8704 (a long cycle variety) and cotton variety IRMA. In this report, only the maize yields are reported. The hedgerow of pigeon peas was every 6 rows of maize. Treatments and partial results are shown in the table 4.4.2. In the interplanted pattern with Canavalia the same pattern was used as previously described. Growth of both maize varieties was good. There were significant yield differences between both varieties. CMS-8704 produced on the average an extra yield of 1.64 t/ha (40%) which could indicate that the variety CMS-8704 seems better adapted to the competition involved in both systems. This may be due to the fact that CMS-8704 has drought tolerant characteristics and more vigor as compared to CMS-8806. No significant differences were found regarding the impact of these sustainable agronomic technologies on maize yield. In the pattern used in this trial, the competition for maize/legume species was not strong enough to generate significant yield loss. The biomass production was approximately similar to that produced in experiment A. The Canavalia covers the ground quickly about one month after maize harvesting which generated an approximate amount of 4.5 t/ha biomass.

Table 4.4.2: Effects of different sustainable agronomic technologies on yield of maize grown on an alfisol in the lowland sudan-guinea, djalingo (1991).

TREATMENTS	CMS-8704 T/HA	CMS-8806 T/HA	AVERAGE T/HA	RGY %
1) Maize Monocrop	5.8	4.12	4.96	100
2) Maize with Alley hedgerow pigeon peas	5.72	3.99	4.85	98
3) Maize interplanted with Canavalia	5.56	4.01	4.78	97
4) Maize with Canavalia with Alley Hedgerow of pigeon peas	5.66	4.05	4.85	98

C. V. 7% : F_{TRT} = N.S.; F_{VAR} = N. S.; $F_{VAR. X TRT.}$ = N. S.

4.4.3 Performance of maize and sorghum after Different preceding Crops in a Representative Alfisol of the lowland savanna of North Cameroon.

This long term study which started in 1989 at Djalingo involved a two year rotation system (legume/cereals crops) in a sandy Alfisol of the lowland savanna. This experiment was carried out in one hectare of land using two cereals crops as test crops (Maize TZPB and sorghum Damougari). Seven preceding crops were used : cowpea, groundnuts, pigeon peas, soybean, Crotalaria, cotton and cereals. A rotation system cotton/cereals (as practiced by many farmers) was used as check. All the preceding crops were planted using conventional tillage and harvested in 1990. Following farmers' practices, crop residues were removed from the soil before planting the cereals in 1991. The fertilizer used was for maize ; 130 N + 60 P_2O_5 + 60 K_2O + 18 S kg/ha while for sorghum it was 60 N + 30 P_2O_5 + 30 K_2O and 12 S kgs/ha. The main objectives of this study were 1) to compare the performance of maize and sorghum after several leguminous crops with their performances after cotton in the Alfisol of the lowland savanna 2) to compare a system of improved fallow management with Crotalaria, with different systems of crop rotation using grain legumes.

Treatments and partial results are shown in table 4.4.3.

Table 4.4.3: Crop rotation experiment and improved fallow management residual effects of different leguminous crops on the yield of maize and sorghum grown under conventional tillage in a sandy alfisol in the lowland savanna, djalingo (1991).

PRECEDING CROPS	TZPB-SR	YIELD INCREASE	RGY %	DAMOUGARI	YIELD INCREASE	RGY%
	YIELD	(T/HA)		(T/HA)	(T/HA)	
1) Cowpea	6.38	0.75	113	1.84	0.56	143
2) Groundnuts	5.89	0.26	104	1.53	0.25	120
3) Cotton (Control)	5.63	-	100	1.28	-	100
4) Pigeon pea	5.87	0.24	104	1.61	0.33	126
5) Soybean	5.78	0.15	102.6	1.28	0	100
6) Cereals	4.48	-1.15	80	1.05	0.23	82
7) Crotalaria	6.69	1.06	119	2.81	1.53	154
Average	5.81			1.62		

F_{TRT} = H.S.; C.V. = 12%.; F_{INT} = N.S.; $F_{PRECROPS}$ = H.S.

In general maize and sorghum growth was good after each one of these preceding crops; more so after the leguminous species. As expected, on the average both test crops showed a better performance after these different legume species as compared to cotton. The residual effects of the legume crops could have been greater if the crop residues were incorporated. For both test crops, the use of the legume species (preceding crops) was associated with superior grain yields of the following cereals as compared to cotton/cereals (the system used by most farmers). This may be partly due to soil N addition for N fixation by the legume species. Other factors include the beneficial impact of the legume species on soil organic matter content, soil structure as well as biological activities.

b- There were highly significant differences among preceding crops regarding grain yield. The highest yield for maize and sorghum were obtained after Crotalaria (improved fallow). The lowest yields were recorded after cereals (continuous cereal cropping). There were highly significant differences between both crops.

c- Contrary to last year, there was no significant interaction between test crops and preceding crops which would indicate that maize and sorghum showed a similar response after these preceding crops. On the average the response of sorghum to legume crops was greater than that of maize. The best preceding crops for maize and sorghum were Crotalaria and cowpea. As compared to the cotton treatment, the beneficial effect of Crotalaria on the following cereals yields resulted in an extra yield of 1.06 t/ha for maize while for sorghum it was 1.53 t/ha. These results confirmed the value of Crotalaria as a valuable component in an improved fallow system management for the region. Previous experiments conducted with Crotalaria here and in similar regions indicate that Crotalaria tend to fix a significant amount of N, loosen soil structure, increase soil organic matter, reduce weeds infestation, improve crop establishment, and reduce Striga damage in cereal crop. The increase in grain yield due to Crotalaria is associated mainly to higher ear weight or panicle weight and 1000 grain weight.

4.4.4 Performance of maize and sorghum after different trap crops grown in rotation on an alfisol severely infested with striga in the subhumid lowland savanna.

This long term study started in 1989 in a farmer's field at Karité. Previous results of this experiment are reported in 1989 and 1990 NCRE/IRA annual reports.

In 1990, several crops were planted as preceding crops groundnuts, cowpea, soybean, pigeon peas, cotton, Crotalaria and cereals (maize-sorghum). They were harvested in the same season and crop residues were removed after harvest following farmers' practices. In 1991, maize and sorghum were planted using a split plot design after these different preceding crops. The test crops used in this experiment were a) maize varieties TZPB-SR and CMS 8503 b) sorghum varieties improved CS 95 and local Damougari. A low rate of fertilizer was used (farmers' rate): 84 N + 20 P_2O_5 + 15 K_2O + 6 S) kg/ha. Crops were planted at the end of June and harvested at the beginning of October. Soil samples were taken before flowering of Striga. Striga counts were made 3 times; 9, 12, 14 WAP (Weeks After Planting), in the 4 central rows. Soil in this site had a natural infestation of Striga hermonthica. The main objective of this experiment was to evaluate the differential response of maize and sorghum to several trap crops grown in rotation on an Alfisol severely infested with Striga hermonthica in the subhumid lowland savanna. Treatments and partial results are shown in table 4.4.4m and 4.4.4s.

Table 4.4.4m : Effects of different trap crops grown in rotation on maize grain yield on an alfisol severely infested with striga in the subhumid lowland savanna of the lowland savanna, karite, (1991)

TREATMENTS	TZPB-SR GRAIN YIELD T/HA	CMS-8503 GRAIN YIELD T/HA	AVERAGE YIELD/T/HA	RGY %
PRECEDING CROPS.				
1) Cowpea	2.85	2.98	2.91	137
2) Groundnuts	2.14	2.35	2.24	105
3) Cotton	2.69	2.58	2.63	124
4) Pigeon peas	2.49	2.52	2.50	117
5) Soybean	2.34	2.41	2.37	111
6) Cereals	2.15	2.09	2.12	-100
7) Crotalaria	3.03	3.54	3.28	154
Average	2.52	2.63	2.58	

F_{TRT} = N.S.; C.V. = 14%.; F_{VAR} = N.S.; F_{INT} = N.S.; L.S.D.$_{TRT}$ = 0.29 T/HA

Table 4.4.4s: Effects of different trap crops grown in rotation on sorghum yield on an alfisol severely infested with striga in the subhumid lowland savanna, karite, (1991)

TREATMENTS	CS-95 GRAIN YIELD T/HA	DAMOUGARI GRAIN YIELD T/HA	AVERAGE YIELD T/HA	RGY %
PRECEDING CROPS				
1) Cowpea	1.00	0.79	0.91	216
2) Groundnuts	0.97	0.72	0.84	200
3) Cotton	0.89	0.68	0.78	185
4) Pigeon peas	0.72	0.62	0.67	159
5) Soybean	0.77	0.66	0.71	169
6) Cereals	0.37	0.48	0.42	100
7) Crotalaria	1.17	0.94	1.05	250
Average	0.84	0.69	0.76	

$F_{TRT.}$ = H.S. ; F_{VAR} = H.S. ; $F_{V \times TRT}$ = N.S. ; $L.S.D_{TRT}$ = 0.18 T/HA. ; C.V. = 19%

In all the plots both crops were adversely affected by Striga hermonthica. Symptoms of Striga damage including chlorosis, blotching, scorching of the leaves, reduction in stem size and height, in ear size and panicle size were observed in most plots. However the magnitude of Striga damage varied with treatments (preceding crops), varieties and crops. Average grain yields of both crops were considered low which is mainly due to heavy Striga infestation in this site. Highly significant yield differences were found among treatments for both crops and varieties of each crop.

A) In the case of maize grain yields varied between 2.09 t/ha and 3.54 t/ha. CMS-8503 (a medium cycle variety) outyielded TZPB-SR (a long cycle variety) although the difference was not significant. The interaction between treatments and varieties was not significant which could imply that both maize varieties responded in similar way to the different preceding crops used in this experiment. The best preceding crop was Crotalaria, followed by cowpea and cotton. As compared to check (continuous maize), Crotalaria treatment produced an extra yield of 1.16 t/ha, (54%) the cowpea treatment produced an extra yield 0.74 t/ha, (37%) and the cotton treatment produced an extra yield of 0.49 t/ha (24%).

B) In the case of sorghum the grain yield varied between 0.37 t/ha and 1.17 t/ha. CS-95 outperformed significantly Damougari (21%). There was no significant interaction between varieties and treatments. The best trap crops for both varieties was Crotalaria, followed by cowpea and groundnuts. As compared to the check (continuous sorghum) the Crotalaria treatment produced an extra yield of 0.69 t/ha, (50 %) the cowpea produced an extra yield 0.49 t/ha (116 %) the groundnuts produced an extra yield of 0.42 t/ha (100%). In general these results confirm the trends found previously.

4.4.5. Effect of different intercropping patterns of cereals/legume species on cereals yields on an alfisol highly infested with striga in the subhumid lowland savanna.

This study which started in 1989 was conducted at Karité in 1991. The test crops used were a) maize TZPB-SR and CMS-8503, b) sorghum CS-95 and Damougari. The legume species used were cowpea, Crotalaria caricea, Cassia obtusifolia. According to treatments these legumes were planted with different patterns. In treatment 2, 3, 4, they were planted in the same hill and removed 20 days after crop emergence. The soil was infested with natural and artificial infestation with Striga hermonthica.

The main objectives of this experiments were 1) to determine the effects of different intercropping patterns on maize and sorghum performance in an Alfisol severely infested with Striga hermonthica 2) to compare the monocropping with intercropping patterns in this soil severely infested with Striga hermonthica. Treatments and partial results are shown in Table 4.4.5m and 4.4.5s.

TABLE : 4.4.5m Effect of different intercropping patterns maize/legume species on maize yield on an alfisol highly infested with striga in the subhumid lowland savanna, karite, (1991).

	TREATMENTS	TZPB GRAIN YIELD T/HA	CMS-8503 GRAIN YIELD T/HA	AVERAGE T/HA	RGY %
1)	Maize/Cowpea (Ratio 2:1 on same row)	1.24	1.88	1.56	122
2)	Maize/Cowpea (same hill)	1.19	1.86	1.52	119
3)	Maize/Crotalaria caricea (same hill)	1.69	1.95	1.82	142
4)	Maize/Cassia obtusifolia (same hill)	1.90	2.25	2.07	162
5)	Maize Monocrop	1.08	1.49	1.28	100
	Average	1.42	1.88	1.65	

F_{TRT} = H.S.; C.V. = 17% ; $L.S.D._{TRT}$ = 0.26 T/HA ; F_{VAR} = H.S.; $F_{V \times TRT}$ = N.S.
Note : RGY = Relative Grain Yield in %
In treatments 2, 3, and 4, cowpea, Crotalaria and Cassia were removed about 20 days after maize emergence.

TABLE : 4.4.5s Effects of different intercropping patterns (sorghum/legume species) on the yield of sorghum grown on an alfisol highly infested with striga in the subhumid lowland savanna, karite, (1991)

	TREATMENTS	DAMOUGARI GRAIN YIELD T/HA	CS-95 GRAIN YIELD T/HA	AVERAGE GRAIN YIELD T/HA	RGY %
1)	Sorghum/Cowpea (2:1 on same row)	0.57	0.63	0.60	128
2)	Sorghum/Cowpea (on same hill)	0.5	0.66	0.62	132
3)	Sorghum/Crotalaria caricea (same hill)	0.71	0.70	0.70	149
4)	Sorghum/Cassia obtusifolia (Same hill)	0.80	0.78	0.79	168
5)	Sorghum Monocrop	0.47	0.48	0.47	100
	Average	0.62	0.65	0.63	

F_{TRT} = H.S.; C.V. = 26% $F_{V \times TR}$ = N.S.; F_{VAR} = N.S.; LSD_{TRT} = 0.17 T/HA
Note : RGY % = Relative Grain Yield in %.
In treatments 2, 3, and 4 cowpea, Crotalaria and Cassia were removed about 20 days after sorghum emergence.

In general, both crops were negatively affected by Striga in their vegetative and reproductive organs. Consequently grain yields were low.

In the case of maize grain yield varied between 1.08 t/ha and 2.25 t/ha. Highly significant differences were found between varieties. CMS-8503 outyielded TZPB-SR significantly in this severely infested Alfisol. There was significant difference between the treatments. All the intercropping treatments outyielded the monocropping (control) treatment. The highest yield was obtained in the case of intercrop maize/Cassia obtusifolia. As compared to the check, this treatment produced an extra yield of 0.79 t.ha (61%). The interaction variety x treatment was not significant.

In the case of sorghum grain yield varied between 0.47 t/ha and 0.78 t/ha. There was no significant difference between varieties. All the intercropping patterns outyielded the control (monocropping). The best treatment was sorghum intercroped with Cassia obtusifolia. As compared to check, this treatment was associated with a yield increase of 0.32 t/ha (65%). More research will be conducted on this subject next year.

4.4.6. Effects of different rates and timings of urea sidedress application on maize and sorghum yield in an alfisol severely infested with striga in the subhumid lowland savanna.

This experiment started in 1991 and consisted of the following treatments a) 2 rates of urea sidedress application for maize 100 and 200 kgs/ha for sorghum 50, and 100 kgs/ha, b) 3 timings of urea sidedress application 7 DAP (days after planting), 14 DAP, and 28 DAP. The following crops were used as test crops a) maize CMS-8503 and TZPB-SR, and b) sorghum Damougari and CS-95. The soil was infested with Striga hermonthica by natural and artificial infestation. The main objective of this experiment was a) to evaluate the response of maize and sorghum to different rates and timings of urea sidedress application on an Alfisol severely infested with Striga b) to determine the value of rates and timing of Urea to alleviate the Striga damage on maize and sorghum. Treatments and partial results are indicated in tables 4.4.6m and 4.4.6s. Both maize and sorghum crops were adversely affected by Striga incidence in their vegetative as well as reproductive stages. The magnitude of the damage varied with crops, varieties and treatments.

In the case of maize grain yield varied between 2.08 t/ha and 4.33 t/ha. CMS-8503 significantly outyielded TZPB-SR in this soil severely infested with Striga. The reverse should be expected in a non-infested soil. The best treatment in this experiment was the use of 100 kgs Urea sidedress application at 14 WAP. The less effective treatment was 100 kgs Urea applied 7 DAP. The interaction variety x treatments was not significant.

In the case of sorghum grain yield varied between 0.62 t/ha to 1.64 t/ha. Local Damougari significantly outyielded local Damougari (0.27 t/ha, 28%). The interaction treatments x varieties was not significant. This experiment confirms the importance of rates and timings of Urea to alleviate Striga damage on maize and sorghum in the subhumid lowland savanna. More research will be conducted on this subject to confirm these trends.

TABLE 4.4.6m: Effect of different rates and timings of urea application on maize yield in an alfisol severely infested with striga in the subhumid lowland savanna, karite (1991)

TREATMENTS UREA SIDEDRESS APPLICATION	TZPB-SR GRAIN YIELD T/HA	CMS-8503 GRAIN YIELD T/HA	AVERAGE YIELD T/HA
1) 100 Urea/ha (7 DAP)	2.08	2.38	2.23
2) 100 Urea/ha (14 DAP)	2.90	4.33	3.61
3) 100 Urea/ha (28 DAP)	2.28	3.25	2.76
4) 200 Urea/ha (7 DAP)	2.63	3.55	3.09
5) 200 Urea/ha (14 DAP)	2.48	3.85	3.16
6) 200 Urea/ha (28 DAP)	2.38	3.20	2.79
Average	2.45	3.42	2.93

F_{VAR} = H.S.; F_{TRT} = H.S.; C.V. = 16% ; L.S.D. = 0.38 t/ha ; $F_{VAR \times TRT}$ = N.S.
Note : DAP = Days After Planting.

Table 4.4.6s: Effect of different rates and timings of urea application on sorghum yield on an alfisol severely infested with striga in the subhumid lowland savanna at karite, djalingo (1991)

TREATMENTS UREA SIDE DRESS APPLICATION	CS-95 GRAIN YIELD (T/HA)	DAMOUGARI GRAIN YIELD (T/HA)	AVERAGE T/HA
1) 50 kg Urea/ha (7 DAP)	0.98	0.62	0.80
2) 50 kg Urea/ha (14 DAP)	1.11	0.66	0.88
3) 50 kg Urea/ha (28 DAP)	1.64	1.28	1.46
4) 100 kg Urea/ha (7 DAP)	1.37	0.99	1.18
5) 100 kg Urea/ha (14 DAP)	1.10	1.05	1.07
6) 100 kg Urea/ha (28 DAP)	1.07	1.04	1.05
Average	1.21	0.94	1.07

F_{TRT} = H. S. ; F_{VAR} = H. S.; $F_{VAR \times TRT}$ = N.S.; L.S.D.$_{TRT}$ = 0.19 T/HA ; C.V. = 17%.
Note : DAP = Days after planting.

4.5 VISITORS

Many persons (national and international) came to visit our field trials in 1991. Among them were : 131 farmers, 26 development and extension agents, 20 international visitors. Most of them were quite impressed with the system of alley cropping with pigeon peas hedgrow and conservation farming technologies used in our experiments. As a result, SODECOTON has decided to apply these technologies in 3 observation villages during 1992 cropping season.

5. SORGHUM RESEARCH UNIT

5.1 INTRODUCTION

Sorghum and pearl millet are the major cereals cultivated throughout the. Adamaoua, North and Far North provinces. The importance of these cereals within this region decreases as one moves from the Far North to the Adamaoua province, corresponding closely with the increase in rainfall and longer growing season. Sorghum is grown during the rainy season and in post rainy season. the latter crop known as "Muskwari", is a transplanted sorghum grown on residual soil moisture. Millet is grown only in the rainy season.

The goal of sorghum breeding is to increase sorghum and millet production through the development of high yielding cultivars resistant to various pests and diseases. Efforts have been directed toward developing short term breeding strategies which included screening of available germplasm and introduction of exotic germplasm from International Research Center. More than 1900 lines of local germplasm have been evaluated. Another goal is developing long-term breeding strategies which included crossing and screening of segregating materials. More than 450 crosses have been attempted, including local x local, local x exotic, and exotic x exotic, which are at present in F1, F2, F3, F4, and F5 generations.

In 1991 emphasis was on breeding sorghum for drought tolerance, striga resistance/ tolerance, identify sources of resistance by screening additional germplasm (local and exotic), identify short cycle and non-photoperiod sensitive lines for pearl millet.

5.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Development of suitable cultivars of sorghum for different ecological zones.		
1.1 Provide improve varieties to various users.	1.1 Genetic materials F1 to F5 are being tested. Preliminary yield trial. Many exotic lines introduced.	1.1 65 crosses were made by hand enasculation. 34 F1 crosses, 23 F2 progenies. 74 progenies, 90 F4 progenies, 68 F4 progenies fron SADCC region, 9 F5 progenies were evaluated, selected and advanced to next generation. Several preliminary yield trials were conducted.

Objectives	Activities	Accomplishments
1.2 Increase sorghum productivity.	1.2 Multilocation trial. Large quantity of seed distributed to farmers and seed companies. International trials are being conducted.	1.2 Two sets of multi-location sorghum variety trials (early & medium) comprised of 6 trials of 20 entries each were carried out on 5 different locations. 10 international trials, dealing with drought, pest resistant, striga, Hybrid were carried out. Breeder's seed of 5 advanced promising sorghum lines were multiplied.
Operation 2: Development of varieties resistant to striga		
2.1 Develop high level of resistance to striga.	2.1 National striga nursery and West and Central africa Striga trial being carried out.	2.1 A West Africa Sorghum Striga trial comprised of 12 entries and a national sorghum striga trial made of 21 entries was conducted. Results are presented in the report.
2.2 Provide range of resistant cultivars.	2.2 Select cultivars resistant/tolerant to Striga hermonthica within local and exotic germplasm.	2.2 A collection of 63 varieties of diverse origin was evaluated in single observation rows replicated twice. This evaluation was made in a field heavily infested with striga.
Operation 3: Maintenance, testing, and evaluate Hybrid parents		
3.1 Maintaining genetic resources for hybrid development.	3.1 Many A/B lines have been maintained and evaluated for drought resistant and disease resistant.	3.1 29 A/B lines of different origin (ICRISAT, Texas A & M) were planted at Guiring and evaluated for % seed set, drought, incidence of sooty stripe, grey leaf spot, and anthracnose, average time to flower, plant height.
3.2 Identify suitable male and female parents.	3.2 Selection of male and female parents which could combine to give the best hybrid.	3.2 In order to select suitable male parents for future use 19 local lines used as male parents were crossed to 6 different A lines (females). The performance of the progenies will be evaluated and their combining ability established. The best combiners may be selected as restorers.

Objectives	Activities	Accomplishments
4.1 Obtain uniform and pure seed of promising selection. Produce adequate seed quantity.	4.1 Multiply breeders seed to meet the requirement of sorghum researchers and private seed agencies.	4.1 The seed of five released varieties were multiplied. All harvestable panicles were bagged soon after panicle emergence to avoid out crossing and to maintain purity of the line. Some of the seed will be distributed to the farmers and other used for research purposes.
Operation 5: Muskwari germplasm collection, maintenance and evaluation.		
5.1 Evaluated the various muskwari collections.	5.1 (Not yet carried out) Cultivars available with defined traits selection will be made within these cultivars.	5.1 A collection of 167 varieties of diverse origin were evaluated in a two rows plot replicated three times. The crops are not yet harvested. However, most of the entries exhibited useful agro- nomic characteristics. Except for the sporadic occurrence of long smut, no other disease was observed in the plots.
5.2 Multiply seed of promising entries for agronomic study.	5.2 Promising varieties will be multiplied.	5.2 The seed of SAFARI 40 a promising Muskwari variety was multiplied on a very small scale.
Operation 6: Development of suitable pearl millet cultivars.		
6.1 Identify agrono-mically superior lines with stable source of downy mildew.	6.1 Select high yielding varieties and resistance to downy mildew.	6.1 43 advanced genera-tion progenies were planted and screened for major pearl millet diseases (ergot, downy mildew, smut) and effective tillering capability. Data were also taken on earliness and lodging.

Objectives	Activities	Accomplishments
6.2 Develop cultivars of	6.2 Preliminary pearl millet yield trial and multilocation yield trials are being conducted in different zones. Maturity cycle is the main criteria of selection.	6.2 A first set of multi-location yield trials composed of 12 entries including two checks (IKMV-8201 and Mouri) was carried out in three locations. A second set made of advanced breeding materials (18 entries) from different research institutes was also carried out in 3 locations. All results are presented in the report.

5.2 SUMMARY OF PROGRAM ACTIVITIES

A large number of diverse breeding lines, elite varieties, preliminary lines and some few hybrids, male and female parents for hybrids production and sources of resistance to various stress factors were evaluated in different nurseries. Selected germplasm accessions and advance breeding lines are under multilocation trial. A crossing program involving local adapted lines, promising exotic lines and sources of resistance to stress factors have been organized.

Particular emphasis was placed on striga/varieties development testing and drought. Pearl millet work included evaluation of local germplasm and mass selection, evaluation of elite breeding material received from other programs to diversify the genetic base of the breeding program. 78 accessions comprised of local germplasm, advanced selections from crosses or introduced material from ICRISAT, India were evaluated and screened for various pests. Multilocation trials were conducted to evaluate early maturing varieties for late sown conditions. A list of sorghum and pearl millet trials and nurseries planted is presented below.

SORGHUM AND MILLET BREEDING TRIALS - 1991

	ENTRIES	REPS	DATE OF PLANTING	LOCATION
Characterization of Sorghum Test Location Environment Trial	12	4	14 - 6	Guiring
West African Sorghum Variety Adaptation Trial	14	3		Guiring
West African Sorghum Hybrid Adaptation Trial (Early)	20	3	14 - 6	Guiring
International Sorghum Variety and Hybrid Adaptation Trial	27	3	14 - 6	Guiring
West African Sorghum Hybrid Adaptation Trial (Medium)	20	3		Sanguere
Cameroon Sorghum Hybrid Observation Nursery-91 Trial 1 and 2 (Early)	54	3		Guiring

Cont'd.

TRIALS	ENTRIES	REPS	DATE OF PLANTING	LOCATION
Cameroon Sorghum Hybrid Observation Nursery-91	54	3		Sanguere
Trial 1 and 2 (Medium)				
Pioneer Hybrid Test-1	21	3		Guiring
Pioneer Hybrid Test-2	21	3	14 - 6	Sanguere
West African Sorghum Striga Trial-91	13	3		Ndonkole
National Sorghum Striga Trial-91	21	3		Ndonkole
Striga Observation Nursery	63			Ndonkole
Preliminary Sorghum Variety Yield Trial-1 (Early)	26	3		Guiring
Preliminary Sorghum Variety Yield Trial-2 (Early)	26	3		Guiring
Preliminary Sorghum Variety Yield Trial-1 (Medium)	26	3		Sanguere
Preliminary Sorghum Variety Yield Trial-2 (Medium)	26	3		Sanguere
Local Germplasm Selection Trial-91	20	3		Guiring Guetale Tchatibali
Multilocation Sorghum Variety Adaptation Yield Trial (Early)	20	4		Guiring Guetale Tchatibali
Multilocation Sorghum Variety Adaptation Yield Trial (Medium)	20	4		Guiring Soucoundou Sanguere
<u>SORGHUM NURSERY</u>				
A/B Lines	56	-	13 - 6	Guiring
Evaluation of Hybrids Parents	25	-	13 - 6	Guiring
Early Germplasms Collection	36	-	- " -	Guiring
Crossing Program-1	16	-	- " -	Guiring
Crossing Program-2	19	-	- " -	Guiring
F1 Generation	34	-	- " -	Guiring
F2 Generation	23	-	14 - 6	Guiring
F3 Progenies	74	-	13 - 6	Guiring
F4 Progenies	90	-	- " -	Guiring
F4 Progenies (SADCC)	68	-	- " -	Guiring
F5 Progenies	9	-	- " -	Guiring
Development of Breeder's Seed of Advanced Promising Sorghum Lines	5	-	- " -	Guiring
Development of Breeder's Seed of Released Varieties.	4	-	- " -	Guiring
West African Pearl Millet Yield Trial	16	6	15 - 7	Guiring
Multilocation Pearl Millet Variety Adaptation Trial-91 (MPMVAT-91)	14	4		Guiring Guetale Yoldeo Tchatibali

Cont'd.

	ENTRIES	REPS	DATE OF PLANTING	LOCATION
PEARL MILLET NURSERY				
Germplasm Selections Evaluation Guiring	19			
F5 Generation Guiring	43			
Seed Multiplication Guiring	2			
Plant Protection				
West African Leaf Disease Nursery	18	2		Yoldeo
International Stem Borer Nursery	12	3		Soucoundou

5.4 RESEACH FINDINGS

Multilocation Variety Yield Trials Evaluation

A Network of variety trials at several locations was carried out over a range of climatic and edaphic environments. The varieties tested were selected from advanced breeding material of the program's exotic collection of different research institutes and local germplasm.

The objectives were:

1) Compare the performance of local varieties with that of introduced varieties
2) Compare the performance of advance breeding lines with that of local and introduced varieties.
3) Identify/develop superior varieties/lines that fit into the existing farming system.
4) Evaluate the magnitude of the genotype x environment (GE) interaction in the sorghum growing areas.

The results of trials are presented below. The first set of these trials aim to evaluate the local germplasm. All multilocation variety tests consisted of 19 to 20 entries planted in 4 rows plot with 4 replications. Seed spacing was 20cm apart in a row and 80cm between rows. Data was collected on grain yield, days to 50% flowering, plant height, plant count after thinning, panicle count at harvest, panicle length and 1000 grain weight. Fertilizer application (60 Kg N; 20 Kg P_2O_5; 20 Kg K_2O/ha) was uniform for all the experiments. Nitrogen was applied in two split doses whereas P_2O_5 and K_2O were applied before sowing.

Evaluation of Local Germplasm (Guiring)

The variation among entries was highly significant for all traits measured, which indicates the presence of significant phenotype variability among the local and improved varieties tested. The varietal means for all traits are presented in Table 1. The mean grain yield was 4600 kg/ha. The highest yielding genotype was CS 95 (5309 Kg/ha) followed by Boulbassiri (5125 Kg/ha), Zouaye (5021 Kg/ha), Wongtosho (5021 Kg/ha). All improved varieties matured early and suffered bird damage which led to a decrease in yield.

Yoldeo

A similar test with the same entries was conducted at Yoldeo. Despite the low yield, variety effects were significant for most of the traits. Analysis and means of different traits are presented in Table 2. The mean grain yield was 2219 Kg/ha. The local variety Zouaye obtained the highest yield of 3421 Kg/ha, followed by S35 (2975 Kg/ha), Wongtosho (2934 Kg/ha), SC 181 (2837 Kg/ha). The late three entries did not differ significantly from each other. The poor yield of all improved cultivars can be attributed to grain loss due to birds combined with delayed harvesting.

Multilocation Sorghum Variety Trial (Guiring Early)

Table 3 contains the yield and agronomic data recorded. Variety effects were significant for all traits and coefficients of variation were low. The mean grain yield was 4842 Kg/ha. ICSV-1079 and CS-63 were the best yielding entries followed by five entries having no significant difference. These are Damougari, CS 251, CS 54, S35, CS 130. All these are high yielding, early maturing varieties having medium plant height.

Guiring (Medium)

Analysis and means are presented in Table 4. The mean grain yield was 2368 Kg/ha and ranged from 2531 Kg/ha for CS 233 to 1284 Kg/ha for CS 316. The highest grain yield was obtained from CS 233 and CS 85. There were no significant differences among the 12 medium yielding entries. Most entries were relatively late maturing and tall.

Soucoundou (Medium)

Twenty entries including a check CS 95 were evaluated at Soucoundou. The mean performance of grain yield and other traits are presented in Table 10. Considering grain yield, the check variety CS 95 ranked first yielding 2425 Kg/ha, followed by CS 61 (2240 Kg/ha), CS 278 (2109 Kg/ha). These genotypes were less attacked by foliair disease, and all were white grain color. All exotic lines were poor yielder. The average grain yield was 1219 Kg/ha. The effect of variety was significant for all traits. High variability (CV 35.6%) was observed on yield. This is due to the heterogeneous nature of the field which was formerly planted in cotton and a part of it in fallow.

Table 1: Trial : Evaluation of Local Germplasm Location: Guiring, Maroua Research Station

Selected Entries	Grain Rank Yield (Kg/ha) *	Days to 50% Flowering *	Plant Height *	Panicle Count at Thin./ha	Panicle Count Harv./ha *	Length (cm) *	1000 Grain Weight
Wongtosho	5021	4	54	355	76562	67500	24.75	33.15
Dadjanaka	4768	9	57	425	75937	64375	23.75	33.45
Barlang	4918	8	55	380	74375	70312	25.25	34.57
Gueling Gueling	5003	6	53	315	67812	68125	22.25	34.10
Boulbassiri	5125	2	61	418	82500	67187	20.00	34.37
Gueling	4690	10	58	403	76562	72187	26.00	31.62
Zouaye	5021	3	51	201	82187	85937	17.00	33.25
S-35	5012	5	53	223	66562	59687	26.25	34.65
CS-95	5309	1	53	215	63437	56562	23.25	34.67
CS-141	4956	7	59	305	59375	53750	24.05	34.97
Overall Mean	4600		57	319	71250	66856	22	34.1
SE ±	261.1		0.67	13.24	3992.7	5705	1.32	0.83
CV (%)	11.35		2.39	8.28	11.21	17.07	12.02	4.91

* Significant at 5%

Table 2: Trial : Evaluation of Local Germplasm Location: YOLDEO

Selected Entries	Grain Rank Yield (Kg/ha) *	Days to 50% Flowering *	Plant Height *	Panicle Count at Thin./ha	Panicle Count Harv./ha *	Length (cm) *	1000 Grain Weight
Wongtosho	2934	3	65	293	45625	45312	25.50	25.90
Barlang	2678	5	67	287	55000	55000	25.50	26.10
Boulbassiri	2650	6	70	322	47187	46562	20.25	26.00
Danougari	2531	8	66	199	55625	55937	14.25	26.90
Walaganari	909	17	72	292	40312	40312	19.25	22.25
S-35	2975	2	65	206	42187	42187	27.50	30.55
CS-95	2191	10	67	210	31250	31562	24.75	29.00
CS-54	2343	9	66	206	46875	41875	25.50	28.90
CS-120	2600	7	68	212	51876	51250	25.25	28.15
CS-181	2837	4	68	265	53312	54687	25.75	29.55
Overall Mean	2219		68	258.97	48033	47077	22.5	26.23
SE ±	292.2		0.88	12.39	5179.9	5038.2	1.47	0.81
CV (%)	26.33		2.60	9.57	21.57	21.40	13.07	6.24

* Significant at 5%

Table 3: Trial : Multilocation Sorghum Variety Adaptation (Early-91)
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height *	Plant Count at Thin./ha	Panicle Count Harv./ha *	Panicle Length (cm) *	1000 Grain Weight
CE-196-7-2-1	4950	10	57	240	113437	102500	22.25	24.87
CC-210	4718	13	63	223	82500	79062	26.50	34.15
ICSV-1079	5603	2	58	218	75625	74062	28.25	28.05
CS-63	5715	1	65	208	67812	90000	32.25	35.30
CS-54	5362	5	58	240	68437	71250	24.25	37.52
ICSV-111	5009	8	60	226	70937	63750	24.25	38.02
CS-251	5375	4	63	225	67812	67187	24.50	36.25
CS-278	4962	9	65	341	91875	68437	28.50	39.22
S-35	5256	6	58	213	64375	62187	25.00	36.32
CS-130	5243	7	58	218	75312	60000	25.00	36.90
Damougari	5406	3	59	186	89375	85312	14.50	34.37
Overall Mean	4842.27		61	235.78	76760	72154	26.00	33.9
SE ±	299.22		1.23	18.31	5570.7	4218.3	1.09	0.81
CV (%)	12.36		4.06	15.53	14.51	11.69	8.42	4.79

* Significant at 5%

Table 4: Trial : Multilocation Sorghum Variety Adaptation (Medium-91)
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height *	Plant Count at Thin./ha	Panicle Count Harv./ha *	Panicle Length (cm) *	1000 Grain Weight
CS-144	2512	8	70	238	65605	52500	24.75	29.22
CS-233	3531	1	65	261	67812	62500	23.75	39.05
CS-229	2284	10	68	221	65937	62812	24.25	32.05
CS-181	3131	4	66	282	68437	54687	22.00	33.10
CS-244	3468	3	63	227	64375	55000	25.50	31.60
CS-251	2650	7	63	205	63125	51875	24.00	33.10
CS-278	2296	9	65	251	62500	53750	24.00	32.05
CS-61	2746	5	62	206	55000	44687	23.00	33.97
CS-95	2709	6	61	211	61875	51250	24.00	31.62
CS-85	3503	2	68	232	63437	57500	25.00	28.02
Overall Mean	2368.16		66	221.19	65031	52562	23.74	30.22
SE±	629.5		1.43	12.41	2640.6	5143.23	1.36	1.60
CV (%)			4.33	11.23	8.12	19.57	11.53	10.60

* Significant at 5%

Striga

The objectives of the program are:

- Developing reliable screening techniques
- Identifying striga resistant/tolerant sorghum cultivars
- Increasing resistance level through intercrossing of different sources of resistance.

Three trials were carried out. The National Sorghum Striga Nursery composed of 21 entries including one susceptible check (CK60B), The West and Central Africa sorghum Striga Trial and one evaluation of germplasm collection.

West and Central African Sorghum Striga Trial

The trial was affected by drought at planting and at the end of cycle by bird damage, so very high CVs were obtained for grain yield which rendered the interpretation of data difficult. However, some conclusion may be drawn. None of the entries tested was totally striga free. The less susceptible lines were IS 15843, CS-95, CS-210. The mean striga emergence levels in the trials was very high; 13.3/m^2. Although the trial was affected by drought, some selections that withstood the drought were advanced for further testing. High yielding varieties were CS-95, CS-210, 82-S.51xCS-61. The check varieties S-35 and Damougari yielded very low. S35 was severely attacked by birds.

SELECTION AND TESTING PROGRAM

A/B Observation Nursery

Hybrid development is not a major objective of our program. The single purpose was to maintain some germplasm and identify female parents as well as restorers which may help for future breeding strategies. 56 A/B lines were planted at Guiring. The A lines were bagged soon after panicle emergence and % self fertility/seed set was evaluated. Except for 5, all female parents maintained the sterility and didn't show symptoms of sterility breakdown. Incidence of various diseases was moderate but long smut appeared in severe proportions on some entries. Further evaluation of the selected lines may reveal stable multiple disease resistant lines and sterility.

Hand Emasculation

A total of 65 single crosses were made during the 1991 cropping season at Guiring. Parents were selected on the basic of defined characteristics (drought tolerance, striga tolerance, disease tolerance, color of the grain and yield). These crosses involved local x local; local x exotic; exotic x exotic.

F1 Generation

Thirty four F1 crosses selected from 1990 hand emasculations were grown at Guiring. All plants were selfed. The progenies will be grown as F2 in Guiring. Selection will follow in the subsequent generation.

F2 Generation

Twenty three (23) lines were advanced to F2 generation. The best plants were tagged and harvested. A total of 100 plants were harvested after final selection. These plants were threshed separately. The progenies will be grown as F3 in the next generation.

F3 Generation

Progeny from 74 selected F2 single plants were planted in five rows/plot. About two hundred plants were selected and harvested. All lines were selected for disease tolerance, earliness, height and yield potential.

F4 Generation

A total of 167 progenies selected during the last cropping season were grown. Selfing and selection were followed. At harvest five to six plants were selected within each family. Some lines which did not show desirable characteristics were dropped. The selected crosses will be advanced to F5 generation.

COLLABORATIVE RESEARCH

Genetic improvement of crop species depends upon the quantum of genetic resources available and the proportion of genetic variability exploited by breeding programs. A proportion of useful introductions could contribute significantly to the improvement of the crop. Therefore, a set of trials composed of elite lines from advanced research institutes and different national programs were carried out. It was encouraging to find several accessions showing high agronomic scores, high yielding potential, divergent panicle characteristics and multiple disease resistance. The result of different trials are presented below in brief.

Characterization of Sorghum Test Locations Environment Trial

Twelve entries were evaluated at Guiring. The effect of varieties was significant for most of the traits. Variety mean and agronomic data are presented in Table 5. The mean grain yield was 2994 ranged from 3912 for CSH 11 (Hybrid) to (1758 Kg/ha) for IS 3693 A group of the first high entries were not significantly different from each other in terms of grain yield even though the maturity cycle was different. The highest yielding entries CH 1 and CH 11 are hybrids. S-35 the local check ranked 4th. The high coefficient of variation (CV 23.09) for the trial is probably due to significant genotypic and phenotypic variability among the varieties tested.

International Sorghum Variety and Hybrid Adaptation Trial (Medium)

The test consisted of 27 entries all evaluated at Guiring. The varietal mean is presented in Table 6. It was one of the best tests conducted at Guiring and aimed to compare the performance of hybrids with that of varieties. The mean grain yield was 3949 Kg/ha ranging from 6700 Kg/ha for ICSH 88065 to 1045 Kg/ha for 5 DX 60. The effect of variety was significant for all characters. The highest yielding entry was ICSH 88065, hybrid. A group of six entries were found to be high yielding and not significantly different from each

other. Four of the six entries were hybrid. These are ICSH 110, SPH 768, ICSH 88065, ICSH 90002. The best high yielding varieties are ICSV 111, SPV 669. The hybrids maintained better plant stands, vigorous growth, earlier flowering and better panicle exertion; but most of hybrids succumbed to charcoal root disease at harvesting time. That led to serve loging. The Check S35 yielded 3795 Kg/ha and ranked 16th.

West African Sorghum Hybrid Adaptation Trial (Early Duration)

Earlier reports from different research activities reviewers indicated that small farmers could not grow hybrids because the grain yield advantage of hybrids over varieties was not apparent. The chances of identification of high yielding hybrids could be high in a collection of hybrids of diverse origin.

This test consisted of 18 hybrids and two varieties used as checks. Grain yield and agronomic data are presented in Table 7. The effect of hybrid was significant for all trait except the number of plant count after thinning. This implies uniform plant stand. Grain yield were high with overall mean at 4499 Kg/ha ranging from 6000 Kg/ha for ICSH 507 to 9016 Kg/ha for ICSH 89013. The Check variety ICSV 111 and S-35 yielded 4750 Kg/ha, 4641 Kg/ha and ranked 7th and 10th respectively. A group of 15 entries including the two check varieties were found to be high yielding and not significantly different from each other. All hybrids maintained vigorous growth and better panicle exertion.

West African Sorghum Variety Adaptation Trial (Early)

The objectives of early variety trials were to 1) compare the performance of recent early maturity selections with that of some exotics and 2) identify and increase superior varieties for extensive multilocational testing. The trial consisted of 14 entries. Yield and agronomic data are presented in Table 8. The effect of variety was significant and the coefficient of variation relatively high. Grain yields were high, averaging 4388 Kg/ha and ranging from 6112 Kg/ha for 90W 186 to 2008 Kg/ha for ICSV 401. S-35 a "local" contribution yielded 4008 Kg/ha and ranked 10th. A group of 8 entries were found to be high yielding and not significantly different from each other. The best yielding were 90W 186, Naga White, CSM 219, CE 314-18, 90W 177, SSV-2.

West African sorghum Variety Adaptation Trial (Medium)

The objective is to identify medium cycle varieties for the intermediate rainfall zone. (800-1200mm annual precipitation). Varietal means are presented in Table 9. The effect of variety was significant for all characters except for plant count after thinning. Mean grain yield was 3450 Kg/ha and ranged from 5095 Kg/ha for S-35 the local control to 270 Kg/ha for blanc de Bagou, a local from Benin. The second high yielding variety was 83-3148-2-1 with 4866 Kg/ha

Table 5: Trial __: Characterization of Sorghum Test Location Environment Trial-91
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height (cm) *	Plant Count at Thin./ha	Panicle Weight (Kg/ha) *	1000 Grain Weight
CSH 1	3406	3	51	135	70937	4553	32.97
CSH 11	3912	1	63	152	68437	5359	24.15
E35-1	3331	5	71	225	64062	4068	33.05
ICSV-112	3605	2	65	158	67812	4337	22.65
FRAMIDA	3134	7	69	241	69375	4203	38.05
IRAT 204	3112	8	52	136	73125	3943	33.37
NAGA WHITE	3165	6	59	185	71562	3818	31.07
S-35	3353	4	60	205	64062	4128	35.02
Overall Mean	2994.79		62	184.47	67942	3867	30.79
SE	405.60		1.50	10.52	2482.82	439.18	0.92
CV (%)	27.09		5.07	11.41	7.31	22.71	6.03

* Significant at 5% Level.

Table 6: Trial __: Characterization of Sorghum Test Location Environment Trial-91
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height (cm) *	Plant Count at Thin./ha	Panicle Weight (Kg/ha) *	1000 Grain Weight
ICSH 8710001	4054	12	60	188	60833	5612	25.86
ICSH 88065	6700	1	57	240	72083	8337	26.60
ICSH 89020	4516	10	56	198	64583	5762	25.06
ICSH 89051	4666	8	49	188	67916	5641	30.30
ICSH 89123	4383	11	60	181	66666	6066	24.70
ICSH 90002	5333	4	60	190	66666	6387	28.43
ICSV 88013	4854	7	55	193	70000	5858	22.73
ICSV 111	5012	6	60	213	70833	7012	36.93
SPH 468	5554	3	55	191	70833	6954	30.43
SPV 669	5137	5	62	220	68333	6462	29.13
ICSH 110	6282	2	59	193	70833	8320	30.00
S-35	3795	16	60	215	65416	4854	35.23
Overall Mean	3949		62	198	67206	5187.80	27.44
SE	646.03		1.67	9.91	2328.62	840	1.46
CV (%)	28.34		4.62	8.65	6.00	28.05	9.22

* Significant at 5% Level.

Table 7: Trial __: West African Sorghum Hybrid Adaptation Trial-91 (Early)
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height (cm) *	Plant Count at Thin./ha	Panicle Count at Harv./ha	1000 Grain Weight
ICSH 780	5175	3	55	195	70833	61666	30.63
ICSH 89001 NG	4583	11	58	208	68333	56666	29.16
ICSH 89005 NG	4200	16	66	185	73333	63333	26.53
ICSH 90002 NG	4808	6	60	183	67500	69166	31.33
ICSH 90003 NG	4733	8	59	186	71666	60833	28.10
ICSH 90004 NG	5225	2	63	205	70833	65000	30.50
ICSH 507	6000	1	58	200	69166	62500	28.26
ICSH 89002 NG	4883	5	69	203	71666	65833	27.86
ICSH 890007 NG	4216	14	60	173	63333	58333	24.40
ICSH 90005 NG	4975	4	63	201	66666	64166	28.00
ICSH 89009 NG	4691	9	61	176	76666	60000	26.00
ICSH 89012 NG	4450	12	60	166	69166	66666	24.43
ICSH 90006 NG	4066	17	63	181	67500	58333	27.73
ICSH 89004 NG	4283	13	59	193	70833	65833	24.90
INRAN SORGHUM HYBRID-1	4208.33	15	64	158.33	60000	49166	26.93
INRAN SORGHUM ICSV 111	4750.00	7	59	223.33	65000	61666	34.20
S-35	4641.66	10	60	226.66	65833	59166	34.16
Overall Mean	4499.17		61	190.50	68458	60333	28.14
SE	667.47		1.18	7.06	5137.19	5417.34	1.01
CV (%)	25.70		3.36	6.42	13.00	15.55	6.25

* Significant at 5% Level.

Table 8: Trial __: West African Sorghum Variety Adaptation Trial-91 (Early)
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height (cm) *	Plant Count at Thin./ha	Panicle Count at Harv./ha *	1000 Grain Weight
CE 145-66 TRANS 2	4520	9	65	195	99166	83750	27.06
CE 314-18	5362	4	58	193	93750	88750	32.86
CE 315-14-1-1	4937	7	61	233	86250	83333	29.13
SSV-2	5079	6	63	218	69583	67916	28.03
CSH 219	5395	3	70	215	71250	69166	37.13
90W 194	4591	8	68	225	67083	61666	29.00
90W 186	5112	1	66	265	74166	65416	33.23
90W 197	5145	5	67	253	69583	70833	28.96
MAGA WHITE	5795	2	59	208	74583	66666	33.70
S-35	4008	10	61	210	66666	58333	35.73
Overall Mean	4388.69		63	211.55	72440	67708	31.20
SE	643.2		0.71	10.93	7027.30	5700.76	1.24
CV (%)	25.40		1.96	8.95	16.80	14.58	6.91

* Significant at 5% Level.

Table 9 : Trial __: West African Sorghum Variety Adaptation Trial-91 (Medium)
Location: Guiring, Maroua

Selected Entries	Grain Yield (Kg/ha)	Rank	Days to 50% Flowering *	Plant Height (cm) *	Plant Count at Thin./ha	Panicle Count at Harv./ha *	Panicle Weight (kg/ha) *	1000 Grain Weight
83-313-1-1	3983	7	57	190	66250	70416	4895	30.10
83-3148-2-1	4866	2	62	263	63333	80833	5741	28.43
90W 187	4312	4	67	310	60000	65000	5375	24.76
90W 190	4233	5	64	295	66666	74166	5204	25.46
90W 193	4691	3	65	298	62083	72500	5983	28.33
CS-85	4200	6	62	276	68750	65416	5487	24.53
S-35	5095	1	58	231	62500	61250	6000	36.73
Overall Mean	3450		65	286.57	62794	63480	4359.36	26.38
SE	563.03		1.22	14.43	4822.86	7919.73	708.95	0.80
CV (%)	28.27		3.27	8.73	13.30	21.81	28.10	5.25

* Significant at 5% Level.

Table 10: Trial : Multilocation Sorghum Variety Adaptation (Medium-91)
Location: Guiring, Maroua Research Station

Selected Entries	Grain Yield (Kg/ha) *	Rank	Days to 50% Flowering *	Plant Height (cm) *	Plant Count at Thin./ha	Panicle Count Harv./ha *	Panicle Length (cm) *	1000 Grain Weight
CS-233	1671	5	67	260	60312	41562	28.25	27.85
CS-289	1512	6	70	250	61562	49062	28.00	26.42
CS-265	1484	7	74	261	66875	43125	31.75	24.65
CS-159	1937	4	74	213	67812	53750	22.00	26.32
CS-244	1446	8	64	220	52500	31562	26.25	27.07
CS-251	1359	9	65	210	58125	33750	27.50	24.92
CS-278	2109	3	68	291	66562	47812	28.75	28.02
CS-61	2240	2	62	205	59062	42812	26.50	28.47
CS-95	2425	1	60	202	56250	43750	25.00	28.45
Overall Mean	1219.2		58	225	57156	37281	27.2	24.0
SE±	217.3		1.98	9.35	5093.9	4887.9	1.42	0.95
CV (%)	35.6		5.80	8.29	17.82	26.82	10.46	7.98

* Significant at 5% Level.

PEARL MILLET

Introduction

The objective of pearl millet improvement program is to identify varieties for the 300 - 900 mm rainfall by selecting varieties having the following characteristics :

1) Photoperiod sensitive full season varieties that farmers can sow with the early rains as his normally practice.

2) photoperiod insensitive early maturing (80 - 110 days) varieties for late planting (July) Due to variation in rainfall, the major hust of our research activities is on developing low sensitive/insensitive early maturing varieties. Emphasis is toward selecting for drought tolerance, resistance or tolerance to diseases and pests (downy mildew, ergot), developing adapted varieties and genetic material with high yield potential, stable and thus contribute towards increasing and stabilizing millet production in the region.

Two sets of multilocation trials were also carried out across major pearl millet growning areas namely Maroua, Yoldeo, Guetale and Tchatibali. No fertilizer was applied. The plant density was kept at about 42000 plants/ha having a row to row distance of 80 cm and plant to plant distance of 30 cm. At final thinning one plant per hill was maintained for all the pearl millet experiments. Data was collected on grain yield, days to 50% flowering, plant height, plant count after thinning, panicle count at harvest, panicle length, and 1000 grain weight. All analyses were performed using the standard RCB Anova. The first set of multilocation trials was composed of early maturing entries. This trial aimed to evaluate early maturing (80-100 days) entries suitable for late planting conditions (July). Fourteen

varieties and four replications were used at each location. The results are presented below in brief. The second set of multilocation trials were PMCT trials received from ICRISAT Sahelien center. These were 6 replicates randomized block design trials composed of 18 entries mostly of early maturing cycle.

Rainfall and Trial management

Rainfall at Tchatibali was characterized by a relatively late start and early termination. However in all experimental sites, rain was well distributed in July, August and up to mid-September. The month of August received unusually high precipitation. Most of the test materials flowered in the third week of September coinciding with rains, but there was no failure of seed set or "pollen wash" effect. Only the late flowering types on poor soil suffered drought during the reproductive phase because of early termination of rain.

Early maturing entries trials

Guiring

Table 11 contains the means and agronomic data recorded. Excellent moisture at planting and timely rainfall contributed to high yields. The effect of variety was significant for grain yield, days to 50% flowering, plant height, panicle length and 1000 grain yield. The mean grain yield was 3137 kg/ha. Entry IKMV 8201 and CPM-17 were the top yielders with overall average yield of 3721 kg/ha and 3634 kg/ha followed by CPM-14 (3453), CPM-18 (3350) and CPM-24 (3346). No significant difference was observed between IKMV-8201 and CPM 17. The maturity and height of both entries were similar. The local check Mouri ranked 12th behind other local varieties Tchaare dari and Gouzouma.

Yoldeo

The analysis of variance and means of the trial are presented in table 12. The effect of variety was significant for grain yield, days to 50% flowering, plant height, panicle length and 1000 grain weight. The mean grain yield was 1461 kg/ha and ranged from 2071 kg/ha for IKMV-8201 to 1168 for CPM-22. The highest seed yield was that of IKMV-8201, an ICRISAT accession at 2071 but was not significantly different from Mouri the check variety which ranked 2nd.

Guetale

Analysis and means are presented in table 13. The effect of varieties was significant for all characters except for plant count after final thinning and panicle count at harvest. The mean grain yield was 1903 kg/ha. The highest yielding genotype were CPM-17 (2259 kg/ha), IKMV-8201 (2253.13 KG/HA), Douvayad PM 1988 (2206 kg/ha), Mouri (2128 kg/ha), CPM-21 (2040 kg/ha). These entries did not differ significantly from the check varieties Mouri. All above mentioned high yielding entries were observed to have medium plant height, around 180 m and were early in maturity. 50% days of flowering range from 55 to 62 days. The length of panicle did not necessaryly have significant effect on yield.

Tchatibali

Table 14 contains the yield and agronomic data recorded in 1991. Very little drought stress was observed at filling stage. Variety effects were significant for most of the traits recorded. The mean grain yield was 1680 kg/ha and range from 1984 kg/ha to 1475 kg/ha. The highest yielding genotype was CPM-18 followed by Gouzouma PM 1988, CPM-21, Mouri, CPM-15. These last four varieties did not differ significantly from IKMV-8201 and CPM-17 which ranked 11th and 12th and yield 1600 kg/ha each. Maturity cycles did not differ either.

Table 11 : Trial: Pearl millet multilocation variety adaptation trial-1991
Location: Guiring, Maroua research station.

Selected Entries	Grain* yield kg/ha	rank	Days to* 50% flowering	Plant* height (cm)	Plant count after thinn./ha	Panicle count at harv./ha	Panicle length (cm)	1000 grain weight (gram)
CPM-14	3453	3	49	271	51562	129063	32.0	14.53
CPM-15	3046	9	46	252	50000	128125	32.5	15.20
CPM-17	3634	2	45	267	53750	128750	34.2	15.80
CPM-18	3350	4	45	271	53750	140937	32.3	14.85
CPM-21	3056	7	46	265	52187	132812	30.3	15.17
CPM-24	3346	5	45	267	54062	138125	27.5	14.85
IKMV-8201	3721	1	47	268	50312	130000	30.7	15.57
Mbankara	2825	13	51	262	51875	141250	31.5	14.20
Tchaare	3056	8	47	272	52812	135312	32.3	14.35
Overall mean	3137		47	264	52276	131227	31.70	14.71
SE	282.91		1.23	6.66	2520.80	11111.04	1.77	0.36
CV%	18.04		5.16	5.03	9.64	16.93	11.16	4.9

* Significant at 5% level.

Table 12: Trial: Pearl millet multilocation variety adaption trial 1991
Location: Yoldeo Farmer'field

Selected Entries	Grain* Yield kg/ha	Rank	Days to* 50% flowering	Plant* height (cm)	Plant count after thinn./ha	Panicle count at harv./ha	Panicle* length (cm)	1000 grain* weight (gram)
CPM-15	1465	5	49	191	37812	80312	32.5	14.30
CPM-17	1443	6	48	201	34062	81562	36.5	14.85
IKMV-8201	2071	1	47	205	37187	94375	32.0	14.85
Mouri	1790	2	56	203	36875	79062	31.3	14.25
Mbankara	1546	4	55	187	38125	78750	32.0	14.22
Gouzouma	1656	3	54	198	37500	77812	32.0	14.13
Tchaare	1371	7	50	193	36250	76562	36.3	13.55
Overall mean	1461		49	192	37031	78660	32.5	14.25
SE	138.49		2.00	6.28	1237.27	5836.23	1.47	0.35
CV%	18.95		8.14	6.54	6.68	14.84	9.08	5.04

* significant at 5% level

Table 13: Trial: Pearl millet multilocation variety adaptation trial 1991
Location: Guetale

Selected Entries	Grain* Yield kg/ha	Rank	Days to* 50% flowering	Plant* height (cm)	Plant count after thinn./ha	Panicle count at harv./ha	Panicle* length (cm)	1000 grain* weight (gram)
CPH-14	1956	6	59	168	37500	100625	33.25	13.5
CPH-17	2259	1	55	193	35625	115312	36.50	14.37
CPH-18	1715	12	59	177	27187	101562	32.50	13.55
CPH-21	2040	5	56	172	38437	121562	30.50	14.00
CPH-24	1875	8	55	172	36562	104687	30.25	13.95
IKMV-8201	2253	2	55	183	39687	11250	31.75	14.30
Mouri	2128	4	62	187	38437	96875	30.75	13.77
Gouzouma	1884	7	60	196	36250	103750	31.25	13.10
Douvayad	2206	3	62	191	40937	122187	31.50	13.62
Overall mean	1903		58	180	36674	105848	32.35	13.73
SE	226.20		1.46	6.82	2159.23	9871.94	1.38	0.33
CV%	23.77		5.00	7.56	11.78	18.65	8.58	9.90

* Significant at 5% level

Table:14 Trial: Pearl millet multilocation variety adaptation trial 1991
Location: Tchatiballi

Selected Entries	Grain yield kg/ha	Rank	Days to* 50% flowering	Plant* height	Plant count after thinn./ha	Panicle count at harv./ha	panicle length (cm)	1000 grain* weight (gram)
CPH-14	1684	6	56	167	38437	102187	31.0	12.77
CPH-15	1693	5	58	176	38125	96562	25.75	13.22
CPH-18	1984	1	58	181	38437	126562	26.50	13.75
CPH-21	1793	3	56	156	36250	115625	26.75	13.33
Mouri	1753	4	60	202	37500	105000	28.75	13.35
Tchaare	1681	7	59	172	38125	110000	30.00	12.95
Overall mean	1680		56	175	37522	108482	28.34	13.18
SE	161.82		2.53	9.61	1220.68	9395.65	1.53	0.21
CV%	19.26		8.91	10.94	6.51	17.32	10.86	3.31

* significant at 5% level

Collaborative Research Trials

Pearl millet yield trial/nursery (RMB-ICRISAT)

Through the millet research network, a set of 4 pearl millet trials were received from ICRISAT Sahelien center and planted at various locations. Data were collected on grain yield, days to 50% flowering, plant height, plant count after thinning, panicle count at harvest, panicle length, 1000 grain weight. All analysis were performed using the standard RCD Anova. The summary of results are presented below by location.

Guiring

Table 5 contains the yield and agronomic data recorded. This was an excellent test with uniform plant stands. Normal rainfall in planting time (15 July) contributed to above average grain yield. Grain yield were relatively high, averaging 3040 kg/ha and ranging from 3410 kg/ha for ICMV IS 85321 to 2631 for ICMV IS 82271. The effect of varieties was significant for most of the traits. ICMV IS 88210 was the second high yielding variety. The local check Mouri ranked 10th but was not significantly different from its 9 preceding entries. The average days of 50% flowering were 49 days. All high yielding varieties were of early to medium cycle.

Guetale

Grain yield at Guetale were relatively low with an average 1879 kg/ha. The low yields are most probably due to high rainfall in early July. The effect of varieties was significant for most of the traits. ICMV IS 89201 had the highest grain yield of 2387 kg/ha and ICMV IS 91203 ranked second followed by ICMV IS 85321, ICMV IS 88201, ICMV IS 89202. These entries were not significantly different.

Tchatibali

The effect of varieties was significant for major traits. High variability (CV = 28.5%) was observed on yield. This is due to the heterogeneous nature of the field and to high rainfall in mid-July. The genotype ICMV IS 88210 was the highest yielding entry, followed by ICMV IS 82270 and the local variety Gouzouma.

Table 15: Trial: Pearl millet yield trial/Nursery (ICRISAT)
Location: Guiring, Maroua research station

Selected Entries	Grain* Yield kg/ha	Rank	Days to* 50% flowering	Plant* height (cm)	Plant count after thinn./ha	Panicle length (cm)	Panicle weight kg/ha	1000 Grain weight (gram)
ICMV IS 88210	3339	2	51	255	38750	43.50	4979	13.90
ICMV IS 88212	3154	7	50	264	38333	46.66	4747	14.25
ICMV IS 82298	3185	4	46	260	39166	42.16	4816	13.75
ICMV IS 88201	3162	6	47	260	35416	41.50	4635	14.88
ICMV IS 91203	3264	3	50	264	37500	44.66	4747	14.53
ICMV IS 89202	3108	8	49	260	36666	45.33	4960	14.58
ICMV IS 88217	3183	5	51	277	37916	43.66	4872	14.45
ICMV IS 85333	3083	9	48	270	38125	41.00	4622	14.60
ICMV IS 85321	3410	1	49	256	35833	42.66	4795	15.18
Gouzouna	2804	16	57	273	39166	37.66	4389	14.00
Mouri	3043	10	52	264	36458	38.66	4658	14.36
Overall mean	3040		50	263	37708	42.97	4672	14.34
SE	245.05		1.23	6.10	1326.6	3.08	353.33	0.23
CV%	19.74		6.06	5.67	8.62	17.57	18.5	4.02

* Significant at 5% level

Table 16: Trial: Pearl millet yield trial/Nursery (ICRISAT-91)
Location: Guetale

Selected Entries	Grain yield kg/ha	Rank	Days to* 50% flowering	Plant height (cm)	Plant count after thinn./ha	Panicle length (cm)	Panicle weight (kg/ha)	1000 Grain* weight (gram)
ICMV IS 88212	1933	7	61	183	41250	42.16	3256	13.53
ICMV IS 89201	2387	1	57	175	39166	38.66	3879	13.23
ICMV IS 88201	211	4	58	177	38958	37.83	3520	13.75
ICMV IS 91203	2125	2	60	185	40417	42.66	3285	14.01
ICMV IS 90269	1847	9	58	164	34375	39.66	2939	13.65
ICMV IS 89202	2068	5	57	183	38958	43.00	3643	13.33
ICMV IS 85327	1872	8	57	180	38542	45.83	3308	13.85
ICMV IS 85321	2120	3	56	174	38333	35.33	3195	14.03
Gouzouna	2035	6	68	222	37500	29.83	3500	13.10
Mouri	1531	17	67	180	32500	31.00	2370	13.81
Overall mean	1879		60	181	37789	39.36	3198	13.51
SE	180.97		1.33	6.16	1859.64	1.55	33.41	0.23
CV%	23.58		5.45	8.32	12.05	9.65	25.03	4.26

* = Significant at 5% level

Table 17: Trial: Pearl millet yield trial/Nursery (ICRISAT-91)
Location: Tchatibali

Selected Entries	Grain* yield kg/ha	Rank	Days to* 50% flowering	Plant* height (cm)	Plant count after thinn./ha	Panicle* length (cm)	Panicle* weight (kg/ha)	1000 Grain* weight (gram)
ICMV IS 88210	1850	1	62	182	36042	37.16	2881	13.21
ICMV IS 88224	1602	9	60	200	37708	40.00	2129	12.70
ICMV IS 88219	1643	7	59	175	36458	35.66	2666	12.61
ICMV IS 88201	1647	6	61	175	38958	36.66	2758	12.53
ICMV IS 91203	1739	4	61	179	38125	34.16	2579	12.45
ICMV IS 82270	1768	2	59	184	38125	33.16	2997	12.88
ICMV IS 90269	1633	8	62	186	37083	36.33	2681	12.00
ICMV IS 85333	1691	5	62	191	38333	41.16	2868	12.58
Gouzouna	1745	3	60	187	34583	39.50	2352	12.58
Mouri	1458	12	59	171	36042	33.33	2341	12.55
Overall mean	1545		61	182	36203	36.40	2457	12.64
SE	179.85		1.51	9.77	1885.30	2.58	295.60	0.32
CV%	28.50		6.09	13.12	12.75	12.37	29.46	6.26

* = significant at 5% level

Combined Analysis

The analysis of variance and means over the three locations for grain yield, plant height and panicle length are presented in Table 18. The mean grain yield over location was 2160 Kg/ha and ranged from 2390 Kg/ha for ICMV IS 89305 to 1930 Kg/ha for ICMV IS 82271. The variety by location interaction was not significant for grain yield which indicates that the relative differences among these varieties was consistent over the three locations. The Check variety Gouzouma ranked 4th and yielded better than most introduced lines.

Table 18: Trial: PMCT-2 Combined Means of 3 Locations: Guiring, Guetale and Tchatibali

Selected Entries	Grain Yield (Kg/ha)	Rank	Plant Height	Head Length
ICMV IS 89305	2390	1	203	38
ICMV IS 89201	2340	2	211	40
" " 91203	2320	3	205	41
" " 88201	2310	5	208	38
" " 89202	2220	6	209	41
" " 82270	2200	7	204	39
" " 88210	2190	8	208	43
" " 88212	2180	9	216	42
" " 88224	2180	10	212	39
" " 88217	2090	11	215	49
" " 90269	2080	12	205	40
" " 82298	2070	14	205	37
" " 86330	2030	15	211	40
" " 88219	1980	16	208	43
" " 89301	1950	17	204	40
" " 82271	1930	18	202	36
GOUZOUMA (Check)	2320	4	228	32
MOURI (Check)	2080	13	214	33
Overall Mean	2160		209	39
SE±	180		7	7
CV (%)	23		9	14

5.5 VISITORS

- Dr. N. F. Beninati visited sorghum program September, 1991
- Dr. M.C. Ikwelle, Lake Chad Basin, Nigeria. January 6-8, 1992.

6.1 BAMBUI TLU 1991

6.1.1 INTRODUCTION

The TLU at Bambui is responsible for farming systems research in the Western Highlands, with an emphasis on maize and rice based cropping systems. The Western Highlands, comprising the North West (NWP) and West Provinces (WP), cover less than 10% of the land area in Cameroon, but contain 25% of the population, and produces over 60% of the national maize crop. The zone is mostly derived savannah, ranging in altitude from 400 to 3000 m, with annual rainfall between 1500 and 2500 mm.

The goal of the Bambui TLU is to increase and/or stabilize the productivity of cereal-based farming systems in the NWP & WP through the development, release and adoption by farmers of appropriate agronomic packages. Since 1982, significant progress has been made toward achieving this goal with the generation of farmer recommendations for maize and rice, built around new high yielding varieties that have been released and adopted by large numbers of farmers. In farmer managed trials, these recommended practices yielded marginal rates of return well above levels necessary to compensate farmers for the risk associated with adoption of a new technology.

Criteria for maize and rice variety testing originally emphasized productivity and disease resistance (on-farm trials, 1982-85). A second generation of varieties, that entered on-farm testing in 1989, have incorporated additional characteristics desired by farmers, a result of TLU feedback to the breeders. These included harder (flinty) grain for longer storage life, earliness, shorter plants, tolerance to low pH soils, and adaptation to the high altitude zone for maize; and, enhanced grain quality (long, narrow, translucent grains) for rice, to make it more competitive in the market with imported rice from Asia. An ever growing population, leading to higher crop:fallow ratios, combined with increased farming of steeply sloping and marginal lands, has caused considerable soil erosion losses, a general degradation of soil fertility, and steadily declining food crop yields, only partially offset by increasing use of chemical fertilizers. In response, the TLU has initiated a program of researcher-managed on-farm soil conservation (mainly use of contour bunds for erosion control) and soil fertility improvement (Tephrosia fallow) trials in 1991, in collaboration with the Provincial Delegation of Agriculture Adaptive Research Service and the U.S. Peace Corps 10-year Agroforestry Project. TLU farmer surveys in the next 4 years will be less oriented toward diagnosis and systems description, and more toward assessing technology retention, diffusion and impact.

6.1.2 SUMMARY OF ACTIVITIES

The TLU-Bambui benefitted from the addition of a soils agronomist (Dr. Olu Osiname) in 1991. With this new expertise and experience, the TLU was finally able to address long neglected, albeit critical, soil fertility problems, characteristic of many research zones in the western highlands. Several activities directed at diagnosing soil fertility constraints and relating these to specific soils and soil management practices were initiated, with the ultimate aim of developing effective soil fertility management recommendations.

These activities included extensive soil sampling from on-farm maize trial sites, to assist in soil characterization following physical and chemical analysis and their correlation with trial yield results. Additional samples were taken from non-trial farms where farmers use traditional soil management practices (e.g., ankara). Soil sampling and analysis was supplemented with pot experiments to identify nutrient elements limiting crop growth in each soil type. A program of on-station maize fertilizer trials (phosphorus), plus collection and collation of results from previous soil studies and mapping endeavors, complemented the on-farm soils research.

On-farm trials in 1991 comprised a third year of testing the new generations of maize (mid and high altitude) and rice varieties, and two new agroforestry trials (erosion control and improved fallow) in connection with the just started 10 Year Peace Corps Agroforestry Project; in addition to the normal maize minikit trials. A survey of farmers traditional maize stores, initiated in 1990, was completed, providing reliable estimates of storage losses suffered by farmers in 2 research zones (Ndop Plain and Bui Highlands). Other surveys carried out or in process included a maize variety retention survey of all on-farm trial farmers in 1989 and 1990, and pre-testing of a baseline survey questionnaire for the agroforestry program by peace corps volunteers.

With respect to training and extension liaison activities, TLU staff (Mr. Samatana) participated in an orientation course for extension agents in the West Province under the auspices of the National Agricultural Extension and Training Project. Finally, the long awaited maize technical bulletin, produced collaboratively by IRA-Bambui, UCD and MIDENO is finished and ready for field testing.

6.1.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Identify farmers' circumstances and practices.		
1.1. Evaluate maize storage losses in farmers' traditional stores.	1.1 Survey of 40 farmers stores in the mid and high altitude zones.	1.1 Survey completed; loss estimates obtained; paper written for future publication. Value of storage losses ranged from negligible to 31%. Discussion below.
1.2. Assess soil fertility over a wide range of sites in the Western Highlands.	1.2.1 Soil sampling from over 60 on-farm trial sites in the NWP & WP.	1.2.1 60 soil samples NWP & WP analyzed at UCD lab. Complementary ear-leaf sample analysis not completed. Discussion below.

Objectives	Activities	Accomplishments
	1.2.2 Soil and plant sampling from "ankara" and non-ankara sites on farmers' fields.	1.2.2 10 "ankara" sites Bambui plain & 5 sites Ndop Plain monitored cropping season. Soil & leaf samples taken. Soil analysis completed. Discussion below.
1.3. Identify factors affecting technology adoption and research impact.	1.3.1 Maize and rice recommendation retention survey.	1.3.1 Almost all farmers participating in 1989 & 1990 TLU on-farm maize variety trials interviewed. 90% still growing new varieties. Discussion below.
	1.3.2 Maize and rice variety diffusion survey.	1.3.2 Postponed until 1992.
	1.3.3 Baseline survey of farmers participating in the agroforestry research program.	1.3.3 Questionnaires pretested by peace corps volunteers.
1.4. Produce a map of the Western Highlands based on soil fertility characteristics.	1.4.1 Collation of information from publications from previous soil mapping studies in the NWP&WP; with compensatory soil sampling and analysis where necessary.	1.4.1 A complete 1: 200,000 scale soil map NWP produced by IRA-Ekona. Soil sample sites located on map in attempt to relate soil chemical characteristics to mapping units.
Operation 2: Identify improved and well adapted varieties.		
2.1. Assess the performance of new foodcrop varieties (maize and rice).	2.1 Joint researcher-farmer managed trials of 2nd generation maize and rice varieties.	2.1.1 Almost 90 maize trials in mid & high altitude zones. Yield & farmer assessment results from 60, despite constraints political situation. Discussion below.
	2.1.2 On-Station field trials to evaluate new mid-altitude maize varieties in maize/legume intercropping.	2.1.2 Trials carried out Mfonta & Babungo. Yields of all varieties reduced by intercropping with beans/soybeans. Discussion below.
2.2. Confirm value and acceptability of IRA/MCRE maize varieties.	2.2 Distribution of 300 maize trial minikits to extension agents.	2.2.2 300 minikits distributed. New varieties outyielded local varieties. Farmers assessed the new varieties as superior to their local variety.

Objectives	Activities	Accomplishments
Operation 3: Identify appropriate technologies for enhancing and sustaining soil fertility.		
3.1. Evaluate the effect of improved soil conservation practices.	3.1 Long term (1991-94) soil erosion control (contour bunds and hedgerows) trials in collaboration with Peace Corps Volunteers (PCV) in 4 villages.	3.1.1 PCV's set out more than 15 trial plots in 3 villages. TLU staff set out another 3 in 4th village. Contour bunds laid out, fixed with temporary plantings of tephrosia or guatemala grass. Good farmer response
3.2. Evaluate the yield benefits from planted fallow.	3.2 Long term (1991-94) planted fallow (relay planted green manure crops and alley-cropping) trials in collaboration with Peace Corps Volunteers in 4 villages.	3.2.2 Over 15 trial plots set out by PCV's in 3 villages, and 1 by TLU in 4th village. Calliandra callothyrsus hedgerows established on some farms, following temporary tephrosia plantings. Farmers showed great interest.
3.3. Determine fertilizer recommendations for specific recommendation domains.	3.3 On-station pot, greenhouse and field fertilizer response trials.	3.3.3 Bulk soil samples taken from 25 sites NWP & WP for evaluation P availability to maize. P deficiency symptoms observed all but 1 site. Tissue analysis still pending.
Operation 4: Increase knowledge of improved crop production materials and methods.		
4.1. Developing technical bulletins.	4.1 Completion of Maize Technical Bulletin in collaboration with UCD.	4.1 Technical maize bulletin prepared in collaboration with UCD and MIDENO. Ready for field testing.
4.2. Training of extension staff.	4.2 Participation of TLU researchers in training courses for AVV (Agents de Vulgarisation de Village) in the West Province, as the National Extension and Training Program gets under way.	4.2 TLU (Samatana) participated in orientation course for AVV's in the West Province, under the National Agricultural Extension and Training Project.

6.4 RESEARCH FINDINGS

Survey of farmers traditional maize stores:

Maize storage losses as a priority constraint in the western highlands of Cameroon has been repeatedly brought to the attention of the TLU staff and MINAGRI extension agents by farmers during surveys and on-farm trial operations. Farmer estimates of actual losses are, however, wide ranging and necessarily imprecise. Information on rates and types (quantitative/qualitative) of loss are essential to a number of economic assessments, including: estimates of the economic value of storage losses to the farmer, cost & returns analysis of improved storage technologies (structures or pest control measures), etc..

Farmers have, furthermore, cited "short storage life" as the major liability for IRA/NCRE improved maize varieties, because of their tendency toward a softer, dents grain type. In contrast, many of the local varieties have hard, flinty grains and, according to farmers, store better. There was a need to verify and quantify this liability, to justify steering breeder objectives toward harder grain varieties, involving a yield trade-off. The main culprits responsible for storage losses are insects: notably the maize weevil (*Sitophilus zeamais*). It seemed reasonable to assume that softer grains would be more susceptible to insect attack, if not to grain molds, as farmers tell us.

To obtain reliable estimates of storage losses under farmers conditions, the TLU initiated a survey of farmers traditional maize stores in Ndop Plain and the Bui Highlands in 1990. The objectives of the survey were to 1) assess real maize storage losses in farmers' traditional stores, 2) identify and characterize insect and fungal agents responsible for storage losses, and 3) estimate economic losses due to storage pests. The study was a collaborative one, with the IRA-Bambui Pathologists (Nankam and Ngoko) and IRA-Dschang Entomologist (Asanga) taking responsibility for the second objective[1]; and the FAO Postharvest Food Loss Reduction Project (PHFLRP) assisting with laboratory processing of storage maize samples. Methods used for assessing storage weight loss were "Count & Weigh" and "Thousand Grain Mass".[2]

Twenty stores each in Ndop and Bui were sampled (10-ears) bimonthly from October through April, after which sampling was done monthly until September or when the store was depleted, whichever came first. Samples were processed for loss assessment at the FAO lab in Bamenda, and subsamples provided for pathology and entomology evaluations. A basic questionnaire was completed for each farmer at the beginning of the survey (see 1990 TLU Annual Report), and "current status" questionnaires filled out during each sampling from the store. The former sought basic information on farm household composition, storage methods, and general maize removal and use patterns; the latter, quantities of maize removed in the previous week and how it was used.

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[1] For results pertaining to objective 2, see Maize Pathology and Entomology reports.

[2] Adams, J.M. and Harman, G.W. 1977. The evaluation of losses in maize stored in a selection of small farms in Zambia with particular reference to the development of methodology. Report of the Tropical Products Institute (Tropical Development and Research Institute), G109, Ministry of Overseas Development, London. 149 pp.

The TLU developed a model for estimating the value of maize in storage, that was the subject of a paper presented at the 1990 FSR/E Symposium at MSU.[3] The model operates on a number of assumptions about storage practices and attribution of value by the farmer, among which:

1) Stored maize undergoes both quantitative (weight) and qualitative (% damaged grains) losses from storage insects, rats and molds, while in the store.
2) Maize is removed piecemeal from the store throughout the storage period ($\leq$12 months).
3) Maize is removed to meet target food or sale quantities (Food maize). Feed maize is a by-product of screening (sorting) the Food maize.
4) Quality standards for maize consumed by the household or sold in the market tend to decline as one moves away from the immediate postharvest period and toward the next harvest; as stores are drawn down and prices rise. The quality of feed maize will also decline.
5) Farmers value their maize at the time of end use, or (for the purpose of the model) at the time of removal from the store.

Assumptions 1-4 have been confirmed by observation and in conversations with farmers in the North West Province. Assumption 5 is taken to be rational, and justifies the model. [Model specification is described in the 1990 TLU Annual Report.]

Data required for model estimation include:

1) Changes in quality of stored maize (% damaged grains) over the storage season.
2) Quantitative (weight) loss assessments in each storage period.
3) Quantities of maize removed from the store in each period by the farm family for consumption and sale.
4) Quality estimates for food and feed maize over the year.
5) Market prices for maize.

All of the information for items 1-4, except quality changes in Feed maize, was obtained for the period October 1990 to September 1991 through the survey. Three years of weekly price series data for 11 markets in the NWP was provided by FAO-PHFLRP.

A Grain Type Index based on visual evaluation of the sampled maize ears was developed and used to estimate the effect of grain texture (dents/soft vs flinty/hard) on storage losses, both qualitative and quantitative. The 10 ears of each sample are sorted 3-ways into dents, flinty and mixed grain ears, with the ears in each group accorded a value of 0, 1 and 0.5, respectively. The values are summed and divided by 10, yielding a index value between 0 and 1; where 0 represents pure dent, 1 pure flint, and intermediate values relative flintiness. The index is a continuous variable suitable for regression analysis.

Results and discussion: The survey covered 2 distinct zones (Ndop Plain and Bui Highlands) that differ both in altitude (1150-1300 m and 1400-2400 m, respectively) and storage method ("banda" and "wunchum/nchang", respectively). Storage losses in the warmer Ndop Plain

[3] McHugh, D. "The effect of storage loss rates on the valuation of maize stored in farmers' traditional stores and removed periodically for food, feed or sale in Cameroon", 18 pp.

are much more serious. Therefore, a separate analysis was done for each zone. The analysis for Ndop is presented below.

Quantitative and qualitative losses: Out of a possible 160 observations in Ndop Plain (20 stores x 8 sampling times through August), 108 were obtained. Early store depletion and farmer absence during sampling visits were among the reasons for the loss of observations. Estimated potential quantitative (weight) losses[4] for the 20 farmers in Ndop ranged from 0.1 to 35% (mean=7%); while estimated final qualitative losses (% damaged grains in last storage period sample) ran from 2% to 64% (mean=23%).

It is presumed that levels of maize storage losses are directly proportional to the insect population. And because insect populations grow exponentially, the loss curves should similarly represent an increasing loss rate over time, at least up to a point (examples might include exponential, quadratic or S-shaped curves). However, using the survey data, regression analysis showed no significant gains in efficiency of estimation for these functional forms over a simple regression. Therefore, a linear trend line was estimated.

Quantitative and qualitative loss estimates were regressed against time in the store (days from 1 October to the sampling date), time in the laboratory (days between sampling and processing dates), and the Grain Type Index. The latter was included, as mentioned above, to determine whether grain type has an effect on storage loss levels.

$$D = -0.0875 + 0.0008\,T_S + 0.0022\,T_L - 0.0572\,G$$
$$[\,t = \quad 4.8 \qquad 2.9 \qquad 1.4\,]$$
$$R^2 = 0.27$$

and

$$W = -0.039 + 0.0003\,T_S + 0.0004\,T_L + 0.0248\,G$$
$$[\,t = \quad 4.3 \qquad 1.3 \qquad 1.3\,]$$
$$R^2 = 0.18$$

Where: D = % Damaged Grains (weight basis)[Decimal]
W = % Weight Loss [Decimal]
T_S = Time in Store (days after 1 October)
T_L = Time in Lab (days from sampling to processing)
G = Grain Type Index $0 \leq G \leq 1$

Regression results do not bear out the hypothesis that flintier grains (higher index) are associated with lower losses (implying a significant negative coefficient). On the contrary, the coefficient was not significant (and positive to boot). Explanations might include the following:

1) Omitted variables (e.g., initial quantity stored, storage management levels, moisture content variations, etc.),

[4] Potential quantitative loss, in this context, is the estimate (using a laboratory gravimetric assessment method) of the % weight loss of the sample taken in the last storage period (normally July or August in Ndop). This represents the total quantity of maize (weight basis) that would be lost to the farmer if all the maize was left in the store for the whole storage period, and none removed during the year for consumption, sale or animal feed.

2) Inadequacy of the index (Perhaps it is too subjective; although flintiness and dentiness are easily distinguished visually), or
3) Grain type has no bearing, in fact, on how well maize stores.

The first explanation seems the most likely. In any case, it is clear that this question will only be resolved by way of a controlled experiment. In the meantime, we must be guided by farmers' perceptions and assessments in justifying the current grain-type breeding objectives (i.e., flinty grains).

Time in store (T_S) had a positive effect on quantitative and qualitative loss levels. Days in the laboratory (T_L), in a plastic bag without removing or killing the weevils found in the sample, had a similar significant positive effect on qualitative loss, but was not significant for quantitative loss.

The loss trend line was re-estimated, leaving out T_L and G, after adjusting all observations for losses due to delayed laboratory processing. Because of the wide range in losses experienced, three trend lines were estimated for both quantitative and qualitative losses: mean loss trend (all observations), maximum loss trend (top 25% observed loss levels in each sampling/storage period), and minimum loss trend (lowest 25% observed loss levels in each period){figures 1 and 2}.

Mean trend lines (n=108):

$$D = -0.0405 + 0.0007\,T_S \qquad R^2 = 0.20$$
$$[t = 5.1]$$
$$W = -0.0234 + 0.0003\,T_S \qquad R^2 = 0.18$$
$$[t = 4.8]$$

Maximum trend lines (n=28):

$$D = -0.0180 + 0.0013\,T_S \qquad R^2 = 0.56$$
$$[t = 5.7]$$

$$W = -0.0373 + 0.0007\,T_S \qquad R^2 = 0.49$$
$$[t = 5.1]$$

Minimum trend lines (n=28):

$$D = -0.0756 + 0.00008\,T_S \qquad R^2 = 0.22$$
$$[t = 2.7]$$

$$W = -0.0037 + 0.00002\,T_S \qquad R^2 = 0.11$$
$$[t = 1.8]$$

The minimum weight loss trend is not significantly different from zero, indicating negligible losses for 25% of the farm household maize stores. In contrast, stores having the highest loss levels averaged 31% damaged grains in the last storage period and a 13% potential weight loss.

Fig 1: Stored Maize Weight Loss Trends

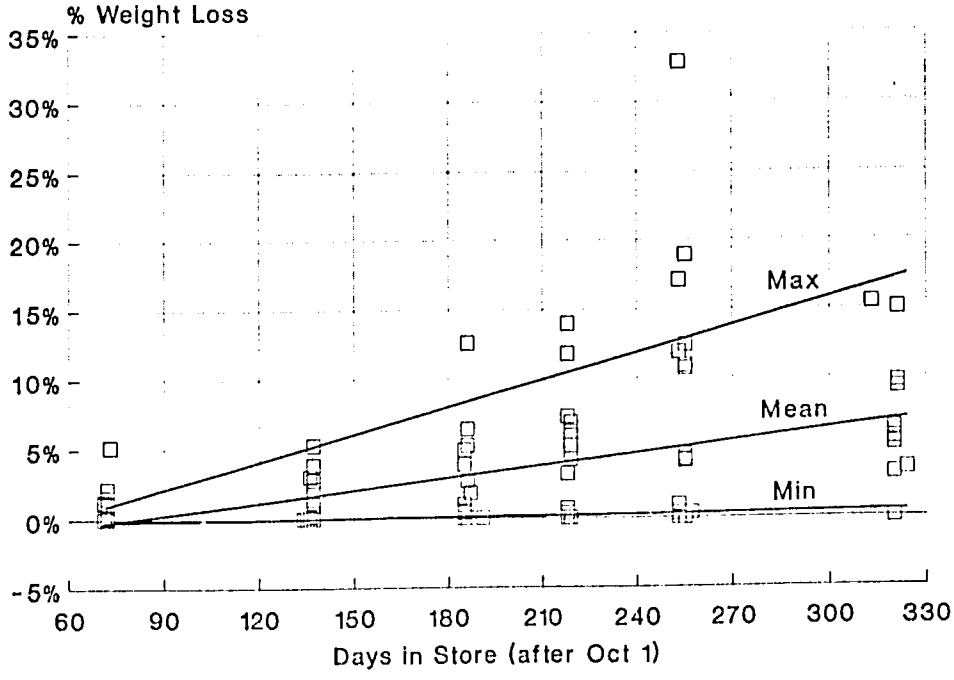
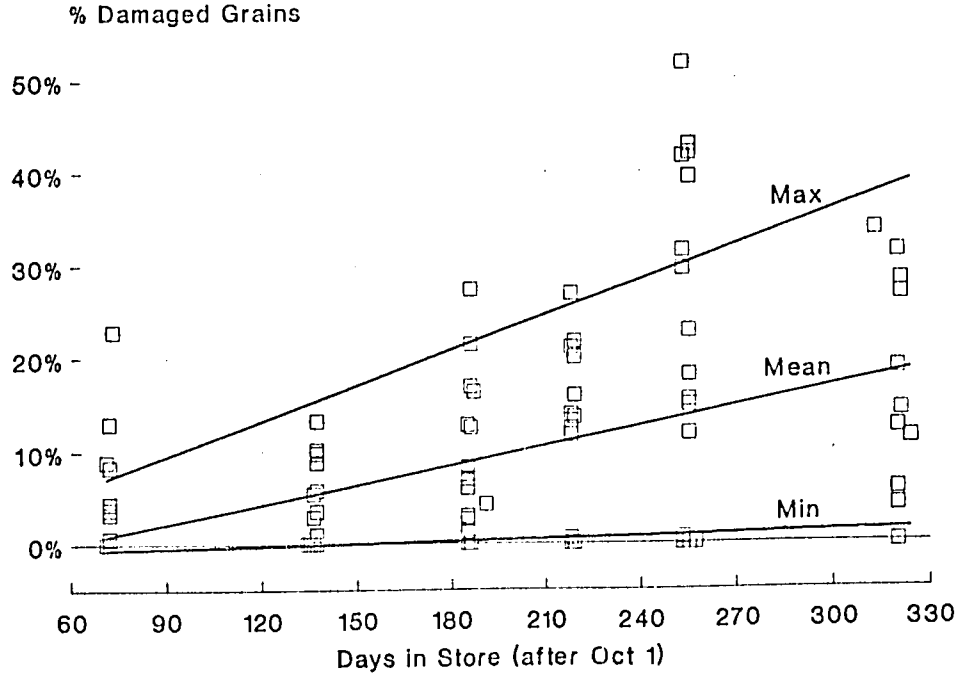


Fig 2: Stored Maize Quality Loss Trends



A linear relationship was shown to exist between qualitative and quantitative storage loss levels [as noted by Adams and Schulten, 1978], which is specified below.

$$W = 0.301\ D$$
$$[t = 16.0] \qquad R^2 = 0.59$$

This compares with a coefficient of 0.22 (i.e. ratio D/W of 4.5) proposed by Adams and Schulten (1978).

Using this relationship, curves can be described showing the effect of qualitative losses on the level of economic losses sustained by the farmer, under varying assumptions of maize removal rates, initial stored quantity, changes in food and feed maize quality standards and prices. We now turn to these latter important variables in the maize valuation model.

Rates of maize removal and initial stored quantity: Farmers were questioned during each sampling visit about quantities of maize removed in the previous week for consumption and sale. Monthly removal rates were extrapolated from these estimates, giving a range of rates from 161 to 226 kg dried shelled maize equivalent (mean = 180, SD = 22.4) from October to July, and 105 kg in August when all stores with maize remaining were emptied {figure 3}. There is no obvious explanation for the apparent peak in March-April, but assuming a basic household need for 180 kg of food maize per month, there is a mean shortfall of 75 kg (42%) in August. In several cases, the store was depleted in July or even June.

Total initial quantity was difficult to estimate at the beginning because of the farmers storage method of piling maize in the ear with husks in amorphous stacks above the ceiling of the house ("banda"). Therefore, it is calculated by combining estimated total quantity removed for food and sale, adding 20% for use as feed maize (levels expected to result from sorting the maize, given mean loss trends presented above and quality standards discussed below), and assuming a 7% weight loss (the overall mean in Ndop). The estimated mean initial stored quantity is 2.5 tons shelled grain equivalent.

Food and feed maize quality standards: Quality standards in this instance mean % damaged grains (by weight) permitted in food or feed maize. It is assumed that feed maize will always be of lower quality than food maize, except in the beginning of storage when the maize in the store is at or above food quality standards. Secondly, as stated in the 4th assumption of the storage valuation model, these quality standards are expected to decline over the storage season.

To obtain estimates of changes in food maize quality, technicians with FAO-PHFLR Project sampled maize brought to a mill in Ndop for grinding to make fufu, and maize being sold in the weekly Ndop market, at various times during the year. Estimates of % damaged grain were regressed against time to give a quality trend line. The best fit was a quadratic function, which yielded an R^2 of 0.81. Estimated food maize quality varied from 0% damaged grains at the beginning of storage to 7.5% damaged grains in the last storage period. No quality measurements were obtainable for feed maize; so we used an "educated" guess of a quality decline from 10% to 90% damaged grains over the storage season.

Fig 3: Rate of maize removal from store
(Ndop Plain, 1990-91)

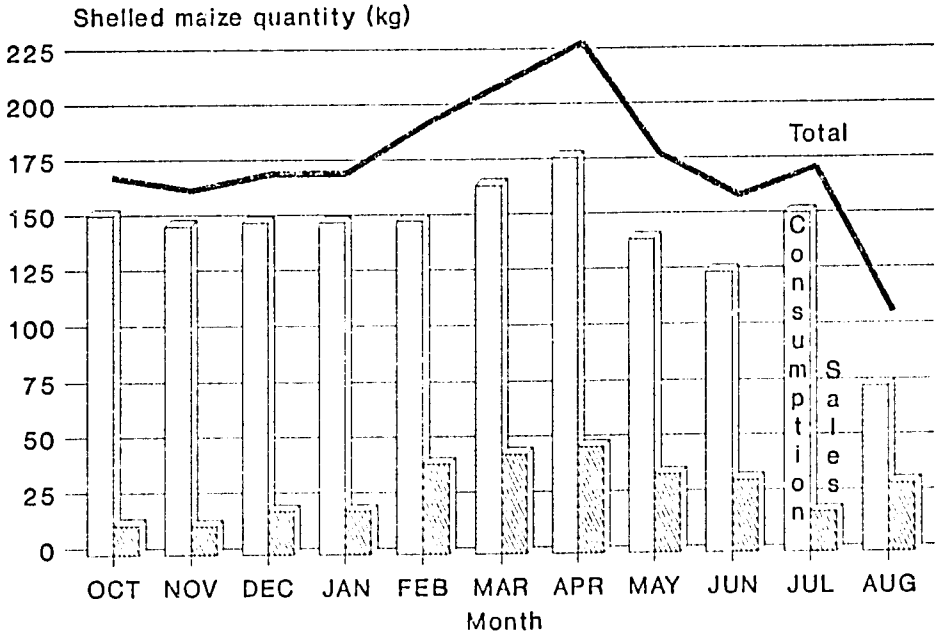
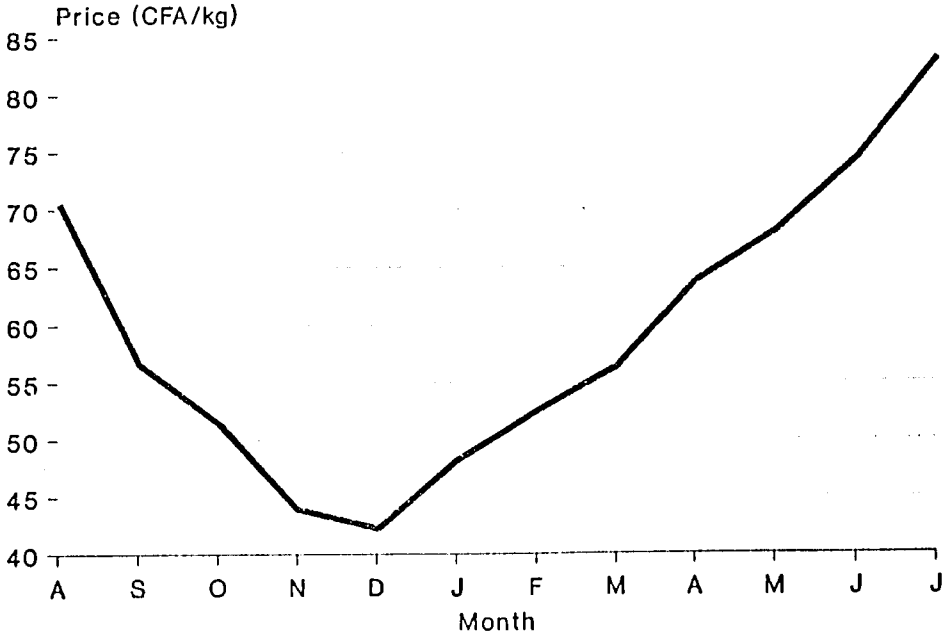


Fig 4: Monthly Maize Prices in the NWP
(3 year mean of 11 markets, 1988-91)



Source: FAO-PHFLRP; Bamenda, Cameroon

Prices: FAO-PHFLRP has been monitoring foodcrop commodity prices in 11 weekly (mostly 8-day) markets in the North West Province for the last 3 years. From these, 3-year mean monthly prices were computed {figure 4}. Shelled maize prices peak in July (83 CFA/kg), begin dropping as the harvest progressively comes in from higher elevation areas in the Province (August-November), bottoming out in December (42 CFA). This is the normal trend.

However, in some years (poor harvest, strong market demand) prices remain high, peaking at 130 CFA in some markets. In 1988 in contrast, prices remained at or below 35 CFA throughout the year in most markets, reaching a low of 20 CFA. Therefore, 3 price scenarios are presented in valuing storage losses to the farmer in the following section: mean price trend {figure 4}, a single high price (100 CFA) and a single low price (20 CFA). Feed maize prices are fixed at 15% of food maize price (suggested by Dr. S. Almy of TLU-Ekona, in 1990), to reflect a low opportunity cost and limited marketability.

Estimates of the economic value of storage losses: Using the above mean estimates for qualitative and quantitative losses, removal rates, initial stored quantity, quality standards and prices, an estimate of the value of the stored maize to the farmer was calculated employing the valuation model described in the 1990 TLU Annual Report. Under these (mean) assumptions, 303 kg of food maize is removed from the store in the last storage period (August), a surplus of 123 kg; and the total value of the 2.5 tons of stored maize, accumulated over the year, is 137,869 CFA.

If there had been no losses, and the maize removed at the same rate, the value to the farm family would be 151,780 CFA, with 520 kg removed in August (an excess of 340 kg that could be sold). This implies a storage value loss to the farmer of 23,329 CFA (15%).

Under assumptions of maximum storage losses (maximum loss trend line, figures 1 & 2), the value loss amounts to 32%, with the store being depleted in June, when only 155 kg of maize is left. Under minimum loss assumptions, the value loss is negligible.

If the farmer wants to speculate and sell all the maize as food and feed maize at one time, under the above mean loss and price assumptions, she/he can maximize total revenue by selling in July at 179,841 CFA (2134 kg food maize + 220 kg feed maize, with a 5.8% real weight loss). However, this is only 37,341 CFA above total revenue earned if the maize is sold immediately after harvest and drying, yielding a modest 26% to cover storage costs. Surely storage costs (sorting labor, storage structure maintenance and depreciation costs, interest, etc.) would offset the total revenue gain. Therefore, the farmer would be better advised to sell all after harvest. If, however, control measures (chemical, hermetic, etc.) can effectively prevent quantitative and qualitative storage losses, the farmer stands to gain a margin of up to 65,000 CFA (46%) by selling in July, part of which could be used to pay for the control measure.

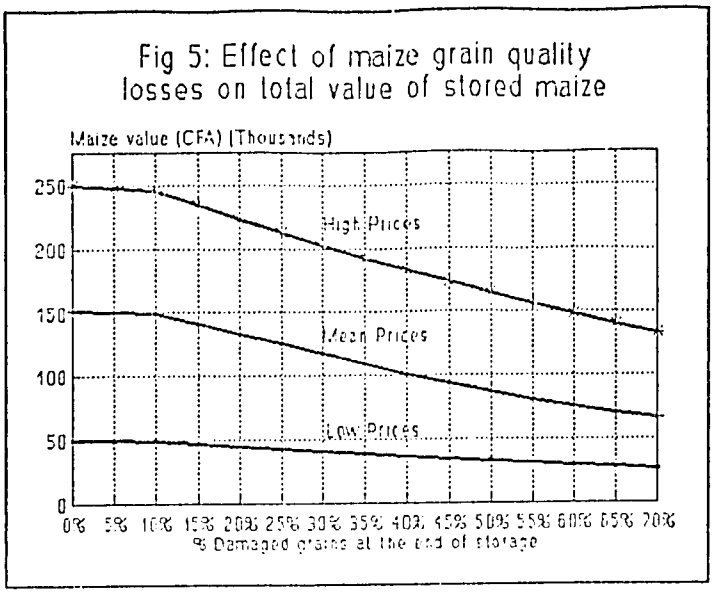


Figure 5 shows the effect of final qualitative loss levels on the value of stored maize under the 3 price scenarios, while maintaining all other above-mentioned assumptions.

On-farm mid-altitude maize variety trial:

In the third year of testing new, 2nd generation mid-altitude maize varieties on farm, the TLU moved closer to a farmer managed trial design. Aside from maize variety, choice of associated crop (soybeans) and a standardized low fertilizer rate (100 kg/ha 20-10-10) using the farmers' application method (i.e., sidedressed 4-6 weeks after planting), all other management operations were controlled by the farmer (land clearing, tilling & ridging, time of planting, plant density & configuration for maize and soybeans, and weeding frequency & timing). Plot size was increased (10 ridges x 4 m = 40-60 sq m) and replications reduced to one. The 5 treatments comprised 3 new varieties (ATP, EARLY WHITE and SYNTHETIC), a 1st generation improved variety check (COCA or KASAI) and the farmer's LOCAL variety.

During the 1st season (March-August), the trial was planted on 56 farms in 4 Divisions in the North West Province and 4 Divisions in the West Province. A modified version of the trial (fewer varieties: ATP, EARLY WHITE, MSR and LOCAL) was carried out during the second season (August-December), on 25 farms in two areas where maize is double-cropped in the NWP (Bali and Fundong). Almost a third of the 1st season trial results were lost, primarily because of communication problems and restrictions on TLU staff movement during the critical period from June to October as a result of the political situation.

After harvest, maize of each variety was put in net bags with a label, and placed in the farmer's maize store. Farmer assessments were elicited at harvest (yield, plant type, ear aspect) and 2-3 months after harvest (storability, cooking quality, taste).

Tables 1, 2 and 3 present the yield and farmer assessment results. Pooling results from all mid-altitude locations (table 1), the improved varieties outyielded LOCAL by a mean of 0.5 tons (24%), with KASAI and COCA topping the list. Among the improved varieties, only EARLY WHITE yielded less than the top yielders. Because of the trials that were lost and the resulting loss of degrees of freedom, compounded by high CV's typical of on-farm experiments, it was not possible to discern treatment differences at the 5% level in 2 zones when the data was partitioned by research domain (table 2). Even a 1.1 t/ha yield advantage for KASAI over LOCAL in Ndop Plain was not significant. The disparity in the number of trial sites in the three research domains (n=31, table 2) and total trial sites (n=39, table 1) can be explained by the fact that a few trials were planted in mid-altitude areas that don't fall within these domains (i.e., Bali, Fundong and Nwa).

The relative performance of each variety across environments is evaluated by regressing its yield against the site mean yield, i.e. modified stability analysis

Table 1: Mean grain yield (kg ha^{-1}) for selected mid-altitude maize varieties in on-farm trials across all mid-altitude zones in the North West and West Provinces (1991).

Variety	Sites with C O C A	Sites with K A S A I	All Sites
	(16 farms)	(23 farms)	(39 farms)
COCA	2764 a[1]		
KASAI		3092 a	
COCA & KASAI			2957 a
ATP	2324 ab	2956 a	2697 ab
EARLY WHITE	2410 a	2669 ab	2563 b
SYNTHETIC 3	2335 ab	2828 ab	2626 ab
LOCAL	1842 b	2427 b	2187 c
SE	198.3	155.8	121.8
CV	34%	27%	29%

[1] DMRT (p=0.05).

Table 2: Mean grain yield (kg ha^{-1}) for selected mid-altitude maize varieties in on-farm trials, by research zone, in the North West and West Provinces (1991).

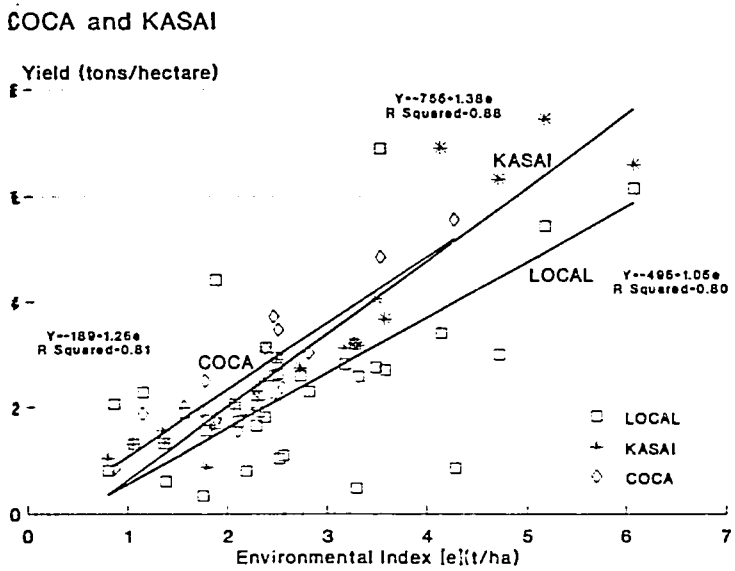
Variety	High Plateau West Province	Ndop Plain/ Noun Dept	Banenda Plain
	(14 farms)	(9 farms)	(8 farms)
COCA	2910 a[1]		
KASAI		3626 (NS)	2563 a[2]
ATP	2342 ab	2883	2671 a
EARLY WHITE	2480 ab	3156	2475 a
SYNTHETIC 3	2370 ab	2873	2664 a
LOCAL	1859 b	2507	2103 b
SE	221.7	336.1	148.5
CV	35%	34%	17%

[1] DMRT (p=0.05) [2] DMRT (p=0.10)

Table 3: Mean farmer expressed preference ranking (1-5), at harvest, for selected mid-altitude maize varieties in on-farm trials, by research zone, in the North West and West Provinces (1991).

Variety	High Plateau West Province	Ndop Plain/ Noun Dept	Bamenda Plain
	(14 farms)	(9 farms)	(8 farms)
COCA	2.43 a[1]		
KASAI		2.44 (NS)	2.50 ab[2]
ATP	2.57 a	2.89	1.88 a
EARLY WHITE	3.21 ab	3.00	3.75 b
SYNTHETIC 3	2.50 a	2.56	3.12 b
LOCAL	4.29 b	4.00	3.75 b
SE	0.381	0.504	0.522
CV	48%	51%	49%

[1] DMRT (p=0.05) [2] DMRT (p=0.10)



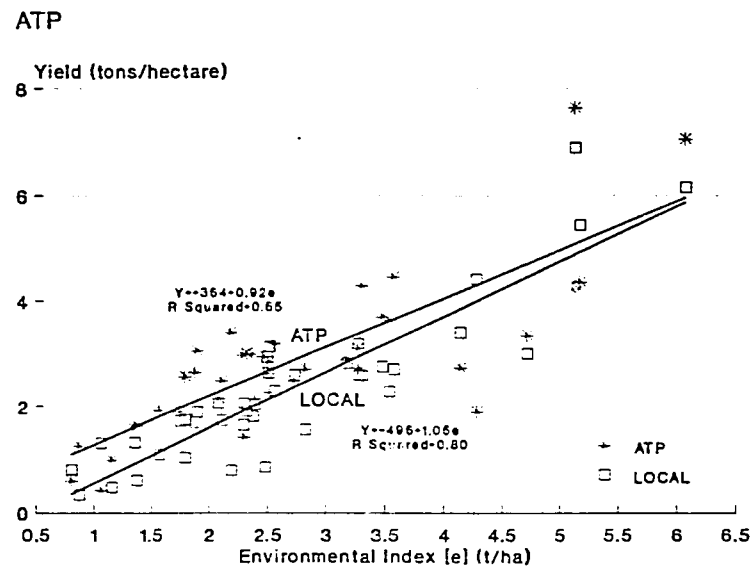
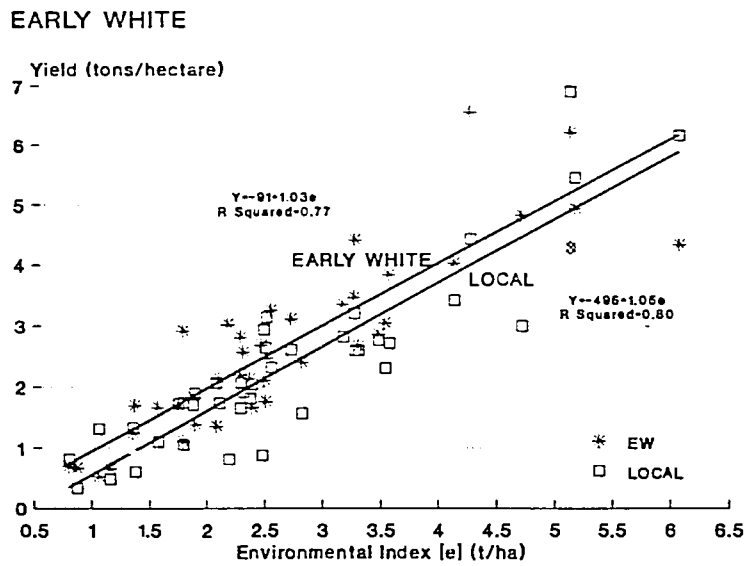
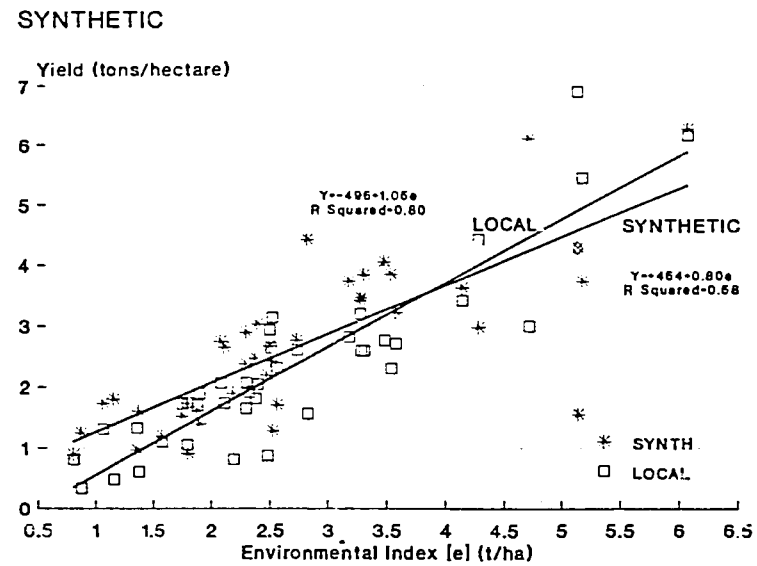


Fig 6: Effect of Environment on Yield of Maize Varieties





(Figure 6). Regression lines for all improved varieties, except EARLY WHITE (P=0.10), are significantly different from the LOCAL regression line (P=0.05); to the extent one can have confidence in such statistics when "X" is partly explained by "Y", violating at least one of the assumptions for regression analysis.

Farmers assessed the improved varieties, except EARLY WHITE, to be superior to their LOCAL varieties (table 3) at harvest time. Postharvest assessments ranked the varieties as follows: the best storers are LOCAL, SYNTHETIC and ATP in that order; the varieties with best cooking quality are COCA, KASAI and SYNTHETIC 3; the best tasting as fufu are COCA, SYNTHETIC 3 and KASAI; the best tasting as roasted ears are ATP, EARLY WHITE and LOCAL. The varieties assessed best overall were COCA, KASAI and SYNTHETIC 3; although there are yellow-corn-preferring niches where ATP is highly valued.

In 2nd season trials in Bali, none of the NCRE varieties performed better than the LOCAL. Mean yields on 14 farms ranged between 1.9 and 2.3 t/ha. Early White and LOCAL were significantly earlier maturing than ATP and MSR (an average 4-5% lower grain moisture content at harvest). Farmer assessments at harvest favored LOCAL. Bali farmers showed no interest in a yellow variety. So ATP should be excluded from the trials in Bali in the future.

On-farm high-altitude maize variety trial:

For a third year, new open pollinated maize varieties for the high altitude zone (above 1500 m) were tested on farms in the Bui Highlands of the North West Province. The trial design was similar to that of the mid-altitude maize variety trial described above (i.e., "near farmer managed"). Three new varieties (HAP, IMPROVED-NDU LOCAL and POOL 9), plus a farmer's LOCAL variety check, were planted on 27 farms, at altitudes ranging from 1950 to 2200 m. The maize was intercropped with *Phaseolus* beans, with a uniform application of 100 kg/ha 20-10-10 compound fertilizer at 6-8 weeks after planting. Yield results were obtained from 18 sites.

This year's on-farm trial results (table 4) represent a definite setback for the high-altitude maize program. It had been hoped that after two years of promising on-farm results (for the HAP variety in particular), and following a third year of verification trials, the first NCRE/IRA improved variety could be released for this important maize growing zone. However, there was no significant yield difference between the new varieties and the farmers' LOCAL varieties. More disappointing yet, farmers ranked the LOCAL variety first when their assessments were elicited at harvest time. The range of trial elevations was too narrow (350 m) to detect a varietal response to altitude.

Table 4: Mean grain yield (kg ha^{-1}) of selected high altitude maize varieties in on-farm trials (n=18), and mean farmer expressed preference ranking (1-5)[Bui Highlands, 1991].

Mean Variety	Mean Yield Unadjusted	Mean Yield Adjusted*	Preference Ranking
LOCAL	2621 (NS)	2446 (NS)	1.7 a**
IMP NDU LOCAL	2522	2533	2.5 ab
POOL 9	2213	2186	3.0 b
HAP	2152	2343	2.8 b
SE	231.2	204.5	0.28
CV	41.3%	35.9%	47.9%

* Covariance analysis (covariate = final maize stand) ** DMRT (5%)

Mid-altitude maize/legume intercropping:

Three new mid-altitude maize varieties, ATP, SYNTHETIC pool 3 and EARLY WHITE, which have shown good potential in earlier trials, and the LOCAL variety were compared in an on-station legume intercropping trial at Mfonta (Bambui Plain) and Babungo (Ndop Plain). The two legumes in the trial are field beans (*Phaseolus vulgaris*) and soybeans (*Glycine max*). The objective was to study the performance of the new mid-altitude maize varieties under a legume intercropping system popular in the North West Province.

The treatments consisted of 4 maize varieties and 3 legume regimes - none, beans and soybeans. The experimental design was RCB with all combinations of maize varieties and legume regimes, replicated four times. All plots received the recommended fertilizer rate of 60-30-30 N- P_2O_5 - K_2O. Ear leaf samples of maize were taken at silking at Babungo and analyzed for plant nutrient elements.

Results showed that legume intercropping significantly lowered grain yields of all maize varieties tested **(table 5)**, with the bean intercrop competing more with the maize than the soybean intercrop **(table 6)**. Higher maize yields under the bean intercrop than under the soybean intercrop at Mfonta was due to mediocre bean performance at the site. The main cause of maize grain yield reduction was competition for N by both crops **(table 7)**. Maize intercropped with beans showed strong N deficiency symptoms at flowering. Similar N deficiency symptoms by maize intercropped with soybeans showed at the grain filling stage.

Under good growth conditions, as was the case in Babungo, there were no significant differences among the maize varieties in their effects on legume grain yield. The yield of Beans and Soybeans under sole crop was double the yield obtained under intercropping with maize **(table 8)**. The yield gain for sole-cropped soybeans was primarily due to a higher number of pods per plant **(table 9)**.

Table 5: Mid-Altitude maize variety grain yields (kg ha^{-1}) under legume intercropping.

Maize Variety	Babungo, Ndop Plain			Mfonta, Bambui Plain		
	Sole crop intercrop	With Bean maize	With Soybean intercrop	Sole Crop maize	With bean intercrop	With soybean intercrop
Local	7082	3838	4430	2067	2638	1769
Synthetic pool 3	7587	4196	5836	1936	2225	1320
Acid Tolerant Pop (ATP)	6939	4414	4987	3000	1686	1539
Early White	6486	4009	5360	2260	2136	1939
SE of Mean	356.5	282.8	282.8	179.0	200.0	200.0
CV %	18.0%				33.9%	

Table 6: Effect of legume intercropping on plant height and flowering of new mid-altitude maize varieties, Babungo.

Maize Variety	Plant height, cm			% Tasseling 70 days after planting		
	Sole crop intercrop	With Bean maize	With Soybean intercrop	Sole Crop maize	With bean intercrop	With soybean intercrop
Local	128.0	85.7	100.1	66.1	37.5	54.8
Synthetic pool 3	112.0	86.5	101.7	47.8	30.1	39.6
Acid Tolerant Pop (ATP)	109.1	74.7	102.3	39.8	12.9	27.7
Early White	113.3	95.1	106.7	81.8	71.4	89.0
SE of mean	2.40	3.04	3.04	1.94	3.96	3.96
CV		27.5%			10.4%	

Table 7: Effect of legume intercropping on maize ear-leaf nitrogen content, Babungo.

	Sole Crop	Intercropped Beans	Soybeans
Local	2.73	2.20	2.52
Synthetic Pool 3	2.61	1.94	2.09
ATP	2.67	2.18	2.16
Early White	2.58	2.17	2.11

Table 8: Grain yields of beans and soybeans sole cropped or intercropped with maize.

	Grain yields, kg ha^{-1}, Babungo		Grain yields, kg ha^{-1}, Mfonta	
Cropping system	Beans	Soybeans	Beans	Soybeans
Intercropped with Local	826	1407	253	1081
Intercropped with Synthetic pool 3	637	1484	192	1294
Intercropped with ATP	696	1446	185	1452
Intercropped with Early White	773	1456	262	1083
Sole crop legume	1458	3670	387	1161
SE of Mean	126.9	136.1	53.1	150.1
CV	25.0%	12.5%	36.0%	21.4%

Table 9: Effect of maize intercropping on the number of pods and %, unfilled pods per soybean plant, Babungo.

Cropping System	No. pods/plant	% unfilled pods per plant.
Intercropped with Local	19	12.1
Intercropped with Synthetic pool 3	15	13.3
Intercropped with ATP	17	11.1
Intercropped with Early White	17	11.9
Sole crop soybean	35	11.6

Effect of rate, method and time of fertilizer application on a maize/bean intercrop:

Earlier farm surveys showed that, on average, farmers use about 100 kg of 20-10-10 compound fertilizer per hectare for their maize crop. The minimum fertilizer recommendation by research is 250 kg/ha. This trial was therefore conducted to verify whether through method and time of application farmers can maximize the benefits from the very low fertilizer rate they can afford.

Two rates of fertilizer, 100 and 200 kg 20-10-10 per hectare were banded at planting, sidedressed at 4 weeks after planting or broadcast before ridging. The idea of broadcast before ridging was to verify if such a practice would have a priming effect on the mineralization of nutrients locked up in soil organic matter.

The results presented in **table 10** show that at Babungo, banding fertilizer at planting was superior to either broadcast before ridging or sidedressing four weeks after planting. The expected priming effect of broadcast fertilizer did not materialize at either rate of fertilizer application.

At Mfonta however, the yields were very poor and followed no trend. Although the trial was planted late (end of April), it appears that both the rate and timing of fertilizer application test will not be suitable for an environment like Mfonta. The trial will continue next season to identify what method is suitable for which environment.

Table 10: Effect of rate, time and method of fertilizer application on maize/legume intercrop performance.

Treatment	Babungo Maize yield, kg ha^{-1}	Babungo Bean yield kg ha^{-1}	Mfonta Maize yield kg ha^{-1}	Mfonta Bean yield kg ha^{-1}
Control No fertilizer	3339	462	258	18
100kg 20-10-10 Broadcast before ridging	4274	395	266	65
100kg 20-10-10 banded at planting	5002	645	246	26
100kg 20-10-10 sidedressed 4 weeks after planting	3498	469	227	19
200kg 20-10-10 Broadcast before ridging	4592	381	305	57
200kg 20-10-10 banded at planting	5626	538	209	37
200kg 20-10-10 Sidedressed 4 weeks after planting	4409	462	294	19
SE of Mean	411.9	92.9	63.9	
CV	18.8%	38.8%	49.6%	

Ankara land preparation system and soil chemical characteristics:

Diagnostic Farm surveys and previous on-station field trials have confirmed that the "ankara" land preparation system (where grasses are buried and then burnt) improve crop yield mostly during the same season it is prepared. The actual chemical changes taking place in the soil during the process have not been fully quantified.

At the beginning of the season, soil and maize ear leaf samples were taken from "ankara" beds and adjacent non-ankara plots at 12 locations for analyses. The objective is to verify the contributions of "ankara" to the fertility of the soils where the system is practiced and proceed to develop a sustainable technology that would produce the same effect without the destruction of soil properties accompanying "ankara".

Some results of soil analyses are shown in table 11. Analyses of plant and soil profile samples taken at maize harvest have not been completed.

"Ankara" land preparation reduced soil acidity. Even though samples were taken about six weeks after preparation, pH changes of up to 0.8 were observed in places. The "ankara" effectively neutralized up to 1.28 meq/100g of exchangeable AL in the soil.

A significant feature of the "ankara" system is an increase in exchangeable bases, Ca, Mg, and K. The balance among Ca:Mg:K ratios is an important index of soil fertility. Earlier reports had indicated that a mg/k ratio below 2 may give rise to Mg deficiency especially in basaltic soils. The efficiency of the "ankara" system therefore, may depend on the degree of balance it maintains among Ca: Mg: k.

The "ankara" system seems to improve available P mostly where initial P content is moderate to high.

Table 11: Soil chemical characteristics under "Ankara" and No Ankara land preparation methods.

Site	Land prep. Method	Ph	OC%	Ca	Mg	k	Al	H+	ECEC	CEC7	BRAY
							MC /	100g			PPM
1 Bambui Plain	1 No Ankara	6.1	7.33	3.80	1.31	0.35	-	-	5.46	29.4	4.9
2 "	Ankara	6.4	3.74	4.84	2.72	0.98	-	-	8.54	23.3	4.9
3 "	2 No Ankara	6.0	8.50	2.64	0.85	0.27	-	-	3.76	30.3	5.8
4 "	Ankara	6.4	3.34	4.55	2.31	0.39	-	-	7.25	17.8	4.0
5 "	3 No Ankara	6.2	7.72	6.28	2.01	0.44	-	-	8.73	27.0	6.7
6 "	Ankara	6.5	3.80	8.53	3.49	1.46	-	-	13.48	27.1	4.6
7	4 No Ankara	5.6	3.62	2.75	1.26	0.29	-	-	4.30	21.2	5.1
8 "	Ankara	6.0	3.90	5.21	3.19	0.68	-	-	9.0	25.7	9.3
9 "	5 No Ankara	6.2	5.90	6.46	2.71	0.68	-	-	9.85	28.6	6.5
10 "	Ankara	6.6	8.11	9.66	3.83	1.17	-	-	14.66	24.9	7.4
11 "	6 No Ankara	6.0	3.03	4.89	1.87	0.61	-	-	7.37	17.2	28.2
12 "	Ankara	6.4	3.55	6.64	2.36	1.20	-	-	10.20	18.6	34.9
13 Ndop Plain	1 No Anakar	5.3	2.67	2.67	0.72	1.25	0.18	0.03	4.85	7.0	15.9
14 "	Ankara	5.6	2.99	2.68	0.83	0.47	-	-	3.98	6.9	21.1
15 "	2 No Ankara	5.1	1.61	1.36	0.47	0.64	1.28	0.11	3.86	11.4	25.7
16 "	Ankara	5.8	0.82	1.97	0.97	0.06	-	-	4.00	9.[illegible]	45.3
17 "	3 No Ankara	6.5	2.83	3.27	1.35	0.84	-	-	5.46	7.8	16.2
18 "	Ankara	6.6	2.28	4.10	1.83	1.25	-	-	7.18	9.3	43.6
19 "	4 No Ankara	5.2	2.52	2.61	0.94	0.66	0.28	0.13	4.62	8.3	11.2
20 "	Ankara	5.6	2.44	3.29	1.25	0.72	-	-	5.26	9.9	13.4
21 Baloun	1 No Ankara	6.1	4.0	6.62	3.26	0.27	-	-	10.15	22.0	10.1
22 "	Ankara	6.3	3.4	6.81	3.90	0.86	-	-	11.57	19.8	12.0
23 Bamendjou	1 No Ankara	6.3	2.6	5.70	2.73	0.14	-	-	8.57	17.7	6.8
"	Ankara	6.4	2.5	6.14	3.34	0.53	-	-	10.01	18.3	8.3

Rapid assessment of soil fertility status of the Western Highlands of Cameroon

Soil samples were taken from over a wide range of sites in both Northwest and West Provinces at maize planting. The on-farm maize variety trial sites were included to allow an assessment of maize grain yield at sample sites. The objective of the exercise was to rapidly determine soil fertility constraints to maize production and make suggestions for a new direction in soil fertility research in the Western Highlands of Cameroon.

Maize ear leaf samples were also taken at silking from the on-farm variety trial sites and analysed for plant nutrient content along with the soil samples. Only the results of soil analysis are discussed in this report.

The samples were grouped into two sets; those from mid-altitude (1000 - 1500m) sites and those from high altitude (> 1500m) sites.

Multiple regression analyses were performed on the data using site mean yield as dependent variable and soil parameters as independent variables.

The range and means for soil parameters are presented in table 12. The means for soil pH, exchangeable Ca and K are similar for both mid-altitude and high altitude zones. While organic carbon and CEC are higher, exchangeable Mg and available P are lower in the high altitude than in the mid-altitude zone. In both zones, the minimum value observed for each parameter, except pH, is above the critical level described in the literature for maize production.

Regression analysis of maize grain yields against soil parameters showed that exchangeable K in the soil was the most important single factor ($R^2 = 0.32$) influencing yield in the mid-altitude zone. The best correlations with yield were from Ca, Mg and K. Organic carbon gave a negative correlation while correlation with available P was low.

In the high-altitude zone, a complex interaction among pH, Ca, Mg and available P control maize yield. The R^2 for this regression was 0.72. Exchangeable Ca in the soil appears to have a strong effect on the availability of Mg and P.

The partial results presented above show that the interactions among the basic cations, Ca, Mg and K are strong factors determining the soil fertility status (i.e. ability of the soil to release to the plant the required nutrients in the appropriate proportions) of soils of Northwest and West Provinces of Cameroon.

Table 12: Chemical characteristics of soil samples from the Western Highlands.

Soil characteristic	Mid-Altitude Minimum	Mid-Altitude Maximum	Mid-Altitude Mean	High Altitude Minimum	High Altitude Maximum	High Altitude Mean
$pH_{(H2O)}$	4.90	6.60	5.85	5.00	6.60	5.63
Organic carbon %	2.30	11.00	4.19	3.34	10.62	6.45
Ca me/100g	0.50	16.40	6.74	0.52	2º.40	6.06
mg me/100g	0.20	6.20	2.85	0.17	1.90	0.72
CEC 7 me/100g	11.50	40.40	25.24	22.80	51.90	32.42
Bray 1 P, ppm	2.20	50.00	9.55	2.20	24.70	6.26

Table 13: Correlation matrix for regression between site mean maize yields and soil parameters, Mid-Altitude zone.

	pH	org.C	Ca	Mg	K	CEC	Bray-1 P	Mean Yield
pH	1.00							
Org. C	-0.293	1.000						
Ca	0.633	0.219	1.000					
Mg	0.465	0.255	0.895	1.000				
K	0.450	0.026	0.665	0.501	1.000			
CEC	0.163	0.501	0.615	0.677	0.388	1.000		
Bray-1 P	0.129	0.481	0.544	0.510	0.438	0.391	1.000	
Mean yield	0.231	0.220	0.477	0.396	0.563	0.405	0.29	1.000

Table 14: Correlation matrix for regression between site mean yields and soil parameters, High-Altitude zone.

	pH	Org.c	Ca	Mg	K	CEC	Bray-1 P	Mean Yield
pH	1.000							
Org C %	-0.022	1.000						
Ca	0.819	0.064	1.000					
Mg	0.763	0.224	0.935	1.000				
K	-0.001	0.123	0.266	0.317	1.000			
CEC	-0.021	0.586	0.221	0.263	0.010	1.000		
Bray-1 P	0.379	-0.004	0.590	0.677	0.203	0.310	1.000	
Mean Yield	0.523	0.007	0.282	0.295	-0.076	-0.121	-0.102	1.000

Maize variety retention:

Accomplishment of the goal to increase maize production requires more than the availability of improved technologies (e.g., better maize varieties). Farmers must *adopt* the technology for it to be of any use. In the case of an improved maize variety, one obvious attraction for would-be adopters is a high yield potential. However, as important as yield is to the farmer, other factors (varietal characteristics) come into play when she/he decides whether or not to plant the variety. These include (among others): earliness, plant height, husk tip cover, grain color, grain type, cooking quality and taste.

The TLU has taken pains to monitor farmers' maize characteristic preferences over the years, and provided guidance to the NCRE maize breeders in the development of new varieties with traits that correspond to these preferences. But when all is said and done, the best proof of adoptability is adoption.

One indicator of adoption is retention in subsequent years of the new technology by farmers who participate in the on-farm trial program. Though less than a perfect measure of adoption, this indicator has the virtue of being easily and inexpensively monitored. The TLU began observing farmers' technology retention behavior as early as 1987, when a survey was conducted of farmers who participated in the minikit trial program in all previous years (1983-86).

In 1991, 86 farmers in the mid-altitude zone who had grown maize variety trials on their farms in 1989 or 1990 were visited and interviewed. The results of these interviews were very encouraging. Mean retention rates for the improved maize varieties (i.e., % farmers still growing at least 1 improved variety on part of their farm in a subsequent year) was 91% **(table 15)**. By variety, the highest retention rates were reserved for KASAI (83%), COCA (44%) and ATP (28%). Sixty-nine percent (69%) of the respondents retained only 1 improved variety, while 23% retained 2 varieties. Although 4 to 8 varieties had been tested on each farm, farmers were disinclined to keep seed and plant more than 1 or 2 new varieties the next year. Preservation of the seed was apparently a key problem. This resulted in relatively low retention rates for some varieties, which, if tested alone, would probably have been retained by more farmers.

The farmers retaining at least 1 improved variety planted the new varieties on an average 51% of their maize land That means that the improved varieties were planted on 46%[5] of the total land area planted to maize on the trial farmers farms. Eighty-three percent (83%) of the trial farmers who had tested KASAI planted it on 43% of their maize-cropped land, or 36% of total maize land for these farmers. For COCA the figures are 44%, 36% and 16%, respectively. For ATP, 28%, 37% and 10%.

When assessing specific characteristics of the new varieties, in comparison with the LOCAL (farmer's) variety, the respondents found that, on average, the new varieties do not store as well, but taste better and have superior cooking qualities.

Table 15: Maize variety retention rates by farmers (%), by sub-zone, in the mid-altitude zone of the North West and West Provinces.

Sub Zone	V COCA		A KASAI		R BACOA		I MSR		E SYNTH		T ATP		Y E.WHITE		All	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Ndop	17	41	36	92	8	12	18	17	17	6	9	33	8	25	37	95
Banenda	14	57	22	68	7	0	11	0	11	0	7	14	7	0	23	91
W.Prov.	14	36	21	86	9	0	13	0	13	0	9	33	9	0	26	85
All	45	44	79	83	24	4	42	7	41	2	25	28	24	8	86	91

[5] 91% of trial farmers retaining the new varieties x 51% of each retaining farmer's maize-cropped land planted to the new varieties.

Training of extension staff in West Province:

One of the mandated responsibilities of the TLU in its goal of improving linkages between research, extension and farmers, is to train extension personnel. This can be met in two ways: 1) short refresher courses, and 2) on-the-job training. During the 1991 campaign, the TLU used both approaches.

From 4 through 9 March 1991, the National Agricultural Extension and Training Project (PNVFA) organized a seminar for its extension staff in the West Province. The objective of this seminar was to train extension agents (AVV) and their supervisors on the new methodologies to be used by the project.

The topics covered were:
1) Presentation of the project;
2) The Training & Visit approach;
3) Linkages between research and extension; and,
4) The role of agricultural support services (credit, inputs and product markets, ...)

A resource person was invited from the TLU-Bambui (Samatana), to present the third topic. His presentation included: goals of the TLU, description of TLU activities, methodologies used in generating new recommendations, collaboration with extension agents and farmers in on-farm research (including the responsibilities of each partner), research results and current recommendations (e.g., maize varieties), and future research strategies.

In the field, extension agents participated in all TLU on-farm trial operations, from selecting participating farmers through trial harvest, yield measurements and eliciting farmer assessments of trial treatments; as well as implementation maize minikit trials. They also collaborated in TLU surveys (e.g., maize variety retention).

6.5 VISITORS

Visitors to Bambui in 1991 included:
* Agroforestry PCV's Christopher Glaudel, Andrew Jones, James Gleit and David Walsh.
* Mr. Werner from Germany (GTZ), re: publication of an FSR/E manual.
* Mr. Ernest Gibson (USAID/ARD).
* Dr. Dunstan Spencer, Director RCMP/IITA.
* Mr. Quincy Benbow (USAID Project Officer).
* Dr. E.A. Atayi, COP/NCRE.
* Mr. John Niba Ngu, Minister of Agriculture.
* Drs. Karl Schleich, Kurt Raquet and Theda Kirchner, PAFSAT.
* Mr. George Yebit, Chief ARS/MIDENO.
* Ms. Lorraine Pearson, Agriculture APCD/Peace Corps.
* Dr. Moussie, Coordinator TLU/NCRE.
* Drs. R. Lal, C. Sachs, Ohio State Consortium team for SANREM Project.
* Agroforestry PCV's Craig Benson, Stefan Cherry, Julie Rencik, Amy Mutt, Ben Addlestone and Frank Lynch.

6.2 TLU EKONA

6.2.1 INTRODUCTION

Ekona TLU is responsible for the Coastal Humid Forest Region of Cameroon. The TLU works to improve food crop production of smallholders in South West Province through diagnosis of agricultural constraints and opportunities, testing of improved varieties and agronomic cultural practices, and informational liaison between the extension service and IRA.

Since its creation in 1986, TLU work at Ekona has focussed on (a) provision of baseline data on smallholder agriculture to guide IRA researcher in food crop and soils, (b) on-farm testing of NCRE maize and IRA/IITA cassava varieties, (c) soil and weed management trials on-station, and (d) post-harvest problems of maize (storage) and other food crops (marketing). Liaison with extension has been effected through annual training and planning workshops, collaborative research and minikit distributions.

The basic approach of the TLU involving a combination of on-station trials, researcher and farmer managed trial in focus villages, and minikit distributions, will continue. However, the operational objectives have been reformulated to more clearly signify TLU priorities. Increased emphasis has been given to biological technologies for enhancing and sustaining farm systems productivity. Agroforestry and fallow management studies will be emphasized in the technology development focus of TLU Ekona.

6.2.2 SUMMARY OF PROGRAM ACTIVITIES

In 1991, the Ekona TLU accomplished some of its major objectives. Focus village meetings were held in February and the TLU annual workshop in March. Both were very successful, with over 80 participants at the workshop. Trials included establishment of researcher/farmer managed: fallow management, alley cropping, egusi beetle control, cassava quality and cassava and maize variety tests test kits; and farmer managed minikits trials. Data for economic analysis were collected for most of the trials. Preliminary results from the cassava adaptability trials have so far indicated that none of the improved cassava can be boiled and eaten without processing. The relative importance of using improved maize, fertilizing and weeding have been established for some sites in S.W. Province. By not using improved maize and not fertilizing with N, a farmer may obtain only 30% of possible maize yield. Suppression of weeds by smothering though effective in control, may reduce maize yield, particularly in moisture stressed situations as in Yoke, 1991-II. The land productivity study which started March 1990 was completed in June 1991. The results show that average yields per crop under farmers mixed cropping pattern are relatively lower than potential (monocropped). A maximum efficiency gap of 50% was estimated. The twelve market provincial survey was only completed in June. A retention survey for improved maize varieties was carried out in 54 villages in the four main research zones.

It is becoming increasingly expensive to maintain the old Toyota Land cruiser. Insufficient transportation has limited our activities, particularly on bad roads in South West Province. The rains came earlier than anticipated. This encouraged some of the farmers to plant earlier than we scheduled. Our relationship with the extension agents has deteriorated significantly, due to the discontinuation of financial incentives which they were having while the IITA researchers were at Ekona. This has been overcome by institutionalization of the relationship in a memorandum between MINAGRI and IRA.

Since January 1991, we have had consultations with the IITA staff of TLU and ICRAF Scientist of IRA Nkolbisson. The unit presented its activities in the Divisional (Ndian & Meme) launching of the National Extension & Training Program (NETP) of the Ministry of Agriculture.

6.2.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Feedback information on farming systems and markets.		
1.1 Complete cassava harvesting from 1990 productivity study.	1.1 Analysis of land productivity in farmers' mixed cropping pattern.	1.1 Low individual plant populations and crop yields in farmers' multiple cropping system realized. Higher land and income equivalent ratios (LER and IER) of 2.9 and 3.5 respectively were recorded.
1.2 Retention survey of maize minikit program participants.*	1.2 Analysis of maize retention rate and determinants of retention.	1.2 High appreciation for IRA maize was expressed. Consequently, 85% of the maize minikit users kept seed to plant in a future season.
1.3 Village level resource management survey.	1.3 Analysis of technology use and village level factors influencing technology adoption.	1.3 Delayed to 1992. Collaborative work with TLU Nkolbisson.
1.4 Price monitoring in 4 markets.	1.4 Price data for use in economic analysis of trials.	1.4 Delayed to 1992 due to new strategy still being worked out. This will reduce operational cost and increase research scope.
1.5 Publish and distribute monographs for farming systems and market price surveys.	1.5 Information made available on provincial farming systems and markets.	1.5 Production and distribution of both reports completed.

Objectives	Activities	Accomplishments
Operation 2. Identify biological technologies for improving & sustaining soil fertility.		
2.1 Establish selected plant species for agro-forestry and other fallow managenent experiments.	2.1 Source of continuous supply of seeds for agro-forestry and rotational fallow management study guaranteed.	2.1 Agroforestry and rotational fallow seedlot nurseries have been established at two locations: Yoke (SDS): Leucaena leucocephala, cassia spectabilis, Sesbania and pigeon peas. Ekona Centre (LV): Gliricidia, Leucaena, Cassia, Caliandra and Acassia.
2.2 Establish alley system with leucaena, plantains, cassava + maize with peanut (for grain and weed control)	2.2 Extension agents and farmers will observe the system. Opportunity to know what Alley system entails and benefits derived.	2.2 The hedgerow establishment phase commenced but no crops were established because of lateness in commencing the work. Cassava + Maize intercrop studies in already established hedgerow continued.
Operation 3: Evaluate IRA improved component technologies. 2nd season 1991 on-station.		
3.1 Design and establish in incremental steps, improved component technologies developed by IRA.	3.1 Combination of improved technologies identified for different categories of farmers in S.W. Province.	3.1 Trial commenced at 2 sites in 1991-II but incomplete for conclusive report. Maize leaf color and vegetative cover scores, though subjective correlated highly with stover and green cob yields.
3 Identification of low cost maize stem borer and egusi beetle control methods.	3.2 Maize stem borer control 2nd season. Identify about 20 farmers in KC and LV zones. Demarcate areas for insecticide application as well as control. Observe effects on growth and grain yield.	3.2 Maize stemborer control carried forward to 2nd season 1992. Appropriate methodology is being worked out with the entomologist.
3.3 See 3.2.	3.3 Egusi melon beetle control by application of Marshall ST controls egusi beetles. Assess treated and control plots on farmers field in LV, SDS, KC and MF.	3.3 Seed treatment with Marshall ST25 increased egusi melon seed yield significantly at farm level. This result is similar to earlier observations (see 1990 report).

Objectives	Activities	Accomplishments
3.4 Determine cooking quality of IRA cassava as affected by age at harvest.	3.4 Cassava harvesting and cookability at 6, 8, 10, 12, 14, 16 and 18 months to assess farmer acceptability. Farmer judgement to be recorded and rated. Improved vs local control.	3.4 Yield and softening of cassava root when boiled generally depend on harvesting age. But the improved variety, 8017 even with increasing age and cooking time did not get soft enough to eat.
Operation 4. Increase knowledge of IRA technologies.		
4.1 Farmer exposure to and evaluation of maize CMS 8704, CMS 8501, CMS 8503 maize, CMS 8806 and Ndock 8701; Cassava: 8017 and 8034; and Sweet potato: TIB1.	4.1 Minikits and Test kits distributed to farmers.	4.1 Sent out about 500 minikits of maize and about 2000 cuttings of 8017 and 8034 cassava varieties. The 1990 feedback was 118 out of 500 ie. 24%.
4.2 Facilitate better understanding of farmers needs through continuous interaction.	4.2 Focus village meetings with farmers.	4.2 Meetings were held in February in seven villages: Mautu, Malende, (Fako); Ikiliwindi, Malende, (Mene); Fotabe and Kenbong (Manyu).
4.3 Increase extension agent knowledge of TLU results and IRA technologies. Demonstrate specific trials initially identified for farmer evaluation.	4.3 (a) Annual TLU workshop. (b) Divisional TLU workshops to familiarize extension agents with available improved technologies for extension. (October each year). (c) Training restricted to specific subject matter for testing during proceeding years. Participants limited to supervisors of trials (March).	4.3 (a) Annual workshop with 80 participants from MINAGRI, IRA and Development project staff held in March 1991. Workshop report prepared and circulated. (b) A workshop with 30 extension subject matter specialists from Fako, Mene and Ndian Divisions was held in late September 1991.

6.2.4 RESEARCH FINDINGS

6.2.4 Agro-Technology Report, 1991.

Based on reported diagnosis of farmers circumstances and technical constraints, Ekona TLU set agro-technical goals aimed at addressing three inter-related constraints (1) lack of improved crop varieties required by focus farmers; (2) rapid decline of soil fertility and (3) weed control (Table 1). Deliberately, Table 1 did not emphasize control of pests (other than weeds which are always present) and diseases. Where ever possible, specific studies on these, such as seed treatments, will be conducted. However, given the high costs of some known chemicals, their unavailability to target farmers and application problems, we found it more practical to assume that to be "improved", available varieties should have some level of resistance or tolerance to important diseases and pests. This is a prerequisite to their being tested at farm level.

Table 1: Major Research Focus areas in technology development for S.W. Province.

Constraints		Rationale	Activity in 1991.
1.	Lack of inproved crop varieties.	Contributes highly to farmers yield. Inproved crop varieties lacking in areas surveyed.	Continued to make available to farmers improved maize and cassava. Conducted research to emphasize contribution of variety and other components to overall yield. Contributing in research to develop other crop varieties e.g. cocoyams by emphasizing farmers' need for them.
2.	Declining soil fertility.	Some recent soils may be rich in essential mineral elements. This needs to be sustained. Poorer soils need to be reclaimed. Fertilizers, though essential, may not be available.	Studies on some agroforestry systems, rotational fallow systems and limited fertilizer application, continued in 1991.

Constraints	Rationale	Activity in 1991.
3. Weed Control (other pests and diseases?).	Rank growth of weeds (associated with prolonged, high annual rainfall) compete with economic crops and lead to yield reduction, sometimes up to 80-90% in extreme cases. Cost of control by hoeing is high. Other major pests include egusi melon beetle and maize stem borer (2nd season). Some cultural control of cocoyam pythium rot is being studied. Post harvest studies to reduce losses in storage continues.	Effectiveness of weed control by smothering. Work on econonic use of agroforestry system in weed control (as well as soil fertility improvement) continues. These are low cash input approaches. Fertilizer-weed interaction using relatively higher cash inputs under study. Other pest and disease problem were noted for future studies.

6.2.4. BIOLOGICAL SOIL AMENDMENTS:

6.2.4. (a) Maize and Cassava in Alley System:

An experiment was set up in 1988 to evaluate the contribution of Leucaena leucocephala, Gliricidia sepium and sesbania grandiflora to N required by maize. In this experiment, the effects of N application at 0, 20, 40, 80 kg/ha on maize yield were compared with alley cropped maize using the three legumes. Sesbania was dropped owing to non-copicing after first pruning. The details of trial design, plot size, cultural practices have been given (See 1990 report).

During 1991, the trial was modified to serve as a demonstration of yield maintenance in a typical poor sandy soil. The alleys were also extended from 5m long to 12 m and the number of replications from 4 to 3. The effects of continuously applying N at 80 kg/ha or lower compared with the alley system on soil physical and chemical properties will be determined. The maize was intercropped with cassava.

6.2.4. Results:

Maize height: Height of maize planted in leucaena hedgerows are comparable with maize in which 80 kg fertilizer N was applied and this agrees with previous years' data (Table 2). Maize height was maintained in the Yoke soil (a Palaudult with old sedimentary sand). Height in Leucaena plots were comparable to that at 80 kg/ha N whereas that in gliricidia plot was comparable to that at 40 kg/ha N. Lowest heights were at 20 and 0 kg/ha N (Table 2).

Imperata Cylindrica (Weed) Control: An important observation which was monitored at Yoke was a reduction of the noxious weed, Imperata cylindrica, in one year fallow of leucuena and gliricidia, particularly of leucaena (Table 2). This study will be followed up and inputs from weed scientists will be sought to better understand Imperata biology and its effective control.

Leaf, Woody Stem and N after one year fallow: The leaf weight, length of woody stem of mean diameter of 1.2 cm and estimated N in leaves from one year leucaena and gliricidia prunnings are presented in Table 3. Based on maize growth as indicated by height, the N in leaves alone satisfies the requirements of maize (Table 3) while the woody stems from leucaena and gliricidia is enough to stake 3.04 ha and 2.51 ha of yams, respectively. It is assumed that 2.5m stake length is required per yam at 20,000 yam sets per ha.

Results from yellowing of maize leaves (leaf color) as an index of N deficiency showed that maize associated with leucaena and gliricidia were as yellow as that grown at 80kg N fertilizer (Table 3).

Establishment of Seedlot Plots: Seed availability is an important requirement of the alley system. Since there was no source of continuous supply in the quantity desired, TLU Ekona commenced a seed lot nursery at two sites, Yoke (SDS) and Ekona center (LV) in 1991. These will also serve as demonstration plots for Alley System of crop production.

The Yoke nursery has four entries: Cassia spectabilis, Leucaena leucocephala, Caliandra and the fourth species, pigeon pea, for planted rotational fallow system. Establishment at Yoke was 94% for pigeon pea, 46% for Cassia spectabilis and 83% for Leucaena.

At the Ekona Center, Gliricidia, Leucaena, Cassia, Caliandra and Acassia have been established. The nurseries were being established in enough land area and in sufficient replications to superimpose treatments when required for demonstration or research e.g. weed control or soil fertility improvement.

Yoke as an important site for Agroforestry Research by Ekona TLU: Four general research areas (Lower Volcanic, Sands, Mamfe and Kumba Corridor), have been recognized by TLU, Ekona as being representative of South West Province's major agricultural zones. (See details in TLU Surveys and Annual Reports). More detailed soil classification of these areas are being studied both from primary and secondary information. Yoke, which is in the SDS, is generally the poorest in fertility (Fig. 1). The top soil is sandy to sandy loam and the dominant weed is noxious Imperata cylindrica. Yoke is therefore a suitable site for Agroforestry research strategy of reclaiming agricultural soils from noxious weeds and for the strategy of making impoverished soil rich enough for crop growth (Table 4).

Table 2: Effect of fertilization and alley system on maize height, leaf color (yellowing) at 5 weeks and *Imperata cylindrica* at Yoke.

TREATMENT KG/HA	MAIZE HEIGHT (CM)	LEAF COLOR (1-4)	IMPERATA SCORE (1-4)
0 N	51.7	2.3	4.0
20 N	76.3	3.0	4.0
40 N	93.0	3.0	3.5
80 N	160.3	4.0	3.5
GLIRICIDIA	114.2	3.7	3.0
LEUCAENA	150.3	4.0	2.0
LSD 0.05	32.9	0.96	1.48
CV%	29.6	14.5	13.8

Scores: Leaf color 1 = all leaves yellow
4 = all leaves green
Imperata: 1 = <25% of field infested by imperata taller than maize.
5 = > 75% of field infested by imperata taller than maize.

Table 3: Leaf weight, woody stem (1.2 cm mean diameter) and estimated N from one year leucaena and gliricidia fallow.

	LEAF WEIGHT (KG/HA FRESH)	WOOD (1.2 CM MEAN DIAMETER) M/HA	NITROGEN (KG/HA*
LEUCAENA	19,925	151,950	104,6
GLIRICIDIA	14,600	125,950	74,5

*Assume N in dry leucaena leaf is 3.5% and in gliricidia, 3%.

Table 4: Nutrient levels of soils in TLU, Ekona major research zones in South West Province.

LOCATION OR RESEARCH ZONE	NUTRIENT N %	P Ppm	K Meq	SOIL pH
SANDS	0.10	7.0	0.12	5.6
MANFE	0.11	8.0	0.17	4.7
KUMBA CORRIDOR	0.26	10.0	0.26	5.3
LOWER VOLCANIC	0.36	29.0	0.80	5.7

6.2.4. Package Evaluation of NCRE Improved Agro-Technologies

Three technological components were evaluated on incremental steps in the constraint areas of (1) lack of improved varieties (cassava and maize), (2) low soil fertility and (3) weed competition. This was tested at two focus sites: Yoke ((SDS) dominated by moderately well drained sedimentary sandy clay loam (Palaudult)) and unmapped old volcanic soil (LV, Mile

17). Treatments were incremental combinations of improved and local varieties of cassava and maize; improved soil fertility by application of 20-10-10 fertilizer at 300 kg/ha and weed control at three levels: (a) hoe, (b) smothering by intercropping with peanuts at high population (about 120,000/ha) and (c) by applying metalochlor at 2 kg/ha a-i. pre-emergence. They were arranged as 2x2x2x3 factorial and replicated two times at each site.

Data were collected on (1) cassava establishment (2) maize leaf color (yellowing) as an index of N scored 1-5 (1 =all leaves yellow to 5 = all leaves green), (2) ground cover (1 = ground bare to 5- ground completely covered by economic crop) and (3) weed cover (1- plot completely covered with weeds to 5 no weeds observed). Samples of maize cobs and associated stover yield were also obtained. Plot size was 5m x 6m.

6.2.4. Results and vegetative and weed covers and control:

Results showed a significant positive correlation between stover yield and ground cover (P0.05, r=0.49). Significant relationships were also observed between maize leaf color and cob yield (P0.01, r=0.69) and also with stover yield (P0.01, r=0.78). The nature of the relationships and their coefficients of determinations, R^2, are shown in Table 5, Figs 2 and 3. These parameters, though subjective, can be used to evaluate treatment effects in on-farm investigations where facilities may be lacking for their more detailed studies. Since weed effects have been suppressed by treatments, it is not related to maize cob and stover yields (Table 4).

Table 5: Correlations of vegetative cover, of color and of weed score with cob and stover yields at Mile 17 (LV Site).

	COB YIELD	STOVER YIELD
VEGETATIVE COVER	0.39 (0.15)	0.49 (0.24)
LEAF COLOR	0.69 (0.48)	0.78 (0.61)
WEED SCORE	0.009 (0.008)	0.00 (0.000)

P0.05 df 22 0.404
P0.01 df 22 0.515
R^2 in brackets.

Stover and Cob Yields:

Stover and maize cob yields were highest at the highest treatment factor levels i.e. improved maize fertilized and weed controlled by chemical (HWC), smothering (HWs) or by hoe weeding (HWh) at two periods as farmer would (Figs. 4 and 5). These levels were regarded as H or highest levels. The improved maize variety and fertilizer were excluded, one at a time and are shown as H-MV and H-F. All these were compared with a case in which no improved component was added (L) although, weeding was done twice (Table 6).

There was moisture stress throughout the growing period at Yoke particularly following cob formation. This reduced maize growth and yield compared with Mile 17. Nevertheless the L treatments were obviously the lowest yielding. Non inclusion of fertilizer and improved maize also resulted in reduced yields, particularly at Yoke with poorer soil. These preliminary results should be viewed with caution because of the high CV's (70%) observed in the yields collected. Under conditions of moisture stress, it appears that hoe weeding tends to produce highest yields, an indication that associated crops and weeds may compete for moisture. By estimating one component at a time, yield reduction as percent of the highest at Yoke and Mile 17 are shown in Table 6. Tentative inferences from this study are (1) Maize leaf yellowing and ground cover scores are positively correlated with maize stover and cob yields (2) full expression of treatment effects can be obscured by moisture stress particularly if many crops are grown in association (3) yield advantages of packages of improved technologies showed that removal of fertilizer and improved variety tended to reduce maize cob and stover yields drastically.

Table 6: Effects of substitutive removal of improved technologies on maize stover and cob yields at two sites.

Treatments	Yoke (SDS) (Hoe Weeding)%*		Mile 17 (LV) (Chemical)	
	Stover	Cob	Stover	Cob
1. All factors highest,	100	100	100	100
2. All factors highest,(Yoke-Chen) (mile 17-hoe)	63	53	86	78
3. All factors highest - smothering	47	49	77	80
4. All factors highest - Maize var.	60	44	83	72
5. All factors highest - Fertilizer	34	38	55	54
6. All factors Lowest (Hoe weeded)	29	20	42	35

* Values are expressed as percent highest yield. Note that the highest costing level, i.e. with chemical weed control is not the best (highest yielder) at Yoke where hoe weeding is the best.

6.2.4. Pest Control Studies:

Egusi melon beetle (chrysomelidae) remains an important pest. Previous researcher managed chemical control studies with three formulations showed that Marshal ST 25 seed treatment (250 grams egusi seed with 2.5 gm Marshal ST 25) was the best (See 1990 Report). The study was repeated in 1991 under farmer management at Malende (Sands - unmapped soil) and at Kembong (Manfe M_1 of Lobe Series, Orthoxic Tropoudults or Ferric acrisols, acidic soils on old sandy clay deposits).

Some egusi seeds available to eleven farmers per location were treated with Marshal while others were not. The farmers were instructed to plant the two lots of seeds separately. At about two-three weeks after planting, areas 6 x 5 m^2 were demarcated to denote treated and untreated plots. All management inputs weeding, fertilizer application if any, time to harvest and crop associations and establishment timing, were according to the farmers methods. The farmers were advised to harvest the melons from the demarcated plots separately, process them into dry unshelled seeds and store for weighing by researchers.

6.2.4. Results:

Usable data were collected from only four farmers per site. Data were collected from six farmers at Kembong, M_1 site, but there were no untreated checks for two farmers (Ndip Stella, 333 kg/ha and Ayuk, 266 kg/ha). The results shown in Table 7 indicate that marshal treatment tends to be superior to the check.

Table 7: Effects of seed treatment with Marshal on Egusi melon yield in farmers fields at 2 sites.

SITES							
MALENDE, FAKO				KEMBONG, MANYU			
FARMER	KG/HA EGUSI			FARMER	KG/HA EGUSI		
	TREATED	UNTREATED	MEAN		TREATED	UNTREATED	MEAN
MASSOK S.	599	400	500	TAFER M.	339	253	296
FOBELA B.	566	400	483	SHANG E.	250	167	209
CHIANGO G.	660	366	513	ANDERE M.	334	266	300
TIMAH D.	466	265	366	NDIP SA.	253	170	212
TRT. MEANS	573	358			294		214
LSD 0.05	<---------- 210 ---------->						
LOC. MEANS		466				254	
LSD 0.05	<---------- 197 ---------->						

The melon yield was significantly higher at Malende than at Kembong, (LSD 0.05=197). Treatment with Marshal resulted in higher yields at Malende-Fako but not at Kembong (LSD 0.05 = 201) (Fig.6). High farmer - farmer yield variations were observed at both sites and also between treatments which indicate management variations between farms. This led to a relatively high CV (31%). This trial and the 1990 results are conclusive enough that further studies may not be required, particularly since Marshal ST 25 is not available in local markets.

6.2.4. Effect of Age of Harvesting Cassava on Tuber Root Yields Quality.

Realizing recommendations by CNRCIP's agronomist and breeders that 8017 and 8034 IRA cassava varieties could be eaten boiled (like yam) and in light of complaints often expressed by farmers, we set out to confirm this finding. Given the fact that high cyanide cassava if consumed without adequate processing could be poisonous, Ekona TLU saw this study as being very important since 8017 and 8034 are already well established in farmers fields.

Methodology: In collaboration with village extension workers, four sites were chosen at (a) Malende (Kumba Corridor) (b) Ikiliwindi (Kumba Corridor) (c) Fotabe (Mamfe forest) and (d) Kembong (Mamfe sands). At each site, a local check representing a widely grown cassava variety was selected. In the KC areas, a local white was used while in MF area, red

This experiment showed that the softening of cassava root when boiled and yield depend on the age at which the plant is harvested. However, the parameters used are not enough to draw conclusions on eating quality, textural and other requirements relating to cassava utilization. Inputs by food technologists and other disciplines, will be required.

6.2.4. Maize Minikits

6.2.4. Minikits have been our single systematic way of getting farmer feedback about our improved varieties. Since 1987, samples of maize seed have been sent out to large numbers of farmers for field evaluation and also in the various dishes. Questionnaires are included to get their response.

In 1990 first season about 441 samples and questionnaires were sent out and only 115 usable forms were returned which represents a return rate of only 26%.

Quantities distributed:

1) Lowland: 135 of CMS 8501; 93 of CMS 8503; 94 of 8017 (Suwan1 SR); 59 of 8806 (DMR ESR-Y).
2) Highland: 20 of Kasai; 25 of MSR85, 20 of cocoa.

Evaluation returned: 18 of CMS 8501 (14%), 15 of CMS 8503 (16%), 94 of CMS 8704 (11%), 20 of CMS 8806 (34%), 14 of Cocoa (70%); 21 of MSR 85 (84%) and 14 of Kasai (70%).

Distributions of farmers' tests: 97% of the farmers testing the maize were women. About 40% used a local maize variety (derived from highland types) as local check, and the rest used the soft type called calabar white. An insignificant number used farmer improved varieties like Cuban yellow, Ekona white, Yellow and Mixed color.

Most tests (47%) were planted on land continuously in use, the average being 2.8 years since last fallow[1]. About two-thirds (42%) incorporated grass or left it as mulch on the fields. Most farmers planted their maize in April. 73% weeded their fields at least one time with an average of 5.5 weeks after planting (WAP sd = 2.89), and 19% did a second weeding averaging 8.2 weeks after planting (sd = 2:5).

The IRA highland varieties were harvested 1-3 weeks later than locals, and the lowland varieties averaged harvesting dates of 1-10 days earlier than the locals. Harvesting started at 13.5 weeks on the average and most of the IRA maize was completely harvested by 14 weeks, so their reuse as seed is questionable. Accidental losses were about equal for both local and improved maize, but disease symptoms were more often present on local maize

[1]This question may have been misunderstood.

The fields were visited four weeks after planting to stake two samples of 7m x 3m each per field but where the farm was very small only one sample 8m x 5m was staked. A trained monitor was selected from each of the villages to be supervising the farmer through all activities on the sample plots until harvest. At harvest, the yields of all the crops in the sample plots were obtained in the presence of the farmers, monitor, extension agent and the researcher. Maize yield was converted to dry grain weight at 15% moisture content (MC), groundnuts were measured as fresh pods and as dry grain, egusi melon seed was approximated from the weight of fresh melons using a standard dry seed weight percentage which was derived from processing of 18 melon samples of 9-12 kilos each brought from all zones. The two types of Colocasia (Ibo coco and country coco), cocoyam (Xanthosoma), yams and cassava yields were weighed as fresh roots and tubers.

6.2.4. Results and Implications

Multiple cropping was a rule. Farmers were found to plant up to eight crops (maize, groundnuts, egusi, ibo coco, country coco, yams, cocoyam and cassava) on the same piece of land in the first season. This practice resulted in very low densities of each crop and comparable low yields (Table 9). The yield differences between a multiple crop and a sole crop was quite wide. However, the lower yields and wider yield gaps were compensated by high land and income equivalent ratios (LER and IER) of 2.9 and 3.5, respectively (Table 10). This shows that the yield derived from intercropping system using crop combination considered in this study result in 290% higher total yield than that derived from planting each crop in equivalent area as sole crop while the income derived from intercropping the system using the crop combination resulted in 350% higher total income than that derived from planting each crop in equivalent area as sole. Hence a greater diffusion rate of IRA improved technologies like cassava cuttings, maize seeds, sweet potato vines, soil management practices, etc. is expected to increase the values of LER and IER thus upgrading the socioeconomic condition of the South West farmer.

Table 8: Average intercrop yields (Kg/ha) of maize, egusi, groundnuts, Ibo coco, cocoyam, and cassava on farmers' fields by zone, 1990/91 season.

CROPS	Lower Volcanic	Kumba Corridor	Sands	Manfe	Average S.W.P.
Maize					
Plant density (pph)	13834	20762	10747	16713	15514
Yield at 15%	935	1582	321	833	918
Egusi melon seed:					
Plant density (mph)	6046	23874	18775	6665	13840
Yield dried at constant wt(0% H2o)	115	206	256	59	159
Groundnuts:					
Plant density (pph)	na	11500	103190	20317	78336
Yield dried seed constant wt (0% H2o)	na	477	515	91	361
Ibo coco:					
Plant density (pph)	7279	4345	3333	5298	5064
Yield fresh wt	4221	3390	3071	2696	3345
Cocoyam:					
Plant density (pph)	7262	6973	4667	4630	5883
Yield fresh wt.	7175	2230	2767	2702	3719
Cassava:					
Plant density (pph)	1429	7111	5923	4508	4743
Yield fresh wt.	4953	10302	7500	7190	7486

pph = plants per hectare
nph = melons per hectare

NOTE: White, sweet and water yams ignored because they are not evenly distributed in all the zones.

Table 10: Average level of production, maximum efficiency attained and maximum efficiency gap of sole crop (yield) and intercrop (average yield) maize, egusi, groundnut, ibo coco, cocoyam and cassava in South West Province.

CROPS	Actual farm Yield in (Kg/ha)	Expected farm yield Sole cropping in (Kg/ha)	Average level of production (%)	Maximum efficiency obtained (%)	Maximum gap (%)
Maize	918	3136	29	51	71
Egusi	159	460	35	56	65
Groundnut	842	3742	23	34	67
Ibo coco	3345	6606	51	64	49
Cocoyam	3719	6322	59	114	41
Cassava	7486	8053	93	128	7
Average	2745	4720	48	75	50
LER			2.9		
IER			3.5		

6.2.4. Evaluation of Maize variety retention rates and determinants by minikit users. Objectives, Material and Methods:

A maize retention study of minikit users was carried out between May-June, 1991 in the four key research zones (Lower Volcanic, Kumba Corridor, Sands and Mamfe) of South West Province. The objectives of the study were (i) to evaluate the effectiveness of the minikit approach in technology dissemination, and (ii) to assess the factors that influence IRA maize retention, use and diffusion. A list of 174 minikit users out of over 2000 maize minikit varieties sent out since 1987 for whom completed evaluation questionnaires had been received was compiled. These users were scattered across 63 localities. The IRA varieties assessed in the study were CMS 8501, CMS 8806 and CMS 8704. With the help of a skilled enumerator an attempt was made to recontact as many of the 174 as possible. But completed questionnaires were obtained for 122 farmers. Maize retention and diffusion patterns were measured using five binary variables: (i) whether farmer kept seed after harvesting the test, (2) whether farmer ever planted the seed, (3) whether farmer was still planting the seed in first season 1991, (4) whether farmer has ever sold some of IRA maize, and (5) whether farmer gave or sold seed of IRA maize to other farmers.

6.2.4.8. Results and implications:

IRA maize irrespective of the zone and variety yielded more than farmers indigenous variety. Among respondents expressing a preference, IRA maize roasted or as fufu (maize meal) tasted better than the local (Table 11). Almost every farmer (85%) kept IRA seed to plant in the future season and any farmer who did not keep either lost it in the field (pests, diseases, degeneration) or in storage or ate all that was harvested. Over 40% of the participants were still planting IRA maize in 1991 and 50% sold IRA maize, while approximately 50% sold the maize seed to other farmers (Table 12). Consequently farmers were being exposed to IRA maize, and many more were given access to it.

Kumba Corridor and Lower Volcanic zones had higher retention and diffusion rates, due to more market outlets for surplus. Higher population densities and high immigrants household size, age of participant, harvesting maize dry and eating it flinty were significantly associated with retention behaviors (ever plant, plant 1991, sold cobs/grain and give/sell seeds) (Table 13). Further analysis of respondent characteristics and retention behavior showed that certain personal characteristics were strongly related to diffusion through subsequent sales (Table 14). However, the pace of variety diffusion through sales may well be increased by concentrating efforts on, for example, female participants rather than male participants since most of the food crop farmers in general and maize farmers in particular in the study area are women (Table 14). Further technology retention research should therefore focus on delineation of dimensions of retention behavior (beyond sales), while attempting to identify a stronger set of explanatory variables. Complementary research is needed on which types of retention behavior most rapidly lead to variety diffusion and sustained productivity increases by the largest possible number of farmers. Research is also needed on the degeneration of the maize varieties.

Table 11: Test Participant Assessment of IRA Maize.

	IRA Produced More	Roasted Cobs IRA Best	Roasted Cobs Local Best	Fufu Taste IRA Best	Fufu Taste Local Best
	(Percent of respondents)				
Zone:					
Volcanic	93	56a	35	63a	21
Kumba	94	81	6	58	3
Sands	100	76	10	72	7
Manfe	95	100	0	42	0
Variety:					
CMS 8501	95	69	20	61	10
CMS 8704	96	92	4	58	10
Ndock 8701	92	69	15	62	8

a.Differences by zone significant at <0.05 level.

Table 12: IRA Maize Retention, Use and Diffusion.

	Kept Seed	Ever Planted	Planted 1991	Sold Cobs or Grain	Gave or Sold Seed
	(Percent of respondents)				
Zone:					
Volcanic	88	74b	54b	70a	60b
Kumba	81	55	29	26	29
Sands	90	79	52	41	52
Manfe	79	53	26	26	47
Variety:					
CMS 8501	87	65	39b	46	48
CMS 8704	81	81	62	54	54
Ndock 8701	85	54	31	23	38

Table 13. Association Patterns and Significance Levels for Retention Behavior[1]

	Ever Plant	Plant 1991	Sell Cobs or Grain	Give or Sell Seed
Maize features:				
Harvest some maize dry	.16 +	.09 +	.00 +	.09 +
Eat flinty maize	.01 +	.06 +	.02 +	.06 +
Eat only white maize	.82	.50	.86	.54
Participant:				
Female	.07 -	.84	.18 +	.65
No education	.31	.02 -	.00 +	.52 +
Age	.01 +	.09 +	.00 +	.29 +
Family size	.19 +	.76	.00 +	.26 +
Location:				
Lower Volcanic	.21 +	.07 +	.00 +	.05 +
Kumba Corridor	.09 -	.08 -	.01 -	.01 -
Sands	.11 +	.26 +	.65	.68
Manfe	.14 -	.12 -	.07 -	.93

[1]Chi-square significance levels for qualitative variables and t-test significance levels for age and family size. Directions of association only given for P<.030.

Table 14. Canonical Coefficients for Respondent Characteristics and Retention Behavior.

	First	Second
Family size	.27	.55
Participant age	.48	.31
Participant was female	.31	-.53
Participant had some education	-.37	.53
Family usually eats flinty maize	.02	.35
Family usually harvests some maize dry	.23	-.12
Ever plant IRA maize	+.14	-.84
Planted IRA maize in 1991	-.08	1.15
Have sold IRA fresh cobs or grain	+1.04	-.02
Have given or sold seed of IRA maize	-.21	.38

6.2.5 VISITORS:

Prof. Joseph Owona - Minister, MESIRES
Niba Ngu - Minister of Agriculture
Francis Cook - US Ambassador to Cameroon - Yaounde
Ayuk Takem - Director of IRA
E. Atayi - Chief of Party, NCRE
T. Stilwell - Deputy Chief of Party, NCRE
D. Baker - TLU Coordinator, NCRE Nkolbisson
J. Poku - Chief of Farming Systems, IRA Nkolbisson
Richard J. Carroll et al, - ROTREP Market Demand Consultants
Philip Doby - Overseas Development Administrator (technical adviser).
M. Atangana - Administrative Officer, NCRE
Thomas Gass - Eng. Agr. International Potato Centre (CIP) Bamenda
John Bridge - CAB International, UK.
Rose Epie et al. - USAID Television Team
Elango, Susan Allo - GATSBY representative in Douala.
Students from University of Douala
Students from University of Buea
Students from Intensive Vocational Training Centre, Buea
Economics Team from Agric Delegation, Buea
Quincy Benbow - NCRE Project coordinator
Dennis Ignasios - UMES
Robert R. Dadson - UMES
Will Anderson - Peace corps representative
Lori Pearson - Peace corp Associate Director
A. A. Dankyi, CRI Kumba
Ildofonse Njodsalishye - IDINA, Ivory Coast
A.F.K. Kissiedu - Crop Research Inst. Ghana
A.M. Daramola - IARE/OAU Ibadan Nigeria
George Ndawage - ISAR, Rwanda
Kamran Frooghi - SOGETRAP Bamenda
Asanga Cletus - Dschang
Nkounjo David - Prov. Chief of Service SWP
Kengni Fidels - MINAGRI "
Verdonck Rombaut - CCSP
Jacob Ngeve - IRA Nkolbisson
G. Atuahene Amankwa - Kumasi Ghana
R.A.D Jones - Sierra Leone
Henk Mutsaers - IITA
Joseph B. Suh - IITA Ibadan Nigeria
Njume Joseph Ndolu - SDDA Muyuka
Joanne Wainuright - U.K.

6.3 TLU MAROUA

6.3.1 INTRODUCTION

Maroua TLU has responsibility to improve knowledge of the farming systems of North Cameroon through diagnostic studies and to contribute to the development, testing and dissemination of technologies under farmers' conditions. The zone of action of Maroua TLU is the Far North province and the Mayo-Louti Division in the North province.

Within this region, Maroua TLU has, in past years, confined pre-extension tests within the cotton-growing (SODECOTON) zones where sorghum, groundnut, cowpea and millet are the major crops. Efforts are underway to extend TLU activities in the Mayo-Sava, Mayo-Tsanaga and Logone-Chari Divisions where the National Extension and Training Project (PNVFA) has become operational.

The goal of Maroua TLU is to increase food crop production, improve yield stability, maintain soi' fertility and increase small farmers' income in the mandate region. In moving toward this goal, TLU has placed emphasis on farm level surveys to identify constraints to stable production, sustainable technology generation on-station, on-farm tests, and training of extension agents.

On-farm testing within Maroua TLU consists of three levels. First, relatively complex technologies are tested, often using a relatively complex experimental design in representative observational villages with observers trained and paid by TLU. Technologies/practices which prove adaptable biologically and acceptable to farmers are promoted to regional testing in about 30 widely dispersed sites to cover a wide range of conditions. The design is simplified and tests are observed by SODECOTON and MINAGRI extension agents. Successful technologies in regional tests are then extended to farmers as minikits. This extremely simple test is conducted by hundreds of farmers who respond to an evaluation questionnaire. A technology is then considered ready when acceptability is high and a technical bulletin is prepared.

The resources invested in diagnostic surveys will decrease over the next four years in favour of technology verification. Technology development on-station will focus on soil moisture and striga management for stable sorghum yields. The regional test program will gradually move away from collaboration with SODECOTON in favour of the PNVFA.

6.3.2 SUMMARY OF PROGRAM ACTIVITIES

Five research operations (as listed in the Accomplishments section) were conducted in 1991. As part of diagnostic studies, the agricultural practices survey (3rd year) was terminated in 4 TLU research villages. A survey of storage practices is in progress ; steps were taken to initiate the sorghum marketing study in collaboration with IRA Project Garoua early in 1992. Other surveys planned are in progress (agroforestry survey). Preliminary results of the 1990 adoption survey are reported.

Activities under on-station technology generation in 1991 included the following trials: (1) effect of striga treatment on subsequent striga generation, (2) effect of cowpea association on striga population in sorghum, (3) screening cover crops for soil protection, (4) observation of pigeon pea hedgerows and associated crops and (5) effect of muskwari planting date and depth (1990-91).

In the four TLU research villages, the sorghum/cowpea association test entered its third (and possibly final year). The land preparation test was simplified in design following farmers' feedback in 1990. The collaborative work of TLU and the IRA/Bean Cowpea CRSP included both testing of four cowpea storage techniques (2nd year) and a researcher/farmer managed cowpea variety test.

Regional variety tests with SODECOTON and PNVFA were also conducted for 5 sorghum varieties and 5 peanut varieties. Minikit tests of seed treatment (sorghum) and compound maize were implemented for the third consecutive year.

Total rainfall in the Extreme North province was abnormally high in 1991 (800 to 1100 mm) but distribution was typically poor. Drought periods in June caused severe stress to young sorghum and high humidity associated with high rainfall in August caused increased disease pressure in cowpea.

Difficulties included 1) arrival of Systems Agronomist after the start of the rains in late May, 2) disabling computer virus, and 3) increasing cost of running aging vehicles and the fact that TLU had to operate with fewer vehicles after turning one over to the NCRE Grain Legumes program.

6.3.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Improve knowledge of farmers' circumstances, practices and institutional framework.		
1.1 Provide baseline data on farming systems of EN for evaluation of impact of improved technologies and setting of research priority.	1.1.1 Agric. practice survey (3rd year) and monitoring food crop prices.	1.1.1 1991 data collected with increased emphasis on striga occurrence in sorghum fields. Survey concluded. Working paper on agric prices in progress.
	1.1.2 Survey of storage practices for sorghum, peanut, millet. Marketing survey for sorghum.	1.1.2 Description of storage techniques and informal contacts with key respondents initiated. Action report in progress. Marketing study delayed for better collaboration.

Objectives	Activities	Accomplishments
1.2 Identify farmers' strategy against drought and long term approach to sustainable agriculture.	1.2 Analysis of 1st and 2nd year agric.practice survey data; survey of farmers' attitudes toward agroforestry, soil protection, use of manure.	1.2 Survey questionnaire developed in collaboration with IRA Forestry section and begun in TLU villages. Analysis of 3 years agricultural survey in progress (30%).
Operation 2: Generate technology to stabilize yields of sorghum		
2.1 Identify practices to reduce striga populations in rainfed sorghum.	2.1 Long term trials and crop association trials.	2.1 Preliminary results on long term effect of herbicides. Evidence of decreased reproductive potential of striga when cowpea associated with sorghum.
2.2 Identify viable practices to conserve soil moisture and fertility in rainfed sorghum.	2.2 Cover crop screening trial and alley cropping trial.	2.2 Adapted species of cover crops identified and seed multiplied. Soil moisture depletion by pigeon pea at more than 60cm from hedgerow.
2.3 Identify viable practices to conserve soil moisture in Mouskwari.	2.3 Leguminous cover crop screening trial and seed multiplication.	2.3 Few adapted legumes available. Muskwari water use study on-going.
Operation 3: Identify improved varieties, cropping patterns and soil moisture conservation techniques.		
3.1 Assess yields, acceptability, and profitability of new sorghum, cowpea, peanut varieties under farmers' conditions.	3.1 Regional tests of sorghum, and peanut varieties; cowpea variety test in TLU villages.	3.1 K32 and M416 appear to possess qualities desirable to farmers. Improved sorghum CS 141 and CS 210 inferior in yields to S35 and locals.
3.2 Assess yields acceptability and profitability of sorghum/ cowpea intercrops under farmers' conditions.	3.2 Sorghum/cowpea association tests to increase LER and combat striga; researcher/ farmer managed tests.	3.2 Djigari/Vya with LER>1.10 for third consecutive year under farmers conditions. Ready for regional testing.
3.3 Assess performance and acceptability of improved land preparation techniques under farmers' conditions.	3.3 Soil prep.methods and N fertilization in traditional and improved systems; researcher/ farmer managed tests.	3.3 Animal plowing gave 54% sorghum grain yield response and 49% higher gross benefits over no-plowing.

Objectives	Activities	Accomplishments
3.4 Monitor farmers preferences and utilization of IRA varieties.	3.4 Analysis of 1990 adoption survey.	3.4 Preliminary results showing adoption rates of 13, 23 and 31% respectively for sorghum S35, improved peanuts and cowpea varieties in Far North Province.
Operation 4: Identify low cost, practicable post harvest technologies for reducing grain losses.		
4.1 Determine and assess profitability of improved storage techniques.	4.1. Second year experiment on improved cowpea storage techniques in collaboration with IRA/ CRSP.	4.1 Two hundred farmers and 30 PNVFA agents exposed to improved cowpea storage techniques. Regional tests planned for 1992.
Operation 5: Disseminate knowledge of improved crop production		
5.1. Communicate findings to extension agents and farmers.	5.1 Writing and disseminating working papers and extension leaflets, minikits tests.	5.1 870 minikits distributed with > 50% response to evaluation. Six training sessions for PNVFA specialists. Field day at Koza with PNVFA and CRTV featuring TLU tests.

6.3.4 RESEARCH FINDINGS

6.3.4 SURVEYS

Adoption of Improved Technologies

A region wide survey was conducted in September 1990 to evaluate the extent of adoption of improved varieties of, and recommended practices for sorghum, cowpea and peanuts and identify factors associated with adoption (or non-adoption) of these practices. A total of 36 villages in the cotton growing zones were selected with a probability proportionate to size (number of farmers). In this report, preliminary results on variety adoption for all three crops and factors associated with the adoption of S35 sorghum are presented. The percentage of farmers in each region (SODECOTON) who planted at least one part of their holdings to new varieties is given in Table 1.

Table 1. Adoption of improved varieties in Northern Cameroon (% of farmers per region).

	Maroua	Kaele	Tchatibali	Guider	
Number of farmers in the sample	479	253	176	167	Mean[1/]
Sorghum	23.6	4.0	17	8.4	13.4
Peanuts[2/]	14.6	13.0	18.7	27.5	23.4
Cowpeas	39.0	29.6	26.6	12.6	30.6

1/ Weighted average
2/ Excludes variety 28 206

Maroua region (Diamare and Mora-Mokolo) has the largest proportion of adopters, followed by Tchatibali region (Mayo-Danay). The overall averages indicate that cowpea varieties are more frequently adopted than sorghum varieties. The extent of adoption of peanut varieties (23.4%) does not include variety 28-206 which has been introduced and used by farmers for many decades.

6.3.4. Adoption of sorghum variety S35

The results indicate that 13% of farmers in the TLU mandate area have adopted sorghum S35, with an average of 0.7 ha per adopter i.e. 43% of sorghum holdings. As to geographical distribution of S35 adopters, 28,9% are in Mora, 25,2% in Koza, 17% in Dogba, 6.7% in Karhay I and 5.2% in Bogo. In 1990 S35 represented 8.7% of the total area planted to sorghum in the region.

A comparison is made in table 2 between adopters and non-adopters of S35 in regard to farms characteristics and the use selected improved practices. The results show that S35 adopters generally have larger sorghum fields and plant small areas of dry season sorghum. They maintain more frequent contacts with extension and use more of the recommended practices in cultivating sorghum.

An index was constructed to represent adoption of the S35 package (seeds and improved practices) among farmers. Each quarter of ha planted to S35 was assigned one point and the score incremented by one (zero otherwise) for each recommended practice adopted by the farmer. The index used as dependent variable was then regressed on selected personal attributes (socio-economic factors) of farmers. A step wise regression model (table 4) indicates that the area planted to rainy season sorghum (+), to Muskwari (-), the number of years the farmer has been planting S35 or any other improved variety (+) and the origin of the variety contributed significantly to the variability in adoption rates.

Table 2. Farmers' characteristics and use of selected improved practices in relation to adoption of sorghum S-35 in North Cameroon.

Indicators	Adopters	Non-adopters	All farmers
Number of farmers	135	873	1,008
Average man-equi./farm	5.1	3.7*	4.0
Area in rainy s. sorghum (ha)			
- total sown (ha)	234.4	919.9	1,154.3
- per farm (ha)	1.7	0.9*	-
Area in S35 (ha)-total	100.6	0	100.6
Area in cotton/farm (ha)	1.8	1.4 n. s.	-
Area in dry s. sorghum/farm (ha)	0.3	0.7*	-
Contacts with extension/year	3.7	2.7*	-
Years planting S35 since 1985	2.7	0.2*	-
Years planting cotton	15.3	14.1 n. s.	-
% treating seeds	66.6	47.9	50.4
% rotating sorghum-cotton	46.6	26.9	29.6
% line sowing	69.6	67.0	67.4
Number of weeding/season	2.5	2.4 n. s.	-
% applying fertilizer	33.3	34.0	33.7

Note: '*' = Significant at 5% ; n.s. = Non-significant.

Table 3. Summary of step wise regression analysis of adoption rate on selected variables.

Variable	Coefficient (b)	t-ratio	R^2	F-ratio
Rainy season sorghum area	1.34	3.93*	0.30	11.20
Dry season sorghum area	-1.14	-2.09*		
Years planting new variety	4.32	2.17*		
Origins of variety	2.94	2.74*		
Cotton area	0.79	1.83		

Note: '*' = Significant at 0.05 level.

6.3.4. ON-FARM TESTS

6.3.4. Minikit tests

In 1991, 870 minikit tests of maize varieties and sorghum seed insecticide treatment were distributed in the mandate area in collaboration with SODECOTON and MINAGRI agents. Two varieties of maize (CMS 8704 and DMR ESR-Y), meant to be consumed fresh, early in the cropping season, were tested for the third year. One variety of maize (Pool 16 DR) was suggested by the IRA maize breeder for evaluation for the first time for grain production on fertile soils. Seed treatment with thioral was tested for the first year after testing a more expensive insecticide (Marshall) in previous years.

Evaluation forms were returned by 57% of the farmers testing maize varieties and by 40% of farmers/extension agents who tested thioral treatment on sorghum seed. The opinion of farmers who tested the maize varieties is presented in Table 4. CMS 8704 was appreciated by almost 89% of farmers who responded to the evaluation questionnaire and DMR ESR-Y by 78%. These varieties were especially appreciated for their ability to emerge, taste, and cooking quality. While Pool 16 DR was appreciated for its ability to emerge, its overall appreciation by responding farmers was only 53%, color and taste being unfavorable points.

Seed treatment with thioral was felt by responding farmers to favorably affect emergence (96%), plant survival (84%), plant growth (77%), disease and insect resistance (64%), striga resistance (54%), and yield (65%).

Table 4. Opinion (as percentage) of responding farmers who tested maize minikits in 1991.

	CMS 8704		DMR ESR-Y		Pool 16 DR	
	Good	Poor	Good	Poor	Good	Poor
Energence	71	10	74	20	83	6
Insect and disease resistance	56	20	53	20	55	15
Tolerance to weeds and striga	51	22	42	22	45	20
yield	54	29	52	26	52	25
Color	55	38	69	27	38	22
Cooking quality	65	27	89	8	50	21
Taste	75	0	78	18	50	21
Overall	89	4	78	18	53	18

Note: Intermediate responses (fair) can be calculated by difference from 100.

6.3.4. On-farm regional tests

In 1991, regional tests were conducted with peanut and sorghum varieties. All tests involved one replication per farmer.

6.3.4.2. Peanut Varieties

This was the second year of testing peanut varieties developed by the IRA peanut section. Four new varieties with short maturity cycle were compared with two control varieties, the farmers' current variety and one of two recommended varieties (55-437 in drier zones and 28-206 in more humid zones). Twenty eight tests were conducted, 20 with SODECOTON collaboration and 8 with MINAGRI. All of the tests were harvested without problems in spite of early season drought at most sites.

There was no consistently superior variety in terms of grain yield except in the Mayo Louti Division where the recommended variety (28-206) produced 40 to 50% more than the new varieties and 30% more than the locals (Table 5). Note that the local was generally 28-206 of poorer seed quality as reflected in a 7% reduction of stand at 15 days (data not shown).

In the Far North province, mean grain yields fell within a narrow range (1.24 to 1.44 t/ha in SODECOTON tests and 1.11 to 1.24 t/ha over all tests). This was the first year in which the improved varieties were tested against 55-437, a variety recommended for the drier zones. IB 77 and 5021 were the best varieties in the 1990 regional tests in terms of grain yield, although M 416 was much appreciated by farmers in terms of grain quality. Thus it will be wise to continue testing for another year before progressing to the minikit stage.

The short duration varieties produced significantly less hay than the locals (Table 6).

The groundnut section team accompanied the TLU on a visit of all tests in August, enabling them to observe their varieties under farmers' conditions and to record the incidence of major peanut diseases.

Table 5. Yield of peanut grain in on-farm regional test of peanut varieties, 1991.

	5021	55-437	IB 77	M 416	K 32	Local	CV	SE
	kg/ha							
SODECOTON								
Dianare (4)	1380	1128	1264	1313	1354	871	15.3	93.1
Mora-Mokolo (4)	1591	1465	1474	1129	1302	1444	17.6	122
Kaele (4)	1385	1262	1335	1334	1329	1152	31.9	207
Mayo Danay (4)	1417	1335	1327	1200	1482	1622	13.9	97.2
PNVFA								
Bourha (3)	526	438	601	618	549	573	30.8	69.2
Mora (2)	988	968	859	996	998	767	15.8	104.1
Koza (3)	1019	1344	1209	971	1302	1240	11.3	76.9
MEANS								
Far North	1238	1158	1198	1111	1226	1139	21.2	50.9
SODECOTON	1443	1282	1350	1244	1367	1273	21.2	70.3
PNVFA	826	910	894	845	944	872	19.2	59.7
28-206								
Mayo Louti (4)	1236	1846	1278	1429	1411	1625	17.5	128.5

1/ Number of tests in parentheses.

Table 6. Yield of peanut hay in on-farm regional test of peanut varieties, 1991.

	5021	55-437	IB 77	M 416	K 32	Local	CV	SE
	kg/ha							
SODECOTON								
Dianare	2531	2431	2323	2227	2192	4201	16.7	221
Mono	1697	1889	1940	1672	1578	2930	23.5	229
Kaele	2209	2520	2328	2828	2293	3071	24.3	309
Mayo Danay	2316	2438	2331	2111	2119	3209	21.3	258
PNVFA								
Bourha	1350	988	1138	1092	1130	2798	20.5	167.8
Mora	2004	2097	2814	1778	1520	1972	26.7	382.6
Koza	2088	2900	2440	2084	2213	4336	15.8	244.2
MEANS								
SODECOTON	2188	2319	2230	2209	2045	3353	21.5	128.6
PNVFA	1790	1982	2045	1635	1634	3168	27.5	198.7
Far North	2056	2207	2169	2018	1908	3291	23.0	106.8
28-206								
Mayo Louti	2410	2719	2452	1996	1490	3533	32.3	392.7

1/ Number of tests in parentheses.

A comparison of gross benefits was made for the peanut variety test. Since labor at harvest was the only input that varied between treatments (significantly higher for the local check), gross benefits per hour of harvesting (limiting factor) were also ranked as shown in Table 7 for the 20 tests in SODECOTON region.

Table 7. Gross benefits in peanut variety test 1991 (SODECOTON, Far North)

Variety	Value of production Grain + Hay (CFA/ha)	Labor at harvest hours/ha	Value CFA	Gross benef. /ha	Gross benef. /h	Rank /ha	Rank /h
5021	467365	244	30744	436621	1789	2	5
IB 77	452800	203	25578	427222	2105	3	1
M 416	430345	248	31248	399097	1609	6	6
K 3237-80	440390	216	27216	413174	1913	5	4
55407 Check	447105	204	25704	421401	2066	4	2
Local check	553240	264*	33264	519876	1970	1	3

Note: Peanut grain valued at 195 F/kg in December; Peanut hay at 85 F/kg and harvesting at 126 F/hour.

The low yield of M 416 both in grain and hay results in the smallest gross benefit of all the varieties tested. Since these varieties are compared to both the local and improved checks (55 437), eliminating the check varieties places 5021 and K 32 higher in the list of possible substitutes for the checks.

Farmers' appreciation of these varieties in a post harvest survey appears consistent with the trend noticed in 1990 peanut variety test with respect to M 416 in particular. They ranked M 416 (57%) and K 3237-80 (39%) as first and second in regard to overall performance. Sixty eight percent indicated their readiness to adopt M 416 and 46% for K 3237-80. An important reason appears to have been the red grain color, large grain size and sweet taste. Farmers' low opinion of 5021 and IB 77 is related to the above criteria and their susceptibility to diseases (36% of farmers). In sum, despite the low yield and resulting low gross benefit of variety M 416, farmers felt that it fills a particular need.

6.3.4. Sorghum Varieties

After 3 years of multilocational trials, two short cycle (CS 141 and CS 210) and one purified traditional variety (Gueling), promising stable high yields of good quality grain and stover were identified by the IRA sorghum section for regional testing. These were compared with two control varieties, the farmers' currently popular variety and one of two recommended varieties (S 35 in the Far North province and Djigari for Mayo Louti Division). Twenty eight tests were initiated in collaboration with SODECOTON (20) and MINAGRI (8), of which six were abandoned because of uniformly poor stand and growth from early season drought and insect attack.

In general, yields of sorghum grain were excellent since rainfall was very favorable after the early season drought. The improved, short cycle varieties did not perform well in this rainy year (Table 8). Farmers' current varieties were generally best and Gueling performed very well regionally. This supports the view that more local varieties should be incorporated into sorghum breeding since these varieties are adapted to the environment and preferred by farmers for their taste. One year of testing is not sufficient to eliminate the improved varieties, however, in this abnormally high rainfall year. Also CS 141 showed some promise by producing excellent stover biomass in addition to reasonable grain yield (Table 9). Yields of trials followed by MINAGRI agents were very low and five out of eight MINAGRI trials were abandoned.

Site mean yields ranged from 290 to 3180 kg/ha providing sufficient variability to study yield determinants with the existing data. Striga numbers fluctuated considerably from 0 to 371,500/ha at 90 DAP but were not correlated to mean site grain yield.

Table 8. Yield of grain in on-farm regional test of sorghum varieties, 1991.

	CS 141	CS 210	S 35	Gueling	Local	CV	SE
	kg/ha						
Diamare (7)	1309	1375	1873	1922	1798	29.1	182
Kaele (4)	1844	1641	1642	1997	1811	16.2	145
Mayo Danay (4)	1701	1361	1722	2100	2610	32.4	308
PNVFA (3)	588	414	620	366	803	61.9	199
MEANS-Far North							
SODECOTON (15)	1556	1442	1771	1990	2018	28.0	127
Overall (18)	1395	1271	1579	1719	1815	30.3	111.3
			Djigari				
Mayo Louti (4)	1565	868	1360	1509	1627	17.8	124

1/ Number of tests in parentheses.

Table 9. Yield of stover in on-farm regional test of sorghum varieties, 1991.

	CS 141	CS 210	S 35	Gueling	Local	CV	SE
	kg/ha						
Dianare (6)	5564	4171	3964	5837	6432	34.2	726
Kaele (4)	4568	3787	3011	5180	4533	28.9	608
M. Danay (3)	3072	3193	2778	3133	3360	29.5	529
PHVFA (3)	2016	1916	1850	2239	1879	34.4	393
MEANS-Far North							
SODECOTON (13)	4683	3827	3397	5011	5139	32.3	394.3
Overall (16)	4183	3469	3107	4491	4528	33.5	331.0
Djigari							
Mayo Louti (4)	8086	2468	7066	5495	7090	26.2	792

1/ Number of tests in parentheses.

A partial budget was elaborated to compare gross benefits (value of grain and stover) in sorghum variety tests. Since the level of inputs (seeds, fertilizer, seed treatment) was the same across treatments, labor at harvest (although not significantly different among varieties) constituted the only variable cost. Gross benefits per ha and per hour of harvesting (limiting factor) are compared and ranked as shown in Table 10. Variety CS 210 has a much smaller gross benefit as a result of both low grain and stover yield in relation to the other varieties.

Table 10. Gross benefits (CFA) of short-cycle varieties of sorghum tested in 1991 (SODECOTON, Far North).

Variety (CFA/ha)	Value of production Grain + Hay hours/ha	Labor at harvest hours	Value	Gross benefit /ha	Gross benefit /h	Rank	Rank
CS 141	436805	54	6804	430001	7963	3	3
CS 210	287025	50	6300	280725	5615	5	5
S 35	352180	46	5796	346384	7531	4	4
Gueling	485275	52	6552	479479	9221	2	1
Local	496415	54	6804	489611	9067	1	1

Notes: Sorghum grain evaluated at 55 F/kg in December ; stover 75 F/kg and labor at 126 F/hour.

All of the farmers were questioned at the time of weighing the harvest about the varieties tested. In terms of overall performance, S 35, Gueling and CS 141 were respectively appreciated by 60, 45 and 40% of the farmers. Reasons appear to be white grain color, stem height and stover yield. The frequencies of farmers who characterized each variety with respect to certain quality or disadvantages are given in Table 11 to emphasize farmers' perception and feedback to the station.

Table 11. Farmers assessment of sorghum variety characteristics.

Characteristics	Frequency (%)
Good quality of "boule"	S 35 (50); CS 210 (50); Gueling (29)
Good quality of local beer (bil-bil)	S 35 (36); Local (43); Gueling (36) CS 210 (14); CS 141 (14)
Susceptibility to striga	CS 210 (24); S 35 (14); CS 141 (10)
lodging	CS 141 (10); CS 210 (14)
bird damage	S 35 (43); Gueling (10)
grain mold	S 35 (45); CS 210 (30); CS 141 (20)

6.3.4. Research Village Trials Sorghum Cowpea Association

Association of cowpea with sorghum has been envisaged to utilize resources (solar radiation, soil moisture, and nutrients) more efficiently. The use of locally grown spreading cowpea (Vya) has been proposed to shade Striga hermonthica growing on sorghum, thereby reducing striga's ability to reproduce. Thus the main agronomic observations are yield and striga numbers.

Four farmers conducted the trial in each of four TLU research villages. The treatments included two of the most popular sorghum varieties (Djigari and S-35) in monoculture and in association with Vya in alternate holes of the same row. A pure stand of Vya provided a means of calculating Land Equivalent Ratios (LERs).

Results over all 16 sites show that excellent yields are likely with this association. Note that no fertilizers or pesticides were applied. S 35 grain yields were reduced only 27% and cowpea grain by 22% in association, resulting in an LER of 1.5 (Table 12). This is the first of three years in which S-35/Vya LER is greater than 1.0 while the Djigari/Vya LER was 1.13 in both 1989 and 1990 and 1.11 this year. Djigari/Vya association appears to be a very stable system which should advance to regional testing.

As this was the first year in which sorghum stalk and cowpea hay yield were measured, many sites had to be eliminated from the analysis. Complete data were only available for seven sites. Nevertheless, this crop association appears to be very efficient in utilizing resources, as stalk and hay yields remained high when grown in association (Table 13).

For this reason as in previous years, a partial budget was constructed to evaluate the benefits of moving from sorghum in pure stand to sorghum/cowpea association. Thus in Table 14, marginal rates of return are presented for the choice between Djigari or S-35 in monoculture and Djigari/Vya or S-35/Vya.

Table 12. Mean grain yields of sorghum and cowpea grown as monocrops or in association in farmer-managed tests, 1991.

	----- Monocrops ----			--- Associations ---			
Sites	Djigari	S-35	Vya	Djigari	S-35	CV	SE
Djoulgouf (4)							
Sorghum	1612	750	-	690	577	82	373
Cowpea	-	-	303	97	140	92	82.4
LER	-	-	-	0.75	1.23		
Djingliya (4)							
Sorghum	1449	1316	-	569	929	42	225.4
Cowpea	-	-	129	237	307	46	51.7
LER	-	-	-	2.23	3.09		
Gatouguel (4)							
Sorghum	1029	1350	-	937	958	56	297.0
Cowpea	-	-	410	123	193	100	121.3
LER	-	-	-	1.21	1.18		
Zouaye (4)							
Sorghum	1374	1047	-	980	809	42	220.8
Cowpea	-	-	294	142	240	36	40.3
LER	-	-	-	1.20	1.59		
Mean (16)							
Sorghum	1368	1116	-	794	818	54	139.4
Cowpea	-	-	284	150	220	78	42.3
LER	-	-	-	1.11	1.51		

1/ Number of tests in parentheses.

Table 13. Mean sorghum grain and stover and cowpea grain and hay yields in seven farmer-managed tests of sorghum/cowpea association, 1991.

	----- Monocrops ----			--- Associations ---			
	Djigari	S-35	Vya	Djigari	S-35	CV	SE
Sorghum							
Grain	1357	1281	-	1023	961	28	123.9
Stover	4464	1597	-	3625	1975	44	482
Cowpea							
Grain	-	-	255	215	315	44	43.9
Hay	-	-	1368	809	1058	38	155.1
LER	-	-	-	1.5	2.0		

1/ Number of tests in parentheses.

Table 14. Partial budget of the sorghum cowpea association, 1991.

Item	Djigari pure		S-35 pure	Djigari/Vya	S-35/Vya
Sorghum yield					
(kg/ha) grain	1368	1116	794/150	818/220	
stover, hay[1]	4464	1597	3625/809	1975/1058	
Total of prod. (CFA/ha)	410040	181155	414310	327045	
Variable costs					
seeds (kg)	20	20	13.3/8.3	13.3/8.3	
value (CFA/ha)	1600	1600	3139	3139	
labor (hr)	111	108	116	116	
seeding + harvesting value (CFA/ha)	13986	13608	14616	14616	
Total (CFA/ha)	15586	15208	17755	17755	
Net Benefit (CFA/ha)	394454	165947	396555	309290	
Marginal Rate of ret. (%)					
Wrt Djigari pure			100	-	
Wrt S-35 pure			9060	5630	

[1] Average of 7 tests

The highest MRRs involve moving from S-35 pure to Djigari/Vya. Djigri/Vya intercrop is still profitable despite a comparatively low MRR. Moving from Djigari pure to S 35/Vya is a dominated option.

The effect of sorghum cowpea association on striga population was not clearly demonstrated. Striga numbers at 90 DAP were 39000/ha for the sorghum pure stands and 27000/ha when associated with cowpea. This decrease of 30% could have been associated with decreasing sorghum density (reduced 25% in association with cowpea). Future observations should focus on indicators of striga reproductive potential such as numbers of flowers, numbers of mature striga capsules, or some correlated parameter.

6.3.4. Soil Preparation for Sorghum

Sixteen tests were initiated and 14 harvested for grain (11 for stover) in the four TLU research villages. Soil tillage with animal plow was compared to direct seeding (no-tillage) at the mainplot level and three sorghum varieties at the subplot level of a split plot design.

The effect of plowing on sorghum grain yield was significant (Table 15). Mean response to plowing on sorghum grain yield ranged from 10% at Djingliya to infinite at Gatouguel and 54% overall. Soil moisture content to 30 cm depth was measured at 15 DAP in the Djigari plots by the IRA soils section. Mean soil profile moisture content of plowed soil was 29% higher than the control. This suggests that plowing increased soil water availability to sorghum during early growth, helping the plant to avoid drought stress.

The sorghum varieties responded to plowing similarly. Variety itself was not a significant factor. Plowing did not significantly affect stalk yield in the 11 sites where data were available.

The trial was then analyzed in terms of costs and returns to plowing versus no plowing for each variety, since variety itself was not a significant factor. Labor use had been monitored on all treatments and showed significant differences between plowed and non-plowed plots. There was no other input level varying within a variety factor, thus gross benefits and labor productivity could be estimated as in Table 16. The percent increase in gross benefits between plowed and non-plowed treatments was 24, 56 and 68% for Djigari, S-35 and the local, respectively. Except for Djigari, the value of production per hour is higher for plowed plots.

Table 15. Yield of sorghum grain and gross benefits in 24 farmer-managed research village tests of soil preparation, 1991.

	Djigari		S-35		Local		Mean		ES
	-	+	-	+	-	+	-	+	[illegible]
Djoulgouf	276	607	489	670	255	513	340	598	[illegible]
Djingliya	634	900	966	1008	990	1056	863	954	[illegible]
Gatouguel	0	1367	0	1395	0	1743	0	1501	[illegible]
Zouaye	1496	1379	978	1215	1329	1935	1268	1510	[illegible]
Mean	687	992	695	1026	735	1250	706	1089	[illegible]
Value of production at 55 F/kg (CFA/ha)	37755	54560	38225	56430	40425	68750	-	-	-
Total labor used hrs/ha	183	279	210	234	225	250	-	-	-
Valued at 126 F/hr	23058	35154	26460	29484	28350	31500	-	-	-
Gross benefit CFA/ha	14727	19406	11765	26946	12075	37250	-	-	-
Labor. productivity CFA/hour	206.5	195.6	182.0	241.1	179.7	275	-	-	-

Note: '+' and '-' mean with and without plowing, respectively.

An additional important economic advantage of plowing was improved plant establishment as reflected in a 79% reduction in the number of reseeded holes. The effect carried through to plant density at 30 DAP and at harvest (18 and 17% increase due to plowing, respectively). Future tests will include careful observation of erosion which could affect the sustainability of such a land preparation system.

6.3.4. Cowpea Variety

Two erect IITA varieties were proposed by the IRA cowpea section. They were compared to the most commonly grown spreading (Vya) and semi-erect (BR1) varieties. The crop was treated once with insecticide by the IRA cowpea section and a second time by TLU observers. The cowpea team accompanied TLU on a trip to observe all of the tests in September.

Yields were generally low during this season probably due to very high rainfall in August, resulting in a increased disease pressure. The IITA varieties did not prove to be well adapted to the environment in 1991. Grain yield of IT86D364 was significantly lower than BR1 and Vya and yield of IT86D719 was significantly lower than BR1 (Table 16).

Of the sixteen tests initiated, grain was harvested from 13 and hay from nine. Hay yields of IT86D364 were significantly lower than those of BR1 (Table 17). BR1 surpassed Vya in grain and hay production as expected in these trials receiving two insecticide applications.

Table 16. Yield of grain in on-farm test of cowpea varieties, 1991.

	BR1	Vya	IT'364'	IT'719'	CV	SE
	kg/ha					%
Djoulgouf (3)	573	660	310	454	29	82.6
Gatouguel (4)	798	634	478	555	45	139.8
Zouaye (2)	429	371	253	338	23	57.5
Mean (9) 641	584	372	473	38	65.4	
Djingliya (4)	315	286	367	-	37	59.4
Mean (13)	541	493	370	-	44	56.6

1/ Number of tests in parentheses.

Table 17. Yield of hay in on-farm test of cowpea varieties, 1991.

	BR1	Vya	IT'364'	IT'719'	CV	SE
	kg/ha					%
Djoulgouf (3)	2123	1411	1050	1788	26	237
Gatouguel	-	-	-	-	-	-
Zouaye (2)	457	1001	332	526	21	88.1
Mean (5) 1457	1247	763	1283	36	190.8	
Djingliya (4)	604	507	387	-	29	71.9
Mean (9) 1078	918	596	-	45	131	

1/ Number of tests in parentheses.

6.3.4. On-farm Tests of cowpea Storage Techniques: 1990-1991

A major constraint to increased cowpea production is the loss in storage due cowpea weevils (Callosobruchus maculatus). Four storage methods devised by the IRA/Bean-cowpea CRSP project have been tested by TLU with the participation of collaborative farmers in the 4 research villages (Djingliya, Djoulgouf, Zouaye and Gatouguel). The methods include (1) improved traditional practice of storage in ash, (2) storage in pods on a wooden platform "Danki", (3) solar heaters and (4) storage of cowpea in sealed clear plastic bags (double or triple bagging).

To improve the demonstration value of the experiments, 6-10 farmers in each village were earlier given the varieties BR2 (improved) and VYA (Local) to plant and use the harvest for the experiments. Two farmers were selected for each technique. Except for the pod storage technique on dankis, most farmers had mixed BR2 with VYA or other locals.

Ash storage: Farmers using this technique were asked to thresh approximately 30 kg of seed in advance. The necessary wood ash and two traditional containers (canaris) were also supplied. Equal volumes of ash and cowpea seeds were mixed and poured into the canaris, covered with a layer of 3-4 cm and left for 2 1/2-3 month storage.

Storage in pods: The objective was to have farmers use a variety which has a breakage resistant pod as well as seed resistance (BR2) and determine whether this method offers a recognizable benefit while allowing farmers to compare this storage method to others being demonstrated. Approximately 2 sack-fulls (100 kg) of pods were placed on a danki (BR2 and VYA).

Solar Heater treatment: A 3 x 3 m sheet of black plastic was laid on an insulting mattress of dried weeds directly placed against the ground. Thirty kilos of seeds were spread out evenly on the black sheet, and covered with another 3 x 3 m sheet of clear plastic, with edges folded together to limit air circulation around seeds. The duration of the treatment was about 2 hours (between 11 and 13.00 hrs) which normally brings up the temperature inside the plastics to above 65° c. Following the solar exposure, seeds were placed in a double or triple bag of clear plastic (50 kg capacity) and tightly sealed to prevent further bruchid infestation.

Triple Bagging: The method is also use singly without other prior treatment. Two or three clear plastic bags were placed one inside the other and 30 kg of cowpea seeds placed inside, tightly sealed so that little to no air space remained.

Control Treatment: 30 kg of seeds were placed untreated in a typical harvest bag commonly used by farmers.

An important aspect of the demonstration was the artificial infestation of the cowpeas in each treatment with bruchid infested grains from the laboratory. This level of initial infestation (0.5%) was sufficient to ensure that nearly every seed would be damaged by the end of 3-4 months of storage.

Although the length of the storage period varied somewhat between villages (77-87 days), the seeds in the control treatment were heavily damaged in every village and the efficacy of the storage methods was easily observed. Adult C. maculatus emergence and oviposition in samples of 100 grains is presented in table 18.

Table 18. Callosobruchus maculatus adult emergence and oviposition in samples of 100 cowpea seeds receiving different storage treatments, October, 1990-February 1991.

Village and days of storage	Treatment	Total # emergence hole/100 seeds	# Eggs/100 seeds
Gatouguel (87 days)	Control	334	995
	Ash storage	0	0
	Ash storage	2	0
	Solar heater	5	0
	Solar heater	6	1
	Double bagging	9	33
	Double bagging	157	977
	Pods on danki (BR2)	6	0
Zouaye (84 days)	Control	89	335
	Ash storage	6	0
	Ash storage	3	0
	Solar heater	1	0
	Pods on danki (BR2)	2	1
	Pods on danki (VYA)	8	3
Djoulgouf (78 days)	Control	73	162
	Ash storage	10	1
	Ash storage	11	0
	Solar heater	5	0
	Solar heater	5	0
	Triple bagging	6	1
	Pods on danki (BR2)	2	1
	Pods on danki (VYA)	49	0
Djingliya (77 days)	Control	118	532
	Ash storage	11	0
	Solar heater	2	0
	Triple bagging	0	1
	Pods on danki (BR2)	6	0
	Pods on danki (VYA)	8	0

Source: IRA/Bean-Cowpea CRS Project-1991

The four storage methods were tested with the objective of evaluating their respective advantages and disadvantages so that farmers themselves can choose the methods which best suit their needs.

One obvious advantage of all the four techniques is that they are within the capacity of the farmers to adopt. Ash storage and storage on dankis are traditional methods that researchers attempted to improve. These two techniques are applicable to the majority of northern Cameroon farmers who typically produce 100-200 kg of cowpea per farm. The recommended "canari" which holds about 40 kg of seeds, sells for 1000-1500 FCFA and can last several years. After 2-3 months in ash storage, the farmer can earn 6500 FR (40 x 200 F/kg-1500 F) in gross revenue after sale.

Triple bagging may be suited for both small and larger farmers (1-2 tons). Selling 50 kg of cowpea seeds after 3-4 month storage can yield 10.000 FCFA minus the cost of the sacks (150 x 3 = 450 F), leaving a gross benefit of 9550 FCFA.

Many farmers mentioned the difficulty to acquire plastic bags in the village and the fact that the bags must remain sealed for 3-4 months (thus making the produce unavailable for home consumption) as possible disadvantages of this technique.

Solar heating can probably be adapted to suit the needs of most producers. The total investment in black and clear plastic amounts to 7500 FCFA. Selling 50 kg for 10.000 FCFA would more than pay for the solar heater and for the past treatment in plastic storage bags or in canari. Another advantage of the solar heater is that the investment can be shared by a group of farmers, thus lowering the cost per person.

The same experiment was run in October 1991 in the 4 TLU villages to confirm the 1990 results and assess farmers' feedback in a second year. The resounding success of this collaborative operation has made it possible for TLU and IRA/CRS project to recommend cowpea storage techniques for the 1992 regional testing, one step prior to full extension.

6.3.4. ON-STATION TECHNOLOGY GENERATION

Effect of Striga Treatment on Subsequent Striga Populations

Technology generation for control of S. hermonthica usually focuses on current year control to protect the sorghum crop. A successful technology must also reduce striga seed populations, thereby reducing striga pressure in subsequent years.

Two trials to test striga control practices: 1) Integrated approach to striga control, and 2) Herbicide control of striga, conducted on the same plots for two years (1989 and 1990), were followed up by a crop of sorghum in 1991 with intensive observation of S. hermonthica to test the long term effect of striga control on striga population pressure in subsequent years.

Striga numbers were not significantly affected by previous year treatments in the herbicide trial, but previous years Garlon treatment had significantly more striga in the integrated approach trial (Table 19). In general, striga numbers in both trials were related to plot position along the slope and grain and stover yield were more related to spittle bug infestation than to striga. Since previous sorghum variety may influence spittle bug (Poophilus costalis) populations, previous sorghum variety influenced yield significantly (Table 20) without affecting striga.

Table 19. Striga numbers (means adjusted for covariate 'position') in follow-up of 1989-90' integrated approach' treatments, 1991.

1989-90 Treatments	Weeks after planting 8	10	12	14	16
	/m²				
Control	3.7	16.2	14.2	11.2	21.6
Handweeding	3.2	9.4	4.5	5.0	7.2
2, 4 - D	5.3	7.8	5.8	5.9	8.7
Garlon	6.9	22.8	30.3	26.9	19.5
Modified FAO	8.1	8.8	11.9	7.0	10.8
Soybean	3.7	10.0	0.0	2.3	4.5
Millet	10.1	27.3	8.9	6.7	9.2
Cowpea (alt. row)	7.1	10.8	4.7	7.2	11.1
Cowpea (alt. hill)	3.8	17.0	15.8	8.6	10.2
Cowpea (same hill)	3.3	22.8	8.4	6.7	12.8
SE	n.s.	4.8	5.2	4.4	3.4

Table 20. Djigari grain and sorghum yields, spittle bug (Poophilus costalis) infestation, and striga numbers in 1991 follow-up of herbicide and integrated approach trials, 1991.

1989-90 Treatments	Grain kg/ha	Stover t/ha	Bug %	-- Striga numbers at 16 WAP --- Total	Flowers	Capsules	Dead
				/m²			
HERBICIDE TRIAL							
Djigari	167	3.47	55	17.2	6.5	4.0	3.6
CS-54	237	5.61	42	24.0	8.6	6.3	3.9
SE	23.4	0.16	1.3	2.1	1.0	0.6	n.s.
INTEGRATED APPROACH TRIAL							
Damougari	450	4.94	49				
S-35	590	5.15	39				
SE	46	n.s.	2.4				

6.3.4. Effect of Cowpea Association on Striga Population in Sorghum

An important researchable issue is the appropriate proximity of the sorghum and cowpea seed at planting. Thus a trial was conducted in which the distance between cowpea and sorghum was varied to observe the effect on striga emergence and life cycle and yield of sorghum and cowpea.

Seven within row sorghum, cowpea combinations were used in addition to sorghum pure crop. Numbers of cowpea (cv. Vya) were varied (1 or 2 per hole after thinning) as well as distance between sorghum and cowpea stands.

Striga populations were generally very low in the experimental area with the highest mean count of 2.4 m^2 occurring at 12 WAP. There was no effect of cowpea association on striga numbers and cowpea groundcover was not correlated to striga numbers. However, the number of striga carrying mature capsules was significantly correlated to cowpea groundcover (-0.508; p=0.006). Mature capsule-bearing striga numbers were highest in the pure sorghum treatment (Table 21). Thus while the cowpea may not inhibit striga emergence, shading by the cowpea may inhibit capsule formation leading to a long term reduction in striga numbers.

Yield of sorghum grain and stover were not significantly affected by cowpea association treatment. Pure sorghum yielded 735 kg/ha grain and 1.55 t/ha stover compared to 890 kg/ha of grain and 1.64 t/ha of stover for the cowpea association treatments.

Groundcover and hay yield were significantly affected by cowpea planting pattern (Table 21). Groundcover and yield of cowpea grain and hay were lowest when one cowpea plant was left in the hole with sorghum (T7). Groundcover and yield were highest with two holes of cowpea (each containing one cowpea plant) per hole of sorghum (T3 through T6 Mean = 69% groundcover; 340 kg grain and 2.2 t hay/ha). Yield was reduced by about 10% on average with one hole of cowpea (containing two cowpea plants) per hole of sorghum (T2 and T8; X = 53% groundcover; 305 kg grain and 1.4 t hay/ha).

Table 21. Sorghum and cowpea yields in trial of sorghum/cowpea association at Ndonkole, 1991.

	Cowpea Density /ha	Sorghum Grain kg/ha	Sorghum Stover t/ha	Cowpea Cover %	Cowpea Grain kg/ha	Cowpea Hay t/ha	Striga Capsules /m^2
T1	0	740	1.55	0	0	0	6.6
T2	42,000	950	1.55	58	300	1.55	1.0
T3	42,000	730	1.64	79	360	2.85	1.5
T4	42,000	690	1.54	64	320	1.85	1.3
T5	42,000	860	1.35	67	360	1.81	2.7
T6	42,000	1180	2.14	66	320	2.24	1.5
T7	21,000	910	1.66	22	200	0.78	4.7
T8	42,000	910	1.58	49	310	1.32	5.0
SE		220	0.23	7	61	0.32	1.6

6.3.4. Screening Cover Crops for Soil Protection

Vegetative cover is necessary to protect the soil surface from rain drop impact and consequent surface compaction and runoff. We propose planting a forage legume after sorghum establishment which might take advantage of any residual moisture after sorghum harvest. This would increase the likelihood of the soil being covered during the dry season, hindering wind erosion. Ideally, there would be some residue left on the surface at the beginning of the next rainy season so that infiltration, and therefore soil moisture content, would be increased, alleviating early season drought, a major constraint to sorghum production. Soil degradation due to sheet and gully erosion would be slowed as well.

Several promising forage legumes (Table 22) were planted on a gravelly ferruginous Alfisol in June, 1991 along with a spreading cowpea variety (Vya) and finger millet (Eleusine coracana) in three replications. Interrow distance was 1 m for all species. Biomass was sampled periodically at which time soil surface temperature was determined at 2 cm depth.

Table 22. Forage legumes screened at Houda, 1991.

Name	Source*
Mucuna pruriens	IRZ
Calopogonium mucunoides I 6750	ILCA
Canavalia ensiformis	ILCA
Canavalia gladiata	ILCA
Centrosema brasilianum I 155	ILCA
Centrosema pascuorum I 9857 (cv Cavalcade)	ILCA
Chamaecrista rotundifolia I 10918 (cv Wynn)	ILCA
Macroptilium atropurpureum I 69 (cv Siratro)	ILCA
Stylosanthes guianensis I 164	ILCA
Stylosanthes hamata I 75 (cv Verano)	ILCA

*Seed kindly furnished by H. D. Klein, IRZ-Garoua and S. Tarawali, ILCA-Kaduna.

Canavalia ensiformis, C. gladiata, and Mucuna pruriens produced 2.5 t D. M./ha by late September and C. ensiformis continued to accumulate biomass after the end of the rains (fig. 1). Other species which accumulated as much biomass as spreading cowpea were Macroptilium atropurpureum, Calopogonium mucunoides, and Chamaecrista rotundifolia. Cowpea gave an additional 600 kg grain/ha. Species which either did not establish well or did not grow well on this degraded site were finger millet, Stylosanthes hamata, S. guianensis, Centrosema pascuorum, and C. brasilianum.

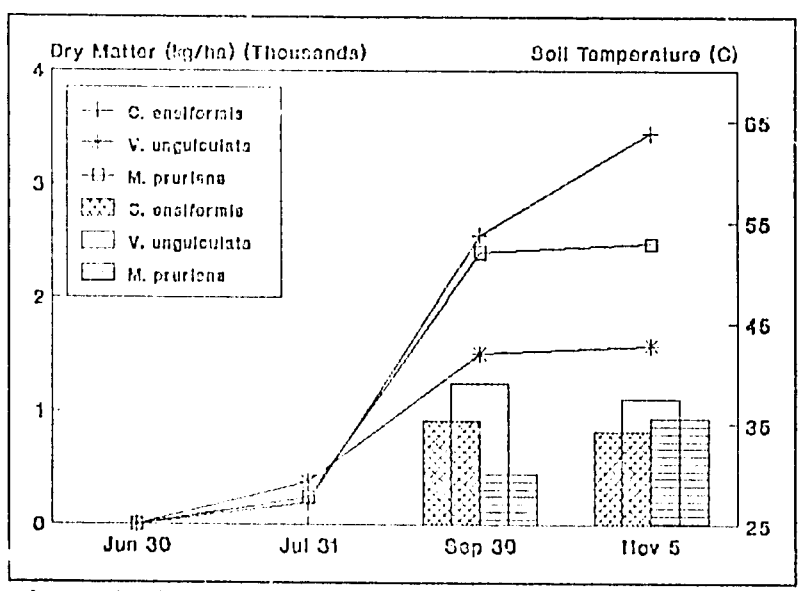


Figure 1 Biomass (lines) and soil surface temperature (bars) under selected forage legumes in screening trial, 1991.

Soil surface temperature reflected the degree of cover by the species (Fig. 1). In early October daytime soil surface temperature under cowpea was significantly higher than under Canavalia ensiformis or mucuna while C. ensiformis, with an erect stature, covered the soil less well than the spreading mucuna. By November, soil temperature was generally lower than in October and mucuna, which has senesced almost completely, no longer provided the best cover.

Production of seed of Canavalia ensiformis and mucuna was successful with almost 10 kg being produced on about 80 m^2.

6.3.4. Observation of Pigeon Pea Hedgerows and Associated Crops

While alley cropping is considered to be a biologically sustainable cropping system in the humid and subhumid zones, it may not be appropriate in semi-arid areas. The tree species which are most adapted to dry conditions may be those which most compete with an associated crop for soil moisture. Thus, a trial was conducted to observe the growth and response to pruning of pigeon pea (Cajanus cajan) and the yield of associated crops.

Pigeon pea was established from seed with the onset of the rains in 1990 on a ferruginous Alfisol in association with a crop of cowpea (4.8 m between hedgerows). In June, 1991 the pigeon pea was pruned to 30 cm height and biomass was estimated. The prunings were spread in the alleys and peanut variety 5021 was planted there and on control plots without trees. Mainplots were split for application of 100 kg/ha of triple super phosphate. Soil moisture tensiometers were installed in two of the three replications in both pigeon pea and control plots at 10 and 25 cm depth and several distances from the hedgerow. Peanut was harvested from the central rows separately from the border rows in each plot.

Pigeon pea pruning biomass, after a normal rainfall year and a six month dry season, averaged 740 kg D. M./ha. Pigeon pea regrew well after pruning, attaining an average height of 2.1 m during the rainy season. Fifty percent of the pigeon pea stand was lost during the first year of growth and an additional 20% was lost after pruning.

Yield of peanut in pods averaged 1.42 and 1.62 kg/ha in the central rows of the pigeon pea and control plots, respectively, a decrease of 12% (Table 23). In the border rows, the yield decrease in the pigeon pea plots was 27%. This was quite likely a result of competition between pigeon pea and peanut for moisture in dry periods. Higher soil moisture tension was recorded 20 and 60 cm from pigeon pea hedgerows than 140 cm from the hedgerows or in control plots during dry periods (Fig. 2). This effect was observed at 25 cm depth and only weakly at 10 cm.

Yield of peanut in pods averaged 1.56 and 1.43 t/ha with and without TSP, respectively, an increase of 9%.

Table 23. Pod yield of peanut in central and border rows in plots with pigeon pea, 1991.

Treatment	Peanut Pod Yield: Central Rows	Peanut Pod Yield: Border Rows	Difference
	kg/ha		
No tree	1620	1660	-40
Pigeon pea	1420	1210	210
SE	n.s.	n.s.	n.s.

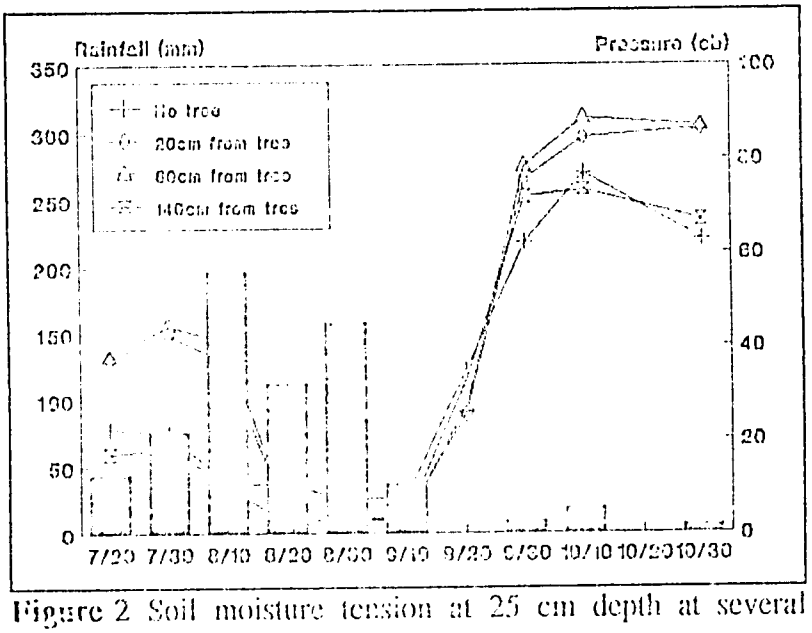


Figure 2 Soil moisture tension at 25 cm depth at several distances from pigeon pea hedgerows.

6.3.4. Muskwari Planting Date and Depth (1990-91)

Soil moisture availability is the main agronomic constraint to dry season sorghum production. Early planting carries a risk of stand loss due to transient flooding, and late planting may suffer from profile moisture depletion. Six transplanting dates were combined with three transplanting depths factorially in a split plot experimental design at Salak in 1990-91.

Both factors were significantly related to yield of grain. Increasing depth of transplanting from 10 to 30 cm resulted in a significant yield increase of 32% (from 425 to 563 kg/ha). Delay in planting resulted in significant yield reduction (Table 24). Planting in October resulted in 61% reduction in yield compared to September planting. The results of this spoil trial indicate that early and deep transplanting are appropriate.

Table 24. Yield of grain and stover of 'muskwari' sorghum and rainfall during 10 days prior to planting at Salak, 1990-91.

Date	Yield Grain	Yield Stover	Rainfall During Previous 10 Days
	kg/ha	kg/ha	mm
10 Sept.	646	1290	13
20 Sept.	791	1950	29
30 Sept.	772	1460	1
10 Oct.	175	410	21
20 Oct.	358	790	0
30 Oct.	334	690	2

6.3.5 VISITORS

Dr. Baker, IRA/NCRE, Economic Analysis Unit, June
R. Bernsten, Michigan State Univ., June
J. Sterns and G. Dimithé, Michigan State Univ., June-August
G. Weber, IITA/RCMP, Savanna Systems Research Group, June
Benbow, USAID and E. Atayi, IRA/NCRE Chief of Party, July
USAID Camera crew, July and October
R.E.L. Romero and G.E. Wyrwal, FAO Striga Team, August.
M. Moussie, IRA/NCRE, TLU Coordinator, November.

6.4 NKOLBISSON TLU

6.4.1 INTRODUCTION

Nkolbisson TLU has the responsibility for farming systems diagnosis, on-farm testing, and extension liaison in the Center and South provinces. The TLU primarily concentrates on the Center Province, which encompasses Yaounde, the second largest urban market in Cameroon, and nearly 75 percent of farms in the TLU's mandated research zone.

The goal of Nkolbisson TLU is to enhance rural incomes and food security through more productive and sustainable crop production systems. Until 1991, research focused on improved maize, cassava, and sweet potato varieties, maize fertilization, weed control, and mixed cropping patterns. Research on these themes is near completion and promising alternatives are being verified through regional testing and demonstrations in conjunction with the extension service of the Ministry of Agriculture (MINAGRI).

Research on agroforestry and planted fallow now constitutes the primary technology development focus of the TLU and this is expected to be the case throughout the 1991-1994 phase. The TLU continues to complement its technology testing program with selected diagnostic surveys but resources invested in diagnostic research are small relative to technology verification and promotion activities.

6.4.2 SUMMARY OF PROGRAM ACTIVITIES

During the 1991 cropping seasons, the TLU carried out 12 on-station trials and over 60 farmer managed on-farm trials. Of the 60 on-farm trials, 20 were on alley cropping, 12 on weed control, and 20 on planted fallow with groundnut-cassava and sole maize.

Regarding the regional tests, the TLU distributed over 1000 variety and fertility tests, and over 1500 regional maize adoption tests. Over 70% of participant farmers implemented the tests. However, due to insufficient supervision and follow up, completed data were collected from only a small percentage of farmers.

As part of the regional tests, the TLU provided training to over 50 agricultural delegates in Center and South provinces. During the year, five TLU national counterparts left for long-term training in the U.S. and Europe.

After careful scrutiny of the questionnaire, the Resource Management Survey got underway by the end of the year, and is expected to be completed by mid February, 1992. The extension survey was dropped out because it was given a low priority.

6.4.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Farming systems diagnosis.		
1.1. Provide information and identify research needs.	1.1 Village-level resource management survey.	1.1 Survey is in progress; to be completed in 31 villages by the first quarter of 1992.
	1.2 Extension agent survey.	1.2 Not carried out. Not considered as a top priority for this year.
1.2. Evaluate technology adoption and impact.	1.2. (No activities in 1991 work plan.)	1.2 Adoption and retention survey planned for 1992.
Operation 2: On-farm technology evaluation.		
2.1. Identify well-adapted and acceptable varieties.	2.1 Farmer maize variety tests.	2.1 trial failure due to mid-season drought.
	2.2 Farmer evaluation surveys	2.2 Contingent upon implementation of 2.1.
	2.3 Harvest 1990 cassava planting methods trial.	2.3 Data analysis completed. Improved variety significantly outperformed local variety. No yield difference between farmers' and recommended planting methods.
2.2. Testing support for IRA researchers.	2.2 Hybrid versus open-pollinated maize trial.	2.2 Data analyzed. No sufficient evidence to show yield and net benefit differences between hybrid and open-pollinated maize varieties. Trial to be continued in 1992.
Operation 3: Assessment of crop protection practices.		
3.1. Identify labor-saving weed control method.	3.1 Maize weed control trial.	3.1 Analysis completed. Based on combined data over 3 seasons, herbicide application is found to be profitable for farmers facing labor constraints, and is as good as the farmers' practice on small scale.

Objectives	Activities	Accomplishments
	3.2 Fallow-weed control greenhouse trial.	3.2 This trial related to 4.2.1
3.2. Identify stem borer control method.	3.2.1 Maize stem borer on-station monitoring.	3.2.1 Infestation of borers occurs two weeks earlier in the transition than in the forest zone.
	3.2.2 Maize stem borer trial.	3.2.2 Seed treatment appears to be more important in the transition than in the forest zone.
Operation 4: Technologies for sustainable soil improvement.		
4.1. Evaluate benefits from leguminous hedgerows.	4.1.1 Cassia/food crop trial (on-station).	4.1.1 Based on one year data, no biomass difference shown for 3 tree/crop arrangements at 2 sites.
	4.1.2 Establishment of Calliandria hedgrows.	4.1.2 Ten sites at Mkolfep well established; ready for cropping during first season, 1992.
4.2. Identify species and practices for legume fallow.	4.2.1 Sesbania and Mimosa fallow management on-station trial.	4.2.1 Sesbania and Mimosa significantly improved soil fertility and were effective in controlling weeds.
	4.2.2 Maize-Cajanus cajan fallow test.	4.2.2 Thirteen sites well established ; ready for cropping during first season, 1992.
	4.2.3 Groundnut-Crotalaria-Desmodium fallow test.	4.2.3 Twelve sites planted. Establishement is erratic; further efforts needed to improve establishement in 1992.
4.3. Finalize maize fertilization recommendation.	4.3. Regional maize fertilization tests for urea and 20-10-10.	4.3. Materials distributed to 204 participant farmers/tests. Received completed farmer assessment surveys from only 38 farmers (19%).

Objectives	Activities	Accomplishments
Operation 5: Dissemination and extension liaison.		
5.1. Validate on-farm test results.	5.1. Regional testing program.	5.1. Materials distributed to 212 farmers/tests. Maize variety test implemented by 157 (74%) farmers. Completed farmer assessement surveys received from only 54 farmers (34%).
5.2. Communicate TLU findings to extension agents and farmers.	5.2. Farmer field days.	5.2. No field days, but five draft practical advice leaflets prepared for maize and cassava.
5.3. Provide materials to farmers.	5.3.1 Regional adoption plots.	5.3.1 Materials distributed to 765 farmers. Test implemented by 643 (84%); farmer assessment survey received from 385 (60%).
	5.3.2 Pilot village-level maize seed multiplication.	5.3.2 Fields harvested. Farmers sold seeds to neighboring farmers through extension agents.
5.4. Train MINAGRI personnel.	5.4. Training sessions for regional tests and demonstrations.	5.4. Training related to TLU regional program provided to over 50 MINAGRI delegates.

6.4.4 RESEARCH FINDINGS

6.4.4.1 Village -Level Resource Management Survey (Operation 1)

The objective of this survey is to identify and analyse the availability, distribution and management of village-level resources, and conditions that affect acceptability and adoption of technology.

Materials and Methods

Thirty one villages were selected for the survey from the South and Center provinces using stratified random sampling method. The survey was to be conducted using a single (one time), group-interview technique.

Results

The survey (interview) is in progress covering 31 villages in both the South and Center provinces, and is expected to be completed in Mid-February, 1992.

6.4.4. Cassava Planting Methods Trials (Operation 2)

This is the third and final year of this trial designed to evaluate flat and angle planting (recommended by IRA breeders) of cassava cuttings for local and improved varieties.

Materials and Methods

During 1990, local and 8034 (improved) were each planted flat versus angle (approx. 45) with two cuttings per hill. Spacing for cassava hills was 1 x 1 meter. Participating farmers planted local groundnut varieties at their desired population. Farmers, who chose to plant maize, sowed it at low populations (approx. 6000 plants/ha).

Results

Cassava tuber yields were obtained from six farms in Meyos and Nkol-Fep villages in the forest zone. As observed in past years, planting method had no significant effect on cassava tuber yield (Table 1). The effect of variety on tuber yield was significant. Improved variety (8034) produced 2616 ± 1204 kg/ha more than the local.

Table 1: Effect of Cassava variety and planting method on Cassava tuber yields (kg/ha), 1990

Variety	Flat 2 cuttings	Angle 2 cuttings	Mean
Local	6854	8468	7661
8034	11186	9367	10277
Mean	9020	8918	
SE (±)	602		851

The results of this and past trials have consistently shown the superiority of improved cassava varieties (8034 and 8061) over the local. These findings lend support for further testing of the improved varieties in the regional program covering Centre and South Provinces involving farmers and MINAGRI extension services.

6.4.4. Hybrid/Open-pollinated Maize Variety Trials (Operation 2)

This is a collaborative trial with the Lowland Breeding Program. It appears that medium and large scale farmers are now widely cultivating maize as a cash crop. Market-oriented farmers may be willing to purchase hybrid maize seed if hybrids sufficiently out-

yield available open-pollinated varieties. This trial, therefore, was to determine yield and economic benefits of hybrid maize relative to the best available open-pollinated varieties at different fertility levels.

Materials and Methods

During the first and second seasons, hybrids (8321-18 and 8644-31) and open-pollinated (CMS 8501 and CMS 8704) maize varieties were planted at 0,0, 60,0, 120,0, and 120 N,90 P fertilization levels at Minkomeyos and Ntui. The treatments were arranged in split-plot design with fertilizer levels as the main plots and maize varieties as the sub-plots. Each treatment was replicated four times.

Results

There were no significant differences between the hybrid and open-pollinated varieties during the first and second seasons at both locations (Table 2). The effect of fertilizer was only significant in the second season at both locations. Fertilized plots produced 931 ± 263 and 759 ± 268 kg/ha more at Minkomeyos and Ntui, respectively. Interactions between maize variety and fertilizer were not significant in either season at both locations.

Table 2: Comparison of hybrid and open-pollinated maize varieties at Minkomeyos and Ntui,1991

	Minkomeyos		Ntui	
Maize variety	Mean grain yield (kg/ha)	Partial benefit (FCFA/ha)	Mean grain yield (kg/ha)	Partial Benefit (FCFA/ha)
First Season				
CMS 8501	4045	269804	2686	167879
CMS 8704	4179	279891	2868	181548
8321-18	4236	279166	3063	236691
8644-31	4788	370566	2893	178441
SE (±)	304		182	
Second Season				
CMS 8501	1883	107635	2220	132948
CMS 8704	2424	148229	2469	151660
8321-18	2458	145779	2276	132185
SE (±)	181		136	

Hybrid varieties gave 9 and 19 % financial benefit relative to open-pollinated varieties at Minkomeyos and Ntui, respectively, during the first season (Table 2). In the second season, hybrid varieties had 17847 FCFA/ha financial advantage over open-pollinated at Minkomeyos, while open-pollinated had 10119 FCFA/ha advantage over hybrid varieties at Ntui. During the second season, there was a mid-season drought at Ntui, and open-pollinated are more tolerant to drought than are hybrid varieties. Further testing is necessary to confirm the above results.

6.4.4. Sole Maize Weed Control Trials (Operation 3)

A series of on-farm weed control studies were initiated in 1989 to develop weed control recommendations for sole maize production. In second season of 1989, alachlor GD significantly outperformed either hand weeding or a lower rate of alachlor GD plus hand weeding. In 1990 trials, alachlor GD was not significantly different from the other two treatments. Although the combined results over three seasons showed that the recommended rate of alachlor GD consistently increased yields and profits relative to the farmer's standard practice, additional testing was required to finalize the formulation of weed control recommendation for small-scale sole maize production.

Materials and Methods

During the first season of 1991, alachlor GD at 2.75 kg/ha, alachlor GD at 1.5 kg/ha plus hand weeding at six weeks after planting and hand weeding at four weeks after planting, were arranged in an RCB design on 12 farms with one replication per farm. Hand weeding was carried out by the participating farmers. The trial was conducted in the forest zone.

Results

The results summarized in Table 3 were obtained from five farms. Due to poor supervision by the village contact person, seven farmers weeded all three treatments at four weeks after planting. Therefore, the data from these farms were not included in the analysis. The mean yield from the hand weeded plots was higher (though not significant) than those from alachlor treated plots, even though the hand weeded plots had an average of 96 ± 38 more weeds per m^2 than the alachlor treatments (Table 3). Higher yield from hand weeded treatment probably stemmed from the fact that it had an average of 2182 ± 982 more plants per ha at harvest than the average of the alachlor treatments

Table 3: Evaluation of weed control methods in sole maize, first season, 1991

Weed control method	Weed density 4 WAP[a] (no/m^2)wt;	Weed dry 4 WAP(g/m^2)	Maize yield (kg/ha)
Alachlor GD[c] (2.75 kg/ha)	52	67	5113
Alachlor GD (1.5 kg/ha) + hand weeding at 6 WAP	88	83	5192
Hand weeding at 4 WAP	166	72	5735
SE (±)	31	9	648

a) WAP - Weeks after planting
b) Fresh ears without husk
c) Alachlor GD - a formulated mixture of alachlor plus atrazine

It appears that further testing is unnecessary. Based on the previous results, farmer's standard practice for sole maize is as good as alachlor treated fields on a small scale. Farmers facing a labor constraint can obtain comparable or higher yields and profits while substantially reducing labor requirements by using alachlor as a preemergence herbicide.

6.4.4. Maize borer control trials (Operation 3)

Preliminary field monitoring carried out in 1990 to provide information on maize borer incidence, severity and losses in farmers fields (forest and transition zones) showed that severity at harvest was significantly lower in fields where some form of chemical control or marshall seed treatment was used. Therefore, this trial was conducted to determine the appropriate rates and combinations of carbofuran insecticide and marshall seed treatment.

Materials and Methods

Carbofuran insecticide with or without marshall seed treatment were factorially arranged in an RCB design on 23 farms with one replication per farm, 12 in Nkolfep (forest zone) and 11 in Kiki (transition zone), during the second season of 1991. The treatments included untreated seeds, no carbofuran; treated seeds, no carbofuran; untreated seeds, 0.1 carbofuran(10%) g/plant; treated seeds, 0.1 carbofuran g/plant; untreated seeds, 0.2 carbofuran g/plant; and treated seeds, 0.2 carbofuran g/plant. The insecticide treatment,superimposed on farmers' fields,were applied as granular shakes at 5 and 6 weeks after planting in Kiki and Nkol-Fep, respectively.

Results

Forest zone

Seed treatment had some positive effect on all the variables listed in Table 4, but only mid season plant densities or stand establishement was significant. Plots with treated seeds had 3600 + 900 plants/ha more than those with untreated seeds. It should be cautioned that the farmers planted at their own densities and this observation could have been due to differences in the initial densities. There were slight yield and financial benefits from seed treatment (7% increase) (table 4).

Table 4: Evaluation of marshall maize seed treatment on sole borer control second season 1991.

	Forest zone				Transition zone			
Treatment	BINCD[a] %	PROLIF[b] ear/plant	HYLD[c] kg/ha	Partial benefits FCFA/ha	BINCD %	PROLIF ear/plant	GYLD[d] kg/ha	Partial[e] benefits FCFA/ha
No seed treatment	28.1	0.81	4315	582,525	10.1	0.67	1452	182,952
Seed treatment	29.8	0.84	4635	625,325	151	0.76	1857	233,982
S.E (±)	1.6	0.03	287	-	1.1	0.03	109	-

a) BINCD : Borer incidence, rated just before carbofuran application;
b) PROLF : Prolificacy
c) HYLD : Marketable fresh ears without husk
d) GYLD : Grain at 15% moisture
e) Valuation : Fresh ears without husk (135/kg); grain (126 frs/kg) marshall cost - 100 FCFA per 50g, does 1kg to 100kg of maize seeds. Valuation is done without taking into consideration the labour cost in mixing the marshall to the seed.

Transition zone

Although borer incidence was significantly higher in the seed treatment plots (5 ± 1%), prolificacy and grain yield were highly significant on seed treatment. Complementary on-station monitoring showed that borer infestations began as early as 2 weeks after planting in the tranistion zone, probably explaining why marshall was beneficial. This means that protection against maize borer is more important at the seedling establishment stage. Prolificacy was increased by 0.09 ± 0.04 ears/plant and grain yield by 405 ± 154kg/ha in the treated plots, resulting in financial benefit of 51,030 FCFA/ha (28%).

Table 5: Evaluation of two carbofuran rates on sole maize borer control second season 1991.

	Forest zone			Transition zone		
Treatment	PROLIF ear/plant	HYLD kg/ha	Partial benefits FCFA/ha	PROLIF ear/plant	GYLD[d] kg/ha	Partial benefits FCFA/ha
No carbofuran	0.71	2789	376,515	0.72	1725	217350
Carbofuran (0.1g/plant)	0.83	5138	684,380	0.69	1533	193158
Carbofuran (0.2g/plant)	0.92	5500	724,060	0.72	1704	214704
S.E (±)	0.03	351	-	0.03	134	-

d) See table 4 for definitions.

Carbofuran treatment had highly significant effect on prolificacy and marketable fresh ears, but no difference between the insecticide levels in the forest zone (Table 5). The treated plots had on average 0.16 ± 0.04 more ears/plant and 2530 ± 430 kg/ha (47.6%) more marketable fresh ears. This resulted in a financial advantage of 327,705 CFA/ha (87%) over no carbofuran. Note that the partial benefits were evaluated without taking into consideration the labor cost of applying the insecticide.

There was no significant effect of carbofuran levels (0.1 g/plant or 0.2g/plant) on prolificacy or grain yield in the transition zone, and no significant interaction between seed treatment and insecticide in both zones (Table 5).

6.4.4. Maize stemborer on-station monitoring (Operation 3)

The aim of this study was to monitor natural infestations in 3 agroecologies so as to gather baseline information relative to the onset of borer infestation, evolution, severity, etc. in relation to crop growth in each location. This information is useful in designing appropriate control practices for the pests.

This trial was implemented in 4 locations, Ntui (transition), Minkomeyos (semi-humid), Nkoemvone (humid) and Mbalmayo (humid) during the first and second season of 1991. Twenty-five plants per variety were randomly sampled at 2, 5, 9 and 14 weeks after planting and various incidence and severity ratings were made. Detailed description of the methods used are given in the entomology section of this report.

Results

Infestations began two weeks after planting in Ntui with about 40% incidence on CMS 8704; then dropped around 9 weeks after planting when incidence was 52%. Unfortunately, Ntui results for the 4th sampling date (14 weeks after planting) were lost due to the IRA strike. However, results from first season monitoring showed that at harvest Mussidia nigrivenella, a species that bores only ears and not stems, was the most important (above 80%) in Ntui at harvest.

On the other hand, infestations began later at Mbalmyo (3 weeks after planting) but increased sharply reaching a peak of 92% on both varieties, 9 weeks after planting (see lowland entomology section). Borer severity rated by the total number of larvae and pupae per 25 plants at each sampling date, the mean number of larvae and pupae per plant and percent stem tunnelling at 9 and 14 weeks after planting were highest in Mbalmayo relative to Ntui and Minkomeyos.

In Minkomeyos at 2 and 4 weeks after planting, infestations were not very important. Peak incidence (54%) occurred at 9 weeks after planting CMS 8704 dropping to 88% 14 weeks after planting.

As noted earlier, borer infestation commenced as early as two weeks after planting in the transition zone and protection against maize borers is more appropriate at the seedling establishment phase. Again, the first season observation that ear borers are more abundant in this zone at harvest is of prime importance because maize is consumed as dry grain. M. nigrivenella, the most abundant in Ntui at harvest completes its life cycle in storage but should not be considered as a storage pest as such because the adults live and start the cycle in the field. Any reasonable approach to control should be based in the field and not in storage.

6.4.4. Improved Fallow Management for Soil Fertility Maintenance and Weed (Operation 4)

Short duration natural fallow is not efficient in restoring soil fertility. Thus, the cultivation of leguminous planted fallows in alternate seasons is expected to improve the nutrient status of soils by adding biologically fixed N and recycling nutrients from the subsoil to the surface. Effective vegetation cover over soil during the fallow period will also suppress the growth of weeds and reduce erosion. This trial had Sesbania sesban and Mimosa invisa var. inermis as the planted fallow species to add biologically fixed N and suppress the growth of weeds in maize.

Materials and Methods

The trial was established at Minkomeyos and Ntui. Natural, Sesbania and Mimosa fallows established in March 1990 with a maize crop, were either burnt (natural fallow only), mulched or manually incorporated into the soil in March 1991. Maize (Ndock 8701), Sesbania and Mimosa were again planted in the residue during the first season. Maize and Sesbania were planted simultaneously, while Mimosa was relay planted four weeks after

planting maize. During the second season, the fallow species were allowed to grow, and groundnut was planted after maize harvest. The trial was conducted in a split-plot design with four replications. The main plot consisted of fallow x residue management and sub-plots were zero and 60 kg N/ha.

Results

The results show that there was a significant effect of the legume treatments on maize grain yield. The mean grain yields for the fallow treatments are given in Table 6. At Minkomeyos, the grain yield from the Mimosa plot was significantly better than Sesbania or groundnut, resulting from the highest nitrogen (76 ± 7 kg/ha) from Mimosa top growth and the lowest weed biomass (635 ± 196 kg/ha). At Ntui, Mimosa and Sesbania were significantly different from groundnut, but in this case, were not significantly different from each other (Table 7). Furthermore, groundnut outperformed the others at Ntui, but gave the lowest yield at Minkomeyos.

Table 6: Response of maize grain yield to fallow and residue management at Minkomeyos and Ntui, 1991.

Fallow treatment	Added Nitrogen	Weed Biomass, 3WAP[a]	Mean grain Yield
	kg/ha (SE)		
Minkomeyos			
Natural fallow	55 (±6)	1256 (±160)	4936 (±380)
Mimosa	76 (±7)	635 (±196)	5772 (±465)
Sesbania	72 (±7)	949 (±196)	4142 (±465)
Groundnut	5 (±10)	1523 (±278)	3199 (±658)
Ntui			
Natural fallow	25 (±18)	1225 (±94)	2987 (±184)
Mimosa	16 (±22)	803 (±115)	2849 (±225)
Sesbania	22 (±22)	966 (±115)	2783 (±225)
Groundnut	6 (±32)	486 (±163)	3980 (±319)

a) WAP - weeks after planting, and major weeds were Chromoleana odorata, Ageratum conyzoides and Digitaria horizontalis

In addition there was a highly significant difference between incorporation and mulching at Ntui (Table 7) but not at Minkomeyos. This difference was significant between Natural fallow and Mimosa or Sesbania. The average improvement of incorporation over mulching at Ntui were: NF:101 Mimosa:1293 Sesbania:926 (SE: ±450) kg/ha.

Table 7: Comparison of incorporation versus mulching at Ntui, 1991

	Maize grain yield		Weed Biomass, 3 WAP	
Fallow Treatment	Incorp.	Mulch	Incorp.	Mulch
Natural fallow	2767	2666	779	1526
Mimosa	3495	2202	334	1273
Sesbania	3246	2320	606	1325
Mean	3169	2396	573	1375
SE (±)	184		94	

At both locations the effect of fertilizer was highly significant, fertilized plots yielding 1771 ± 243 and 1866 ± 133 kg/ha more at Minkomeyos and Ntui, respectively. Also at Ntui, there was a significant interaction between fertilizer and type of legume on grain yield - Mimosa versus Sesbania. The average effect of fertilizer on Mimosa plots was 2467 ± 267 kg/ha, while for Sesbania it was only 1527 ± 267 kg/ha.

6.4.4. Maize-Legume Intercrop Trial (on-farm) (Operation 4)

Pigeon pea (Cajanus cajan) has shown rapid growth in preliminary trials on station and on farmers' fields. In order to be acceptable to forest and transition zone farmers, it should be established with little or no additional labor and should not substantially compete with food crops. It is therefore necessary to assess it under the circumstances in which it will be used.

One promising strategy for sole maize cropping patterns is to intercrop annual leguminous species during the first season, only slightly reducing the maize population, in order to establish an improved fallow during second season. The objective of this trial then is to assess the effects of second season Cajanus cajan fallow on soil fertility and following sole maize.

Materials and Methods

Maize and pigeon pea were simultaneously planted in ten farms each in Nkol-Fep and Kiki during the first season. Each farm had two plots; sole maize, and maize and pigeon pea established in alternate rows. Similar to the trial on the station, natural and pigeon pea fallows should be allowed to grow during the second season.

Results

Maize and pigeon pea were well established in seven and six farms in Nkol-Fep and Kiki, respectively. Nearly all the seven farmers cleared the natural fallow plots and cut the pigeon pea, and planted crops in both plots during the second season. Farmers managed the cutting and mulching operations without TLU input. Cut plants had good regrowth and the plots will be ready for cropping during the first season in 1992.

6.4.4. Legume Relay in Groundnut-Cassava mixture(on-farm) (Operation 4)

Simultaneous establishment of leguminous species is not feasible for groundnut-based mixtures, due to inter-species competition. At the same time, farmers do not appear to be willing to clear and prepare land during second season in order to plant leguminous fallow species. It is possible to establish second season legume fallows by relay planting leguminous species into first season cassava fields immediately following groundnut harvest.

Materials and Methods

Crotalaria and Desmodium were planted into cassava fields immediately following groundnut harvest during the first season. The trial was carried out at 12 farms in Nkol-Fep in the forest zone. Each farm had three treatments consisting of Natural, Crotalaria and Desmodium fallows. The treatments were superimposed on farmers' own fields and participating farmers were responsible for maintaining the fields.

Results

Adequate establishment appears to be the primary constraint on the success of this strategy. Establishment was erratic for both species. This was partly due to poor emergence probably caused by poor seed lots. Further efforts are necessary to find out causes of poor emergence. In the meantime, other options involving species other than Crotalaria and Desmodium should be explored.

6.4.4. Cassia Mulch/Green Manure Trial (Operation 4)

Cassia spectablis is one of the naturalized trees that grow well and produces a lot of biomass in the forest/transition zones. Its foliage contains about 3 % N on dry weight basis. By planting this in certain arrangements with food crops, it is possible to produce N-rich organic matter for soil fertility improvement. The advantage of this method is that the food crops can be grown simultaneously with the production of tree biomass on the same field; about 20 % of the area is occupied by the trees and the rest by crops.

Materials and Methods

Cassia was planted in three different arrangements; single hedge row at 5m intervals, block planting, and double row hedge at 10m intervals at Minkomeyos and Ntui in 1989. The first cutting of trees was carried out in March 1990 and the treatments were imposed then. The design was split-plot with four replications. The main plots were tree arrangement and the sub-plots consisted of maize/natural fallow, maize/Desmodium fallow, and maize/soybean.

Results

This is the first year of results. As expected, Cassia was well established at both sites. Tree arrangement did not significantly influence biomass production. Consequently, tree arrangement did not significantly impact on maize grain yield at either Minkomeyos or Ntui (Table 8). Cumulative effect of Cassia mulch plus fallow/soybean residue also did not have

any significant effect on grain yield at both sites. The impact of mulch/green manure on soil properties, and thereby on crop yields, is usually expected within two to three years of mulch application.

Table 8: Effect of cassia mulch on maize grain yield, Minkomeyos and Ntui, 1991

Fallow treatment	Single Row	Block Planting	Double Row	Mean
Minkomeyos				
Natural fallow	3020	1955	3667	2880
Desmodium fallow	3112	2317	3108	2846
Soybean rotation	2800	2501	2939	2747
Mean	2978	2258	3238	
SE (±)		214		125
Ntui				
Natural fallow	1350	2098	1382	1610
Desmodium fallow	1446	1999	1912	1786
Soybean rotation	1466	2438	2005	1970
Mean	1421	2178	1766	
SE (±)		330		112

6.4.4. Legiuminous Hedgerow Trial (on-farm) (Operation 4)

Increased and sustained crop production relies heavily on soil fertility. The continuous use of inorganic fertilizers in the tropics leads to soil acidification, aluminum toxicity, etc, which renders the soil unproductive with time.

Leguminous hedgerows are potential biological technologies for improving and sustaining soil fertility. Some leguminous species are able to fix atmospheric nitrogen, increase biomass production and act as breaks to erosion processes. Appropriate arrangement of the food crop and tree components over space and time is necessary to maximize benefits and minimize adverse effects of agroforestry associations.

Leucaena and Calliandria hedgerows were planted in farmers' fields to evaluate the effects of the hedgerows on soil fertility and crop yield with and without supplementation by second season leguminous fallows.

Materials and Methods

Calliandria seedlings were planted at four meter intervals in ten farms each in Nkol-Fep and Kiki during the first season. In each farm, TLU demonstrated the planting of the seedlings to the farmer, who then completed the planting. In Kiki, border hedges, instead of alleys, were established in some fields where the areas were too small for alleys. To increase the short benefit, farmers were encouraged to plant food crops during the establishment phase of the hedgerows. Farmers were also asked to plant the same food crops in similar plot areas without hedgerows as a control. During the first season of 1992, when

the hedgerows would have been fully established, TLU would compare two cropping patterns with and without hedgerows: (a) first season cultivation followed by second season natural fallow (b) first season cultivation followed by second season improved fallow.

Results

The establishment of Calliandria seedlings was excellent in all the ten fields in Nkol-Fep, and alleys are ready for cropping during the first season in 1992, along with Leucaena fields established in 1990. In Kiki, soils are poorer and establishment has been erratic and poor. Plots will not be ready for cropping by first season in 1992, fertilizer application to the hedges has been necessary in order to hasten good establishment. The good establishment obtained in Nkolfep has kindled farmers' interest in the system and their expectations are high.

6.4.4. Regional Maize Fertilization Test (Operation 4)

From its previous tests, the TLU has proven that a fertilization rate of 60 kg. N/ha gives significant grain yield and economic benefits. The TLU needs to validate this rate of application at the regional level (South and Center provinces) before recommending as a profitable and farmer-accepted maize fertilization rate. Similar results have also been found with the use of composite fertilizer, 20-10-10, in past TLU on-farm trials. Because it is readily available, this fertilizer is widely used by farmers. The objective of this test was to evaluate the yield and economic benefits of the recommended rate of fertilizers (urea and 20-10-10) relative to no fertilizer use.

Materials and Methods

Two hundred and four farmers, 4 from each of the 51 agricultural delegations, were identified to participate in the test. The test was designed with only one replication per site with two treatments: with and without fertilizer. Farmers were asked to implement the test on any maize variety they prefer to grow.

Results

Since data were collected from only 38 farmers for both fertilizer tests (19% of farmers who received seed), no statistical analysis could be done to make any valid inferences on the findings of the test. Many of the MINAGRI extension agents lacked the motivation and interest to follow up the tests. Some had difficulty in filling the Farmer Assessment Surveys. A limited number of visits by TLU technicians were not enough to follow up the conduct of the test and the management of the Farmer Assessment Survey.

As this was the first experience with MINAGRI extension agents, the TLU has started to make some modifications on how to improve collaborative work with the existing extension system in the two provinces not covered by MINAGRI's Extension and Training project (PNVFA) funded by the World Bank.

6.4.4. Maize Variety Adoption Study (Operation 5)

During the past two years, two maize varieties (CMS 8704, CMS 8501) have been tested and proven to perform well in both TLU's research villages and at the regional level where the varieties were distributed to several hundred farmers in different environments (53 villages). This test had to be repeated to confirm past results. The objectives of this study were: a) to confirm the performance of these varieties across the Center and South provinces through regional adoption test, and b) to obtain farmers'appraisal on the agronomic and taste characterstics of the varieties.

Materials and Methods

The total number of participating farmers selected for this study was 765 (fifteen from each of the 51 villages). Farmers were given 200 grams of seed from one of the two IRA varieties. Two-thirds of the farmers took CMS 8704 and the remaining third took CMS 8501. Assessment survey questionnaires were also distributed to extension agents of those villages participating in the adoption test. Included in the questionnaires are questions concerning production systems practiced by farmers (slash & burn, plowing, intercropping, weeding, planting dates), an appraisal on agronomic performance (resistance to disease, ear size, number of ears per plant), and an assessment on taste (roasted, boiled, sanga, foufou).

Results

Of the 765 participating farmers who obtained IRA variety seeds, 643 (84%) implemented the adoption test. Completed questionnaires with reliable data were received from 60 percent of the farmers who implemented the test.

Results of the farmer assessment survey showed that the overall performance of IRA maize varieties have been rated better than local varieties (Table 9). Concerning the agronomic performance, farmers in the Forest-Savana and Semi-Humid zones preferred IRA varieties. Seventy-eight percent of farmers from the Forest-Savana region rated IRA varieties higher than local varieties for the ear size. The same was true for 68 percent of Semi-Humid Forest zone. In contrast, only 30 percent preferred IRA varieties in the Humid Forest zone.

As to taste characterstics, the preference for IRA varieties was much better than local varieties across the three TLU zones. More than two-thirds of the farmers chose the IRA variety, whether the maize was roasted, boiled or eaten as Sanga.

Table 9: Farmers Assessment of IRA Vs. Local Maize Varietics

	IRA Variety Better			Local Variety Better		
	For-Sav	S.H For	H. For	For-Sav	S.H For	H.For
	(Percentages of Respondents *)					
Prod. Performance						
Disease Resistance	65	51	43	8	17	28
# of ears/plant	60	57	30	4	13	25
Ear Size	78	68	30	6	16	58
Taste Assessment						
Roasted Cobs	77	78	87	1	4	3
Boiled Cobs	66	83	72	5	6	15
Sanga	72	77	60	0	1	16
Foufou **	58	57	66	12	5	8

*. Remaining % of farmers indicated no difference between IRA & Local var.
**. Only small % of farmers (17%) indicated consuming maize in this form

Information on household characterstics and cropping practices was also obtained from the maize adoption survey. Table 10 shows farmers' cropping practices by household categories (sex, age, educational level). Female farmers do more intercropping, and slash & burn than their male counterparts. The survey also showed that male farmers generally plant late compared to female farmers (51 vs. 39 percent). Farmers with a higher level of formal education (post primary) tend to do less slash & burn and intercropping than farmers with no or some primary education. There is no significance difference in cropping practices between young and old farmers.

Table 10: Cropping System by Household Category

	SEX		AGE		EDUCATIONAL LEVEL	
	Male	Female	<=45	>45	Primary	>Primary
	(Percentages within same category)					
Slash & burn (69)*	62 a	74	68	72	73 a	60
Plough (57)	52	61	59	52	57	59
Late planter (44)	51 a	39	43	46	45	41
Intercropping(66)	53 a	76	66	66	69 b	60
> one Weeding(33)	400 a	29	33	33	33	34

*. Percentage of participants practising such method.
a. Differences by Category sig. at <0.05 level.
b. Differences by Category sig. at <0.10 level.

6.4.4. Regional Maize Variety Test (Operation 5)

The Lowland Maize Breeder has identified a) CMS 8806 as the best early maturing yellow variety and b) NDOCK 8701 as one of the best late white varieties tested in several environments (NCRE Terminal Report 1986-90). These varieties need to be validated in farmers fields under farmers' conditions before releasing them to the TLUs large scale adoption tests. The objective of this test is to validate the performance (production & taste) of the varieties and assess farmers' appraisal in relation to local varieties.

Materials and Methods

Two hundred and twelve farmers from 51 agricultural delegations of the South and Center provinces were identified to participate in the variety test. These farmers were given 200 grams of seed for one of the two IRA maize varieties. Fifty five percent of the farmers took CMS 8806, while the remaining 45 percent took NDOCK 8701. Farmers were asked to plant the IRA variety and a local variety in adjacent plots using whatever cropping practices they like as long as the practice was the same in both plots.

Results

Of the 212 farmers who received seed, 157 (74 percent) implemented the varietal test. Because of inadequate supervision and logistics problems, partially completed survey questionnaires were received from only 54 farmers (34%).

Although no sound statistical analyses can be done on grain yield and other production traits because of insufficient and unreliable data, some useful information was obtained from the Farmer Assessment Survey. Survey results show that IRA varieties were rated better than local varieties in production qualities, such as germination, ear size and number of ears per stalk (Table 11). CMS 8701 performed relatively better than CMS 8806 for its germination and ear size qualities (67% vs. 50%, and 58% vs. 46%, respectively).

Table 11: Production performance of IRA and local varieties (according to farmers evaluation)

Variety	Germination	Res. lodging	# Ears	Ear Size
	(percentages of respondents)			
CMS 8806				
IRA V. better	50	36	54	46
Local better	29	21	36	36
No difference	21	43	10	18
CMS 8701				
IRA V. better	67	48	52	58
Local better	12	12	28	13
No difference	21	40	20	29

Table 12: Farmers Evaluation on Taste Preferences: IRA Vs. Local

Variety	Roasted cob	Boiled cob	Sanga	Foufou
	(percentages of respondents*)			
CMS 8806				
IRA Var. better	92	63	55	17
Local Var. better	4	4	5	0
No difference	0	19	32	6
CMS 8701				
IRA Var. better	70	61	47	18
Local Var. better	9	9	5	0
No difference	17	13	3	37

*. Remaining %ages are those who indicated not consuming maize in that form

IRA varieties were rated highly for their taste when eaten roasted or boiled (Table 12). Only a small percentage of farmers (about 20%) eat Foufou made from maize.

Overall, the 1991 varietal test results conform with previous TLU tests which showed that IRA varieties were rated better than local varieties in both production/agronomic performance and taste preferences. The TLU will conduct one more confirmation trials (1992) before releasing those varieties for large scale, regional adoption tests.

6.4.4. Pilot village-level maize seed multiplication (Operation 5)

A seed retention survey designed by the TLU and implemented by a Dschang University student in 1990 revealed that adopted IRA maize varieties were diffused mainly through market sales in Nkolfep and provision to other farmers in Kiki. This finding, coupled with persistent demand by farmers for the largely adopted improved maize variety CMS 8704, prompted the TLU to design and implement an on-farm CMS 8704 multiplication activity.

Materials and Methods

TLU, the lowland maize breeding unit, MINAGRI extension agent and three farmers collaboratively planted maize seed multiplication fields in Nkometou village in the forest zone during the first and second seasons. Each field was 500m^2. The lowland maize breeder provided foundation seeds, while the TLU furnished other inputs (fertilizer, insecticide, quality control,etc). Planting carried out by farmers was delayed by at least two weeks over neighboring established fields in order to avoid contamination from them, thereby maintaining seed purity. Initially, it was agreed that TLU, participating farmers and extension agent would equally share the yield or the proceeds from sale according to the task involved the whole process, that is, land donor; land preparation; field management; drying and shelling; and inputs and expert advice (TLU and Breeding Unit).

Results

During the first season a total of 322 kg of dried seed was harvested from 1500m^2. Due to drying, handling and storage problems as a consequence of little sunshine, high humidity, insect and mould attack, the extension agent could not sell the seeds as initially planned. The maize breeder bought all the seeds at 200 frs/kg, 4/5th of the proceeds was given to the farmers, while 1/5th was retained by the TLU as a token to cover the cost of inputs. During the second season, the activity was repeated with the same collaborators. It is hoped that as there is a longer drying season thereafter, less handling and storage problems will be encountered. The seeds have been harvested and are being taken care of by the farmers and extension agent, while the TLU is playing an advisory role. Sales and other useful information will be given in subsequent reports.

6.4.5 Other Activities

Dr. Moussie attended the RCMP Research Review Meeting at IITA, Ibadan, from August 27-29, 1991. He served as a lead discussant for the paper entitled "**Adaptability and adoptability of alternative cropping systems**". He also participated in the 2-day Annual Program Meeting of the National Extension and Training Project (PNVFA) held in Yaounde from July 30-31, 1991. He participated as a member of the **Orientation & Reflection Commission.**

Dr. Moussie represented TLU Nkolbisson during the Women in Development (WID) Workshop organized by UNDP in Yaounde. He and Dr. Tonye made a presentation of IRA/TLU's experience on agroforestry research in the region.

Dr. Poku attended and presented a paper at the American Society of agronomy annual meetings in Denver, U.S.A., October 27-November 1, 1991.

Nkolbisson TLU put out demonstration plots at Ebolowa in preparation for the postponed Agro-Pastoral show.

The primary TLU coordination activity during the year was the organization of the **Annual TLU Workshop**. The Workshop was held in Yaounde from December 10-12, 1991. A preliminary report on the specific recommendations of the Workshop was submitted to the Director of IRA through NCRE's Chief of Party. Dr. Moussie made a series of site visits to the TLUs to get familiar with research activities, and review research progress and methodology of each TLU. Mission reports were prepared and circulated. In addition, discussions and meetings were held with Peace Corps/Cameroon concerning the orientation and integration of volunteers in TLU activities, particularly in agroforestry work.

Five national counterparts left the TLU for long-term training. Four left for the U.S., and one went to Belgium. Two counterparts also moved to other research units: Ms. Ndemah moved to Entomology, while Mr. Ndoumbe joined Biometry unit. In return, the TLU received two new personnel: Mr. Fouaguegue, an agricultural economist, and Mr. Kaho, agronomist.

The TLU received two university students for orientation to TLU activities. Mr. Bruce Whitehouse, an exchange student from a U.S. University, spent five weeks with the TLU conducting an informal survey on farmers' attitudes toward the collaboration mode initiated by TLU Nikolbisson. He prepared a report on his study. Mr. Roudolphe Boum, a Cameroonian student in Germany spent a week with the TLU getting an overall orientation of TLU activity in the region.

5.4.6 VISITORS

1. Quincy Benbow, NCRE Project Officer--overview of field activities
2. Robert Schilling, groundnut researcher from Montpellier
3. Lori Pearson, Peace Corps Ag. Director, Peace Corp-TLU collaboration
4. Professor Lal & colleagues, Ohio State University
5. Professor David Watson's group, consultant for pest management project
6. Joseph Taber, consultant on natural resources, University of Arizona
7. Drs. Akobundo, Mulongoy, & Atta Krah, from IITA, Ibadan
8. New Peace Corps volunteers assigned to Ekona & Bambui agroforestry units
9. Women in Dev't (WID) workshop participants from Africa UNDP offices
10. Bruce Whitehouse, U.S. University exchange student, trainee
11. Rudolphe Boum, a Cameroonian student in Germany, trainee
12. Several farmers from the region looking for advice

7. ECONOMIC ANALYSIS UNIT

7.1 INTRODUCTION

The function of the Economic Analysis Unit (EAU) is to provide IRA with a capacity for economic analysis relative to its research and development mandate. Project support is being given for establishment and operation of an Economic Analysis Unit in recognition of the challenges being faced by IRA as a result of Cameroon's on-going economic crisis and structural adjustment.

The goal of the Economic Analysis Unit is to increase IRA's research efficiency, productivity and impact. The top priority of the unit is carrying out economic studies for institute-level priority setting and programming and for measuring research benefits. To complement its own studies, the EAU assists IRA researchers through research collaboration, advisory services and training.

7.2 SUMMARY OF PROGRAM ACTIVITIES

The Economic Analysis Unit (EAU) was created in September 1991, following transfer of the TLU Coordinator to the position of Senior Economic Analyst in mid-July (and home leave in July-August). As reported in the semi-annual report, some progress was made on the EAU work plan during the first half of the year due to a designed overlap with the Nkolbisson TLU for 1991. The main activities during the first half of the year were:

a. benefit/cost study on Nkolbisson TLU research
b. collaboration with Michigan State University on a rates-of-return study for sorghum, cowpea and maize research in northern Cameroon
c. collaboration with IITA RCMD for design of Resource Management Survey

During the final four months of 1991, main activities--in order of time allocation--were as follows:

a. Data analysis. Several multivariate statistical methods were evaluated, and empirical analyses were completed on research targeting and technology diffusion patterns.
b. Conference papers. Three papers were written and presented:
   1) D. Baker and J. Ayuk-Takem. "Agricultural Research Policy in Cameroon: Implications of Economic Crisis and Structural Adjustment." Paper presented at International Symposium on Agricultural Policy Analysis in Sub-Saharan Africa, University Center at Dschang, Cameroon, 3-6 November, 1991.
   2) D. Baker. "Puzzle Resolution in Southern Cameroon: Building FSR-Development Linkages." Paper presented at 11th AFSRE Symposium, Michigan State University, East Lansing, 5-10 October, 1991.
   3) M. Besong, D. Baker and B. Bakia. "Maize Variety Retention by Mini-Kit Users in South West Cameroon." Paper presented at 11th AFSRE Symposium, Michigan State University, East Lansing, 5-10 October, 1991.
c. Resource Management Survey. The questionnaire was pre-tested and finalized. Area sample frames were developed and samples were selected for the southern half of the country. Contacts were made for the Center-South survey.

d. IRA Research Division. Participated in several meetings related to proposal for second phase of World Bank research project, development of research budgeting guidelines, and design of IRA Priority Setting Study.

e. TLU carry-over. Wrote handing-over notes for new TLU Coordinator. Participated in TLU Workshop and gave presentation on "TLU approaches and accomplishments." Helped finalize NCRE-Peace Corp agroforestry collaboration. Prepared case study material for "Women in Development" training course site visit to NkolFep.

f. Project. Prepared NCRE input for USAID program performance indicators. Gave recommendations on work plan and reporting formats for 1991-1994 phase.

7.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Analyze economics of IRA research.		
1.1. Evaluate policy and other factors affecting technology demand.	1.1.1 Analytical paper on policy-research linkages.	1.1.1 Paper completed and presented.
	1.1.2 Village level resource management survey.	1.1.2 Questionnaire finalized, sample villages selected, and interview schedule set.
1.2. Determine research priorities.	1.2. IRA priority setting study.	1.2 Worked on design; implementation to take place in 1992.
1.3. Appraise research benefits.	1.3. Pilot benefit/cost analysis of returns to IRA research.	1.3 Finished for Nkolbisson TLU. Secured external support for second study in northern Cameroon.
Operation 2: Institute economic analysis support services.		
2.1. Improve economic budgeting and analysis skills of IRA researchers.	2.1.1 Develop guidelines for research budgeting.	2.1.1 Guidelines were developed by Mr. Kaiser, former Head of Research Services. Pre-testing to take place in 1992.
	2.1.2 Organize training workshops.	2.1.2 Postponed until 1992.
2.2. Help IRA researchers plan and implement economic studies.	2.2. Design and analytical support for two or more studies.	2.2. Support given for a maize retention study (Ekona) and a smallstock practices survey (Nkolbisson).

7.4 RESEARCH FINDINGS

7.4.1 Benefit-cost Analysis of TLU Recommendations

IRA needs information on research rates-of-return for priority setting, and for justifying research funding. Unfortunately, lack of data make it impossible to calculate post-adoption rates-of-return to research in Cameroon. A practical alternative is to estimate expected returns based on adoption rate projections for specific recommendations. Nkolbisson TLU research between 1986 and 1990 represents a good case for this type of study since several recommendations are essentially finalized and data on research costs and per hectare benefits can be accurately determined.

7.4.1. Methods

The benefit/cost model used was developed by Rudolf Contant and Anthony Bottomley at ISNAR. In the Contant-Bottomley model, costs of producing, delivering and adopting a technology are compared to changes in the value of production. Model implementation requires data on only eight critical factors: annual research costs, duration of research, probability of research success, cost of adoption per hectare, benefits of adoption per hectare, adoption period, ceiling on adoption, and life of the innovation. The last three factors are used to determine the number of hectares on which adoption has taken place, using an assumed logistic adoption pattern. Once hectares have been projected, total benefits and costs of adoption are calculated, and then research costs are netted out--giving complete cost and benefit streams from the beginning of research until end of the useful life of the resulting innovation. Probability of research success (PRS) is introduced multiplicatively to determine expected adoption benefits and costs since there is a 1-PRS chance than research will fail and no adoption will take place.

The main modification introduced in this study was use of actual research expenditures rather than projected average annual research costs. In partitioning costs for multi-technology trials, the general principle followed was to include costs for all tests which contributed either genetic material or information used in recommendation development. For variety development, proportional costs were charged on the basis of all varieties retained at each stage of testing. Full trial costs were charged for all variety specific recrossing and selection activities and all on-farm tests carried out for purposes of developing the recommendations.

Data on adoption benefits and costs were derived from on-farm, farmer managed trial data rather than estimated. Thus, uncertainty with respect to model results stems mainly from projected adoption rates. Parametric sensitivity analysis was carried out on factors related to adoption (varying base estimates by as much as plus/minus 90 percent).

7.4.1. Results and Discussion

Research costs, model parameters and return results are summarized in Table 1. As can be seen, projected internal rates of returns (IRR) for research needed to develop the TLU's recommendations were quite high. Moreover, variation of uncertain model parameters (ie. all except research costs) by plus or minus 50 percent did not reduce the average IRR for any TLU activities below 45 percent--showing that the findings are robust to substantial divergence in expected adoption patterns.

Table 1: B/C data and results for maize variety, cassava variety, and maize fertilization research

	CMS 8704	CMS 8501	CMS 8806	Cassava	Urea	20-10-10
On-station research:						
Years	8	9	6	8	2	2
Total cost ('000) [a]	14,243	18,734	10,548	24,340	2,000	2,000
On-farm research:						
Years	3	4	3	3	3	3
Total cost ('000)	3,371	3,382	2,954	6,807	6,046	6,286
Adoption:						
Cost/hectare	270	270	270	313	18,449	20,706
Benefit/hectare	183,500	127,000	81,000	156,315	381,875	172,750
Ceiling (ha)	14,000	8,000	4,000	13,750	8,000	4,000
Period (yrs)	8	8	8	12	15	15
Life of innovation (yrs)	14	10	12	15	20	20
Probability of success (%)	90	85	80	58	70	65
Internal rate of return (%)	114	81	76	78	108	66

[a] Costs shown are actual expenditures. In the B/C model, costs are actualized/discounted to a common base of 1986--as are all other data. Only 31 percent of cassava breeding cost is attributed to TLU recommendation development; this is based on expected area of adoption relative to other Provinces.

Research on CMS 8704 and maize-urea fertilization have the highest expected returns, due to high per hectare benefits and anticipation that there will be widespread acceptance of these recommendations. Expected returns to the cassava variety research are reasonable despite low projected adoption rates, since the varieties were "borrowed" from another research area. An important findings from the fertilizer analyses is the high return to 20-10-10. Even though 20-10-10 is less profitable than is urea, there can be financial benefits to farmers and society from second best technological options.

The most difficult problem encountered in this study was inadequate records on research costs. IRA research cost accounting procedures need to be improved if benefit/cost analysis is to be extended to other research units.

7.4.2 RESEARCH ZONE DISCRIMINATION

The primary objective of this research was to distinguish Nkolbisson TLU research villages and zones on the basis of developmental circumstances rather than crop patterns, thereby illustrating to IRA researchers the importance of developmental dynamics and constraints for research priority setting and targeting. A second objective was to develop and illustrate a statistical approach for assessing research village representativeness.

7.4.2. Methods

A household characteristics survey was administered in 1989 to 112 households scattered across the Center Province. In 1990, the same survey was administered to a random sample of 48 households in Nkol Fep and Kiki--the Nkolbisson TLU's research villages in the developed forest zone and forest-savanna transition zone (see NCRE annual

reports for 1989 and 1990). Using these data, 14 indices were formed for measuring various developmental features and constraints. Differences in indices between the TLU's research villages were tested using ANOVA. Ten indices were significantly different between villages ($P<0.05$). Descriptions of these indices and their hypothesized relationships to the TLU's primary research zones are given in Table 2.

Table 2: Indices and hypothesized association with TLU research zones

Variable	Description of index	Forest	Transition
LABOR	ranking of labor access constraint	-	+
LAND	ranking of land access constraint	+	-
PEST	ranking of pest problems	-	+
WEED	ranking of weed problems	+	-
SELL	number of crops sold	+	-
BUY	number of crops purchased	-	+
CASH	cash access aside from food crops	+	-
KNOW	knowledge of where get inputs	+	-
FIELDS	number of fields	+	-
INTENSE	land management intensity	-	+

The above ten indices were used to estimate a linear discriminant model for the research villages. The same variables were then used to estimate a three group discriminant model using the regional data. The third group encompassed villages from the less-developed and populated forest zone to the south Yaounde (where there is not a TLU research village). An augmented regional model--with livestock ownership (LVSTCK) added and cash income sources disaggregated into trade (TRADE), coffee or cocoa (COFCOC), and wages (WAGE)--was then estimated. Village representativeness was assessed by comparing coefficients for both data sets using the augmented regional model.

7.4.1. Results and Discussion

At both the village and regional level, the linear discriminant models developed were effective in allocating households to the correct developmental zone. The village model correctly classified all 48 households used in the analysis. When the village model was used for regional classification, 69 percent of households were correctly classified (for a completely different sample and shifting from two to three zones). The augmented regional model correctly allocated just under 80 percent of households.

Households in the three group, regional model were distinguished by measurements along two dimensions (factors). The first, and most important, factor corresponds to a development/market integration continuum. This is indicated by the standardized variables having high coefficients for this factor (Table 3).[1] In classification, the first factor clearly distinguished the forest zone north of Yaounde from the other two, less-developed zones.

[1] COFCOC (involvement in coffee or cocoa production) and INTENSE (index for land intensity) are negatively related to the developmental continuum due to features which are specific to southern Cameroon, ie. cocoa production is relatively more important in less developed areas and hilling/bunding is mainly done on savanna fields in the transition zone.

Table 4: **Augmented discriminant model coefficients for regional and village samples**

Variable	Regional Model Factor 1	Regional Model Factor 2	Village Model
LAND	.329	.302	.310
SELL	.281	.175	.041
BUY	.355	.237	-.518
FIELDS	.483	.064	.223
PESTS	.610	-.123	-.453
TRADE	.394	-.172	.408
WAGE	.182	-.274	.018
LABOR	.082	-.183	.064
LVSTCK	-.128	.251	.042
INTENSE	-.244	.508	-1.150
WEEDS	-.279	.679	.243
COFCOC	-.444	.245	.207

The second factor is heavily weighted by variables which distinguish the transition zone from the less-developed forest zone. For interpretation, variables with negative signs for Factor 2 in Table 4 represent distinguishing features of the less-developed forest zone, as compared to positive coefficients which relate to the transition zone.

With respect to the first objective, the analysis confirms there are three distinct research zones, distinguishable by developmental patterns and constraints. For priority setting, the most rapid acceptance and diffusion of varieties undoubtedly will take place in the densely-populated, land-constrained, market-integrated forest zone north of Yaounde. In the face of reduced research and extension resources, that zone should be the top priority. Secondary priority should be given to the transition zone. Farmers are intensively involved in crop production and need assistance. However, diffusion is likely to be slower since households do relatively little crop buying and selling, and do not have as much cash to invest in new technologies. The forest zone to the south of Yaounde should be lowest priority since there is as yet less pressure to change.

With respect to the issue of research village representativeness, the results are mixed. The TLU villages are representative of their research zones with respect to severity of land and labor constraints, involvement in trading, relative number of fields, number of crops sold, and intensity of land use (based on direction and size of coefficients relative to coefficients for factor 1 in regional model). However, the research villages are atypical of their zones with respect to crops purchased (higher in Kiki than in Nkol Fep but usually higher in developed forest zone villages than in transition zone villages), involvement in cocoa and coffee production (atypically low in Kiki), ranking of weed problems (higher in Nkol Fep than in Kiki but generally higher in transition zone villages), and severity of pest problems (high in Kiki but generally more severe in forest zone villages). For three of these indices, however, Kiki is typical of transition zone villages relative to southern forest villages (based on interpretation of factor 2).

To the extent the TLU does have a problem with representativeness, it could well be due to a lack of forest areas fields in Kiki--with consequent low productivity (due to reliance on savanna fields) and lower than normal involvement in cocoa production.

7.4.3 LOGIT ANALYSIS OF IRA MAIZE SALES

In 1990, a maize retention survey was carried out in Nkolbisson TLU's research villages. Analytical efforts to identify significant relationships between participant characteristics and variety retention or diffusion proved largely unsuccessful, as was reported in the 1990 NCRE annual report. However, strong univariate associations were identified between participant characteristics and subsequent sale of IRA maize.

The purpose of this research was to develop and assess a statistical approach for analyzing binary choice models when there is substantial multicollinearity among independent variables. Such a technique is necessary for IRA/NCRE adoption, retention and impact research since household and personal characteristics normally used as independent variables tend to be highly correlated.

7.4.1. Methods

The analysis is based on all farmers in the TLU's three research villages who participated in maize variety tests during first season 1989 and who were recontacted during the 1990 retention survey. In total, 53 test participants were interviewed in both years. Due to design of the retention survey, the only characteristics included in the analysis were: sex and age of participant, whether participant had any education, size of family, and whether the family had any income from cocoa sales, wage employment or buying-selling. The personal characteristics included are typical of those generally used in adoption studies. The income variables were hypothesized to be negatively related to IRA maize sales since they are substitute activities for generating household cash requirements.

A logit model was used, in which the probability of selling IRA maize was specified as having logistic distribution. This is a standard technique for analyzing binary choice decisions. Due to high correlation among the independent variables, only one of eight estimated parameters was significant at a $P < 0.10$ level with maximum likelihood estimation of the logit model. Therefore, a principal components regression approach was used. Prior to estimating the logit model, principal components analysis was used to construct two orthogonal indexes representing participant characteristics. Parameters estimated following principal components transformation are biased when small components are removed in order to reduce dimensionality, but the bias is small when individual variables are not highly correlated with excluded components and efficiency for parameter estimation can be greatly increased.

7.4.1. Results and Discussion [2]

The first two principal components accounted for 58 percent of total variation among the independent variables, and all excluded components had eigen values less than one. All variables were standardized prior to model estimation, so component coefficients would not be affected by unit and could be compared to assess relative importance. The largest coefficients in the first component were for sex and cocoa revenue. This component distinguishes male participants having cocoa income from female participants in families not having cocoa income. The second component distinguished older participants without education and from large families, from young participants who had some education.

When the component (factor) scores were used in the logit model, both parameters were significant at $P<0.10$. A log likelihood test of the null hypothesis that all parameters were zero was rejected at $P<0.05$. However, a relatively small proportion of choice behavior was explained by the model (McFadden's $R^2=.15$). Consequently, only modest success was achieved in correction classification, 64 percent for non-sellers, 68 percent for sellers, and 66 percent overall.

Effects of the original variables on the probability of selling IRA maize are shown in Table 4. Parameters and their standard deviations were derived from parameters of the principal components logit model using component coefficients as weights. Probability effects for binary independent variables are based on differences in probabilities for the two values with all other variables equal to zero (their mean). Probability effects for age and size are based on the derivative of the logistic function.

Not having someone in the family with wage employment and not having any education had the strongest effect on the probability of selling IRA maize. Otherwise, changes in various participant characteristics, including sex and access to other revenue sources, affected the probability of selling IRA maize by five to eight percent.

Table 4. Maximum likelihood estimates of principal components logit model

Variable	Values Before Standardization	Parameter Estimate	Standard Error	Change in Probability
Sex	male=1; female=2	-.300	.159 *	.083
Age	actual	-.218	.159	.054
Family size	actual	-.256	.134 *	.064
Employment	yes=1; no=2	.941	.253 **	.239
Cocoa sales	yes=1; no=2	-.202	.132	.055
buy-sell	yes=1; no=2	.172	.091 *	.048
education	none=1; some=2	-.438	.174 **	.105

One asterisk indicates significance at P<0.10; two at level P<0.05.

[2] This section is extracted, with minor modification, from the "Puzzle Resolution" paper cited above.

The general conclusion of the analysis is that certain participant characteristics do have small, significant effects on the probability that farmers will sell IRA maize, resulting in variety diffusion. In practical terms, the additional stimulus to diffusion would be minor, even if the above effects were confirmed using a separate population. Moreover, targeting on the basis of personal characteristics could result in an impact-equity trade-off, at least with respect to early adopter benefits. Participant characteristics targeting may not necessary for variety introduction, but the adoption literature shows that population characteristics--particularly revenue access--do affect adoption rates for capital using and/or risky technologies and therefore should be useful in targeting for developmental impact as the TLU turns to technologies aside from IRA varieties.

7.5 VISITORS

a. M. Kawalec (FAO), M. Corbett (World Bank consultant), and D. Mitchnik (World Bank)--World Bank research project
b. Karen Dvorak (RCMD, IITA)--resource management survey
c. M. Teuscher (GTZ/IRZ--priority setting study and World Bank project

8. SOIL AGRO/FORESTRY

8.1 INTRODUCTION

The soil/Agroforestry Unit based in the North-West Province is designed to address soil fertility constraints and assure crop productivity on a sustained basis. Our approach is largely based on the use of agroforestry and improved fallow techniques. Main research themes include:

1) Site Characterization
2) Species Evaluation and
3) Soil Fertility Management.

8.2 SUMMARY OF PROGRAM ACTIVITIES

During the 1991 cropping season, the following activities were undertaken by the Agroforestry/Soils Unit of I.R.A. Bambui Station:

(A)

1) Microlevel characterization of soils at six research sites in the Northwestern highlands.
2) Screening of herbaceous legumes as sources of nitrogen for crop production.
3) Contribution of Tephrosia and Crotalaria to nitrogen fertilization in a maize-based cropping system.
4) Evaluation of selected woody leguminous species for soil fertility management in agroforestry systems.

(B) In order to avoid unnecessary transportation problems, nurseries were set up in the following areas to locally produce hedgerow species seedlings for use in alley cropping experiments in the respective trial sites: Bambui station, Babungo, Befang, T.D.C.-Mbiyeh, and R.T.C. Mfonta.

(C) Collaborative work has continued to exist between our unit and:

a- Other research units at the station,
b- The adaptive research units of MIDENO and PAFSAT, particularly for the nurseries establishment, and for experience exchange within the framework of the SCICC meetings.
c- The Soils Laboratory at the Dschang University Center for our plant and soil samples analyses.

8.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Site Characterization		
1.1. Provide understanding of soil properties.	1.1 Soil analyses of six locations.	1.1. Soils have been grouped into two classes based on chemical properties and elevation.
Operation 2: Evaluation of herbaceous species		
2.1. Identify suitable herbaceous sp for major agroecological zones.	2.1 Field trials at 3 locations involving 20 species.	2.1 Cover crops have been identified for the major agroecological zones.
2.2. Determine N contribution of herbaceous legumes.	2.2 Field trials at 5 locations with Tephrosia and Crotalaria.	2.2. First season trials are completed with promising results. Trials continue to examine residual effects.
Operation 3: Evaluation of species for Agroforestry		
3.1. Assess woody species as soil improver.	3.1 Preliminary trial at low altitude zone in Befang.	3.1. Calliandra and Leucaena show the highest potential in the area.
3.2. Tephrosia for soil conservation.	3.2 Preliminary trial at high altitude zone at Mbiyeh.	3.2. On-going; Guatemala grass is established but Tephrosia is slow to establish.

8.4 RESEARCH FINDINGS

8.4.1 Microlevel Characterization of Soils at Six Research Sites in the North-West Highlands.

Site characterization has been recognized as an essential component of technology development, and is recommended by international research groups such as TSBF (Tropical Soils Biology and Fertility) Program and IBSRAM (International Board for Soil Research and Management). In short, site characterization helps target research on specific issues and facilitates transfer of proven interventions to comparable agroclimatic environments. Apart from the soil classification work carried out by FAO for the Western Cameroon Highlands, soil samples have been collected by several workers in the region serviced by the NCRE and analyzed for different purposes. This study is intended to provide an understanding of the chemical properties of soils from six IRA experimental sites so as to determine how they could be managed for sustainable cropping with respect to use of agroforestry, improved fallow, or chemical amendments.

At each site, twelve bulk samples (each comprising 30 core samples) were collected from a hectare of land in plots that had been under fallow for five years or more. In addition, twelve profile pits (two per site) were dug to examine subsoil fertility and physical obstructions that might affect nutrient cycling by agroforestry species. Results of the latter study will appear in subsequent reports.

A summary of the major characteristics of the soils encountered is shown in (Table 1). The soils are grouped into two main classes based on selected properties. Evidently, the class A soils are higher in basic cations (Ca, Mg, and K) and lower in iron and aluminum oxides than the class B soils. Class A soils are found at relatively lower altitudes and fix less P compared to the class B soils which are located at higher elevations (Fig 1, and Table 2). Basing phosphorus fertilization on the standard phosphorous requirements (SPR) (0.2 ppm of solution P) criterion, high amounts of P will be needed for optimum crop yields. But, this will be too expensive for farmers given the high costs of P fertilizers (146000 CFA/ton), vis-a-vis the current farm gate prices of agricultural commodities. However, experiences here and elsewhere have shown that crops and crop varieties differ in their P requirements. For instance, cassava and some maize varieties thrive and produce reasonable yields at levels of solution P much lower than the "standard" 0.2 ppm. Thus, (Table 2) contains calculated P fertilizer requirements for attaining lower levels of solution P (0.005 and 0.1 ppm) which may be adequate for low P-demanding crops.

Organic carbon correlates positively and strongly with effective cation exchange capacity (ECEC) in most soils of the tropics. In the present study, this relationship is valid for only the class A soils with relatively low DCBFe_2O_3 and DCBAl_2O_3 values. The above relationship did not hold for the class B soils where higher values of Fe_2O_3 and Al_2O_3, and low pH values were recorded (Fig. 2 and Table 1). The above supports the established fact that organic carbon plays an insignificant role with respect to ECEC improvement in acid soils which are high in iron and aluminum oxides.

From a management standpoint, our results indicate that low pH and high P fixation are among the most important limiting factors to crop production in the highland soils. Phosphorus plays a key role in symbiotic nitrogen fixation, therefore, for a biological N fixing system such as Agroforestry to be successful, adequate P fertilization must be ensured. As well, liming may be needed to raise the soil pH to levels where Al and Fe toxicities will not be detrimental to crop growth. Experiments will be initiated in the up-coming seasons to assess yield potentials of major crops using the SPRs at some selected sites.

Field observation of this year's trials revealed widespread N deficiency on maize despite high correlation between organic carbon and total N ($r=0.81^{**}$). The problem was more pronounced in the highlands where soil organic matter (SOM) is relatively high, (> 7.0 %.). This therefore, brings into question the quality of the soil organic matter. Recent advances in soils research have indicated inhibition of N mineralization and N release from SOM for materials with polyphenols to N ratio greater than 0.5. The contribution of Agroforestry under the prevailing circumstance is to attempt to improve the quality of existing SOM by introducing legume species which produce biomass high in N and presumably low in polyphenols.

8.4.2 Screening of Herbaceous Legumes as Sources of Nitrogen for Crop Production.

Twenty green manure crops were screened for their potential use as N sources for crop production in a field experiment at three locations, viz: Befang (600m), Mfonta (1300m), and Mbiyeh (2100m).

Six species thrived at Befang. Biomass produced at four months after planting is shown in Table 3. Dolichos, Mucuna and Canavalia survived at Mfonta, and only Lupin thrived at Mbiyeh. The trial at Befang was continued to determine the N contribution of the legumes to a second season maize crop, planted after incorporation of the legume species. The trial was laid out in a split-plot design, with green manure species as main plots, and fertilizer N (0, 30, 60, 90, and 120 kg/ha) as subplots. There were four replications. Maize growth at 12 weeks after incorporation of legumes showed that Canavalia was superior to the others (Fig. 3). Only the three top legumes were reported. Maize yield was higher in the Canavalia plots, but this was not significantly different from that of the other plots (Fig. 3). The study will continue to examine the residual effect of the incorporated biomass. This is necessary because the legumes possess different concentrations of N, lignin or polyphenol and may therefore decompose and release nutrients at different rates.

8.4.3 Contribution of Tephrosia and Crotalaria to Nitrogen Fertilization in a Maize-based Cropping System.

Previous agronomic work in the North-West Province has demonstrated the potential of Tephrosia and Crotalaria as improved fallow species. The purpose of this study was to determine nitrogen contribution of the above two species, relay-cropped with maize-bean association. The treatment design was factorial with species at three levels (No species, Tephrosia, Crotalaria), and nitrogen (N) at five levels (0, 30, 60, 90, 120 kg/ha). There were four replications at each of five sites namely, Mfonta, Babungo, Mbiyeh, Befang, and Upper farm. The above protocol was modified in the course of the season due to poor performance of the species and/or the beans at some locations. The experiment was carried out for two seasons, March-September and September-December.

Growth and biomass of fallow species:

Mfonta: Crotalaria survived and produced more biomass when planted during the March-September cropping season than thereafter (Table 4). Adequate soil moisture as a result of regular rainfall might have contributed to its good performance during the season. Tephrosia on the other hand, germinated but died two weeks later. It was replanted four times with seeds from different sources, but without any success. The exact cause of failure of Tephrosia is still unknown but foliar and root diseases are the most probable suspects. Tephrosia was replaced with Crotalaria in August when maize was nearing maturity.

Babungo: Tephrosia and Crotalaria performed well at this site. Biomass yields of both legumes were suppressed by intercropped maize at high fertilizer rates (Fig. 4). Biomass yields of legumes were not adversely affected by intercropped beans during the second season. Therefore, it may be practicable to relay crop the fallow species with beans in order to generate sufficient biomass to enrich the soil for the subsequent crops. Legume species tolerant to shading might be another alternative for association with maize in the first season.

Mbiyeh: Tephrosia outperformed Crotalaria. The growth of the latter was so poor that it was replaced with Sesbania which seems more promising.

Befang: The two species grew well during the first season but biomass yields of both were inversely related to N fertilizer as was observed at Babungo (Fig. 4). Second season Crotalaria did extremely well unlike Tephrosia which was a complete failure. Again, the real cause of failure of Tephrosia during the September-December cropping season remains unknown.

Upper-Farm: The growth of the two species were too slow to be of any value as green manure crops in this environment. However, Lupin pea that has shown promise at similar elevations (Mbiyeh, and Dzeng) will be considered for future experiments.

Crop yields:

The test crops, maize and beans responded to N at all the sites except Upper-farm which was dropped (Table 5). Association of maize and beans with the fallow species resulted in reduced crop yields when no fertilizer N was applied, indicating competition between crops and the fallow species for a limited soil N (Fig. 6). A starter N fertilizer or manure may be necessary to offset this initial yield drop. Growth of second season bean at Babungo after incorporation of green manure is shown in Fig. 5. Bean growth at early flowering and podding stages was significantly better in the Tephrosia plots than in the Crotalaria and control plots. However, at harvest, we noticed a decline in bean yield above 30 kg N/ha (Table 6). This may imply an overdose of N beyond 30 kg/ha, which might have stimulated vegetative growth of the crop at the expense of the reproductive parts. Until this trend is confirmed during the subsequent seasons, it may be spurious to conclude that the excess N came from the incorporated organic materials undergoing decomposition. Benefits of green manuring are usually longterm, therefore, the above results should be viewed as preliminary.

8.4.4 Evaluation of Selected Woody Leguminous Species for Soil Fertility Management in Agroforestry Systems.

Two studies were carried out. The objective of the first was to compare the growth and biomass yields of five species under intensive pruning management. The trial was sited at Befang. The following species were tested: *Leucaena leucocephala, Calliandra calothyrsus, Erythrina sp., Albizia sp., and Mellitia sp.* Cutback was done at 7 months after planting (MAP) and every three months thereafter. Data on growth and biomass production are presented in Fig. 8. Leucaena and Calliandra grew more rapidly, followed by Albizia, Mellitia and Erythrina. Biomass production was highest for Calliandra, followed by Leucaena, Erythrina, Albizia, and Mellitia. Wood weight at 7 MAP was highest for Calliandra, followed by Leucaena and Albizia. The study continues to determine the behavior of the species under intensive pruning management.

The second study was conducted at Mfonta and Babungo to find out whether or not initial growth and biomass production of Leucaena could be stimulated with poultry manure. Leucaena was chosen because seeds are readily available from local sources. Treatments were six rates of poultry manure (0, 0.5, 1.0, 1.5, 2.0, and 2.5 kg/plant) with four replications at each location in a RCB design. Leucaena was planted in July and was cut back in

November. This was followed by pruning at four month intervals. Preliminary results shown in Fig. 9 demonstrate beneficial effects of starter manure on Leucaena establishment in our zone of operation. Plants that received manure had vigorous early growth, produced more biomass, and were more able to withstand moisture stress during the dry season than plants which received no manure. The study continues to compare the economic advantages of using starter manure as opposed to not using it. There is a general misconception that agroforestry species thrive on any soil regardless of its fertility status. Our findings so far dispel that notion.

Table 1: Some characteristics of surface soil (0-20 cm) in the North-West Highlands.

CHARACTERISTICS:				
Class A	-Ndop Plain	(babungo)		
	-Menchum Valley	(Befang)	-Bambui plain	(Mfonta)
Class B	-Bui Highlands	(Mbiyeh, Dzeng)		
	-Bambui Highlands	(UpperFarm)		
Elevation	600 - 1200 m	1300 - 2100 m		
Temperature (AIR)	16.9 - 29.5^{0}c	12.3 - 21.3^{0}c		
Exchangeable cations:				
Ca (meq/100g)	7.65 - 9.54	0.75 - 2.25		
Mg (meq/100g)	2.62 - 3.74	0.48 - 0.70		
K (meq/100g)	1.33 - 1.44	0.39 - 0.58		
PH (Water):				
	5.65 - 6.01	4.75 - 5.34		
Oxides:				
Fe_2O_3 (%)	5.11 - 5.49	7.01 - 10.34		
Al_2O_3 (%)	1.61 - 2.85	5.21 - 6.29		
Other properties:				
Org. C (%)	2.43 - 4.55	7.35 - 8.03		
Clay (%)	15.89 - 18.92	20.60 - 28.15		
Sand (%)	19.66 - 34.26	3.56 - 6.93		
S.P.R. (mg/kg)	211 - 486	1106 - 3090		

Table 2: Fitting of Data into Sorption Equations and Estimated P Requirements Based on Selected Levels of solution P.

Sites	P sorption equations		P requirements (mg P/L)			
	Freundlich	Langmuir	0.005	0.1	0.2	Scale*
	r		mg/kg			
1-Mfonta	0.961	0.989	296	865	1106	very high
2-Upper Farm	0.991	0.953	1595	2735	3090	very high
3-Babungo	0.951	0.991	59	166	211	medium
4-Befang	0.939	0.939	238	425	486	medium
5-Mbiyeh	0.954	0.730	600	1352	1629	very high
6-Dzeng	0.985	0.934	1000	1548	1706	very high

*P sorption scale based on SPR (0.2 mg P/L), Juo and Fox (1977).

Table 3: Dry biomass (kg/m^2) of green manure crops, Befang.

Species	Biomass	S_d
Cajanus cajan	1.75	0.68
Crotalaria juncea	3.3	0.72
Sesame	1.7	0.36
Dolichos lablab	1.6	0.8
Local crotalaria	2.35	1.4
Carnavalia	2.85	1.04
Grass fallow	3.55	2.7

Table 4: Dry biomass yield (kg/ha) of cover crops at different sites.

Sites	Season 1			Season 2		
	Tephr	Crotal	SE.	Tephr	Crotal	SE
B'go	7432	4917	456	4085	4623	352
Befang	1675	2413	367	-	4983	-
Mfonta	no germ ination	6020	-	-	3430	289
Mbiyeh	N.D.	N.D.	-	N.D.	N.D.	

Table 5: Maize and Bean responses to N at different test sites.

N	1		2		3		4	
	Maize	Bean	Maize	Bean	Maize	Bean	Maize	Bean
0	3803	-	1852	905	752	104	2100	407
30	4174	-	2794	1021	486	163	2497	419
60	4551	-	3572	1038	846	157	2774	557
90	4965	-	4334	1067	1304	201	2968	652
120	5636	-	4994	1201	1125	144	3200	570
SE	211	-	151	63	201	18	176	70

1=Befang 2=Babungo 3=Mfonta 4=Mbiyeh

Table 6: Bean yield (kg/ha) as affected by incorporation of green manure, and applied mineral N fertilizer. Babungo.

	Green Manure Species		
N levels (kg/ha)	Control	Tephrosia	Crotalaria
0	1070	1187	1057
15	1223	1173	1187
30	1167	1183	1113
45	1093	1153	1153
60	1120	1113	960

S.E.=86.6

8.5 VISITORS

Dr. Atayi NCRE Chief of Party
Mr. Gibson USAID

Dr. Spencer Director RCMP

Mr. Benbow NCRE Project Officer (USAID)
Dr. Gillman Officer in Charge IITA Humid Forest Station

9. GRAIN LEGUME MAROUA

9.1 INTRODUCTION

The main objective of the Grain Legume section is to develop and identify grain legume varieties, mainly cowpea, adapted to the northern ecologies of Cameroon. It has been shown that cowpea is one of the most important grain legumes which constitute the main source of cheap protein for most Cameroonians.

In the early stages of cowpea research in Cameroon, emphasis has been put on pest management. During Phase I of the Bean Cowpea CRSP Project (1982-1987), yield losses have been established, effective storage methods have been recommended (drums, double bagging, funigants, etc). During the second phase of the Bean Cowpea CRSP Project since 1987, the activities have been narrowed down to developing varieties resistant to storage insect pests (Callosobruchus maculatus and bruchidius atrolineatus).

The new approach of the Grain Legume section of the NCRE Project is to develop a broad base system of research on cowpea and minor activity on other legumes. In addition to breeding for storage pests resistance, emphasis will be put on other aspects such as:

- Field insect pests (aphids, thrips, maruca)
- Parasitic weeds (Striga)
- Seed quality : - Color (white or brown)
- Size (Large seed)
- Testa (rough)
- Diseases (virus)
- Dual purpose (grain + fodder)

9.2 SUMMARY OF PROGRAM ACTIVITIES

The activities of the 1991 season could be summarized as follows:

Participation in various business meetings
- IITA/GLIP planning meeting in Kano Nigeria
- CRSP/NCRE (Grain legume) program meeting in Yaounde
- NCRE/staff meetings in Yaounde

Preparation of work plans and reports
- 1991 Work Plan
- Four year work plan
- Semi-Annual Report

Installation of the 1991 Trials
- Preparation of land, seed and planting materials
- Planting of the trials

Management of the trials and data collection

- Hand crossing of selected cowpea varieties
- Weed control and insecticide application
- Collection of data on plant characteristics and parasites (insects, diseases, striga).
- Recording of post harvest data (grain yield, pod yield, fodder yield, seed characteristics)

Analysis of data and report writing

9.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1. Identify high yielding and adapted varieties		
1. Identification of good performing varieties to be tested in different locations.	1.1 On-station testing of different varieties.	1.1 Varietal trials have been conducted and good performing lines identified.
	1.2 On-farm testing of best performing varieties previously identified.	1.2 4 Varieties have been tested and the more adapted ones identified.
Operation 2. Evaluation of germplasm and varietal development		
2. Obtain gene reservoirs from which lines could be selected for varietal trial or for hybridization and create new varieties.	2.1 Field testing of introduced and locally collected material.	2.1 124 entries have been tested, described and single plant selection has been performed.
	2.2 Crossing of selected lines among themselves.	2.2 17 different F1 crosses have been obtained.
Operation 3. Evaluation of Genotype under different insecticide treatment		
3. Preliminary identification of good performing genotypes under low insecticide application.	3. Field testing of genotypes in combination with chemical treatment.	3. 46 lines have been compared at 3 levels of insecticide treatments and good performing lines identified.
Operation 4. Evaluation of Cowpea lines for their resistance to Striga.		
4. Identification of source of resistance to Striga under natural infestation.	4. Field testing of selected lines on Striga sick plot.	4. 2 sets of 20 lines have been tested on a naturally infested striga plot.

Objectives	Activities	Accomplishments
Operation 5. Seed production and varietal purification.		
5. Purify varieties and make seed available for testing on farmer's field.	5.1. On-station seed multiplication of selected varieties.	5.2 Varieties have been multiplied and single plant selection has been done.

9.4 RESEARCH FINDINGS

9.4.1. Identification of high yielding and adapted varieties

The objective of these trials is to identify high performing varieties with good agronomic characteristics. Most of the trials originated from the IITA Kano sub-station.

9.4.1. Cowpea Advanced Varietal Trial 1.

This trial is composed of 20 varieties. It was planted on July 8th 1991 at Guiring, Maroua in four replications. The planting was done in plots of 4 rows, 4 meters long and spacings of 75 cm between rows and 20 cm within rows. The two central rows were harvested for statistical analysis. Data on pod yield, grain yield, fodder yield, days to 50% flowering, days to maturity, virus score, number of plants at harvest were recorded and presented in Table 1.

The analysis of variance showed a significant difference (1%) between varieties for all trails, except for the number of plants at harvest. As far as grain yield is concerned the line IT86D-719 ranked first (Duncan's multiple Range Test) and yielded 2605 kg/ha followed by IT87-829-5 (1975 kg/ha); IT87D-941-1 (1766 kg/ha), IT89KD-374 (1650 kg/ha) and IT89KD-457 (1645 kg/ha).

Fodder yield is also an important trait in Northern Cameroon because fodder is used for animal feed during the dry season. The line IT89KD-792 ranked first and yielded 3530 kg/ha of dry fodder followed by IT86D-719 (3025 kg/ha), IT89KD-793 (2930 kg/ha), IT90K-348 (2837 kg/ha), and IT89KD-381 (2775 kg/ha).

For virus infestation which was based on visual score (1-5):1 meaning virus free and 5 completely damaged) the line IT86D-719 was the most resistant. The lines IT89KD-457; IT88D-856-10; IT89KD-363-1 showed good level of resistance, whereas lines IT89KD-374, IT89KD-793, and IT89KD-381 were among the most susceptible ones. Although the line IT89KD-374 was badly affected by virus it is still among the best grain yielders as shown earlier. The general tendency is that the resistant lines are the best grain yielders.

It could be noticed that IT86D-719 ranked first for grain yield and second for fodder yield. Based on visual observation during the growing season some lines have good potential for both grain and fodder such as IT86-D-719, IT87D-829-5, IT87D-298 and IT89KD-363-1.

9.4.1. Cowpea Advanced Varietal Trial 2.

This trial consists of 20 entries and was planted on July 8th 1991 at Guiring, Maroua in 3 replications. Planting was done in the same way as in trial 1; plots of 4 rows, 4 m long and spacing of 75 cm between rows and 20 cm within rows. The two central rows were harvested for analysis. Data on pod yield, grain yield, days to 50% flowering, days to maturity, virus score, number of plants at harvest, fodder yield were recorded (see Table 2).

The analysis of variance showed highly significant differences (1% level) between varieties for pod yield and grain yield and a significant difference (5% level) for virus score. There was no significant difference for other traits.

For grain yield, the entry IT87D-590-5 ranked first and yielded 2417 kg/ha, followed by entries TVX 3226 (2378 kg/ha), IT89KD-785 (2345 kg/ha), IT 88DM-363 (2338 Kg/ha) and IT89KD-374 (2261 kg/ha). For pod yield, the same entries as above were the best yielders. Entry IT89KD-784 ranked first and yielded 3133 kg/ha. For virus infestation most of the entries showed a good level of resistance. On a scale of 1 to 5 the highest score was 3 which stands for moderately resistant. The entry IT89KD-785 was the most resistant followed by IT88DM-368, TVX3236 and IT86D-715. Entries IT88D-867-11 and IT89KD-391 were the most infested in this trial with a score of 3.0.

Although there was no significant difference between entries for fodder yield it should be noted that entry IT88D-867-11 gave the highest yield 3228 kg/ha and IT89KD-351 gave the lowest yield 1272 kg/ha.

As general remarks, water logging was observed in some plots during the crop season and termites damage was also observed in some plots immediately before fodder harvest. These factors could bring other sources of variation for fodder yield than varieties themselves. This is probably a reason why a high coefficient of variation was obtained for that trait.

Based on visual observation in the field some lines showed good potential for grain and fodder such as IAR-48, IT883-729. It could be noticed that most of the leaves still remain green while the pods are ready for harvest on entries IAR 48 and IT86D-715 in this trial.

9.4.1. Cowpea Advanced Varietal Trial 3.

The trial was planted on July 8th 1991 in 3 replications at Guiring, Maroua and consists of 20 entries. Plots were 4 rows, 8m long and the spacings were 1 meter between rows and 50cm within rows. The two central rows were harvested for analysis. Data on pod yield, grain yield, fodder yield, days to 50% flowering, days to maturity, virus score, and number of plants at harvest were recorded (see Table 3).

The analysis of variance showed highly significant differences (1% level) between entries for all traits except the number of plants at harvest where the difference is not significant. For grain yield the entry TVX3236 ranked first and yielded 1813 kg/ha followed by entries IT90K-373 (1560 kg/ha), IT89KD-444 (1329 kg/ha), IT89KD-374-1 (1308 kg/ha) and IT89K-234 (1214 kg/ha). For fodder yield entry IT89KD-354 ranked first and yielded

2648 kg/ha of dry fodder followed by entries IT89KD-337 (2244 kg/ha), IT89KD-453 (2000 kg/ha), TVX 3236 (2000 kg/ha), and IT89KD-355 (1779 kg/ha). For virus infestation entries IT89KD-444, TVX3236, IT89KD-337, and IT89KD-374 were among the most resistant ones whereas entries IT89KD-299, DAN'ILA, APL-1 and IT89KD-355 showed susceptibility to virus. It could be noticed that TVX 3236 which ranked first for grain yield is not significantly different from the best fodder producer in this trial.

Based on visual observation in the field during the season some entries have been identified for further evaluation. these entries are: IT89KD-453, IT89KD-337, IT89KD-444 and IT89D-2075.

9.4.1. Cowpea Advanced Varietal Trial 4.

This trial was planted on July 9th 1991 in 3 replications at Guiring, Maroua and comprises of 20 entries. Like in trial 3, plots were 4 rows, 8m long, and the spacings were 1m between rows and 50cm within rows. In this trial two entries KANANNADO and KANO-1696 did not flower and were removed from the analysis. Data on pod yield, grain yield, fodder yield, days to 50% flowering, days maturity, virus score, number of plants at harvest were recorded on the two central rows (see Table 4).

The analysis of variance showed highly significant differences between varieties for fodder yield, virus score, flowering date and maturity date. No significant difference was obtained for pod yield and grain yield. For fodder yield, entry IT89KD-474 ranked first and yielded 2575 kg/ha of dry fodder, followed by IT89KD-448 (2298 kg/ha), IT89KD-245-1 (2239 kg/ha), IT89KD-275 (2060 kg/ha), and IT89KD-251 (1983 kg/ha). For virus infestation entries TVX 3236, IT89KD-256, IT89KD-448, were among the most resistant whereas entries IT89KD-374, IT89KD-387, KANO late and IT89KD-107-5 were among the most susceptible ones. Although there was no significant difference for grain yield, entry TVX 3236 gave the highest yield (725 kg/ha).

Based on visual observation during the season, some entries have been identified for further evaluation. Those entries are: IT89KD-260, IT89KD-260-1, IT89KD-244, IT89KD-256, KANO late, and IT89KD-251. It has been observed that for both trials advanced 3 and advanced 4, the spacing of 1mx50cm is too wide for this location and could be reduced. Some striga were observed on IT89KD-245, KANO 1696 and TVX 3236. Entry IT89KD-252 seemed to be segregating for virus resistance and maturity date.

9.4.1. Cowpea Preliminary Trial 1.

The trial consists of 20 entries and was planted on July 9th, 1991 at Guiring, Maroua in 3 replications. Planting was done in plots of 4 rows, 4m long, and spacing of 75 cm between rows and 20cm within rows. The two central rows were harvested for statistical analysis. Data on pod yield, grain yield, fodder yield, days to 50% flowering, maturity date, virus score, number of plants at harvest were recorded (see Table 5).

The analysis of variance showed highly significant differences between varieties for all traits except number of plants at harvest where the difference was not significant. For grain yield entry IT90K-300-9 ranked first and yielded 2317 kg/ha, followed by entries

IT86D-719 (2171 kg/ha) IT89KD-775 (1922 kg/ha) IT89KD-307 (1422 kg/ha), and IT90K-102-6 (1400 kg/ha). For fodder yield entry IT86D-719 ranked first and yielded 4278 kg/ha of dry fodder followed by entries IT90K-82-2 (3950 kg/ha), IT90K-261-3 (3588 kg/ha), IT90K-261-4 (3221 kg/ha) and IT90K-102-6 (2916 kg/ha). For virus infestation entries IT90K-300-9, IT89KD-775, IT89KD-309, and IT86D-719 were among the most resistant lines whereas entries IT90K-59-5, IT90K-59-3, IT84S-2246-4, and IT90K-268-8 were among the most susceptible lines.

It could be observed that the best three varieties for grain yield were among the most resistant to virus. It could also be observed that entry IT86D-719 ranked second for grain yield and first for fodder yield. From visual observation, some entries have been identified for further evaluation either because they have good potential for fodder or grain or both. Those entries are: IT90K-300-9, IT86D-719, IT90K-261-1, IT90K-82-2, and IT90K102-6.

9.4.1. Cowpea Indicator Trial.

The trial was planted on July 9th, 1991 and consists of 16 lines. It was planted at Guiring, Maroua in plots of 3 rows, 4m long and spacings of 75cm between rows and 20cm within rows. The central row was harvested for analysis. Data on pod yield, grain yield, virus score, were analysed (see Table 6).

The analysis of variance showed highly significant differences between the entries for all traits. For grain yield entry IAR48 ranked first and yielded 2355 kg/ha followed by TVU 347 (2330 kg/ha), IT82E 16 (2220 kg/ha), and VITA 4 (2066 kg/ha). For pod yield entry TVU 347 ranked first and yielded (3200 kg/ha) followed by IAR 48 (3130 kg/ha), TVX 3236 (3022 kg/ha) and TVU 36 (2800kg/ha). For virus infestation entries TVU 347, TVU 563, K-28, IT82E 16, TVU 36 were among the most resistant lines whereas entry TVU 3000, was the most susceptible line.

Most of the lines showed a very good level of resistance to virus which is the most important disease in the area. Striga and a few other diseases have been observed on TVU 990.

9.4.1. Cowpea Virus Nursery.

The trial was planted on July 8th, 1991 at Guiring, Maroua in a single replication. Plots were of 4m long and the spacings were 50cm between rows and 20cm within rows. Data on pod yield, grain yield, days to 50% flowering, days to maturity, virus score, number of plant and fodder yield were recorded. A stat function has been performed on those data. (see Table 7).

The pod yield ranged from 425 kg/ha with the entry IT85F 2805 to 4125 kg/ha with the entry IT82E-16. The grain yield ranged from 350 kg/ha to 3225 kg/ha with the same entries IT85F 2805 and IT82E-16 respectively. The fodder yield ranged from 25 kg/ha with the entry IT84S-2135 to 2950 kg/ha with the entry IT82E-16. Virus score ranged from 1 which means virus free with the entry IT82E-16 to 3.5 which is near severe infestation with the entry IT83D-442.

9.4.1. Cowpea On-Farm Trial.

This is a collaborative research trial with the TLU and the Grain Legume program. 4 varieties BR1, IT86D-719, IT86D-364 and VYA have been tested on farmers' fields in four villages: Djoulgouf, Djinglya, Gatougel and Zouaye. Spacings were 80cm x 50cm for Vya and 80cm x 25cm for others. Data on grain yield, fodder yield, plant stand at 30 days after planting were recorded. Results on grain yield and fodder yield are presented (see Table 8).

On the average, the variety BR1 gave the highest yield (541 kg/ha) and is statically superior to IT86D-364 with a grain yield of (370 kg/ha). It is followed by Vya (493 kg/ha) and IT86D-719 (473 kg/ha). The analysis of variance location by location showed significant differences between varieties at Djoulgouf whereas no significant difference has been observed at other locations. For fodder yield, the analysis of variance across locations did not show any significant difference between entries.

The analysis of variance location by location showed significant difference between varieties at Djoulgouf and Zouaye. At Gatougel fodder could not be harvested because of heavy rains. Yields have been generally low on farmers' field due to various factors among which were unusually heavy rains in most areas, and inappropriate crop management.

9.4.2. Evaluation of Germplasm and Varietal Development
Evaluation of Germplasm

The trial was planted in one replication on July 10th, 1991 at Guiring, Maroua. It consists of 124 entries, half of which are IITA lines and the rest are from local collections or introductions from USA. Planting was done in plots of 2 rows, 6m long and spacings were 1m between rows and 50cm within rows. The whole two row plots were harvested for analysis.

Qualitative data such as plant type, leaf color, flower color, pod color, leaf type, pod position, grain color, visual rating for grain yield potential, visual rating for fodder yield potential and quantitative data such as: pod yield, grain yield, fodder yield, number of grains/pod, percent virus free plants, mean pod length, virus score (scale 1-5), days to 50% flowering, days to maturity, 1000 seed weight were recorded on all entries.

For qualitative traits, the observations revealed that there was variation among entries for most of the traits. Two major groups of plant types were observed, a spreading type and erect type. The prevailing flower colors are white, pink, and yellow. The leaf type varied from large to small, and from narrow to wide. Differences were also observed on pod color (black, green, and pink). Leaf color also varied from light green to dark green. A wide range of grain color was observed (white, brown, black). Pod position varied from upright to spreeding.

For quantitative traits, the stat function of the MSTAT program was performed and correlations between some variables were calculated using the CORR function (see Table 9). The germination was very poor for some entries and had affected the plant stand.

Grain yield varied from 17 kg/ha to 1958 kg/ha, fodder yield varied from 42 kg/ha to 6667 kg/ha. Variations were also observed for number of grain/pod which varied from 7 to 18; % virus free plants (from 0 to 100); pod length (9.7cm to 22cm); virus score (1.5 to 5); 1000 seed weight (64,5 grams to 260,5 grams).

Simple correlation calculations revealed that there was a significant negative correlation between virus score and grain yield (r = - 0.45) and a non significant correlation between virus score and fodder yield (r = - 0.11). There was also a significant correlation between % virus free plant and grain yield (r = 0.51); number of days to maturity and fodder yield (r = 0.50). The late varieties have the tendency to produc more fodder. The correlations between plant stand and fodder yield (r = 0.06), number of grain per pod and 1000 seed weight (r = - 0.12) were not significant.

Variation was observed within some entries for their reaction to virus diseases. Based on visual observations in the field and confirmation of yield, 42 entries (34%) have been identified for further evaluation. The best looking two plants in each entry were selected and harvested separately.

9.4.2. Varietal Development

The overall objective of this program is to obtain the basis for creating new varieties over the long term. Cowpea lines known to have good characteristics have been selected and crossed. Such characteristics are bruchid resistance striga resistance, virus resistance, seed quality (size and color).

Some of the selected lines are Vya (local cultivar with good seed quality) BR1 (improved line with good seed quality and bruchid resistant), B 301 (striga and virus resistance). A total of 9 lines are involved. 17 different F1 crosses and some reciprocals have been obtained and part of the F1 seeds have been planted during off season.

9.4.3. Evaluation of Genotypes under Different Insecticide Treatments

The trial was planted on July 9th, 1991 at Guiring, Maroua in a split plot design, with insecticide treatment as main plots, and entries (varieties) as sub plots. Three levels of insecticide treatment (0,1,2) and 46 entries were investigated in two replications, in plots of 3 rows, 4m long.

Data on plant stand, days to 50% flowering, days to maturity, virus score, number of pods per plant, number of infested pods per plant, number of insect perforations per 10 pods, fodder yield, pod yield, grain yield, % virus free plant were recorded. Some of the variables were analyzed.

The analysis of variance did not show any significant difference for the insecticide treatment for all traits, but showed significant difference between varieties for virus score, number of pod per plant, fodder yield, grain yield, number of insect perforations per 10 pods. The interaction was not significant.

Simple correlations and descriptive statistics function were performed on some of the variables (see Table 10). These analyses showed that there are variations between varieties for most of the traits. Virus scores varied from 1.5 to 4.5, the number of pods per plant from 10 to 62, fodder yield from 120 kg/ha to 2663 kg/ha, and grain yield from 113 kg/ha to 1493 kg/ha. No correlation was found between the number of infested pods per plant and the grain yield and between the number of insect perforations per 10 pods and grain yield. Significant correlation was found between number of pods/plant and grain yield, (r=0.80), virus score and grain yield (r = - 0.40).

Since this experiment was a preliminary investigation of the reaction of cowpea lines to different insecticide treatments, it is recommended that it be repeated by selecting fewer varieties, and those which performed well on the average and especially under no insecticide application. Such lines are IT85F-2687, IT85D-3517, IT82E-16, TVU-1890, IT86D-715 and IT86D-721.

Based on visual observation, some entries have been identified for further evaluation. Some of these entries are IT82E-16, IT85F-867, IT85F-2684, IT82D-889, IT85D-351, IT86D-472, and IT84S-2135. A total of 20 entries have been identified under no insecticide treatment. Such entries have good potential for either grain yield, fodder yield or for both. The low insect pressure at Guiring this year and the frequent heavy rains, may explain the non response of the insecticide treatment.

9.4.4. Evaluation of Cowpea Lines for Resistance to Striga

The original objective of these trials was to identify sources of resistance to striga under natural infestation and at the same time compare the yield potential and other characteristics of selected lines originating from IITA. Due to the fact that natural striga infestation was not uniform more emphasis will be put on yield potential in the presentation of the results.

9.4.4. Cowpea Preliminary Trial 4.

It was planted on July 10th, 1991 at Guiring, Maroua in 3 replications, and consisted of 20 entries. Planting was done in plots of 4 rows, 4m long, and spacings of 75cm between rows and 2ocm within rows. Data on pod yield, grain yield, fodder yield, days to 50% flowering, days to maturity, virus score, plant stand, and number of striga per plot were recorded. Some of these data were analyzed (see Table 11).

The analysis of variance showed a significant difference between varieties for grain yield, pod yield, and virus score. No significant difference was found for days to 50% flowering, days to maturity and fodder yield. Striga infestation was not uniform, therefore, it was meaningless to analyze the number of striga per plot.

For grain yield, entry IT90K-101-3 ranked first and yielded 1639 kg/ha, followed by TVX 3236 (1445 kg/ha) and B 301 (1422 kg/ha). For virus score entries IT90K-101-4, IT90K-101-3, B 301, IT90K-81-4 were among the most resistant lines, whereas entries IT90K-76-4, IT90K-76-6, IT90K-109-1 and IT90K-91-3 were moderately resistant. It should be noticed that most entries showed good level of virus resistance.

Although, striga count was not analyzed, the following entries showed various degrees of susceptibility: IT90K-111-5, IT90K-109-1, IT90K-101-3, IT90K-85-6, TVX 3236, IT90K-87-2, IT90K-91-3. Only one striga plant was observed in a plot of B 301 [illegible] one replication.

For fodder yield where no significant difference was observed, yield ranged from 372 kg/ha to 1367 kg/ha. Most of the entries lost their leaves at maturity. IT90K-245 had good grain quality and most of its leaves did not drop at maturity.

9.4.4. Cowpea Advanced Trial 7.

It was planted on July 10th, 1991 at Guiring, Maroua in 3 replications, with plots of 4 rows, 4m long and spacings of 75cm between rows and 20cm within rows. 20 entries were tested. Data on pod yield, grain yield, fodder yield, days to 50% flowering, days to maturity, virus score, plant stand and number of striga per plot were recorded (Table 12).

The analysis of variance showed significant differences between entries for pod yield, grain yield, fodder yield, and virus score. No significant difference was found for other traits. The number of striga per plot were not analyzed. For grain yield entry TVX 3236 ranked first and yielded 2572 kg/ha, followed by IT89KD-107 (2328 kg/ha), IT89KD-453 (2028 kg/ha). For fodder yield entry IT89KD-85-3 ranked first and yielded 2783 kg/ha followed by IT89KD-453 (2538 kg/ha), TVX 3236 (2272 kg/ha). For virus score entries IT89KD-107, IT89KD-785, IT88D-856-10 and B 301 were among the most resistant lines whereas entries APL-1, IT90K-59 were the most susceptible lines. Here again, most of the entries showed good level of resistance to virus.

The following entries showed various level of susceptibility to striga: IT90K-76, IT88D-676-1, IT89KD-453, IT89KD-355, IT88D-643-1, IT89KD-338, IT88D-856-10, TVX 3236, IT89KD-95-4, IT88S-678-3, IT90K-109. Based on visual observation during the season some lines have been identified for further evaluation, such lines are IT89KD-85-3, IT89KD-107, IT89KD-249, IT88D-867-11, IT88D-643-1.

9.4. Seed Production and Varietal Purification.

Six varieties have been multiplied at Guiring Station. They included BR1, BR2, VYA, IT82D-716, IT86D-715, and IT86D-364. They were scored for virus infestation during the growing season. The best looking plants (virus free and good yield potential) were identified and harvested separately at maturity. Seeds from single selected plant are kept separately and will be planted plant to row next season for further selection.

It was observed that Vya was badly infested with virus. Virus infestation was severe on IT82D-716 while the infection on BR2 and IT86D-364 was mild. 96 single plants were selected from Vya, 99 from IT82D-716, 96 from BR1, 100 from BR2, 76 from IT86D-364 and 50 from IT86D-715. The rest of the seeds will be made available for on-farm tests during next season.

Table 1. Cowpea Advanced Trial 1.

Selected Entries	Grain Yield (Kg/ha)	Pod Yield (Kg/ha)	Fodder Yield (Kg/ha)	Virus Score (Scale 1-5)
1. IT86D - 719	2605	3400	3025	1.1
2. IT87D - 829-5	1975	2625	1925	2.7
3. IT87D - 941-1	1767	2283	1554	2.6
4. IT89KD - 374	1650	1935	1287	4.4
5. IT89KD - 457	1645	2192	1772	1.7
6. IT89KD - 361-1	1479	1967	2338	2.2
7. IT87D - 298	1367	1795	2470	3.9
8. IT89KD - 329	1317	1392	821	3.6
9. IT89KD - 320	1317	1637	1062	3.7
10. IT89KD - 792	1308	1283	3530	3.6
Means	1252	1592	2067	3.4
L.S.D. (0.05)	415.5	538	1055	0.50
C.V. %	23.49	23.86	36.09	10.37

Table 2. Cowpea Advanced Trial 2.

Selected Entries	Grain Yield (Kg/ha)	Pod Yield (Kg/ha)	Virus Score (Scale 1-5)
1. IT87D - 590-5	2417	3128	2.2
2. TVX 3236	2378	3017	1.8
3. IT89KD - 785	2345	3133	1.7
4. IT88DM - 363	2338	2988	1.8
5. IT89KD - 374	2262	2878	2.5
6. IAR - 48	2100	2650	2.5
7. IT88D - 676-1	1912	2462	2.5
8. IT88S - 729	1867	2378	2.2
9. IT87D - 697-2	1578	1900	2.8
10. IT87D - 879-1	1500	2000	2.5
Means	1547	1993	2.5
L.S.D. (0.05)	477	597	0.3
C.V. %	18.73	18.03	2.4

Table 3. Cowpea Advanced Trial 3.

Selected Entries	Grain Yield (Kg/ha)	Pod Yield (Kg/ha)	Fodder Yield (Kg/ha)	Virus Score (Scale 1-5)
1. TVX 3236	1813	2277	2002	2.3
2. IT90K - 373	1560	1896	1239	3.0
3. IT89KD - 444	1329	1661	1273	2.0
4. IT89KD - 374-1	1308	1617	1019	3.2
5. IT89K - 234	1214	1446	738	3.3
6. IT89KD - 374	1147	1396	1169	1.8
7. DAN'ILA	1023	1250	806	3.8
8. IT89KD - 389	970	1489	781	3.0
9. IT87D - 2075	883	1171	952	3.5
10. IT89KD - 453	875	1229	2002	2.7
Means	931	1178	1260	3.1
L.S.D. (0.05)	359	453	745	0.8
C.V. %	23.33	23.23	35.77	3.1

Table 4. Cowpea Advanced Trial 4.

Selected Entries	Fodder Yield (Kg/ha)	Virus Score (Scale 1-5)
1. IT89KD - 474	2575	2.8
2. IT89KD - 448	2298	2.7
3. IT89KD - 245-1	2239	2.8
4. IT89KD - 275	2061	3.0
5. IT89KD - 251	1983	2.8
6. IT89KD - 260	1854	3.0
7. IT89KD - 252	1438	3.3
8. IT89KD - 244	1406	3.0
9. IT89KD - 256	1158	2.7
10.IT89KD - 249	1121	3.0
Means	1329	3.0
L.S.D. (0.05)	731	0.8
C.V. %	33.11	15.17

Table 5. Cowpea Preliminary Trial 1.

Selected Entries	Grain Yield (Kg/ha)	Fodder Yield (Kg/ha)	Virus Score (Scale 1-5)
1. IT90K - 300-9	2317	1705	1.5
2. IT86D - 719	2171	4278	2.0
3. IT89KD - 775	1922	1622	1.8
4. IT89KD - 307	1422	1450	2.3
5. IT90K - 102-6	1400	2917	2.7
6. IT89KD - 286	1378	1250	2.3
7. IT84S - 2246-4	1367	1450	3.2
8. IT90K - 101-1	1355	2350	2.7
9. IT89KD - 309	1305	1245	2.0
10.IT90K - 59-3	1110	1862	3.8
Means	1210	1905	2.7
L.S.D. (0.05)	500	1283	1.0
C.V. %	25.04	40.76	22.25

Table .. Cowpea Indicator Trial

Selected Entries	Grain Yield (Kg/ha)	Pod Yield (Kg/ha)	Virus Score (Scale 1-5)
1. IAR 48	2355	3133	1.5
2. TVU 347	2333	3200	1.0
3. IT82E - 16	2222	2755	1.2
4. VITA 4	2067	2688	1.5
5. TVU 563	2022	2467	1.2
6. TVU 36	2022	2800	1.3
7. K-28	1845	2288	1.2
8. TVX 3236	1733	3022	1.5
9. IT86D - 782	1711	2311	1.3
10.IT85D - 3577	1688	2200	1.8
Means	1653	2240	1.6
L.S.D. (0.05)	786	1054	0.5
C.V. %	29.24	27.63	17.61

Table 7. Cowpea Virus Nursery, Minimum, Maximum and Mean of Pod Yield, Grain Yield, Fodder Yield and Virus Score.

Variable	Minimum	Maximum	Mean
1. Pod Yield (Kg/ha)	425 (IT85F-2805)	4125 (IT82E-16)	1562
2. Grain Yield (Kg/ha)	350 (IT85F-2805)	3235 (IT82E-16)	1190
3. Fodder Yield (Kg/ha)	25 (IT84S-2135)	2950 (IT82E-16	1002
4. Virus Score (Scale 1-5)	1.0 (IT82E-16)	3.5 (IT83D-442)	2.3

Table 8. Cowpea On-Farm Trial, Grain Yield and Fodder Yield in Four Villages
8.1. Grain Yield (Kg/ha)

	Djoulgouf	Djinglya	Gatouguel	Zouaye	Mean
1. BR1	573	315	798	429	541
2. Vya	660	286	634	371	493
3. IT86D-364	310	367	498	253	370
4. IT86D-719	454	--	555	338	473
C.V. %	22.6	-	45.4	23.4	-
L.S.D.	285.84	-	447.21	259.16	165

Table 8.2. Fodder Yield (Kg/ha)

	Djoulgouf	Djinglya	Gatouguel	Zouaye	Mean
1. BR1	2123	604	--	457	1078
2. Vya	1411	507	--	1001	918
3. IT86D - 364	1050	387	--	332	596
4. IT86D - 719	1788	--	--	526	-
C.V. %	25.8			21.5	35.9
L.S.D.	1066	--	--	536.1	693.7

Table 9. Cowpea Germplasm Evaluation

9.1 Minimum, Maximum, Mean, and Standard deviation of Selected Quantitative Traits

	Minimum	Maximum	Mean	Standard Deviation
1. Pod yield (kg/ha)	25	2650	825	600
2. Grain yield (kg/ha)	17	1958	607.5	458
3. Fodder yield (kg/ha)	42	6667	1965	1461
4. Number of grain/pod	7	18	12.4	2.12
5. % Virus free plants	0	100	47.4	41.4
6. Pod length (cm)	9.7	22	15	2.7
7. Virus Score (Scale 1-5)	1.5	5.0	3.3	0.9
8. Days to 50% Flowering	43	70	53	7.8
9. Days to Maturity	63	92	76	7.7
10. 1000 Seed Weight (Grams)	64.5	260.5	151	31.8

Table 9.2 Correlation Between Selected Quantitative Traits

x	y	r	Probability
1. Virus Score	Grain Yield	- 0.45	< 0.01
2. % Virus Free plant	Grain Yield	0.51	< 0.01
3. Days to Maturity	Fodder Yield	0.50	< 0.01
4. Nb. grain/pod	Grain Yield	0.34	< 0.01
5. Virus Score	Fodder Yield	- 0.11	Not signifacnt
6. Pod length	Nb. of grain per pod	0.33	< 0.01
7. Nb. of grain/pod	1000 seed weight	- 0.12	Not significant
8. Plant stand	Fodder Yield	0.06	Not significant

Table 10. Minimum Insecticide Application

10.1 Grain Yield and Fodder Yield of Selected Entries under Zero Treatment compared to average mean yield.

Entry	Grain Yield (Kg/ha) Zero Treatment	Grain Yield (Kg/ha) Average Yield	Fodder Yield (Kg/ha) Zero Treatment	Fodder Yield (Kg/ha) Average Yield
1. IT85F-2687	1475	1492	2025	2475
2. IT85D-3517	1200	1188	1625	1650
3. IT82E-16	1112	1079	2125	2075
4. TVU 1890	1112	1104	1600	1437
5. IT86D-715	1025	1108	2650	2662
6. IT86D-721	1000	858	2287	1679
7. IT86D-719	975	1104	687	908
8. IT86D-1038	975	1054	875	921
9. IT87F-1393	925	750	1575	1595
10.IT86D-371	925	921	862	1208
11.B301	887	995	1550	1232
12.IT86D-716	875	987	1387	1266
13.IT85F-2684	850	895	1437	1525
14.IT86D-714	825	737	1512	1587
15.VITA 7	812	954	987	1258
16.IT86D-713	812	862	2337	1741

Table 10.2 Minimum, Maximum, Mean and Standard Deviation of Selected Quantitative Traits

	Minimum	Maximum	Mean	Standard Deviation
1. Virus Score (Scale 1-5)	1.5	5.4	2.6	0.8
2. Nb. of Pod/plant	10	62	32	11.6
3. Nb. of Infested pod/plant	2	14	5	2.7
4. Fodder Yield (Kg/ha)	120	2663	1208	598
5. Pod Yield	208	2032	975	448
6. Grain Yield	113	1493	655	328
7. Nb. of perforations	1.0	7.0	2.0	1.3
8. % Virus Free Plant	6.0	100.0	64.7	28.5

Table 10.3 Correlation Between Selected Quantitative Traits

x	y	r	Probability
1. Virus Score	Fodder Yield	- 0.02	Not Significant
2. Virus Score	Grain Yield	- 0.40	< 0.01
3. Fodder Yield	Grain Yield	0.52	< 0.01
4. Nb. of Pod/Plant	Grain Yield	0.80	< 0.01
5. Nb. of Perforation/ 10 Pods	Grain Yield	- 0.30	< 0.10

Table 11. Cowpea Preliminary Trail 4.

Selected Entries	Grain Yield (kg/ha)	Virus Score (Scale 1-5)
1. * IT90K - 101-3	1639	1.6
2. * TVX 3236	1445	2.3
3. * B301	1422	1.7
4. * IT90K - 85-6	1212	2.0
5. IT90K - 81-4	1156	1.8
6. IT90K - 101-4	1117	1.5
7. * IT90K - 87-2	1078	2.3
8. IT90K - 81-8	1072	2.2
9. * IT90K - 111-5	1056	2.5
10.* IT90K - 91-3	1050	2.5
Means	1035	2.2
L.S.D. (0.05)	558	0.7
C.V. %	32.6	19.6

* Striga Observed in at least one plot.

Table 12. Cowpea Advanced Trial 7.

Selected Entries	Grain Yield (kg/ha)	Fodder Yield (kg/ha)	Virus Score (Scale 1-5)
1. * TVX 3236	2572	2272	2.2
2. IT89KD - 107	2328	1655	1.5
3. * IT89KD - 453	2028	2538	2.2
4. * IT88D - 643-1	1938	1100	2.8
5. IT88D - 867-11	1878	1183	2.8
6. IT90K - 59	1878	1355	3.8
7. * IT89KD - 95-4	1712	1511	1.8
8. IT89KD - 785	1617	1417	1.5
9. B301	1600	872	1.7
10.* IT90K - 109	1589	1172	2.5
Means	1613	1355	2.35
L.S.D. (0.05)	571	1135	0.9
C.V. %	21.3	50.6	23.1

* Striga Observed in at least one plot.

9.5 VISITORS

During the 1991 cropping season the program was visited by:

- Mr. Quincy Benbow: USAID Project Officer (Yaounde)
- Dr. E. A. Atayi, NCRE Chief of Party (Yaounde)
- A team of the Steering Committee of the EEC On-Farm project led by Drs. Roger Jones, Chairman of the Committee and Joseph Suh of IITA/Ibadan, Nigeria.
- A team of researchers of the Plant Improvement Working group led by Mr. J.M. Lacape, Cotton Breeder and Coordinator of the group.
- Mr. Bedinga Le Diamzo, Section Entomologie vivrier IRCT Station de Babedjia, Tchad.

10. PLANT PATHOLOGY - BAMBUI

10.1 INTRODUCTION

The Plant Pathology Unit in Bambui (PPB) has responsibilities to identify maize, sorghum and millet diseases in their growing zones and to assess the importance of these diseases in collaboration with the maize, sorghum and millet improvement teams and develop varieties and/or cultural practices to control diseases in collaboration with the agronomy teams. The unit is based in Bambui and covers all the agro-ecological zones where these three commodities are grown.

The goal of Plant Pathology Unit in Bambui is to enhance production of maize, sorghum, and millet in Cameroon by reducing yield losses due to diseases through development of resistant/tolerant genotypes and/or appropriate cultural practices. Sources of resistance to some of the main diseases have been identified, through field screening techniques and incorporated into selected genotypes or elite lines.

A major challenge facing the PPB during 1991-1994 as during the previous years will be personell shortages and restricted budgets. Of the two pathologists now available, the most senior will leave for PhD. in December 1991. A technician and laboratory attendant are the only available personal. Because of this situation, some of the activities, though necessary, may not be carried out.

10.2 SUMMARY ACTIVITIES

The activities in the Unit were oriented in three directions:

1) Population improvement and development of resistant varieties,
2) Study disease epidemiology, pathogen biology, and monitor new diseases, and ,
3) Support to other units.

Four operations were carried out as far as population improvement was concerned. Two were on maize and two on sorghum. As regards the study of epidemiology of diseases, biology of pathogens, and the monitoring of new diseases, 6 trials were carried out of which four were on maize and two on sorghum.

All the trials were planted as scheduled. Sorghum trials planted in the Extreme-North, were visited only once during the cropping season, almost at the stage of maturity. Because of the limited funds and manpower, it was not possible to visit the trials before or at flowering time as recommended by ICRISAT. Most of the leaves were dried out when we visited the sites. Most of the foliar diseases were then missed because it was difficult to differentiate between infected and dying leaves because of the senescence. The sorghum breeding and Agronomy teams were very cooperative in monitoring our experiments at Yoldio, Ndenkole and Mouda.

Maize trials planted at Upper Farm (Bambui) were damaged by IRZ's cows. No significant data were collected at that location.

In support of other Units, PPB evaluated trials for the maize breeding teams based at Bambui and Nkolbisson, and for TLU Bambui. The evaluation was carried out in Adamaoua, West and North West and Centre Provinces.

10.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
OPERATION 1: Population improvement and development of resistant varieties.		
1.1. Asses efficiency of early generation selection on the resistance to rusts and blights.	1.1. Test different generations of selfings in artificial inoculation.	1.1. S4 was formed in 1991 and will be advanced to S5 in 1992.
1.2. Identify donors of genes for resistance to diseases and understand their mode of inheritance.	1.2. Evaluation of crosses between local and improved varieties.	1.2. -Kasai COCA BM89, FM87. were tolerant to Puccinia polysora. -Coca, A89, AE89, A90 A90 S3 and S4 BM89, FM87 were tolerant to E turcicum and to Diplodia.
1.3. Assessment of the level of resistance of released varieties and advanced breeding lines to dead heart.	1.3. Evaluation of available sorghum assertion to dead heart.	1.3. Guel-gueling, Barlang, Framida CS 316, CS318. Resistant to Dead Heart.
1.4. Identify sources of resistance to main sorghum foliar diseases.	1.4. Evaluation of disease screening nurseries from ICRISAT-Mali and Texas A&M University.	1.4. ICRISAT trial (see Sorghum breeding report) -SC418 -TAM 428 -TX 434 -SC J62 -81 EON 85 -BYX 378 Resistant to Antrachnose (Collectotrichum graminicola.)

Objectives	Activities	Accomplishments
Operation 2: Study disease epidemiology, pathogen biology, and monitor of new diseases.		
2.1. Assess importance of stalk and ear rots and their study in relation to etiology, interaction with plant nutrient and element status.	2.1. Study the epidemiology and etiology of ear and stalk rots.	2.1. -Pathogens were isolated. -Artificial inoculation was done on 5 advanced maize genotypes. -Five weeks after inoculation diseases developed faster on Santa local, and Pool 9 (more than 3 internodes were attacked) than on HAP I, HAP II and Coca.
2.2. Determine effect of biotic and abiotic factors of the development of phaeosphaeria leaf spot and Diplodia leaf stripe.	2.2. Study the epidemiology of leaf spot and leaf strip of maize.	2.2. EC 573 showed some tolerance under Matural infestation. Artificial inoculation may be necessary to confirm preliminary findings.
2.3. Identify alternate host(s) on which rusts overseason and develop appropriate cultural control measure.	2.3. Survey of rusted hosts during dry season.	2.3 Lemon grass (Cympognis citratus) and Serge grass (Imperata Cylindrica) were the most prominant grass on which rusts were found to overseason on. Both of them were Puccinia ssp Or G citratus, Puccinia Purpurea was present, and Puccinia Imperatae was the pathogen found on I Cylindrica.
	2.3.2 Identification of primary source of infection and type of primary propagules.	2.3.2 Urediospores and teliospores were the primary sources of infection
	2.3.3 Evaluate possible control measures based on the destruction of the overseasoning alternate host(s).	2.3.3 Destruction may be a good control measure for I cyluidrica; however C. citratus is also used to cure some human diseases; so eradication of that species may be controversial

Objectives	Activities	Accomplishments
2.4. Evaluation of lowland and highland materials to turcicum leaf blight.	2.4. Test composite and inbreds in different localities of the maize growing zone.	2.4. At Foumbot, inbreds 9432, 89286, 89311, and 131 showed good level of resistance to E turcicum and to P polysora. At the same location, composite CMS 8501, CMS 8704, DMR - ESR-W CMS 8701, Yaounde 8701, Kasai, were resistant to E turcicum p. polysora, Helainthospoium maydis.
2.5. Determine effect of nutrient status on the severity of head smuts of sorghum.	2.5. Study the effect of nitrogen level on the disease.	2.5. This trial failed at Mdonkole and Mouda due to poor germination despite the effort of the Agronomy team based at Maroua.
2. 6. Study the etiology of anthracnose of sorghum.	2.6. Determine the existence and identity of races of collectotrichum spp. existing on sorghum. Study the relationship between the three phases of the disease.	2.6 Did not take place because differentials were not available to characterize the races of collectotrichum.

10.4 RESEARCH FINDINGS

The details of maize, sorghum and millet pathology trials carried out in 1991 are given in table 1. Most of the experiments were conducted in replicated trials. Traditional agronomic practices were used. 20-10-10 fertilizer (150kg/ha) were applied at planting and Urea (100kg/ha) at sidedressing. The rows were 5m long, with 0.25m spacing within rows. Disease incidence and severity were recorded weekly based on a modified James Scale (Actual % area of plant infected). The results are presented briefly below:

10.4.1 Extended Anthracnose virulence Nursery (EAVN) and International Sorghum Antrachnose Virulence Nursery.

Twenty entries were evaluated for each experiment at Yoldeo. S-35 was the local check. Data on grain yield were not recorded at the preliminary stage of the evaluation. Anthracnose incidence and severity was our main target. Data on the incidence and severity of Anthracnose and Grey Leaf Spot (the most prevalent disease) are summarized in Table 2 and 3. TAM 428, SC 167-14, TX 434, QL-3 (INDIA), 82 BH5718,19, RTX430 84 L5373 were resistant to both diseases - SC328 and SC414-12E were susceptible to both diseases - variable reaction to each one was also noted.

10.4.2 Epidemiology and etiology of Phaeosphaeria Leaf Spot

The objective was to monitor the development of the disease on the plants and to evaluate high altitude varieties for their resistance to the disease.

Seven entries were planted at Upper Farm (1900 m.a.s.l.) April 91 Data collection were done as in 1990. The first symptoms occurred on July 20 at the soft dough stage. The disease incidence, (number of infected leaves (ear leaf, and the two adjacent ones) were recorded. The trials were evaluated only two times; then the field was damaged by cows from IRZ. The few plants that were not destroyed were used to continue the data collection. Due to high variability noted for reaction of entries to disease and inconsistency of the statistical analysis, the trials were dropped though FC573 showed some high level of resistance.

Assess efficiency of early generation selection on the resistance to rusts and blight.

The objective is to evaluate early generation selections on resistance to rusts and blight. Cycles of selfing (S_1, S_2, S_3, S_4, S_5) are formed each season without selection and remnant seed kept for generation testing. S_4 was formed in 1991 and will be advanced to S_5 next cropping season. During this season, all the cycles of selfing will be replanted, and each cycle will be evaluated.

Identification of donors of genes for resistance to diseases

Seventeen composites and 20 inbreds were tested at Foumbot. They were naturally inoculated. The summary of their reaction to four main diseases is given in tables 4 and 5 Inbreds 89286, and; are resistant to E turcicum, and P polysora, Helminthosporum maydis; composites CMS 8501, CMS 8704, and Kasai are resistant to E. turicum, and H. Maydis, and tolerant to P. polysora.

Identification of alternate hosts on which rust fungi overseason

The objective was to search species on which rust fungi overseason. Surveys were carried out in the dry season in North-west and West provinces. The locations visited were Foumbot, Dschang, Mbouda, Penka Michel, Santa, Nfonta, Bali, Bafut. Two grasses were infected with rusts: Cympogonis citratus (Lemon grass) and Imperata cylindrica (Serge grass). The characterization of pathogens was carried out in collaboration with the Dschang University Center. Puccinia Purpurea was found on C. citratus, while Puccinia imperatae infected I. cylindrica. Both fungi are different from P. Polyrona and P. sorghi. However, our target is to verify if maize is host to these pathogens, and we will continue to investigate more grasses in lowland and mid-altitude areas.

Table 1: Experiments planted in 1991.

TRIALS	LOCATIONS
Effect of inbreeding depression on the resistance to rust and blight.	Nfonta.
Epideniology and etiology of root and Stalk rots.	Santa & Upper Farm.
Epideniology of Phaeophaenia Leaf Spot	Upper Farm.
Epidenology of Diplodia Leaf Stripe	Nfonta & Nkolbisson
Comparative reaction of Lowland and highland composites to blights and rusts.	Foumbot & Nkolbisson.
Comperative reaction of Lowland and Highland inbreds to blight	Foumbot & Nkolbisson.
Search for alternate hosts to naize rusts.	West, North West.
Effect of Nitrogen on the severity of Head smut.	Ndonkole & Mouda.
Evaluation of advanced sorghum lines to Dead heart.	Ndonkole & Mouda.
Evaluation of sorghun Varieties to foliar disease.	Yoldeo.

Table 2: Incidence of Anthracnose on some sorghum varieties

DESIGNATION	ANTHRACNOSE		GRAY LEAF SPOT	
	Inc.(1-100%)	Sev.(1-5)	Inc.	Sev.
81EON69	5	1	20	2
82 C5964	5	1	5	1
82 EONII2	50	3	10	2
RTx 430	10	1.5	1	1
BTx 623	10	1.5	5	1
84 EON 457	5	1	20	2
CS 354 I	100	5	1	1
82 L1346	5	1	5	1
84 L5723	10	2.5	10	2
84 C5373	1	1	1	1
84 C9442	20	2	20	2
82 C973-1	5	1	50	3
84 L5663	5	1	70	4
82BH5718, 19	60	4	1	1
BTx 378	5	1	80	4
81 EON 85	5	1	80	4
BRANDES	5	1	1	1
R1186	5	1	10	2
82C6468	10	1.5	20	2
BTx 398	5	1.5	30	2
S-35	10	1.5	50	2

TABLE 3: Reaction of 21 sorghum genotypes to Anthracnose and Grey Leaf Spot.

DESIGNATION	ANTHRACNOSE		GREY LEAF SPOT	
	Inc.	Sev.	Inc.	Sev.
TAM 428	5	1	10	1
SC 748-5	50	3	1	1
-	60	3	20	20
SC 167-14	5	1	5	1
SC 562	50	3	30	2
SC 7	50	2	10	1
TX 434	5	1	1	1
Tx 398	5	1	5	1
SC 120	5	1	30	2
SC 414-12E	70	4	30	2
-	50	3	20	2
B 35-6	5	1	20	2
SC224	5	1	10	1
QL-3 (India)	10	1	10	1
SC 418	5	1	30	2
Tx 2536	1	1	60	3
Tx 378	10	1	40	2
SC 326-6	5	1	50	3
SC 283	5	1	60	3
SC 328	40	3	40	3
S-35	10	1	10	1

Table 4: REACTION OF INBREDS TO BLIGHT FOUMBOT 1991

Entries #	Names	H. turcicum ***	H. maydis ***	P. sora **	Poly-	Diplodia ***	Yield (kg/ha) ***
20	9432	1.50	3.00	1.25		1.50	5792
14	230	1.50	1.50	2.50		1.25	4366
1	273	1.25	2.50	2.00		3.00	4337
17	1393	3.25	2.50	2.50		1.00	3773
15	1368	1.75	1.75	1.50		2.00	3221
6	74	1.75	2.25	3.25		2.50	3014
12	89286	1.00	1.00	1.25		2.75	2952
10	122	2.50	2.00	2.00		1.75	2944
16	68	3.75	1.75	1.25		2.75	2730
13	249	4	2.00	2.50		1.75	2709
19	9613	3.75	2.50	2.00		2.50	2482
3	89311	1.00	2.50	1.25		3.00	2458
8	9499	1.00	3.00	1.75		1.25	2102
11	5012	3.25	2.00	1.75		3.00	1743
2	2096	2.75	1.25	1.50		2.50	1658
18	2097	3.00	1.50	1.50		1.00	1503
7	89299	1.25	1.00	2.50		3.75	1358
9	Expl 20-1	1.25	1.50	2.00		2.50	1335
5	131	1.00	1.00	1.25		1.00	981
4	Expl 52-1	2.25	1.25	2.00		3.75	935.8
LSD	(0.05)	0.82	0.64	1.02		0.91	564.7
Sx		0.29	0.23	0.36		0.32	199.4
CV		26.5	24.0	38.3		28.4	15.2

Table 5: Reactions of Composites to Blights and Rusts. Fbt91

Entry #	Name	H. turcicum **	H. maydis ***	P. polysora *	yield (kg/ha) ***
9	CMS 8501	1.5	1.75	1.75	7032
2	Across TZUT SR-W	2.25	2.25	2.25	5722
11	CMS 8704	1.5	1.0	1.75	5680
12	Yaounde 8701	1.5	2.0	1.5	5423
7	FBT (3)-MSR-85	1.0	2.0	2.25	5100
17	DMR-ESR-W	1.0	1.5	2.0	4981
10	Synthetic 1	1.25	2.0	2.5	4790
15	CMS 8710	1.0	2.0	1.5	4727
5	KASAI	1.25	1.0	1.75	4643
4	SHABA	1.25	1.75	2.5	4587
6	FBT(5)-MSR-87	1.25	1.25	2.75	4562
1	BSR SYN.2	1.75	1.75	2.25	4002
14	POOL 16 DR	1.25	1.75	2.25	3995
13	6 SYN 2	2.25	2.0	2.25	3654
8	DMR-ESR-Y	2.25	1.25	2.0	3400
16	BACOA	1.0	1.5	3.0	2860
3	COCA	1.25	1.25	2.75	2605
	CV	37.8	23.5	26.7	22.5
	LSD	0.77	0.55	0.83	1461
	Sx	0.27	0.19	0.29	513.7

TABLE 7: Identification of sources of resistance to GLS & Antrachnose

DESIGNATION	DISEASE REACTIONS			
	ANTHARCHNOSE		GLS	
	Inc. %	Sev (1-9)	Inc.	Sev.
SC120	1	1	5	1
SC 418	25	3	30	3
SC 7	30	3	15	2
B 35-6	1	1	5	1
Tx 398	50	3	35	3
Tx 2536	25	2	30	2
TAM 428	-	-	-	-
SC 326-6	1	1	10	1
SC 167 -14	30	3	15	2
SC 328	65	4	15	2
SC 283	25	3	20	3
SC 748-5	5	1	25	3
Tx 378	5	1	20	2
Tx 378	5	1	30	3
Tx 378	5	1	35	2
SC 414-12E	5	1	50	3
Tx 434	5	1	40	2
Ql-3 (India)	20	2	30	2
SC 562	5	1	50	3
SC 224	25	3	45	3
S-35	10	1	10	1

TABLE 8: Evaluation of maize advanced lines to rots.

DESIGNATION	Ear rots (1-5)	Stalk rots (1-5)	Yields kg/ha.
Pool 9	1.50	3.75	3563.13
HAP 1	1.50	2.75	3939.9
Santa Local	1.75	3.25	4211.95
COCA	1.50	1.00	4888.5
HAP 2	2.25	1.75	5113.8
CV	51.4	51.64	15.68

10.5 VISITORS

Dr. K. Caldwell from IITA was scheduled in 1991. But the trip did not take place. Mr. Ngoko attend a training course on Millet and Groundnuts diseases in Niamey. The trip was sponored by ICRISAT. Mr. Ngoko also visited IITA for a week. The trip was organised and financed by NCRE.

11.1 HIGHLAND CEREALS ENTOMOLOGY

11.1.1 INTRODUCTION

The cereals entomology research unit at Dschang is responsible for research on post harvest grain problems nationwide but has concentrated activities in the Western highland because of limited means. A national approach to grain post harvest problems in Cameroon is considered important to lay a basis for future research priorities on the topic. It became necessary for the unit to include some limited research on rice field insects following a request from the rice research unit based in Dschang.

The over all research goal of the unit is to reduce and maintain post harvest losses of food grain in Cameroon to the bare minimum. Research activities have concentrated on finding solutions to maize storage problems since maize is the most important cereal grain in Cameroon in terms of tonnage and also has the greatest storage losses.

Work in the past was mainly on non chemical control methods, but it has become necessary to screen some new stored grain insecticides for use by peasant farmers for quick control of infested grain since they are tempted to use dangerous products sold in the open market.

11.1.2 SUMMARY OF PROGRAM ACTIVITIES

During the period, two special reports were written early in the year for two important experiments concluded at the end of 1990. The two experiments include (a) an experiment to evaluate the use of 3- and 11-liter plastic cans with tight-fitting covers for maize storage and (b) an experiment to test the efficacies of two new grain storage insecticides (SOFAGRAIN and SUMICOMBI) on maize stored under four different methods.

In the first experiment it was discovered that tightly covered cans of both sizes effectively control the heavy weevil population in the containers and maintained the grain in good condition for 12 months. The experiment was repeated using maize of high (17.4% and 20.3%) and low (13.9%) moisture contents stored in larger containers (25-liter plastic cans).

In the second experiment, it was discovered that the efficacy of both products is affected by storage method and climate. A similar experiment was conducted to test the efficacy of one of the products on maize stored under two major storage methods. The results have been reported here.

The experiment to identify sources of stored grain insect pest resistance of some selected maize varieties grown and stored in three sites was terminated during the year and the results analyzed and reported here.

A concluding report on the farmers' maize storage survey conducted in two divisions in N.W. Province in collaboration with TLU Bambui is being compiled and partial conclusions have been included in this report.

One major operation concerning the use of natural plant materials by farmers for stored grain protection was started during the year with farmers questionnaires finalized and contacts made with the personnel of the Ministry of Agriculture in S.W. Province and TLU Ekona.

Mr. Asanga attended a short course on Diseases and Insect Pests of Millet and Diseases of Groundnuts held at ICRISAT Sahelian Centre, Niamey, Niger, 5 - 16 August, 1991. A special report of the course was written and circulated.

Mr Asanga also attended a workshop on the Regional Research Project on Maize and Cassava (RRPMC) at IITA, Ibadan, Nigeria from 9 - 13/12/91 and presented three maize Post Harvest Research proposals for funding by the project.

The major problems hindering the execution of operations in the research unit are lack of technical staff, reliable transport and laboratory equipment. The unit needs at least three Ingenieurs des Travaux Agricoles (ITA) stationed at Buea, Bamenda and Bafoussam to coordinate the research activities of the unit in these three Provinces of major concern and possibly another one in Garoua for the three Northern Provinces. The need of a strong 4WD vehicle exclusively for the Unit cannot be over emphasized. If motorcycles could also be provided to the proposed provincial coordinators, then field data collection will be facilitated. A long list of laboratory equipment has always been submitted every year but very few items have been received.

11.1.3 ACCOMPLISHMENTS

OBJECTIVES	ACTIVITIES	ACCOMPLISHMENTS
Operation 1: Identify the use of natural plant materials by farmers for grain storage pest control.		
1. Document plants and their products presently used by farmers for stored grain pest control.	1. Design farmer's questionnaires and contact TLU's and Agric. Delegations to help in collecting the information.	1.1 Some 100 copies of the designed farmers' questionnaires were given to the South West Provincial Chief of Service for Agriculture for distribution to Divisional Delegates for data collection. Twelve completed forms were received (4 from Manyu, 2 from Kumba, and 6 from Fako).

OBJECTIVES	ACTIVITIES	ACCOMPLISHMENTS
Operation 2 : Identify grain post harvest losses associated with each storage method and agro-ecological zone.		
2.1. Document the major grain storage methods in the various areas.	2.1 Collaborate with TLUs and extension agents to visit and describe various barns.	2.1 Storage methods were described in collaboration with TLU Bambui only for maize in Bui Division and Ndop Sub-Division in N.W. Province. Maize storage methods in Fako and Meme Divisions of S.W. Province had been reported after a special survey in 1988.
2.2. Quantify losses associated with each storage method and recommend improvements.	2.2. Monitor barns of stratified random samples of farmers over the traditional storage period.	2.2 Sub-Samples of maize from 20 farmers in Ndop and 20 farmers in Bui for five months (February, April, May, June and August) collected by TLU Bambui workers were received for entomological evaluations. The numbers of insects per kg of grain (Particularly weevils) and percentage insect and mold damaged grains were much higher in the Ndop samples than in the Bui samples.
2.3. Document stored grain insect species and their intensities.	2.3. Identify insect species present in each barn sample.	2.3 From the five sets of samples received the prevalent insect species identified included the maize weevil and red flour beetle. There were a few cases of the Square Necked Grain Beetle in both areas while the Angoumois Grain Moth was identified in three samples from Bui Division only.
Operation 3: Identify sources of stored grain insect pest resistance from the major grains at various ecological zones.		
3.1 Identify maize varieties which show resistance to natural infestations by storage pests.	3.1. Some 20 popular maize varieties were harvested and stored in 3 sites (Dschang, Foumbot and Santchou) for quarterly evaluation.	3.1 The 20 varieties of maize harvested and stored in three sites (Foumbot, Dschang and Santchou) in September 1990 were evaluated for resistance to storage insect pests quarterly for 12 months terminating in September 1991 and the results have been analyzed. In Dschang there were 10 additional varieties.

OBJECTIVES	ACTIVITIES	ACCOMPLISHMENTS
Operation 4: Survey rice field insects and identify rice varieties resistant to major insect pests.		
4.1. Document insects present in rice fields in different rice ecologies.	4.1. Organize sweepnet and light trap collections from various fields for identification.	4.1 There was no follow up for the collection of rice field insects in Menchum Valley as arranged because of transport constraints.
4.2. Identify rice varieties resistant to stem borers.	4.2. Establish rice stem borer nurseries at various ecological zones.	4.2 Data collection for rice stem borer nurseries was only completed for one trial at Ndop (the National Coordinated Varietal Trial - NCVT irrigated with 18 entries). The incidence of stem borer attack was generally low.
Operation 5: Test the efficacy of stored grain insecticides on maize under major traditional storage methods and suitability of plastic cans for storage of high and low moisture maize.		
5.1. Test the efficacy of popular grain storage insecticides on maize under two different methods.	5.1. Test the manufacturer's rate of SOFAGRAIN on dehusked maize cobs and threshed maize stored in jute bags.	5.1 The second and third sampling and evaluation were done on the 07/08/91 and 07/11/91 respectively. The controls were inferior to the insecticide treated grain but the untreated maize cobs were superior to the untreated threshed grain. On the contrary the insecticide was more effective in controlling insects in the threshed grain than on maize cobs.
5.2. Test the suitability of plastic cans with tightfitting lids for high and low moisture maize storage.	5.2. Threshed maize of 3 moisture contents (20.3% , 17.4% and 13.9%) was stored in 25 liter plastic cans on the 12/11/90 for the 1st 2mcs and on 11/01/91 for the 3rd mc respectively.	5.2 First evaluation after 10 months from installation was done on schedule (i.e. on 12/09/91 for the 17.4% mc and 20.3% mc; on 11/11/91 for the 13.9% mc maize respectively). No live insects were found in any can. Germination percentage dropped in all cases but much more in the 20.3% mc grain.

11.1.4 RESEARCH FINDINGS

The research findings during the period in review are summarized under the five major operations carried out.

11.1.4. Identify the Use of Natural Plant Materials by Farmers for Grain Storage Pest Control.

A farmers' questionnaire was designed and after discussion with the S.W. Provincial Delegate of Agriculture Buea and his Provincial Chiefs of Service for Agriculture and Forestry, 100 copies were given to the Provincial Chief of Service for Agriculture for distribution to the Divisional Delegates.

In October 12 completed forms were received (4 from Manyu, 2 from Kumba and 6 from Fako). Out of the 12 forms only 6 were completed for farmers who actually use natural plant materials for stored grain protection. Due to transport constraints, a follow up to visit the farmers was not possible.

Contacts will be made with the Agricultural Provincial Delegates of other Provinces particularly, West and N.W. Provinces next year. Preliminary contacts were made before the finalization of the questionnaire.

11.1.4. Identify Grain Post Harvest Losses Associated with Each Storage Method and Agro-Ecological Zone.

Objectives :

- Document grain storage Pests and intensities over the storage period in various agro-ecological zones.
- Document the various storage methods and quantify losses associated with each method and zone.

11.1.4. Materials and Methods: The operation was carried out in collaboration with TLU Bambui who were conducting a survey of farmers traditional maize stores at Ndop Sub-Division and Bui Division in N.W. Province. There were not enough staff and means to include other crops or extend the area.

The TLU staff collects and pays for a sample of 10 cobs of maize periodically from each of the monitored farmers. In 1990, 30 farmers were selected from each of the two zones but were reduced to 20 each in 1991.

The samples were sent to the UNDP/FAO Post Harvest Food Loss Reduction Project (PHFLRP) in Bamenda for loss assessment and separation of insects. The insects and sub samples were then sent to the entomologist for insect identification and other entomological evaluations. Five sets of samples for Feb., April, May, June and August were received.

11.1.4. Results and Discussion: Apart from identification of insect species, other entomological evaluations such as insect intensities per kg of grain, percentage of insect and mould damaged grain, and percentage germination were not reliable because of the long delays of the samples before they are received. However since the delays affected all the samples, the evaluation data is suitable for comparison.

The principal insect pest identified in terms of intensity and severity of grain damage was the maize weevil (Sitophilus zeamais) particularly in Ndop area where the numbers per kg ranged from 5 to 123 on the average. Other stored grain insect pests identified included the Red Flour Beetle mainly in Ndop, the Angoumois Grain Moth (Sitotroga cerealella) in Bui and the Square-necked Grain Beetle (Cathartus quadricollis).

Tables 1 - 4 summarize the numbers of maize weevils per kg of grain and the percentage of insect damaged grain during each sampling for each area.

11.1.4. Identify Sources of Stored Grain Insect Pest Resistance from the Major rains at Various Agro-ecological Zones.

Objectives:

- Evaluate traditional and introduced grain varieties for storage pest resistance.
- Investigate whether there are any differences in insect infestation and damage due to differences in ecological zones.
- Quantify grain storage losses due to insect and mould damage.

11.1.4. Materials and Methods: Only maize varieties were evaluated during the period in review. Seeds of old and new maize varieties were obtained from breeders and grown in three sites as follows: 20 varieties in Foumbot and Santchou and 30 varieties in Dschang in March 1990 and harvested in September 1990. Storage was in husk hung in bundles of 20 cobs per replication per variety at random. Six evaluation criteria were used during each observation at three monthly intervals for 12 months terminating in September 1991.

11.1.4. Results and Discussion: Evaluation criteria during each observation included the number of weevils/kg of grain, number of other insects/kg, % insect damaged grain, % mold damaged grain, % grain moisture content, and % grain germination. During the first three observations, husk tightness rating on a scale of 1 - 5 and husk extension in cm were also recorded. For this report, three evaluation criteria data (numbers of weevils/kg, % insect damaged grain and % grain germination) at the first and last observations are reported in tables 5 - 7.

From the evaluation data, it is clear that the insect populations and % insect damaged grain increased tremendously over time while the seed viability measured by % grain germination reduced to unacceptable levels by the end of the experiment. Dschang site which is highest in elevation and coldest among the three sites is supposed to store maize best but because of the highly infested environment used and artificial heating of the IRA dry house in which the storage was located, insect populations and spoilage were accelerated.

11.1. Survey Rice Field Insects and Identify Rice Varieties Resistant to Major Insect Pests.

Objectives :

- Document insect species present in rice fields in various rice ecologies.
- Identify rice varieties resistant to stemborers.

11.1.4. Materials and Methods : The first objective was not executed during the period in review. For the second objective, arrangements were made with the rice breeder to superimpose rice stem borer nurseries on some of his selected advanced yield trials at Ndop and Santchou but finally only one trial was used in Ndop. Two observations are usually made in order to evaluate the varieties including dead heart count at full tillering and white head count at the milk stage.

11.1.4. Results and Discussion: The data on the deadheart and white head counts in a National Coordinated Varietal Trial (NCVT) irrigated is reported in tables 8 and 9. It was observed that the incidence of stem borers in Ndop was very low hence it cannot be concluded that all the varieties scored are fairly resistant to stem borer damage.

11.1.4. Test the Efficacy of Popular Stored Grain Insecticides on Maize Under Popular Traditional Storage Methods and the Suitability of Plastic Cans for Storage of High and Low Moisture Maize.

Objectives :

- Test the efficacy of SOFAGRAIN on the protection of maize under two popular storage methods.
- Find out whether a second dose of the chemical will improve its effectiveness.
- Find out whether big size plastic containers with tightfitting lids can be used for long term storage of high and low moisture maize without losses from storage pests.

11.1.4. Materials and Method

The experiment was installed in IRA Dschang drying shed on 7 Feb., 1991 using a mixture of several maize varieties harvested from Dschang in September 1990. Two forms of maize were used (husked maize cobs and threshed maize) and both stored in jute bags hung in the drying house. The manufacturer's dose of 50 g of the commercial chemical/100 kg of grain was used. There were four replications per treatment. Observations were done at three monthly intervals on 08/05/91, 07/08/91, and 07/11/91 when the experiment was terminated. In the second experiment, 25-litre plastic cans with tight- fitting lids were used to store maize of three moisture contents (20.3%, 17.4% and 13.0%).

11.1.4. Results and Discussion :

A summary of the evaluation data for the three observations using six evaluation criteria is given on table 10. From the data it is observed that the non treated maize of both forms had the higher insect population and more damage than the treated maize over the storage period. Untreated threshed maize supported higher insect population and is more damaged than maize stored in cobs. On the other hand better insect pest control is obtained when chemical is applied on shelled maize than when applied on maize cobs.

The second experiment is intended to be terminated in 1992 after 18 months of storage. One evaluation was done after 10 months of storage and it was discovered that there were no live insects in any container.

Tables 1 and 2 : Number of Maize Weevils/kg of Maize Sample Collected Periodically from Farmers' Stores in Ndop and Bui Areas in N.W. Province.

Table 1 - Ndop Sub-Division

Sample No.	No. of Maize Weevils/kg or sample							
	Dec.1990	Feb.1991	April 1991	May 1991	June 1991	Aug.1991	Means	Rank
00	19.7	38.00	-	-	270.54	57.20	64.24	19
1	-	8.53	-	3.38	147.72	-	26.60	10
3	77.49	29.02	55.81	-	47.25	-	34.92	12
4	44.16	113.12	-	-	160.31	-	52.93	16
6	7.13	119.88	-	-	72.01	58.10	42.85	13
7	4.27	11.79	82.50	1.01	-	-	16.59	5
9	37.25	17.97	69.23	-	32.22	105.31	43.66	14
10	1.30	41.15	-	-	74.48	90.64	34.59	11
11	-	-	-	-	41.78	31.82	12.26	4
13	1.44	15.47	-	-	68.46	45.65	21.83	9
14	12.98	114.46	12.83	22.72	150.54	27.24	56.79	18
16	0.62	1.14	-	-	7.27	20.72	4.95	15
17	-	19.90	-	1.21	12.65	-	5.62	2
20	64.31	70.92	61.40	16.85	486.38	43.61	123.91	20
21	-	11.70	27.27	1.18	1	-	6.69	3
23	-	1.96	2.30	2.16	105.38	-	18.63	8
25	3.31	1.37	-	10.88	94.73	-	18.38	7
27	1.39	136.73	52.17	10.41	90.58	-	48.54	15
28	0.66	-	-	-	53.90	48.03	17.09	6
29	33.16	45.40	4.19	0.67	157.60	94.83	55.97	17
Totals	309.19	798.51	367.70	70.47	2,073.80	623.15	707.04	
Means	15.46	39.92	18.38	3.52	103.69	31.16	35.35	

Table 2 Bui Division

Sample No.	No. of Maize Weevils/kg of Sample							
	Dec.1990	Feb.1991	Apr.1991	May 1991	Aug.1991	Sept.1991	Means	Rank
61	-	-	-	-	5.28	1.05	1.05	14
62	-	-	-	-	-	-	-	1
63	-	1.50	-	-	2.58	1.82	0.98	12
64	2.78	-	-	-	1.32	0.62	0.78	10
65	3.35	-	-	-	-	-	0.55	8
66	-	-	-	-	5.12	4.15	1.54	16
67	-	-	-	-	-	4.56	0.76	9
68	-	-	-	-	-	-	-	1
69	-	-	-	-	6.72	1.65	1.39	15
70	-	-	-	-	-	-	-	1
71	-	-	-	-	23.60	-	3.93	18
72	-	-	1.66	-	8.69	57.20	11.25	19
73	-	-	-	-	-	-	-	1
74	2.53	3.14	-	-	68.42	-	12.34	20
75	1.42	3.69	-	-	-	-	0.85	11
76	3.37	-	-	-	9.78	-	2.19	17
77	-	0.83	-	-	-	-	0.13	5
78	-	-	-	-	1.15	0.55	0.28	7
79	-	-	-	-	-	1.19	0.19	6
80	1.88	-	-	-	4.20	-	1.01	13
Totals	15.33	9.16	1.66	-	136.86	72.79	39.22	
Means	0.77	0.46	0.08	-	6.84	3.64	1.96	

Tables 3 and 4 : Percentage Insect Damaged Grain of Maize Samples Collected Periodically from Farmers' Stores in Ndop and Bui Areas in N.W. Province.

Table 3 - Ndop Sub-Division

Sample No.	% Insect Damaged Grain							
	Dec.1990	Feb.1991	Apr.1991	May 1991	June 1991	Aug.1991	Means	Rank
00	-	8.53	1.02	14.15	14.23	48.88	14.46	18
1	2.67	3.01	11.65	16.07	23.84	-	9.54	13
3	7.14	7.50	10.34	1.77	6.80	-	5.59	9
4	9.53	13.39	0.63	-	42.85	-	11.06	15
6	-	10.54	-	1.03	24.85	12.57	8.16	11
7	5.13	-	11.67	3.66	-	-	3.41	5
9	1.36	3.12	12.73	-	17.72	6.16	6.84	10
10	-	5.35	7.51	1.79	23.48	17.85	9.33	12
11	-	-	-	-	11.24	5.50	2.79	4
13	0.32	1.03	0.39	-	6.17	0.72	1.43	1
14	4.90	3.31	9.05	7.04	43.62	5.20	12.18	16
16	0.88	-	-	0.64	0.40	9.57	1.91	3
17	-	2.04	2.67	2.45	2.50	-	1.61	2
20	2.34	6.27	14.77	-	89.05	7.04	19.91	20
21	-	0.76	11.79	19.28	-	-	5.30	8
23	0.39	0.89	4.61	1.61	16.00	-	3.91	6
25	0.35	-	1.42	9.09	47.90	-	9.79	14
27	6.98	13.78	12.30	21.21	31.04	-	14.21	17
28	2.59	-	0.62	-	7.93	12.57	3.95	7
29	2.48	14.70	4.68	1.53	32.85	63.01	19.87	19
Totals	47.06	94.22	117.85	101.32	442.47	189.07	165.25	
Means	2.35	4.71	5.89	5.07	22.12	9.45	8.26	

Table 4 - Bui Division

Sanple No.	% Insect Damaged Grain							
	Dec.1990	Feb.1991	Apr.1991	May 1991	Aug.1991	Sept.1991	Means	Rank
61	-	-	-	-	4.10	-	0.68	12
62	-	-	-	-	1.32	-	0.22	2
63	-	-	-	-	0.67	0.72	0.23	3
65	-	-	-	-	-	-	-	1
66	-	-	-	-	6.75	1.83	1.43	15
67	-	-	-	-	7.32	-	1.22	14
68	0.76	-	-	-	0.69	-	0.24	6
69	-	0.95	-	-	9.40	5.30	2.60	17
70	0.34	-	-	-	?	2.66	0.50	11
71	0.35	-	0.40	2.22	8.28	-	1.87	16
72	-	0.71	-	9.60	4.65	3.94	3.15	18
73	0.30	-	-	-	47.72	-	8.00	19
74	-	0.66	-	2.56	71.35	-	12.43	20
75	1.89	0.39	-	-	-	-	0.38	10
76	0.56	-	-	-	4.82	-	0.89	13
77	1.51	-	-	-	-	0.37	0.31	8
78	-	-	-	0.74	0.78	-	0.25	7
79	0.94	-	-	-	0.48	-	0.23	3
80	-	-	-	0.58	0.80	-	0.23	3
Totals	6.65	2.71	0.40	15.70	171.12	14.82	35.19	
Means	0.33	0.14	0.02	0.78	8.56	0.74	1.76	

Tables 5 - 7 : Numbers of Live Weevils/kg of Grain, % of Insect Damaged Grain and % Seed Germination After 3 and 12 Months of Storage of 20 Varieties of Maize Grown and Stored in 3 Sites in West Province in 1990/91.

Table 5 : No. of Live Weevils/kg of Grain

Maize Variety	No. After 3 Months Dschang	Foumbot	Santchou	No. After 12 Months Dschang	Foumbot	9 Months Santchou*
ACROSS 8701	18.5	4.5	1.5	143.33	201.50	111.50
ATP B'BUI 89 A	9	3	1.5	178.50	145	43
BACOA	7	8.5	3	164.50	147	-
CHS 8501-CI	16	3	6	240	144	132.50
CHS 8503-CI	23	0.5	5	200	179	192
COCA	8.5	5.5	8	380	191	232.66
COMPOSITE 290	13.5	13	5	184	224	75.33
EARLY WHITE Fbt 89	14	5	0.5	205	131.50	88
EKONA WHITE	9	5	0	273	129.50	158.50
EKONA YELLOW	21	8.5	1	357.33	199	86
HAP SANTA 89 A	9	0.5	1.5	196	126	114.50
KASAI I	7	0	0	60	206	14.66
LOCAL	5.5	0	0.5	89.33	93	13.50
MLC	13.5	0	1.5	125	193	98.66
MSR(Fbt 87)	19	3	0.5	163.50	172	51
NDOCK 8701	10.5	0	7	261	140.50	84
SHABA	3.5	2	3.5	196	171.50	35.33
SUWAN I	25.5	1	4.5	299	170.50	47.33
SYNTHETIC (Fbt 89)	16.5	0.5	1.5	453.33	200	170.50
TOTALS	269	64	56.5	4168.82	3291	1768.3
MEANS	13.45	3.2	2.82	219.41	164.55	93.06

* All the maize was destroyed by rats after 9 Months sampling was done in Santchou.

Table 6 : % Insect Damaged Grain

MAIZE VARIETY	AFTER 3 MONTHS Dschang	Founbot	Santchou	AFTER 12 MONTHS Dschang	Founbot	9 MONTHS Santchou*
ACROSS 8701	3.30	0.27	1.24	56.79	47.21	14.68
ATP B'BUI 89 A	1.64	0.87	3.12	44.08	46.85	13.54
BACOA	2.69	0.47	1.32	43.53	61.26	-
CHS 8501-CI	0.61	5.31	3.39	46.86	68.95	16.24
CHS 8503 CI	2.37	1.15	3.91	42.86	50.43	36.74
CHS 8507 CI	2.39	1.16	1.81	-	43.32	7.72
COCA	1.26	1.98	2.27	69.87	58.31	47.02
COMPOSITE 290	2.19	1.66	1.33	54.70	43.36	51.42
EARLY WHITE(Fbt 89)	10.65	0.19	0.16	49.71	45.11	20.68
EKONA WHITE	8.75	0.64	0.93	55.45	51.18	22.44
EKONA YELLOW	4.14	0.20	1.04	35.57	57.43	6.98
HAP SANTA 89 A	1.11	0.36	2.86	53.18	41.65	28.55
KASAI I	1.85	1.38	0.59	42.10	47.04	13.10
LOCAL	1.48	0.33	1.12	43.29	40.59	2.72
MLC	2.77	0.55	3.01	62.35	59.79	24.17
MSR (Fbt 87)	5.24	0.78	3.06	55.77	46.83	9.65
MDOCK 8701	9.18	0.47	1.23	58.28	62.56	24.23
SHABA	2.56	1.05	1.09	57.26	44.93	12.00
SUWAN I	10.06	0.20	2.31	56.11	40.87	4.34
SYNTHETIC (Fbt 89)	1.71	0.40	2.38	62.82	67.85	27.57
TOTALS	75.95	19.42	38.17	990.58	1025.52	383.79
MEANS	3.79	0.97	1.90	52.13	51.27	20.19

* All the maize was destroyed by rats after 9 months sampling was done in Santchou.

Table 7 : % Seed germination

MAIZE VARIETY	AFTER 3 MONTHS Dschang	Foumbot	Santchou	AFTER 12 MONTHS Dschang	Foumbot	9 MONTHS Santchou*
ACROSS 8701	56	87	94	10.6	15	63
ATP B'BUI 89 A	64	75	91	2	0	35
BACOA	62	76	83	5	1	-
CMS 8501-CI	44	80	74	0	8	7
CMS 8503 CI	68	75	84	0	8	39
CMS 8507 CI	86	80	89	-	14	82
COCA	66	74	72	0	4	29
COMPOSITE 290	64	85	84	0	2	5
EARLY WHITE(Fbt 89)	68	72	94	3	0	4
EKONA WHITE	60	81	94	0	4	42
EKONA YELLOW	58	90	92	0	14	33
HAP SANTA 89 A	72	69	82	0	1	29
KASAI I	58	76	96	10	2	8
LOCAL	96	93	92	18.6	12	73
MLC	72	82	81	0	0	56
MSR (Fbt 87)	62	96	94	0	0	12
NDOCK 8701	40	82	88	0	14	35
SHABA	68	72	62	0	0	50
SUWAN I	58	84	83	0	8	54
SYNTHETIC3(Fbt 89)	68	79	97	0	2	49
TOTALS	1290	1608	1726	49.2	109	705
MEANS	64.2	80.4	86.3	2.58	5.45	37.10

* All the maize was destroyed by rats after 9 months sampling was done in Santchou.

Table 8 : Cameroon Rice Stem Borer Screening (CRSBS) - 1990
Deadheart Field Count Sheet.

Name of Variety	Rep. 1		Rep. 2		Rep. 3		Rep. 4	
	Total No.of tillers	No. Infes-ted	Total No.of tillers	No. Infes-ted	Total No.of tillers	No. Infes-ted	Total No.of tillers	No. Infes-ted
ITA 222	1739	1	991	0	805	1	1521	0
ITA 212	1468	1	1161	1	748	0	418	0
ITA 308	1294	1	936	0	1138	1	981	3
NANG NG HIEP 75-5	1021	2	774	1	1492	3	1231	1
CISADANE	810	0	1073	3	892	5	1321	2
CICA 8	1148	0	1129	1	790	1	1175	0
IR 7167-33-2-4	879	4	1020	3	976	3	1121	2
IR 7167-33-2-3	836	1	1221	1	829	4	962	2
TAINAN V	826	1	850	2	882	2	1147	1
IR 46	1632	2	854	2	1133	1	1162	1
KAUSHIUNG SENYU	1067	1	1154	1	1127	0	1126	1
B 298838-SR-51-1-2-3-1	1087	4	1359	3	932	1	628	1
RNR 29692	861	6	791	2	1094	2	1321	2
B 2162-CMR-57-1-3-1	1025	3	933	1	949	3	1084	3
TOX 3145-34-2-3	1035	4	865	3	1384	1	1280	4
TOX 3344-3-4-1	1524	2	887	1	745	2	1481	3
BNK 7033-3-3-2-2-3	1027	6	987	2	1304	4	1002	2
TOX 3344-34-3-2	1651	6	733	3	1370	2	1020	1

N.B. Percentage deadhearts ranges from 0 - 0.7% which could be considered negligible.

Table 9 : Cameroon Rice Stem Borer Screening (CRSBS) - 1990
White Head Field Count Sheet.

Name of Variety	Rep. 1		Rep. 2		Rep. 3		Rep. 4	
	Total No.of Productive Heads	No. Infested	Total No.of Productive Heads	No. Infested	Total No.of Productive Heads	No. Infested	Total No.of Productive	No. Infested
ITA 222	1253	5	1001	1	870	0	1300	1
ITA 212	1022	7	1221	3	722	0	511	17
ITA 308	1198	4	1169	3	1211	0	917	3
NANG NG HIEP 75-5	982	4	887	0	1009	2	1041	4
CISADANE	873	0	903	1	808	1	1008	0
CICA 8	1042	1	1123	1	932	1	982	0
IR 7167-33-2-4	962	0	1007	0	1121	4	1013	1
IR 7167-33-2-3	849	0	940	0	746	0	911	10
TAINAN V	1022	0	1055	0	990	0	837	1
IR 46	1415	2	1561	0	1208	4	1110	3
KAUSHIUNG SENYU	1349	1	1211	1	1234	0	1131	1
B 298838-SR-51-1-2-3-1	1442	2	1140	2	952	2	587	0
RHR 29692	1221	2	1198	1	962	0	936	0
B 2162-CMR-57-1-3-1	1202	2	972	1	838	0	1002	0
TOX 3145-34-2-3	1308	0	1470	7	1285	0	1190	3
TOX 3344-3-4-1	1450	3	940	0	992	1	817	0
BNK 7033-3-3-2-2-3	1280	4	1311	3	1182	1	993	10
TOX 3344-34-3-2	1414	0	1200	4	962	0	1001	1

N.B. Infestation level ranges from 0 - 3.3% which is very low or scores of less than 01.

Table 10 : Evaluation Data of Maize Treated with SOFAGRAIN (Thresned and in Cobs) and Stored for 9 months in Dschang.

Treatment	No. of Live Insects per kg of Grain		% Damaged Grain By Insects	By Mould	% mc	% Germt.
	Weevils	Other Insects				
INITIAL DATA						
THRESHED MAIZE	14	0.66	1.42	7.34	17.06	56
MAIZE IN COBS	20	12	3.64	4.25	16.4	48
1st OBSERVATION (3 MONTHS AFTER INSTALLATION)						
CONT.GR	391	14.5	46.01	6.16	15.45	14
CONT.COB	192	38.5	22.01	4.25	15.70	41
GRAIN T	15.5	2	7.23	6.89	15.70	62
GRAIN TT	1.5	1	7.97	6.78	16.07	56
COB T	31	2.5	11.41	8.40	15.67	62
COB TT	43	4	16.78	25.82	15.72	47
2nd OBSERVATION (6 MONTHS AFTER INSTALLATION)						
CONT.GR	350.5	28.5	49.13	5.34	17.9	0
CONT.COB	350	62.0	28.54	7.94	17.5	27
GRAIN T	2.5	0.5	7.06	5.94	17.3	25
GRAIN TT	1	1	6.62	6.78	16.0	31
COB T	69.5	9.5	20.02	8.67	17.0	41
COB TT	57.5	9.5	12.47	5.88	17.4	35
3rd OBSERVATION (AFTER 9 MONTHS INSTALLATION)						
CONT.GR	478.5	113	80.09	9.17	16.52	0
CONT.COB	232	92.5	43.82	9.12	16.62	11
GRAIN T	2.5	9.5	10.98	7.75	16.92	14
GRAIN TT	2	0	7.42	8.00	16.57	16
COB T	151.5	56.5	29.76	10.91	16.00	13
COB TT	93.5	27	22.80	16.54	15.65	18

CONT.GR = Threshed Grain Not Treated ; CONT.COB = Untreated Maize in Cobs ; GRAIN T = Threshed Grain Treated Once ; GRAIN TT = Threshed Grain Treated Twice ; COB T = Maize Cobs Treated Once ; and COB TT = Maize Cobs Treated Twice.

10.3 LOWLAND CEREALS ENTOMOLOGY

10.3.1 INTRODUCTION

The lowland Cereals Entomology unit is charged with carrying out basic and applied research on insect pests of maize in the forest region of Southern Cameroon covering the South West, Centre, South and East provinces. The main entomological constraints to maize production are Lepidoterous field insect pests seconded by Coleopterous storage pests. A large proportion of maize in this region is consumed fresh and only small quantities are stored as seeds. Consequently priority should be given to solving field pest problems. Storage insects cause most of their damage indoors (relatively stable environment) and control methods developed elsewhere could be applicable here.

The goal of the Lowland Cereals Entomology unit is to develop environmentally sound and economically profitable maize insect pest control methods for the rural farmer through an integration of suitable and appropriate cultural, biological, host plant resistance and chemical methods. In 1987, 88, 89, 90 research activities carried out by Mrs. Aroga at Minkomeyos consisted of assessing Furadan (insecticide) for control of stem borers, effects of intercropping peanut and manioc with maize on the dynamics of borer populations and influence of planting dates, land preparation method and soil fertilization on borer incidence. In 1989 Dr. Bosque-Perez (I.I.T.A) provided seeds (rating scale also) of some maize genotypes with known resistance to some stem borer species. Mrs. Aroga in collaboration with Dr. Thé is assessing the performance of these materials and some local one vis-à-vis natural infestations of *Bussola fusca* at Minkomeyos. So far, no results or recommendations are available from these activities for on-farm assessment.

In 1990 an additional Entomologist Ms R. N. Ndemah joined the project and was attached to the Nkolbisson TLU. Second season 1990 sampling for stem borers in farmers' maize fields in two agroecologies; semi-humid forest and forest/Savannah transition by the Nkolbisson TLU entomologist revealed marked differences in incidence, severity, impact on yield and field management practices between these two zones. This implies or suggests that stem borer research should be ecologically circumscribed as results obtained in one zone are likely to be in appropriate in another. To complement the above findings, the TLU Entomologist is carrying out on-station monitoring during 1991 in three agroecologies represented in the lowland forest. This to determine the composition of the borer complex and the species largely responsible for losses in each zone.

10.3.2 SUMMARY OF PROGRAM ACTIVITIES

The activities of this unit were jointly carried out by the two Entomologists: Mrs. Aroga and Ms. Ndemah:

Ms. NDEMAH

During the cropping seasons of 1991, maize borer monitoring was carried out in 4 on-station locations: Ntui (transition), Minkomeyos (semi-humid forest), Nkoemvone and Mbalmayo (humid forest) and at the 51 sites of the Nkolbisson TLU regional testing program. 23 on-farm maize borer control (carbofuran by marshall seed treatment trials were carried out in Nkolfep (forest zone) and Kiki (transition zone).

Mrs AROGA

The activities of 1991 cropping seasons have been based on 2 locations: Mikoameyos and Ntui. A total number of 10 experiments have been conducted.

10.3.3 ACCOMPLISHMENTS

Objectives	Activities	Accomplishments
Operation 1: Pest monitoring and studies on pest biology		
1.1. Provide information on incidence, severity and losses.	1.1.1 Maize borer monitoring at 4 on-station and 51 regional test sites in 3 agroecologies: high humid, semi-humid and forest/savannah transition.	1.1.1 "Hotspot" locations identified. Borers more abundant and damaging on stems in the forest zone whereas ear borers are more of a problem in the transition zone during the first season.
	1.1.2 A trial on yield reduction at Minkomeyos. Different categories of plants have being marked: unattacked, those with holes on leaves and those with holes on stems.	1.1.2 The yield of different categories of plants (attacked and unattacked) has been compared.
	1.1.3 A trial on impact of Mussidia sp at Minkomeyos.	1.1.3 A trial was done on the influence of Mussidia sp at Minkoameyos, Mendong and Ntui for. Their harvests were staggered on 4 dates spaced two weeks apart. Each time the rate of attack on the ears and the distribution of the species present were noted.

Objectives	Activities	Accomplishments
1.2. Determine borer complex distribution and relative abundance of species at various agroecologies and assess zonal significance.	1.2.1 Identify and compare abundance of borer species present on 2 maize varieties largely adopted by farmers: CMS 8501 and CMS 8704 at 3 agro-ecologies.	1.2.1 Sesamia spp, Eldana saccharina and Musidia nigrivenella were the predominant borers found in all the locations with M nigrivenella particularly abundant in Ntui (transition zone). Chilo spp encountered early seasons at Ntui and at harvest in Mbalmayo.
	1.2.2 Distribution of different species in the year at Minkomeyos is followed up monthly.	1.2.2 The distribution of species of stem borers and grain borers on maize was studied from April 1991 to April 1992.
1.3. Develop fast suitable and appropriate methodologies to estimate populations in pest management trials on-farm and on-station.	1.3.1 Relate various infestation measures to yield.	1.3.1 Due to workload coupled with IRA strike, not sufficient data was taken to answer this objective. Carried forward to 1992.
1.4. Characterize biology of pests.	1.4.1 Larvae reared.	1.4.1 A total of 4867 larvae (1463 B.f, 1726 S.c and 215 E.s) were reared in the first season and part of the second season. Information on their biology and stages of development was collected.
	1.4.2 Insects are allowed to oviposit on unattacked plants in order to determine their reference at the time of egg-laying.	1.4.2 A total of 160 females of B.f. (51), S.c (59) and E.s. (50) were allowed to oviposit on plants of sound maize. Their egg laying was monitored daily and the place of oviposition recorded.
Operation 2: Identify role of natural enemies in dynamics of pest populations.		
2.1. Monitor and document incidence of natural enemies of various stem borer stages.	2.1.1 Mass collection and rearing of various stages of stem borers.	2.1.1 Some larval and pupal parasitoids of Busseola fusca and Sesamia calamistis collected. These will be sent via IITA for identification.

Objectives	Activities	Accomplishments
2.2. Assess selectivity of insecticides vis-à-vis parasites at trial sites.	2.2.1 Monitor incidence of natural enemies of stem borers at on-farm insecticide trial sites.	2.2.1 No progress due to workload. Carried forward to 1992.
Operation 3: Assess efficacy of various insecticides.		
3.1. Identify cost effective rates of insecticides for "quickest impact".	3.1.1 On-farm assessment (in the 2 TLU pilot villages) of Carbofuran with or without marshall seed treatment.	3.1.1 Significant grain weight (15% moisture) and financial benefit of Marshall maize seed treatment in Kiki and highly significant marketable fresh ear weight and financial benefits of 0.1g/plant 10% carbofuran in Nkolfep. (Full results under Nkolbisson TLU section).
	3.1.2 Four doses of furadan are compared for their efficacity against stem borers at Minkoneyos.	3.1.2 Four rates of furadan were applied on maize 40 days after planting and the effectiveness of each, as well as influence on the distribution of species has been compared.
3.2. Generate data on insecticide residues in protected crop.	3.2. Residue analysis in harvested crop.	3.2. Not realized due to lack of appropriate equipment for chromatography.
Operation 4: Assess effect of some field management practices		
4.1. Assess effect of marshall seed treatment on stand establishment and borer incidence/severity.	4.1 24 on-farm trials in the 2 TLU pilot villages.	4.1 Plots receiving seed treatment had 3600 ± 900 plants/ha more in Nkolfep than those without seed treatment. (See Nkolbisson TLU section of this report for details).
4.2. Identify and compare impact of various types of association on borer attack.	4.2. A trial on impact of intercropping maize, peanuts and cassava.	4.2. Two trials were conducted to evaluate the influence of intercropping maize with peanut/cassava on stem borers population dynamic.

Objectives	Activities	Accomplishments
4.3. Evaluate influence of soil fertility on the evolution of attack.	4.3. A trial on 4 rates of 20-10-10 at Minkomeyos.	4.3. Four rates of NPK (20-10-10) were utilized to fertilize the soil. The influence on development of attacks, distribution of species and sequence of appearance of species was evaluated.
4.4. Evaluate influence of type of land preparation on pillulation of borers.	4.4. A trial on the influence of burning stubble on the evolution of attacks with 3 types of plots; one with stubble burned, one without stubble and another with stubble.	4.4. The trial were not conducted due to workload.
Operation 5: Identify maize varieties with some resistance to stem borers		
5.1. Identify tolerant varieties.	5.1. A trial on the comparison of 84 varieties implemented with the collaboration of the breeding unit.	5.1. The behavior of 84 varieties with respect to attacks of stem borers and grain weevils was compared at Minkoameyos in the first crop season. Of these varieties, 61 were chosen for their tolerance and their behavior is being monitored at Ntui.
5.2. Identify susceptible varieties.	5.2. Four varieties from IITA known to be very susceptible compared with local varieties.	5.2. The trial were not conducted due to workload.

10.3.4 RESEARCH FINDINGS

10.3.4.1 MONITORING MAIZE BORERS AND THEIR NATURAL ENEMIES (Operations 1 and 2)

This activity was a follow-on of an earlier extensive study carried out during the second season of 1990 in farmers' fields. The objectives were to monitor natural infestations of these Lepidoterous pests in three agroecologies so as to gather baseline information on:

1. The relative abundance of the various borer species and subsequently determine which species is or are largely responsible for losses in each zone.

2. When infestations begin, their evolution, severity etc, in relation to crop growth stage in each location (important for type, time and method of control to achieve optimum effects).

3. Which locations to recommend to the breeders (hot spots) for screening germplasm for resistance, as no facilities for artificial infestations are available.

4. The incidence of natural enemies parasites, predators etc as a first step towards quantifying their role in the suppression of borer populations, as well as diagnose the role of alternate host plants (native grasses) as sources of infestation and refuge for these natural enemies when field maize is out of season.

All the above information which has been lacking so far is very necessary for the elaboration of sound and meaningful control measures for these pests.

MATERIALS AND METHODS

Two plots of 20m x 5m each were planted to the composite maize varieties, CMS 8501 and CMS 8704, within one week in four locations; Ntui, (forest/savannah transition) Minkomeyos, (semi-humid forest) Nkoemvone (humid forest) and Mbalmayo (humid forest) during the first and second seasons of 1991. Both maize varieties have the same maturity cycle. At 2, 5, 9 and 14 weeks after planting, 25 plants were randomly sampled per variety and various borer incidence, severity, and species composition counts and measures made.

RESULTS

Due to the IRA strike and other reasons, not all the observations were realized as planned. However, findings from preliminary analyses of available data are:

Objective I

Second season

At 9 weeks after planting, Sesamia spp and Busseola fusca were the predominant borers, with Sesamia spp. being the more abundant, especially on CMS 8704 in all 3 locations; Ntui, Minkomeyos and Mbalmayo. At Mbalmayo the incidence of Sesamia was equally high on CMS 8501

At 14 weeks after planting, a complex of 5 species: B fusca Sesamia spp, Eldana saccharina, Musidia nigrivenella and Chilo spp were found in Mbalmayo, with E saccharina being the most abundant on CMS 8501 and Chilo spp on CMS 8704 (Figure 1 & 2).

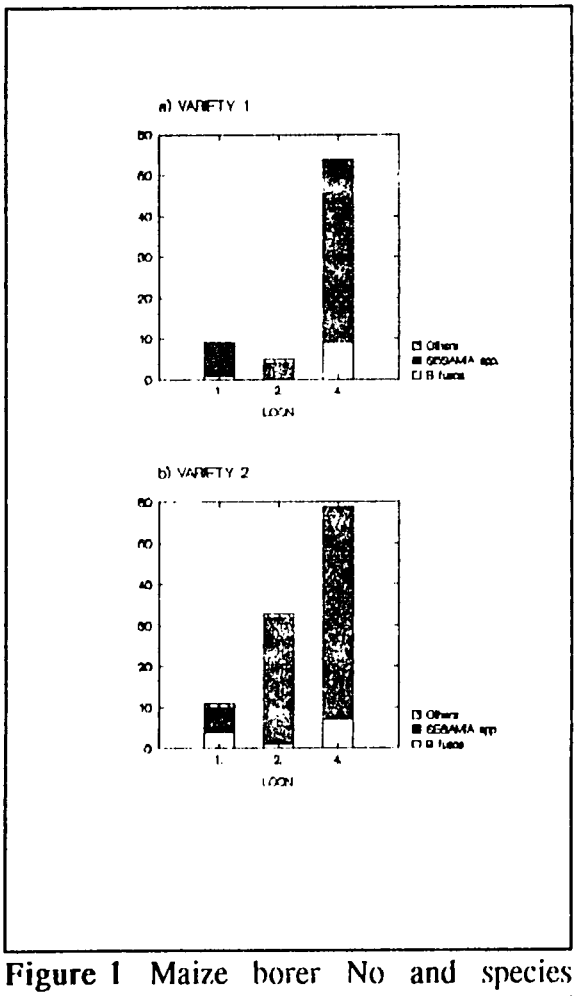


Figure 1 Maize borer No and species composition at 9 weeks after planting (2nd season 1991)

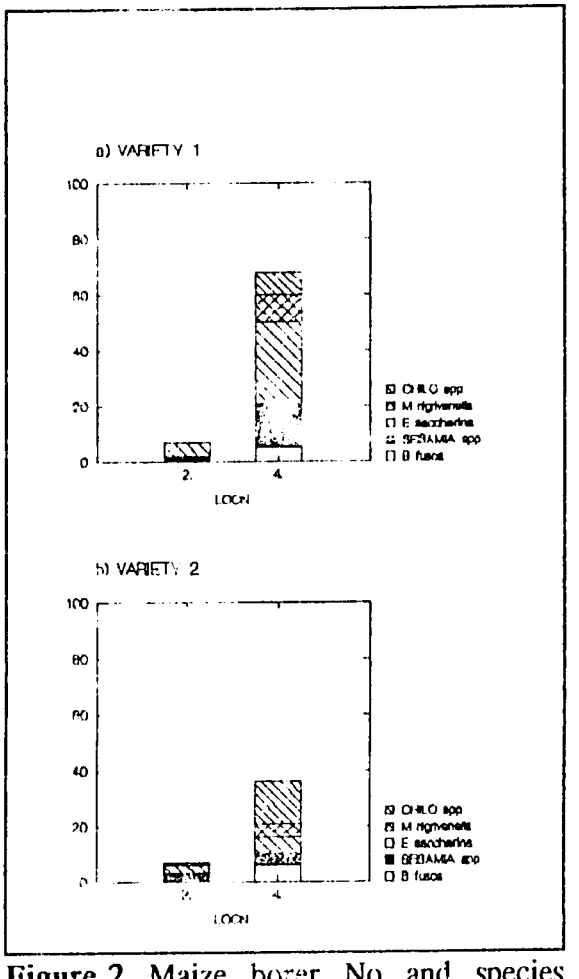


Figure 2 Maize borer No and species composition at 14 weeks after planting (2nd season 1991)

LOCN = Location
1 = Ntui
2 = Minkomeyos
4 = Mbalmayo

Variety 1 = CMS8501
Variety 2 = CMS8704

First season

At harvest (14 weeks after planting in Minkomeyos and 15 weeks after planting in Ntui and Nkoemvone) M nigrivenella was the most abundant in Ntui, 80.9% on CMS 8501 and 87.6% on CMS 8704. In absolute numbers there were 78 out of 89 M. nigrivenella larvae on CMS 8704 and 17 out of 21 on CMS 8501. In Minkomeyos Sesamia spp was the most abundant on CMS 8501 (39%) while E saccharina was more on CMS 8704 (58.1%). E saccharina was most abundant on CMS 8501 (72%) in Nkomvone while on CMS 8704 Sesamia spp (41.A%) and M. nigrivenella were the most important (50.7%). (Table I).

Table 1 : Distribution and species composition of borer larvae and pupae in stem and ears of 25 plants at first season 1991.

Location and variety	Total number	% in ears	% in stems	% ears with borer damage	stem length tunnelled	No and percentage			
						B fusca	Sesamia spp	E saccharina	M nigrivenella
Ntui									
CMS 8501	21	90.5	9.5	40	1.2	0 0%	1 4.8%	3 14.3%	17 80.9%
CMS 8704	89	92.1	7.9	65.4	0.5	0 0 %	8 9%	3 3.4%	78 87.6%
Minkomeyos									
CMS 8501	18	33.3	66.7	17.9	1.5	1 5.6%	7 39%	4 22.2%	6 33.3%
CMS 8704	31	29.0	71.0	19.23	2.6	2 6.4%	8 25.8%	18 58.1%	3 9.7
Nkoenvone									
CMS 8501	25	32	68	32	6.7	3 12%	4 16%	18 72%	0 0%
CMS 8704	73	56.2	43.8	16	2.0	2 2.7%	30 41.1%	4 5.5%	37 50.7%

Objective 2

Second season

Infestations began quite early in Ntui (2 weeks after planting with about 40% incidence on CMS 8704, dropped, then reaching 52% on CMS 8501, 9 weeks after planting. Due to the IRA strike, Ntui results for the 4th sampling date are missing.

On the other hand, during the first samplings in Mbalmayo at 3 weeks after planting infestations were low (below 40% on CMS 8704) but increased sharply, reaching a peak of 92% on both varieties, 9 weeks after planting. Borer severity rated by the total number of larvae and pupae per 25 plants at each sampling date, the mean number of larvae and pupae per plant and percent stem tunnelling at 9 and 14 weeks after planting were highest at

Mbalmayo, with a mean number of larvae per plant of 2.72 and 12.13% stem tunnelling on CMS 8501, 14 weeks after planting (Figures 3 and 4 and Table 2). At Ntui and Minkomeyos, infestations remained less severe throughout the sampling dates except at 9 weeks after planting when the mean number of larvae per plant was 1.32 on CMS 8704 at Minkomeyos (Figure 3 and 4 and Table 2).

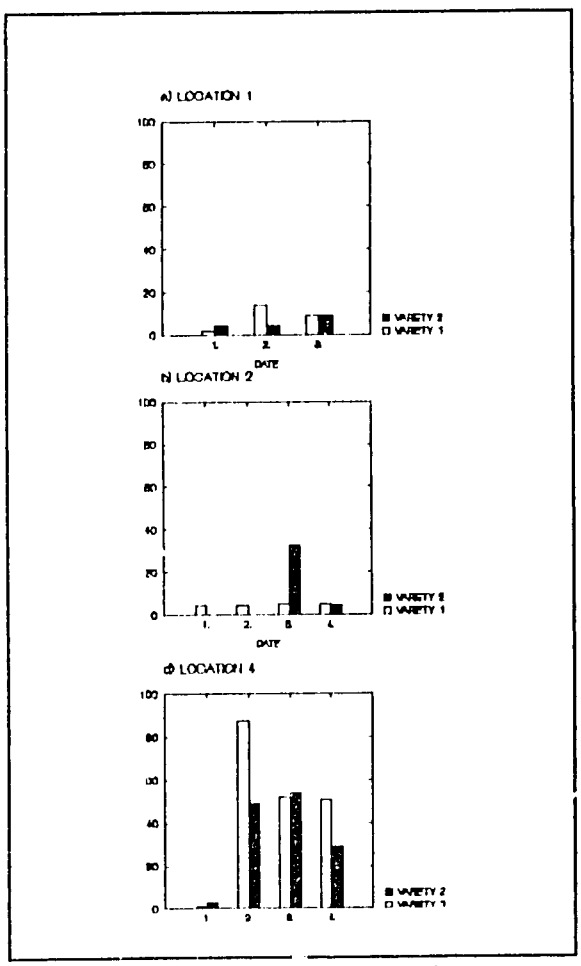


Figure 3 Total No of larvae and pupae per 25 plants against sampling date

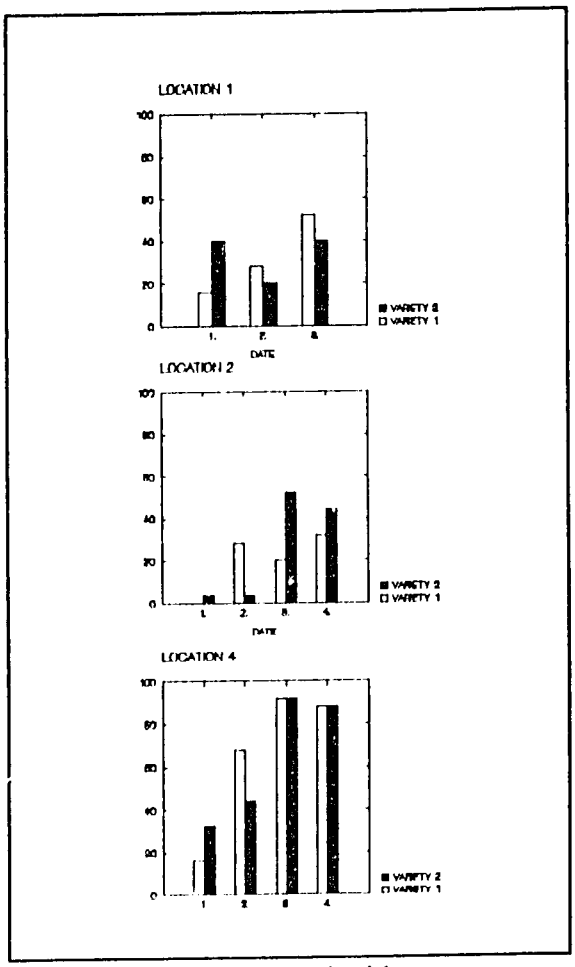


Figure 4 Percent borer incidence on stems against sampling date.

1 = Sampling at 2 weeks after planting (2WAP)
except at Mbalmayo = 3 WAP
2 = Sampling at 5 WAP Location 1 = Ntui
3 = Sampling at 9 WAP Location 2 = Minkomeyos
4 = Sampling at 14 WAP Location 4 = Mbalmayo

Table 2 : Mean number of larvae per plant and % stem tunnelling per 25 plants at 9 and 14 weeks after planting, 1st season 1991.

Location and variety	9 weeks after planting		14 weeks after planting	
	Mean No of larvae per plant	% stem tunnelling	Mean No of larvae per plant	% Stem tunnelling
Ntui				
CMS 8501	0.36	0.014	M.D	M.D
CMS 8704	0.44	0.028	M.D	M.D
Minkomeyos				
CMS 8501	0.20	0.006	0.28	1.85
CMS 8704	1.32	0.005	0.28	1.23
Mbalmayo				
CMS 8501	2.28	0.028	2.72	12.13
CMS 8704	2.32	0.04	1.44	5.8

1st season

In Ntui at harvest, over 90% of the larvae encountered were in the ears of both varieties as opposed to less than 10% in stems. On the contrary in Minkomeyos and Nkoemvone over 66% of the larvae encountered were found in stems except on CMS 8704 in Nkoemvone where 56% of the larvae were in ears. 40% of CMS 8501 and 65.4%, CMS 8704 ears had grain with borer damage in Ntui while at Minkomeyos and Nkoemvone ear damage was less important. Stem tunnelling was most important in Nkoemvone (Table2).

Objective 3

Second season

From the descriptions under objectives I and 2 above, Mbalmayo clearly shows as a hotspot where the breeders could screen germplasm for detecting varieties with sources of resistance to stem borers. Based on stem damage incidence, severity, and species composition, this location had the highest ratings (Figures 1, 2 and Table 2).

1st season

By closely following up the CMS 8704 and CMS 8501 maize adoption plots of the Nkolbisson TLU regional testing program the following hot spots (based on trial site observations and discussion with farmers) were diagnosed. Nkolkosse, Ngoumou, Evoudoula (semi-humid forest), Ngoulemakong, Ngomezap, Mvieng (humid forest) and Bafia town (transition). To these sites should be added Nkolfep (semi-humid) one of the TLU pilot villages, where infestation were so severe during the first season that farmers had to treat with insecticide.

Objective 4

Findings, both from the field monitoring and on-farm control trials consistently reveal marked differences in incidence and severity of maize borers following locations. Both biotic and abiotic factors account for these observations: Biotic factors, notably parasites, predators and alternate host plants could play a crucial role in the sound and strategic control of these pests.

Some hymenopterous and Dipterous larval and pupal parasites were collected. These will be sent via IITA for identification. However, due to work load most of the work planned was not realized. Henceforth, this will form a major operation.

Discussion

As a first indication of the importance of monitoring, results of the maize borer control (carbofuran by marshall seed treatment) factorial trial designed and implemented by the Nkolbisson TLU as a consequence of results from preliminary monitoring, confirmed the importance of surveys in developing suitable and appropriate control measures. Carbofuran at the rate of 0.1g/plant gave both highly significant yield and financial benefits in Nkolfep (forest zone), where borer incidence and severity is very high whereas Marshall seed treatment had both significant yield and financial benefits over no seed treatment in Kiki (transition zone) where infestations though lower, begin quite early (see appropriate section under Nkolbisson TLU of this annual report).

Secondly, contrary to the believe up till now that Busseola fusca was the most damaging borer species in the lowland forest (evidenced by the Busseola screening trials to detect sources of resistance at Minkomeyos), Sesamia spp, Eldana saccharina and Musidia nigrivenella were the most abundant species in all the locations sampled, Chilo spp is also becoming important.

ON-FARM ASSESSMENT OF TWO CARBOFURAN RATES WITH OR WITHOUT MARSHALL SEED TREATMENT (Operations 3 & 4).

See section on identifying appropriate crop protection practices under the Nkolbisson TLU

Experiment No. 1: **Yield reduction due to stem borers on Bafia and DMR varieties**

The objective of this experiment was to evaluate the yield loss attributable to different types of attacks of borers; that is holes on the leaves, death of the tassel and holes in the stems. The results are presented in tables 1, 2, 3 and 4.

1. Holes in the leaves

One of the first signs of attacks in maize is the presence of holes more or less circular on the surface of the leaves. These holes may be sparse or abundant, depending of the severity of the attacks.

The results in tables 1 and 2 show that around 70% of the plants presenting holes in the leaves had borers in their stems. The weight of the cobs had been affected by this type of attack. This could be explained by fact that these attacks occurred very early when the plant did not yet pass its critical period. The holes in the leaves should cause a reduction of the foliar surface. That should be able to provoke disturbances in the development of the plant. The average height of the plant was also affected by the attacks. The average length of the ears seems not be affected by the type of attack.

2. Holes on the stem

his Another sign of attack by borers is somewhat diffused. It is demonstrated by the presence of several holes on the stem. The precise location of these holes vary according to the species. They may be circular at the base of the stem or at the level of the nodes (*Sesamia calamistis*) be over the nodes (*Eldana saccharina*) or between the nodes (*Busseola fusca*). This provokes a disruption of the internal structures of the plant, which affects the normal development of the ear and of the grain (Appert and Deuse 1982). Within the framework of this work, tables 1, 2 and 3 show that more of the plants with a hole have several tunnels inside and the average percentage of the stem length bored varies with the number of the holes. It will become more important with a large number of holes in the stem (table 4).

The mean weight of the ears is also inversely proportional to the number of holes per stem. In establishing a correlation between the average percentage of the stem length bored and the average weight of the ears, we obtained a negative coefficient of correlation $r = -0.73$ in the case of the variety DMR. In the case of the variety Bafia, the coefficient was weakly positive ($r = 0.2$). The reduction of the height of the plant and of the length of the ears seems to be less important here with respect to the first two categories of attacks.

CONCLUSION

The different types of attacks considered in this work seem to influence to a degree the yield of maize. The holes on the leaves seem to cause more losses may be because they intervene during the phase where the plant is more sensitive. It is therefore important to take into account this type of damage at the time of choosing methods of control.

Table 1: Variation of plant height and mean ear weight of DMR as a function of the type of attack

Categories	Number of plants	% plants without borers	% average with stem bored	average weight of ears (g)	average height of plants
Healthy Plants	10	10	0.9	227.5	2.22
Plants with bored leaves	10	70	7	167.5(26)*	1.94 (13)
Plants with dead tassel	9	89	8.4	115 (38)	1.72 (22)
Plants with 1 stem borer	6	83	6.2	162.5(25)	2.13 (4)
Plants with many stem borers	21	100	9	154 (35)	2.02 (9)

* The figures in parenthesis represent percentage of reduction compared to the first category

Table 2 : Variation of plant height and of mean ear weight of Bafia as a function of the type of attacks

Categories	Number of plants	% plants without borers	% average with stem bored	average weight of ears (g)	average height of plants
Healthy Plants	15	20	0.4	112	2.45
Plants with bored leaves	15	69	8.4	50 (55)*	2.04 (17)
Plants with dead tassel	15	87	9.6	53 (53)	1.60 (35)
Plants with 1 stem borer	10	70	3.2	67.5(40)	2.04 (17)
Plants with many stem borers	15	100	11.4	84 (25)	1.93 (21)

* The figures in parenthesis represent percentage of reduction compared to the first category

Table 3: Variation of length of ears as a function of types of attacks

Categories	DMR		Bafia	
	Number of ears	average length (cm)	total number of ears	average length (cm)
Healthy plants	17	16	10	19
with bored leaves	17	13 (21)*	10	17 (12)
with dead tassel	15	13 (21)	11	15 (23)
with 1 hole in stem	14	14 (13)	8	17 (11)
many holes in stem	15	16 (5)	21	18 (9)

* The figures in parenthesis represent percentage of reduction compared to the first category.

Table 4: Variation of average percentage of stem damaged as a function of the number of holes on the stem

Holes per plant	DMR		Bafia	
	% mean of stem infected	mean weight of ears (g)	% mean of stem bored	mean weight of ears (g)
1	6.20	162.50	4.50	94.50
2	7.13	160	6.00	74.00
3	10.06	145	7.60	55.00
+ de 3	10.09	158	18.40	99.00

Experiment N° 2: Influence of Mussidia nigrivenella on grain yield of maize.

The objective of this study was to evaluate the impact of Mussidia sp which is a larva of lepidoptera which attack stored maize and which appears prior to harvest. The variety utilized was "Bafia". At maturity, 4 plots were harvested at two week intervals. The ears were classified following their degree of attack in four categories:

- sound ears (cat. 1)
- ears slightly attacked (cat. 2)
- ears heavily attacked (cat. 3)
- ears completely destroyed (not useable) (cat. 4)

The average weight of each category was recorded, as well as the distribution of the species present. The following results were obtained:

1. Attacks on ears

Table 1 presents the variation of attacks on ears of the variety Bafia harvested at 15, 17, 19 and 21 weeks after planting, respectively. Examination of this table shows that at 15 weeks after planting, only 24% of the ears showed no signs of attack. 50% were already slightly attacked, while 9% were heavily attacked or completely destroyed. Moreover the average weight of the ears begins to be reduced when they were heavily attacked (Table 2). A reduction of 17% was recorded on the average weight of ears passing from cat. 1 cat. 3. This reduction increases to 56% in the category of the destroyed ears. This means that in harvesting the dry maize 15 weeks after planting, 9% of the ears are already lost because they were completely destroyed by borers.

Table 1: Variation of the attacks of borers on ears of maize, variety Bafia harvested at 15, 17 and 21 weeks after planting

Weeks after Planting	ears harvested	Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5
15						
Total number	1014	201(20)*	446(44)	108(11)	73 (7.2)	170 (17)
Mean weight per ear (g)	60.5	70.35	73.1	58.25	31.05	47.2
17						
Total number	312	53 (17)	159(51)	46(14.7)	13 (4.2)	41(13.1)
Mean weight per ear (g)	64.3	72.6	84.9	73.9	42.3	42.7
21						
Total number	378	22 (6)	214(57)	55(14)	18 (5)	69 (18)
Mean weight per ear (g)	57	68.20	65.7	46.4	16.7	46.4

The figures in parenthesis represent the %

Table 2: Variation of impact of attacks of stem and ear borers of maize on average weight of ears as a function of dates of harvest

Harvest date	Weight Reduction in relation to Cat. 1 ears			
	Category* 1	Category 2	Category 3	Category 4
15 weeks	-	-4	17	56
17 weeks	-	-15	-2	45
21 weeks	-	4	32	75

Cat. 1: sound ears. Cat. 2: ears slightly attacked

At 17 weeks after planting, one notes a reduction of the percentage of sound ears. Moreover the proportion of ears slightly attacked increased (from 44% to 51%). Similarly with the ears heavily attacked (from 11% to 15%). On the other hand we recorded a decrease in the percentage of ears completely destroyed. With respect to average weight, the reduction is significant only between sound ears and completely destroyed ears.

At 19 weeks after planting, one notes a special situation. The percentage of sound and slightly attacked ears increases while that of the ears heavily attacked diminishes. Completely destroyed ears were not recorded.

At 21 weeks after planting, the percentage of sound ears lowers considerably in favor of ears slightly attacked. The percentage of other categories of ears increase also although weakly.

Distribution of species

The study of the distribution of species of stem and ear borers encountered at the time of harvest reveals that *Mussidia nigrivenella* was most abundant on the maize during the period of harvest. This species would therefore be more responsible for the losses caused at maturity. This is not surprising when we know that this larva is present on the maize before harvests. Nevertheless, one has noted the presence of some representatives of S.c and E.s especially in the first harvests.

Experiment N° 3: Study of the biological cycle of *Busseola fusca (B.f.), Sesamia calamistis (S.c.),* and *Eldana saccharina (E. s.)*

The objective of the study was to determine the different phases of development of the larvae of three species of stem borers reared on an artificial nutrient regime made of entire plants or parts of plants. At the total, 1463 larvae of B.f., 1726 larvae of S.c. and 215 larvae of E.s. were reared.

The results are the following

1. Morphology

The eggs are generally laid inegg masses plaques of which the size varies from one species to the other.

The larvae of S.c. are rose on its dorsal part and the ventral section is white with a reddish head and a clear brown thoracic plate. B.f. is white colored with a range of black spots of each side of the body. Its head is dark with a dark head capsule and anus. The larva of E.s. is a dirty grey colored.

The nymph of S.c. has an unravelled form colored clear chestnut or yellowish which darkens as development continues. The nymph of B.f. is colored clear chestnut on the abdomen while this color is darker on the back. E.s. nymph is smaller.

The adult of S.c. is a butterfly colored grey with a tiff of bristles on its head. It is spotted with clear points on the anterior wings. The posterior wings are colored beige. The adult of E.s. is a butterfly colored cream, with a pointed head covered with a tiff of yellow dark bristles, and two dirty yellow antennas. The adult of B.f. has a grey chestnut spotted color. The anterior wings are spotted dark brown with black edges. The posterior wings are a dirty white.

2. Development

a) *Busseola fusca*

The female lays eggs without precise order between the foliar sheath and the stem. These eggs have a cream color which begin to darken 2 days after oviposition. Starting on the 4th day after laying one observes a change of color to rose. The hatching begins on the 7th day and finish on the 8th day.

Upon hatching the larvae measure 2mm long and 0.5 mm diameter and have a dark color. This becomes clear as the larva develops, passing through clear violet, then cream. It passes through several larval instars before entering the nymphal stage. This stage can last thirty days. The larvae surround themselves with cocoons formed from debris and 3-4 days later form the chrysalis. The insect remains in this state at least weeks. After this period, the insect exits the cocoon.

b) *Sesamia calamistis*

The female of S. c. lays her eggs in very masses plaques between the foliar sheath and the stem. Hatching begins on the 7th day and finishes one or two days later. The larval stage lasts on average 23 days.

At the end of preceding stage the larvas shorten while increasing in diameter. One notes a reduction of length on the order of 30% and sometime more, and an increase of diameter of about 25%. The larvae weave cocoons from available debris and 3 to 4 days later form chrysalides. About twelve days later adults exit from cocoons leaving them intact.

c) *Eldana saccharina*

The female of E.s lay their eggs between the foliar sheath and the stem, but also in balls on the surface of the leaves. Hatching begins on the 7th day and finishes 1 or 2 days later. The larval stage lasts over a month (38 days on average) and the nymphal one 11 days.

Experiment N° 4: **Study of the Oviposition of *Busseola fusca, Sesamia calamistis* and *Eldana saccharina***

The objective of this study was to follow and compare the development of egg laying of *Busseola fusca, Sesamia calamistis* and *Eldana saccharina.* It was conducted in first and second cropping seasons of 1991.

RESULTS AND DISCUSSION

1. Oviposition sites

Tables 1 and 2 present the sites where the eggs of B. f. ; S.c. and E.s. have been collected in the field and in the greenhouse. Examination of these results show the following:

In the field, the majority of the eggs of B.f. (53%) have been found on the second leaf. Those of S.c. (53%) were on the third leaf. This is the same as found in 1989, but the behavior of B.f. was different. It was not possible to harvest eggs of E.s. in the field.

In the greenhouse, the behavior of B.f. and S.c. was similar. The majority of these females (54.5% of B.f. and 42% of S.c.) laid their eggs on the second leaves. Meanwhile, a large quantity of eggs (30% B.f. 34% S.c.) were found on the third leaves. In the case of E.s. 55% of the eggs were harvested on the first leaf. Generally, more than 90% of the total eggs deposited by the female have been on one of the first three leaves. B.f. seems to prefer the second leaves while S.c. tends to choose the third leaves. As for E.s., it prefers the first leaves.

2. The rate of egg laying

Examination of this data revealed that egg laying was spread out by the females of the three species. Meanwhile, we can note some differences in their behavior. The females of B.f. were depositing the majority (47% of the total) of their eggs the first day. This was reduced the following days until completely stop before the 10th days.

In the case of the female of S.c., a large proportion (24% of the total) of eggs were deposited on the first day. On the second day the oviposition was reduced to about 40% of that of the first day. On the third day the largest number of eggs (25% of the total) was harvested. Oviposition was reduced beginning with the 4th day, and continued until the 9th day which was the last.

With the female of E.s. we noted an analogous situation to that encountered with B.f.. A large number of eggs laid (45% of the total) the first day which later diminished.

In general a large proportion of eggs is deposited at the beginning and the rate diminishes until it stops one or two days before the death of the female. The female of S.c. lays more eggs than other species. E.s. seems to be the least prolific.

Table 1: Oviposition of B.f. and S.c. in field in 1st crop season

Species	total number of eggs	Location of Oviposition				
		1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf
B.f.	137	0	73 (53) *	48 (35)	16 (12)	0
S.c.	83	0	24 (29)	44 (53)	15 (18)	0

* The figures in parentheses represent the .

Table 2: Oviposition sites of B.f. , S.c. and E.s. in greenhouse in 1st cropping season 1991.

Species	total number of eggs	Location of Oviposition				
		1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf
B.f.	3789	560 (15)*	2034 (545)	1116 (30)	19 (0.5)	0
S.c.	5721	753 (13)	2413 (42)	1963 (34)	439 (8)	153 (3)
E.s	364	201 (55)	99 (27)	26 (7)	38 (11)	0
Total	9814	1514 (16)	4546 (47)	3105 (32)	496 (5)	0

* The figures in parentheses represent the %

Experiment N° 5: **Influence of four rates of Furadan on attacks by Stem Borers**

This study was conducted at Minkoameyos. The objective was the comparison of the influence of four rates of carbofuran, on the rate of attack, and the distribution of species presents, as well as their sequence of appearance. This product was applied 40 days after planting and the five rates compared are the following: 0kg/ha, 5kg/ha, 10kg/ha, 15kg/ha, 20kg/ha.

The product was applied on the maize variety DMR planted on plots of 5m x 4.8m with two meters between plots.

1. Variation of rate of attack

Table 1 presents the variations of attack on maize treated at 40 days after planting with Furadan at different rate. From the table it seems that the maize was less attacked by the borers in 1st crop season 1991 compared to the second crop season 1990. There is very little difference among the plots treated at different rates and among treated and untreated plots in the 1st season 1991. This is also true when the percentage of stem bored and the yield are considered. A similar situation had already been recorded in the 1st crop season 1990 (cf. annual report 1990). This seems to indicate that in the zone of study it would not be profitable to treat maize in the first crop season. Considering table 1, it can be seen that until 6 weeks after planting, the attacks are similar on all treatments. That is normal because the insecticide treatment has been applied after this period. Considering the attacks at 9 weeks after planting, one notes a very strong reduction of the rate of attacks on the treated plots. The same remarks can be made at 12 weeks after planting. This should demonstrate effectiveness of the product which increases with rate.

2. Percentage of stem length bored

The percentage of the stem length tunnelled (table 1) is very low for every treatment and even the check. This should be not the influence of the insecticide treatment. This situation, which is different from that noted in 2nd crop season 1989, is probably due to random chance, the plants being submitted to natural infestation conditions where the insects chose at random the plants to infest. The results of 1989 were showing some significant differences among the different rates and the check (cf. annual report 1989). Moreover the rate of attacks as well as the length of the stems infested in 89 were more greater than the ones noted in 90. This indicates that in 90 the attacks by the borers was less severe in the zone of Minkoameyos.

3. Yield

The yield in dry grains of the different treatments did not show significant differences for both seasons of 1991. This should be attributed to the degrees of attack which were not very different among treatments. Nevertheless, the results of 1989, presented greater degrees of attacks and were very different among the rates and showed some significant differences from the viewpoint of yield among the rates, and with respect to the check. This should signify that the effectiveness of the furadan and the differences among rates, can be shown only when the attacks are strong. This suggests that the use of furadan to control borers should only be considered in very heavy infestations otherwise, its use is less profitable.

4. Distribution of species

The total number of insects encountered in first season was less than that of the 2nd. At 3 weeks after planting, S.c. was more abundant than either treatment in 2nd cropping season. One noted light differences of proportions among the treatments. At 6 weeks after planting, it is B.f. which was most common, especially in the 1st crop season. One notes a decrease of the total number of insects in this period. At 9 weeks after planting, this number diminishes further, and in this period one records some representatives of E.s.. The very important reduction of the number of insects on the treated plots especially of *Busseola* should be attributable to the influence of the product. We know that during the growth stages of the plant when the product was applied the larvae of this species were in the whorls where the granules of furadan were placed. These were destroyed by contact of the product. At 12 weeks after planting, the proportion of the E.s. is greater in all treatments. At this time one notes a high population of *Mussidia nigrivenella* among the larvae.

We can therefore conclude that the use of furadan did not influence the sequence of appearance of the species. Indeed we know that S.c. was more abundant 3 weeks after planting, B.f. from 6 weeks after planting and E.s. 9 weeks after planting. This trend has been recorded here at all rates of product. Meanwhile, one has noted a change of the total number of insects especially for *Busseola fusca*.

Table 1: Variation of rate of attacks of stem borers on maize treated with different rates of furadan 40 days after planting (2nd season 90)

Rate of attacks in %					% of stem bored	Yield t/ha
treatment	3SAS	6SAS	9SAS	12SAS		
1	5	20	22.5	45	1.5	6.55
2	5	15	10	22.5	2	7.175
3	7.5	17.5	0	20	1	7.125
4	5	25	2.5	20	1.4	6.475
5	2.5	12.5	5	17.5	4	7.075
lsd (5%)	-	-	-	-	2.037	1.315
c.V.	-	-	-	-		13.88

* SAS: Weeks after planting

Experiment N° 6: Influence of Fertilization on attacks by Stem Borers

This study had the objectives of comparison of impact of three rates of NPK (20-10-10) on attacks of borers, and the evaluation of the influence of fertilization of the soil on the sequence of appearance and species distribution of borers in the zone. The variety of maize used was DMR. The rates compared were the following: 0kg/ha, 100kg/ha, 250kg/ha, 500kg/ha.

RESULTS

1. Variation of rate of attacks

Table 1: Variation of the rate of attack the stem borers on maize fertilized with different rates of NPK (2nd crop season 1990)

Treatments	Rate of Attack (%)				% of the stalk bored	Yield t/ha
	3SAS*	6SAS	9SAS	12SAS		
1	7.5	25	40	65	14	4.7
2	16.7	36.7	37.5	62.5	18	5.2
3	15	30	50	60	18.5	4.4
4	12.5	20	27.5	75	17	3.4
L.S.D					7.251	1.973
C.V.					26.96	27.88

* SAS: weeks after planting

Table 1 presents the rate of attacks on maize fertilized with different rates of NPK in 2nd season 1990. The examination of this table shows: that The rate of attacks were generally higher on plots fertilized with respect to the check regardless of the date of observation. This had already been noted in the 1st season 1990 and seems to indicate that of more vigorous maize attract the insects.

2. Percentage of stem length tunnelled

The percentage of the stem length bored is greater in the 2nd season than the 1st. This is also higher on the fertilized plots with respect to the check. This is not surprising since the rate of attacks was higher on these plots. One should be able to say that the more the maize is developed, the more it constitutes a source of nutrient for the insects.

3. Yield

There were no significant differences among the treatments. This may be due to the fact that the rates of fertilizer applied were not sufficient to show differences among the treatments.

4. Distribution

At 3 weeks after planting, the proportion of S.c., was greater in the 2nd season. At 6 weeks after planting it is B.f. that was more abundant. At 9 weeks after planting, E.s. is found in greater numbers and this continues at 12 weeks after planting. During these two last periods one notes the appearance of M.n. but in very small numbers. We can therefore conclude that fertilization does not influence the sequence of appearance of the species. We noted some differences in the number of larvae per plant among the treatments, but we were not able to discern a particular trend.

Experiment N° 7: **Influence of intercropping maize with peanut on stem borers populations dynamics**

The objective of this study was to evaluate the influence of this practice on stem borer populations dynamic. The influence of every type of plot on development of attacks, distribution of species and their sequence of appearance have been evaluated and compared.

RESULTS

1. Variation of the attacks

Tables 1 and 2 present the rate of attacks on varieties DMRY and Bafia in the second crop season 1990 and 1st crop season 1991. In the second crop season 1990, the rate of attacks on of the associated maize (treatment 1) were slightly higher than those on pure maize (treatment 2). This trend is not very clear on the variety Bafia. On variety DMR-Y the differences are significant. In the first crop season 1991, the rate of attacks were slightly higher on the associated maize for the two varieties. This is explained in the case of

treatment1 (associated maize) that the plants of maize are more dispersed and more accessible to insects who choose their hosts at random. There appears to be an indication that the planting density influenced the attacks.

Table 1: Rate of attacks of stem borers on maize intercropped with peanut in second season 1990.

Variety	Treatment	Rate of attack (%)				% of the stem bored	Yield t/ha
		3SAS*	6SAS	9SAS	12SAS		
Bafia	1	10	15	40	55	5.7	1.5
	2	10	10	35	65	9.3	2.7
LSD (0,05)						11.8	0.9
CV						49.6	13.5%
DMR-Y	1	5	45	30	25	9.7	2.9
	2	5	15	15	55	8.4	4.5
LSD (0.05)						9.1	2.3
CV						31.7	19.3

* SAS: Weeks after planting

Table 2: Rate of attacks of stem borers on maize intercropped with peanut in the 1st season 1991.

Variety	Treatment	Rate of Attack (%)				% of the stem bored	Yield t/ha
		3SAS*	6SAS	9SAS	12SAS		
	1	10	15	22.5	10	0.6	1.4
Bafia	2	2.5	5	12.5	0	1.4	3.4
LSD (0,05)						2.4	1.1
CV							15
DMR-Y	1	7.5	12.5	7.5	2.5	0.6	2
	2	5	5	7.5	7.5	1.2	5.3
LSD (0.05)						2.2	2.9
CV							35.3

* SAS: weeks after planting

2. Percentage of stem length bored

The average percentage of the stem length tunnelled in the plots with associated maize were not very different from that of pure maize. One had to remark that on the local variety stem tunnelling on associated maize was slightly superior to pure maize for the two cropping seasons.

3. Yields

The grain yields of the plots with associated maize are less than those of plots with pure maize for the two varieties. The differences recorded are significant at the 5% level for most cases. This was different from what was expected. We expected that the yields of associated plots would be greater supposing that the peanut would provide nitrogen to the maize.

4. Distribution of species

The number of larvae per plant was generally greater on associated plots (T1) than plots of pure maize (T2). This was true for the two varieties of maize used, and for all stages of development of the plant.

At 3 weeks after planting, we collected a large number of larvae of B.f. with respect to other species present, notably S.c.. This situation differs from that of 1989, and which is frequently encountered. At 6 weeks after planting, only the larvae of B.f. were collected, but in smaller numbers than that of 3 weeks after planting. At 9 weeks after planting, the number of B.f. is always greater and only some representatives of S.c. and of E.s. (on the variety Bafia only) have been recorded. At 12 weeks after planting, the proportion of B.f. lowers in favor of E.s. and above all of M.n.

Based on these results, we can conclude that the mixture of maize/peanut has influenced the populations of stem borers. The sequence of appearance of species has been modified. Instead of collecting more S.c. 3 weeks after planting as usual it was rather B.f. which was abundant until 9 weeks after planting. However, we await the results of second season 1991 to have more clear idea of what is happening.

Experiment N° 8: **Influence of intercropping maize with cassava on Stem Borers population dynamics**

The objective of this trial was to evaluate the influence of this cultural practice on the stem borers populations dynamic. The trial was conducted at Minkoameyos. The distribution of the species and their sequence of appearance were evaluated.

RESULTS

1. Variation of the attacks

Tables 1 and 2 present rate of attacks of stem borers on the varieties DMR-Y and Bafia, intercropped with cassava.

Table 1: Variation of rate of attacks of stem borers on maize intercropped with cassava in the second crop season 1990.

Variety	Treatment	Rate of attack (%)				% of the stem bored	Yield t/ha
		3SAS*	6SAS	9SAS	12SAS		
Bafia	1	10	25	20	50	10.40	1.80
	2	15	25	20	55	6.45	3.12
LSD (0,05)						9.00	1.10
CV						-	-
DMR-Y	1	5	25	25	70	11.20	2.92
	2	5	25	35	50	10.50	4.25
LSD (0.05)						6.10	0.75
CV						-	-

* SAS: weeks after planting

Table 2: Variation of rate of attacks of stem borers on maize intercropped with cassava in the 1st crop season 1991.

Variety	Treatment	Rate of Attack (%)				% of the stem bored	Yield t/ha
		3SAS*	6SAS	9SAS	12SAS		
Bafia	1	0	0	0	0	0.71	2.50
	2	0	0	0	0	0.22	3.05
LSD (0,05)						1.85	0.79
CV						-	12.37
DMR-Y	1	0	5	10	5	0.50	5.50
	2	2.5	7.5	5	2.5	1.02	7.00
LSD (0.05)						2.54	2.13
CV						-	10.82

* SAS: Weeks after planting

In the first cropping season 1991 (cf.table 2) attacks were not recorded on the variety Bafia on both types of plots. On the variety DMR-Y, the attacks which occurred were relatively weak, and were nearly identical among the two treatments and during the season.

In the second cropping season (table 1), these attacks were more severe. This is not surprising when we know that maize generally suffers more severe attacks the second crop seasons with respect to pure maize. These attacks were very little different among the two types of plots, for both varieties. This differs from the situation noted in 1989. According to the results of that year the rate of attacks were higher on the associated maize.

2. Percentage of stem length bored

The percentage of the stem length tunnelled was relatively low in the 1st crop season on the two varieties. In the second crop season, it was greater especially on the plots where the maize was associated with manioc. The differences recorded were not significant at the 5% level.

3. Yield

The yield of the plots of pure maize was significantly higher at the 5% level compared to maize/manioc. An analogous situation had been observed in 1989. These differences should be attributable partly to the competition made to maize by the manioc in the associated plots. The needs of manioc are especially heavy for nitrogen and potassium at the beginning of the season. These two elements are also very useful for maize, above potash whose contribution plays a big role in high yields.

Experiment N° 9: **Tolerance of varieties to natural infestations of stem borers and ear borers**

The objective of this study was to compare behavior of 84 varieties of maize under natural infestation of stem borers.

RESULTS

The observations were done six weeks after planting. Based on the data collected to this date we have been able to calculate:

1) Avoidance as the percentage of uninfested plants.
2) Tolerance as the percentage of infested plants which survived.

$$\text{Tolerance} = \frac{\%\ LF}{\%\ LF + \%\ DH} \times 100 \quad \text{where LF is leaf feeding, DH is dead hearts}$$

3) Survivability = 100 - % DH

Starting with these results, it was possible of classify the varieties according to their degree of tolerance or susceptibility. These varied from 1 to 5. The varieties with a rating of 1 or 2 were retained for continuation of the experiment. Meanwhile, those with ratings of 4 have been used as check

a) attacks on the ears. At harvest, a good part of the ears harvested were already showing signs of attack. Of the 84 varieties only 23 (27%) had sound ears. Two varieties (2%) were already heavily attacked. No variety has presented ears completely destroyed.

b) average percentage of stem length bored: it was observed that 12 varieties (14%) had more than 10% of their stems bored.

c) average weight: considering the average weight some significant differences were found among the varieties.

We have not been able to find a clear correlation between the percentage of the stems infested and average weight of the ears. Neither was there a correlation betweenthe weight of ear and attacks on the ears.

Distribution of species

Data was analyzed for the distribution of species of stem borers and ear borers present at harvest. The data revealed that four species (*Busseloa fusca, Sesamia calamistis, Eladan saccharina* and *Mussidia nigrivenella*) were present. The total number of insects present was very small. S.c. was most abundant being (36% of the total) followed by B.f. (28.5%), then M.n. (21.5%) and finally E.s. (14%).

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