OUA/STRC JOINT PROJECT-31

S A F G R A D

SEMI-ARID FOOD GRAIN RESEARCH AND DEVELOPMENT

A N D

IDRC-UPPER VOLTA
NATIONAL COWPEA IMPROVEMENT PROJECT

REPORT 1983

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

I.I.T.A.

B.P. 1783, OUAGADOUGOU (UPPER VOLTA)

CONTENTS

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Ouagadougou, April 14, 1984

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INTRODUCTION

Semi-Arid Food Grain Research and Development (SAFGRAD) is a regional project financed by several doner agencies. At present, most funding is provided by the USAID. The over-all coordination is provided by the Technical Research commission of the organisation of African Unity (OAU/STRC). The main theme of the project is to organize research and development efforts in the Semi-Arid tropics of Africa for three cereal crops - maize, sorghum and millet and two grain legumes - cowpea and ground nut. In addition, the other componant of SAFGRAD is the farming system unit.

International Institute of Tropical Agriculture, IITA through a contract with USAID has the responsibility to undertake and coordinate regional research and training activities for two crops, maize and cowpea, in the SAFGRAD project.

Four IITA Scientists - Maize Breeder and Project Leader, Maize Agronomist, Soil Fertility specialist (cowpea agronomist) and an Entomologist funded by USAID/SAFGRAD and one cowpea breeder funded by IDRC, (primarily for national cowpea program) are based at the national Agricultural Research Station, Kamboinsé (about 15 km North-West to Ouagadougou) which serves as the headquarter for IITA/SAFGRAD research program. The five IITA Scientists along with the Upper Volta national scientists work as members of two teams : (1) A maize team - consisting of breeder, agronomist and an entomologist (25%) and (2) A cowpea team - consisting also of breeder, agronomist and an entomologist (75%). The SAFGRAD/IITA team started their work in 1979 whereas the IDRC funded cowpea breeding program started in 1977. Constant support and backstoping is provided by IITA staff based at IITA headquarter, Ibadan, Nigeria.

The overall objectives of the IITA/SAFGRAD program are :

1. To assist and strengthen the national maize and cowpea improvement programs in the SAFGRAD member countries.

2. To develop improved genetic materials and improved agronomic practices capable of producing higher economic yield in the semi-arid region.

3. To organise systematic testing and exchange of improved genetic materials and improved technology among the SAFGRAD countries.

4. To assist in manpower development by arranging various types of training programs for national researchers and technicians.

To fullfil the overall objectives enumerated above, four major areas of work have been defined :

1. Resident research activity in Upper Volta at various experiment stations representing different ecological conditions of the semi-arid tropics. The research programs in Upper Volta are conducted in collaboration with the national research scientists of the Ministry of Scientific Research and Higher Education, Upper Volta, who have been assigned to work with the IITA team.

2. Regional research and production program in cooperation with the national programs of the SAFGRAD member countries. Regional maize variety trials initiated since last four years were continued. Regional cowpea variety trial, regional maize & cowpea agronomy trials and entomology trials were also organised for the fourth year.

3. Support and assistance to national maize and cowpea programs through personal visits, motivations and advice.

4. Training.

The present report summarises the results and accomplishments in these four areas of work carried out during the calender year 1983. Sincere efforts were also made to collaborate and assist the Farming System Unit (FSU) of SAFGRAD project in their village level studies and the Accelerated Crop Production Officers (ACPO's) of SAFGRAD project based in different member countries in their on-farm testing trials.

The IITA/SAFGRAD programs has completed five crop seasons so far, and it should be recognised that the results obtained and presented in this report will need further confirmation in a wider range of environments. Full details on all the experiments are beyond the scope of this report, and therefore, additional information may be obtained by addressing a request to the appropriate scientist concerned.

PHYSICAL ENVIRONMENT : SOILS AND WEATHER

Maize and Cowpea resident research was conducted at six locations in Upper Volta representing different agro-climatic regions. These locations were : (1) Farako-Bâ (Bobo-Dioulasso), (2) Kamboinsé, (3) Saria, (4) Loumbila (5) Saouga (Gorum-Gorum) and (6) Pôbé. Geographic location (latitude) and rain fall data during the crop season 1983 at these locations are given in the following Table.

Farako-Bâ is about 10 km from Bobo-Dioulasso which is about 360 km South-West from Ouagadougou. Kamboinsé is about 15 km North-West and Loumbila is about 15 km North-East to Ouagadougou. Saria is located about 80 km. West of Ouagadougou, Saouga is about 300 km North from Ouagadougou and Pôbé is about 190 km North from Ouagadougou.

Farako-Bâ lies in the mean annual rainfall zone of about 1100 mm. While the annual mean rainfall at Kamboinsé, Saria and Loumbila is between 750-800 mm. The average rainfall at Saouga and Pôbé is between 400-500 mm.

Soils at Farako-Bâ are classified as "faiblement ferrallitiques" where as soils at Kamboinsé, Saria and Loumbila are generally classified as "ferrugineux tropicaux".

The 1983 growing season in Upper Volta was characterised, in general, by a bad rainfall distribution pattern. Total rainfall at many locations was considerably lower as compared to long term average precipitation due to late start & early cessation of rains in many parts of Upper Volta . Farako-Bâ which is in the South-West part of Upper Volta received only 755 mm if rain fall as against an average of 1000 mm. Due to early cessation of rains the crops suffered due to water stress in the later part of the crop growth.

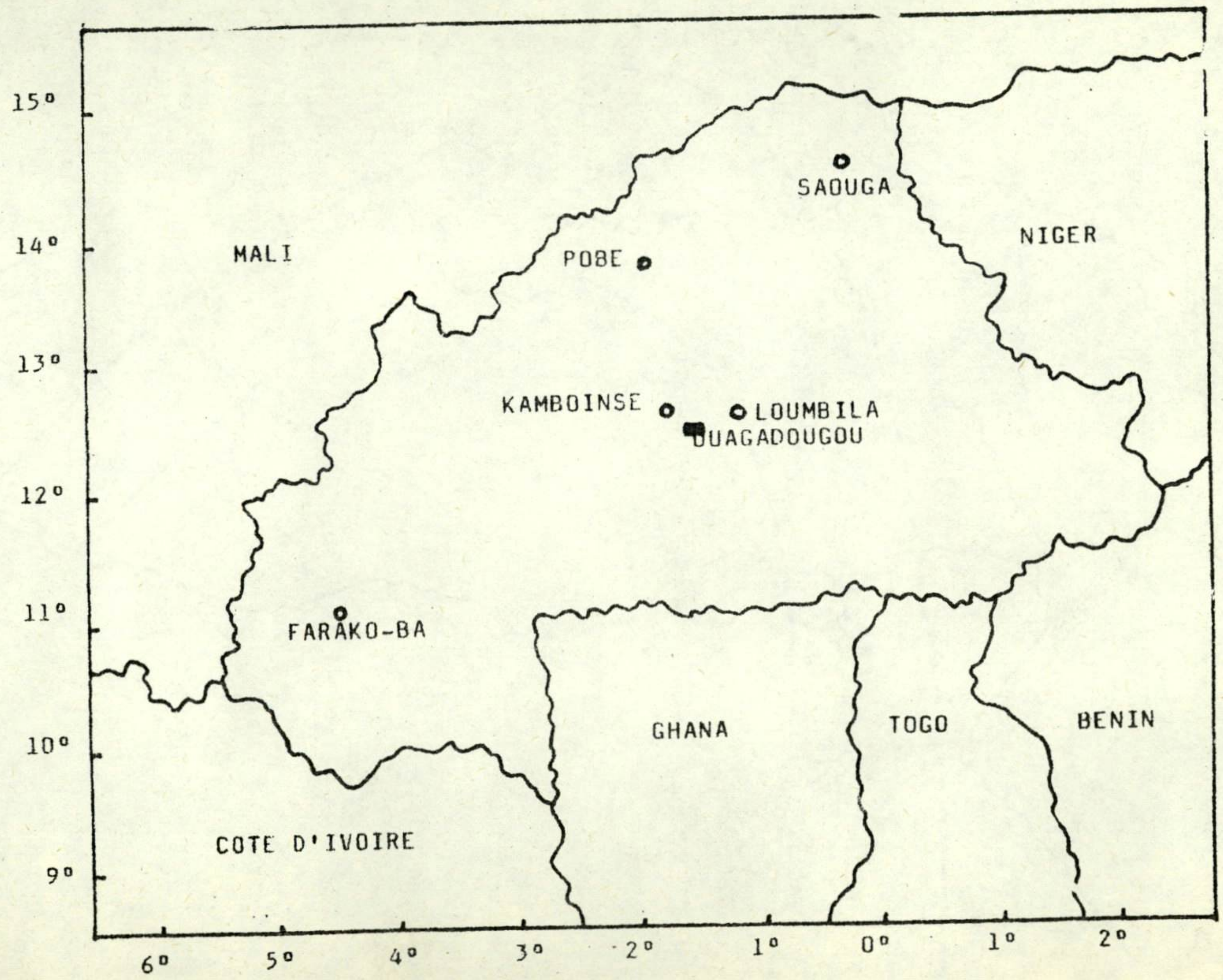
Soil variability both micro and macro was noticed at all the locations and this was considered to be an important factor influencing the coefficient of variability in some experiment.

DECLARATION

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

Rainfall data (mm) for locations in Upper Volta where maize and cowpea research trials were conducted, 1983.

Month	Farako-Bâ 11°06'N	Saria 12°16'N	Kamboinsé 12°28'N	Pobé 13°81'N	Saouga 14°28'N
April					
1-10	0.0	2.0	0.2	0.0	0.0
11-20	25.7	0.0	0.2	0.0	0.0
21-30	5.0	5.0	0.0	0.0	0.0
Total	30.7	7.0	0.4	0.0	0.0
May					
1-10	35.8	10.7	3.9	0.0	0.0
10-20	86.0	54.5	21.7	0.0	0.0
21-31	0.0	9.6	0.8	36.5	2.5
Total	121.8	74.8	26.4	36.5	2.5
June					
1-10	12.9	27.7	19.8	18.9	0.0
11-20	52.2	97.3	152.5	7.2	3.6
21-30	39.1	26.5	22.7	8.4	0.0
Total	104.2	151.5	195.0	34.5	3.6
July					
1-10	82.8	98.3	41.5	91.0	28.2
11-20	25.3	71.8	76.8	46.3	0.0
21-31	57.7	77.9	58.0	62.2	13.3
Total	165.8	248.0	176.3	199.5	41.5
August					
1-10	55.4	54.5	26.1	79.2	85.2
11-20	117.4	33.0	61.0	5.3	59.5
21-31	21.4	35.5	49.4	9.4	14.0
Total	194.2	123.0	136.5	93.9	158.7
September					
1-10	99.9	79.5	29.7	0.0	9.4
11-20	27.9	72.5	59.1	49.0	4.5
21-30	3.6	2.0	0.0	7.0	0.0
Total	131.4	154.0	88.8	56.0	13.9
October					
1-10	0.0	12.7	40.0	5.0	0.0
l-20	3.1	0.0	0.0	0.0	0.0
-31	0.0	0.0	0.0	0.0	0.0
al	3.1	12.7	40.0	5.0	0.0
April-Oct.	751.2	771.0	663.4	425.4	220.2

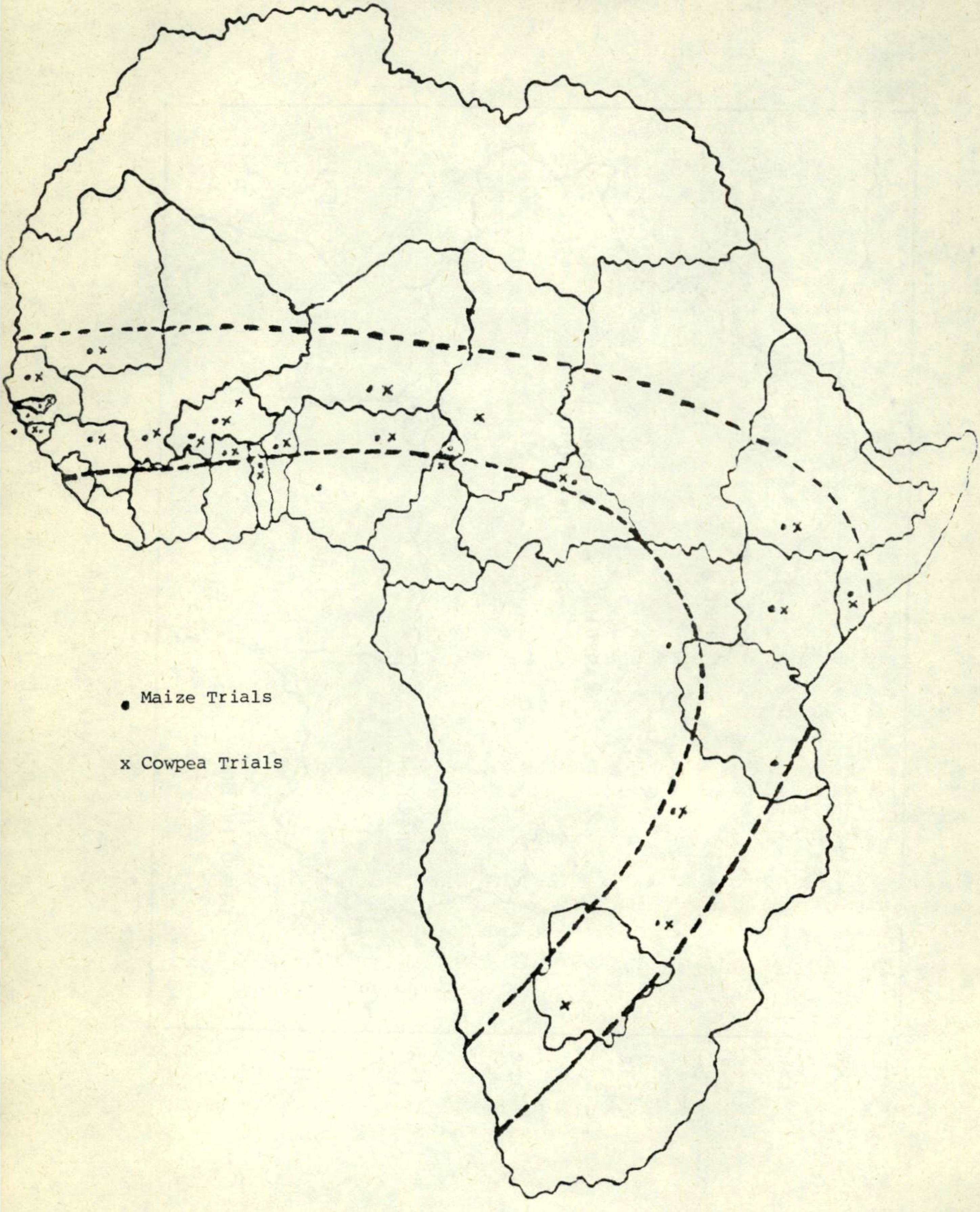


EXPERIMENT STATIONS IN UPPER VOLTA

UTILISED BY IITA/SAFGRAD RESEARCH PROGRAM

MAIZE AND COWPEA REGIONAL TESTING SITES

IN COUNTRIES WHICH PARTICIPATED IN 1983 SAFGRAD TRIALS



• Maize Trials

x Cowpea Trials

SUPPORT TO NATIONAL PROGRAMS AND TRAINING

Strengthening of national maize and cowpea programs in the semi-arid areas is one of the important objectives of IITA/SAFGRAD efforts. This objective is accomplished through various types of activities including the technical support and training of young scientists and technicians working in the SAFGRAD member countries.

Mutual review of results obtained by individual national research programs other institutions is done every year in the SAFGRAD maize and cowpea workshop which is organized every year. The fifth workshop was held at Ouagadougou, Upper Volta from April 25-27, 1983 which was attended by thirty maize researchers and twenty five cowpea researchers from 19 countries. These workshops have proved to be effective in exchange of ideas and results, as well as, in identifying the weaknesses and strengths of various programs for mutual benefit. Through discussions and presentation of research papers reviewing the information on important problems, attemps were made to assist national programs in focussing their national research and production efforts. The workshop also provided an opportunity to plan the IITA/SAFGRAD resident and regional testing program to solve some of the production problems which are common in the semi-arid areas in tropical Africa.

Through the SAFGRAD/IITA regional trials, attempts were made to identify and distribute promising genetic materials as well as other agronomic practices which could benefit the national programs in increasing the maizeand cowpea production. In 1983, 135 regional trials were organised with the assistance of 24 national programs in the semi-arid region.

With an objective to provide an opportunity to national maize and cowpea researchers to observe, in the field, the performance of various promising varieties in different countries and also to get a personal insight into the pratical problems and facilities in various national programs, a group visit of national scientists as a "monitoring tour" is organized each year during the crop season. In 1983, one maize and/of cowpea researcher each from Senegal, Gambia, Upper Volta, Nigeria, Guinea and Mali were invited to participate in the maize and cowpea monitoring tour of East & Southern African countries in January 1983. The national researchers accompanied by IITA/SAFGRAD scientists and the scientists from IITA, Ibadan, visited the national maize and cowpea programs in Zambia, Zimbabwe, Botswana, Kenya, Somalia and Ethiopia.

In addition, maize and cowpea researchers from some national programs, and regional and international institutions collaborating in the SAFGRAD regional trials were also invited to visit the IITA/SAFGRAD resident research program in Upper Volta. All such individual of group visits, during tie crop season, proved to be of considerable benefit in providing additional information and training to the national research workers.

Efforts were made by IITA/SAFGRAD team to visit as many member countries as possible to have personal discussions with the Directors of Agricultural Research and their researchers to assist, advise and encourage in strengthening their national maize and cowpea programs. Such visits also proved to be useful in strengthening the established links between IITA/SAFGRAD scientists and the SAFGRAD Accelerated Crop Production Officers (ACPO's) who are located in various national programs to provide laision between extension and research in different member countries.

To increase the technical competance of national programs, various types of training programs are arranged or conducted for young national researchers and technicians. One of the most important training is through formal maize and cowpea production training courses organised and conducted by IITA, Ibadan, Nigeria. Research technicians and extension leaders from SAFGRAD member countries (in addition to participants from other countries) participate in these training courses which are of normally one to three months duration and involve classroom instruction and field experience. IITA/SAFGRAD team assists the national programs in identifying the candidates and arranging for their participation.

In addition to formal IITA training courses at IITA, Ibadan, young research technicians gain practical field experience in research methodology by spending 5-7 months with IITA/SAFGRAD team during the crop season at the experiment station, Kamboinsé, Upper Volta. Participants in this training program work closely with one or two of the research scientists and participate in all field operations from planning of the experiments to the analysis of the data. During 1983 crop season, one technician from Guinea worked in the Entomology program, & another from Guinee participated in maize agronomy program. Like wise, one technician from Somalia worked in the maize breeding and one from Zambia in cowpea breeding. Two technicians came from Botswana one working in the entomology program & the other in the cowpea agronomy program. All six trainees worked in IITA/SAFGRAD program in Upper Volta from June-December 1983. In addition, two technicians from Upper Volta got practical training experiance in cowpea entomology for three month period.

Opportunity is also provided to the students for different degree programs from various universities to conduct their research trials at Kamboinsé in collaboration with the IITA/SAFGRAD scientists. In 1983, two students from University of Ouagadougou, Upper Volta did their thesis research in cowpea agronomy and conducted their research trial with IITA/SAFGRAD cowpea agronomist.

M A I Z E P R O G R A M

MAIZE BREEDING

Genetic improvement of maize in the SAFGRAD project was carried out under four major objectives constituting the four areas of activities : (1) Early maturity and yield, (2) Medium maturity and yield, (3) Quality Protein and (4) Drought tolerance. Under each of these objectives, yield trials were conducted to test the performance of various materials, population improvement cycle in the promising composites was continued and breeding to advance and develop additional materials (back-up) were realised. In addition, Uniform testing of promising materials in the semi-arid zone of SAFGRAD member countries was organized and coordinated through the semi-arid regional testing program with the assistance of national programs scientists.

Activities for genetic improvement in Upper Volta were done at 3 locations representing two agroclimatic regions : (1) 700-900 mm rainfall - Kamboinsé and Loumbila and (2) 1000-1100 mm - Farako-Bâ. The total rain fall during the cropping season this year was 663 mm at Kamboinsé and Loumbila and 755 mm at Farako-Bâ. Thus, from the point of view of rain fall, this year was a bad year at Farako-Bâ where total precipitation fell short by 195 mm from the long term average for this station. Low to moderate level of incidence of maize streak virus and mottle/chlorotic stunt was observed at all the three stations, which was quite severe in late plantings.

In all the genetic improvement trials and breeding nurseries NPK was applied at 74:46:30 kg/ha, and plant population were 53,000 per hectare.

Early Maturity and Yield

Early maturing (90 days maturity) high yielding varieties are needed for Sudan Savanna zone in semi-arid tropics having annual precipitation of about 800 mm and a growing season of about 3-3½ months.

Population improvement

TZE SR (Y) as a population was synthesied and developed at IITA, Ibadan. One cycle of F.S. family selection in this population was completed in 1982. Experimental varieties by recombining 10-12 families were developed and advanced to F2 generation this year. To initiate the second cycle of reccurent selection, 65 selected full-sib families (based on 1982 results) were planted and randomly mated to develop a C1 population. To initiate the 2nd cycle of selection this population has been planted during dry season to develop a new set of full-sib families. These families will be evaluated in international progeny testing trial during 1984.

Evaluation of Early Maturing Materials

Twelve early maturing varieties developed and proposed by various national and international institutes were evaluated in a SAFGRAD regional trial, RUVT-1. This trial was conducted at two locations in Upper Volta, Kamboinsé and Farako-Bâ. The performance of these varieties as compared to a local check is given in Table 1. At Kamboinsé, there were no significant differences for yield among the varieties tested. However, Synth. C, SAFITA-104 and Pop. Senegal Oriental were promising. Among these varieties, SAFITA-104 is the only one which took same number of days to 50 % flowering was local check which was 7-8 days less than the other varieties. At Farako-Bâ, the plant stand, growth and yield were adversely affected by various soil problems. Data, therefore, is comparatively less reliable. However, Pirsabak (1) 7930, E V 8188, E V Gusao 81 Pool 16, TZE SR (W) and Temp. x Trop. N° 3 were the promising varieties.

Breeding for back-up Pool

With an objective to develop a wide genetic pool for early maturity and high yield, several early maturing materials were crossed among themselves and also with the selected local varieties. Fifty seven F3 populations of crosses involving Pool-16, Pool-18, TZE 4, TZE 3, SAFITA-2, SAFITA-104, Early yellow, Pool-27 and TZE SR and 5 local

Table 1. Performance of varieties tested in RUVT-1, 1983.

P E D I G R E E	Grain yield (kg/ha)		Days to flower	A V E R A G E	
	Kamboinsé	Farako-Bâ	Kamboinsé	Plant height	Ear height
1. Synth.C	4308	2410	51	166	85
2. SAFITA-104	4000	1692	41	143	54
3. Pop. Senegal Oriental	4000	1744	50	166	85
4. Temp. x Trop. N° 42	3949	2410	49	167	79
5. Prisabak (1) 7930	3949	2769	47	148	70
6. E V Gusao 81 Pool 16	3949	2564	48	149	71
7. E V 8188	3897	2410	41	146	54
8. Temp. x Trop. N°3	3795	2461	51	153	79
9. SAFITA-2	3641	2410	50	155	75
10. TZE SR (W)	3538	2461	50	168	88
11. E V 7982	3282	2051	48	149	65
12. M T S	3179	1744	50	182	105
13. Check Variety (J.F.S.)	3949	2000	43	161	79
Mean	3803	2240	48	158	76
L.S.D. 5%	N.S.	486	2.12	-	-
C.V. %	18.04	16.0	3.5	-	-

varieties were grown during this year. Individual plant selection was done for earliness and vigour and the selected plants were crossed among themselves (among different F3 populations). These crosses have been harvested and based on ear characters, equal number of grains from the selected ears have been bulked to develop one white and one yellow grain back-up pool. The two bulks will be grown next year to allow one more generation of random mating within each pool.

Similar program was carried out with the F3 generation of crosses involving 15 US x Trop. materials crossed to Pool-16, Pool-27 and TZE 3 (W).

Medium Maturity and Yield

Medium maturing (105-110 days maturity) varieties are aimed at northern guinea savanna zone of semi-arid tropics with annual rain fall around 1000 mm in 4 months crop season. These varieties could also be useful in the lower slopes of Soudan savanna zone where season can be stretehed due to residual moisture in the soil.

Population Improvement

TZUT (W) - this population was originally synthesised at IITA, Ibadan. Full-sib families were developed at IITA in 1982 season and the 250 selected families were sent for evaluation at five to six locations during 1983. Kamboinsé was one of the location for testing. Population improvement in TZUT (W) is done and testing coordinated by IITA, Ibadan.

The grain yield and other agronomic characters of the selected families based on trial conducted at Kamboinsé are given in Table 2 and 3. Average yield of all families was 3627 as compared to best check which yielded 4053 kg/ha. The average yield of selected best 10 families was 4757 and 5077 kg/ha to develop two experimental varieties. Information on the selected families has been sent to IITA, Ibadan to develop the experimental varieties by recombing the best families during 1983 dry season.

Table 2. Performance of selected full-sib families to develop experimental variety Kamboinsé TZUT (W), 1983.

Families No.	Grain yield (kg/ha)	Days to flower	Plant height	Ear height
TZUT. (W)				
Fam. 4	4907	50	202	100
Fam. 11	5547	50	202	95
Fam. 115	4907	52	212	108
Fam. 119	5120	52	207	97
Fam. 139	4693	51	211	102
Fam. 146	4480	51	203	105
Fam. 154	5333	53	208	115
Fam. 234	5120	51	215	103
Fam. 235	4693	50	218	110
Fam. 246	5973	51	212	112
Mean of selected families	5077	51	209	105
Mean of all families	3627	51	200	102
TZB GUSSAO (Check)	4053	52	232	117

Table 3. Performance of selected full-sib families to develop experimental variety Kamboinsé (E) TZUT (W) 1983.

Families	Grain yield (kg/ha)	Days to flower	Plant height	Ear height
5	4480	49	213	100
83	5120	49	195	87
90	4480	48	220	107
96	5973	50	214	92
134	4693	48	220	110
192	4480	48	205	108
195	4267	50	212	100
228	4693	50	213	120
243	4480	49	222	120
254	4907	50	217	106
Mean of selected families	4757	49	213	105
Mean of all families	3627	51	200	102
TZB GUSSAO (check)	4053	52	232	117

TZUT (Y) - this population was derived from original TZUT at IITA, Ibadan by seperating the segregating yellow grained seeds. Yellow grain seeds from 305 S1 lines were sent to Kamboinsé in 1982, to initiate the population improvement in the SAFGRAD project. S1 lines were recombined during 1982-83 dry season. Another cycle of recombination was done during 1983 rainy season. One hundred and eighty H.S. families have been planted during the dry season of 1983-84 to develop full-sib families to initiate the first cycle of recurrent selection. Selected 250 F.S. families will be sent for progeny testing trial at 5-6 locations during 1984 rainy season.

TZSR (Y)-1

Population improvement in this composite is being handled by IITA, Ibadan. Selected 250 F.S. families were sent to Upper Volta for testing as one of the 6 locations for conducting this progeny trial. This trial was conducted at Farako-Bâ. Due to early cessation of rains this year, the yield levels at Farako-Bâ were in general low. Grain yield and other agronomic characters of selected families are given in Table 4. The average yield of all families was 2047 kg/ha as compared to 2987 of the best check variety (TZB Gusao). The average yield of selected 10 families was 3989 kg/ha. Information on the selected families has been sent to IITA, for developing the experimental varieties.

SAFITA-102

This is a white grain composite synthesied and developed in the SAFGRAD project. Phil. DMR composite was crossed to TZPB and advanced to several generations through selective sibbing to develop this population. This composite has been tested in SAFGRAD regional trials and has been found to be promising. In 1983, population improvement program was initiated in this composite. A big size block was planted at Farako-Bâ to develop the full-sib families. Due to adverse climatic conditions only 122 families could be produced. These families will be evaluated in 1984 and C1 population will be produced by recombining the better families.

Table 4. Performance of selected full sib families to develop experimental variety Farako-Bâ TZSR Y (1) 1983.

Family N°.	Grain yield (kg/ha)	Days to flower	Plant height	Ear height
51	4053	62	173	92
69	4693	64	150	77
77	3627	66	145	65
84	3840	65	133	62
98	3840	63	182	92
117	4053	64	190	88
132	4053	65	153	78
160	4053	63	175	97
210	4053	66	152	77
223	3627	64	160	68
Average	3989	64	161	80
Mean of all families	2047	66	153	73
TZSR (Y) check	2773	63	160	88
TZB GUSSAO check	2987	65	162	75

Evaluation of Medium Maturing Materials

Several trials were conducted during the 1983 rainy season to evaluate the performance of various materials developed by IITA, CIMMYT and other international organizations as well as by various national programs. These trials are organized and coordinated by different institutes. The results are summarized below :

EVT LSR (W)

This trial consists of white grain streak resistant varieties developed at IITA, Ibadan. Nine varieties were tested along with two checks at Kamboinsé. The performance of these varieties is presented in Table 5. No significant difference was found among the varieties for grain yield. However, Across 7729 SR, US x Trop. N° 27 (check) and Ejura LSR-W 81 were the higher yielding varieties.

EVT LSR (Y)

Yellow grain streak resistant varieties (7) developed at IITA and two check varieties were tested in a trial at Kamboinsé. Performance of these varieties is given in Table 6. Difference in yield among the varieties was found to be statistically non-significant. However, a check variety, US x Trop. N° 27 gave the highest yield. Among the streak resistant varieties, EV Bertoua LSR (Y) and Tocumen (1) 7835 SR were promising.

EVT 16 A

Twelve experimental varieties developed by CIMMYT with three checks were tested in this trial at Kamboinsé and Loumbila. The performance of these varieties is given in Table 7. At Kamboinsé, La Molina (1) 8033, Across 7748 RE and US x Trop. N°27 (check) were the promising materials. At Loumbila, the yield levels in general were low and C.V. high due to soil problems.

Table 5. Performance of varieties tested in EVT. LSR (W) at Kamboinsé, 1983.

PEDIGREE	Grain yield (kg/ha)	Days to flower	Plant hight	Ear hight
1 Across 7729-SR	3200	55	189	100
2 US.Trop.N°27	2667	55	187	97
3 EJURA LSR-W 81	2560	60	186	106
4 Ferke LSR-W 81	2453	58	205	111
5 Sekou LSR-W 81	2453	60	207	105
6 SAFITA-102	2347	57	184	100
7 Across LSR-W 81	2240	57	190	101
8 BERTOUA LSR-W 81	2240	57	197	106
9 Poza Rica 7843 SR	2133	57	199	105
10 IKENNE LSR-W 81	2027	59	209	136
11 Poza Rica 7882 SR	1920	59	170	86
Mean	2385	58	193	105
L.S.D. 5 %	N.S.	N.S.	-	-
C.V. %	41.1	4.9	-	-

Table 6. Performance of varieties tested in EVT-LSR (Y) at Kamboinsé, 1983

PEDIGREE	Grain yield (kg/ha)	Days to flower	Plant height	Ear height
1. US x Trop. N° 27	3947	50	193	137
2. Tocumen (1) 7835 SR	3627	49	200	116
3. Bertoua LSR-Y	3627	56	237	129
4. Across 7728-SR	3520	54	239	142
5. Niaouli LSR-Y	3413	54	229	127
6. SAFITA-102	3307	55	215	116
7. Across LSR-Y	3307	55	234	139
8. Fereke LSR-Y 81	3200	55	239	132
9. Ikenne LSR-Y	3200	55	235	127
Mean	3461	54	225	129
LSD 5 %	N.S.	1.24	-	-
C.V. %	12.07	1.78	-	-

Table 7. Performance of varieties tested in EVT-16 A at Kamboinsé and Loumbila, 1983.

PEDIGREE	Grain yield (kg/ha)		Days to flower	AVERAGE	
	Kamboinsé	Loumbila	Kamboinsé	Plant height	Ear height
1. La Molina (1) 8033	5333	960	44	170	81
2. Across 7748 RE	5227	1173	44	177	84
3. Local check-I US x Trop. N°27	5120	1387	44	198	103
4. Guaira 8045	5013	2667	45	180	85
5. Local check-II SAFITA-102	4907	960	41	188	126
6. Across 7845 RE	4907	1600	41	184	97
7. Tlaltizapan 8146	4907	1493	41	162	83
8. Across 8033	4907	1387	41	175	90
9. Pirsabak 8146	4693	1067	40	172	89
10. Local check-III TZB Gussao	4587	1493	41	204	117
11. Capinapolis 8146	4587	2133	48	176	91
12. Across 8146	4373	1813	42	160	78
13. La Molina 8146	4373	1280	49	164	84
14. Sete Lagoas 8033	4160	533	53	166	87
15. Coimbatore 8146	3947	1600	54	168	82
Average	4736	1436	45	176	92
L.S.D. 5%	1003	N.S.	1.12	-	-
C.V. %	15.36	88.46	2.02	-	-

EVT 14 A

Eleven experimental varieties developed by CIMMYT along with two checks were compared in this trials at two locations - Kamboinsé and Loumbila. The performance of the varieties is presented in Table 8. Significant differences in yield were observed at Loumbila only. At Kamboinsé, US x Trop. N° 27 (check), Across 8131, Across 7635 RE and Suwan (1) 8131 were the promising varieties. At Loumbila, the yields were low. US x Trop. N° 27 (check) was the highest yielding entry. Across 8131 performed well at Loumbila also.

RUVT-2

SAFGRAD Regional Variety Trial RUVT-2 in Upper Volta was conducted at two locations -Kamboinsé and Farako-Bâ. The trial at Farako-Bâ was conducted by IVRAZ-IRAT program. Eleven varieties developed by different national and international institutes along with one check variety were tested in this trial. At Kamboinsé, significant differences for yield were obtained. IRAT 178, US x Trop. N° 27, TZPB (Onne) and Pool 34 QPM (check) gave about the same yield. Pool 34 QPM and US x Trop. N° 27 were 4-5 days early in days to flower. Bako composite was un-adapted to this climate. The data from Farako-Bâ are statistically analysed and presented in Table 16. Looking at the mean yield, IRAT 178, US x Trop. N° 27 seem to be promising giving similar yield (6.8 tons/ha). Data on grain yield and other agronomic characters is presented in Table 9.

Pioner material

On the request of Pioner seed company, seven of their hybrids with two check varieties were tested in this trial at Kamboinsé and Loumbila. Differences in yield at both locations were statistically non-significant. However at Kamboinsé, hybrid x 304 C, US x Trop. N° 27 (check) and hybrid 507 were the better entries. At Loumbila, US x Trop. N° 27 gave the highest yield followed by 6875 R and 304 C. The performance of different entreis is given in Table 10.

Table 8. Performance of varieties tested in EVT 14 A at Kamboinsé and Loumbila, 1983.

P E D I G R E E	Grain yield (kg/ha		Days to flower	A V E R A G E	
	Kamboinsé	Loumbila	Kamboinsé	Plant height	Ear height
1. Across 8131	3733	1280	53	161	79
2. Check variety N°1 US x Trop. N°27	3627	1707	52	198	104
3. Suwan (1) 8131	3627	1173	48	164	80
4. Across 7635 RE	3520	960	49	179	88
5. Pozarica 8126	3413	640	49	179	94
6. Suwan 8131	3413	1280	48	167	79
7. La Molina 8131	3307	1067	48	162	87
8. Islamabad (1) 8131	3093	1280	52	171	84
9. Across 7726 RE	2987	427	53	177	86
O. Suwan 8126	2880	640	54	175	90
1. Across 8035	2880	533	50	167	81
2. Iboperenda 8035	2560	747	52	167	77
3. Check variety N°2 SAFITA-102	2453	640	56	180	88
Mean	3192	952	51	160	86
L.S.D. 5%	N.S.	267	11.84	-	-
C.V. %	29.0	15.73	18.4	-	-

Table 9. Performance of varieties tested in RUVT-2 at Kamboinsé, 1983.

	PEDIGREE	Grain yield (kg/ha)	Days to	Plant height	Ear height
1	IRAT 178	3787	55	193	103
2	Check variety Pool 34 QPM	3787	50	175	90
3	TZPB (ONNE)	3733	59	215	117
4	Temp. Trop. N°27	3733	52	194	96
5	TZSR-1	3680	56	214	133
6	EV 8176	3680	56	220	132
7	Poza Rica 7843	3573	57	212	123
8	SAFITA-102	3573	55	196	111
9	Elite x E. Mex Comp.	3413	55	211	123
10	ATK 82 ZR	3360	56	199	110
11	Fereke 7622	3147	55	198	109
12	Bako Comp.	800	66	265	162
Mean		3356	56	208	117
L.S.D. 5 %		720	1.49	12.63	18.42
C.V. %		15.49	2.02	4.21	10.9

Table 10. Performance varieties tested in "Pionner trial" 1983 in two locations Kamboinsé & Loumbila".

PEDIGREE	Grain yield (kg/ha)		Days to flower	Average	
	Kamboinsé	Loumbila	Kamboinsé	Plant ht.	Ear ht.
1 X 304 C	4907	2027	55	182	99
2 US. TROP N°27	4373	2133	57	175	86
3 507	4160	747	56	168	98
4 3094	3840	747	56	179	101
5 6875 R.22	3413	2155	57	177	98
6 SAFITA-102	3413	853	55	173	97
7 3204 MF	3413	427	53	173	97
8 5065 A.	3200	853	56	180	106
9 X 5800	2667	640	56	175	99
Mean	3710	1176	56	176	98
L.S.D. 5 %	1056	1373	1.49	-	-
C.V. %	19.43	60.68	2.02	-	-

Quality Protein

Development of quality protein maize (QPM) varieties is not a major program in the SAFGRAD project. However, some efforts have been put to test the QPM materials developed by CIMMYT to identify the best population/variety for the semi-arid environment. Some efforts have also gone to improve the population identified as the most promising for this ecology.

Population improvement :

Pool 34 QPM

This quality protein population developed by CIMMYT was identifed as promising material in this environment (trial conducted in 1982) not only for yield but also from the hard endosperm and its stability point of view. Full-sib families were produced in the dry season 1982-83 and the selected families were planted at Kamboinsé in 1983 season for evaluation in breeding nursery. The best 10 families were planted in 1983-84 dry season to develop an experimental variety for testing in 1984 rainy season. C1 population will also be developed during the 1983 dry season to initiate normal full-sib recurrent selection program in 1984. Ten seeds of 107 F.S. families have been sent to CIMMYT, Mexico for chemical analysis to monitor the protein quality. These results were utilized to develop the experimental variety as well as the C1 population.

Evaluation of QPM materials

Nine QPM varieties developed by CIMMYT and one QPM check along with two normal maize varieties were tested in EVT 15 A trial at Kamboinsé . Performance of these materials is presented in Table 11. There were no significant differences among the varieties for yield. The highest yielding entry was E V Los Banos 8140 followed by a cross 8140 and San Jeronimo 8140. Pool 34 QPM was about 5-6 days early in days to 50% flowering.

Table 11. Performance of varieties tested in EVT 15A at Kamboinsé, 1983.

PEDIGREE	Grain yield kg/ha	Days to flower	Plant height	Ear height
1. San Jeronimo 8039	3093	52	159	87
2. Pichilingue 8039	3093	50	161	85
3. Across 8039	2667	51	165	90
4. San Jeronimo 8140	3520	51	170	81
5. San Jeronima (1) 8140	3200	51	172	87
6. Poza Rica 8140	2987	52	167	84
7. Los Banos 8140	3840	52	167	81
8. Across 8140	3733	52	169	90
9. Across 7940 RE	3413	52	169	81
10. Across 7726 NRE	3307	53	167	87
11. Pool 34 QPM (check)	2880	46	169	75
12. SAFITA 102 (check)	2453	55	174	97
Mean	3182	52	168	86
LSD 5%	N.S.	2.8	N.S.	N.S.
CV %	30.8	4.0	6.5	11.1

Drought Tolerance

Risk of drought is one of the major factor affecting yield stability in the sudan savanna zone of semi-arid tropics. Drought spells occur in the northern guinea savanna zone also and could substantially affect the grain yield. Initiated in 1981-82 dry season, breeding for drought tolerance is becoming one of the major activity of the genetic improvement in the SAFGRAD project.

Evaluation of materials

Preliminary work to evaluate different genetic materials for tolerance to drought was done by conducting a trial with 24 populations representing wide genetic back ground at Loumbila in 1981-82 dry season (with irrigation). In spite of unforeseen problems making the conclusions difficult, two populations -Pool-16 and Jaune Flint de Saria- seemed to be more tolerant to Water stress as compared to other material tested.

In 1982-83 dry season, a similar trial was conducted at Vallée du Kou (near Bobo-Dioulasso) to compare the performance of 12 populations/ varieties for tolerance to drought at seedling, flowering and at grain filling stage. Water stress was imposed by cutting-off irrigation for 2-3 weeks in different blocks and comparing the performance without the water stress. Data on several morphological and physiological characters were taken. All the date have not yet been statistically analyzed. However, on the basis of average performance it was observed that three populations viz pool 16, Jaune Flint de Saria and TZE 4 seem to have better tolerance to water stress as compared to other materials . On the basis of review of literature as well as our data and observations, it seems that three characters are positively correlated to drought tolerance 1. Synchronus male and female flowering 2. Lower plant height (up to certain height) and 3. small tassel size.

Population improvement

Based upon our results and also the information obtained from other institutions, three populations were selected for the population improvement program during 1983 season. These populations are : (1) Pool 16 and SAFITA-2 (2) Tuxpeno D.R. (from CIMMYT) and (3) SAFITA-104 x German inbred line (obtained as having tolerance to drought). Full-sib recurrent selection program was initiated in 1983 rainy season. Full-sib families were developed in the three populations by crossing the plants selected on the basis of three characters mentioned above (considered to be releted to drought tolerance,263 full-sibs in Pool-16 SAFITA-2, 205 in Tuxpeno D.R. and 41 F.S. families in SAFITA-104 x German line have been finally selected. All these families along with four checks have been planted in replicated trial at Loumbila during 1983 dry season. These families will be evaluated for their performance under 2-3 weeks of water stress at seedling stage and at grain filling stage in two different blocks. The third block will not get any stress. Based on the performance of these F.S. families, populations will be reconstituted and experimental varieties developed recombining the selected families.

Breeding for Back-up Pool

In 1981-82 dry season, 76 individual plants from the preliminary trial which was conducted at Loumbila (described above) were selected as drought tolerant and were selfed . Thes 76 S1 ears were planted during 1982 and were sib increased. The S1 sibbed materials along with some other S1 lines (drought tolerant plants selfed) of JFS, TZPB and SAFITA-2 were planted for seed increase in 1983 rainy season. This material now represents a wide genetic base and all these have been planted in large size plots at Loumbila during the dry season of 1983-84 . This whole block will be subjected to 2-3 weeks of water stress at seedling stage (20-21 days after planting) and again at grain filling stage (15-20 days after 50% silking). Individual plants, irrespective of material, will be selected at flowering and crossed among themselves to produce one early maturing and one medium maturing bulk back-up population. Final selection of plants will be done after they have been exposed to water stress at grain filling period. The two populations will be used as back-up pools for future work on breeding for drought tolerance.

Collection and Evaluation of Local Varieties

National Upper Volta maize program cooperates and collaborates in our SAFGRAD project activities. One of the objective of national program is to collect, evaluate and catalogue the local varieties grown in different parts of Upper Volta. A total of 210 local varieties collected from different parts of the country were grown in separate trials at Kamboinsé and Loumbila for evaluation and seed increase. Data on several morphological characters were taken. Table 12 presents the data on some characters of the selected local varieties. The promising varieties identified are : Kamandaogo tollo, Boursango tollo, Kamanyango windigui, Kamandaogo kobo, Local Yellow Saria, Koudougou 1 and Noubindou si Mossi.

In addition, 5 local varieties have been selected to develop an extra early (75 days to maturity) population. These varieties are Kamandaogo tollo, Boursanga tollo, Kamangbe Kapibabora, Korion Kouro and Tinzin Zambo. These varieties have been planted in the dry season 1983-84 to develop a composite through chain crossing. Extra early composite will be useful for Sahel savanna zone and also for specific farming system situations in other semi-arid ecologies.

Semi-Arid Regional Adaptation Testing

As in the past years, IITA/SAFGRAD organized and coordinated two regional uniform variety trials viz. RUVT-1 and RUVT-2 in 1983. RUVT-1 consists of early maturing varieties and RUVT-2 consists of medium maturing varieties. The varieties included in both the trials were nominated by various national and international institutions participating in the SAFGRAD project. The decisions on varieties to be tested and the sites

Table 12. Performance of varieties tested in local material, Kamboinsé, 1983.

PEDIGREE	Yield (kg/ha)	Days to flower	Plant height	Ear height
1. Kamandaogo Tollo	2667	36	137	47
2. Boursango Tolle	2453	38	135	47
3. Kamandaogo Kobo	2347	38	158	68
4. Mamanyanga windigui	2240	36	142	55
5. Kaman yanga Rambo	2133	41	162	63
6. Kamandaogo Rambo	2133	42	154	62
7. Local Y. Koudougou 1	2027	42	198	108
8. Local Y Saria	2027	37	164	83
9. Noubindou Si Mossi	2027	37	139	63
10. Local Y. Ouagarou	1920	49	191	100
11. Yakaraghin ingané	1813	35	142	53

where these trials were to be conducted, were decided in the SAFGRAD maize and cowpea workshop held from April 25 to 27, 1983. In 1983, 50 sets of RUVT-1 and 35 sets of RUVT-2 were sent to 24 countries. Because of different cropping season and other logistic problems, at the time of writing this report, data from 9 locations for RUVT-1 and 14 locations for RUVT-2 were received and are reported in this report.

The results for RUVT-1 are summarized in Tables 13 and 14 (grain yield) and in 15 (Days to flower). Table 13 records the yield data from 5 locations where C.V. was less than 25% and Table 14 records the data from 4 locations having higher C.V. At Samaru, Nigeria two varieties Temp. x Trop N° 42 and EV Gussao Pool-16 yielded significantly higher than the local check (4744 kg/h). At other locations, none of the varieties tested gave significantly higher yield than the check variety. However, at Farako-Bâ, Upper Volta, Pirsaback (1) 7930, EV Gussao Pool-16, Temp. x Trop N°3 and TZESR were promising varieties. In Sefa (Senegal), Temp. x Trop N° 42 and Temp. x Trop N° 3 were promising. At Kamboinsé, Upper Volta, synth.C, Pop. Senegal oriental and SAFITA-104, were promising varieties. In Ethiopia, Synth.C and TZE 12 seem to be better varieties among the varieties tested. Considering the over all mean, of the five locations, Temp. x Trop N° 42 and EV Gussao Pool-16 were the two promising materials. At two locations in Mali and at Bamban (Guinee) the differences among the varieties were non-significant. At Bamban, SAFITA - 104 and EV Gussao Pool-16 were better varieties. In Mali, SAFITA-104, EV 8182 and EV 7982 appear to have performed well. At Broukou (Togo) TZESR (W) EV 7982, Temp. x Trop N° 42 and EV Gussao Pool-16 are the promising materials among the new varieties tested.

The grain yield data from 8 locations where RUVT-2 was conducted and had less than 25% C.V. are recorded in Table 16. The data from other 6 locations are recorded in Table 17. Data on days to flower are given in Table 18.

In Senegal, IRAT 178, Temp x Trop N° 27 and ATK were the three promising varieties. At Kamboinsé Upper Volta, IRAT 178, Temp. x Trop N°27 and TZPB (onne) and at Farako-Bâ, Upper Volta IRAT 178 and Temp. x Trop N° 27 were the promising materials. At Samaru in Nigeria, Trop. x Temp N°27 ATK, IRAT 178 and TZSR-1 were among the promising varieties. In Sotuba (Mali) IRAT 178 and Elite x E.M. comp. were the promising varieties.

Table 13. Grain yield (kg/ha) of varieties tested in RUVT-1, 1983.

VARIETIES	Samaru (Nigeria)	Farako-Bâ (Haute-Volta)	Sefa-Casamance (Senegal)	Kamboinsé (Haute-Volta)	Nazret (Ethiopia)	Mean of 5 locations
1. Temp. Trop. N° 42	5705	2410	3077	3949	4603*	3785
2. " " N° 3	3590	2461	3026	3795	3770	3328
3. TZESR (W)	4615	2461	2821	3538	3658	3419
3. Pirsaback (1) 7930	4295	2769	2256	3949	4211	3496
4, SAFITA-2	3526	2410	2308	3641	4122	3201
6. M T S	4167	1744	1846	3179	1252	2438
7. SAFITA-104	2436	1692	2000	4000	3936	2813
8. EV 7982	5064	2051	2051	3282	3036*	3112
9. SYNTH.C	3974	2410	2615	4308	4716	3605
10. Pop Senegal Oriental	4295	1744	2462	4000	1170	2734
11. EV 8188	2564	2410	1945	3897	4060	2976
12. EV Gussau Pool-16	5449	2564	2359	3949	4252	3715
13. Check Variety	4744	2000	3128	3949	5410	3846
Average	4186	2240	2454	3803	3707	-
LSD 5%	564	486	564	N.S.	1178	-
C.V. %	11.7	16.0	16.6	18.0	22.2	-

* Yield of Temp x Trop N° 58 instead of Temp. x Trop N°42 in entry N° 1 and EV Kamboinsé TZE 12 instead of EV 7982 in entry N°8, at Nazret (Ethiopia).

Table 14. Grain yield (kg/ha) of varieties tested in RUVT-1, 1983.

VARIETIES	Broukou (Togo)	Bamban (Guinee)	Massantola (Mali)	Katibougou (Mali)	Mean of 4 locations
1. Temp x Trop N° 42	3077	410	718	1436	1410
2. Temp. x Trop. N°3	2667	564	667	718	1154
3. TZESR (W)	6154	564	615	1025	2090
4. Pirsaback (1) 7930	1282	513	769	2205	1152
5. SAFITA-2	2333	564	564	1538	1000
6. M T S	410	769	308	1128	654
7. SAFITA-104	564	862	1026	2000	1013
8. EV 7982	3590	718	667	2256	1808
9. SYNTH.C	718	718	1026	1538	1000
10. Pop. Senegal Oriental	308	615	359	1692	744
11. EV 8188	2102	718	615	2615	1513
12. EV Gussao Pool-16	3077	872	718	1590	1564
13. Check Variety	5282	410	1026	2308	2257
Average	2351	607	698	1696	-
L.S.D. 5%	1128	N.S.	N.S.	N.S.	-
C.V. %	34.2	42.5	47.1	47.7	

to
Table 15. Days/flower of Varieties tested in RUVT-1, 1983.

VARIETIES	Broukou (Togo)	Samaru (Nigeria)	Sefa-Casamance (Senegal)	Massantola (Mali)	Kamboinsé (Hte-Volta)	Bamban (Guinee)	Katibougou (Mali)	Mean of 7 L
1. Temp. x Trop N° 42	50	47	49	56	49	65	52	53
2. Temp. x Trop N° 3	51	48	51	59	51	70	55	55
3. TZESR (W)	49	50	49	56	50	69	57	54
4. Pirsaback (1) 7930	48	49	48	53	47	65	50	51
5. SAFITA-2	51	47	50	57	50	74	50	54
6. M.T.S.	54	47	51	58	50	69	54	55
7. SAFITA-104	46	47	45	50	41	69	50	50
8. EV 7982	47	47	47	54	48	69	50	52
9. SYNTH.C.	52	48	52	58	51	67	57	55
10. Pop Senegal O.	50	47	49	56	50	67	54	53
11. EV 8188	47	47	45	51	41	62	52	49
12. EV Gussao Pool-16	50	47	50	56	48	66	52	53
13. Check Variety	53	51	51	62	43	71	50	54
Average	50	48	49	56	48	68	53	-
L.S.D. 5%	1.7	1.7	1.7	2.2	2.12	5.24	N.S.	-
C.V. %	2.36	2.4	2.47	2.7	3.5	5.37	16.8	-

Table 16. Grain yield kg/ha of varieties tested in RUVT-2, 1983.

VARIETIES	Sefa-Casamance (Senegal)	Nioro (Senegal)	Kamboinsé Hte-Volta	Samaru Nigeria	Sotuba Mali	Farako-Bâ Hte-Volta	Gussao Nigeria	Santiago Cap-Vert	Mean of 8 locations
1.IRAT 178	4320	4960	3787	3933	5013	6884	1813	3733	4305
2.SAFITA-102	3093	3840	3573	2467	4533	5251	2547	3647	3618
3. Elite x E.M x Comp.	3360	3840	3413	3133	4800	5868	1920	3360	3712
4. TZSR-1	3040	4053	3680	3800	4320	6323	2133	2933	3785
5. Poza Rica 7843	2933	3413	3573	2800	3733	6147	1707	2187	2997
6. Fereke (1) 7622	3200	3840	3147	2933	3733	6405	1813	3307	3547
7. Temp. x Trop.N°27	3520	3893	3733	4800	4213	6882	2400	2933	4047
8. ATK 82 ZR	3520	4480	3360	4533	3413	6466	1920	2613	3788
9. EV 8176	3253	3787	3680	3533	4000	6403	2453	2027	3642
10. TZPB (Onne)	2987	4267	3733	3733	4267	5974	2240	2987	3774
11. Bako Comp.	1227	1760	800	2000	1813	4296	747	1173	1727
12. Check Variety	3727	3520	3787	3133	4640	5612	3307	3200	3873
Average	3187	3804	3356	3400	4040	6034	2000	2800	-
L.S.D. 5%	781	800	720	640	1120	N.S.	640	1013	-
C.V. %	14.2	15.0	15.5	16.5	19.3	21.2	23.2	24.9	-

Table 17. Grain yield kg/ha of varieties tested in RUVT.2, 1983.

VARIETIES	Pita Guinee	Bordo Guinee	Yundum Gambia	Kita Mali	Broukou Togo	Kaedi Mauritania	Mean of 6 locations
1. IRAT 178	3573	2987	2293	1733	1387	2453	2404
2. SAFITA-102	2667	3200	480	1472	1813	2133	1961
3. Elite x E. mex comp.	2560	1920	1387	1584	2827	1707	1998
4. TZSR-1	2880	1867	2187	2112	5227	1920	2699
5. Poza Rica 7843	3093	2827	1600	2112	3147	1760	2423
6. Fereke (1) 7622	3093	1813	1813	2043	1760	1707	2038
7. Temp x Trop N° 27	1547	1920	1600	1515	3787	1813	2030
8. ATK 82 ZR	2987	2827	2080	2448	3787	1867	2666
9. EV 8176	2240	1760	2027	1909	4960	1173	2345
10. TZPB (Onne)	3253	1920	960	1520	4533	1600	2298
11. Bako Comp	1760	1973	1280	1632	853	213	1285
12. Check Variety	960	1600	1920	1819	1920	2027	1708
Average	2551	2218	1636	1825	3000	1698	-
L.S.D. 5%	960	1045	907	N.S.	2027	1173	-
C.V. %	26.0	32.4	37.8	39.0	46.8	47.3	-

Table 18. Days to flower of varieties tested in RUVT-2, 1983.

VARIETIES	Kamboinsé (Hte.Volta)	Sefa -C. (Senegal)	Broukou (Togo)	Farako-Bâ (Hte-Volta)	Yundum (Gambie)	Santiabo (Cap-Vert)	Bordo (Guinee)
1. IRAT 178	55	53	56	63	55	62	58
2. SAFITA-102	55	54	57	65	66	62	58
3. Elite x E.Mex.Comp	55	53	55	63	59	59	60
4. TZSR-1.	56	55	55	62	56	62	61
5. Poza Rica 7843	57	55	45	66	58	63	60
6. Fereke 7622	55	55	57	64	57	62	59
7. Temp. Trop N° 27	52	53	52	61	54	59	58
8. ATK 82 ZR	56	54	55	65	58	64	60
9. EV 8176	56	54	56	65	57	64	63
10. TZPB (Onne)	59	55	56	63	56	62	60
11. BAKO Comp.	66	60	61	72	57	73	72
12. Check Variety	50	53	60	62	54	48	56
Average	56	55	55	64	57	62	60
LSD 5%	1.49	1.7	1.8	2.4	2.38	2.7	N.S.
C.V. %	2.02	2.18	2.3	2.55	2.89	3.03	3.16

Table 18 bis.

Sotuba (Mali)	Gusao (Nigeria)	Kaedi (Mauritanie)	Kita (Mali)	Nioro (Senegal)	Pita (Guinee)	Mean 13 L
51	54	54	58	56	64	57
53	54	54	62	55	63	58
51	53	52	65	53	61	57
52	53	55	59	56	64	57
55	56	54	58	55	64	57
53	54	57	60	55	65	58
51	50	54	63	52	56	55
54	54	55	53	54	63	57
55	56	55	61	56	64	59
54	57	59	60	57	68	59
56	58	65	64	61	72	64
55	55	51	64	50	65	56
53	54	55	61	55	64	-
2.67	2.7	3.21	5.17	2.75	N.S.	-
3.5	3.5	4.07	4.27	3.47	17.71	-

In Cap-Vert, IRAT 178 and SAFITA-102 were the promising materials. Taking the overall average for 8 locations, IRAT 178 and Temp. x Trop N° 27 seem to be the two promising varieties. It may be indicated that IRAT 178 is a complex hybrid variety. All other varieties included in this trial, are open pollinated composite varieties.

In Guinee, IRAT 178 and Poza Rica 7843 appear to be promising materials. In Togo TZSR-1,EV 8176 and TZPB (onne), Temp. x Trop N° 27 and ATK were better varieties. In Mauritania, IRAT 178 and SAFITA-102 were among the better varieties. In Gambia, IRAT 178, TZSR-1, ATK and EV 8176 were the promising materials.

Bako composite which is a variety from Ethiopia, was unadapted in most of the locations where this trial was conducted.

Production Plots and Seed Increases

In collaboration with National Seed Service and the extension office, twelve half/hactare plots of SAFITA-2 were established in the farmers fields. In general the farmers were satisfied with the performance of this variety. These production plots served as seed production plots and about 10.0 tons of seed is available with farmers for use during the next year.

Foundation seed of SAFITA-104 and SAFITA-102 were also produced in ½ to 1.0 hactare isolation plots at Kamboinsé. This seed will be used in 1984 by National Seed Service.

In addition, more than 100 varieties/composites of different origin were sib pollinated for seed multiplication for various purposes to be used during the next season.

MAIZE AGRONOMY

1. INTRODUCTION

The program was initiated in 1979 to identify and help solve the agronomic problems for maize production in the Semi-Arid Tropics of Africa. Most of the research effort has been concentrated in the Sudan Savanna (700-900 mm rainfall ; Kamboinsé and Saria Research Stations in Upper Volta and on-farm trials), but experimentation in the Northern Guinea Savanna was again started in 1983.

Most of the results of the research in the Sudan Savanna are applicable to regions in the 700-900 mm belt where there are ferruginous tropical soils with problems of soil compaction, prone to surface sealing or crusting and where dry periods occur during the growing season. Some of the results may also apply to other types of soils or to regions outside the 700-900 mm belt, but this needs testing at the local level, and it should not be assumed that they apply to all of the Semi-Arid Tropics.

In the French Soil Classification System, the soils of the Kamboinsé and Saria Stations seem to fall mostly within two categories "Sols Ferrugineux Tropicaux" and "Sols Hydromorphes" (in the lower parts of the toposequence). The Soil Taxonomy classification (USDA) equivalents are likely to be Haplustalfs, Paleustalfs and Plinthustalfs in the former case, and Tropaquents, Tropaquepts and Tropaqualfs in the case of hydromorphic soils.

The soils at the Kamboinsé Station (excepting the hydromorphic soils) have, typically, the following characteristics :

(1) a loam to sandy loam texture,
(2) about 12 % clay (0.002 mm),
(3) about 30 % silt,
(4) about 58 % sand,
(5) about 1 % organic matter,
(6) a C/N ratio around 11,
(7) a pH-H_2O around 6,
(8) about 2.3 meq. exchangeable Ca/100 g,
(9) about 0.8 meq. exchangeable Mg/100 g,
(10) about 0.21 meq. exchangeable K/100 g,
(11) about 0.11 meq. exchangeable Na/100 g,
(12) about 12 ppm of available P (Olsen),
(13) Total P contents of 80-160 ppm,

The soils at the Farako-Bâ Station (1100 annual rainfall, Northern Guinea Savanna) are classified as "Sols Faiblement Ferrallitiques" (Weakly Ferrallitic Soils).

The SAFGRAD/IITA maize agronomic research has generally been conducted under 2 management levels : low and high. The "low" management level is a combination of low density (usually around 44,000 plants/ha) and low fertilizer (usually around 37-23-15 kg/ha of N-P_2O_5-K_2O). This would allow grain yields of about 2-2.5 ton/ha. The "high" management level consists of high density (usually around 59,000 plants/ha) and high fertilizer (usually around 97-46-30 kg/ha of N-P_2O_5-K_2O in the Sudan Savanna), which would allow grain yields of up to 4-5 ton/ha. These management levels also involve S and B_2O_3 as follows :

6-1 and 12-2 kg/ha at the low and high fertility respectively. In the Northern Guinea Savanna, the high fertilizer rate is increased to about 157-69-45.

Total rainfall in Kamboinsé and Farako-Bâ in 1983 was below average and its distribution quite irregular, especially in the latter location. Kamboinsé received 663.4 mm total rainfall and Farako-Bâ only 755.3 mm (yearly averages are 800 and 1100 mm, respectively). Although the rains in Kamboinsé went from June to mid September, the season was characterized by a low precipitation in the month of August (136.5 mm). In Farako-Bâ, there were dry spells in the month of July and the rains ended by mid September, i.e. about one month earlier than usual.

When discussing the results of the trials no mention will be made of final plant densities (at harvest), except in those cases, if any, whe~e they were subtantially below the intended ones or quite different between treatments.

2. Objectives and Strategy

2.1. The specific objectives of the SAFGRAD/IITA Maize Agronomy Program are :

2.1.1. To assess the ralative importance of the different soil, climate, and management factors affecting maize production in the Semi-Arid Tropics (SAT).

2.1.2. To establish suitable management practices for the production of maize in the SAT, under both low-medium and medium-high management/ input conditions.

2.1.3. To help in the training of national researchers of the SAFGRAD Member countries.

2.1.4 To participate in the Breeding Program in the formulation and execution of a crop improvement program relevant to the conditions of the SAT, with particular emphasis on increasing the tolerance of maize to drought.

2.2. In order to achieve the above mentioned objectives and have a truly regional impact, the basic approach will consist of :

2.2.1. Research trials conducted directly by the SAFGRAD/IITA Maize Agronomist in Upper Volta.

2.2.2. Research trials conducted in SAFGRAD Member countries in collaboration with local researchers.

2.2.3. Regional Maize Agronomy Trials (REMAT) in which :

a) cultural practices that have been proven sucessful in Upper Volta or in other locations are tested at a regional level.

b) The regional significance of certain issues (the residual effect of fertilizers, for example) is evaluated.

2.2.4. In-service training of national researchers through their direct participating in the cropping season activities in Upper Volta.

2.2.5. A two-way flow of information between the maize agronomists and the ACPO's (Accelerated Crop Production Officers) in SAFGRAD member countries.

2.2.6. The exchange of results and other relevant information among the maize researchers working in the area, through written reports, field visits, conferences, etc.

3. Trials at Farako-Ba (Northern Guinea Savanna)

3.1. Planting Date Trial

An experiment consisting of a factorial combination of 4 planting dates, 2 management levels, and 2 varieties was set up in a split-split-plot arrangement with 5 RCB. The planting dates were : (1) June 22, (2) July 8, (3) July 22, and (4) August 7. The varieties were (1) SAFITA-2 (90 days to maturity) and (2) SAFITA-102 (110 days). The management levels were : (1) low and (2) high. The low management level involved a low fertilizer level (F1) and a low density (D1) whereas the high management level consisted of a high fertilizer level (F2) and a high density (D2).

The fertilizer levels (kg/ha) were :

	14-23-15	+	Urea	=	Total
F1	100		50		37-23-15
F2	300		250		157-69-45

The plant densities and spacings (1 plant/hill) were :

D1 : 44,400 plants/ha (75 x 30 cm^2)
D2 : 59,300 plants/ha (75 x 22.5 cm^2)

There was a highly significant effect of planting date on maize grain yield (Table 1). Yields were highest for the first planting date (2310 kg/ha for June 22) and decreased with each successive planting date, being only 110 kg/ha for the last date (August 7). The average decrease in yield was close to 50 kg/ha day for per delay in planting after June 22. However, as the highly significant Management x Date interaction indicates, the drop in yield with later plantings was more pronounced at the high than the low management level. In fact, the highly significant increase in yield between low and the high management

Table 1. Planting date trial. FARAKO-BA (Upper Volta), 1983. Maize grain yield (kg/ha, at zero percent moisture).

Management level (* *)	Variety (* *)	Planting date (* *)				Mean
		June 22	July 8	July 22	August 7	
M1	SAFITA-2	1655	1195	855	190	970
	SAFITA-102	1530	1175	515	40	815
	Mean	1595	1185	685	115	895
M2	SAFITA-2	3025	2445	965	210	1660
	SAFITA-102	3040	1940	350	10	1335
	Mean	3030	2190	655	110	1500
Variety	SAFITA-2	2340	1820	910	200	1315
	SAFITA-102	2285	1560	430	25	1075
Mean		2310	1690	670	110	1195

Management x Date (**)			
Management x Variety (ns)	C.V.	Main plot	20.2
Date x Variety (*)	%	Sub-plot	27.0
Management x Date x Variety (ns)		Sub-sub-plot	17.1

*, * * : Significant 5 and 1%

n s : Non significant

L.S.D. 's at 5 %

Management levels	150
Dates	211
Varieties	93
Varieties at same Management	132
Varieties at same Date	186
Varieties at same Date and Management	264
Dates at same Management and same or different Variety	249

levels was present only in the June 22 and July 8 planting dates, but there was no difference in yield between both management levels for the July 22 and August 7 planting dates. Thus, early planting is essential for obtaining a good response to improved management (fertilizer and density).

The early variety, SAFITA-2, was significantly better than the medium-maturity one, SAFITA-102, except for the first planting date (June 22) when both varieties gave comparable yields (significant Date x Variety interaction.

Total rainfall and its distribution was poor in Farako-Bâ in 1983 It rained 755,3 mm, well below the average of 1100 mm. In addition, the rains ended by mid september instead of October. It seems that part of the date of planting effect on yield can be attributed to lack of enough moisture at the end of the season. Streak virus disease was also a factor involved in the lower yields found in later plantings. The percentage of plants with streak was 64.2 and 89.7 % for the July 22 and August 7 plantings respectively (L.S.D. = 5.4, at 5 % level). Although no counts are available for the June 22 planting, streak incidence was certainly much lower in the first 2 planting dates (51.3 % of plants of SAFITA-102 showed streak for the July 8 planting).

Stem borer damage was not a factor of importance in explaining the effect of planting date on yield. The percentage of stalks attacked by borers was 11.9, 8.1, 8.1 and 5.0 for planting dates 1 to 4, respectively (L.S.D. = 7.1, at 5 % level). None of the plants showed "dead-heart". The average number of independent borer channels was 1.04 (in 8 plants sampled/ plot) and was not statistically different between the 4 planting dates.

3.2. Density trial

In order to estimate the response to plant density and the optimum density (for maximum yield) of two of the promising varieties of the Maize Breeding Program, SAFITA-2 and SAFITA-102, they were planted at the following densities and arrangements :

	Density	Spacing	Plants/hill
D1	17,800	75 x 75 cm^2	1
D2	40,000	75 x 50 cm^2	1-2-1-2
D3	53,300	75 x 25 cm^2	1
D4	80,000	75 x 25 cm^2	1-2-1-2
D5	106,700	75 x 12.5 cm^2	1

The experiment was planted on June 21 in 6-row plots, 5-m long and replicated 5 times. Grain yield was measured in the 2 central rows.

The fertilizer level was 300 kg/ha of 14-23-15 at planting and 250 kg urea/ha split in 2 equal applications at 30 and 55 days after planting (DAP). The total amount of $N-P_2O_5-K_2O$ was thus 157-69-45 kg/ha. It was realized that the density response curves are a function of the fertility level, but in order to simplify the experiment, rather than to look at the response at different levels of fertility, it was decided to look at a sort of "upper" envelope of the density curves. The effective plant densitics at harvest time were very close to the intended ones, as follows : 17800, 38300, 53100, 77000, and 106400 for SAFITA-2, and 17800, 38300, 52800, 77000, and 103,500 for SAFITA -102.

The grain yield results (Fig.1) indicate that, under the experimental conditions of 1983, SAFITA-2 gave the highest yield at a density of around 80000 plants/ha and showed a pronounced decline in yield at the highest density. In the case of SAFITA-102, yields close to the maximum were obtained at about 53000 plants/ha and yields stayed fairly stable at higher densities.

A more precise analysis to determine the optimum density will be carried out by applying Duncan's model (Duncan, W.G. 1958. The relationship between corn population and yield. Agron. J. 50:82-84).

3.3 Ridging and Earthing-up Trial

Ferruginous tropical soils are the most common soils in West African Savanna whereas ferrallitic soils are common in the forest zone. Although ferrallitic soils can occur in the Sudan Savanna (Jones, M.J. and

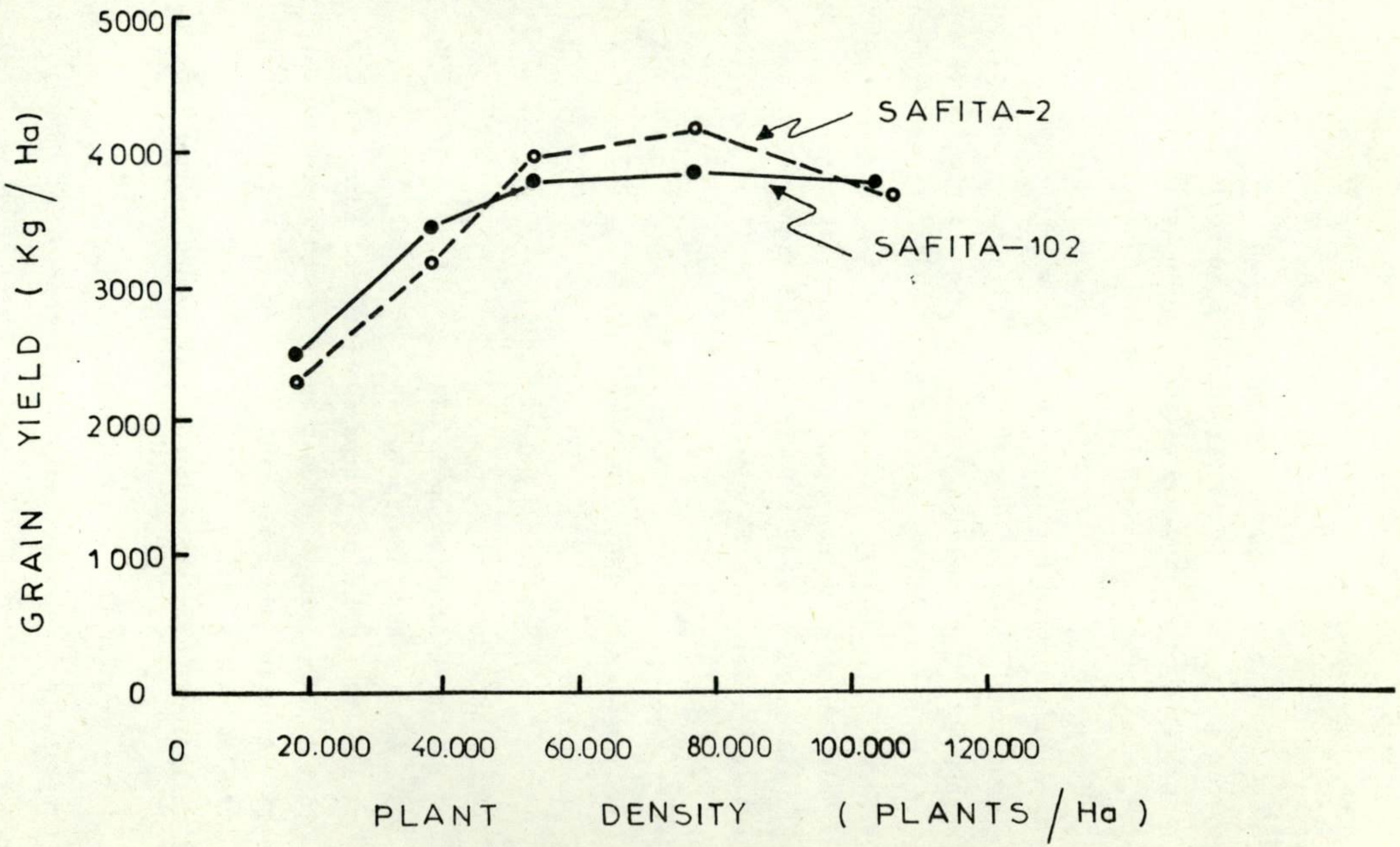


FIG.1. THE EFFECT OF PLANT DENSITY ON THE MAIZE GRAIN YIELD OF 2 MAIZE VARIETIES.
DENSITY TRIAL. FARAKO-BA (UPPER-VOLTA), 1983.

A. Wild, 1975. Soils of West African Savanna. CAB. Great Britain.246 p.) they are more likely to be found in the Guinea Savanna than in the Sudan Savanna. Given the higher water infiltration rates of ferrallitic soils and higher rainfall of the Guinea Savanna, periods of excess moisture during the growing season are possible but they can also occur in ferruginous tropical soils presenting a very compact subsoil. Responses to cultural practices such as ridging, earthing up and tied ridging need to be evaluated under both (and other) types of soils and climatic zones.

Experiments conducted in the past years in the Sudan Savanna in ferruginous tropical soils have shown no differences in maize grain yield between planting on the flat and planting on simple ridges (provided that three are no stand differences) and have showed also a very marked positive effect of tied ridges. In order to test the usefulness of these techniques under Northern Guinea Savanna in ferrallitic soils, an experiment was planted on June 23, in a latin square design. The variety was TZPB and the fertilizer used the same as the F2 level of the planting date trial.

The following 8 ridging and earthing up systems were tested in a tractor plowed plot :

T1 : planting on the flat
T2 : As T1 + Earthing up 35 DAP
T3 : As T1 + Earthing up 70 DAP
T4 : As T2 + Tying of ridges every second furrow 35 DAP
T5 : As T2 + Tying of ridges every second furrow 70 DAP
T6 : Planting on simple ridges
T7 : As T6 + Earthing up 35 DAP
T8 : Planting on ridges tied every second furrow + Earthing up 35 DAP.

There were no statistically significant differences in the maize grain yield between any of the treatments (Table 2). Thus, under the experimental conditions of 1983, there appears to be no advantage

Table 2. Ridging and earthing-up trial. FARAKO-BA (Upper Volta), 1983. Maize grain yield (at zero percent moisture), days to silking, ears with incomplete pollination, and stem and root lodging (after the arcsine transformation).

Treatment	Grain yield kg/ha (n s)	Days to 50% silking (**)	Ears with incomplete pollination (%) (* *)	Stem lodging % (*)	Root lodging % (* *)
T1. Planting on the flat.	3130	67.6	16.9	14.1	15.3
T2. Planting on the flat. Earthing up 35 DAP.	3360	66.6	10.9	20.3	13.3
T3. Planting on the flat. Earthing up 70 DAP.	3160	67.8	16.1	12.2	9.8
T4. Planting on the flat. Earthing up 35 DAP + ridge tying every other furrow.	3200	67.9	13.2	16.5	25.2
T5. Planting on the flat. Earthing up 35 DAP + ridge tying every other furrow at 70 DAP.	3410	67.6	12.6	15.7	19.2
T6. Planting on ridges.	2870	71.5	21.3	15.1	17.1
T7. Planting on ridges. Earthing up 35 DAP.	3040	70.1	16.7	10.0	20.2
T8. Planting on ridges tied every other furrow. Earthing up 35 DAP.	3040	70.2	19.9	13.9	20.4
Mean	3150	68.7	16.0	14.7	18.8
C.V. (%)	15.0	2.6	35.6	38.3	37.0
L.S.D. (5 %)	477	1.8	5.7	5.7	7.0

*, * : significant at 5 and 1%. n s : Non significant.

of ridging (simple or tied) nor of earthing up (simple or tied) over planting on the flat (and keeping a flat bed) in terms of grain yield. Nevertheless, there were statistically significant differences between treatments for other variables. The number of days to 50% silking was significantly higher in all treatments involving planting on ridges (>70 days) than in all flat planted treatments (<68 days). The percentage of ears with incomplete pollination was also generally higher in the former. Although there were statistically significant differences between treatments in the degree of stem and root lodging, the only apparent trend seems to be that early earthing up (35 DAP) does not decrease root lodging but rather increases it, whereas late earthing up (70 DAP) had the lowest root lodging.

3.4. Maize-Cowpea Rotation and Relay-Cropping Trial

A cowpea-maize rotation experiment started in Saria Station (Sudan Savanna) since 1979 has consistently shown higher maize yields when maize follows cowpeas than when maize follows maize, under both low and high fertility conditions and a significant positive effect of Furadan 5G on maize grain yield. An experiment to study if the same results apply under Northern Guinea Savanna conditions was started in 1983. In addition the trial will try to answer two more questions : (1) is there an effect of cowpeas when relay-cropped with maize on the maize yield in the following year ?, and (2) is there an interaction between the cowpea genotype and the rotation effect ?

The experiment involves a factorial combination of 2 management levels x 8 rotations x 2 Furadan levels in a split-split-plot arrangement with 4 replications.

The management levels for maize were low (low fertilizer level = 58-57.5-3 7.5 kg N-P_2O_5-K_2O/ha, and low density =44,400 plants/ha), and high (high fertilizer level = 150-57.5-37.5 kg N-P_2O_5-K_2O/ha, and high density = 59,300 plants/ha). In the case of cowpeas, no fertilizer is to be directly applied either in sole or relay-cropped cowpeas, except for the 1983 (first year) sole cowpea plots which received 50 kg P_2O_5/ha as SSP. The cowpeas were planted at 59,300 and 53,300 plants/ha for varieties 1 and 2 respectively.

The crop rotations are as follows (M = maize, C1 or C2 = cowpeas variety 1 or variety 2, M-C = cowpeas relay-cropped with maize) :

Rotation	1983	1984	1985	1986
R1	M	M	M	M
R2	M	C1	M	C1
R3	C1	M	C1	M
R4	M-C1	M-C1	M-C1	M-C1
R5	M-C1	M	M-C1	M
R6	M	M-C1	M	M-C1
R7	C2	M	C2	M
R8	M-C2	M	M-C2	M

The Furadan levels were :

N1 = No Furadan

N2 = 1.5 of Furadan 5G/plant applied both at planting and 60 DAP. The maize variety (TZPB) and sole cowpeas were planted on June 22. Relay-cropped cowpeas were planted on July 22 (C2) and September 1st (C1). The cowpea varieties were C1 = TVx 3236 (semispreading, photoinsensitive) and C2 = local Logfrousso (spreading, photosensitive). Maize grain yields (Table 3) were not significantly different (5% level) between rotations but were significantly increased by the high management level (2070 VS 3310 kg/ha) and by the application of Furadan (2580 VS 2800 kg/ha).

The average percentage of stalks attacked by borers was 7.64 and was not statistically different between rotations, but it was significantly decreased by the application of Furadan from 12.15 to 3.12 % (L.S.D. = 4.03, at 5 % level). The number of independant borers channels (in 6 stalks sampled per plot) was significantly decreased by Furadan

Table 3. Maize-cowpea rotation and relay-cropping trial. FARAKO-BA (Upper Volta), 1983. Maize grain yield (kg/ha, at zero percent moisture).

Rotation (ns)	Furadan (*)	Management (* *) M1	M2	Mean
R1 = M M M M	N1	1980	3670	2830
	N2	2020	3580	2800
	Mean	2000	3630	2810
R2 = M C1 M C1	N1	2010	3220	2610
	N2	2220	4240	3230
	Mean	2110	3730	2920
R4 = M-C1 M-C1 M-C1 M-C1	N1	2010	3000	2510
	N2	2570	2910	2740
	Mean	2290	2960	2620
R5 = M-C1 M N-C1 M	N1	2180	3290	2730
	N2	1870	2900	2380
	Mean	2020	3100	2560
R6 = M M-C1 M M-C1	N1	1930	2930	2430
	N2	2410	3680	3040
	Mean	2170	3300	2740
R8 = M-C2 M M-C2 M	N1	1840	2920	2380
	N2	1780	3420	2600
	Mean	1810	3170	2490
F u r a d a n	N1	1990	3170	2580
	N2	2140	3460	2800
Mean		2070	3310	2690

Management x Rotation (n s)	C.V.	Main plot	32.5
Management x Furadan (n s)		Sub-plot	23.8
Rotation x Furadan (n s)		Sub-sub-plot	18.5
Management x Rotation x Furadan (n s)			

*, ** : Significant at 5 and 1%
n s : Non significant
L.S.D.'s at 5%

Management levels	568
Rotations	464
Furadan levels	206
Furadan levels at same Management	292
Furadan levels at same rotation	505
Furadan levels at same Rotation and Management	715
Rotations at same Management and same or different Furadan	478

from 1.62 to 0.25 (L.S.D = 0.78, at 5 % level). Thus, part of the positive effect of Furadan on the grain yield was due to borer control, but since no plant presented "dead heart" and the number of independent borer channels was very low, the positive effect of Furadan on maize yield was also due to factors other than borer control.

Cowpea grain yields (sun-dried, likely moisture content : around 10 %) were highly different between the different rotations involving cowpeas, as might be expected, but none of the other main factor effects and interactions were statistically significant (Table 4).

The highest grain yield was obtained with TVx 3236 when planted as monocrop (1894 kg/ha), whereas the local Logfrousso gave only 1215 kg/ha as monocrop (L.S.D. = 217, at 5 % level). The relative performance of both varieties when relay-cropped was quite different : TVx 3236 gave only 149 and 134 kg/ha in Rotations 4 and 5, but local Logfrousso gave 829 kg/ha in Rotation 8. These results are no doubt, closely related to the rainfall distribution pattern of 1983, characterized by a very early end of the rains (see discussion about Planting Date Trial) and can be expected to differ in a more "normal" year but they illustrate, nevertheless, real conditions (risks) faced by farmers in semi-arid environments. In this trial, sole cowpeas without Furadan were severely attacked by aphids whereas Furadan-treated plots were free of aphids for 5-6 weeks after planting and had a more vigorous growth. Insecticide sprays were started at 46 DAP and repeated weekly. However, the early aphid damage was not reflected in the final yield. In the case of relay-cropped cowpeas, insecticide sprays started at 5 WAP and were also continued weekly.

3.5 Timing of Nitrogen Application Trial

Given the higher rainfall, better water infiltration rates and deeper soils found in some Northern Guinea Savanna soils, it was conside-

Table 4. Maize-cowpea rotation and relay-cropping trial. FARAKO-BA (Upper Volta),1983.
Cowpea grain yield.

Rotation (**)	Furadan (ns)	Management (ns) M1	Management (ns) M2	Mean
R3 = C1 M C1 M	N1	1610	2045	1827
	N2	1798	2123	1961
	Mean	1704	2084	1894
R4 = M-C1 M-C1 M-C1 M-C1	N1	223	117	170
	N2	169	88	129
	Mean	196	103	149
R5 = M-C1 M M-C1 M	N1	187	87	137
	N2	184	77	130
	Mean	185	82	134
R7 = C2 M C2 M	N1	1288	1079	1184
	N2	1272	1220	1247
	Mean	1280	1150	1215
R8 = M-C2 M M-C2 M	N1	920	846	883
	N2	934	615	775
	Mean	927	730	829
Furadan	N1	846	835	840
	N2	871	825	848
Mean		859	830	844

Management x Rotation (ns)	C.V. %	Main plot	27.2
Management x Furadan (ns)		Sub-plot	35.2
Rotation x Furadan (ns)			
Management x Rotation x Furadan (ns)		Sub-sub-plot	27.0

*, ** : Significant at 5 and 1%
NS : Non significant
L.S.D.'s at 5 %

Management levels	163
Rotations	217
Furadan levels	104
Furadan levels at same Management	147
Furadan levels at same Rotation	233
Furadan levels at same Rotation and Management	329
Rotations at same Management and same or different Furadan	244

red important to conduct an experiment with the following objectives : (1) to determine the best time to apply the N fertilizer from the point of view of maize grain yield, (2) to establish an N response curve, and (3) to measure the residual N fertilizer effect. To this effect, a factorial combination of 2 nitrogen levels and 5 timings of N application was set up in a split-plot arrangement with 5 replications. There were in addition, 2 additional treatments : one without added N and another with 100 kg N/ha.

The N levels were 50 and 150 kg N/ha. The timings of N application are given below :

Timing	Days after planting		
	16	36	52
T1	1/1	-	-
T2	1/2	1/2	-
T3	1/2	-	1/2
T4	-	1/2	1/2
T5	1/3	1/3	1/3

The additional treatment with 100 kg N/ha received the T5 split application.

The experiment was planted on June 22, at a density of 53,300 plants/ha (75 x 25 cm^2) and with the variety TZPB. There were blanket applications of 75 kg P_2O_5 (SSP) and 60 kg K_2O/ha (KCl). The N source was urea.

The grain yield response to N fertilizer (3 equal split applications) is shown in Fig.2. The response appears to be almost linear and the grain yield increase is of the order of about 15 kg grain/kg of added nitrogen. The yield increases when N was increased from 0-50-100-150 kg N/ha were always statistically significant, even

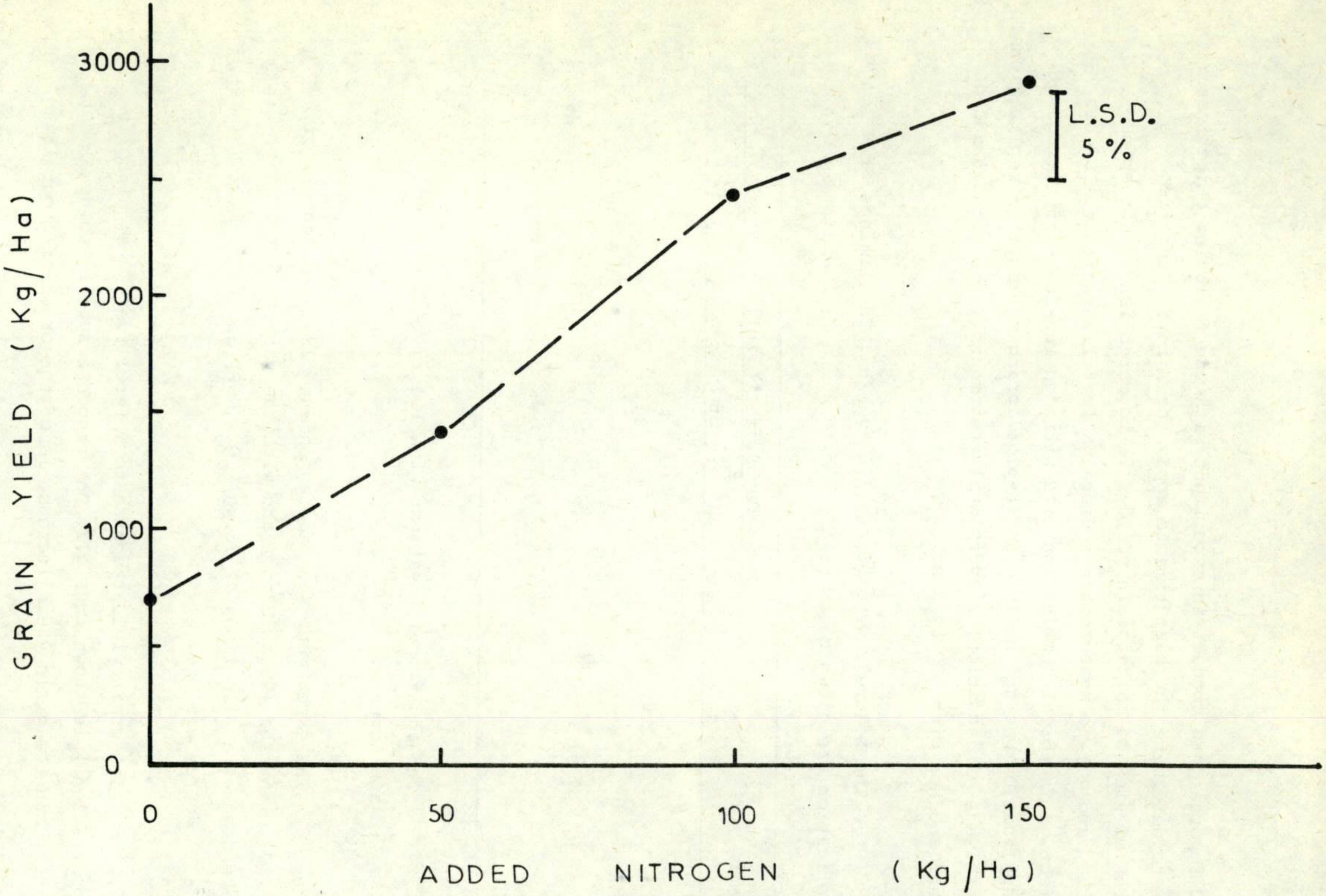


FIG. 2. THE EFFECT OF NITROGEN FERTILIZER ON MAIZE GRAIN YIELD. TIMING OF NITROGEN APPLICATION TRIAL. FARAKO-BA (UPPER-VOLTA), 1983.

by the relatively inefficient approach of mean comparison by analysis of variance. Given the rainfall distribution pattern in 1983, the yield response to N application was likely below average. At the same time, the likelihood of a residual N effect is greater.

There were no significant differences in grain yield between the different timings of N application (Table 5) and Nitrogen level x timing interaction was not statistically significant. The fact that comparable yields were obtained when N was all applied early or in several split applications is somewhat surprising but could be directly related to the low total rainfall observed in Farako-Bâ in 1983 (755.3mm). Although the timing of N application had no statistically significant effect on yield, it had, however, a significant effect (5 % level) on both grain size (weight of 1000 grains) and grain number (number of grains/m^2) but no consistent trend could be detected. Thus, for instance, the grain number was lowest in T1 and T5 and an highest in T3 (1237, 1256, and 1406, respectively ; L.S.D. = 126), whereas grain size was lowest in T4 and highest in T5 and T1 (167, 172, and 179 respectively ; L.S.D. =8.8).

3.6 Nitrogen and Phosphorus Response and Residual Fertilizer Effect Trial

In order to measure the grain yield response to nitrogen and phosphorus and, especially, to estimate the residual effect of N and P fertilizer in a semi-arid environment, a factorial combination of 9 levels of N-P x 3 plant densities was set up in a split-plot arrangement with 4 RCB.

The fertilizer levels were as follows :

Level	N	P_2O_5	K_2SO4
F1	0	0	80
F2	0	75	80
F3	50	75	80
F4	100	75	80
F5	150	75	80
F6	150	50	80
F7	150	25	80
F8	150	0	80
F9	150	75	0

Table 5. Timing of nitrogen application trial. FARAKO-BA (Upper Volta), 1983.

Maize grain yield (kg/ha, at zero percent moisture).

Timing of application (n s)				Nitrogen level (* *) kg/ha		Mean
				50	150	
	------DAP------					
	16	36	52			
T1.	1/1	-	-	1490	2980	2240
T2.	1/2	1/2	-	1550	2820	2190
T3.	1/2	-	1/2	1550	3250	2400
T4.	-	1/2	1/2	1480	3270	2370
T5.	1/3	1/3	1/3	1410	2910	2160
Mean				1500	3050	2270

Nitrogen level x timing (n s)	C.V.	Main plot	17.7
	%	Sub-plot	13.5

*, ** : Significant at 5 and 1%

n s : Non significant

L.S.D.'s at 5%

Nitrogen levels	317
Timings	279
Timings at same Nitrogen level	395
Timings at different Nitrogen levels	469

The absolute N-P check treatment is F1. The response to N (in the presence of 75 kg $P_2 O_5$/ha) is evaluated by treatments F2 to F5. The response to P (in the presence of 150 kg N/ha) is measured with treatments F5 to F8. Although K is not generally dificient in West African Savanna soils it was added in all treatments, except F9 in order to ensure that the response to N and P is not limited by a lack of K. The contrast F5 VS F9 indicates if K deficient or not. The K was added as potassium sulfate so that enough sulfur was provided (about 14.5 kg S/ha) in case of dificiency. Thus, an apparent response to P is due in fact to P and not to the S in the single super phosphate (source of P). The P and K fertilizers were broadcast and incorporated at planting. The N (urea) was split in 3 equal applications : 16, 36, and 52 DAP.

The densities and spacings (1 plant/hill) were :

D1 : 26,700 plants/ha (75 x 50 cm^2).
D2 : 44,400 plants/ha (75 x 30 cm^2).
D3 : 66,700 plants/ha (75 x 20 cm^2).

The trial was planted on June 22, 1983 with the variety TZPB. In order to estimate the residual fertilizer effect, the trial will be planted again in 1984 and 1985 in the same plots, but without any additional fertilizer application.

Maize grain yields (Table 6) were highly significantly different between fertility levels and plant densities. The response to fertilizer was significantly affected by plant density.

At all fertilizer levels but one (F1), grain yield reached a maximum and then declined at the highest density (66,700 plants/ha). A more precise analysis will be carried out later by using Duncan's model (See Density Trial). A preliminary analysis indicates that the optimum density for maximum yield increased as either the N or P level was

Table 6. Nitrogen and phosphorus response and residual fertilizer effect trial. Farako-Bâ (Upper Volta), 1983. Maize grain yield (kg/ha, at zero percent moisture).

Fertilizer level (* *)				Density (* *) plants/ha			Mean
				26,700	44,400	66,700	
	N	P_2O_5	K_2SO_4				
F1.	0	0	80	690	590	650	645
F2.	0	75	80	1190	1290	895	1125
F3.	50	75	80	2045	1990	1915	1980
F4.	100	75	80	2325	3345	3145	2935
F5.	150	75	80	2965	3870	3660	3500
F6.	150	50	80	2995	3395	3155	3180
F7.	150	25	80	2080	2535	2020	2215
F8.	150	0	80	695	745	380	605
F9.	150	75	0	3410	3760	3330	3500
Mean				2045	2390	2130	2190
Fertilizer level x Density (*)				C.V.	Main plot		23.6
				(%)	Sub-plot		15.2

*, * * : Significant at 5 and 1%

n s : Non significant

L.S.D.'s at 5%

Fertilizer levels	436
Density	157
Densities at same Fertilizer level	472
Densities at different Fertilizer levels	582

increased. Nevertheless, the intermediate density of 44,400 plants/ha gave grain yields that were either the highest or very close to the highest at all fertilizer levels. For this reason, the response to N and P fertilizer was (tentatively) evaluated by taking into account yield data at 44,400 plants/ha. (Fig.3).

The following (tentative) conclusions follow :

1. K is not a yield limiting factor (first year). Comparable yields were obtained under F5 and F9.

2. P is a factor limiting yield more than N. Addition of N without any P increased yield by only 155 kg/ha, whereas addition of P without any N increased yield by 700 kg/ha (L.S.D. = 582, 5% level).

3. Both P and N are yield limiting factors. The response to N appears to be almost linear, but that of P is clearly curvilear. Nevertheless, the highest N and P_2O_5 rates included in this trial (150 and 75 kg/ha) don't seem to reach the highest possible yield.

4. The average grain yield increase was of about 17 kg grain/kg of added N . Assuming a total N content in the crop of 30 kg N/ton grain yield, the average yield increase (510 kg grain/30 kg of added N) corresponds to an efficiency of N fertilizer recovery of 51 %.

5. The addition of 75 kg P_2O_5 brought a yield increase of 41.7 kg grain/kg of added P_2O_5. Assuming a total P content in the crop of 10 kg P_2O_5/ton grain yield, the yield increase (417 kg grain/10 kg of added P_2O_5) corresponds to an efficiency of P_2O_5 fertilizer recovery of 41.7 %.

The grain yield response to N fertilizer in this experiment was very similar to that found in the Timing of N application trial

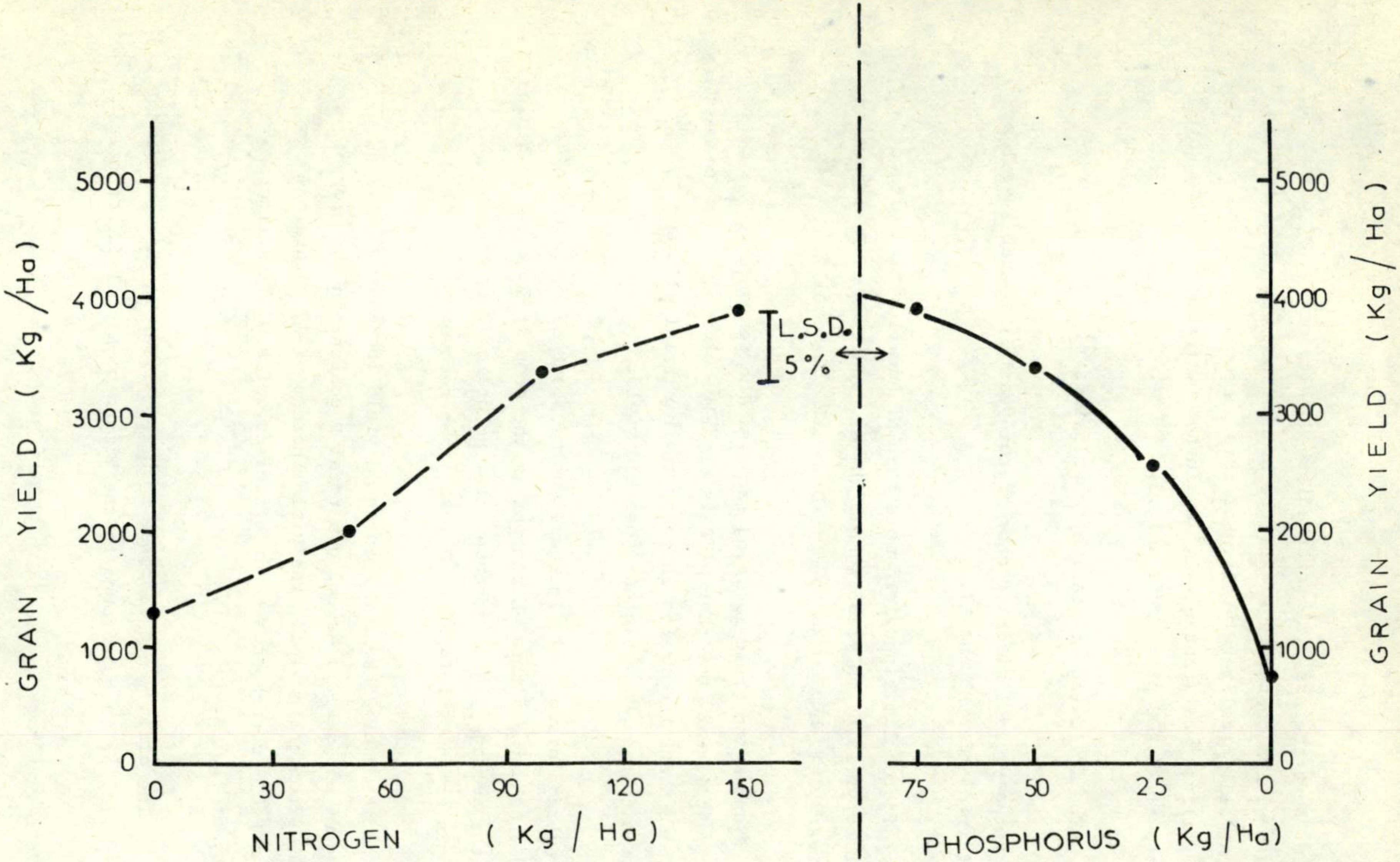


FIG. 3. THE EFFECT OF NITROGEN AND PHOSPHORUS ON MAIZE GRAIN YIELD AT A DENSITY OF 44.400 PLANTS / HA. NITROGEN AND PHOSPHOSRUS RESPONSE AND RESIDUEL FERTILIZER EFFECT TRIAL. FARAKO-BA (UPPER-VOLTA), 1983.

and lower grain yields in the latter can be attributed to being located on a more gravelly soil.

4. Trials at Kamboinsé (Sudan Savanna)

4.1. Toposequence Trial

The risk of drought stress depends not only on the rainfall distribution pattern, but on soil characteristics that are connected with soil water infiltration, percolation and storage. These characteristics change markedly along the toposequence. Plateau soils tend to be sandier or more gravelly, less deep and lower in organic matter content than the hydromorphic soils of the lower part of the toposequence. Drought stress is less likely in maize planted in hydromorphic soils.

An experiment was started in 1981 to determine the positions alont the toposequence for which ridge tying can be recommended in maize and to evaluate whether the ridges should be tied every furrow or only every second furrow.

The experiment was again conducted in 1983. There were five strips of land more or less perpendicular to the slope, each of which represented one of the following positions on the toposequence : plateau upper slope, mid-slope, lower slope and hydromorphic bottomland. Each strip was subdivided into three blocks to make three replications running parallel to the slope. The experiment was a factorial combination of two planting dates (June 25 and July 11) and three ridging systems :

(1) simple ridges,
(2) ridges tied every other furrow,
(3) ridges tied every furrow.

For logistic reasons, the plots were not plowed this season. Rather, all the old ridges were tied every furrow on May 31. At each of the planting dates, the corresponding plots had the ridges (furrows) reopened as necessary following the ridging treatments (re-randomized). No fertilizer was applied in 1983. The variety was JFS (Jaune Flint de Saria) at 59,300 plants/ha.

Mean maize grain yields were significantly (1 % level) : (1) increased from the plateau to the bottomland position (1900 to 4000 kg/ha) , (2) decreased by the late planting date (2920 VS 2360 kg/ha for June 25 and July 11, respectively), and (3) increased by tying the ridges (2180, 2750, and 3000 kg/ha for simple ridges, 1/2 tied ridges, and all ridges tied, respectively). The significant Position x Ridging system interaction reflects the yield response to tied ridges in all positions except the bottommost one (Fig.4).

The Position x Date interaction was also statistically (1 % level) significant. This is due to the fact that the July 11 date gave lower yields than the June 25 planting date in all positions except in the bottom-most one, where yields were 4280 and 3720 kg/ha, respectively. Given that all the plots had tied ridges between May 31 and planting, this suggests that the soils at the lower part of the toposequence can effectively store more moisture within the root zone. However, the relatively high yields (1-2 ton/ha) obtained with simple ridges in this trial, from the plateau to the lower-slope positions, in relation to either previous years results or other trials planted at similar dates in 1983, indicate that if tied ridges are present several weeks before the crop is actually planted, soil moisture reserves are increased and the risk of drought stress decreased (although not equally) in all positions along the toposequence.

Although ridge tying (either every other furrow or all furrows) increased yields in all positions along the toposequence except the bottommost, yields were lowest in the plateau and tended to increase going down the toposequence being highest at the bottom. Once again, no negative effect of ridge-tying was observed in the hydromorphic soil. The yield increases due to tying 1/2 of the ridges or all of them were

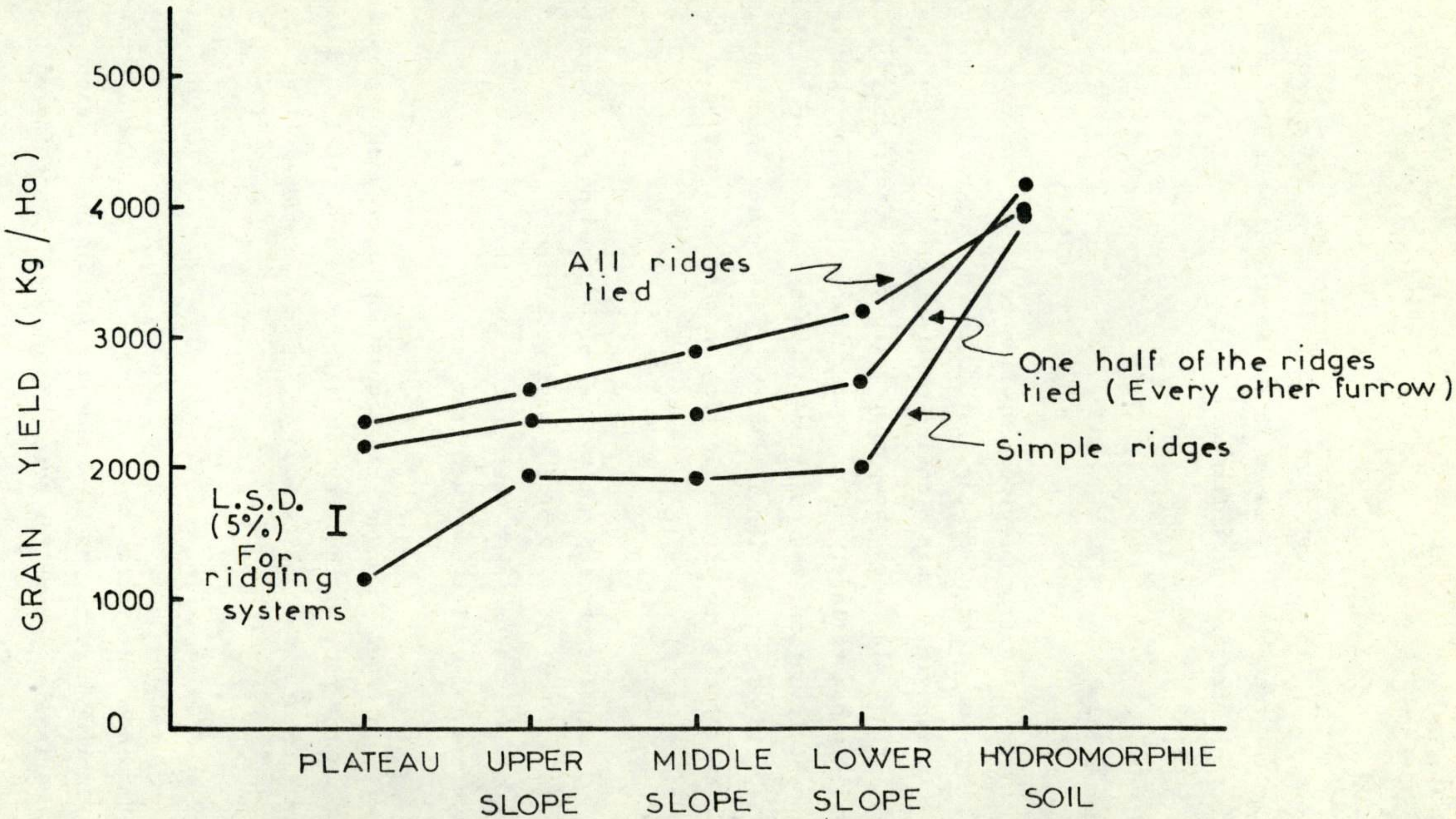


FIG.4. EFFECT OF CROP POSITION ALONG THE TOPOSEQUENCE AND TIED RIDGES ON MAIZE GRAIN YIELDS. KAMBOINSE (UPPER-VOLTA), 1983. MEANS OF TWO PLANTING DATES.

of about 40 and 15 %, respectively (bottomland position excluded), which are smaller than those observed in 1981 and 1982, but the same general findings and trends are confirmed.

4.2 Seedbed Trial

Results from previous experiments have shown that planting on tied ridges or planting on the flat followed by a tied earthing-up give higher maize yields than planting on the flat or planting on simple ridges. It has also been shown that maize planted directly on old tied-ridges, without tillage, yields better than planting on the flat after hand-hoe cultivation. The question of whether hand-hoe cultivation of old tied ridges before planting (without destroying them) can improve yields in relation to direct planting on them (without prior hand-hoe cultivation) still needs to be investigated.

Studies carried out by the Maize Breeding Program have identified JFS and Pool-16 as 2 of the most promising materials for drought tolerance. It can be asked whether the same thing is true of SAFITA-2, an experimental variety derived from Pool-16.

In order to answer the 2 questions above, an experiment was set up in the plots of the previous (1982) seedbed trial as a factorial combination of 3 seedbeds x 2 varieties x 2 management levels.

The 3 seedbeds were :

S1 : Hand-Hoe cultivation and planting on the flat ; no earthing-up.

S2 : Planting directly on tied ridges built in 1982, without any cultivation except for scrapping of weeds. Earthing up 35 DAP.

S3 : Planting on tied ridges built in 1982 but after previous hand-hoe cultivation (without destruction of the old ridges). Earthing up 35 DAP.

The varieties were JFS and SAFITA-2. The management levels were M1 = low fertilizer (F1) and low density (D1) and M2 = high fertilizer (F2) and high density (D2). The fertilizer rates (kg/ha) were :

	14-23-15	+	Urea	=	Total
F1 :	0		0		0-0-0
F2 :	200		100		74-46-30

The densities and spacings were :

D1 : 44,400 plants/ha (30 x 75 cm^2)
D2 : 59,300 plants/ha (22.5 x 75 cm^2)

The trial was planted on July 4 in a split-split plot design, replicated 4 times, in 5-row plots, 8-m long.

Maize grain yields (Table 7) were very significantly affected by management level, variety, and seedbed. The low management level gave an average yield of 1705 kg/ha as compared with 2465 kg/ha for the high management level. There was, however, no response to the high management level in the flat seedbed (595 kg/ha) due to the high degree of drought stress (highly significant Seedbed x Management interaction).

At both management levels SAFITA-2 gave higher yields than JFS in the presence of tied ridges, but yields were similar under the flat seedbed (significant Seedbed x Variety interaction). The yield superiority of SAFITA-2 over JFS was highest at the high management level (3840 VS 2960 kg/ha, means of seedbeds with tied ridges).

There was a very large increase in yield at both management levels due to the use of tied ridges. The flat seedbed gave only 595 kg/ha, but planting on tied ridges gave mean yields of 2855 and 2805 kg/ha for seedbeds 2 and 3 .

The average number of days from planting to 50% silking was 47.8 and 52.5 for JFS and SAFITA-2, respectively (L.S.D. = 1.4, at 5 %).

Table 7. Seedbed trial. Kamboinsé (Upper Volta), 1983. Maize grain yield (kg/ha, at zero percent moisture).

Management level (* * *)	Variety (* * *)	Seedbed (* * *) S1	S2	S3	Mean
M1	JFS	580	2150	1950	1560
	SAFITA-2	610	2660	2275	1850
	Mean	595	2405	2110	1705
M2	JFS	595	2945	2975	2170
	SAFITA-2	600	3655	4020	2760
	Mean	595	3300	3495	2465
Variety	JFS	585	2550	2460	1865
	SAFITA-2	605	3160	3150	2305
Mean		595	2855	2805	2085

Seedbed x Variety (*)			
Seedbed x Management (* * *)		Main plot	13.1
Variety x Management (n s)	C.V.	Sub-plot	15.3
Seedbed x Variety x Management (ns)	%	Sub-sub-plot	15.8

*, * * * : Significant at 5 and 0.1%

ns : Non significant

L.S.D.'s at 5 %

Seedbeds	237
Varieties	209
Management levels	201
Management levels at same Seedbed	348
Management levels at same Variety	284
Management levels at same Seedbed and Variety	492
V arieties at same Seedbed and same or different Management	502

Based on 1983 results, it appears that (1) hand cultivation of old tied ridges prior to planting does not bring a yield increase in relation to direct planting on them, (2) SAFITA-2 can tolerate severe drought stress as well as JFS with the advantage that it responds better to improved moisture conditions.

4.3 Genotype x Management Interaction Trial

Studies carried out under controlled irrigation by the Maize Breeding Program during the 1982 dry season and subjecting many genotypes to drought stress at different physiological stages, indicated that among the most promising materials in terms of drought tolerance were Jaune Flint de Saria (JFS) and Pool-16 .

In order to estimate which of the 2 materials has more tolerance to drought and to evaluated if there is an interaction between the management level (degree of drought stress and fertility) and these 2 genotypes, an experiment was conducted in a factorial combination of 2 ridging systems and 2 varieties and with 25 low-fertility replications and 26 high-fertility replications.

The ridging systems were (1) simple ridges , (2) Tied ridges. The trial was planted on old (1982) ridges ; there was no soil preparation in the case of tied ridges, but there was hand-hoe cultivation of the furrows in simple-ridges plots. The varieties were (1) JFS (yellow flint, 90 days to maturity, issued from a local population after mass selection by IRAT), (2) Pool-16 (white dent, 90 days to maturity, CIMMYT material). The experiment was established in plots where in the 3 previous years, the grain yield response to several levels of chemical fertili-er (13-24-14), local phosphatic rock with and without urea, and animal manure was evaluated. The low-fertility replication included the absolute-check plots and treatments with 1 to 10 ton of manure/ha year, including one with 5 ton manure + 150 kg of phosphatic rock. The high-fertility replications included treatments with chemical fertilizer rates of 37-23-14/ha/year or more and plots with 40 ton manure/ha/year (alone or with phosphatic rock and urea). No fertilizer was applied in 1983.

The trial was planted on July 1st at a density of 53,300 plants/ ha.

Because of the experimental layout, the statistical analysis had to be carried out separately for the low and high fertility sets of replications. Maize grain yields (Table 8), under both low and high fertility conditions, were significantly improved by tying the ridges and were significantly better for JFS than for Pool-16 ; the ridging system x Variety interaction was not statistically significant. Under simple ridges (more drought stress conditions), JFS gave higher yields than Pool-16 under both low and high fertility conditions (895 VS 685 and 1300 VS 1070 kg/ha, respectively). Under tied ridges (less drought stress conditions), JFS also gave high yields than Pool-16 under low fertility (2105 VS 1740 kg/ha, L.S.D. = 213, at 5 % level), but under high fertility conditions both varieties gave comparable yields (2155 VS 2020 kg/ha, L.S.D. = 220 at 5 % level). From this data it appears that JFS as a variety has better adaptation than Pool-16 to stress conditions of low fertility, drought, or both.

The average number of days from planting to 50% silking was 51.3 and 55.8 (under low fertility ; L.S.D. = 1.0, at 5 %), and 49.2 and 53.2 (under high fertility ; L.S.D. = 0.7, at 5 %) for JFS and Pool-16 respectively.

When the results of this trial are compared with those of the Seedbed trial, it appears that SAFITA-2 represents a definite improvement over its parent population, Pool 16, in terms of (1) adaptation to stress conditions of drought and fertility and (2) responsiveness to improved moisture and fertility management. The trials were planted with only 3 days difference and it seems unlikely that all the differences observed in the performance of Pool-16 and SAFITA-2 relative to that of the common check (JFS) can be due to differences in the planting date. Nevertheless, both trials will be repeated in 1984.

Table 8. Genotype x Management interaction trial. Kamboinsé (Upper Volta),1983. Maize grain yield (kg/ha, at zero percent moisture). F1 and F2 designate the low and high fertility replications, respectively.

Ridging system F1 (* * *) F2 (* * *)		Variety F1 (* * *) F2 (*) JFS	Pool-16	Means
1. Simple ridges	F1	895	685	790
	F2	1300	1070	1185
2. Tied ridges	F1	2105	1740	1925
	F2	2155	2020	2085
Means	F1	1500	1210	1355
	F2	1725	1545	1635

Ridging system x Variety	C.V. %			
F1 (n s)		Main plot	F1	55.6
F2 (n s)			F2	54.5
		Sub-plot	F1	27.6
			F2	24.1

*, * * * : Significant at 5 and 0.1 %

n s : Non significant

L.S.D.'s at 5 %	F1	F2
Ridging systems	311	361
Varieties	151	155
Varieties at same Ridging system	213	220
Varieties at different Ridging systems	346	393

4.4. Stress Trial

The risk of drought stress and soil compaction have been identified as yield limiting factors for maize cultivation in the semi-arid tropics of West Africa, especially in the Sudan Savanna. These 2 stresses are not independent in the sense that the more compact the soil, the more difficult it is for water to infiltrate and percolate down the profile. Nevertheless by using old tied-ridges, total water infiltration can be increased even in fairly compact soils while at the same time maintaining a high soil compaction.

In order to explore if there is genetic variability in maize for tolerance to drought stress under conditions of soil compaction, an experiment involving 20 half-sib families of maize and 2 management levels was planted on July 13, in single-row plots (4.3-m long) and replicated 4 times.

The 20 half-sib families were 20 ears of maize coming from 2 different open-pollinated maize fields : 10 ears (families 1 to 10) came from a local Koudougou maize field, and the other 10 ears (families 11 to 20) came from a JFS maize field.

Koudougou and Saria are two neighbouring localities in Upper Volta and, judging from plant types, grain color and texture, maturity, etc, JFS and local Koudougou seem to be genetically related materials.

The 2 management levels were :

M1 (More stress) : Hand-hoe cultivation before planting ; planting on the flat. No earthing up.

M2 (Less stress) : Planting on tied ridges (built in 1982). Earthing up and building up of ridges and ties 30 DAP.

The trial was planted at a density of 59,300 plants/ha, with a uniform application of 300 kg/ha of 14-23-15 and 150 kg/ha of urea, for a total of 111-69-45 kg/ha of $N-P_2O_5-K_2O$.

Grain yields were significantly (1 % level) affected by the stress level and although there were no significant differences between the average yields of families (Table 9), the Management level x Family interaction was statistically significant (5 % level) in spite of the very high C.V.'s observed in the trial (30.6 and 40.8 %).

The significant Management level x Family interaction implies that the relative performance of the 20 families was not the same under both levels of drought stress. This can be more easily appreciated in Fig.5. Families 3 and 17 which were the top performers under less stress did very poorly under more stress. On the other hand, families 2 and 7, the top performers under more stress did not achieve the mean yield under less stress.

It appears that this approach could be utilized by the Breeding Program in order to improve maize tolerance to drought while at the same time carrying out the breeding effort under conditions of soil compaction, widespread in the West African Savanna. It is suggested to conduct the population improvement program under a stress nursery, with and without tied ridges as described in this experiment (or with some appropriate modifications). This approach can be followed during the rainy season and the recombination during the dry season. It needs to be decided what are the best criteria for family selection and whether only one of several experimental varieties should be created.

Table 9. Stress trial. Kamboinsé (Upper Volta), 1983. Maize grain yield (kg/ha, at zero percent moisture).

Family (n s)		Management level (* *) More stress	Less stress	Mean
1		1525	2875	2200
2		2525	2430	2480
3		1190	3760	2475
4		1665	3530	2595
5		1920	3300	2610
6		1905	2470	2190
7		2505	2940	2720
8		1935	3035	2485
9		1685	3335	2510
10		1490	3405	2450
11		1450	2875	2165
12		2160	2715	2435
13		1365	2960	2160
14		1730	2780	2255
15		1720	3025	2375
16		1370	3245	2310
17		1485	4105	2795
18		1415	3145	2280
19		1220	3200	2210
20		2105	2615	2360
	Mean	1720	3085	2405
Mean	1 - 10	1835	3110	2475
	11 - 20	1600	3065	2335

Management level x Family (*)	C.V.	Main-plot	40.8
	%	Sub-plot	30.6

*, * * : Significant at 5 and 1%

n s : Non significant

L.S.D.'s at 5 %	
Management levels	493
Families	729
Families at same Management level	1031
Families at different Management levels	1105

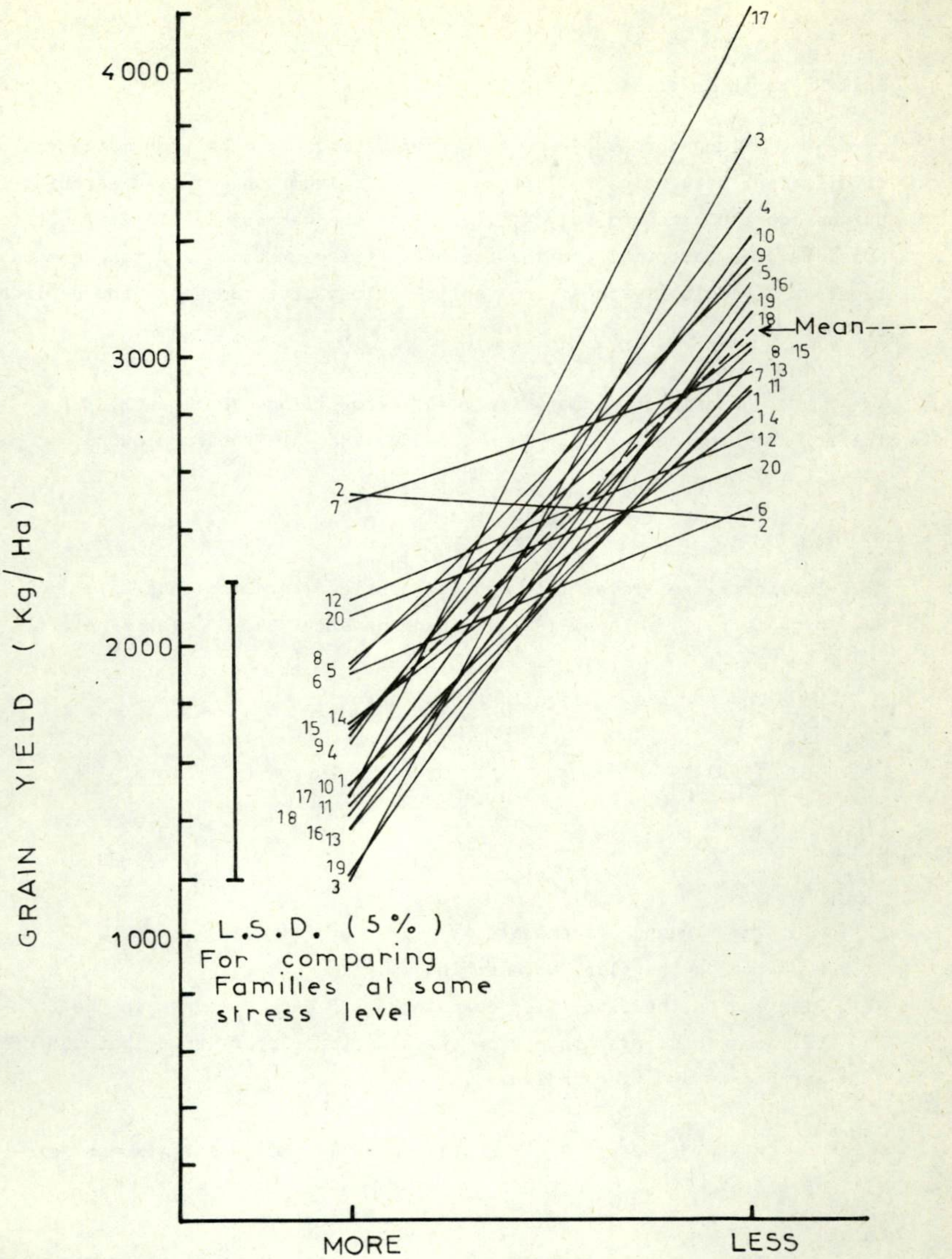


FIG.5. MAIZE GRAIN YIELD OF TWENTY HALF-SIB FAMILIES UNDER TWO STRESS (MANAGEMENT) LEVELS. STRESS TRIAL. KAMBOINSE (UPPER-VOLTA), 1983.

4.5. Soil Preparation Trial

A long-term experiment for evaluating the effect on maize yield of different methods of soil preparation (Tillage) and of tied earthing up was again planted on July 4, 1983, with the variety SAFITA-2. The trial consists of a factorial combination of 4 tillage Methods x 2 management levels x 2 Ridging systems, in a split-split-plot arrangement and replicated 6 times.

The tillage methods are : (1) Zero-tillage (Paraquat), (2) Traditional hand-hoeing, (3) Oxen plowing, and (4) Tractor plowing.

The management levels were :

M1 : low fertilizer level (F1) and low density (44,400 plants/ha).
M2 : high fertilizer level (F2) and high density (59,300 plants/ha).

The fertilizer levels (kg/ha) were :

	14-23-15	+	Urea	=	Total
F1	0		0		0-0-0
F2	200		150		97-46-30

The ridging systems are :

R1 : Planting on the flat. No earthing up.
R2 : Planting on the flat. Tied earthing up 25 DAP. However, in the zero-tillage plots, planting is on the old tied ridges (rows that had been earthed-up and tied in 1982).

All plots were hand-hoe cultivated 14 and 25 DAP (except zero-tillage plots).

There were no statistically significant differences in grain yield between the tillage methods. Plowing with oxen or tractor did not give higher yields than conventional hand-hoeing, which agrees with the 1982 results but not with those of previous years. The mean yields were

1600, 2180, 1640 and 1900 kg/ha, for zero-tillage, hand-hoeing, oxen plowing and tractor plowing, respectively. Although zero-tillage without tied earthing up gave lower yields than other tillage methods, zero-tillage with tied ridges and tied earthing-up gave yields comparable to those of other tillage methods (Fig.6). Flat zero-tillage plots had often very low stands but this factor alone could not explain the yield differences.

There was a highly significant (1% level) increase in yield from the low to the high management level (1630 to 2035 kg/ha, respectively), but such an increase was negligeable in the plots without tied earthing-up (significant Mnagement x Ridging interaction).

The most significant and spectacular yield increases were due to earthing up and tying the ridges, under both management levels and under all tillage methods. The mean yields were 800 and 2865 kg/ha for plots without and with tied earthing up, respectively (L.S.D. = 240, at 5 %). The yield increases due to tied earthing up ranged from 1145 to 2750 kg/ha (L.S.D. = 678, at 5 %), which are far higher than those found in 1982 (360 to 820 kg/ha ; L.S.D. = 356, at 5 %).

The results of 1983 and those of previous years indicate that (1) ridge-tying or tied earthing up are more reliable ways of decreasing the risk of drought stress than tillage methods ; (2) even when there is response to tillage, tied earthing up gives large increases in yield ; and (3) a modified minimum-tillage technique seems to offer good potential in these soils. Such minimum tillage technique consists of planting directly on old tied ridges, without soil preparation before planting except for any measures as needed for weed control. The tied ridges are later built up or earthed up as necessary during the season, especially during other cultural operations such as weedings or fertilizer applications. The first establishment of tied would depend on the means at the disposal of the farmer, i.e. it can be at planting or during the season (at the time of earthing up). Obviously, this modified

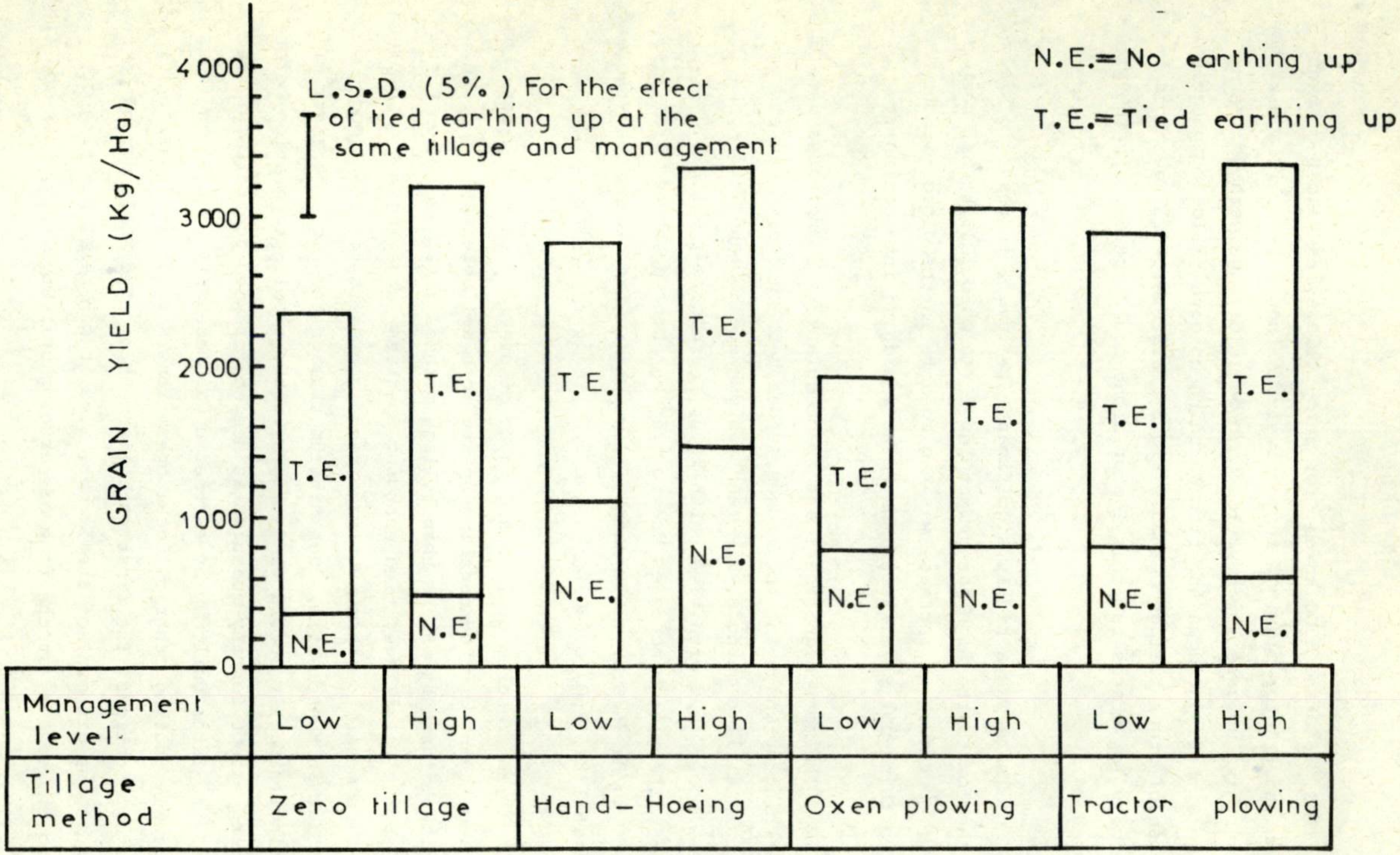


FIG.6. THE EFFECT OF TILLAGE METHODS AN TIED EARTHING UP ON THE GRAIN YIELD OF MAIZE. KAMBOINSE (UPPER-VOLTA), 1983.

minimum tillage technique can be applied in land that has or has not been tilled before and it does not preclude the future use of tillage in the system. By taking advantage of the same tied ridges over more than one season, the labor cost involved in making them is reduced. Even if tillage + tied ridges (or tied earthing up) were to give higher yields than planting without tillage on old tied ridges, the yield difference should be weighed against the time and labor cost involved in tillage.

4.6. Soil Preparation Trial. Bis

The soil preparation trial previously described involved both monocrop maize and cowpea until 1982 as far as the tillage methods is concerned. Due to heavy striga infestation, the cowpea crop was dropped in 1983 and another trial was planted with maize, (variety JFS) on July 4. The trial consisted of a factorial combination of 4 tillage methods x 2 digging systems x 2 furadan levels, in a split-split-plot arrangement with 6 replications.

The tillage methods were the same as described in section 4.5.

The digging systems were :

D1 : Planting on the flat, no digging of holes at first cultivation.
D2 : Planting on the flat (all tillage methods); digging of small holes (about 40 cm long x 20 cm wide x 10 cm deep) simultaneously with the first cultivation. The holes are dug between the rows without earthing up the plants.

All plots (except under zero tillage) were cultivated with a hand-hoe 14 and 35 DAP.

The furadan levels were :
F1 : no Furadan
F2 : 4.5 g Furadan 5G/plant at planting, 30 and 60 DAP in 3 equal application (4.4 kg a.i./ha/application), applied to the soil in small holes adjacent to the plants.

The trial received a uniform application of 200 kg 14-23-15 and 100 kg urea/ha.

The statistical analysis showed differences in grain yield between tillage systems that would be significant at the 7.4 % but not at the 5 % level. Mean yields were 290, 1265, 1360 and 875 kg/ha, for zero tillage, hand hoeing, oxen plowing, and tractor plowing, respectively (L.S.D. = 876, at 5 %). Furadan application had no effect on yield (930 and 965 kg/ha for F1 and F2 levels, respectively). There was a highly significant effect of digging systems on maize yield : 624 kg without holes and 1272 kg/ha with holes (L.S.D. = 207, at 5 %). Given that Furadan had no effect on yield and did not interact with other main factors, only the mean yields of both Furadan levels are presented (Table 10).

Zero-tillage plots showed the lowest grain yields and this was due in part to lower plant stands than under other tillage methods. The tillage-method results are similar to those of the soil preparation trial (Section 4.5.). It is important, however, to keep in mind that the results of both trials are not directly comparable in the sense that the history of land management (preceding crops, fertilizer levels, etc) was different in both trials and different maize varieties were used. In addition, tied ridges can hold (catch) a greater volume of water than the holes dug in the trial discussed in this section (4.6). Nevertheless, digging of holes between the maize rows gave yield increases that were not only statistically significant but also economically attractive. Although the labor time involved in the digging of such holes was higher than initially thought (17.5 man-days/ha - estimated in another plot of about 1150 m^2), the mean yield increase (648 kg/ha) is greater than the cost of such labor (123 kg/ha), if one takes an opportunity cost for labor of 50F CFA/hour and a price of 57F CFA/kg of maize. This does not take into account the fact that such holes can last for more than one season and thus benefit the following crop.

4.7. Maize-Cotton Intercropping Trial

Soil fertility has been identified as one of the factors limiting maize yield in the Sudan Savanna and good maize response to fertilizers has often been shown, especially in the presence of improved water managements techniques, i.e. tillage and/or tied ridges. Nevertheless, the use of

Table 10. Soil preparation trial. Bis. Kamboinsé (Upper Volta), 1983. Maize grain yield (kg/ha, at zero percent moisture).

Tillage method	Digging System		Yield increase due to digging of holes
	No holes	With holes	
1. Zero tillage	61	517	456
2. Hand-hoeing	908	1627	719
3. Oxen plowing	1016	1708	692
4. Tractor plowing	512	1238	726
Mean	624	1272	648
L.S.D. (5%)	207		

fertilizers remains very low in general and it is thought that this is due, in part, to a limited availability of cash to farmers. The introduction of a cash crop like cotton in the cropping system could help in this respect.

Maize and cotton can be intercropped with many of the conventional advantages of intercropping systems, particularly risk reduction of a complete crop failure.

In order to explore further and develop the viability of a maize-cotton intercropping in the Sudan savanna, an experiment was conducted in 1983, involving 4 cropping systems in 4 RCB :

Cropping system	Crop (s)	Density (each crop) plant/ha	Ridges
C1	Cotton	83,300	Simple
C2	Cotton	83,300	Tied
C3	Maize	83,300	Tied
C4	Maize-Cotton	41,700	Tied

The trial was planted on June 13, without previous tillage on old tied ridges . The tied ridges of the C1 cropping system were opened on June 25. The varieties were local Saria (maize) and Coker (cotton). There was a uniform application of 300 kg 14-23-15 and 170 kg urea/ha.

The spacings were 80 cm between rows and 30 cm between hills. There were 2 plants/hill for monocrop maize and cotton, and 2 plants/ hill with alternating hills of each crop for the maize-cotton association. The plots had 6 rows, 5 m long, of which the central 4 were harvested. The cotton was sprayed with insecticide each 12-15 days, starting 35 DAP. Maize was harvested at maturity on August 31 (79 DAP) and the stalks were cut in order to minimize competition to cotton in the intercropped plots. Cotton was harvested 5 times, from October 3 to December 21.

Cotton grown on simple ridges had a yield of 1160 kg/ha (Table 11) which increased by 60 % to 1850 kg/ha in the presence of tied ridges (L.S.D. = 236, at 5 %). When cotton and maize were grown in association (at 1/2 the recommended monocrop density for each crop), the yields obtained were 1575 and 2200 kg/ha, respectively, which represent 85.1 % and 74.3 % of the monocrop cotton and maize yields, respectively (in the presence of tied ridges). Thus maize-cotton intercropping systems, using tied ridges, appear very promising since the land-equivalent ratio (L.E.R.) reached a value of 1.59, very good indeed for semi-arid conditions.

Local Saria, the maize variety is an early material (43 days to 50 % silking), rather short, and not very leafy, which helps in minimizing light competition with cotton.

5. Trials at Saria (Sudan Savanna)

5.1. Tied Ridges Trial

The objective of this trial was to evaluate the effect of the tied ridges in a leached ferruginous tropical soil "à pseudoglay de profondeur", i.e. subject to periodic reducing conditions in part of the profile. The trial was located in Block 4 of the Saria Station, in the lower part of the toposequence but not on "bas-fond".

Only 2 treatments were compared : planting on the flat and planting on tied ridges, in 4 RCB. The trial had been conducted in 1982. The old ridges were destroyed and built again with a hand-hoe before planting on July 31, 1983. The flat plots were also hand-hoed. There was a uniform application of 300 kg/ha of 14-23-15 and the local Saria variety was planted at a density of 44,400 plants/ha. The plots had 5 rows, 10-m long. There was a very pronounced and statistically significant decrease in maize yield (Table 12) due to the use of tied ridges. The flat seedbed gave 1260 kg/ha but yield was only 690 kg/ha under tied ridges. The reasons for this drop in yield are not clear. This was the first time in 5 years of looking at the effect of tied ridges on maize yield, that a significant negative effect on yield has been observed in the IITA/SAFGRAD Maize Agronomy Program.

Table 12. Tied ridges trial. SARIA (Upper Volta), 1983. Grain yield (at zero percent moisture) and other variables.

Variable	Ridging system		L.S.D. (5 %)	C.V. (%)	F Test
	Flat	Tied ridges			
1. Grain yield (kg/ha)	1260	690	388	17.7	*
2. Days to 50% silking	44.8	47.8	1.8	1.7	*
3. Plant height (cm)	170	172	24	6.2	ns
4. Density at harvest (plants/ha)	43200	43700	2000	2.1	ns
5. Ears/plant	0.97	0.78	0.17	8.7	*
6. Shelling percentage	82.2	78.6	1.5	1.0	**
7. Weight of 1000 grains (g)	120	107	2.8	1.1	**
8. Grains per square meter	1050	645	344	18.0	*
9. Plants attacked by streak (%)	7.8	7.7	6.0	34.3	ns

*, * * : Significant at 5 and 1%

n s : Non significant

When the trial was conducted in 1982, maize grain yields were 1800 and 1520 kg/ha for the flat and tied-ridges treatments, respectively (L.S.D. = 515, at 5 % level ; C.V. = 13,8 %), a difference in yield that would be significant only at the 18.1 % level of significance. Since consistently positive results with tied earthing up had been observed in the 1981 Soil Preparation trial at Saria (Fig.7), higher up along the toposequence (Block 2), the possibility of a negative effect of tied ridges on maize yield was not contempleted.

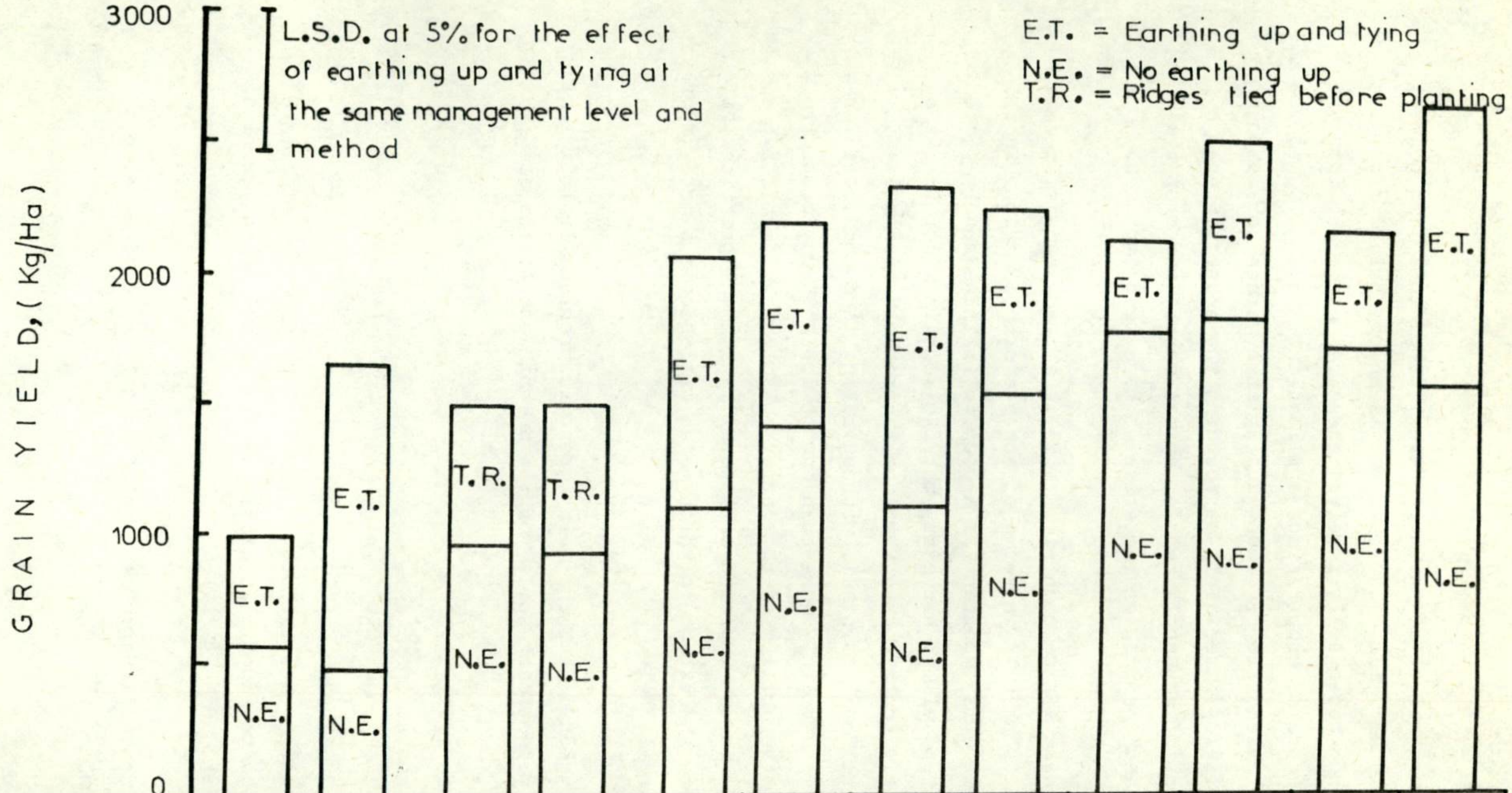
However, from the evidence now available, it is clear that in some situations tied ridges can have a detrimental effect on maize yield.

In the 1983 trial at Saria, early plant growth was equal if not better under tied ridges. This is reflected in the similar plant heights (170 and 172 cm) in both treatments. However, silking was significantly delayed under tied ridges (44.8 VS 47.8 days), an indication of some stress. Such stress was not due to superficial waterlogging conditions but could have been related to stronger reducing conditions may be in the subsoil under tied ridges. Plots with tied ridges had less grains/m^2, smaller grains, and less ears/plant than plots without them.

6. Overview of the Main Agronomic Problems for Growing Maize in the Semi-Arid Tropics of West Africa and Possible Solutions.

Considering the wide variability in soils and climate found in the SAT of West Africa, it is difficult and risky to generalize. Moreover, the amount of information available is limited. It is, however, better to have a general picture to improve upon than not to have it. The following overview is presented as a rough schematic framework to be modified and completed with the expertise of other maize workers and future research.

In the SAT of West Africa the rainy season lasts from 2 to 5 months, for a total annual rainfall of about 400 to 1200 mm. Maize has been moving northwards, from the forest to the Savanna, slowly



Management level	low	high	low	high	low	high	low	high	low	high	low	high
Soil préparation method	Zero tillage (paraquat)		Traditional (hand hoe) but ridging before planting		Traditional (hand hoe)		Tractor plowing, start of rains		Oxen plowing		Chisel plowing and disk harrowing	

FIG. 7. THE EFFEC OF SOIL PREPARATION METHODS AND TIED EARTHING UP ON THE GRAIN YIELD OF MAIZE. SARIA (UPPER-VOLTA), 1981.

replacing sorghum and millet as the main cereal crop. Today, in general, in the 1000-1200 mm belt, maize can be grown as an open field crop, i.e. in fields that do not necessarily receive intensive management from the point of view of manure or crop residue applications. In the 700 to 900 mm belt, however, maize tends to be grown usually as a garden or compound crop, i.e. in the fields immediately surrounding the houses, where, by continuous additions of household refuse, animal manure and crop residues, the soil physical and chemical characteristics have been improved.

In some West Africa countries maize is already a major cereal crop in the 1000-1200 mm belt in terms of acreage or production. In the 700-900 mm belt, maize is important as a crop to fill the hungry period before the sorghum and millet harvests, but its role is minor in terms of acreage. It is difficult to say what the future holds for maize in the 700-900 mm belt. Total rainfall, without taking into consideration its distribution, is certainly more than enough for a 90-day crop. It would appear that the ability of the farmer to solve the fertility problems- where present - and to use improved soil water management practices, if needed, will dictate the extent to which maize will become a more important cereal in such rainfall belt.

It is suggested that the main agronomic problems limiting maize production in the predominant soils of the SAT of West Africa are :

1) Soil fertility
2) Soil compaction
3) The risk of drought stress.

To this list other factors of lesser importance or of a more localized nature may be added : lodging, termite damage, weeds, striga, soil acidity, streak.

The soil fertility problems relate mostly to deficiencies of nitrogen and phosphorus.

The soil compaction problem, if present, arises because of (1) mineralogy (low contents of amorphous irron and aluminium oxides), (2) low organic matter, (3) soil management factors (removal of crop residues, lack of tillage), (4) compaction by rainfall impact.

The risk of drought stress can be high because of the following factors :

(1) Erratic rainfall distribution patterns (dry periods of 1 week or longer during the growing season are common and unpredictable, late start or early end of the rains in some years).

(2) Surface sealing and/or surface crusting, which result in lower water infiltration rates and increase runoff losses.

(3) Soil compaction. Soil or subsoil compaction decreases the water percolation rate and also reduces the effective water infiltration rate.

The solution generally adopted by farmers in order to grow maize in the 700-900 mm belt is to grow maize as a garden or compound crop. By adding household refuse, animal manure and/or crop residues and by cultivating with a hand-hoe before planting the farmer can reduce the problems of (a) risk of drought stress, (b) soil fertility and (c) soil compaction. This solution can work fairly well but because of the limited amounts of available refuse, manure and residues, only very small plots can be put into maize production.

If maize production is to be increased other solutions are required, namely :

<u>Soil fertility</u> :

Nitrogen : chemical fertilizer and/or legume rotations.

Phosphorus : chemical fertilizer and/or local phosphatic rock.

Soil compaction can be reduced by :

(1) Tillage (hand-hoe, donkey, oxen or tractor)
(2) Crop residues (maintenance of soil organic matter and biological activity).

Risk of drought stress :

The research conducted in the last 5 years has shown that in ferruginous tropical soils the risk of drought stress can be reduced by the following practices, alone or in combination (not necessarily in order of importance):

(1) Soil tillage (oxen or tractor best).
(2) Tied ridges (established at planting time or at the time of earthing up).
(3) Cultivations (scarifications) for breaking the soil crust or a sealed soil surface.
(4) Any sort of small holes, catchments or basins, or terrain irregularities to retain rainfall water and slow down runoff.
(5) Planting maize on lower slope and hydromorphic soils.
(6) Use of crop residues as mulch.
(7) Use of early varieties (80-90 days to maturity for the 700-900 mm belt).
(8) Appropriate planting dates.

MAIZE ENTOMOLOGY REPORT - 1983

Maize suffers from insects right from seedling stage till harvest time in the Semi-arid environment. However, the intensity of attack differs in different agro-ecosystems. Available information on pest complex revealed that borers (Sesamia and Chilo) are of a great importance in East and Southern Africa while termites, millipedes and armyworms in West Africa.

In Upper Volta termite is the main pest which can inflict severe damage to maize under drought spell. In 1983, a trial consisting of 25 elite maize populations was conducted to see their relative susceptibility against termites under natural infestation. Observations were taken on percent plants infested by termites at 15 days interval and at the time of harvest.

Results are presented in Table 20. Out of 25 populations only three viz. Tuxpeno-DR, Temp. x Trop n° 3 and SAFITA-102 consistently showed less infestation due to termites.

In addition to termite, observations were also taken on armyworm infestation. TZSR Yellow and TZB Gussao were relatively less infested than other populations (Table 21. Y.S. Rathore).

Table 20. Percent infested plants due to termites in 3 elite populations of maize at Kamboinsé, Upper Volta, 1983.

Maize populations	Preharvest observations	Post harvest observations		
	% infested plants*	% plants lodged	% standing plants with	
			healthy roots	Moderately damaged roots
Tuxpeno-DR	6.21	54.98	5.06	33.50
Temp. x Trop N°3	4.72	55.62	5.88	20.61
SAFITA-102	6.73	57.52	4.76	26.78
Trial mean	6.92	74.83	1.50	10.10
L.S.D. at 5%	-	16.18	-	12.70
C.V.	150.95	15.34	313.76	89.16

* Mean of 4 observations taken at 15 days interval

Table 21. Percent infested plants due to armyworm, Pseudaletia unipuncta, at Kamboinsé, Upper Volta, 1983.

Population	% infested* plants
TZSR Yellow	25.42
TZB Gussao	27.47
Trial mean	35.14
L.S.D. at 5%	-
C.V.	41.19

* Mean of 4 observations taken at 15 days interval.

C O W P E A   P R O G R A M

COWPEA BREEDING

(A) Breeding for Insect Resistance

1. Bruchids :

The major objective is to develop bruchid resistant varieties that combine good seed quality, high yield and wider adaptation.

In 1983, two yield trials and breeding materials in different segregating generations developed both at IITA, Ibadan and in Upper Volta were tested to select such varieties.

The first yield trial contained 144 lines developed from crosses of TVu 2027 with SUVITA-2 and KN-1, and selections made from the segregating material received earlier from IITA. The trial was planted at three agroclimatically different locations, Farako-Bâ (annual rainfall 739.3 mm), Kamboinsé (622.9 mm) and Pobé (448.5 mm) as a 12 X 12 simple lattice with two replications. The plot size was a single row 4 m long, 1.5 m apart. Observations were recorded for maturity, yield, seed characters and level of resistance to bruchids.

Results of the top ten cultivars in comparison to controls are presented in Table 1. All the top cultivars came from a single cross between TVu 2027 and SUVITA-2. Except, KVx 30-G156-6-9K, all had the desirable seed characters i.e. large white or brown rough seeds, and the level of resistance to bruchids in some of them was as good as that of TVu 2027. Yields were either better or comparable to that of control varieties.

Table 1. Promising cultivars identified from the Upper Volta Preliminary Yield Trial-1 at different locations for yield, resistance to bruchids and other important agronomic characters in 1983.

Cultivars	Days to 50% flowering			Grain Yield kg/ha			100 grain weight (gm)	Seed colour and texture	Level of bruchid resistance (%, 60 DAI)
	F	K	P	F	K	P			
KVx30-G183-3-5K	55	47	49	593	820	962	25	BR	92.5
KVx30-G467-5-10K	51	45	45	726	840	625	27	BR	95.0
KVx30-G467-5-11K	52	44	46	1073	798	817	27	BR	82.5
KVx30-G156-6-9K	55	49	47	960	790	911	24	TS	80.0
KVx30-G156-9-3K	51	46	50	943	1118	603	28	BR	85.0
KVx30-G200-1-2K	52	43	46	877	811	728	28	BR	80.0
KVx30-G200-1-3K	51	45	46	885	716	1175	23	BR	80.0
KVx30-G246-2-5K	53	46	45	752	834	423	25	BR	87.5
KVx30-G172-1-6K	51	46	45	1031	681	616	30	WR	72.5
KVx30-G194-2-1K	54	47	48	806	799	670	29	WR	75.0
Controls									
TVu 2027	70	73	55	0	64	0	29	WR	90.0
SUVITA-2	50	46	45	706	772	691	20	BR	0.0
KN-1	49	44	44	806	505	636	14	TS	0.0
TVx 3236	50	45	440	710	797	920	11	CR	0.0
Trial mean	53	46	47	789	787	518			
C.V. %	4	8	4	24	24	42			
L.S.D. 5%	4	7	3	373	378	427			

Note : W = White, B = Brown, R = Rough, T = Tan, S = Smooth, C = Cream, F = Farako-Bâ, K = Kamboinsé, P = Pobé.

The second yield trial was obtained from IITA, Ibadan as International Trial-3. It contained 10 varieties including the local check. The trial had four replications in a RBD, and the plot size was 4 rows 4 m long. Central two rows were harvested for yield estimates. The varieties were also evaluated for resistance to bruchid. Data are reported in Table 2. All the varieties produced a very good yield and IT 81D-985 was the highest yielder (2557 kg/ha). But its level of resistance to bruchids was not high. In terms of both good yield and resistance to bruchids, the variety IT 81D-994 seemed to be the best. It also possessed the desirable seed quality.

Regarding the breeding materials, following were evaluated and advanced to higher generation.

(i) Double cross materials involving TVu 2027 (bruchid resistance), TVu 36 (aphids), TVx 3236 (thrips) and varieties performing consistently better across environments for the past several years (SUVITA-2, KN-1, Mougne, 58-57 and TN-88-63) to combine multiple insect resistance with desirable seed and plant characters were grown in the field after selecting for aphid resistance. Individual plants were harvested and a total of 119 are currently being evaluated in the laboratory for aphid resistance. Tne selections already contain very good seed quality in varying plant type backgrounds.

(ii) 226 F4 plants originated out of crosses of TVu 2027 with Worthmore, KN-1 and Local Kamboinsé were advanced to higher generation, and these plants are currently being evaluated for bruchid resistance.

(iii) Photosnetivie material, selected from the cross TVu 2027 x SUVITA-2 and advanced to F3 in 1982, was evaluated for bruchid resistance. 48 plants showed good level of resistance and were grown in the field in 1983 for agronomic evaluation.

Table 2. Performance of the bruchid resistant lines included in the IITA International Yield Trial-3 at Loumbila, 1983.

Cultivars	Days to 50% flowering	Yield kg/ha	100 grain weight	Colour and texture	Level of bruchid resist. (%, 60 DAI)
IT-81D-985	53	2557	23	WR	25
IT-81D-988	52	2197	25	WR	55
IT-81D-994	54	2301	24	WR	70
IT-81D-1007	39	1980	13	rS	25
IT-81D-1020	42	1977	14	rS	35
IT-81D-1032	41	1861	19	rS	15
IT-81D-1064	40	2217	20	rS	20
IT-81D-1137	39	1821	21	WR	10
IT-81D-1157	44	1785	18	BS	25
Local Check	34	1547	11	BS	0
Trial mean	44	2024			
C.V. %	2.2	13.8			
L.S.D. 5%	1.4	105			

Note : W = White, R = Rough, r = red, S = Smooth, B = Brown.

2. Aphids

(A) As mentioned in the 1982 Annual Report, family rows of plants selected from back and thriple crosses of the aphid resistant variety TVu 36 with KN-1, SUVITA-2 and TVx 3236 were screened under artificial infestation. Selections were made on individual plant basis, and the selected plants were advanced to the next generations. In 1983, these selections were evaluated in a replicated yield trial. The trial contained 144 lines and was planted at Farako-Bâ, Kamboinsé and Pobé as a 12 X 12 simple lattice. The plot size was a single row 4 m long, 1.5 m apart. The material was evaluated under natural infestation. Observations were made on aphid infestation, yield, plant type and seed characters. Results of 13 most promising cultivars at the three locations are reported in Table 3. Very little or no aphid infestation was observed. The results for yield and seed characters were highly encouraging. Several of these cultivars produced as good yield as the best check variety at all the three locations. The cultivar KVx 145-99-1, on average, produced the highest yield (1234 kg/ha). In terms of yield and seed quality characters, KVx 145-5-1, KVx 146-13-3 and KVx 146-27-4 were the best. All of these cultivars are currently being evaluated for aphid resistance under artificial infestation, and finally the ones that combine aphid resistance with good seed and plant characters will be selected.

(B) Crosses were made between the selected aphid resistant plants from the triple (KN-1 X TVu 36) X TVu 3236 and (SUVITA-2 X TVu 36) X TVu 3236 and back KN-1 x (KN-1 X TVu 36) crosses and TVu 1509 (thrip resistant) to combine aphid and high level of thrip resistance with desirable seed plant characters. Approximately 400 F2 plants of seven such crosses were grown ans screened for aphid and thrip infestation under natural conditions. Plants with poor growth and high susceptibility were uprooted. A total of 1033 selected plants from these crosses will be advanced to next generation for further evaluation.

Table 3. Performance of promising aphid resistant cowpea cultivars in the Upper Volta Advanced Yield Trial-2 conducted at different locations in 1983.

Cultivars	Yield kg/ha			100 seed weight	Seed colour and texture
	F	K	P		
KVx 145-5-1	1006	1657	741	15	WBR
KVx 145-99-1	1244	1627	831	12	BS
KVx 145-27-4	743	1244	993	17	BS
KVx 145-34-1	685	1172	1160	14	BS
KVx 165-28-3	639	1597	851	13	BS
KVx 165-39-1	760	1331	846	13	BS
KVx 146-13-3	672	1671	957	17	BR
KVx 146-14-3	576	1298	889	15	BR
KVx 146-12-1	793	1450	1168	19	WBS
KVx 146-21-3	593	1060	1333	18	BS
KVx 146-27-4	689	1721	995	11	WR
KVx 146-44-1	618	739	1194	15	CR
KVx 146-53-2	772	1440	1151	18	BS
Controls					
TVu 36	672	1114	704	10	SPS
TVx 6484-51B_1-K	305	333	157	17	WR
SUVITA-2	856	1236	1450	20	BR
KN-1	480	1268	763	14	TS
TVx 3236	902	1116	1144	11	CR
Trial mean	687	1136	853		
C.V. %	24.5	28.6	24.8		
L.S.D. 5%	329	637	415		

Note : W = White, B = Brown, R = Rough, S = Smooth, C = Cream, T = Tan, SP = Speckled.

3. Thrips

A thrip resistant variety TVu 1509 was crossed with TVx 3236, another thrip resistant variety, for further increasing the level of thrip resistance, and with six other varieties (TN 88-63, 58-57, IT 82E-60, KVu 69, IT 82E-71 and IAR 1696) to develop new thrip resistant varieties. Approximately 400 F2 plants from each cross were screened in the field where thrip population was enhanced under natural conditions using a susceptible spreader variety planted three weeks earlier. Plants with poor podding and plant growth were eliminated and the rest were harvested as individual plants. A total of 1529 such plants were selected which will be advanced to next generation for further evaluation.

(B) Plant type, Maturity and Grain Quality

The objective was to evaluate a range of photo and non-photosensitive material varying in plant type (erect to prostate) and maturity (very earlier to late) across different environments.

The following trials in each maturity group representing different seed types were conducted in 1983.

(A) Photosensitive cowpeas :
Upper Volta Advanced Yield Trial-1

(B) Non-photosensitive cowpeas :
a. Medium maturity
(i) Rough seeds :
Upper Volta Advanced Yield Trial-2
IITA Advanced Yield Trial-2
IITA Preliminary Yield Trial-3

(ii) Smooth seeds :
IITA International Trial-2
IITA Advanced Yield Trial-1
IITA Preliminary Yield Trial-4

b. Early maturity

IITA International Trial-1

IITA Preliminary Trial-1

IITA Preliminary Trial-2

Upper Volta Preliminary Trial-4.

The Upper Volta Advanced Yield Trial-1 contained 28 photosensitive varieties. All these cultivars had a rough seed coat. The trial was planted at Farako-Bâ and Kamboinsé representing Guinea and Sudan Savanna areas. It had four replications and the plot size was a 4 row plot with 0.75 m distance both between and within rows. The central two rows were harvested for yield estimates. Results of the top five cultivars are reported in Table 4. The highest yielder at both the locations was TVx 6486-36B_1-K.

In the non-photosentive medium maturity group, except for the Upper Volta Advanced Yield Trial-2 (UVAYT-2) which had 36 cultivars, the rest contained 20 cultivars, and were planted as a RBD with four replications. The plot size was 4 rows, 0.75 m apart. Central two rows were harvested for yield estimates.

UVAYT-2 was planted at four locations, representing a wide range of soil and climatic conditions. Yields and seed characters of the promising seven cultivars are given in Table 5. All of them had large white rough seeds. In terms of yield, KVx 30-309-6G gave the highest grain yield across environments (1133 kg/ha) which was 27 % more than the best check variety, SUVITA-2 (893 kg/ha). KVx 30-470-3G was particularly good in the dry environments.

Both the Advanced Yield Trial-2 and the Preliminary Yield Trial-3 from IITA were planted at Kamboinsé. Results of the promising cultivars are shown in Tables 6 and 7. Yields in general were low, most probably due to drought at flowering. Nevertheless, the yields of the top varieties in both the trial were comparable to that of TVx 3236, and most of them had preferred seed types.

Table 4. Yields of the promising photosensitive cowpea cultivars in the Upper Volta Advanced Yield Trial-1 at two locations in 1983.

Cultivars	Days to 50% flowering		Yield kg/ha	
	K	F	K	F
TVx 6486-36B1-K	49	58	1417	1111
KVx 20-2	55	59	1411	798
KVu 12-2	58	57	1221	961
KVu 18-1	53	59	1202	822
TVx 6486-12B1-K	54	63	1137	912
Control				
IAR 1696	65	57	96	250
TVu 2027	62	72	97	194
Local	58	72	218	257
Trial mean	63	62	639	764
C.V. %	22.0	13.3	84.6	17.9
L.S.D. 5%	19.6	11.6	763.8	193.2

Table 5. Yields and seed characters of promising cowpea cultivars in the Advanced Yield Trial-2 at different locations in 1983.

Cultivars	Yield kg/ha				100 Seed weight	Seed colour & texture
	F	K	P	S		
KVx 30-309-6G	1042	1369	1288	833	20	WR
KVx 30-124-9G	1040	1188	899	708	25	WR
KVx 30-230-2G	1035	920	1464	729	19	WR
KVx 30-523-2G	1031	1062	941	698	27	WR
KVx 30-470-3G	873	929	1553	729	21	WR
KVx 30-305-3G	979	1493	987	646	27	WR
UV-TVx 5050-02C-K	1094	776	680	406	24	WR
Controls						
SUVITA-2	660	896	1243	771	20	BR
KN-1	680	637	1129	188	14	TS
TVx 3236	789	587	1280	560	11	CR
Trial mean	908	960	1025	543		
C.V. %	21.8	24.8	28.4	40.7		
L.S.D. 5%	280.3	336.4	411.6	309.8		

Note : S = Saouga (annual rainfall 254.3 mm)

Table 6. Top performing varieties in the IITA Advanced Yield Trial-2 at Kamboinsé, 1983.

Varieties	Days to 5% flowering	Yield kg/ha	100 Seed weight	Seed colour & texture
IT 81D-975	40	841	16	BR
IT 81D-1189-81	43	822	17	WR
IT 81D-1137	40	658	23	WR
IT 82D-716	41	699	16	WR
TVx 3236-5-2	40	944	15	WBR
TVx 3236	43	468	12	CR
Trial mean	47	523		
C.V. %	5.61	40.3		
L.S.D. 5%	3.7	288.7		

Table 7. Top performing varieties in the IITA Preliminary Yield Trial-3 at Kamboinsé, 1983.

Varieties	Days to 50% flowering	Yield kg/ha	100 Seed weight	Seed colour and texture
IT 82D-703	41	802	14	WR
IT 82D-707	39	812	15	CR
IT 82D-951	45	868	15	WR
IT 82D-652	42	947	23	WR
TVx 3236-01C	42	759	13	CR
Trial mean	42	633		
C.V. %	3.4	26.2		
L.S.D. 5%	2.0	235.6		

In the smooth seed category of the medium maturity group, IITA International Yield Trial-2 was planted at Loumbila whereas the IITA Advanced Yield Trial-1 and the Preliminary Yield Trial-4 were planted at Kamboinsé. Yields (Kg/ha) of the promising varieties in these trials are reported in Table 8, 9 and 10. Yields were better in the International Trial-2 because of favourable moisture conditions at flowering at Loumbila. Whereas the low yields at Kamboinsé both in the Advanced-1 and the Preliminary-4 trials could be attributed to drought at flowering.

The trials from IITA in the early maturity group were planted at Loumbila and the Upper Volta Preliminary-4 was planted at Farako-Bâ, Loumbila and Pobé. The IITA International Trial-1 had 10 varieties, IITA Preliminary-1 and Preliminary-2 had 20 varieties each, and the Upper Volta Preliminary Trial-4 had 28 varieties. Upper Volta Preliminary-4 had three replications and the others four. Plot size in each trial was 4 rows, 4 m long and 0.50 m apart. Central two rows were harvested for yield estimates. Yields of the promising varieties in these trials are reported in Tables 11, 12, 13 and 14.

The yields in general in all the trials at Loumbila are high due to favourable moisture conditions at flowering. In the International Trial-1, (Table 11) IT 82E-13 and IT 82E-32 produced very good yields which were more than 50% higher than IT 80E-60 and Local check, the two standard varieties included in this trial. In the IITA Preliminary Trial-1 (Table 12) and Preliminary Trial-2, the best performing varieties produced as good yields as that of TVx 3236.

In the Upper Volta Preliminary Trial-4, the highest average yield across environments was recorded for TVx 4659-13C-1K (1277 kg/ha), and it was the highest yielder both at Farako-Bâ and at Kamboinsé, which are relatively wetter locations. The yields in general were poor at Pobé, the location that represents Sahel environment. It suggested that early maturity per se may not be that important as compared to total plant adaptation to harsh conditions usually prevailing in such areas.

Table 8. Yields of the promising varieties in the IITA International Yield Trial-2 at Loumbila, 1983.

Varieties	Days to 50% flowering	Yields kg/ha
IT 81D-1205-174	43	1261
TVx 4654-44E	42	1221
TVx 4659-03E	44	1081
TVx 4677-88E	44	1032
TVx 3236-01G	42	1077
Local check	35	909
Trial mean	41	941
C.V. %	2.7	16.0
L.S.D. 5%	1.5	213.2

Table 9. Yields of the promising varieties in the IITA Advanced Yield Trial-1 at Kamboinsé, 1983.

Varieties	Days to 50% flowering	Yield kg/ha
IT 81D-105	44	719
IT 81D-1039	44	742
IT 81D-1054	40	946
IT 81D-1063	42	870
TVx 1948-012F	41	743
TVx 3236	43	678
Trial mean	42	634
C.V. %	5.0	52.6
L.S.D. 5%	3.0	472.8

Table 10. Yields of the promising varieties in the IITA Preliminary Yield Trial-4 at Kamboinsé, 1983.

Varieties	Days to 50% flowering	Yield kg/ha
IT 82D-808	41	615
IT 82D-844	39	636
IT 82D-763	41	683
IT 82D-845	39	650
IT 82D-847	41	660
TVx 1948-012F	41	504
TVx 3236	45	630
Trial mean	40	546
C.V. %	20.0	39.5
L.S.D. 5%	11.2	306.1

Table 11. Performance of varieties in the International Yield Trial-1 at Loumbila, 1983.

Varieties	Days to 50% flowering	Yield kg/ha
IT 82E-77	36	1514
IT 82E-9	34	1663
IT 82E-41	35	1497
IT 82E-13	39	2428
IT 82E-16	39	2252
IT 82E-18	38	1906
IT 82E-32	39	2392
IT 82E-56	35	1441
IT 82E-60	36	1490
Local check	33	1477
Trial mean	36	1806
C.V. %	1.8	17.3
L.S.D. 5%	0.9	453.7

Table 12. Yields of the top performing varieties in the IITA Preliminary Yield Trial-1 at Loumbila, 1983.

Varieties	Days to 50% flowering	Yield kg/ha
IT 82E-636	52	2269
IT 82D-640	40	2084
IT 82D-641	39	2140
IT 82D-654	37	1927
IT 82D-673	46	2067
IT 82E-60	38	1160
TVx 3236-01G	38	2226
Trial mean	39	1657
C.V. %	11.5	25.8
L.S.D. 5%	6.3	605.7

Table 13. Yields of the top performing varieties in the IITA Preliminary Yield Trial-2 at Loumbila, 1983.

Varieties	Days to 50% flowering	Yield kg/ha
IT 82D-871	40	1987
IT 82D-872	42	1824
IT 82D-874	42	1824
IT 82D-885	35	1851
IT 82D-889	34	1530
IT 82E-60	38	1360
TVx 3236	42	2010
Trial mean	37.8	1642
C.V. %	3.7	15.1
L.S.D. 5%	2.0	351.0

Table 14. Yields of top performing cultivars in the Upper Volta Preliminary Yield Trial-4 at different locations.

Cultivars	Yield kg/ha			Days to 50% flowering		
	F	L	P	F	L	P
KVu 69	1031	1633	344	40	35	39
KVu 72	1084	1928	275	49	33	59
KVu 76	1076	1328	498	46	40	40
KVu 131	829	2528	269	47	40	45
KVu 150	754	2378	276	53	50	59
KVu 77	593	1527	632	47	41	42
TVx 4659-13C-1K	1339	2156	336	47	39	43
IT 82E-60	533	1400	466	43	38	37
Local check	728	1606	296	46	35	58
Trial mean	738	1420	457	46	39	43
C.V. %	24.7	27.2	30.7	2.7	13.9	11.2
L.S.D. 5%	297.7	630.1	224.9	2.0	8.9	7.9

(C) Breeding for Resistance to Striga

The objective was to develop and screen *Striga* resistant varieties, study relationship of *Striga* infestation with maturity and plant type of cowpea and study its inheritance.

Development and Screening of Striga Resistant varieties:

Material originating from crosses between SUVITA-2 and several promising varieties at different stages of development was screened to select *Striga* resistant plants. The most advanced (F6 generation) was the material from a cross between TVu 2027 X SUVITA-2. This material was evaluated in the form of a Regional Cowpea Striga Trial (RCST) which was sent to five countries ; Bostwana, Mali, Niger, Nigeria, and Upper Volta. Seven promising selections identified from the last year's trial were tested in an artificially infested *Striga* sick plot alongwith three susceptible and two resistant varieties. The trial was a RCBD with three replications. Plot size was 4 rows, 5 m long at 0.75 m apart. Data were recorded in the central two rows.

Results from Kamboinsé and Ouahigouya (Upper Volta), Magaria (Niger), Seno (Mali) and Kano, Bakura and Samaru (Nigeria) are reported in Table 15. At Bakura, the *Striga* score representes number of *Striga* shoots as compared to per cent infestation of cowpea plants as at other locations. At Samaru, the *Striga* was absent and in stead a score on *Electra*, another plant parasite that attacks cowpea, is reported. In general, *Striga* infestation among the promising selections was lower as compared to susceptible ones, and comparable to the resistant variety, SUVITA-2 particularly in Upper Volta, Mali and Niger. Except in certain cases, yields of the promising selections were also higher than the susceptible varieties. In Kano and Bakura, the *Striga* infestation was relatively higher as compared to at other locations, but SUVITA-2 and some of the promising selections still had less *Striga* than the susceptible varieties. This difference in reaction could be related either

Table 15. Performance of the Regional Cowpea Striga Trial at different locations, 1983.

Varieties	Kamboinsé, Upper Volta		Ouahigouya, Upper Volta		Magaria, Niger	
	Yield	Striga	Yield	Striga	Yield	Striga
1. KVx 30-141-1G	1469	1.0	467	0.0	347	2.6
2. KVx 30-16[illegible]-3G	1408	0.0	383	0.0	237	2.0
3. KVx 30-183-3G	1567	0.0	400	0.0	222	3.0
4. KVx 30-199-4G	1397	11.0	317	0.0	333	2.8
5. KVx 30-312-3G	1289	7.7	467	0.0	278	5.0
6. KVx 30-323-1G	1266	10.3	417	0.0	195	0.0
7. KVx 30-403-1G	1247	2.7	383	0.0	278	2.0
8. SUVITA-2	1486	0.0	450	0.0	375	5.0
9. 58-57	1229	1.0	350	0.0	278	44.4
10. Mougne	826	87.3	150	15.9	205	45.8
11. TN 88-63	1322	82.3	250	13.0	305	21.6
12. Local	34	63.3	0	19.5	222	58.4
Trial mean	1212	22.2	367	4.0	273	16.1
C.V. %	19.1	47.7	23.4	-	38.0	-
LSD 5%	370	17.4	147	-	176	-

Table 15 contd.

Seno, Mali		Kano, Nigeria		Bakura, Nigeria		Samaru, Nigeria	
Yield	Striga	Yield	Striga	Yield	Striga*	Yield	Electra
1907	2.4	1500	30.9	0	25.7	1105	54.5
2262	6.3	1928	5.9	375	39.3	1612	15.2
2162	0.0	1367	8.5	1122	19.0	1213	3.2
1203	5.6	1488	36.0	1542	8.7	1352	38.9
1323	4.7	1395	31.4	586	32.3	1488	5.6
673	2.1	1153	8.6	648	17.3	1415	3.3
1017	8.4	1262	9.6	903	6.3	1452	15.3
1572	3.3	1650	8.3	1416	19.3	1388	7.0
553	19.3	917	29.6	403	37.3	1147	32.1
550	28.1	1188	20.0	931	44.7	-	-
1033	44.7	1328	31.9	736	20.3	1260	18.7
392	21.0	383	28.3	0	10.7	840	22.3
1221	12.2	1297	20.8	722	23.4	1189	18.0
35.9	-	20.2	-	50.5	-	19.5	-
742	-	445	-	750	-	430	-

* Striga shoots per plot rather than % infestation of cowpeas as at other locations.

to higher virulence of the Nigerian strain or a different strain altogether. These results need further verification.

Screening of other material included resistant selections from crosses of SUVITA-2 with KN-1, Kaya Local and TVx 3236. From the cross between KN-1 x SUVITA-2, 50 individual resistant plants were selected from 38 F3 populations. Similarly a total of 43 F2 resistant plants out of 600 from the cross between Kaya Local x SUVITA-2, and 300 out of 500 from the cross between TVx 3236 x SUVITA-2 were slected based on good seed quality and plant characters. All these plants are currently being advanced to next generation for further evaluation next year.

Relationship of Resistance with Maturity and Plant Type

A trial consisting of six varieties, two of them early (IT 82E-60 and KVu 69), two medium (KN-1 and TVx 3236), one late photosensitive (Kaya Local) and one resistant (SUVITA-2), was planted in an artificially created sick plot at Kamboinsé at two different dates to study relationship of *Striga* resistance with maturity and plant type and establish escape mechanisms, if any. The trial was a RCBD with four replications. The plot size was 6 rows, 5 m long and 0.75 m apart. Central two rows were used for observations. Results describing relationship of *Striga* emergence with flowering of varieties are presented in Figure 1, and those between yield and *Striga* infestation in Figure 2. Except in the resistant variety SUVITA-2, where *Striga* did not emerge, the emergence of *Striga* in other varieties was earlier (D1 = 33, D2 = 29) than their flowering (D1 = 50, D2 = 45) at both the dates (Figure 1), suggesting little possibility of escape by shifting from early to late maturing varieties or vice versa.

Striga infestation (Figure 2) was more on all the varieties at the second date of planting, and in general was associated with decrease in yield. However, this drop in yield could partly be associated to other soil and environmental factors. This was particularly true in case of SUVITA-2 where yield drop in the late planting was not due to *Striga*, but probably was caused by drought which coincided with its flowering. Amongst the susceptible varieties, the yield drop by late planting was more pronounced in KN-1 and IT 82E-60.

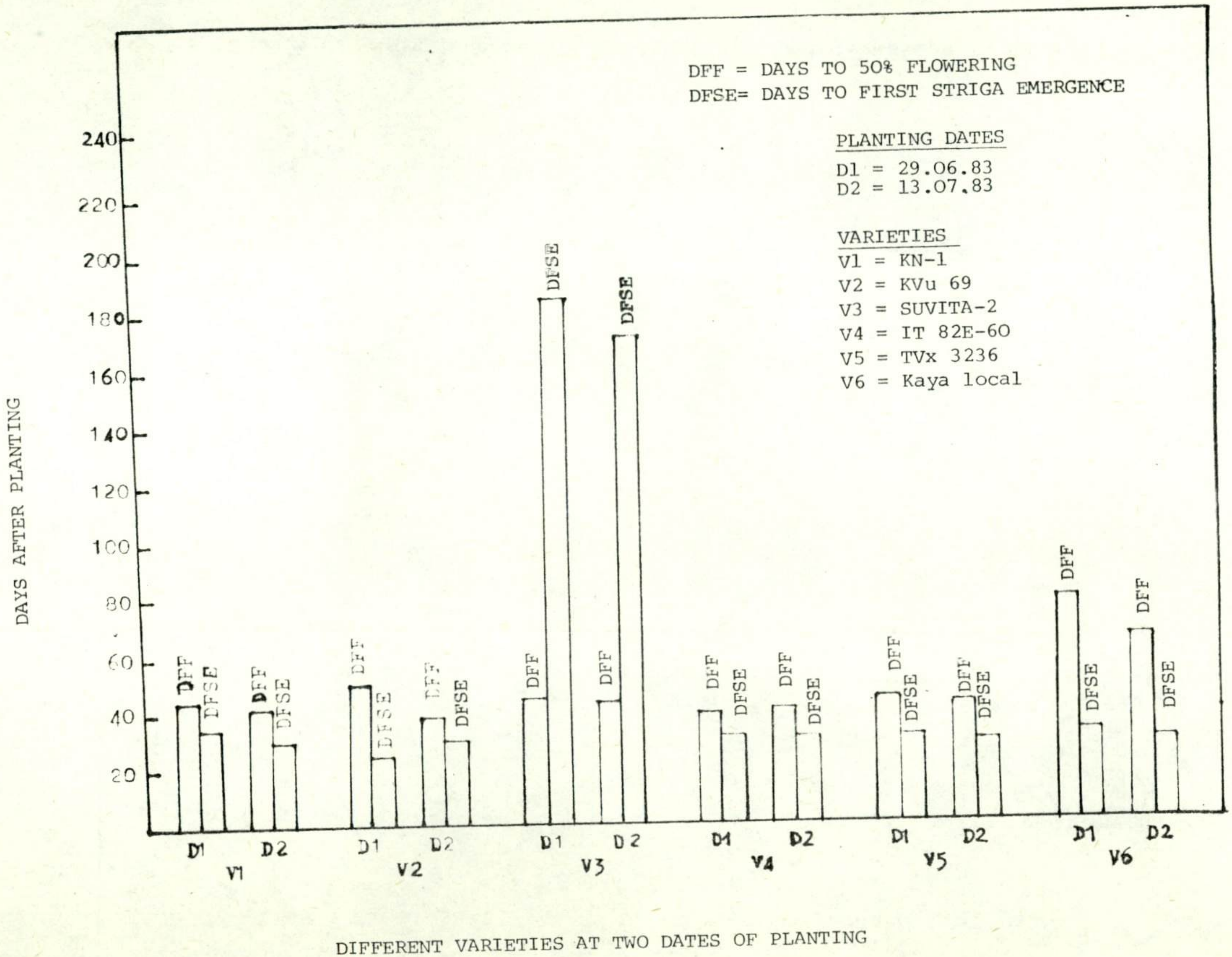


Figure 1. Relationship of striga emergence with cowpea maturity

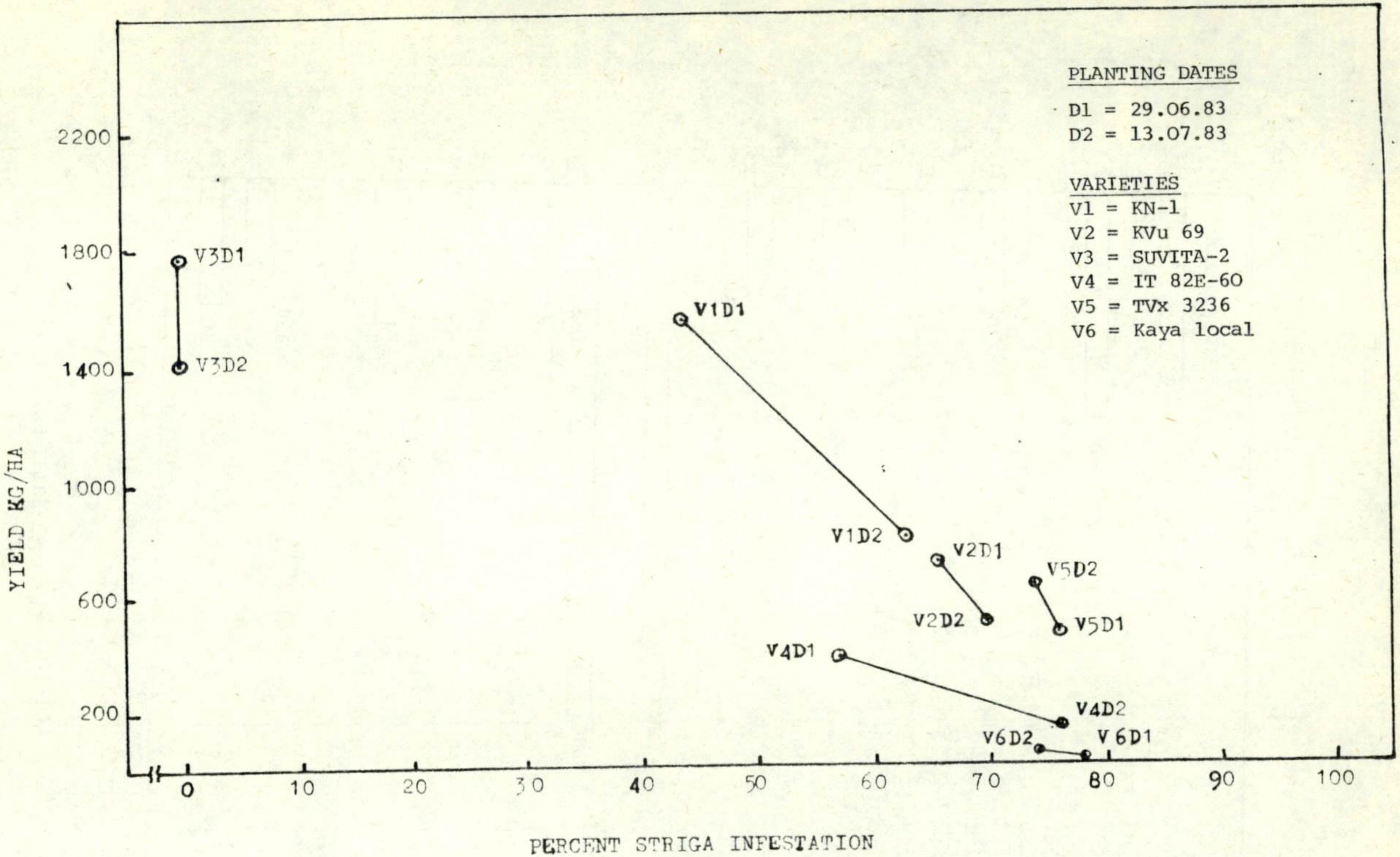


Figure 2. Relationship of yield and striga infestation in cowpea varieties

Striga reduced in all the susceptible varieties. Their yields in this experiment were lower than what they usually produce under normal conditions (refer earlier Annual Reports). As compared to other susceptible varieties, the yield of KN-1 was less affected by Striga damage.Similar results on KN-1 have been reported earlier qhere it was founf to delay Striga emergence by few days. Kaya local produced the lowest yield due to heavy damage in its vegetative phase, which, because of its photosensitive nature, is very long, and poor soil moisture at and after its flowering.

Inheritance of Resistance

The inheritance of resistance to Striga was studied by using F1, F2, BC1 and BC2 segregating populations from a cross between Kaya local and SUVITA-2 alonwith parental material. The experiment was planted in a Striga sick plot.

The results obtained are indicated in Table 16. The segregation ratio of susceptible and resistant plants in F2 generation fitted very closely to an expected ratio of 3 : 1, resistant VS susceptible plants, suggesting that the resistance was simply inherited and controlled by a single dominant gene. These results differed from those received from a cross between KN-1 and SUVITA-2 (Annual Report, 1982) where a 9:7 ratio of susceptible to resistant plants was observed. More studies are underway to further elucidate this problem.

(D) Regional Program

The objective of the regional program is to test promising cowpea varieties developed by different national, regional and international programs across semi-arid environments prevaling in different SAFGRAD membre countries.

In 1983, there were three regional cowpea variety trials.

1. Regional Medium Maturity Variety Trial (RMMT)
2. Regional Early Maturity Variety Trial (REMT)
3. Regional Cowpea Striga Trial (RCST)

Table 16. Segregation for *Striga* resistance in different population of crosses of Kaya local x SUVITA-2 at Kamboinsé, Upper Volta.

Line or cross	Plants		Segregation ratio		P2	Probability of a greater value
	Total	Infested	Resist.	Suscep.		
F1	77	7	1	0	0.63	0.50-0.25
F2	242	71	3	1	2.19	0.25-0.10
BC_1 (Kaya Local F_1)	107	48	1	1	1.34	0.25-0.10
BC_2 (SUVITA-2 X F_1)	373	20	1	0	1.19	0.50-0.25

Results of the RCST have been reported in the Striga section of this report. Results of the other two trials are reported here.

In the RMMT, there were 15 varieties contributed by the national programs in Nigeria, Senegal, Niger, and Ethiopia and IITA's programs in Nigeria and Upper Volta. In 1983, 27 sets of this trial were sent to 16 countries. The countries were Benin (2 sets), Botswana (1), Ethiopia (1), Ghana (2), Guinea (2), Kenya (1), Mali (2), Mauritania (1), Niger (2), Nigeria (3), Senegal (2) Tanzania (1), Togo (1), Zambia (1), Zimbabwe (1) and Upper Volta (3). The trial was a RCBD with four replications. The plot size was 4 rows, 4 m long, 0.75 m apart. Central two rows were harvested for yield estimates.

At the time of this write up, results from 14 locations, mostly from West Africa, were available. Yields (kg/ha) of different varieties are reported in Table 17. On average over the locations, TVx 1999-01F, SUVITA-2, IT81D-1137 and White Wonder Trailing were the best. TVx 1999-01F and SUVITA-2 have shown similar results in the past, thus confirming their superiority in the semi-arid areas of West Africa. Regarding performance at individual locations, SUVITA-2 and White Wonder Trailing produced highest yields at three locations each. TVx 3236 was best at Sotuba, Mali. In general, except few, average performance of most of the varieties across environments was similar. Low yields at Kamboinsé, Pobé and Bordo seemed to be associated with drought conditions.

In the REMT, there were 9 varieties contributed by Senegal and IITA/Nigeria and Upper Volta. Twenty five sets of this trial were sent to 16 different countries. The countries who received this trial were Botswana (2), Benin (2), Ethiopia (1), Mali (2), Gambia (2), Guinea (2), Kenya (1), Mauritania (2), Niger (1), Senegal (2), Tanzania (1), Togo (1), Somalia (1), Zambia (1), Zimbabwe (1) and Upper Volta (3). The trial was a RCBD with four replications. The plot size was 4 rows, 4 m long 0.50 m apart. Central two rows were harvested for yield estimates.

Table 17. Yields of different varieties in the Regional Medium Maturity Trial at Different locations, 1983.

Varieties	Origin	Yields Kg/ha Farako-Bâ Upper Volta	Kamboinsé Upper Volta	Pobé Upper Volta	Bordo Guinéa	Nyankpala Ghana	Sotuba Mali
IAR 48	Nigeria	1023	687	721	463	1561	2385
Mougne	Senegal	1044	661	598	520	1495	2188
TN 88-63	Niger	1074	657	493	797	1553	2438
White wonder Tr.	Ethiopia	1459	305	295	858	1575	2375
SUVITA-2	IITA/Up.Volta	1146	1045	597	485	1591	2542
TVx 3236	"	1148	475	676	536	1831	3250
KN-1	"	1123	504	363	554	1818	2897
TVx 1999-01F	"	1267	679	650	684	1283	2448
TVx 4262-09D	IITA/Nigeria	626	489	334	665	896	1772
IT 81D-994	"	1292	446	18	537	941	2375
IT 81D-1157	.	1209	680	568	509	2067	2073
IT 81D-1137	"	1428	645	635	619	1795	2032
IT 82D -952	"	1000	624	850	440	1601	2980
TVx 4659-03E	"	1228	644	451	445	1522	1730
Local	-	699	41	13	696	1217	500
Trial mean		1118	572	492	587	1556	2266
C.V.%		22.2	36.1	29.8	28.9	16.9	19.4
L.S.D. 5%		352	294	208	243	377	18.6
Rainfall (mm)		739.3	622.9	448.5	-	-	616.9

Table 17 contd.

Yields Kg/ha								
Sikasso Mali	Broukou Togo	Melkassa Ethiopia	Kolo Niger	Samaru Nigeria	Bakura Nigeria	Sinthiou Senegal	Sefa Senegal	Mean
1035	873	1882	1217	2672	2053	860	2166	1400
717	692	2203	1182	[illegible]	2115	1020	2042	1371
1258	0	2540	1380	1760	1771	1135	2042	1350
833	1152	2883	800	2650	2208	720	2500	1472
847	685	1987	1780	2215	2188	785	2875	1483
1047	990	2017	1208	1492	2063	800	2666	1443
823	1305	1792	1260	2265	2386	925	2166	1442
960	1655	2622	1660	2318	2115	655	2417	1572
677	1442	610	1367	0	1396	333	1917	895
868	848	530	1447	2317	2063	475	2250	1172
773	1007	1648	1443	2467	1836	810	1333	1316
1338	933	1865	1695	2388	2167	755	2417	1479
1098	1423	2053	1240	1957	2267	878	2125	1467
680	1475	1562	1082	2932	2313	795	2000	1347
1008	1630	1992	1563	2193	1834	935	2416	1196
931	1074	[illegible]	1355	2157	2052	792	2222	
35.8	31.9	21.9	16.6	13.6	21.6	35.5	34.2	
475	525	587	377	456	632	401	-	
841.4	886.7	789.7	-	616.9	-	-	1085	

The main objective of the trial was to see performance of early maturing varieties particularly in areas where rainfall is limiting, growing conditions are harsh and the season is short. Results from 11 places, again mostly from West Africa, are reported in Table 18. On average over the locations, TVx 4659-1C-1K, IT82E-18 and IT82E-32 were the best varieties. These varieties, in addition to early maturity, also possessed a relatively more vigorous plant type which enabled them to withstand drought conditions better than other varieties in the trial which produced very little biomass and were unable to recover from drought and produce good yields. Also, the poor yielding varieties in this trial were highly susceptible to diseases, particularly brown pod blotch and bacterial blight that confounded to their low yields. Diseases were the main reason for low yields, particularly in those areas, where rainfall was not limiting. These results and those reported in the agronomy section on early maturing varieties tend to lead that early maturity alone may not be sufficient for adaptation in dry areas where poor and sandy soils, high temperatures and sandstorms are common. It needs to be associated with a plant type that can withstand better the harsh growing conditions.

Table 18. Yields of different varieties in the Regional Early Maturity Trial at different locations, 1983

Varieties		Yield Kg/ha					
		Farako-Bâ U.Volta	Loumbila Upper Volta	Pobé U.Volta	Ouallam Niger	Bambey Senegal	Louga Senegal
IT 82E - 18	IITA	1100	1844	746	935	1825	359
IT 82E - 32	"	1223	1530	670	555	1553	233
IT 82E - 60	"	751	1100	583	478	1169	316
IT 82E - 70	"	685	1315	479	213	1132	197
IT 82E - 77	"	762	1459	629	775	1261	333
Bambey - 21	"	734	1261	529	223	1491	277
KVu 69	IITA/UPPER VOLTA	803	1513	935	678	1517	299
TVx 4659 -13C -1K	"	1221	2071	1015	928	1477	372
Local	-	582	1330	80	1545	1353	448
Trial mean		885	1492	630	703	1420	315
C.V. %		30.9	17.3	15.9	47.1	10.0	33.0
L.S.D. 5%		399	377	146	482	208	147
Rainfall (mm)		448.3	-	448.5	314.5	317.6	151.0

Table 18 contd.

Yield kg/ha					
Selibeby Mauritania	Seno Mali	Broukou Togo	Melkassa Ethiopia	Sapu Gambia	Mean
1150	845	1653	1378	2125	1269
1922	638	2228	1685	1532	1252
1750	650	390	1160	1281	875
1967	500	758	573	1344	833
1891	900	470	1233	1125	985
1657	320	700	1298	969	860
1844	548	645	1910	2156	1170
1548	725	1690	1940	1719	1337
1735	278	1583	-	438	937
1718	600	1124	1397	1410	
19.9	16.4	21.4	36.4	39.3	
998	143	350	747	718	
409.4	410.4	886.7	789.7	-	

COWPEA AGRONOMY

The objectivesof the cowpea agronomy research program of SAFGRAD/ IITA are to identify problems in cowpea production and to develop new production technologies for achieving maximum economic yields of cowpeas in the African semi-arid zone. Since this zone is so large, comprising 27 countries and stretching from West Africa through the Sahel and East Africa to Southern Africa, it has been impossible to conduct research simultaneously in all parts of the zone. So, the program has concentrated its main effort in Upper Volta at four locations. These locations, (i.e., Farako-Bâ, in Northern Guinea Savanna ; Kamboinsé/Loumbila/Ouagadougou, in Sudan Savanna ; and Pobé/Djibo and Saouga, in the Sahel) represent the three major agro-climatic zones encountered in the African semi-arid regions. The promising technologies developed in Upper Volta are thereafter tested in verificative agronomy researches conducted in various SAFGRAD's member countries as regional trials.

(A) Maize/Cowpea relay-cropping

Experiments conducted during the four previous years have illustrated the possibility of relay-cropping cowpeas under maize, in Northern Guinea Savanna, and obtaining good yields of both crops in the same piece of land, during the same growing season. Researches on maize-cowpea relay cropping during 1983 aimed at identifying management practices that could maximize the yield of the system. An effort was also made to introduce maize-cowpea relay-cropping system in Sudan Savanna.

Northern Guinea Savanna

1. Response of cowpea cultivars in a maize-cowpea relay-cropping system

Previous experiments have shown that cowpeas can be relay-cropped to maize three to four weeks after maize planting without a great detrimental effect on maize yield. Also, photoperiod-sensitive cowpeas appeared to be more adapted to early planting in maize-cowpea relay-cropping system than the photoperiod-insensitive cowpeas. This experiment was conducted at two dates of cowpea planting to determine the effect of cultivar differences among two cowpea plant types (photoperiod-sensitive versus insensitive) on cowpea performance in a relay-cropping system with maize.

The maize cultivar SAFITA-2 (90 days to maturity) was planted on 30 June, 1983 at 0.75 m row-spacing and 0.25 m between hill within each row. The hills were double planted and thinned to one plant per hill two weeks after planting. Maize plants received N.P.K. (35:77.5 : 35 kg/ha) fertilizer at planting and N(67.5 kg/ha) one month after planting. Seven cowpea cultivars, of which four ('Kaya local'), 'Logofrousso local', 'Ouahigouya local' and IAR 1696) photoperiod-sensitive and three (KN-1, TVx 3236 and VITA-5) photoperiod-insensitive, were planted at two dates : 29 July (one month after maize planting) and 6 September (7-10 days after the maize 50% silking stage) in solid rows alternating with maize rows. The spacings between cowpea plants were 0.75 m between rows and 0.20 m between hills within each row. Cowpeas were double planted and thinned to one plant per hill two weeks after their planting. Cowpea plants were not fertilized, but they were sprayed two times (with Decis 15g a.i./ha at floral bud initiation and Thiodan 500 g a.i./ha at pod formation) during the growing season. The experimental design used was a split plot, with cowpea cultivars as main plots and dates of planting as subplots. The experiment was replicated four times.

Cowpea cultivars, cowpea dates of planting and their interaction had no significant effect on maize physiological (dates of silking and maturity) and vegetative (plant height, ear height and leaf area index measured a week after the 50 % silking stage) traits. Similar results, except for the dates of cowpea planting effect, were also observed for grain yield. Cowpea planted under maize on 29 July significantly reduced maize yield as compared to the 6 September planting (3559 kg/ha versus 3886 kg/ha respectively, LSD 0.05= 274 ; C.V.% = 14$\pm$3). However, this yield reduction represented only 8 %. It can be attributed to early cessation of rains in mid-september while maize plants were just entering the grain filling growth stage. Thus, with cowpeas having made substential vegetative growth, maize grain fill in plots where cowpeas were planted on 29 July occured not only during a dry spell, but also under overcrowded conditions. Active competition between cowpea and maize plants may have resulted in an increased soil moisture stress, which consequently reduced maize yield. The growth of cowpeas planted on 6 september was impeded by the drought. These cowpeas did not branch and consequently did not compete or competed very little with maize plants.

Cowpea grain yield and time of flowering were significantly affected by cowpea cultivars, dates of planting and their interaction. Table 1. shows the effect of interaction : owpea cultivars x dates of planting, on grain yield and time of flowering of cowpeas, respectively. Only the cultivars that flowered earlier gave high grain yields in the first date of planting.Late flowering cultivars in the first date of planting and all cultivars planted on 6 September gave a yield equal to or not significantly different from zero. They were severely damaged by the drought, which was brought by an earlier cessation of rains than normal and by foliar thrips (probably Sericothrips occipitalis) damages. The advantage of photoperiod-sensitive over photoperiod-insensitive cultivars in maize-cowpea relay-cropping system, observed in previous years (1981 land 1982) could not be verified this year. However, the appropriateness of planting cowpeas under maize one month after maize planting was clearly demonstrated. It not only had a little effect on maize yield reduction (8%) but unabled cowpeas to escape drought and so give an acceptable yield. The 1982 year findings and this years observations underline the importance of using early photosensitive (over 60 days after planting) cowpeas in maize-cowpea relay-cropping system. This is particularly important for those farmers who cannot afford the risk of getting low cowpea yields or total cowpea crop failure during years when rains cease in early to mid-september, which may occur one out of seven years.

2. Effect of maize cultivar differences in maturity on yield of relay-cropped cowpeas.

Maize-cowpea relay-cropping experiments conducted to date have shown no advantage of substituting early maturing maize cultivar for a medium maturing one, as a means of maximizing the total grain yield of the system. In 1981, the medium maturing maize increased maize yield by 15 %, but depressed cowpea yield by 30 %. In 1982, the medium maturing maize did not show a yield advantage over the early one, but it depressed the yield of the high yielding cowpea by 27 %. Since the experiment was conducted at a single row-spacing and density, one would suspect the tall, leafy and medium maturing maize cultivar to create an unsuitable environment for the relay cropped cowpeas. This experiment was conducted to study the interaction of maize maturity differences with maize row-spacings and plant population on grain yield of relay-cropped cowpeas.

Two early (90 days to maturity) maize cultivars : SAFITA-2 and 'Jaune de Fo', and two medium-maturing (105 days to maturity) maize cultivars : SAFITA-102 and IRAT-178, were planted on 29 June, 1983 at Farako-Bâ at two row-spacings and plant populations (0.75 m x 0.25 m, corresponding to 53,333 plants per hectare and 1 m x 0.25 m, 40,000 plants per hectare). Two cowpea cultivars : 'Logofrousso local' (photoperiod-sensitive) and TVx 3236 (photoperiod-insensitive) were, respectively, planted under maize on 29 July (one month after maize planting) and 9 september (about one week after maize silking); these dates corresponded, respectively, to the observed optimum time of planting of photoperiod sensitive and insensitive cowpeas in maize-cowpea relay-cropping experiments conducted in 1980 and 1981. The experimental design used was a split plot : with maize cultivars as main plots and a factorial combination of two row-spacings and two cowpea cultivars as subplots. The experiment was replicated four times. The agronomic practices used were as described in the preceeding experiment.

Table 1. Grain yield and days to 50% flowering of cowpeas in a maize cowpea relay-cropping system, Farako-Bâ, Upper Volta, 1983.

Cultivars	Grain yield		50 % Flowering	
	29 July	6 September	29 July	6 September
	--------kg/ha--------		--Days after planting-	
Kaya local	450	0	60	44
Logofrousso local	78	0	70	98
Ouahigouya local	451	0	53	45
IAR 1696	120	0	77	116
KN-1	365	0	45	62
TVx 3236	510	0	45	62
VITA-5	489	0	45	45
LSD (0.05)	155		24	
C.V. (%)	64 ± 17		29 ± 5	

Table 2. Maize yield as affected by cowpeas in a maize-cowpea relay-cropping system, Farako-Bâ, Upper Volta, 1983.

Maize cultivars	Cowpea cultivars +	
	TVx 3236	Logofrousso local
	----------------------kg/ha--------------------	
SAFITA-2	2890 ab	2541 abc
Jaune fe Fo	2119 bc	1917 c
SAFITA-102	3310 a	2408 abc
IRAT-178	2440 abc	2554 abc
LSD (0.10)	953	
C.V. (%)	21 ± 4	

+Means followed by the same letter are not statistically different at 0.10 probability level.

Maize grain yield was significantly affected only by cowpea cultivars. The interaction : maize cultivars x cowpea cultivars was significant at 0.10 probability level. Table 2 shows maize grain yield, and Table 3 shows differences in some physiological and morphological traits of tested maize cultivars. SAFITA-102 yielded equally to SAFITA-2 and IRAT-178, but significantly higher (0.10 probability level) than 'Jaune de Fo' when relay-cropped with the cowpea TVx 3236. When cropped with 'Logofrousso local' (which was planted one month after maize planting) no significant differences in grain yield were observed among maize cultivars ; the average maize yield was reduced by 12 % as compared to relay-cropping with TVx 3236. The difference was significant at 0.05 probability level. As already mentionned in the preceding experiment the yield decrease may be attributed to overcrowding of plots under drought conditions. Also, the drought conditions may be considered as the cause pf reduced growth duration of SAFITA-102 and IRAT 178 (Table 3).

Cowpea grain yield was highly significantly affected by maize cultivars, cowpea cultivars and maize cultivars x cowpea cultivars interaction effects and significantly by the row-spacing effect. Table 4 shows the effect of maize cultivars x cowpea cultivars interaction on cowpea yield. Since the cowpea TVx 3236 was planted on 9 september and because of rain cessation in mid-september, it failed to set pods and so produced no grain yield. Therefore, the effect of maize cultivar differences in maturity group on relay-cropped cowpeas will be discussed based on the reaction of the cultivar 'Logofrousso local'. Maize cultivars 'Jaune de Fo' and IRAT-178 significantly depressed the yield of 'Logofrousso local' as compared to maize cultivar SAFITA-2. SAFITA-102 was intermediate between SAFITA-2 and 'Jaune de Fo'. Since SAFITA-2 was significantly different from the other three cultivars in most of the physiological and morphological traits shown in Table 3, its less competitiveness in relay-cropping with cowpea may be attributed to its earliness, short plant stature and less leafiness. However, it is interesting to note that SAFITA-102 and IRAT-178 flowered and matured at the same time and had similar plant height and LAI (Table 3) ; yet they

Table 3. Some physiological and morphological traits of maize cultivars tested in a maize-cowpea relay-cropping system, Farako-Bâ, Upper Volta, 1983.

Maize Cultivars	Days to 50 % silking (DAP)	Days to 50 % Maturity (DAP)	Plant height (cm)	Ear height (cm)	Leaf area index (LAI)
SAFITA-2	64	92	132	64	1.39
JAUNE de FO	71	94	166	99	1.54
SAFITA-102	70	98	140	77	1.80
IRAT-178	70	96	155	89	1.84
LSD (0.05)	4	2	16	10	0.28
C.V. (%)	7 ± 1	3 ± 0.5	13 ± 2	15 ± 3	21 ± 4

Table 4. Grain yield of cowpeas as affected by maize cultivars in a maize-cowpea relay cropping system, Farako-Bâ, 1983.

Maize cultivars	Cowpea cultivars +	
	TVx 3236	Logofrousso local
	---------kg/ha---------	
SAFITA-2	0 d	630 a
JAUNE DE FO	0 d	499 b
SAFITA-102	0 d	511 ab
IRAT-178	0 d	323 c
LSD (0.05)	120	
C.V. (%)	32 ± 6	

+ Means followed by the same letter do not differ statistically at 0.05 probability level.

tended to depress the yield of relay-cropped cowpeas differently. This suggests that more factors than plant height and LAI (for instance competition at the root system for soil moisture and/or plant nutrients) may also be involved in the competition between maize and cowpea plants during the overlap period in relay-cropping system. Therefore, the best way to ascertain the suitability of a crop variety in relay-cropping system is through actual field testing rather than speculations based on plant type only.

Increasing maize row-spacing from 0.75 m to 1.00 m significantly increased the yield of relay-cropped cowpea by 20 % (mean yield of 446 kg/ha for 0.75 m row-spacing versus 535 kg/ha for 1.00 m). Since this increase had no detrimental effect on maize yield, it is probably advantageous to plant maize at 1 m row-spacing in relay-cropping with cowpea.

The depressing effect of tall and medium-maruting maize cultivars on grain yield of relay-cropped cowpeas observed in this experiment agrees with the 1981 and 1982 results. It held true even when maize row-spacing was increased from 0.75 to 1.00 m and plant density reduced from 53,333 to 40,000 plants per hectare. It appears therefore, that there is no advantage of substistuting short and early-maturing maize cultivars for tall and medium-maturing ones as a means for maximizing the total grain yield of maize-cowpea relay-cropping system.

From the observations of this and the preceeding experiments, and those of previous years, it can be concluded that : - maize growers in the Northern Guinea Savanna will make better use of scarce available moisture and inputs by relay-cropping cowpeas to maize; - the optinum time of planting cowpeas under maize is one month after maize planting ; - delayed cowpea planting up to one week after 50 % maize silking may be detrimental to cowpea yields, especially during years when rains end in early to mid-september ; - high yielding, short, less leafy and early-maturing maize cultivars appear more suitable in maize-cowpea relay-cropping system than the tall, more leafy and medium-maturing ones. As far as cowpea plant types (photo-sensitivity versus insensitivety), differences in maturity groups within cowpea plant types and effect of maize row-spacings are concerned more investigations are still needed for better conclusions.

Sudan Savanna

Maize-Cowpea Relay-Cropping in Sudan-Savanna

Although the duration of the rainy season is short in Sudan Savanna as compared to Northern Guinea Savanna, it is possible to extend the maize-cowpea relay-cropping system in this ecological zone by proper choice of soil and proper management practices, which provide maximum soil moisture reserves at the end of the rainy season and thus increase the growing period. The possibility of introducing maize-cowpea relay-cropping system in Sudan Savanna was again investigated in 1983, at Loumbila, on a lower slope Alfisol.

The maize cultivar SAFITA-2 was planted on 24 June, 1983 under three seed bed preparation methods : planting on flat beds, planting on flat beds followed by earthing-up to make ridges and tying ridges three weeks after maize planting, and planting on tied ridges. The land was plowed to 20-25 cm depth and harrowed before planting. The maize spacings were 0.75 m between rows and 0.25 m between hills within each row. Four cowpea cultivars ,of which : two photo-sensitive ('Kamboinsé local noir', and 'Ouahigouya local') and two photo-insensitive (TVx 3236, and SUVITA-2), were planted under maize (in solid rows alternating with maize rows) at two dates: 18 July and 23 August, 1983. The cowpea spacings were 0.75 m between rows and 0.20 m between hills within rows. The experimental design used was a split plot, with a factorial combination of four cowpea cultivars and three seed bed preparation methods as main plots and cowpea dates of planting as subplots. All agronomic practices were as described in the preceeding two experiments, except that : three sprayings (two with Decis) were done to control insects.

Only the seed bed preparation methods highly significantly affected maize grain yield (GY), time of 50 % silking (SD), plant height (PH), ear height (EH), lodging (LDG) and leaf area index (LAI) as shown in Table 5. Earthing-up and tying ridges three weeks after maize planting significantly increased maize GY, but reduced LDG as compared to planting on flat. Planting on tied ridges significantly increased GY, PH, EH, and LAI ; hastened maize SD and reduced LDG as compared to planting on flat and earthing-up and tying ridges three weeks after planting. Cowpea cultivars, cowpea dates of planting and two and three way interactions had no significant effect on the aforementioned traits.

Cowpea yield was significantly affected by seed bed preparation methods and by time of cowpea planting (198 kg/ha for 18 July and 47 kg/ha for 23 August ; LSD (0.05) =39 ; C.V. (%) = 79 + 15). Planting on flat followed by earthing-up and tying ridges three weeks after maize planting and planting on tied ridges significantly increased the yield of relay-cropped cowpeas as compared to planting on flat, but they did not significantly differ from one another (Table 5). The tendency of tied ridges to reduce cowpea yield as compared to planting on flat followed by earthing-up and tying ridges three weeks after maize planting can be attributed to the large LAI this treatment induced on maize (Table 5). Heavy shading overcast by a large LAI may have impeded the growth of cowpeas and therefore contributed to a reduced grain yield. As observed in 1982, cowpea yields in maize-cowpea relay-cropping system in Sudan Savanna are still low. They would probably not justify the cost of sprayings. Therefore management practices aiming towards maintaining maize yields at an acceptable level, while reducing maize LAI and plant population need be investigated to stimulate the growth and yield of relay-cropped cowpeas.

Table 5. Effect of Seed bed preparation methods on maize grain yield (GY) 50% silking date (SD), plant height (PH), ear height (EH), lodging (LDG) and leaf area index (LAI), and cowpea grain yield (GY) at Loumbila, Upper Volta, 1983.

Seed bed preparation methods	Maize						Cowpea
	GY (kg/ha)	SD (DAP)	PH (CM)	EH (CM)	LDG (%)	LAI (index)	GY (kg/ha)
- Planting on flat beds	1956	53.0	142	80	66	1.75	76
- Planting on flat, tying ridges 3 weeks after planting	2638	53.5	144	80	47	1.84	162
- Planting on tied ridges	3684	51.6	158	90	37	2.18	130
- L.D.S. (0.05)	429	0.7	8	5	9	0.22	43
- C.V. (%)	32 ± 9	3 ± 0.7	11±3	12±3	39 ± 11	24 ± 6	86 ± 34

(B) Maize-Cowpea Intercropping

The objectives of maize-cowpea intercropping system is to obtain a combined intercrop yield greater than a combined sole crop yield. This assumes that : the farmer wants to grow two or more crops, but because of limited resources (labor and agricultural inputs) he cannot grow them properly in separate pieces of land. Therefore, he would save labor and even utilize more efficiently available environmental resources (land, soil, moisture, soil fertility, etc.) by growing the different crops in the same piece of land during the same growing season.

Comparison of two early cowpea cultivars in a maize-cowpea intercropping system.

In Northern Savanna, farmers do traditionally intercrop early cowpeas with cereals as a means of improving their diet during the lean period : August-september. With the availability of newly IITA developed early cowpea cultivars, it is imperative to seek the improvement of the yield of intercropped cowpeas by testing these cultivars against the commonly used local ones. Two cowpea cultivars, IT 82E-60 and 'Dembo Local', were planted at Farako-Bâ, Upper Volta, at two dates : 16 June (14 days before maize planting) and 30 June (the same day with maize planting),1983 and three plants populations : 50,000 plants/ha (or 1 m x 0.20 m spacings) : 55,555 plants/ha (0.50 m x 0.36 m) and 80,000 plants/ha (0.50 m x 0.25 m). The medium maturing maize cultivar TZPB was planted as intercrop with cowpeas on 30 June, in solid rows. The spacing between maize plants were 1 m between rows and 0.25 m between hills within each row, which corresponded to 40,000 plants/ha. Purestand treatments of maize (53,333 plants/ha) and each of the two cowpea cultivars (66,666 plants/ha) were also included. Maize plants in plots that received intercrop as well as purestand treatments were fertilized with N.P.K. (35 : 77.5 : 35 kg/ha) fertilizer at planting and N (67.5 kg/ha) one month after planting. Cowpea plants in purestand plots received 77.5 kg/ha of P_2O_5 as single super phosphate at planting. The experimental design used was a split plot, with date of planting as subplots and purestand and mixture treatments as main-plots. The experiment was replicated four times. The agronomic practices used were as described for maize-cowpea relay-cropping experiments.

Grain yield of maize was significantly affected by plant populations and dates of planting of cowpeas. Whereas grain yield of cowpeas was significantly affected by plant populations ; cultivars, interaction : cultivar x plant populations, and interaction : plant populations x dates of planting. Maize grain yield was significantly reduced in mixture as compared to purestand treatments (Table 6). The high cowpea plant population in the mixture tended to further decrease the grain yield of intercropped maize. The severe yield reduction observed between 50,000 and 55,555 plants/ha appears to be more related to the spacial arrangements of the crops than to density increment (5,555 plants/ha), which was very small. Indeed, cowpea plants in 55,555 and 80,000 plants/ha plant population treatments were planted in solid rows, 0,50 m apart from one another. This corresponded to two cowpea rows between two adjacent maize rows for these treatments as compared to only one cowpea row for the 50,000 plants/ha plant population treatment. Thus, the proximity of cowpea plants to maize plants may have increased the competition, within the root zone, for water and nutrients between the two crops.

The two cowpea cultivars had a similar competitive effect in mixture with maize, as they did not affect maize grain yield differently. The cowpea cultivar 'Dembo local' yielded significantly higher than IT 82E-60 only in mixture with maize (Table 6). Also, its grain yield was significantly higher for the mixture treatments 55,555 and 80,000 as compared to 50,000 plants/ha and the purestand treatment. Thus, this cultivar took advantage of fertilizers (more

Table 6. Grain yields of maize and cowpeas as affected by cowpea cultivars and cowpea plant populations in a maize/cowpea intercropping experiment, Farako-Bâ, Upper Volta, 1983.

Plant Population (plants/ha)		Maize grain yield (+)		Cowpea grain yield (+)	
Maize	Cowpeas	IT 82E-60	DEMBO Local	IT 82E-60	DEMBO local
		---------------------kg/ha	----------------------		
40 000	50 000	1362 b	1330 b	362 c	570 b
40 000	55 555	888 b	788 b	418 c	772 a
40 000	80 000	640 b	853 b	498 bc	777 a
53 333	0	2555 a	2555 a	-	-
0	66 666	-	-	489 bc	477 bc
LSD	(0.05)	722		150	
CV	(%)	57 ± 18		26 ± 10	

+ Means followed by the same letter are not significantly different at 0.05 probability level.

Table 7. Grain yield of maize and cowpeas as affected by the date of planting cowpeas in a maize/cowpea intercropping experiment, Farako-Bâ, 1983.

Date of planting cowpea	Grain yield	
	Maize	Cowpea
	-------------------kg/ha	---------------
14 days before maize	905	559
Same day with maize	1500	532
LSD (0.05)	147	NS
C.V. (%)	22 ± 3	18 ± 2

probably N fertilizer) applied to maize plants in mixture to give a higher grain yield in the mixture as compared to the purestand treatment. The cultivar IT 82E-60 did not respond to mixture treatments. Table 7 shows the response of maize and cowpea grain yield to the dates of planting of cowpea in a maize-cowpea intercropping system. Planting cowpeas 14 days earlier than maize significantly reduced maize yield, but had no effect on cowpea grain yield.

From this experiment it appears that a farmer may get a combined intercrop yield greater than a combined sole crop yield by planting cowpeas at the same time with maize, at 50,000 Plants/ha and in solid rows alternating with maize rows. The local cowpea cultivar, 'Dembo local', appears to be more adapted to intercropping than the introduced IT 82E-60.

(C) Cowpea management

1. Date of planting

Experiments were conducted to determine the optimum date and to identify environmental factors (drought, disease or parasites other than insect pests) that may limit cowpea yields at various planting dates. Six photo-insensitive cultivars were tested at four planting dates at Farako-Bâ (Northern Guinea Savanna) and Kamboinsé (Sudan Savanna) and at three planting dates at Pobé/Djibo (Sahel Savanna). Similar experiments involving five photo-sensitive and one photo-insensitive cultivars and four photo-sensitive and two photo-insensitive cultivars were also established at Farako-Bâ and Kamboinsé, respectively. The experimental design used was split plot, with planting dates as main plots and cultivars as subplots. The experiments were each replicated four times. All the plots received 50 kg/ha of P_2O_5 as single superphosphate. They were sprayed twice with insecticides (Decis : 15 g a.i./ha at floral bud initiation, and Thiodan : 500 g a.i./ha at pod formation), except for the photo-sensitive experiment at Kamboinsé where three sprayings were done.

The results for the Pobé/Djibo experiment are shown in Tables 8 and 9. The growing season received in total 400, 5 mm rainfalls. The first planting was done after the month of June had received 13.5 mm rainfalls in three rains. It was immediately followed by a nine day dry spell. The second dry spell of the season occured from 23 August to 13 september (or 235 to 256 Julian days) when most of the cultivars were flowering. Cultivars IT 82E-60 and KVu-55 were described as extra-early (60 days to maturity) in their area of origin (Oyo State, in Nigeria, and South-Western Upper Volta, respectively), they exhibited photoperiod-sensitivity like other cultivars, but KVu-55 was the earliest or among the earliest cultivars at all dates of planting (Table 8). The yields of both cultivars were not significantly affected by dates of planting, and were the lowest of all cultivars at the first date of planting (Table 8). This low yield was the results of a sand-blow generated by violent winds in early July. The sand blow caused damages on leaves and stems and thinned out the stand of all cultivars, but IT 82E-60 and KVu 55 were severely damaged and could not recover like the other four cultivars. The yield of the latter cultivars tended to decrease with late planting. On the average these four cultivars lost 14 kg/ha for each day the planting was delayed (Fig.1) (the regression coefficient was highly significant). It is interesting to note that TVx 3236, which originated in Oyo state, Nigeria, tended to maintain a higher yield than the three cultivars (SUVITA-2, TN 88-63 and 5857) which originated from dry areas.

From these results it can be concluded that in the Sahel Savanna : -early planting (as soon as rains become established in late June) is conductive to high grain yield of cowpeas ; -cowpea cultivar earliness *per se* is not sufficient for achieving high grain yield, the cultivar must also adapt itself to this environment by growing and flowering profusely and setting pods that reach maturity. This lack of adaptation of the early cultivars that originated from the South and more rainy areas, is shown in Table 9 by the low number of flowers per square meter they produced.

Table 8. Grain yield and time of flowering of cowpeas, Pobé/Djibo, Upper Volta, 1983.

Cultivars	Grain yield			Time of flowering		
	22 June	7 July	16 July	22 June (173 JD)	7 July (188 JD)	16 July (197 JD)
	kg/ha			Julian days		
TVx 3236	992	779	707	234	236	239
SUVITA-2	953	639	629	236	237	243
TN 88-63	782	566	532	237	238	241
IT 82E-60	202	295	321	237	237	238
5857	951	623	519	233	236	239
KVu 55	257	509	406	230	232	235
LSD (0.10)		265			3	
C.V. (%)		34 ± 8			1 ± 0.1	

Table 9. Average number of flowers per day (AFD), maximum number of flowers per day (MFD), total number of flowers (TF) of cowpeas at Pobé/Djibo, Upper Volta, 1983.

Cultivars	A F D	M F D	T F
	Flowers/m^2		
TVx 3236	14	28	190
SUVITA-2	13	27	167
TN 88-63	13	29	179
IT 82E-60	6	10	73
5857	16	31	217
KVu 55	8	14	116
LSD (0.05)	3	6	51
C.V. (%)	34 ± 8	34 ± 8	39 ± 9

At Kamboinsé, in Sudan Savanna, the growing season received a total of 663.4 rainfalls. Three dry spells : from 18 to 26 July (or 199 to 207 Julian days), from 26 August to 6 September (or 238-249 Julian days) and from 16 September to 2 October (or 259-275 Julian days) occured during the growing season. The first and second dry spells occured just when early cultivars were flowering, respectively, at the 6 June and 27 July dates of planting (Table 10) and the third started 5 days before the flowering of early cultivars and continued up to 6 days after the flowering of late cultivars at the 12 August date of planting. On the average 20 kg/ha of grains were lost by photo-insensitive cowpeas for each day the planting was delayed as shown in Fig. 2 (the regression coefficient was highly significant). The extra-early cultivars : IT 82E-70 and KVu 55, yielded similary to KN-1 at all dates of planting except 27 July (Table 10) ; their yield dropped drastically and became insignificant from zero after the 4 July date of planting. The yield of TVx 3236 was significantly greater than that of KN-1 at all dates of planting except 12 August. SUVITA-2 maintained a low yield at the first two dates of planting, which were more rainy than the last two ; but it was the only cultivar for which the grain yield remained significantly different from zero at the last date of planting. Its reaction to dates of planting illustrates its tendency to tolerate more dry than rainy conditions.

Table 11 shows the number of flowers per square meter and number of days to maturity of cowpeas. The number of flowers produced by SUVITA-2 at the 12 August date of planting was insignificantly different from zero in comparison to that of KN-1, yet the former gave a yield that was significantly greater than zero in comparison to the latter. Similarly the number of flowers produced by KN-1 and SUVITA-2 at 27 July was not significantly different from that of IT 82E-70 and KVu 55, but the former two cultivars yielded significanly greater than the latter two. These results suggest that, though the flowers were lower under dry than rainy conditions, flowering *per se* was not the yield limiting factor for photo-insensitive cowpeas, but their inability to set pods. In this respect KN-1, IT 82E-70 and KVu 55 were very sensitive to dry conditions, SUVITA-2 least sensitive and other two cultivars intermediate.

Table 10. Grain yield and flowering dates of photoperiod-insensitive cowpeas, Kamboinsé, Upper Volta, 1983.

Cultivars	Grain yield				Flowering dates			
	16 June	4 July	27 July	12 Aug.	16 June (167JD)	4 July (185JD)	27 July (208JD)	12 Aug. (224JD)
	kg/ha				Julian days			
TVx 3236	1760	1841	1293	347	207	228	253	269
SUVITA-2	993	1071	993	479	212	230	255	269
TN 88-63	1957	1451	1113	460	209	228	252	265
KN-1	1011	1190	811	0	210	229	251	267
IT 82E-70	1199	1374	197	166	204	223	245	264
KVu 55	1307	1000	441	252	208	225	251	265
LSD (0.05)		475				2		
C.V. (%)		24 ± 4				0.5 ± 0.09		

Table 11. Total number of flowers per square meter and number of days from planting to maturity of photoperiod-insensitive cowpeas, Kamboinsé, Upper Volta, 1983.

Cultivars	Total number of flowers				Number of days to maturity			
	16 June	4 July	27 July	12 Aug.	16 June	4 July	27 July	12 Aug.
	Flowers/m^2				days after planting			
TVx 3236	370	560	518	98	57	62	60	59
SUVITA-2	306	370	296	92	62	62	63	61
TN 88-63	458	644	444	190	62	62	61	56
KN-1	602	499	317	186	62	61	60	59
IT 82E-70	522	489	330	176	54	60	58	55
KVu 55	286	216	177	147	55	59	59	55
LSD (0.05)		158				4		
C.V. (%)		31 ± 6				4 ± 0.6		

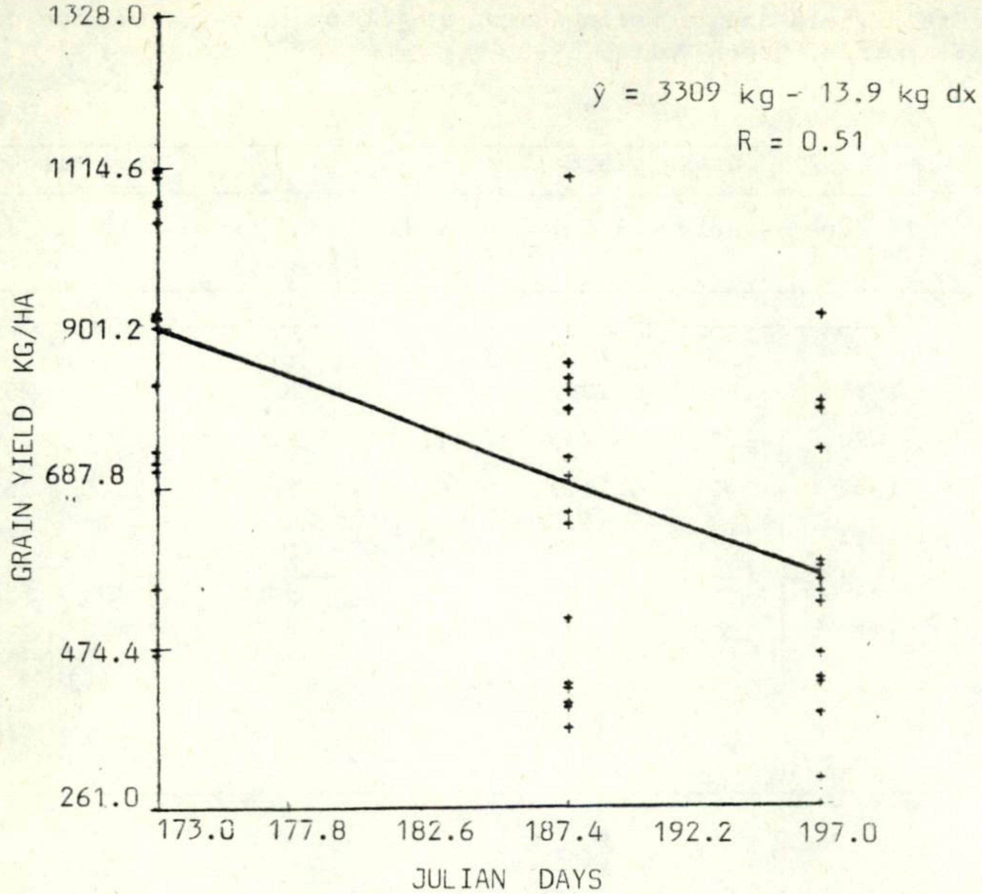


Fig. 1. Effect of dates of planting on mean yield of cowpeas, Pobé/Djibo, Upper Volta, 1983

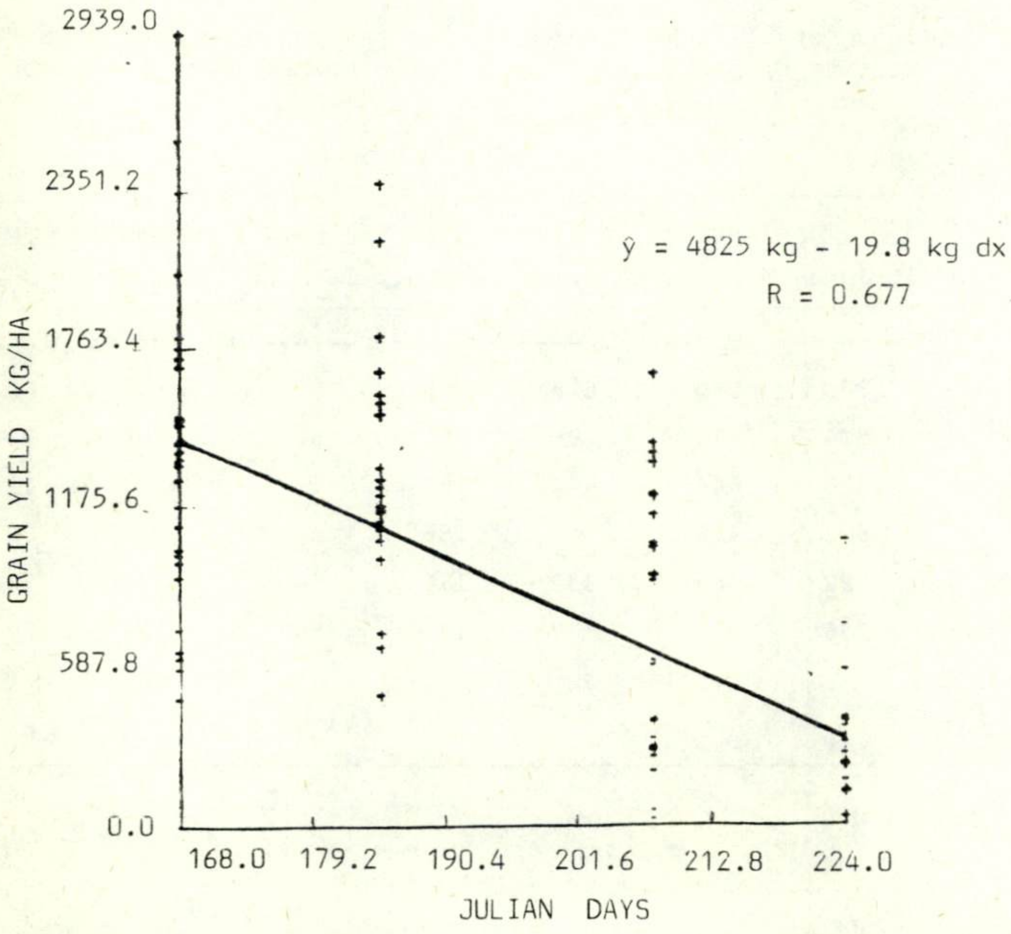


Fig. 2. Effect of dates of planting on mean yield of photoperiod-insensitive cowpeas, Kamboinsé, Upper Volta, 1983.

Grain yield, dates of flowering and total flowers per square mater of photoperiod-sensitive cultivars tested at Kamboinsé, in Sudan Savanna, are shown in Tables 12 and 13, respectively. Relative to the two photoperiod-insensitive checks : SUVITA-2 and KN-1, the yield of the best photoperiod-sensitive cultivar, 'Ouahigouya local' was much lower than that of the best photoperiod-insensitive cultivar TVx 3236 especially at the three first dates of planting (Tables 10 and 12) the yield of other photoperiod-sensitive cultivars was not significantly different from zero at all dates of planting. With the exception of 'Ouahigouya local', all photo-sensitive cultivars tended to fail to flower (as their flowering date approached 365 Julian day, which corresponds to their failure to reach the 50% flowering stage) (Table 13). Their total flowers per square meter was not significantly different from zero. In contrast to photoperiod-insensitive cultivars, their grain yield was apparently limited by their inability to flower. Thus, for three consecutive years 'Kaya local', 'Kamboinsé local noir' and'Kamboinsé local rouge' have failed to give an acceptable yield. Although they originated in Sudan Savanna, they are no longer adapted in this climatic zone, for which the growing season has been shortened for about one month since the last 5 to 10 years. From these results it can be concluded that in Sudan Savanna : - planting adapted photoperiod-insensitive cultivars before mid-July is conductive to achieving high grain yield of cowpeas ; - planting of photoperiod-insensitive cultivars after the end of July or planting long duration photoperiod-sensitive cultivars can lead to a severe yield reduction.

At Farako-Bâ, in Northern Guinea Savanna, the growing season received a total of 755.3 mm rainfall, which was far below the long term average (1100 mm). One dry spell occured during the season : from 18 to 26 July (or 230-238 Julian days) ; it corresponded to the time of flowering of early cultivars at the 7 July date of planting. Rains ended on 17 september (260 Julian Julian day), about one and half months earlier than normal. Pod formation and maturation for the 29 July date of planting ; and floral bud initiation, flowering, pod formation and maturation for the 16 August date of planting occured after the rains had ended. Tables 14 and 15 show, respectively, grain yield, and dates of flowering and number of days from planting to maturity of photo-insensitive cultivars.

Table 12. Grain yield of photoperiod-sensitive cowpea, Kamboinsé, Upper Volta, 1983.

Cultivars	Dates of planting			
	16 June	4 July	27 July	12 Aug.
	kg/ha			
Ouahigouya local	343	312	540	0
Kaya local	27	23	19	0
Kamboinsé local noir	0	0	0	0
SUVITA-2	554	454	681	0
Kamboinsé local rouge	56	51	40	0
KN-1	616	473	3.0	0

LSD (0.05) = 230 CV (%) = 83 ± 23

Table 13. Flowering dates and total number of flowers per square meter of photoperiod-sensitive cowpeas, Kamboinsé, Upper Volta, 1983.

Cultivars	Flowering dates (1)				Total number of flowers			
	16 June (167JD)	4 July (185JD)	27 July (208JD)	12 Aug. (224JD)	16 June	4 July	27 July	12 Aug.
	Julian days				flowers/m^2			
Ouahigouya local	251	265	263	344	85	66	64	3
Kaya local	315	318	341	365	22	18	42	7
Kamboinsé local N.	365	365	365	365	13	16	11	0
SUVITA-2	211	228	258	341	381	426	220	1
Kamboinsé local R.	315	269	316	365	27	45	26	3
KN-1	210	227	253	321	579	527	144	8
LSD (0.05)	43				74			
C.V. (%)	9 ± 2				47 ± 10			

(1) Some plots failed to flower, which means that they delayed flowering indefinitely. To simplify statistical analysis, 31 December (365 Julian day) was used as the probable flowering date.

Table 14. Grain yield of photoperiod-insensitive cowpeas, Farako-Bâ, Upper Volta, 1983.

Cultivars	Dates of planting			
	15 June	17 July	29 July	16 Aug.
	kg/ha			
TVx 3236	1266	1054	1116	362
TVx 1999-01F	1700	1113	1034	389
KN-1	1728	1183	994	456
Dembo local	606	550	585	328
KVu 55	776	729	569	465
IT 82E-70	839	668	779	375

LSD (0.05) = 352 ; CV (%) = 24 ± 4

Table 15. Date of flowering and number of days to maturity of photoperiod-insensitive cowpeas, Farako-Bâ, Upper Volta, 1983.

Cultivars	Dates of flowering				Number of days to maturity			
	15 June (166JD)	7 July (188JD)	29 July (210JD)	16 Aug. (228JD)	15 June	7 July	29 July	16 Aug.
	Julian days				Days after planting			
TVx 3236	213	241	257	275	68	69	66	65
TVx 1999-01F	216	241	260	276	71	69	67	65
KN-1	214	241	258	273	68	70	66	64
Dembo local	210	238	254	272	67	64	62	60
KVu 55	210	237	252	269	67	62	61	61
IT 82E-70	206	234	250	269	65	63	61	61
LSD (0.05)			2				2	
C.V. (%)			0.4 ± 0.07				2 ± 0.2	

In general grain yield is much lower this year as compared to previous year. This is probably due to the early cessation of rains, which shortened the growing season. On the average photo-insensitive cowpeas lost 11 kg of grains per hectare for each day the planting was delayed (Fig.3 ; the regression coefficient was highly significant). The early cultivars tended to yield lower than medium-maturing cultivars at the first three dates of planting. KN-1 and TVx 1999-01F yielded significantly higher than any other cultivars at all dates of planting at the 15 June date of planting only.They thus took advantage of a long growing season to give several flushes of flowering, which enabled more than three harvestings.

Grain yield, and flowering dates and ground cover of photoperiod-sensitive cowpeas are shown in Tables 16 and 17, respectively. The check photoperiod-insensitive cultivar, KN-1, yielded significantly higher than any other cultivars at the 15 June date of planting only. At the three last dates of planting it yielded similarly to 'Ouahigouya local'. Late flowering cultivars : 'Logofrousso local and IAR 1696, were among the lowest yielding cultivars at all planting dates. These results agree with, the 1982 observations for IAR 1696, but not for 'Logfrousso local'. the low yield observed for IAR 1696, in 1982 was atributed to the sprayings of insecticides that were done much earliest in relation to flowering and pod formation of this cultivar. Since such was not the case this year the observed yield reduction may be attributed to direct drought damages. It should be noted that, in contrast to Sudan Savanna, the flowering of photoperiod-sensitive cultivars was not impeded by the drought. This could be related to the relatively low air temperature, good soil water infiltration rate and good soil water holding capacity in Northern Guinea Savanna.

From these results and the 1982 observations, it can be concluded that : in Northern Guinea Savanna : planting cowpeas earlier than mid-July is a prerequisite to achieving high grain yield ; - medium-maturing photoperiod-insensitive cultivars appear to be more adapted than the very early ones, especially for plantings done before mid-July ; some medium maturing photoperiod-sensitive cultivars, such as 'Ouahigouya local',

Table 16. Grain yield of photoperiod-sensitive cultivars, Farako-Bâ, Upper Volta, 1983.

Cultivars	15 June	7 July	29 July	16 August
	kg/ha			
Ouahigouya local	1019	919	571	341
Kaya local	864	678	573	350
Kamboinsé local noir	724	855	558	383
Logofrousso local	455	569	576	298
IAR 1696	574	668	365	175
KN-1	1349	929	770	374

LSD (0.05) = 246 C.V. (%) = 26 ± 5

Table 17. Flowering dates and ground cover of photoperiod-sensitive cowpeas, Farako-Bâ, Upper Volta, 1983.

Cultivars	Flowering dates				Ground cover			
	15 June (166JD)	7 July (188JD)	19 July (210JD)	12 Aug. (228JD)	15 June	7 July	29 July	12 Aug.
	Julian days				%			
Ouahigouya local	240	258	269	279	80	65	41	32
Kaya local	244	266	273	279	76	62	46	30
Kamboinsé local N.	241	269	270	279	74	75	46	34
Logofrousso local	248	275	274	281	74	80	54	35
IAR 1696	266	282	286	286	81	95	57	42
KN-1	214	236	257	273	61	56	56	34
LSD (0.05)	6				16			
C.V. (%)	1.4 ± 0.2				14 ± 2			

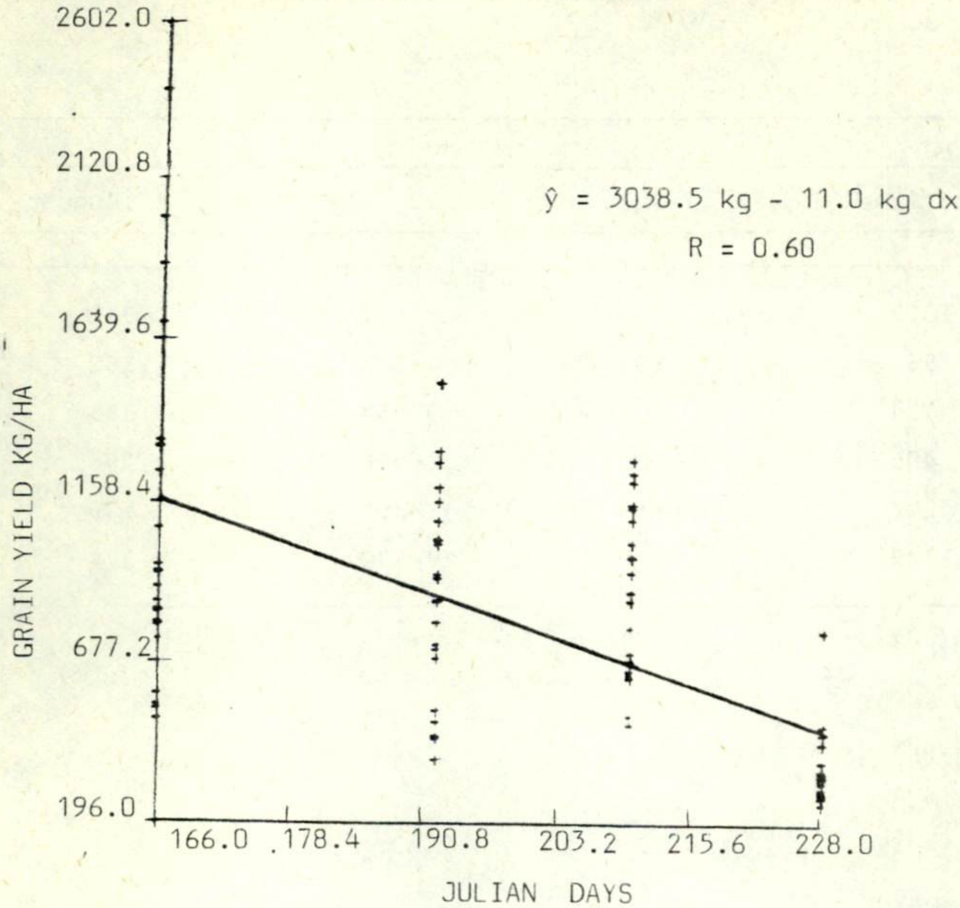


Fig. 3. Effect of dates of planting on mean grain yield of photoperiod-insensitive cowpeas, Farako-Bâ, Upper Volta, 1983.

have a yielding ability very similar to that of improved photo-insensitive cultivars, especially if plantings are not done very early in the growing season, end of June ; -planting late maturing photoperiod-sensitive cultivars could result in a severe yield reduction, particularly during years when rains end early in the growing season ; -when planted early, photoperiod-sensitive cowpeas provide better ground cover than the insensitive ones (Table 17).

2. Plant population

The plant population experiment for semi-erect early cultivars was repeated in 1983 at two locations : Farako-Bâ and Pobé/Djibo, Upper Volta. It included two cultivars : KN-1 and TVx 309-1G at Farako-Bâ, and SUVITA-2 and TVx 309-1G at Pobé/Djibo ; two row-spacings : 0.75 m and 0.50 m ; and three plant populations : 50,000, 75,000 and 100,000 plants per hectare. The experimental design used was a split plot : with the combination of two row-spacings and three plant populations as main plots, and the two cultivars as subplots. All agronomic practices used were as described in 'Date of planting experiments', except that cowpea plants were sprayed four times at ten day intervals beginning with floral bud initiation.

At both locations only cultivars affected significantly grain yield of cowpeas ; KN-1 yielded significantly higher (1592 vs 928 kg/ha; LSD (0.05) =162 ; CV (%) = 22 $\pm$ 3) than TVx 309-1G at Farako-Bâ ; and SUVITA-2 yielded significantly higher (771 vs 246 kg/ha ; LSD (0.05) = 145 ; CV (%) = 47 $\pm$ 7) than TVx 309-1G at Pobé/Djibo. As observed in 1982 at Farako-Bâ, it appears that plant populations and row-spacings are not the major yield limiting factors for semi-erect early cultivars.

3. Response of local cowpeas to soil applied P_2O_5

Cowpea management trials conducted in Northern Guinea and Sudan Savanna have shown local photoperiod-sensitive cultivars to respond very little to soil applied P_2O_5 in early planting as compared to improved photoperiod-insensitive cultivars. The yields obtained by local cowpeas, in Northern Guinea Savanna, were comparable to those obtained with improved photoperiod-insensitive cultivars that were fertilized. It is, therefore, imperative to study if the low response to soil applied P_2O_5 exhibited by local cowpeas is a valuable trait (associated with an efficient use of the native soil fertility), which can contribute to reduced fertilizer requirements, hence, lower the cost of inputs in achieving high grain yield in cowpea production. Three photoperiod-insensitive (viz.'Dembo local', TVx 3236 and (KN-1) and three photoperiod-sensitive (viz. 'Ouahigouya local', 'Kamboinsé local rouge' and Logofrousso local') cultivars were tested at three P_2O_5 levels (viz.0, 50 and 100 kg/ha) using single super phosphate 18 % fertilizer (SSP) at Farako-Bâ, Upper Volta. Volta phosphate (27.6 % P_2O_5) (VP) was also included at the rate of 100 kg/ha of P_2O_5 for comparison. The experiment was planted on 13 July on a medium slope Oxisol having the following characteristics : gravelly sandy-loam soil (with a lateritic layer at 40 cm. depth) pH =5.6, CEC = 2.10 - 3.00 me/100g, exchangeable base saturation = 52 %, organic matter content = 1.23 %, P content = 3.22 ppm (Bray P1). Phosphatic fertilizers were broadcast and plowed under at planting. Cowpeas were planted at 0.75 m x 0.20 m spacings (corresponding to 66,666 plants/ha after thinning) all other agronomic practices used were as described for plant population experiments.

Table 18 shows soil test for P (samples were taken about eight weeks after cowpea planting) and P content of cowpea leaves at flowering. Applied P_2O_5 of both phosphate carriers tended to increase the soil assimilable P (Bray P1), which resulted in an increased P content in cowpea leaves. However, the 100 kg/ha of P_2O_5 of VP had an effect similar to that of 50 kg/ha of P_2O_5 of SSP in both soil assimilable P and P content of leaves, which illustrated, thus, its low solubility.

Leaf P content at flowering and days to 50% flowering and 50% maturity of cowpeas were significantly to highly significantly affected by P_2O_5 levels and cowpeas cultivars. Table 19 shows leaf P content and days to 50% flowering and 50% maturity of cowpeas. Photoperiod-sensitive cultivars accumulated more P in the leaves than the photoperiod-insensitive cultivars ; they also flowered and matured later than the latter cultivars.

Table 18. Soil test for P and leaf P content of cowpeas at flowering, Farako-Bâ, Upper Volta, 1983.

Rates of applied P_2O_5 (kg/ha) (+)	Soil P test (ppm)	P contentin leaves (%) (‡)
0	3.22	0.16 d
50 SSP	4.67	0.21 b
100 SSP	5.99	0.25 a
100 VP	4.71	0.20 bc
LSD (0.05)	-	0.03
CV (%)	-	24 ± 4

(+) Two phosphate fertilizer carriers were used : SSP = single super phosphate 18 % ; VP = 'Volta Phosphate', a natural rock phosphate (27,6 % of P_2O_5) from Upper Volta.

(‡) Means followed by the same letter are not significantly different at 0.05 probability level.

Table 19. Leaf P content at flowering, days to 50% flowering and 50% maturity of cowpeas in a phosphate fertilizer experiment, Farako-Bâ, Upper Volta, 1983.

Cultivars	Leaf P content (+)	Days to 50 %	
		Flowering (+)	Maturity (+)
	----%-----	----------days after planting-------	
Ouahigouya local	0.21 b	60 b	82 b
Dembo local	0.20 bc	46 d	66 d
TVx 3236	0.18 c	49 c	67 cd
Logofrousso local	0.24 a	80 a	103 a
Kamboinsé local rouge	0.22 ab	61 b	82 b
KN-1	0.18 c	50 c	69 c
LSD (0.05)	0.02	2	2
C.V. (%)	16 ± 3	5 ± 0.9	4 ± 0.7

(+) Means followed by the same letter are not significantly different at 0.05 probability level.

Grain yield of cowpeas and ground cover were significantly affected by P_2O_5 levels, cowpea cultivars and their interaction. Table 20 shows the interaction : P_2O_5 levels x cultivars, on grain yield and ground cover. Grain yield of all cultivars, except 'Dembo local' and 'Logofrousso local', increased significantly with the first P_2O_5 increment of SSP, after which it reached a plateau. The 100 kg/ha of P_2O_5 of VP had no significant effect on grain yield as compared to the unfertilized treatment. 'Dembo local' (photoperiod-insensitive) and 'Logofrousso local' (photoperiod-sensitive), both local cultivars that originated from Farako-Bâ areas, yielded significantly lower than the four introduced cultivars.They did not significantly differ from each other at all P_2O_5 levels, except at 100 SSP, where 'Dembo local' significantly out-yielded 'Logofrousso local'. The yield of 'Dembo local' was reduced by Septoria leaf spot disease that caused early leaf drop slightly after flowering. 'Logofrousso local' was very late in both flowering as well as maturity (Table 19) ; it suffered severely of drought damages due to early cessation of rains in mid-September and the associated foliage thrip damages.

The other two photoperiod-sensitive cultivars : 'Ouahigouya local' and 'Kamboinsé local rouge', suffered also of drought damage, as they flowered in mid-September, just at the onset of the dry spell. But, since they were about 20 days earlier than 'Logofrousso local', they took advantage of soil residual moisture to yield better than the latter; they also did escape the foliage thrip damages.

The four high yielding cultivars yielded similarly to one another at all P_2O_5 levels, except at 100 SSP where TVx 3236 significantly out-yielded KN-1. It should be noticed that 'Ouahigouya local' and TVx 3236 tended to yield higher at 0 and 100 VP levels than the other cultivars.

Increasing levels of P_2O_5 of SSP significantly increased ground cover of all cultivars (Table 20). 100 kg/ha of P_2O_5 of VP significantly increased the ground cover of 'Ouahigouya local ' and 'Logofrousso local' only.

Table 20. Grain yield of cowpeas and ground cover as affected by cowpea cultivars and P_2O_5 levels, Farako-Bâ, Upper Volta, 1983.

Cultivars	Grain yield (+) P_2O_5 levels (kg/ha)				Ground cover (+) P_2O_5 levels (kg/ha)			
	0	50 SSP	100 SSP	100 VP	0	50 SSP	100 SSP	100 VP
	kg/ha				%			
Ouahigouya local	600	1093	1037	714	29	64	80	46
Dembo local	192	395	485	280	39	50	53	35
TVx 3236	508	1099	1337	790	29	53	61	39
Logofrousso local	212	124	112	205	44	90	97	60
Kamboinsé local Rouge	415	950	1085	617	33	75	83	43
KN-1	355	1094	1020	553	47	60	76	56
LSD (0.05)	301				13			
CV (%)	32 ± 6				15 ± 3			

(+) Two phosphate fertilizer carriers were used : SSP = single super phosphate 18 % ; VP = natural rock phosphate from Upper Volta (Volta phosphate with 27.6 % P_2O_5).

The grain yield and ground cover observations from this experiment agreé with the 1981 and 1982 management results in that : photoperiod-sensitive cultivars respond positively to applied P_2O_5, in Northern Guinea Savanna only in late planting (late-July to early-August), which corresponds to the occurence of drought slightly after flowering (this is because the applied P_2O_5 stimulates vegetative growth, which enables plants to produce more assimilates to mature large numbers of pods and, therefore, provide high grain yield). And that was exactly what happened this season in early planting. The results also underline the necessity of applying P_2O_5 in sufficient amount to local photoperiod-sensitive cultivars, even though they respond very little to this fertilizer. This is very important for maintening yield stability, especially during years when rains end in mid-september.

Using the yield of the best unfertilized cultivar, 'Ouahigouya local', as reference (since the interaction : cowpea cultivars x P_2O_5 levels, was significant), TVx 3236 was agronomically the most effective cultivar in utilisation of the applied P_2O_5 (Table 21). It provided the highest income at all levels of P_2O_5 (Table 21). 'Ouahigouya local' was next to TVx 3236 in both aspects. these two cultivars were also the only ones for which a farmer could get back the money invested in purchasing VP, had he or she had to make a choice between planting 'Ouahigouya local' without the application of 100 VP or plant either 'Ouahigouya local' or TVx 3236 with 100 VP fertilization, under the conditions of this experiment. VP was less effective in increasing cowpea yields (Table 21) and provided less income as compared to SSP. However, since it has a strong back-ground effect, its full assessement should take into consideration its effect in the subsequent cereal crops. Also since it is locally produced and cheap, its use is to be encouraged with some selected cowpea cultivars, such as TVx 3236 and to some extent 'Ouahigouya local'.

From this experiment it can be concluded that : -the occurence of a protracted dry spell beginning mid-september affected severely the yield of photoperiod-sensitive cowpeas than under normal conditions ; - under these conditions, early photoperiod-sensitive cultivars responded positively to applied P_2O_5 as did photoperiod-insensitive cultivars ; -some cultivar differences in relative agronomic effectiveness in use of

Table 21. Relative agronomic effectiveness (RAE) and Net incomes (NI) related to the application of different P_2O_5 levels to cowpeas, Farako-Bâ, Upper Volta, 1983.

Cultivars	R A E (+)			N I (‡)		
	50 kg/ha of P_2O_5 SSP	100 kg/ha of P_2O_5 SSP	100 kg/ha of P_2O_5 VP	50 kg/ha of P_2O_5 SSP	100 kg/ha of P_2O_5 SSP	100 kg/ha of P_2O_5 VP
	%			1000 Fr CFA		
Ouahigouya local	182	173	119	31.3	7.6	0.5
Dembo local	66	81	47	-38.6	-47.6	-42.9
TVx 3236	183	223	132	31.9	37.6	8.1
Logofrousso local	21	19	34	-65.7	-84.9	-50.4
Kamboinsé local R.	158	181	103	17.0	12.4	- 9.2
KN-1	182	170	92	31.4	5.9	-15.6

(+) R A E was computed based on yield increase over the yield of the best unfertilized cultivar : 'Ouahigouya local' (thus 600 kg/ha = 100) (Table 20).

(‡) N I was computed using the formula : NI = (GY fc-600 kg/ha) x cowpea price - (P_2O_5 kg/ha x fertilizer price/kg P_2O_5) ; where GY fc = yield of fertilized cowpea cultivar ; 600 kg/ha = yield of unfertilized 'Ouahigouya local', 1 kg of P_2O_5 SSP cost was 361 CFA Fr and 1 kg of P_2O_5 VP, 109 CFA fr ; cowpea prices was 100 CFA Fr/kg.

both phosphatic fertilizers were observed ; -natural rock phosphate, 'Volta phosphate', can be economically used as source of P_2O_5 with some selected cowpea cultivars. This experiment is to be repeated for better conclusions.

4. Tied ridges and toposequence study

4.1. Sudan Savanna

The tied ridges and toposequence study was repeated again in 1983. The objectives of the study was to reconfirm the effect of planting on tied ridges versus on flat, dates of planting and positions in the toposequence observed in 1981 and 1982 in Alfisol (with low soil water infiltration rate), at Kamboinsé in Sudan Savanna. Because of *Striga* infestation in the plots, KN-1 was replaced by SUVITA-2, a *Striga* resistant cultivars. The experiment compared two seed bed preparation methods (viz. planting on flat vs tied ridges), two dates of planting (viz. 7 vs 27 July) and five positions in the toposequence (viz. upper slope, upper to medium-slope, medium slope, medium to lower slope, lower slope). The experimental design used was a 2^2 factorial (two seed bed preparation methods and two dates of planting) in complete randomized blocks repeated four times at each position. The plots were fertilized with 50 kg/ha of P_2O_5 as single super phosphate. Other agronomic practices used were as described for the plant population experiment.

Soil moisture content was monitored during a nine day dry spell (from 18 to 26 July). This dry spell occured after the crop had received 96.3 mm of rainfall in ten days. The results are shown in Table 22. By suppressing or reducing water runoff, planting on tied ridges improved soil water reservoir replenishment as compared to planting on flat. This is shown by soil moisture content above pF 3.0 in all layers of soil profile (except to some extend for the 0-10 cm layer) even after eight days of dry spell in tied ridge plots as compared to flat plots, where the soil moisture content was already close to or slightly below pF 3.0 after four days of dry spell, except in the lower-slope position (Table 22). Eight days after the onset of the dry spell, soil water content on flat

Table 22. Soil water content, measured at three dates during a ten day dry spell, as affected by seed bed preparation methods, Kamboinsé, Upper Volta, 1983.

SOIL Profile	Dates of sampling (days after the rains ended)						pF values(‡)		
	4 Days		8 Days		11 Days (†)				
	Planting on tied ridges	Planting on flat	Planting on tied ridges	Planting on flat	Planting on tied ridges	Planting on flat	2.5	3.0	4.2
	%								
				Upper - slope					
0 - 10 cm	10.0	6.8	7.8	5.0	10.5	7.9			
10- 30 cm	10.9	8.8	9.7	7.4	10.6	8.5			
30- 60 cm	10.9	7.5	11.1	7.9	9.5	7.2	11.4	8.7	5.1
				Upper to medium-slope					
0 - 10 cm	10.3	6.7	7.2	5.4	10.3	7.5			
10- 30 cm	10.1	8.3	8.8	7.1	10.5	7.9			
30- 60 cm	10.7	8.9	10.3	8.6	11.0	8.9	10.1	7.7	4.1
				Medium-slope					
0 - 10 cm	10.9	7.3	8.1	7.0	11.2	7.8			
10- 30 cm	11.3	8.7	9.9	7.6	11.2	8.6			
30- 60 cm	11.0	8.7	11.0	8.7	11.0	8.9	13.4	9.7	5.1
				Medium to lower-slope					
0 - 10 cm	10.1	7.4	8.0	6.2	10.6	8.4			
10- 30 cm	10.6	8.8	10.7	7.5	10.7	8.5			
30- 60 cm	9.9	9.2	10.8	8.5	10.9	8.9	13.3	9.4	5.0
				Lower-slope					
0 - 10 cm	11.6	10.3	10.2	8.1	10.6	9.8			
10- 30 cm	12.4	11.5	11.9	9.7	10.7	10.2			
30- 60 cm	12.5	10.7	11.9	10.2	9.9	9.3	13.4	8.1	3.4

(†) This sampling date corresponded also to one day after a 34 mm rain fall.

(‡) 2.5 pF = field capacity; 4.2 = permenant wilting point.

plots was below pF 3.0 in most layers (except the lower slope), with the upper layer approaching pF 4.2. A 34 mm rainfall replenished soil water reservoir close to the field capacity level (pF 2.5) in tied ridges only (Table 22).

Grain yield was significantly affected by positions in the toposequence, seed bed preparation methods, dates of planting x seed bed preparation methods interaction, and positions x dates x seed bed preparation methods interaction. Table 23 shows the interaction : positions x dates x seed bed preparation methods, on grain yield. Tied ridges significantly increased grain yield as compared to flat plots at all positions in the toposequence, except at the lower-slope, in late planting only. Late planting on flat plots significantly reduced grain yield at all positions, except the medium and lower-slopes, as compared to early planting on flat. Late planting on tied ridges significantly increased grain yield as compared to early planting on flat on the lower-slope position only. In general, grain yield tended to be higher in the lower-slope as compared to the upper slope positions.

Since the second date of planting experienced a protracted dry spell (which was interrupted by a 40 mm rainfall 14 days after the onset of the dry spell) from slightly before flowering to maturity, the better performance of cowpea on tied ridges and lower slope position in late planting might be related to a better supply of moisture to cowpea plants in these plots as shown on Table 22. Therefore, tied ridges and lower-slope position, by improving the replenishment of moisture to soil water reservoir, contributed also to reducing moisture stress to cowpea and consequently prevented cowpea yield from dropping drastically.

The beneficial effect of early planting (regardless of seed bed preparation methods), tied ridges in late planting and lower slope position (especially in late planting) on grain yield agree with the 1981 and 1982 observations. It can, therefore, be concluded that in Sudan Savanna, on Alfisol : early planting (before mid-July) is a prerequisite to achieving high cowpea grain yield ; - planting on tied ridges is most beneficial to cowpea grain yield in late planting ; -planting on lower-slope position offers a high and stable yield as compared other positions.

Table 23. Grain yield of SUVITA-2 as affected by positions in toposequence x dates of planting x seed bed preparation methods interaction, Kamboinsé, Upper Volta, 1983.

Positions in toposequence	7 July date of planting (+)		27 July date of planting (+)	
	planting on flat	planting on tied ridges	planting on flat	planting on tied ridges
	----------------------------kg/ha----------------------------			
Upper-slope	1028 def	951 fgh	818 gh	1033 def
Upper to medium-slope	1209 abc d	1119 bcdef	817 gh	1345 a
Medium-slope	943 fgh	1099 bcdef	775 h	992 efg
Medium to lower-slope	1187 abcd	1052 cdef	969 fg	1161 bcde
Lower-slope	1090 bcdef	1226 abc	1267 ab	1368 a

LSD (0.05) = 183 ; CV (%) = 11 $\pm$ 4

(+) Means followed by the same letter are not significantly different at 0.05 probability level.

4.2. Northern Guinea Savanna

At Farako-Bâ, KN-1 (photoperiod-insensitive) and 'Logofrousso local' (photoperiod-sensitive) were compared at four seed bed preparation methods (viz. planting on flat, planting on flat followed by ridging three weeks after planting, planting on tied ridges and planting on flat followed by ridging an tying ridges three weeks after planting) on a medium slope Oxisol (with a good soil water infiltration rate). The experiment was planted on 11 July, 1983. The experimental design used was a factorial combination of four seed bed prepration methods and two cultivars in randomized complete blocks replicated four times. All agronomic practices used were as described for the Kamboinsé tied ridges experiment. The objective of the study was to determine the effects of seed bed preparation methods on a medium slope Oxisol in Northern Guinea Savanna.

Grain yield of cowpeas was significantly affected by cultivars only. KN-1 yielded significantly higher (1588 kg/ha) than Logofrousso local (599 kg/ha ; LSD 0.05 = 160 kg/ha and CV % =20 $\pm$ 7). Thus, in contrast to the results obtained in Sudan Savanna on Alfisol, seed bed preparation methods had no effect on cowpea yield. These results agree with the 1981 and 1982 cowpea management trial observations. It appears, thus, that in Oxisol, where soil water infiltration is good, tied ridges are not required to improve soil water infiltration to replenish soil water reservoir and, hence, insure high and/or stable grain yield.

(D) Striga Resistance

The Striga (Striga gesneroides) resistance study was repeated to gather informations on the date of Striga emergence and on Striga density and to examine their relationships to cowpea yield. The study was conducted at Kamboinsé, on a medium slope Alfisol, in a Striga sick plot that was artificially reinfested at the time of planting. It included six cowpea cultivars and three dates of planting in a split plot design, with dates of planting as main plots and cowpea cultivars as subplots. The agronomic practices used were as described in dates of planting experiments, except that : cowpeas were sprayed with insecticides four times at 10 day intervals beginning with the floral bud initiation stage of each cultivar.

Tables 24, 25 and 26 show, respectively, grain yield of cowpeas, number of days from planting to flowering of cowpeas, number of days from planting to first Striga emergence in cowpeas and density of Striga in cowpeas. SUVITA-2 yielded significantly higher than any other cultivars at the first two dates of planting ; at the last date of planting it yielded equally to all cultivars except 'Kaya local' and 'Kamboinsé local noir'. Since it was free of Striga, its yield decline with delayed planting reflect only drought damages. All the other cultivars were equally infested by Striga (Table 26) ; and Striga plants emerged from their plots at about the same time at each date of planting (Table 25). Striga density increased with early plantings (Table 26) ; so were also Striga damages on flowering and grain yield (Table 24) of cowpeas, except for KN-1.

KN-1 was the only photoperiod-insensitive cultivar tested. Striga emerged from its plots slightly before its flowering, so it sustained little damages on flowering. Its drastic yield decline at 18 July and 12 August dates of planting could be attributed more to its high sensitivety to drought (exhibited in date of planting experiments at Kamboinsé) than Striga damages. In fact its flowering, at the mentionned dates, occured during dry spells.

KN-1 failed to delay Striga emergence as observed in 1982. Also none of the susceptible cultivars flowered before Striga emergence. With these exceptions the results agree in general will the 1982 findings i.e., flowering close to Striga emergence provided better yield than flowering long time after Striga emergence. Thus, in the absence of resistance, early flowering may be a critical factor in limiting Striga damages.

(E) Verificative Research

Experiments conducted at the Kamboinsé Station have shown cowpeas to respond positively to soil tillage and seed bed preparation methods and to some extend to soil applied P_2O_5 as single super phosphate (SSP). Also the improved photoperiod-insensitive cultivar : TVx 3236, has

Table 24. Grain yield and number of days from planting to 50 % flowering of cowpeas under Striga infestation, Kamboinsé, Upper Volta, 1983.

Cultivars	Grain yield			Days to 50% flowering		
	21 June	18 July	12 Aug.	21 June	18 July	12 Aug.
	----------- kg/ha--------			-Days after planting----		
Ouahigouya local	12	468	338	168	58	45
Kaya local (1)	8	0	18	193	166	73
Kamboinsé local noir (1)	0	0	50	163	166	51
SUVITA-2	1571	1034	261	51	47	47
Kamboinsé local rouge (1)	0	382	178	168	57	46
KN-1	697	171	116	49	46	45
LSD (0.05)		202			37	
CV (%)		45 ± 11			22 ± 5	

(1) Some plots of these cultivars failed to flower under heavy Striga infestation, which means that they delayed flowering indefinitely. To simplify statistical analysis, 31 December was used as the probable date of flowering.

Table 25. Number of days from planting to first emergence of Striga in cowpeas, Kamboinsé, Upper Volta, 1983.

Cultivars	Date of planting		
	21 June	18 July	12 August
	--------------------days after planting------------------		
Ouahigouya local	37	32	37
Kaya local	38	32	37
Kamboinsé local N.	37	32	38
SUVITA-2 (a)	193	166	141
Kamboinsé local R.	38	34	34
KN-1	39	33	34
LSD (0.05) = 4;		C.V. (%)= 3 ± 0.6	

(a) This cultivars was free of Striga, which means that it delayed Striga emergence indefinitely. To simplify statistical analysis 31 December was used as the probable date of Striga emergence.

Table 26. Density of <u>Striga</u> in cowpeas, Kamboinsé, Upper Volta, 1983

Cultivars	21 June	18 July	12 August	Mean
	Plants/m^2			
Ouahigouya local	31	10	11	17
Kaya local	24	33	14	24
Kamboinsé local Noir.	25	25	10	20
SUVITA-2	0	0	0	0
Kamboinsé local Rouge	32	21	12	22
KN-1	30	31	12	24
Mean	24	20	10	18

Comparison of means:	LSD (0.05)	CV (%)
Planting dates	7	56 $\pm$ 10
Cultivars	9	60 $\pm$ 16
Cultivars, same dates	NS	
Cultivars, diff.dates	NS	

consistantly given good performance under the experiment station conditions and is considred to be released;this cultivar would be of any value to farmers only if under their field conditions and their input levels, it yield equally or higher than local cultivars. It is therefore imperative to verify the applicability, th farmers' conditions, of the new technologies developed at experiment stations.

Cultivars : TVx 3236 (improved photoperido-insensitive to be released) and 'Kamboinsé local rouge' (unimproved photoperiod-sensitive actually used by farmers) were tested at : -two P_2O_5 levels (0 and 50 kg/ha of P_2O_5 as SSP), -and five methods of soil tillage and seed bed preparation (viz. tillage + planting on tied ridges, tillage + planting on flat followed by ridging and tying ridges three weeks after planting, tillage + planting on flat, no tillage + planting on flat followed by ridging and tying ridges three weeks after planting, and no tillage + planting on flat). The experimental design used was a split plit plot, with P_2O_5 levels as main plots, soil tillage and seed bed preparation methods as subplots and cultivars as sub-subplots. The experiment was replicated four times on farmer's fields at two locations : Oipassi and Pabré, in Sudan Savanna, near the Kamboinsé station. Cowpea plants were sprayed two times (at floral bud initiation and at pod formation) with insecticides. The soil characteristics in the surface layer (0-30 cm) at the sites, where the experiment was conducted, are shown on Table 27.

At both locations, grain yield of cowpeas was significantly affected by P_2O_5 levels, soil tillage and seed bed preparation methods, cultivars and cultivars x P_2O_5 levels interaction. At Oipassi, planting on tied ridges on a soil that was plowed by a donkey significantly increased cowpea grain yield as compared to other treatments ; planting on flat followed by ridging and tying ridges three weeks after planting on a soil that was plowed by a donkey significantly out-yielded planting on a flat whether the soil was tilled or not, but did not differ significantly with ridging and tying ridges three weeks after planting on a soil that was tilled ; the last three treatments did not significantly differ

Table 27. Soil characteristics (0-30 cm surface layer) at the sites the experiment was conducted : Oipassi and Pabré, Upper Volta, 1983.

	Oipassi	Pabré
Clay (2 μ) %	18.9 - 27.1	7.8 - 8.3
Silt (20 - 50 μ) %	24.5 - 30.2	26.8 - 29.0
Sand (50 - 2000 μ) %	42.7 - 56.7	62.6 - 64.8
Organic matter %	0.62 - 0.82	1.07 - 1.08
pH (H_2O, 1 : 2½ susp)	5.8 - 6.1	5.8 - 6.6
Available P (Bray P1) ppm	1.16 - 3.38	2.1 - 2.51
C E C me/100 g	3.37 - 5.55	1.42
Exch. base saturation %	62.7 - 79.3	86.6 -100

Table 28. Effect of soil tillage and land preparation methods on grain yield of cowpeas on farmer's fields at two locations in Sudan Savanna, Upper Volta, 1983.

Land preparation methods	Locations	
	Oipassi (+)	Pabré (+)
	kg/ha	
- Tillage + planting on tied ridges	671 a	755 a
- Tillage + Ridging and tying ridges three weeks after planting	527 b	702 a
- Tillage + planting of flat	358 c	425 b
- Zero tillage + ridging and tying ridges three weeks after planting	475 bc	675 a
- Zero tillage + planting on flat	390 c	415 b
- LSD (0.05)	136	179
- CV (%)	38 ± 8	41 ± 8

(+) Means followed by the same letter are not significantly different at 0.05 probability level.

from one another (Table 28) . At Pabré, planting on flat whether the soil was tilled or not significantly reduced cowpea yield as compared to the three other treatments, which did not significantly differ from one another (Table 28). TVx 3236 responded positively to levels of P_2O_5 at both locations, whereas 'Kamboinsé local rouge' responded at Pabré only (Table 29). Also, both cultivars significantly differed from each other at Oipassi only.

The superiority of the technologies developed at experiment stations (viz. application of 50 kg/ha of P_2O_5, planting on tied ridges, and the cultivar TVx 3236) was confirmed under the farmer's conditions. TVx 3236 was not only very responsive to P_2O_5 levels, but yielded equally or higher than the local cultivar at all input levels. It appears, thus suitable for release to small farmers as it seems to present no risk of yield drop below the level of the local cultivar. As far as planting on tied on ridges is concerned, it seems to be highly recommanded on compact soil with relatively high clay, low sand and low organic matter content, such was the case at Oipassi (Table 27). Where the soil is less compact, and contains less than 10% clay, over 60 % sand and over 1 % organic matter, such was the case at Pabré (Table 27), planting on tied ridges could be subtituted for planting on flat followed by ridging and tying ridges three weeks after planting whether the soil was plowed or not without a substantial yield reduction.

Table 29 . Grain yield of cowpeas as affected by cowpea cultivars and levels of single super phosphate fertilizer on farmer's field at two locations in Sudan Savanna, Upper Volta, 1983.

Cultivars	Locations			
	Oipassi (+)		Pabré (+)	
	P_2O_5 levels		P_2O_5 levels	
	0 kg/ha	50 kg/ha	0 kg/ha	50 kg/ha
	kg/ha			
TVx 3236	578 b	892 a	399 b	880 a
Kamboinsé local rouge	237 c	228 c	402 b	697 a
LSD (0.05)	157		263	
CV (%)	64 ± 10		67 ± 10	

(+) Means followed by the same letter are not significantly different at 0.05 probability level.

(F) REGIONAL TESTING

Regional Maize/Cowpea Relay - Cropping Trial for Northern Guinea Savanna

Experiments conducted in Northern Guinea Savanna, in Upper Volta have shown that : relay cropping cowpeas four weeks after maize planting has no great adverse effect on maize yield, and photoperiod-sensitive cowpea cultivars appear more adapted in relay cropping with maize than spreading photoperiod-insensitive cultivars. This is because photoperiod-sensitive cultivars can be planted early under maize canopy; they would grow profusely, flower after maize harvest and yield high. Whereas spreading photoperiod-insensitive cultivars must be planted about 35 days before maize harvest for them to flower after maize harvest and yield high, if soil moisture is not depleted before their maturation. Any planting done earlier than the afore mentioned time would result in these cultivars flowering while still under maize canopy. This would subject them to a strong competition for light and nutrients from maize and cause a yield loss.

A maize/cowpea relay cropping experiment, involving four photoperiod-sensitive and four photoperiod -insensitive cowpea cultivars, was sent to eight locations in four SAFGRAD member's countries to verify the applicability of the maize-cowpea relay cropping fingings, obtained in Upper Volta, to these countries. An early cultivar (90 days to maturity) was planted at 0.75 cm x 0.25 m spacings, two grains per hill and one plant per hill after thinning (fifteen days after planting). Cowpeas were planted : four weeks after maize planting and one week after maize silking, for photoperiod-sensitive and insensitive cultivars, respectively, in solid rows alternating with maize rows. The cowpea spacings were 0.75 m between rows and 0.20 m between hills within each row. Two grains were planted per hill and seedlings thinned to one plant per hill two weeks after cowpea planting. The maize crop received the recommended agronomic practices for the region. Whereas cowpea plants were sprayed with insecticides twice during the growing season. The experimental design used was a randomized blocks with four replications. The rainfall data at the three sites for which data were received are shown on Tables 30, 31 and 32 Maize was planted on 14 July at Sefa, Senegal, and 5 July at Nyankpala, Ghana.

Table 30. Rainfall at Sefa, Senegal, 1983.

Pentad N°	May	June	July	August	September	October
	mm					
1	0	48.8	45.8	15.3	36.3	3.8
2	0	0	49.1	53.6	0	0
3	0	0	155.4	23.5	17.4	24.7
4	0	19.9	68.7	3.7	34.8	0
5	0.8	35.3	2.1	17.9	22.0	0
6	0.7	1.1	14.5	33.8	34.1	0
Total	1.5	105.0	335.6	147.8	144.6	28.5

Table 31. Rainfall at Nyankpala, Ghana, 1983.

Pentad N°	May	June	July	August	September	October
	mm					
1	0	22.3	31.8	6.2	25.0	5.9
2	20.4	18.2	36.5	46.1	31.2	0
3	69.2	15.8	54.7	45.8	5.2	0
4	19.3	18.8	0	0.3	22.2	0
5	59.7	27.5	0	22.5	23.2	0
6	14.6	5.6	0	23.8	8.1	0
Total	183.2	108.2	123	144.7	114.9	5.9

Table 32. Rainfall at Broukou, Togo.

Pentad N°	May	June	July	August	September	October
	mm					
1	0	41.0	38.0	5.0	11.3	23.2
2	23.0	18.0	55.1	1.2	32.7	0
3	34.4	39.0	54.5	22.1	32.5	0
4	18.5	80.5	34.0	28.4	32.8	0
5	29.3	27.9	4.5	0	92.5	0
6	5.4	0	33.3	8.0	6.8	0
Total	110.6	206.4	219.4	64.7	208.6	23.2

Maize grain yield at the three sites are shown on Table 33. Cowpea cultivars and cowpea dates of planting had no significant effect on maize yield at any of the three locations. Cowpea cultivars significantly affected cowpea grain yield at all three locations (Table 34). At Sefa, Senegal, the late maturing photoperiod-sensitive cowpeas : IAR 1696 and 'Logofrousso local' yielded significantly higher than the photoperiod-insensitive cultivars : KN-1, TVx 3236, SUVITA-2 and VITA-5 ; 'Kamboinsé local noir' (intermediate maturing photoperiod-sensitive) was intermediate between the two groups. At Nyankpala, Ghana, 'Kamboinsé local noir' yielded significantly higher than any other cultivar except the local check ; 'Logofrousso local', IAR 1696 and the four photoperiod-insensitive cultivars did not significantly differ from one another. At Broukou, Togo, IAR 1696, local check and KN-1 were among the highest yielding cultivars.

Late maize planting at all three locations is responsible of low maize yield. Sandy soil and frequent heavy rainfalls at Sefa might have further reduced maize yield through sever leaching of soluble nitrogen fertilizer. N fertilizer should have been applied in quantity above 100 kg/ha N in at least three split applications for achieving a yield above 3000 kg/ha at this locations. The low cowpea yield at Nyankpala, Ghana, might be ascribed to late planting and early cessation of rains. As a consequence, only intermediate maturing photoperiod -sensitive cowpeas were advantaged (Table 34). At Broukou, Togo, in addition to late planting and early cessation of rains, the prevalence of a virus disease (probably aphid born or cowpea mosaic virus) caused sever damages to cowpeas. Only resistant cultivars : IAR 1696 and KN-1 and to some extend the local check gave an acceptable yield. The results are, in general, in agreement with this and previous years Upper Volta's observations and suggest that maize-cowpea relay cropping system can be successfully extended to Northern Guinea Savanna in other West African countries.

Table 33. Effect of cowpeas on maize grain yield in a maize-cowpea relay cropping experiments, in Northern Guinea Savanna at three locations in West-Africa, 1983.

Dates of cowpea planting	Cowpea Cultivars	Sefa Senegal	Nyankpala Ghana	Broukou Togo
		kg/ha		
- 4 weeks after maize planting	Logofrousso local	611	1355	2652
	IAR 1696	781	1326	2600
	Kamboinsé local N	967	1278	2636
	Local check (1)	785	1148	2757
- I week after maize silking	KN-1	882	1225	2858
	TVx 3236	1081	1378	2678
	SUVITA-2	892	1300	2355
	VITA-2	930	1363	2859
	LSD (0.05)	NS	NS	NS
	C.V. (%)	38 ± 15	12 ± 4	12 ± 4

(I) At Sefa, Senegal, the local check was not included ; therefore the maize yield observed for this treatment reflects the maize sole crop yield.

Table 34. Grain yield response of cowpeas in a maize-cowpea relay cropping experiment in Northern Guinea Savanna, at three locations in West Africa, 1983.

Dates of planting cowpeas	Cowpea cultivars	Sefa Senegal	Nyankpala Ghana	Broukou Togo
		------------	kg/ha	------------
- 4 weeks after maize planting	Logofrousso local	1105 ab	216 c	166 cd
	IAR 1696	1280 a	318 bc	564 a
	Kamboinsé local N	875 bc	569 a	209 c
	Local check	-	524 ab	496 ab
- 1 week after maize planting	KN-1	690 cd	171 c	521 ab
	TVx 3236	596 cd	213 c	230 c
	SUVITA-2	492 d	291 c	61 d
	VITA-5	610 cd	226 c	444 b
	LSD (0.05)	316	215	119
	CV (%)	26 ± 10	46 ± 19	24 ± 9

COWPEA ENTOMOLOGY

The cowpea pest complex in the Semi-Arid regions of the SAFGRAD member countries consists of about 20 species of insects. The most important are aphids (Aphis craccivora), flower thrips (Megalurothrips sjostedji), pod borer (Maruca testulalis), various species of pod-sucking bugs (Clavigralla, Riptortus, Mirperus, Anoplocnemus, Nezara, Aspavia, Dysdercus, etc.) and cowpea weevil (Callosobruchus maculatus).

Recently, Spodoptera Littoralis in West Africa, Apion spp. East Africa and an insect which forms knots (swelling) in the stem of cowpea in South Africa have been found to cause enough damage to warrant our attention.

Following were the major research activities in 1983.

Resident Research

1. Evaluation of promising cowpea cultivars for resistance to flower thrips.

2. Screening of new promising lines for thrip resistance.

3. Evaluation of promising cowpea cultivars for resistance to Maruca.

4. Effect of intercropping on incidence of cowpea pests and grain yield.

5. Evaluation of extra early maturing cowpea varieties for insect infestation and grain yield without protection.

6. Testing of carbofuran granules to control cowpea pests.

7. Studies on seasonal behaviour of *Spodoptera littoralis.*

8. Comparative study of local and Somali population of *C. maculatus*.

9. Testing of breeding material for resistance to *C. maculatus*.

Regional Program

1. Evaluation of promising cowpea cultivars with minimum insecticide protection.

2. Use of standardized sampling procedures to survey cowpea pests.

Resident Research

1. Evaluation of promising cowpea cultivars for resistance to flower thrips

Three cowpea cultivars, TVu 1509, TVu 2870 and TVx 3236 have shown in the past varying degree of resistance as compared to susceptible ones. A trial consisting of these three lines and two susceptible checks, KN-1 and Ife brown, was conducted in a farmer's field near Kamboinsé, Upper Volta.

To control *Maruca*, the experiment was treated with *Bacillus thuringiensis* serotype 3a 3b (Dipel) twice at the rate of 500 g and 1 kg, respectively at an interval of one week starting 40 DAP. To control pod-sucking bugs, the crop was treated with endosulfan 500 g a.i./h 55 DAP. Data (Table 1) showed that both *Maruca* and pod-sucking bugs were adequately controlled.

For thrips, the comparison of each variety was made on the basis of its population in racemes and flowers, number of flowers per meter and grain yield. Results are reported in Table 1.

Table 1. Comparison of thrips, <u>Maruca</u>, pod-sucking bugs, number of flowers and grain yield in five promising cowpea cultivars in a farmer's field at Sakoula, Upper Volta, 1983.

Cultivar	Thrips/+ raceme	Trhips/++ flower	Maruca/++ flower	Pod bugs/* meter	Flowers/** meter	Yield kg/ha
Ife brown	27.48	101.32	0.94	0.10	26.6	412.34
KN-1	22.94	121.10	0.56	0.70	19.2	359.46
TVu 1509	24.62	76.40	0.68	0.90	48.3	647.00
TVu 2870	22.60	97.92	0.70	0.52	61.2	587.44
TVx 3236	19.06	75.28	0.80	0.00	45.3	729.56
Mean	23.36	94.40	0.74	0.44	40.12	547.16
L.S.D. at 5%	N.S.	18.57	N.S.	N.S.	20.93	245.54
C.V.	19.47	14.68	66.21	130.56	39.00	29.93

+ Total of 8 samples, ++ Total of 6 samples, * Total of 5 observations,

** Total of 9 observations.

Population of thrips did not differ significantly in racemes on any of these lines, which is contrary to what was observed in 1982 where TVu 1509 had significantly less thrips than TVx 3236 and the susceptible checks. In flowers, TVu 1509 and TVx 3236 had significantly less thrips than KN-1. But no difference was observed between TVu 2870 and Ife brown (Table 1).

Regarding observations on number of flowers, KN-1 had minimum number of flowers followed by Ife brown but flowers on Ife brown did not differ significantly from those of TVx 3236. No significant difference was observed among the three promising varieties TVu 1509, TVu 2870 and TVx 3236.

Grain yield was significantly higher in TVx 3236 (729.56 kg/h) and was closely followed by TVu 1509 (647.0) and TVu 2870 (587.44). None of these yields were significantly different from each other. TVu 1509 which did not differ significantly from TVx 3236 also did not differ significantly from Ife brown (412.34 kg/ha).

Mechanism of resistance in the three promising cowpea cultivars appeared to be due to tolerance.

Screening of new promising lines for thrip resistance

Several new elite materials less susceptible to thrips damage have been identified at IITA, Nigeria. They were planted in an unreplicated trial in a farmer's field near Kamboinsé to see their reaction in Upper Volta.

Maruca and pod-sucking bugs were adequately controlled by application of *B. thuringiensis* and endosulfan, respectively.

Results are reported in Table 2. It was found out that the cultivars TVu 6863 and TVu 7376 had less number of thrips both in racemes and flowers as compared to the standard thrips resistant variety TVx 3236 and the susceptible check varieties.

Table 2. Comparison of thrips, Maruca, pod-sucking bugs, number of flowers and grain yield in 9 cowpea cultivars planted in a farmer's field at Sakoula, Upper Volta, 1983.

Cultivar	Thrips/+ raceme	Thrips/++ flower	Maruca/++ flower	Pod bugs/* meter	Flowers/** meter	Yield (kg/ha)
TVu 4544	21.85	93.90	0.35	0.25	17.75	503.3
TVu 4548	20.85	109.05	0.40	0.75	17.25	468.7
TVu 4571	18.40	140.30	0.70	0.25	13.50	268.8
TVu 6863	14.25	62.35	0.30	0.25	14.15	178.1
TVu 7376	14.45	70.95	0.75	0.00	10.50	328.8
TVu 8154	18.50	59.60	0.55	0.00	11.25	145.2
TVu 3236	20.70	74.00	0.20	0.00	18.50	358.5
Ife brown	33.80	137.30	0.40	0.00	10.50	214.9
KN-1	24.75	107.40	0.40	0.50	17.75	167.9
Mean	20.39	94.98	0.45	0.22	14.57	302.6

+ Total of 8 samples, ++ Total of 6 samples, * Total of 5 observations,

** Total of 9 observations.

The data on total number of flowers per meter revealed these varieties (TVu 6863 and TVu 7336) to be inferior to TVx 3236. These differences could be due to inherant flower production capacity which is reflected in low yields.

TVu 4544 and TVu 4548 were the top yielders in spite of higher thrips population indicating that these lines possess a good level of tolerance to thrips.

Evaluation of promising cowpea cultivars fir resistance to Maruca.

Lines which showed less susceptibility during 1981 and 1982 seasons were included in this trial.

Flower thrips and pod-sucking bugs were controlled using monocrotophos at the rate of 200 g. a.i./h at raceme initiation stage and 500 g a.i./h at pod formation stage. Because of early maturity of TVu 946 it was planted twice. First planting (D1) was done along with other varieties and the second (D2) 10 days later. Observations were recorded on number of larvae in flowers, percent infested pods and grains, and grain yield.

Results are presented in Table 3. The second planting of TVu 946 (D2) has been exluded from the discussion because it escaped Maruca infestation. In other varieties, number of larvae in flowers were minimum in TVx 3236 and maximum in KN-1 and differed significantly from each other. But both of these varieties were not significantly different from Kamboinsé Local, TVu 946 (D1) and VITA-5. Percent infested pods were significantly less in Kamboinsé local followed by TVx 3236 and SUVITA-2. Percent infested grains were significantly higher in KN-1 and other varieties had no significant difference. When compared to the results obtained earlier, Kamboinsé local in 1982 had minimum number of larvae in flowers. Performance of TVx 3236 was same as that of last year, and indicated moderate level of resistance in it. This year no difference was found in the performance of TVu 946 and Kamboinsé local where as they differed significantly in 1982.

Another borer, Spodoptera littoralis, also infested the experiment which confounded the results. Significantly higher pod infestation of it was in Kamboinsé local (67.0%). Percent infested

Table 3. Comparison of Maruca population and infestations of Maruca and Spodoptera and grain yield in promising cowpea cultivars at Kamboinsé, Upper Volta, 1983.

Cultivar	MARUCA			SPODOPTERA		Grain yield kg/ha
	Larvae/ 10 fl.+	% infested pods ++	% infested grain	Infested ++ pods	% infested grain	
VITA-5	4.1	0.75	0.80	10.25 (17.02)*	1.81	1556.05
TVu 946 D1	4.3	1.25	0.22	3.25 (10.15)	0.69	703.28
TVu 946 D2	1.2	0.25	0.05	2.50 (6.32)	0.58	811.30
TVx 3236	2.5	2.50	0.36	9.75 (17.75)	1.93	1985.67
Kamboinsé local	3.8	0.00	0.00	69.00 (56.47)	23.68	378.40
SUVITA-2 (check)	5.0	1.75	0.34	15.25 (20.75)	3.48	1308.97
KN-1 (check)	5.6	3.75	0.81	18.75 (23.97)	3.58	961.67
Mean	3.78	1.46	0.27	18.39 (21.78)	5.11	1100.76
L.S.D. at 5%	2.19	2.37	0.42	16.72 (12.63)	5.36	748.96
C.V.	39.06	109.59	104.76	61.25 (38.99)	70.69	1145.79

* Transformed to angle, + Total of 6 samples, ++ Based on a sample of 400 pods.

grains followed the same trend (Table 3).

Grain yield was significantly higher in TVx 3236 followed by VITA-5 and SUVITA-2 and lowest in Kamboinsé local. There was a drought at flowering which reduced the yield and severely affected KN-1, SUVITA-2 VITA-5 and Kamboinsé local (Table 3).

Effect of intercropping on cowpea pests and grain yield

The experiment has been conducted twice in the past with the objective to see the effect of intercropping on thrips population and grain yield. Results showed that intercropping provided no protection from thrips and yield results were conflicting. In 1981, cowpea yields under intercropping were higher than monocrop and were reversed in 1982. In these experiments, insects other than thrips were controlled using appropriate insecticides. The experiment was again repeated in 1983 with slight modifications. The trial was modified to observe the effect of intercropping vs. monocrop under no protection and under minimum protection. For minimum protection two applications of insecticides-one of decamethrin (Decis) at 15 g a.i./h at raceme initiation stage and the second of endosulfan at the rate of 500 g a.i./h at pod formation stage were applied. No protection was where no insecticide at all was used. Also, an additional factor of plant density was added. Monocrop had 66,666 cowpea plants/h while in intercrop two densities, 33,333 plants of cowpea and 26,666 plants of sorghum/h (D1) and 50,000 plants of cowpea and 40,000 plants of sorghum/h (D2) were used.

Results are reported in Table 4 to 8. Significantly more thrips in racemes were found in unprotected plots than the protected. But there was no significant difference in thrips and Maruca populations in flowers (Table 4).

No difference for thrips in racemes was found between the two varieties. However, KN-1 had more thrips and Maruca in flowers (Table 5).

Table 4. Effect of spraying on thrips and Maruca populations in sorghum cowpea intercropping trial at Kamboinsé, Upper Volta, 1983.

Spraying	Thrips/raceme*	Thrips/flower+	Maruca/Flower++
No spraying	12.88	39.85	1.83
Two spraying	6.43	21.50	1.03
L.S.D. 5%	2.08	N.S.	N.S.
C.V.	36.64	67.79	62.13

* Total of 8 samples, + Total of 7 samples, ++ Total of 6 samples

Table 5. Reaction of two cowpea cultivars to thrips and Maruca in a sorghum cowpea intercropping trial at Kamboinsé, Upper Volta, 1983.

Cultivars	Thrips/raceme*	Thrips/flower++	Maruca/flower++
TVx 3236	8.94	25.31	1.14
KN-1	10.38	36.04	1.72
L.S.D. at 5%	N.S.	6.48	0.30
C.V.	25.22	35.92	36.09

* Total of 8 samples, + Total of 7 samples, ++ Total of 6 samples.

Table 6. Effect of cropping systems on infestation of thrips in flower and pod-sucking bugs in a sorghum cowpea intercropping trial at Kamboinsé, Upper Volta, 1983.

Cropping system	Thrips/flower+	Pod bugs*
Monocrop cowpea	34.93	8.56
Intercrop D1	34.58	3.06
Intercrop D2	22.52	2.09
L.S.D. at 5%	7.45	4.98
C.V.	68.00	112.00

+ Total of 7 samples, * Total of 7 observations

Table 7. Effect of interaction of cropping system X spraying on number of flowers per meter in a sorghum cowpea intercropping trial at Kamboinsé, Upper Volta, 1983.

Cropping system	Flowers/meter+	
	No spraying	2 spraying
Monocrop cowpea	28.68	89.69
Intercrop D1	25.19	74.25
Intercrop D2	32.81	58.94
L.S.D. at 10 %	15.4	
C.V.	30.9	

+ Total of 9 observations

Table 8. Effect of interaction : cultivars X cropping systems X insecticide, on the yield performance of two cowpea cultivars in a sorghum cowpea intercropping trial at Kamboinsé, Upper Volta, 1983.

Cropping systems	Insecticide spraying	Cowpea cultivars +	
		TVx 3236	KN-1
Monocrop cowpea	No spraying	14 g	1.5 g
	2 sprayings	893 a	343 bc
Intercrop D1	No spraying	165 ef	39 fg
	2 sprayings	468 b	242 cde
Intercrop D2	No spraying	198 de	36 fg
	2 sprayings	334 bcd	274 cde
L.S.D. 0.05		138	
C.V. %		40 ± 16	

+ Means followed by the same letter are not significantly different from each other at 0.05 probability level.

When results were compared between monocrop vs. intercrop no significant difference was observed for thrips in racemes. In flowers less thrips were found in intercrop D2 as compared to monocrop (Table 6). Population of thrips in intercrop D1 vs. monocrop is in agreement with those of past two years showing no significant difference among them. Pod-sucking bugs were found significantly higher in monocrop plots of cowpea than plots intercropped with sorghum irrespective of their densities (Table 6).

Number of flowers were significantly higher in treated as compared to untreated plots (Table 7). Also, under spraying regime, mono-crop cowpea produced more flowers than any of the two intercrop systems. However, cropping systems did not differ significantly from each other. Under no protection the three cropping systems produced a similar number of flowers.

Cowpea yield performance is shown in Table 8. Insecticide spraying significantly increased grain yield of both the cultivars at all cropping systems. Under no protection only TVx 3236 significantly increased its grain yield under both intercropping systems. The yield difference of protected vs. unprotected TVx 3236 under intercrop D2 system was not statistically significant. The cultivar KN-1 maintained a yield that was consistently lower than that of TVx 3236 at all treat-ments. The results suggest that tendency of TVx 3236 to have less thrips in flowers than KN-1, combined with less pod-sucking bugs induced by the intercrop D2 system (Table 6) produced a yield advantage to TVx 3236 under intercropping system. This was specially so when the densities of both cowpea and sorghum were increased.

To confirm the results obtained at the experiment Station a trial was also conducted in a farmer's field. The trial was unreplicated but carried out in bigger plots 10 x 16 m. The same cropping systems were followed as reported in earlier experiment except that densities of cowpea and sorghum in intercrop D2 were 66,666 and 40,000 plants per hectare, respectively.

Results are reported in Table 9 and 10. Both cowpea cultivars maintained a thrip population in racemes that was very similar under each cropping system, though KN-1 tended to have a slightly higher population than TVx 3236 under monocrop system (Table 9). Results are in agreement with the trial conducted at the Experiment Station in Kamboinsé. In flowers more thrips were found in intercrop. It appeared to follow a distinct pattern of variation with sorghum plant population ; thrips increased with increased sorghum density on TVx 3236 and independent of sorghum density on KN-1. Results on thrips in flowers are different than those obtained at the Experiment Station for intercrop D2 (Table 9).

Population of <u>Maruca</u> larvae seemed to vary independently of sorghum plant population in both cultivars (Table 9).

Thrips and <u>Maruca</u> in flowers were higher in KN-1 as compared to TVx 3236 (Table 9).

Visual observations revealed that monocrop substained more pod-sucking bug damage as compared to intercrop plots. Similar information was obtained from the experiment conducted at the Experiment Station.

TVx 3236 yielded higher than KN-1 at all cropping systems. Contrary to the results obtained at the Experiment Station monocrop TVx 3236 tended to yield higher than both intercrop treatments (Table 10). However, TVx 3236 intercrop D2 yielded higher than TVx 3236 intercrop D1. The yield in KN-1 was very low and was not much different in all the cropping systems.

The farmer's field which factor was responsible in enhancing grain yield in monocrop is not clear. More comparative studies are essential to arrive at a definite conclusion.

Evaluation of extra early maturing varieties for insect infestation and grain yield without protection.

Nine extra early maturing elite cowpea lines developed at IITA, Nigeria and included in the International Trial-1, were tested under no insecticide protection. The idea was that perhaps due to their short growth period some of them may espace the damage, and provide better yields. KVx 69 was used as a local check which also has the same maturity.

Table 9. Population of thrips and Maruca in two varieties of cowpea in a sorghum cowpea intercropping trial in a farmer's field at Sakoula, Upper Volta, 1983.

Cropping Systems	TVx 3236			KN-1		
	Thrips/ raceme+	Thrips/ flower+	Maruca/ flower+	Thrips/ raceme+	Thrips/ flower*	Maruca/ flower*
Monocrop cowpea	20.88	57.30	2.52	26.21	131.57	4.89
Intercrop D1	20.30	63.84	3.39	20.34	110.13	3.15
Intercrop D2	19.59	67.91	3.24	20.21	158.90	5.40
Mean	20.26	63.02	3.05	22.26	133.54	4.48

+ Total of 8 samples ; * Total of 7 samples

Table 10. Grain yield of cowpea in a sorghum cowpea intercropping trial in a farmer's field at Sakoula, Upper Volta, 1983.

Cropping system	Yield kg/h	
	TVx 3236	KN-1
Monocrop cowpea	177.69	6.39
Intercrop D1	87.72	4.16
Intercrop D2	139.70	14.51
Mean	135.07	8.36

Results are reported in Table 11. There was no significant difference in number of thrips in racemes and thrips and Maruca in flowers. Number of pod-sucking bugs were significantly higher on IT 82E-9 followed by KVu 69.

The maximum grain yield (381 kg/ha) was obtained from KVu 69. Among the extra early maturing varieties IT 82E-9 (191.2 kg/ha), IT 82-16 (148.4) and IT 8E-18 (154.1) produced a reasonnable yield.

Testing of carbofuran granules to control cowpea pests

Water is a limiting factor in the Semi-arid regions. It was thought that the granular insecticides applied in the soil at the time of planting may provide sufficient control of cowpea pests and thus avoid the use of water in spraying. An exploratory trial to this effect was conducted in a farmer's field using carbofuran granules.

Three treatments were used, 1) soil application of carbofuran granules at the rate of 3 kg a.i./h, 2) two foliar applications of decamethrin (15 g a.i./h) and endosulfan (500 g a.i./h), 3) untreated check. Two varieties, IT 82E-60 (extra early maturing) and KN-1 (normal duration), were planted 50 cm apart. The trial was unreplicated.

Results are reported in Table 12. Number of thrips in racemes were much higher in untreated check plots as compared to plots that received granules and foliar application. Thrips in flowers in control plot was also high. However, plots that received foliar application had less thrips in flowers as compared to plots with granules. Between the varieties, KN-1 had more thrips than IT 82E-60, indicating that early maturing variety might take advantage of its earliness. This difference resulted probably because long duration variety could not obtain the same quantity of insecticide throughout its reproductive phase because of its natural degredation and run off.

Maruca population was lower in the plots that received foliar application (Table 12).

Table 11. Number of thrips, Maruca, pod-sucking bugs and grain yield in extra early maturing varieties in a farmer's field at Sakoula, Upper Volta, 1983.

Cultivar	Thrips/ raceme *	Thrips/ flower**	Maruca/ flower**	Pod bugs/ meter +	Yield kg/ha
IT 8E - 16	20.83	48.86	0.48	3.38	148.4
IT 8E - 18	24.93	61.55	0.78	3.50	154.1
IT 82E- 9	22.33	54.50	0.50	9.63	191.2
IT 82E- 13	24.73	63.25	1.03	1.88	51.1
IT 82E- 32	21.30	59.70	0.95	2.50	42.5
IT 82E- 41	24.20	45.13	0.73	1.36	11.0
IT 82E- 56	25.95	52.50	0.70	1.50	88.2
IT 82E- 60	23.25	68.08	0.83	1.75	42.6
IT 82E- 77	25.40	47.25	0.45	2.25	62.6
KVu-69 (local check)	30.15	49.08	0.53	6.50	381.0
Mean	24.31	54.99	0.70	2.93	116.97
L.S.D. at 5%	N.S.	N.S.	N.S.	2.91	153.45
C.V.	16.65	2.80	47.38	68.69	90.41

* Total of 6 samples ; ** Total of 2 samples ; + Total of 7 observations

Table 12. Comparison of effectiveness of carbofuran granules and foliar application of insecticide on cowpea insects and grain yield in a farmer's field in Upper Volta, 1983.

Treatments	Thrips/raceme +		Thrips/flower*		Maruca/flower *		Yield kg/ha	
	IT 82E-60	KN-1	IT 82E-60	KN-1	IT 82E-60	KN-1	IT 82E-60	KN-1
Foliar application	3.8	6.4	18.0	68.9	1.3	0.7	885.9	762.1
Carbofuran granules	6.8	7.9	25.2	81.2	2.3	2.9	46.9	240.1
Untreated check	29.1	28.0	67.6	222.8	3.7	1.7	21.6	74.5
Mean	13.2	14.1	36.9	124.3	2.4	1.8	318.1	358.9

+ Total of 7 samples ; * Total of 5 samples

Grain yield differed considerably in various treatments. In both the varieties, plots with foliar application gave better yield than those treated with granules (Table 12). As compared to untreated plots, the ones treated with carbofuran granules gave higher yield in KN-1 but no such difference was observed for IT 82E-60.

The results need varification before drawing final conclusions.

Studies on seasonal behaviour of Spodoptera littoralis

Field and light trap observations of last two years had shown that both late planted and late maturing varieties suffered more due to *S. littoralis*. To confirm these results, a blacklight trap was operated round the year to monitor adult populations of this insect. The results of last two years had shown that population may be present round the year but the most active period was mid August to end of December.

Results of 1983 presented in Figure 1 show that pest was active from January to March and during last half of the year. But the most active period was August to December during which at least 3 generations were completed.

Comparative study of local and Somali population of *Callosobruchus maculatus*

To obtain information on biology and behaviour of *C. maculatus* adults were collected locally and from Somalia and were multiplied on Kamboinsé local at room temperature. Later, an experiment was conducted in an incubator maintained at 30°C, 80$\pm$5 percent relative humidity and 24 hours scotophase. Insects were observed under day light for about two hours. Two varieties Kamboinsé local and TVu 2027 were used as test varieties. Kamboinsé local is highly susceptible to local populations and TVu 2027 is resistant. Observations were taken on number of eggs laid by a female, developmental period, percentage of adult emergence and sex ratio of normal and flight forms.

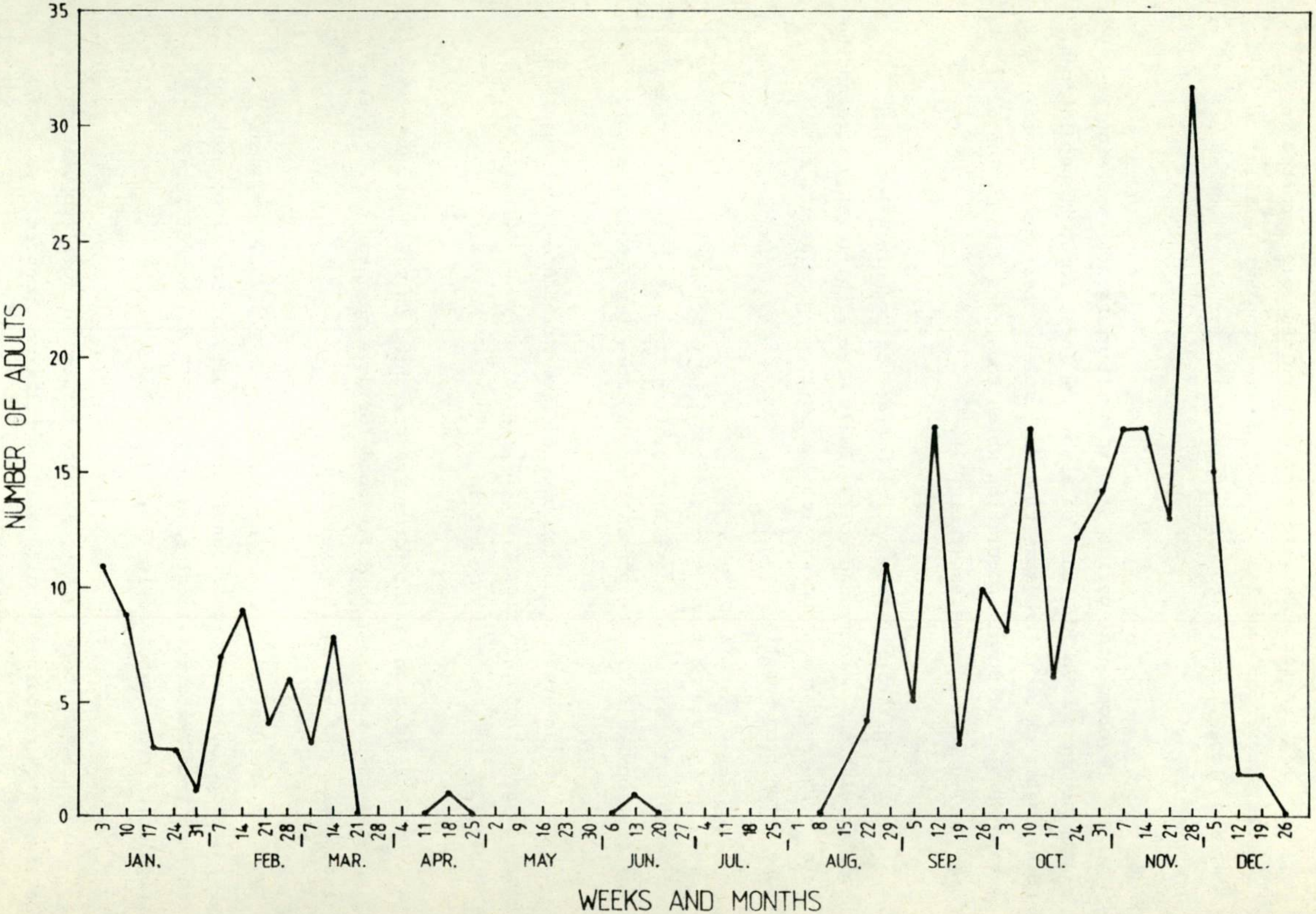


Fig.1. BLACKLIGHT TRAP RECORDS OF S. LITTORALIS AT KAMBOINSE FOR 1983

Results for normal form of C. maculatus are reported in Table 13. Number of eggs laid by both populations were similar on Kamboinsé local. Somali population laid significantly less eggs on TVu 2027.

Developmental period (egg to adult emergence) was significantly higher on TVu 2027 than on Kamboinsé local for both populations. Both sexes took about the same time to complete their development except females of Somali population which took considerably longer time on TVu 2027 than males (Table 13).

Significantly more adults emerged on Kamboinsé local in both populations as compared to TVu 2027. Also significantly more adults were obtained from Kamboinsé local with local populations than population from Somalia.

As evident from sex ratio local population had more females on Kamboinsé local while Somalia population had more males on the same variety. On TVu 2027 both populations had more females (Table 13).

On an average adults obtained from Kamboinsé local survived for longer period than from TVu 2027, irrespective of populations (Table 13). Females survived for longer period than males.

Results on flight forms are presented in Table 14. Data revealed that there was no difference for developmental period between two populations and their sexes.

Percent adult emergence was zero on TVu 2027 for local population. However, significantly more adults of Somali population emerged from Kamboinsé local than on TVu 2027 or that of local population from Kamboinsé local (Table 14).

Sex ratio revealed that more females of local population emerged from Kamboinsé local. Somali population produced less females on both the varieties (Table 14).

Table 13. Comparative information on oviposition, development period, adult emergence and longevity of normal form of local and Somali populations of <u>C. maculatus</u> at 30°C, at Kamboinsé, Upper Volta, 1983.

Treatments		Eggs laid	Development period+			% adult emergence			Sex ratio	Adult longevity		
			♂	♀	Mean	♂	♀	Mean		♂	♀	Mean
Kamboinsé local	LP	116.60	22.12	22.12	22.11	33.26	44.20	38.73	1:1.347	12.80	19.86	16.33
TVu 2027	LP	99.40	40.00	40.65	41.32	12.02	16.00	14.01	1:1.135	10.34	16.52	13.43
Kamboinsé local	SP	116.60	24.99	24.69	24.84	27.56	25.69	26.62	1:0.950	14.64	20.22	17.43
TVu 2027	SP	76.00	36.65	44.85	40.75	7.82	10.40	9.11	1:1.192	9.38	15.67	12.52
Mean		102.15	31.43	33.07	32.25	20.16	24.07	22.12		11.79	18.06	14.93
L.S.D. at 5 %		26.97	14.25	2.27	8.52	7.06	7.71	4.92		3.79	2.18	2.29
C.V.		19.68	33.78	5.12	19.70	26.12	23.92	16.57		24.06	9.03	11.49

LP = local population ; SP = Somali population ; + From egg to adult emergence

Table 14. Comparative information on development period, adult emergence, sex ratio and adult longevity of flight form of local and Somali populations of C. maculatus at 30°C, at Kamboinsé, Upper Volta.

Treatments		Development period+			% Adult emergence			Sex ratio	Adult longevity		
				Mean			Mean				Mean
Kamboinsé local	LP	21.76	16.16	18.96	1.68	1.92	1.80	1:1.100	41.05	36.40	38.73
TVu 2027	LP	0.00	0.00	0.00	0.00	0.00	0.00	0:0.000	0.00	0.00	0.00
Kamboinsé local	SP	23.76	29.48	26.62	4.36	3.00	3.68	1:0.666	52.82	66.53	59.68
TVu 2027	SP	29.80	13.60	21.70	0.87	1.92	1.39	1:0.666	16.60	13.40	15.00
Mean		18.83	14.81	16.82	1.72	1.71	1.71		27.61	29.08	28.35
L.S.D. at 5%		12.25	16.00	12.72	2.35	N.S.	1.75		32.08	28.51	22.75
C.V.		48.53	80.61	56.41	102.69	95.91	77.80		86.62	73.13	59.82

LP = Local population ; SP = Somali population ; + From egg to adult emergence

On an average adults of both populations survived for a longer period on Kamboinsé local than TVu 2027 (Table 14). Longevity of Somali adults, though not significantly different from that of local population, was considerably longer on Kamboinsé local. Males and females from both populations followed the same trend.

Data on normal and flight forms shown in Table 13 and 14 revealed that in general normal forms had longer developmental period, higher percent adult emergence, shorter adult longevity and produced more females than flight forms.

Population from Somalia did not differ much except it produced more flight forms than local population. TVu 2027 which is resistant to local population also found resistant to Somali population. This shows that two populations are similar in their biology, behaviour and reaction to two cultivars.

Testing of breeding material for resistance to *C. maculatus*

Material generated by the breeding program was evaluated for bruchid resistance. Details of the results are given in the breeding section of this report.

REGIONAL PROGRAM

Evaluation of promising cowpea cultivars under minimum insecticide protection.

In 1983, the trial was sent to Niger, Senegal, Gambia, Togo, Benin, and Upper Volta. Nine elite cowpea lines, which performed well during the past three years in different locations in the Semi-arid environment, were selected for evaluation under minimum insecticide protection, where only two insecticide application - one of decamethrin

(15 g a.i./h) at raceme initiation stage and the second of endosulfan (500 g a.i./h) at pod formation stage were applied. At the time of this write up, results were available from Niger, Senegal, Togo and Upper Volta, and are presented in Tables 15, 16, 17, 18 and 19. The data from Maradi, Niger indicated that there was no significant difference between varieties for populations of thrips, Maruca and pod-sucking bugs (Table 15). Amongst the varieties, a significantly higher grain yield was obtained for the local check, TN 5-78 (1413.30 kg/ha), SUVITA-2 (1230.83) and TN 88-63 (1202.10). IT 82E-60, Bambey 21 and TVx 1999-01F were poor yielders (106-355 kg/ha). IAR-48, KN-1, Mougne and TVx 3236 produced a medium level of grain yield (462-665 kg/h) (Table 15).

Results obtained from Kamboinsé, Upper Volta are presented in Table 16. At this location, thrips in racemes were significantly higher in Kamboinsé local (local check) indicating insufficiency of the two applications of insecticide due to its stagered flowering and long duration of reproductive phase. Other varieties had no difference among them. For thrips in flowers and pod-sucking bugs no significant difference was observed. Maruca population was significantly higher on KN-1 followed by SUVITA-2 in spite of adequate control (Table 16). Yield at this location gave a different picture as compared to in Niger. Significantly higher yield was obtained in IAR-48 (1171.5 kg/h) and lower in Kamboinsé local (205.9). There was no significant difference in yield among the varieties TVx 1999-01F, TVx 3236, Mougne and KN-1. Varieties TVx 3236, Mougne and KN-1 were also not significantly different from SUVITA-2 and TN 88-63. Performance of Bambey 21 and IT 82E-60 was better in Kamboinsé as compared to in Niger.

Insect pest population levels in Senegal (Bambey) were low and comparable with those in Niger (Maradi). Thrips density on racemes was negligible in relation to that on flowers (Table 17). The highest levels (2-3 thrips/flower) occured on TN 88-63 and IAR-48 but were not significantly different from those (2 thrips/flower) on TVx 3236, SUVITA-2 and Mougne. Maruca and Pod Sucking Bug populations were also low. They were presumably suppressed by insecticide application. High grain yields were obtained at Bambey : SUVITA-2 (2927 kgs/ha), 58-57, the local check variety (2729 kgs/ha), TVx 1999 (2303 kgs/ha) and TN 88-63 (2112 kgs/ha) significantly out-yielded IT 82E-60 (952 kgs/ha) while IAR-48, Mougne and TVx 3236 were intermediate (1600 - 1800 kgs).

Table 15. Number of thrips, Maruca, pod-sucking bugs and grain yield under minimum spray regime at Maradi, Niger , 1983.

Cultivar	Thrips/ raceme*	Thrips/ flower**	Maruca/ flower**	Pod bugs/ meter+	Yield/ kg/ha
Bambey 21	0.25	0.93	0.04	14.13	105.85
IAT-48	0.25	0.65	0.04	7.50	510.83
IT 82E-60	0.23	0.70	0.05	9.38	166.68
KN-1	0.23	1.00	0.04	11.88	541.25
Mougne	0.28	0.80	0.05	8.38	462.08
SUVITA-2	0.20	0.73	0.07	13.38	1230.83
TN 88-63	0.18	0.78	0.02	9.50	1202.10
TVx 1999-01F	0.30	0.78	0.05	10.63	355.00
TVx 3236	0.30	0.88	0.05	10.88	664.58
TN 5-78 (local check)	0.20	0.88	0 04	9.00	1413.30
Mean	0.24	0.81	0.05	10.46	665.25
L.S.D. at 5 %	N.S.	N.S.	N.S.	N.S.	251.25
C.V.	41.66	32.65	48.99	54.67	26.03

* Total of 7 samples ; ** Total of 6 samples ; + Total of 6 observations

Table 16. Population of thrips, Maruca, pod-sucking bugs and grain yield under minimum protection at Kamboinsé, Upper Volta, 1983.

Cultivar	Thrips/ raceme *	Thrips/ flower**	Maruca/ flower**	Pod bugs/ meter+	Yield kg/h
Bambey 21	2.85	13.78	0.08	16.63	609.6
IAR-48	2.15	19.80	0.18	4.25	1171.5
IT 82E-60	2.53	17.50	0.38	7.38	579.9
KN-1	3.95	20.90	1.00	4.63	815.2
Mougne	4.63	10.70	0.35	4.13	906.5
SUVITA-2	2.85	16.78	0.50	1.13	758.7
TN 88-63	4.28	15.00	0.15	2.25	752.0
TVx 1999-01F	3.53	15.88	0.38	0.75	964.1
TVx 3236	3.13	14.20	0.28	7.75	920.1
Kamboinsé local (local check)	14.58	28.70	0.05	0.13	205.9
Mean	4.45	17.32	0.33	4.90	768.35
L.S.D. at 5%	4.06	N.S.	0.33	N.S.	177.74
C.V.	63.04	51.09	67.76	18.18	15.94

* Total of 7 samples ; ** Total of 6 samples ; + Total of 7 observations

Table 17. Populations of thrips, Maruca, pod sucking bugs and grain yield of promising cowpea varieties in Bambey, Senegal, 1983.

Cultivar	Thrips/ raceme	Thrips/ flower	Maruca/ flower	P.S.B./ m (row)	Grain yield kg/ha
Bambey-21	0.65	1.53	0.10	0.00	1297.00
IAR-48	0.55	2.18	0.10	0.10	1641.80
IT 82E-60	0.70	1.43	0.10	0.10	952.00
KN-1	0.45	0.90	0.10	0.10	1253.00
Mougne	0.73	1.93	0.13	0.00	1788.25
SUVITA-2	0.53	1.95	0.15	0.00	2927.35
TN 88-63	0.98	2.40	0.00	0.10	2111.50
TVx 1999-01F	0.65	1.10	0.13	0.13	2303.00
TVx 3236	0.35	1.90	0.10	0.10	1823.50
58-57 (local)	0.45	1.23	0.10	0.13	2729.20
Mean	0.60	1.66	0.10	0.10	1882.66
L.S.D. (P=0.05)	N.S	0.82	0.04	0.12	711.53
C.V. (%)	-	34.28	31.62	83.67	26.05

Table 19. Minimum insecticide trial, 1983. Grain yield of promising cowpea varieties in Bambey (Senegal), Davie (Togo), Kamboinsé (Upper Volta) and Maradi (Niger).

Cultivar	Grain yield kg/ha				Mean
	Bambey (senegal)	Davie (Togo)	Kamboinsé (Haute-Volta)	Maradi (Niger)	
Bambey 21	1297.00	1712.50	609.60	105.85	931.24
IAR-48	1641.80	1675.00	1171.50	510.83	1249.79
IT 82E-60	952.00	1025.00	579.90	166.68	680.90
KN-1	1253.00	1775.00	815.20	541.25	1096.12
Mougne	1788.25	1682.50	906.50	462.08	1209.84
SUVITA-2	2927.35	1037.50	758.70	1230.83	1488.60
TN 88-63	2111.50	1625.00	752.00	1202.10	1422.65
TVx 1999-01F	2303.00	1900.00	964.10	355.00	1380.53
TVx 3236	1823.50	1875.00	920.10	664.58	1320.80
Local (check)*	2729.20	2000.00	205.90	1413.30	1587.10
Mean	1882.66	1630.75	768.35	665.25	1236.76
L.S.D. (P=0.5)	711.53	583.96	177.74	251.25	N.S.
C.V. %	26.05	24.68	15.94	26.03	-
* Local checks	58-57	VITA-5	Local Kamboinsé	TN 5-78	

Results from Togo (Davie) show high thrips densities especially in flowers (Table 18). Flower Thrips population was highest on Mougne (15 Thrips per flower) followed by TVx 1999-01F and TN 88-63 (9-10 thrips/ flower) and was significantly lower on Bambey-21 and TVx 3236 (6 Thrips per flower). Maruca and Pod Sucking Bug densities were low and presumed adequately controlled by chemical treatment. Grain production at Davie was moderate : VITA-5, the local check variety gave the highest yield (2000 kgs/ha and KN-1 (1775 kgs/ha). Production was intermediate (1600-1700 kgs/h) in Bambey-21, IAR-48, Mougne and TN 88-63, and, was considerably lower in both IT 82E-60 and SUVITA-2 (1000 kgs/ha).

Grain yield across environments is shown in Table 19. Mean yield differences among varieties were not statistically significant. However, there was marked variation in varietal performance in the different trial locations (significant at $p = 0.01$). The local check varieties, SUVITA-2 and TN 88-63 produced substantially higher yields (1400-1600 kgs/ha) across locations. TVx 1999-01F, TVx 3236, IAR-48 and Mougne yielded between 1200-1400 kgs/ha, and Bambey 21 and IT 82E-60 were the lowest producers (less than 1000 kgs/ha). Most of the local (check) varieties, SUVITA-2 and TN 88-63 show a high adaptation for the hot, dry conditions of the Sahel. By the same token, the favourable performance of TVx 3236 and TVx 1999-01F in these arid environments is encouraging.

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