OAU/STRC JOINT PROJECT 31

Semi-Arid Food Grain Research and Development

S A F G R A D

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

I. I. T. A.

ANNUAL REPORT
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SAFGRAD/IITA
B.P. 1783
OUAGADOUGOU, BURKINA FASO

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The cooperation of CIMMYT, IRAT, ICRISAT, F.S.U. and ISP (University of Ouagadougou) as well as that of many ORD Directors was also instrumental in the progress achieved in 1984.

The active participation of the Maize and Cowpea National Programs of the SAFGRAD member countries has been a key element in developing and improving the Regional Maize and Cowpea Networks that SAFGRAD has the role of promoting. The support provided by National Governments and the collaboration of national researchers is acknowledged.

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

The SAFGRAD/IITA Team in Burkina Faso has been successful in accomplishing the project objectives thanks to the continuous administrative and technical backstoping provided by IITA headquarters at Ibadan, Nigeria.

All this effort has been possible with the financial assistance provided to SAFGRAD/IITA by the U.S. Agency for International Development (USAID) and by the International Development Research Center (IDRC) of Canada, to whom we express our gratitude.

Ouagadougou
May 14, 1985

Mario Rodriguez
Maize Agronomist &
Project Leader

PERSONNEL

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Dr. V. L. Asnani	Project Leader (until April) Maize Breeder (until May)
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COOPERATORS (SAFGRAD REGIONAL MAIZE AND COWPEA TESTING)

This is not a comprehensive list of IITA/SAFGRAD contacts and cooperators. It only includes those researchers directly responsible for the conduction of the IITA/SAFGRAD regional trials in 1984. We present our apologies for any errors and omissions and request those whose names were omitted to kindly write to us so that our files are kept up to date.

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INTRODUCTION

Semi-Arid Food Grain Research and Development (SAFGRAD) is a regional project financed by several agencies. At present, most funding is provided by the USAID. The overall coordination is provided by the Scientific Technical and Research Commission of the Organisation of African Unity (OAU/STRC), through the SAFGRAD Coordination Office in Ouagadougou. The main goal 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 groundnut. The project has a Farming Systems Component, contracted to Purdue University.

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

A total of 5 IITA Scientists : one Maize Breeder, one Maize Agronomist, one Soil Fertility specialist (cowpea agronomist), one Entomologist (all 4 funded by USAID), and one Cowpea Breeder (funded by IDRC) are based at the National Agricultural Research Station of Kamboinse (about 15 km North of Ouagadougou) which serves as the headquarters of the IITA/SAFGRAD research program. The five IITA Scientists work as two teams : (1) A maize team - consisting of a breeder, an agronomist and an entomologist (25 %) and (2) A cowpea team - consisting also of a breeder, an agronomist and an entomologist (75 %). The USAID - funded scientists started work in 1979. The IDRC - funded Cowpea Breeding Program had started in 1977 within a national framework, but later providing technical support to the SAFGRAD team. In 1983 the IDRC/Cowpea Breeding Program took a fully regional orientation within the IITA/SAFGRAD project.

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

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

(b) To develop improved varieties and agronomic/management practices capable of giving higher and stable economic yields in semi-arid environment.

(c) To organize and promote systematic regional testing in the semi-arid zone of available genetic materials and technology.

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

The strategy followed to achieve these objectives consists of :

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

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

(c) Support and assistance to national programs through consulting visits, advise, encouragement and motivation, and the provision of small research equipment.

(d) Training in Burkina and in IITA headquarters (Ibadan, Nigeria), as well as through active participation of IITA/SAFGRAD staff in Workshops and Seminars and in the maize and cowpea monitoring tours.

The experience of the last 6 years has permitted the IITA/SAFGRAD Scientists to develop and/or introduce new improved varieties of maize and cowpea and to develop and/or test improved management practices. Salient results of the 1984 activities are presented in this report. For more detailed information, the reader is asked to contact the scientist concerned.

PHYSICAL ENVIRONMENT : SOILS AND WEATHER

The Semi-Arid Tropics (SAT) in West Africa comprise 3 major ecologies :

(a) The Northern Guinea Savanna
Annual rainfall : 900 - 1200 mm
Lenght of rainy season : 4 - 5 months

(b) The Sudan Savanna
Annual rainfall : 600 - 900 mm
Lenght of rainy season : 3 - 4 months

(c) The Sahel Savanna
Annual rainfall : 300 - 600 mm
Lenght of rainy season : 2 - 3 months.

This classification should not be taken rigidly since one major characteristic of the rainfall distribution pattern in the West African SAT is the variability in the annual rainfall and its distribution. For instance, the Farako-Bâ station in the Northern Guinea Savanna of Burkina Faso has received less than 820 mm annual rainfall in the last two years.

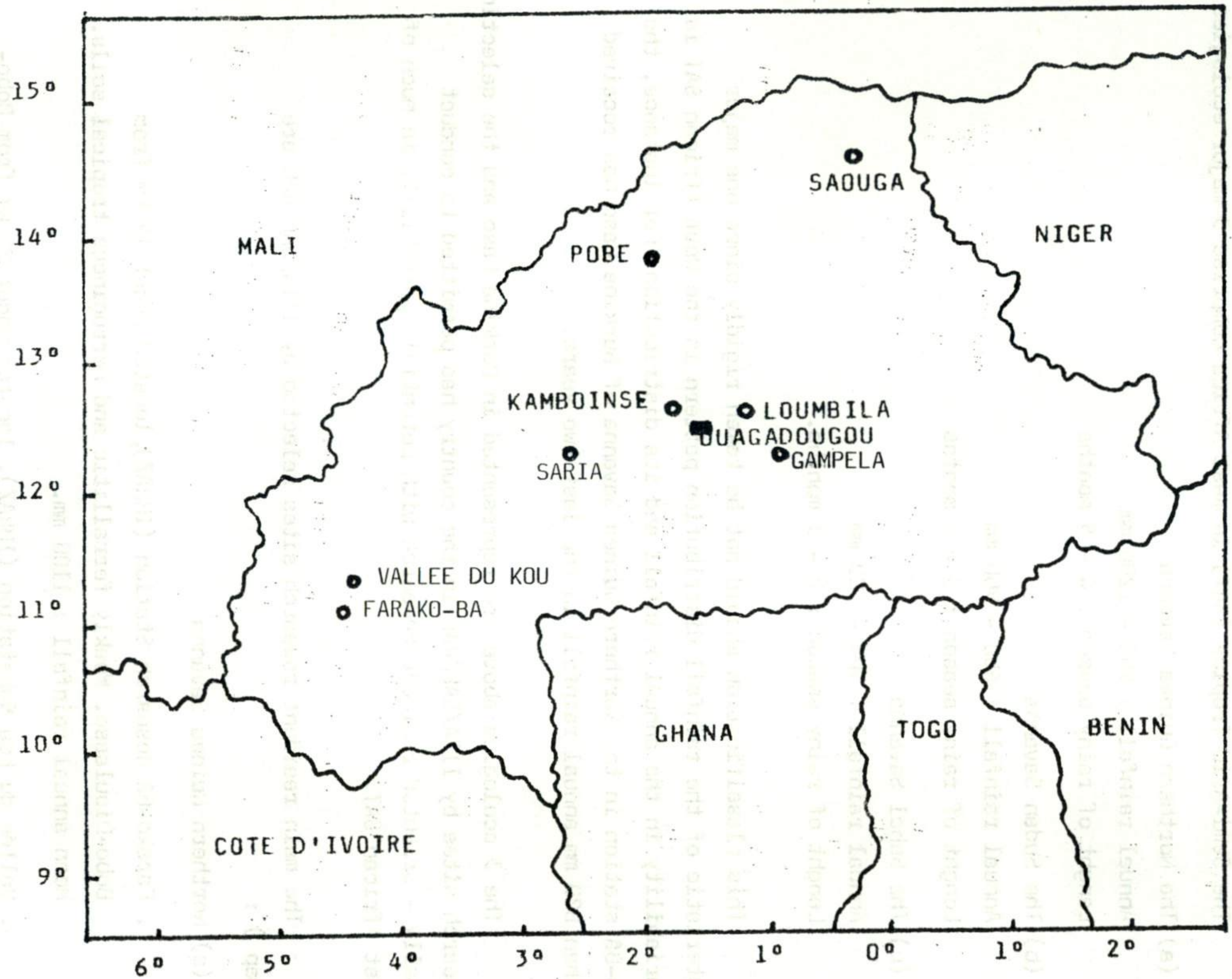
The 3 ecologies above are represented in Burkina Faso and the selection of research sites by IITA/SAFGRAD in the country has permitted to conduct regionally - oriented resident research with potential appicability in much of the West African SAT.

The main resident research sites selected by IITA/SAFGRAD are (see map) :

(a) Northern Guinea Savanna

- Farako-Bâ Research Station (IBRAZ), located about 12 km from Bobo-Dioulasso. Weakly ferrallitic and Ferruginous tropical soils. Mean annual rainfall : 1100 mm.

- Vallée du Kou Substation (IBRAZ), located about 25 km from Bobo-Dioulasso. Mostly Ferruginous tropical soils. Mean annual rainfall : 1100 mm.



MAIN RESEARCH SITES OF IITA/SAFGRAD IN BURKINA FASO

(PRINCIPALES LOCALITES POUR LA RECHERCHE A L'IITA/SAFGRAD)

(b) Sudan Savanna

. Kamboinsé Research Station (IBRAZ), located about 14 km North of Ouagadougou. Ferruginous tropical and hydromorphic soils. Mean annual rainfall : 800 mm.

. Saria Research Station (IBRAZ), located about 90 km West of Ouagadougou, close to Koudougou. Mostly Ferruginous tropical soils. Mean annual rainfall : 800 mm.

. Loumbila (Ministry of Agriculture), located about 15 km North of Ouagadougou, on the road to Kaya. Mostly Ferruginous tropical soils. Mean annual rainfall : 800 mm. Limited irrigation facilities are available. The bulk of the dry-season breeding program used to be carried out at this site. Unfortunately a misunderstanding led to the partial/total loss of the land granted at Loumbila, in spite of the large development investment by IITA/SAFGRAD. It is hoped that this problem can be satisfactorily settled in the near future. In the mean time the dry-season breeding program has been shifted to the Vallée du Kou, but given the distance from Kamboinse Headquarters (close to 400 km) and the overall logistic problems, another solution is essential.

. Gampela (ISP), located about 20 km East of Ouagadougou, Mostly Ferruginous tropical soils. Mean annual rainfall : 700 mm.

(c) Sahel Savanna (Ministry of Agriculture)

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

. Pobé (Ministry of Agriculture), located about 200 km North of Ouagadougou. Mostly Ferruginous tropical soils. Mean annual rainfall : 450 mm.

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

Cowpea work is conducted in the 3 major ecologies, but maize work has dealt only with the Sudan and Northern Guinea Savannas.

Total rainfall was below average and its distribution was very irregular in Burkina Faso in 1984, particularly in the Sudan Savanna. Kamboinsé received only 414 mm rainfall, by far the lowest in many years, and yields were very low. In Farako-Bâ, total rainfall was only 815 mm, but its distribution was such that moderately good yields were obtained. As was observed in the past, low and erratic rainfall distributions are associated with higher experimental coefficients of variation.

The daily rainfall records for Farako-Bâ, Saria, Kamboinse, Loumbila and Pobe are presented in the following pages.

DECLARATION

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

Location (Localité) : Farako-Bâ (Burkina Faso) 11° 06' N

Daily rainfall (Tableau pluviométrique) mm

1984

Date	J	F	M	A	M	J	J	A	S	O	N	D
1							4,6	27,1				
2												
3										0,9		
4							21,3		13,8			
5						7,0	11,0	2,0				
6						3,2	3,3			6,0		
7					0,5	16,7	4,3	9,5	14,1	3,5		
8					33,6							
9								24,2		0,5		
10					6,0				14,2			
11			20,5					12,1	1,4		0,2	
12			0,7					45,2			1,0	
13						3,7			16,4			
14							13,3		22,2	0,5	5,5	
15	tr.	tr.		15,6			1,0	3,6				
16					13,7	4,6	4,6					
17								1,3	15,5			
18						12,1		35,0	3,5	0,7		
19						1,8		1,3				
20					4,1			3,9				
21					12,6				16,2			
22												
23						46,5	2,1	36,5				
24				0,5			34,3	7,5				
25												
26					13,4	8,1	12,4	20,7	8,7			
27						0,1	1,3	21,5				
28					1,8				19,3			
29									11,3	0,5		
30								2,7				
31					16,0		9,4	19,4				
Total (mm)			21,2	16,1	101,7	103,8	122,9	273,5	156,6	12,6	6,7	
No. days (jours)			2	2	9	10	13	17	12	7	3	
Total cumul. (mm)			21,2	37,3	139	242,8	365,7	639,2	795,8	808,4	815,1	
No. days (jours) Cumul.			2	4	13	23	36	53	65	72	75	

Location (Localité) : Saria (Burkina Faso) 12º 16' N

Daily rainfall (Tableau pluviométrique) mm

1984

Date	J	F	M	A	M	J	J	A	S	O	N	D
1								10.0		1.0		
2							14.0					
3									13.5			
4									37.0			
5					6.0			20.0	1.5			
6						22.0	36.0		4.5			
7						29.0	14.0	tr				
8												
9										25.5		
10			33.5		3.5		1.0		12.0			
11			0.5					5.2	1.0	1.0		
12			4.4				12.0	12.5	5.0			
13						12.0	tr					
14									7.0	14.0		
15				29.0					7.0			
16					1.0							
17							4.5	19.0	4.5			
18						6.5	2.5	18.5		8.0		
19												
20							24.0					
21					1.5							
22							3.0		0.5			
23					28.0	5.0						
24							20.0					
25				45.0		1.3						
26					23.0	32.0						
27									8.5			
28									1.5			
29							1.0					
30				tr	tr							
31					13.0		1.0	15.0				
Total (mm)			38.4	74.0	76.0	107.8	133.0	100.2	103.5	49.5		
No. days (jours)			3	2	7	7	12	7	13	5		
Total cumul. (mm)			38.4	112.4	188.4	296.2	429.2	529.4	632.9	682.4		
No. days (jours) Cumul.			3	5	12	19	31	38	51	56		

Location (Localité) : Kamboinsé (Burkina Faso) 12º 28' N

Daily rainfall (Tableau pluviométrique) mm

1984

Date	J	F	M	A	M	J	J	A	S	O	N	D
1						0.3		24.9				
2												
3							1.8		39.5			
4												
5						0.5		0.3				
6					9.5		4.5		0.7			
7					tr	15.5	7.6	tr				
8									2.0			
9										5.5		
10					0.2		1.6		24.0			
11			3.9				0.1	20.2	0.7			
12			0.3			12.3		10.0	3.8			
13							0.6					
14						1.0			4.0	33.5		
15				5.0				0.9				
16					0.3							
17							4.3	13.0	2.0			
18									tr	16.0		
19						4.3	5.8					
20							0.7					
21			0.1		2.0							
22									1.5			
23					13.0		1.9					
24					2.5			0.3				
25				22.5			12.0					
26				1.3	9.5	2.4		34.0				
27												
28					0.6							
29									0.5			
30				2.7								
31					11.0		0.1	15.0				
Total (mm)			4.3	31.5	48.6	36.3	41.0	118.6	78.7	55.0		
No. days (jours)			(3)	(4)	(9)	(7)	(12)	(9)	(10)	(3)		
Total cumul. (mm)			4.3	35.8	84.4	120.7	161.7	280.3	359.0	414.0		
No. days (jours) Cumul.			(3)	(7)	(16)	(23)	(35)	(44)	(54)	(57)		

Location (Localité) : Loumbila (Burkina Faso)

Daily rainfall (Tableau pluviométrique) mm

1984

Date	J	F	M	A	M	J	J	A	S	O	N	D
1								2.4				
2								2.8				
3									29.0			
4												
5												
6						3.1	12.0					
7							3.0			12.0		
8									5.5			
9									0.7	18.0		
10									69.5			
11							0.5	55.0	1.7			
12								23.0	19.8			
13						18.0	27.0					
14										4.7		
15												
16												
17							13.4	6.5	1.3			
18							8.0	2.2		12.0		
19					4.9	9.7						
20							3.0					
21												
22							1.4		4.5			
23												
24					12.9							
25				9.0	6.1		5.3					
26								6.7				
27					23.0							
28												
29												
30												
31					17.8		2.3	18.0				
Total (mm)				9.0	64.7	30.8	75.9	116.6	132.0	46.7		
No. days (jours)				1	5	3	10	8	8	4		
Total cumul. (mm)				9.0	73.7	104.5	180.4	297	429	475.7		
No. days (jours) Cumul.				1	6	9	19	27	35	39		

Location (Localité) : Pobé (Burkina Faso) 13° 81' N

Daily rainfall (Tableau pluviométrique) mm

1984

Date	J	F	M	A	M	J	J	A	S	O	N	D
1							45.0					
2								9.0				
3												
4												
5								18.0				
6							27.0					
7												
8									6.5			
9						6.0		3.0				
10						13.1			10.0			
11							7.0					
12						1.5						
13							6.5		4.5			
14									25.0			
15								5.0				
16									6.0			
17												
18							9.0					
19												
20												
21												
22												
23												
24								1.5				
25												
26						4.7						
27								12.0				
28												
29						9.2	27.0		1.0			
30									3.0			
31							12.0		1.5			
Total (mm)						34.5	133.5	48.5	57.5		–	
No. days (jours)						5	7	6	8			
Total cumul. (mm)						34.5	168	216.5	274.0			
No days (jours) Cumul.						5	12	18	26			

SUPPORT TO NATIONAL PROGRAMS AND TRAINING

One of the most important objectives of the IITA/SAFGRAD Project is to strengthen National Maize and Cowpea Programs in the SAT. To accomplish this objective, various activities are undertaken, including the technical support and training of young scientists and technici ns.

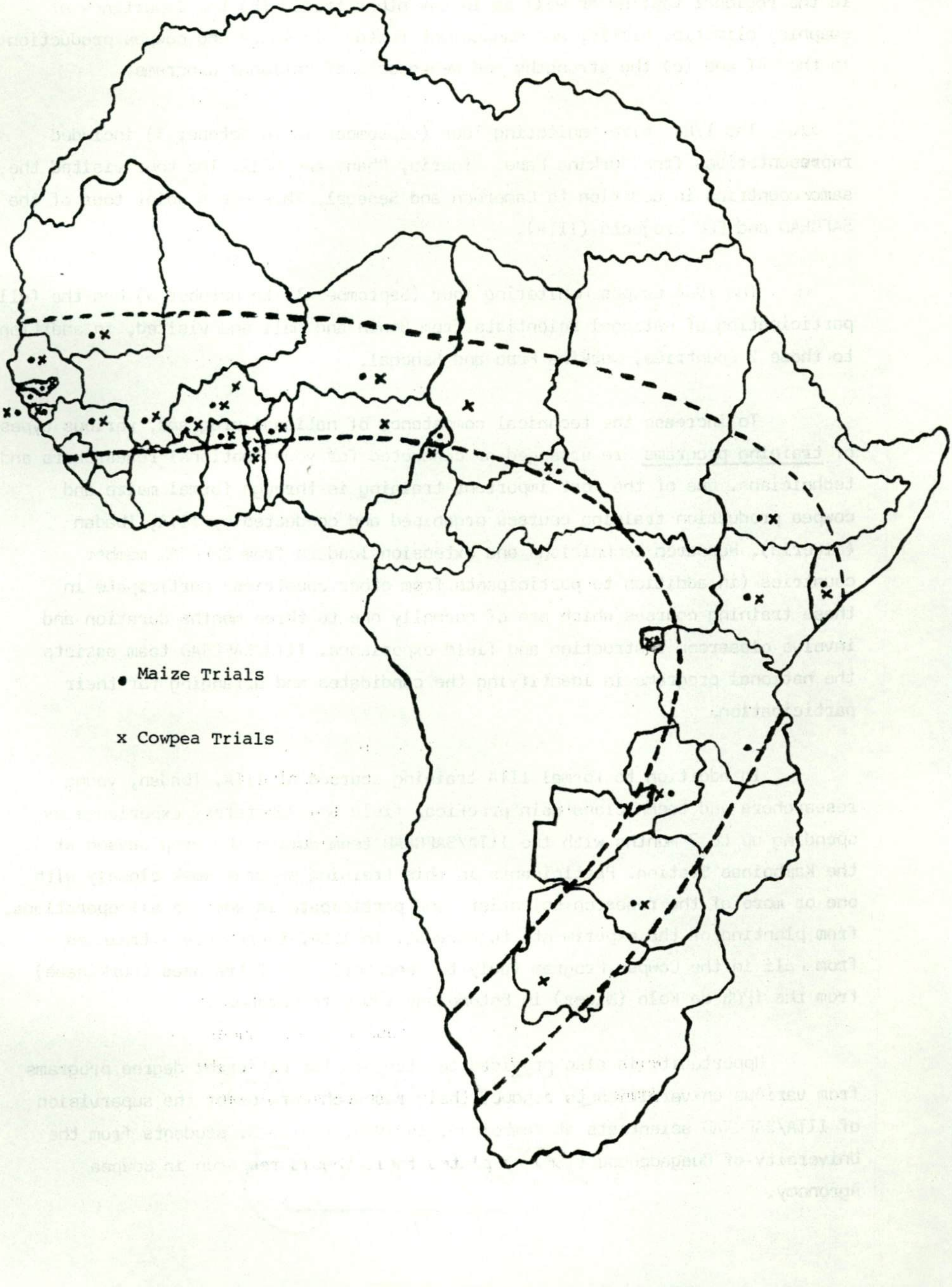
The annual SAFGRAD/IITA Maize and Cowpea Workshop permits the evaluation of the progress being made by National Research Programs, SAFGRAD/IITA and other institutions and to plan future work. The sixth Workshop was held at IITA (Ibadan, Nigeria) from March 5-9, 1985, jointly with the EEC/IITA High Yielding Varieties Technology Project. It was attended by more than 70 maize and cowpea researchers, representing countries from West, East, Central, and Southern Africa. The Workshop is an essential tool in order to have dynamic Maize and Cowpea regional testing programs. The Maize and Cowpea Networks are also strengthened by the friendship and sense of common purpose promoted by the Workshop. An important accomplishment of the IITA/SAFGRAD programs has been the breaking of the barriers between anglophone and francophone countries. It can be stated that most of the leading maize and cowpea researchers in the SAT of both anglophone and francophone countries have been put into personnal contact by the IITA/SAFGRAD activities, mainly through the Annual Maize and Cowpea Workshops and the Annual Maize and Cowpea Monitoring Tours.

The IITA/SAFGRAD regional testing program allows National Maize and Cowpea Programs to exchange their most promising materials and to evaluate under their conditions improved varieties developed by IITA/SAFGRAD and other regional or international organizations (CIMMYT, IITA, IRAT, etc). In addition to the varietal testing, regional agronomy and entomology trials permit wide testing to improved management practices and to better assess the importance of insects pests in the SAT. More than 90 sets of regional trials were requested by and sent to 24 National Programs in 1984 (See map).

Since the start of the Project in 1979, Maize and Cowpea Monitoring Tours have been organized (separately) every year by IITA/SAFGRAD during the growing season. For these Monitoring Tours, national researchers from 4-6 countries for each Maïze and Cowpea are invited to visit 4-6 National Programs, under the leadership of IITA/SAFGRAD staff. The Monitoring Tours permit the

MAIZE AND COWPEA REGIONAL TESTING

COUNTRIES RECEIVING TRIALS IN 1984



the evaluation of (a) the performance of materials management practices included in the regional testing as well as in any other trial, (b) the importance of edaphic, climatic, biotic, and management factors in maize and cowpea production in the SAT and (c) the strengths and weaknesses of national programs.

The 1984 Maize Monitoring Tour (September 10 to October 3) included representatives from Burkina Faso, Nigeria, Ghana and Mali. The tour visited the same countries in addition to Cameroon and Senegal. This was a joint tour of the SAFGRAD and EEC Projects (IITA).

The 1984 Cowpea Monitoring Tour (September 19 to October 3) had the full participation of national scientists from Benin and Mali and visited, in addition to these 2 countries, Burkina Faso and Senegal.

To increase the technical competence 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 researchers and technicians gain practical field and laboratory experience by spending up to 7 months with the IITA/SAFGRAD team during the crop season at the Kamboinse Station. Participants in this training program work closely with one or more of the research scientists and participate in some or all operations, from planting of the experiments to harvest. In 1984, there were 3 trainees from Mali in the Cowpea Program (July to December), and 2 trainees (Burkinabè) from the IPDR de Kolo (Niger) in Entomology (July to October).

Opportunity is also provided to students for different degree programs from various universities to conduct their research work under the supervision of IITA/SAFGRAD scientists at Kamboinsé. In 1984, two B. S. students from the University of Ouagadougou (ISP) completed their thesis research in Cowpea Agronomy.

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

MAIZE BREEDING

A.O. Diallo, V. Asnani, I. Hema

1. INTRODUCTION

SAFGRAD, in collaboration with IITA and CIMMYT, is trying, through resident research and regional testing, to develop 4 types of varieties : (1) early maturing varieties with a reasonable yield ; (2) intermediate maturity varieties of good yield ; (3) drought resistant varieties, and (4) good quality protein varieties.

In Burkina Faso, the trials were conducted at 6 locations (Saria, Kamboinse, Gampela and Loumbila in the 600-900 mm ecological zone ; Farako-Bâ and Vallee du Kou in the 900-1200 mm ecological zone). All the locations suffered from a serious rainfall deficit. The trials received 72-46-28 kg/ha of N-P_2O_5-K_2O except at Vallee du Kou where 85-69-42 kg/ha were applied. The plant density was 53,000 plants/ha for intermediate varieties and 66,000 plants/ha for early varieties.

2. RESIDENT RESEARCH

2.1 Early maturity

Early varieties (82-95 days to maturity) are needed in both the Sudan and the Northern Guinea Savannas.

2.1.1 Population improvement

a) TZESR-Y. This is an early streak resistant population developed by IITA/Ibadan. One cycle of Full sib families selection was completed in 1982. To initiate the second cycle of selection 65 FS families were recombined and 250 FS developed in 1983. This year, these 250 FS families along with 6 checks were tested in 2 locations (Saria and Loumbila) in a 16 x 16 simple lattice design.

In both locations plant stand was affected by drought. At Loumbila supplemental irrigation was needed 10 days after planting.

At Saria the F test (5 % level) was significant. 9 FS families were selected to develop an experimental variety, EV Saria 84 TZESR-Y (Table 1), 9 other FS families were visually selected to develop EV Saria (1) 84 TZESR-Y (Table 2). At Loumbila the F test (5 % level) was not significant. 7 FS families were visually selected to develop EV Loumbila (1) TZESR-Y (Table 3). 10 other FS families were selected across locations to develop Across 84 TZESR-Y (Table 4).

b) TZESR-W. This early, white, streak resistant population is developed and handled at IITA/Ibadan. From 1982 tests 63 FS families were twice recombined and 250 FS families developed for international testing. At Kamboinse one set of this IPTT was planted along with 6 checks. The trial was affected by drought. 9 FS families were visually selected (Table 5) to develop EV Kamboinse (1) 84 TZESR-W.

c) Pool 16. This early white dent CIMMYT pool has performed well in SAFGRAD RUVT-1 trials. Breeding work on Pool 16 began in 1980. At IITA current work includes recurrent selection with international testing of the material per se, a sidecar approach for making the germplasm streak resistant, and development of a streak resistant experimental variety of Pool 16 through beckcrossing. In 1983 the best 84 FS families across locations were recombined and 170 FS developed. These FS families were combined with 80 FS from the streak resistance conversion sidecar of Pool 16 to form an international progeny testing trial (IPTT). At Kamboinse, one set of this trial was planted ; because of drought only visual selection was possible. Table 6 shows the yield performance and other agronomic characters of 8 visually selected FS families to develop EV Kamboinse (1) 84 Pool 16.

2.1.2 Evaluation of early varieties

EVT-ESR. Eleven early streak resistant varieties developed at IITA/Ibadan were tested along with 2 checks (Safita-2 and Temp. x Trop. Nº 27) at Loumbila. No statistical difference in yield was observed and the experimental error was large (Table 7). In terms of stem lodging, Safita-2 (check) was significantly more susceptible than other tested varieties.

2.2 Medium maturity

Medium maturing varieties (96-110 days to maturity) are useful in Northern Guinea Savanna and in the hydromorphic soils of Sudan Savanna.

Table 1. Grain yield and other agronomic characters of 9 selected full-sib families from IPTT-TZESR-Y at Saria, Burkina Faso, 1984. (Yield at 15 % moisture).

Family	Grain yield (kg/ha)	Days to 50 % silking	Plant height (CM)	Ear height (CM)	Root lodging (%)	Stem lodging (%)	Ear harves-ted(Nº)	Ear rot (%)	Ear aspect (1-5)
4	3250	54	117	50	0.0	1.5	17	1.0	3.5
31	4265	53	160	78	0.5	2.5	18	0.0	3.5
37	3656	54	118	55	1.0	3.0	13	0.5	3.5
47	3554	56	140	75	2.0	2.5	18	0.0	2.5
116	4367	53	140	68	0.0	2.5	20	0.0	2.5
140	3453	49	130	38	0.0	2.0	19	0.5	3.5
171	3859	57	125	68	1.5	3.0	19	0.5	3.0
194	2945	55	125	55	0.0	1.0	17	0.5	3.0
223	3453	56	135	58	0.0	1.5	20	0.0	3.0
Means									
Sel. Families	3645	54	132	61	0.6	2.2	18	0.3	3.1
Population	2864	58	129	60	*	1.9	16	*	4.2
Best check	2177	50	129	49	*	1.0	12	*	4.0
All checks	2073	54	120	57	*	1.3	12	*	4.1
LSD(5 %)	1495	4.4	34	27	ns	ns	ns	ns	ns
CV(%)	26	4	13	21	329	99	23	204	20

* Affected by missing values

Best check Safita 104

Other checks TZESR-W, Safita 2, Temp. x Trop. nº 27

Table 2. Grain yield and other agronomic characters of 9 visually selected full-sib families from IPTT-TZESR-Y at Saria, Burkina Faso, 1984 (Yield at 15% moisture).

Family	Grain Yield (Kg/ha)	Days to 50 % silking	Plant Height (cm)	Ear Height (cm)	Root lodging (%)	Stem lodging (%)	Ears Harvested (N°)	Ear rot (%)	Ear aspect (1-5)
2	2539	55	145	63	0.0	0.0	16	0.0	4.0
12	2843	57	135	48	0.0	0.5	19	0.0	3.5
30	3453	57	145	80	1.0	6.0	13	0.0	4.0
98	3656	53	140	63	0.5	1.0	17	0.0	2.5
104	4367	58	123	48	2.0	5.0	15	0.0	2.5
127	4164	57	178	88	0.0	1.5	20	0.0	3.0
196	3859	57	133	53	0.5	3.5	17	0.5	4.5
207	3960	57	150	68	0.0	1.0	19	0.0	3.0
208	4367	57	145	75	0.5	2.0	19	0.0	3.5
Means									
Sel.Families	3690	56	144	65	0.5	2.3	17	0.05	3.4
Population	2864	58	129	60	*	1.9	16	*	4.2
Best Check	2177	50	129	49	*	1.0	12	*	4.0
All Checks	2073	54	120	57	*	1.3	12	*	4.1
L.S.D. (5 %)	1495	4.4	34	27	ns	ns	ns	ns	ns
C.V. (%)	26	4	13	21	329	99	23	204	20

* Affected by missing values

Best check Safita 104

Other checks: TZESR-W, Safita 2 and Temp. x Trop N° 27.

Table 3. Grain yield and other agronomic characters of 7 visually selected Full-sib families from IPTT TZESR-Y at Loumbila, Burkina Faso, 1984 (Yield at 15 % moisture).

Family	Grain yield kg/ha	Days to 50 % silking	Plant height (CM)	Ear height (CM)	Root lodging (%)	Stem lodging (%)	Ears harves-ted (n°)	Ear rot (%)	Ear aspect (1 - 5)
52	2773	63	168	80	1.0	6.0	16	0.0	3.5
106	2567	58	145	85	1.5	4.5	13	0.0	2.5
111	2465	59	148	65	0.0	1.0	11	0.0	3.0
117	2567	62	138	75	8.0	1.0	18	0.0	3.0
159	3091	61	157	80	0.0	2.0	15	0.0	4.0
167	3183	58	140	50	1.5	0.0	18	0.0	4.5
205	2054	61	135	75	7.5	1.0	13	0.0	4.0
Means									
Sel.Families	2671.0	60	147.0	73	2.8	2.2	15	0.0	3.5
Population	1748	62	133	69	6.0	2.0	12	0.7	3.8
Best check	1989	61	133	69	7.0	1.2	13	0.4	3.3
All checks	1285	62	129	62	6.0	1.0	9	0.8	3.3
LSD(5 %)	ns	5	ns	ns	ns	ns	ns	ns	1.0
CV(%)	41.0	4.1	12.4	20.1	52.2	109.2	34	192	12.8

Best check : TZESR-W

Other checks : Safita-2 , Safita 104, Temp. x Trop. N° 27

Table 4. Grain yield and other agronomic characters of 10 selected Full-sib families from IPTT TZESR-Y Across locations (Loumbila, Saria), Burkina Faso, 1984 (Yield at 15 % moisture).

Family	Grain yield (kg/ha)	Days to 50 % silking	Plant height (CM)	Ear height (CM)	Root lodging (%)	Stem lodging (%)	Ears harves-ted(N°)	Ear rot (%)	Ear aspect (1-5)
17	2959	55	130	65	3.0	1.2	18	0.5	3.5
47	2958	60	139	69	4.5	3.5	16	0.0	3.0
66	2856	58	118	51	3.5	0.3	15	0.8	3.3
97	2853	58	158	89	2.0	2.5	17	0.3	3.8
110	2910	58	124	53	1.2	2.5	16	0.5	3.3
182	3113	59	138	66	3.5	2.0	19	0.0	3.5
187	2805	59	128	60	5.0	1.3	17	0.5	3.0
190	3215	59	141	63	1.3	1.3	18	0.3	3.8
222	2756	60	135	61	3.5	1.8	15	0.5	3.5
230	3113	59	125	75	1.8	2.0	17	0.8	3.8
Means									
Sel. Families	2954	59	134	65	2.9	1.8	17	0.4	3.5
Populations	2306	60	131	65	*	2.0	14	*	4
All checks	1679	58	125	60	*	1.0	10	*	3.7

* Affected by missing values at Saria.

Table 5. Grain yield and other agronomic characters of 9 visually selected Full-sib families from IPTT-TZESR-W at Kamboinse, Burkina Faso, 1984 (Yield at 15 % moisture).

Family	Grain yield (kg/ha)	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (N°)	Ear rot
43	366	166	75	3.2	2.1	6.0	1.5
54	610	178	104	0.0	1.9	9.2	2.5
99	429	180	73	3.1	2.2	8.2	2.0
104	1130	172	71	3.7	3.4	10.4	1.5
133	520	173	69	0.0	0.1	9.6	5.0
137	263	185	107	1.5	2.3	6.1	2.0
176	591	169	67	0.8	1.4	6.5	0.0
219	1534	160	82	0.0	2.2	14.6	4.0
221	861	172	85	0.3	2.8	9.0	4.0
Means							
Sel. Families	700	173	81	1.4	2.0	8.8	2.5
Population	236	171	82	1.5	2.1	4.0	1.8
Best check	55	142	75	2.1	4.7	1.2	0.5
All checks	14	153	74	1.3	3.3	0.4	0.5
LSD (5 %)	494	25	26	ns	ns	6.0	4.5
CV (5 %)	102	7	15	148	91	74	89

Best check Safita 2

Other checks: Safita 102, Temp. x Trop. n° 27.

Table 6. Grain yield and other agronomic characters of 8 visually selected Full-sib families from IPTT Pool 16 at Kamboinse, Burkina Faso, 1984 (Yield at 15 % moisture).

Family	Grain yield (kg/ha)	Days to 50 % silking	Plant height (CM)	Ear height (CM)	Ears harvested (n°)	Ear rot (%)	Ear aspect (1 - 5)
9	924	53	152	77	7	14	3.3
72	994	53	149	61	8	20	3.5
77	642	52	150	69	10	19	3.1
113	1039	54	118	35	11	45	4.2
124	1027	52	126	53	11	36	3.5
145	1097	53	147	72	10	47	3.0
183	879	53	135	72	11	40	3.6
214	1027	54	133	65	12	46	3.8
Means							
Sel. Families	954	53	139	63	10	33	3.5
Population	449	54	138	63	7	45	4.2
Best check	382	55*	154	75	3	33	4.6
All checks	260	54*	138	66	3	58	4.1
LSD (5 %)	596	5	22	24	6	-	1.0
CV(%)	64	5	8	18	43	-	17

* Strongly affected by missing data

Best check Temp. x Trop n° 42

Other checks: Safita 2 and Temp. x Trop N° 3

Families 1-81 are segregating for streak resistance.

Table 7. Grain yield and other agronomic characters of Streak Resistant varieties tested in EVT-ESR at Loumbila, Burkina Faso, 1984 (yield at 15 % moisture).

	Variety Name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (No)	Stalk lodging (No)	Ears harvested (Nº)
1	Ikenne-82 TZESR-W	2310	62	178	69	0.50	1.00	25
2	Gusao-82 TZESR-W	2053	61	166	68	7.00	1.30	27
3	EV 8231-SR (BC2)	1895	57	163	51	4.80	0.00	20
4	Mayo Galke-82 TZESR-W	1882	62	174	73	2.80	0.80	29
5	Across-82 TZESR-Y	1865	60	174	60	5.50	0.50	22
6	Temp x Trop nº 27	1797	63	163	59	2.50	0.80	25
7	Kamb. 82 TZESR-Y	1737	63	179	68	1.50	1.00	23
8	Bertoua-82 TZESR-Y	1711	63	174	64	3.00	0.80	22
9	EV 8230-SR (BC2)	1594	57	171	63	3.80	0.00	19
10	Gusao-81 Pool 16	1403	60	164	63	4.00	0.80	16
11	EV 8235-SR (BC3)	1336	62	156	64	3.50	0.00	14
12	Safita-2	1305	59	148	63	8.30	3.30	20
13	Ikenne-82 TZESR-Y	1225	64	175	66	3.50	0.80	15
Mean		1701	61	168	64	4.00	0.90	21
L.S.D. (5 %)		ns	ns	ns	ns	ns	1.60	ns
C.V. (%)		44	6	9	18	124	132	32

2.2.1 Population improvement

a) TZUT-Y. This is the yellow portion of Temp. x Trop. population combining the efficient plant type of varieties from the Corn Belt of the United States with the desease resistance or tolerance of Local African germplasm. 305 S1 lines of this population were recombined twice at Kamboinse since 1982. In 1983-84 dry season, 250 FS families were developed and sent to 3 locations. In Burkina Faso, 2 sets were planted at Loumbila and Saria. At Saria, the trial failed because of drought after planting. At Loumbila the F test (5 % level) was significant. The tables 8 and 9 show the yield performance of selected families to develop 2 experimental varieties Loumbila 84 TZUT-Y and Loumbila (1) 84 TZUT-Y respectively.

b) Population 33. This new genetically broad based population is an intermediate subtropical temperate yellow flint developed by CIMMYT. At Kamboinse one set of IPTT was planted. The trial was severely affected by drought. Ten full sib families were visually selected from which CIMMYT will develop EV Kamboinse (1) 8433.

2.2.2 Evaluation of medium varieties

a) EVT-16A. Seventeen varieties developed by CIMMYT from sub-tropical yellow populations (Pop. 33, 45, 48) were tested along with two local checks (Safita 2 and Temp. x Trop. N° 27) at two locations (Kamboinse and Farako-Bâ).

At Kamboinse, the yield performance and days to 50 % silking were severely affected by drought. The yield was very low and the F test (5 % level) was not significant with a very large experimental error.

At Farako-Bâ a statistically significant difference in yield was observed between varieties. Capinopolis 8245 and Sids 8245 were the higher yielding varieties (Table 10). Capinopolis 8245 yielded 16 % more than the best check (Safita-2). The population 48 is the earliest population but highly susceptible to foliar diseases and root lodging.

b) EVT-14A. Thirteen intermediate yellow experimental varieties developed by CIMMYT from populations 35 and 26 were tested along with 2 checks (Safita 2 and Temp. x Trop. 27) at Kamboinse. Because of severe drought, yield was very low. The F test (5 % level) was not statistically significant and the experimental error was very large.

Table 8. Grain yield and other agronomic characters of 10 selected Full-sib families from IPTT-TZUT at Loumbila, Burkina Faso, 1984 (Yield at 15 % moisture).

Family	Grain yield (kg/ha)	Days to 50 % silking	Plant height (CM)	Ear height (CM)	Root lodging (%)	Stem lodging (%)	Ears harves-ted (n°)	Ear rot (%)	Ear aspect (1-5)
3	1643	61	130	55	4.0	1.5	11	0.0	3.0
13	1745	64	108	68	5.0	2.0	13	0.5	3.0
14	2156	63	135	75	3.0	0.0	13	0.0	3.5
28	2054	61	140	78	10.5	1.5	11	0.5	3.5
113	2773	61	148	83	8.0	1.5	16	2.5	3.5
130	1746	64	138	73	7.0	1.5	11	0.0	3.5
140	2259	60	140	85	9.5	1.0	15	0.5	3.0
177	1951	64	145	70	7.0	0.0	15	1.5	3.5
201	1951	63	120	58	4.2	2.5	12	1.5	3.0
215	2362	59	128	68	1.5	1.0	12	0.0	3.0
Means									
S. Families	2064	62	133	71	6.0	1.3	13	0.7	3.3
Population	*	64	119	60	5.4	*	7	0.8	4.3
Best check	*	66	120	57	4.0	*	9	0.2	3.7
All checks	*	65	112	56	3.5	*	6	0.8	4.4
LSD(5 %)	1139	5.0	ns	ns	ns	2.8	6	1.5	1.3
CV(%)	53	4	13	20	62.0	13	43	95	15

Best check TZESR-W

Other checks: Temp. x Trop n° 27, Safita 102, IRAT 178, BDS III Safita 2.

Table 9. Grain yield and other agronomic characters of 7 visually selected full-sib families from IPTT-TZUT at Loumbila, Burkina Faso, 1984 (Yield at 15% moisture).

Family	Grain Yield (Kg/ha)	Days to 50 % silking	Plant Height (cm)	Ear Height (cm)	Root Lodging (cm)	Stem Lodging (%)	Ears Harvested (Nº)	Ear Rot (%)	Ear Aspect (1-5)
8	2978	62	153	85	0.5	1.5	17	0.5	3.0
19	2362	60	140	90	3.0	2.0	14	0.5	3.5
23	1232	61	145	80	4.0	5.0	14	0.0	4.0
35	2567	61	145	78	0.5	2.5	15	1.5	3.0
44	1540	61	103	53	6.5	4.0	11	0.0	3.0
83	1540	63	140	70	6.0	0.5	12	0.5	3.0
115	2875	60	145	75	7.0	1.5	15	0.5	2.5
Means									
Sel. Family	2156	61	139	76	3.9	2.4	14	0.5	3.1
Population	*	64	119	60	5.4	*	7	0.8	4.3
Best Check	*	66	120	57	4.0	*	9	0.2	3.7
All checks	*	65	112	56	3.5	*	6	0.8	4.4
L.S.D.(5%)	1139	5.0	ns	NS	NS	2.8	6.0	1.5	1.3
C.V.(%)	53.0	4.0	13	20	62.0	126	43	95	15

Best Check TZESR-W

Other Checks: Temp. x Trop Nº 27, SAFITA-102, IRAT 178, BDS III, SAFITA-2.

Table 10. Grain yield and other agronomic characters of varieties tested in EVT-16 A Across locations (Farako-Bâ, Kamboinse) Burkina Faso, 1984 (Yield at 15 % moisture).

	Variety name	Grain yield kg/ha		Mean	Mean		
		Farako-Bâ	Kamboinse		Days to 50 % silking	Plant height (cm)	Ear height (cm)
1	Capinopolis 8245	4558	383	2471	54	157	79
2	Antalya(1) 8233	4319	560	2440	54	156	69
3	Safita-2	3944	762	2353	55	168	88
4	Sids 8245	4432	51	2242	54	162	75
5	Across 7748 RE	3581	872	2227	52	169	73
6	Islamabad 8245	4297	51	2174	56	169	80
7	Tlaltizapan 8233	3864	457	2161	48	159	70
8	Across 8245	3947	325	2136	48	144	61
9	Islamabad(1) 8245	4115	0	2058	55	149	67
10	Chuqui saca 8233	3951	154	2053	54	160	81
11	Temp x Trop nº 27	3358	743	2051	53	164	86
12	Sids (1) 8245	3859	227	2043	47	155	71
13	Tlaltizapan 8245	3796	205	2001	49	157	78
14	Antalya 8233	3375	609	1992	53	156	69
15	Pirsaback 8248	3331	283	1807	51	150	58
16	Tlaltizapan 8248	3224	360	1792	52	151	57
17	Across 7845 RE	3492	51	1772	56	153	75
18	Rampur (1) 8233	3398	128	1763	56	155	65
19	Pirsaback (1) 8248	2789	256	1523	51	150	51
Mean		3770	341	2056			
L.S.D. (5 %)		904	ns				
C.V. (%)		17	140				

c) ELVT-18B. 12 elite varieties from CIMMYT along with 2 checks (Safita 102 and Temp. x Trop. N° 27) were tested at 2 locations, Kamboinse and Farako-Bâ. At Kamboinse the trial was severely affected by drought.

At Farako-Bâ, Ilonga 8032 yielded significantly (32 %) higher than the best check Safita-102. Across 8149 was also promising (30 % more than the best check). Table 11 shows the yield performance and other agronomic characters of tested varieties.

d) ELVT-18A. Fifteen elite late varieties developed by CIMMYT along with 2 checks (Safita-102 and Temp. x Trop. N° 27) were tested at Farako-Bâ. The trial was planted after bush-fallow and affected by Nitrogen and Phosphorus deficiency. No significant difference in yield was observed between the best entry and the best check (Temp. x Trop. N° 27). Poza Rica 8126 and Muneng 8128 were the most promising varieties (Table 12). Across 7729 RE, Safita-102 and Across 8121 were the latest entries and Poza Rica 8126 and Temp. x Trop. N° 27 were the earliest. Londrina 8136 and Across 8121 are highly susceptible to root and stem lodging.

e) EVT-LSR-W. Nine white, late, streak resistant varieties developed by IITA/Ibadan along with 2 checks (Temp. x Trop. N° 27 and Safita-102) were tested at Vallee du Kou. The trial was planted late to enhance the streak attack and a supplemental irrigation was needed. In Table 13 yield data and agronomic characters of tested varieties are reported. There is no significant difference in yield between the best entry EV 8322-SR BC 3 and the best check (Safita-102). However both checks and Gusau 81 TZB are significantly more susceptible to streak than all tested varieties. EV 8322-SR BC 3 is the higher yielding variety. Gusau 81 TZB and Temp. x Trop. N° 27 were more susceptible to root lodging than all tested varieties.

f) Hybrid trial. Two sets including 11 white hybrids developed at IITA/Ibadan along with 2 checks (Safita-102 and Temp. x Trop. N° 27) were tested at two locations (Saria and Loumbila). At Saria five hybrids yielded significantly higher than the best check (Safita-102). The best entry was 8346-1 which yielded 48 % more than the best check. At Loumbila two hybrids significantly out-yielded the best check Temp. x Trop. N° 27. The hybrid 8326-17 was the best yielded at this locality (216 % of the check, Table 14).

Table 11. Grain yield and other agronomic characters of varieties tested in ELVT-18B across locations (Kamboinsé and Farako-Bâ), Burkina Faso, 1984 (yield at 15 % moisture).

	Variety name	Yield(kg/ha)		Mean	Mean		
		Kamboinsé	Farako-Bâ		Days to 50 % silking	Plant height (no)	Ear height (no)
1	Across 8149	130	4083	2107	58	130	61
2	Ilonga 8032	52	4154	2103	61	158	82
3	La Molina 8131	362	3582	1972	51	150	69
4	Suwan(1) 8131	259	3582	1921	53	150	66
5	Across 8035	259	3460	1860	58	153	65
6	Comayagua 8130	310	3391	1851	56	153	74
7	Islamabad(1) 8131	414	3245	1830	52	160	75
8	Across 7726 RE	52	3590	1821	61	156	73
9	Pirsaback(1) 7930 RE	362	3272	1817	53	145	75
10	Poza Rica 8126	156	3457	1807	58	156	80
11	Rattray Arnd(1) 8149	181	3425	1803	58	145	71
12	CIAT 8130	232	3346	1789	55	162	84
13	Check(1) Safita 102	52	3145	1599	62	149	83
14	Check(2) Temp x Trop Nº 27	130	2695	1413	55	137	59
Mean		211	3459				
L.S.D. (5 %)		219	971				
C.V. (%)		73	20				

Table 12. Grain yield and other agronomic characters of varieties tested in ELVT-18 A at Farako-Bâ, Burkina Faso, 1984 (yield at 15 % moisture).

Variety Name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (n°)
1 Poza Rica 8126	2903	63	144	64	7.3	4.3	39
2 Muneng 8128	2773	66	151	71	1.9	1.2	35
3 Los Baños 8027	2718	65	159	73	3.5	1.8	39
4 Ilonga 8043	2695	67	184	89	6.3	2.5	36
5 Check(II) T x T N° 27	2682	63	165	84	1.3	4.0	37
6 La Molina 8128	2669	66	145	70	4.7	3.9	39
7 Poza Rica 8129	2578	65	155	89	7.7	2.6	36
8 Londrina 8136	2520	64	165	74	10.9	11.6	34
9 Santa Rosa 8043	2495	68	179	99	7.7	5.0	37
10 Guarere(1) 8128	2436	67	152	76	4.5	5.6	37
11 Across 7728 RE	2427	67	161	89	4.6	2.0	37
12 Fereke(1) 8128	2424	68	160	78	4.4	5.7	36
13 Across 8024	2360	67	135	65	4.3	7.2	38
14 Poza Rica 8121	2121	68	163	83	6.4	5.0	35
15 Across 7729 RE	2101	69	157	80	0.0	7.5	33
16 Check(1) Safita 102	2090	69	153	64	6.8	4.9	32
17 Across 8121	1582	69	154	75	16.6	5.6	30
Mean	2446	67	158	78	5.8	4.7	36
L.S.D. (5 %)	607	3	ns	23	10	5.0	ns
C.V. (%)	17	3	11	21	122	78	11

Table 13. Grain yield and other agronomic characters of varieties streak resistant tested in EVT LSR-W at Vallée du Kou (Burkina Faso), 1984.
Yield at 15% moisture.

	Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stalk lodging (Nº)	Ears harvested (Nº)	Streak plants (Nº)
1	EV 8322-SR BC3	5591	65	213	117	0.4	0.0	36	0.0
2	GUSAU-81 TZB	5570	65	231	133	2.1	0.8	37	2.5
3	EV 8329-SR BC3	5510	64	209	107	0.9	0.5	38	0.8
4	EV 8343-SR BC3	4963	65	214	120	0.7	0.5	35	0.3
5	SAFITA-102	4770	64	184	105	1.4	1.0	36	4.0
6	SEKOU-81 W	4656	65	223	124	1.1	0.8	32	0.5
7	ACROSS-81 W	4633	65	210	111	1.0	0.0	33	0.3
8	EJURA-81 W	4262	66	206	106	0.9	0.5	29	0.0
9	BERTOUA-81 W	4172	64	209	111	1.1	1.3	28	0.0
10	Temp. x Trop. Nº 27	3595	62	197	95	1.8	1.5	32	2.3
	Mean	4772	65	210	113	1.1	0.7	34	1.1
	L.S.D. (5%)	1354	ns	23	14	1	ns	ns	1.0
	C.V. %	20	3	8	8	67	141	14	84

Table 14. Grain yield and other agronomic characters of hybrids tested in international white hybrid trial at Saria and Loumbila, Burkina Faso, 1984 (yield at 15 % moisture).

Variety Name		YIELD KG/HA			MEAN					
		Saria	Loumbila	Mean	Days to 50 % silking	Plant height (n°)	Ear height (n°)	Root lodging (n°)	Stalk lodging (n°)	Ears harvested (n°)
1	8326-17	2981	3488	3235	62	144	59	2.4	1.0	31
2	8321-18	3181	2996	3089	63	157	71	2.0	0.9	30
3	8346-1	3209	2529	2869	60	134	51	1.0	5.3	35
4	8322-3	3160	2541	2851	61	137	59	3.0	2.9	35
5	8322-13	2824	2712	2768	62	147	59	0.4	1.0	34
6	8346-3	3137	2286	2712	62	148	62	1.9	0.6	32
7	8338-1	2898	1985	2442	62	164	64	0.6	6.5	32
8	8328-10	2324	2301	2313	65	165	70	1.0	1.5	27
9	8321-21	2318	2173	2246	62	121	49	1.0	0.6	29
10	PR-7822-SR	1742	2055	1899	64	149	58	2.0	2.0	24
11	Check	2173	1519	1846	63	146	57	0.9	1.4	20
12	Check	2066	1542	1804	60	141	59	2.5	1.8	24
13	8324-18	1992	1356	1674	63	126	53	1.3	0.4	24
Mean		2616	2268	2442	62	145	59	1.5	2.0	29
Coef. of variation		21	42							
L.S.D. (5 %)		771	1352							

* Checks at Saria : Safita 102 and Safita 2

Checks at Loumbila : Temp x Trop n° 27 and Safita 102

2.3 Drought resistance

2.3.1 Population improvement

A.O. Diallo, M.S. Rodriguez, and V.L. Asnani

After poor soil fertility, drought is the most yield limiting factor for maize production in Sudan Savanna. Drought can also drastically affect yield in the Northern Guinea Savanna. Breeding for drought resistance has thus become the major objective of SAFGRAD/IITA Maize Program. This work started in the 1982 dry season and continued in 1983. Pool 16 was identified as a drought tolerant material when compared to other twenty six materials tested along with it under several drought stress conditions using controlled irrigation. In 1983 rainy season, full sib families were developed and tested in the following dry season. This year (1984) 219 full-sib families along with 6 checks were planted in a split-plot design under 2 ridging systems : single ridges and tied ridges with ridges as main plots and tied ridges as sub-plots with 2 replications. Each family (sub plot) consisted of 2.5 m long with two plants per hill. The spacing between hills and rows was 0.5 and 0.75 m respectively. By using both ridging systems, each family was tested under 2 drought stress environments : more stress and less stress.

The remnant seed of the 219 full-sib families was plantec in a separate nursery and crossed to Pool 16-SR BC 4 F2 (from IITA).

The trial received only 227.4 mm rainfall after planting. Considering the low rainfall and its poor distribution, the trial received small supplementary irrigations to insure some grain harvest.

The F test was statistically significant (5 % level) for ridging systems and for families. The families x ridging systems interaction was statistically significant only at about 10 %. Given the very large experimental error (CV = 89.4 %), these results suggest that the relative family performance was affected by the stress level.

Ten families that performed better than the population mean at each stress level were selected to create an experimental variety. Another 8 families were selected on the basis of lower yield under conditions of more stress and higher yield under conditions of less stress (in relation to the population mean), to develop another experimental variety. For population regeneration, 18 other families, the mean of which was higher than the mean of the population under both conditions (275 and 487 kg/ha under more and less stress, respectively, for the selected families as compared to population means of 140 and 331 kg/ha), were selected and added to the 10 best families. Yield, plant height, and days to silk of the 2 groups of selected families are presented in Tables 15, 16 and Figure 1.

2.3.2 Varietal evaluation

M. Rodriguez and A.O. Diallo

It is important to evaluate the performance of maize populations or varieties under both low and high drought stress conditions in order to identify those that will be better adapted to different farmers' conditions. In addition, if materials less susceptible to drought stress can be identified, they can be recombined to create a drought resistance pool useful in the breeding of drought resistant maize.

The research of the previous 5 years has shown a very marked yield response of maize to ridge-tying under the ferruginous tropical soils common in the Sudan Savanna. By growing a set of varieties under both simple and tied ridges, their performance under 2 drought stress conditions (more and less) can be evaluated. Twenty early maize genotypes were thus evaluated in 1984 at Kamboinse (Burkina Faso) at a uniform density of 44,400 plants/ha and with a fertilizer dose of 97-46-30 kg/ha ($N-P_2O_5-K_2O$). The plots had 3 rows and were replicated six times.

Given the very low rainfall in 1984, the trial received 3 small irrigations, each equivalent to 8 mm. Nevertheless, grain yields were very low, even under tied ridges. There was a statistically significant (5 % level) response to tied ridges (269 VS 509 kg/ha). There were highly significant differences between varieties, with an indication of a possible differential performance under more and less stress conditions (the Ridging System x Variety interaction was statistically significant at the 7 % level in spite of a very high C.V. of 49.2 %). Table 17 shows the mean grain yields, days to 50 % silking and plant height of the 20 materials evaluated (Note : the data for flowering is only from those tied-ridges plots where 50 % silking was reached and it is given to indicate the maturity cycle of each material). The relative performance of all entries at both stress levels is shown in Figure 2. The best (grain yield) 5 materials were Local Loumbila (534 kg/ha), Pool 18 (SAFGRAD), Temperate x Tropical 42, Local Raytiri and Local Koudougou. Although the local varieties of Loumbila, Raytiri and Koudougou are among the earliest in the trial, not all early varieties had a good performance. There was no relationship between days to

Table 15. Yield, days to silk and plant height of 10 best performing under both stress conditions

Entry	More Stress			Less Stress		
	Yield (kg/ha)	Days to 50 % silking	Plant height	Yield kg/ha	Days to 50 % silking	Plant height
29	447	55.5	93	413	55.5	118
35	491	54.1	90	651	55.5	115
70	329	55.0	90	781	54.5	130
80	622	56	93	588	52.5	140
84	283	53	85	495	57.0	108
97	314	51.5	105	791	50.0	153
109	402	54.5	78	457	52.0	118
144	326	53.0	90	960	47.0	148
203	246	54.5	105	358	54.5	132
216	464	53.0	95	519	56.5	113
Mean of selected families	392	54.0	92	601	53.5	128
Pop. Mean	140	54.7		331	54.9	
Check Means	245	51.3		420	52.6	
LSD (5%)	419	9.9		419	9.9	
C.V. (%)	89.4	9.2		89.4	9.2	

F. tests : Ridging * Families * F X F n.s.

* 1 = Significant at 5%

n.s. = Non-significant

Table 16. Yield, days to silk and plant height of 8 families with poor performance under more stress and relatively good performance under less stress.

Entry	More Stress			Less Stress		
	Yield (kg/ha)	Days to 50 % silking	Plant height	Yield (kg/ha)	Days to 50 % silking	Plant height
7	74	58.5	73	789	55.5	135
18	40	52.1	103	436	53.5	147
44	0.0	57.5	95	507	54.5	145
55	64	53.5	80	765	53.5	130
114	92	52	98	715	50.0	145
138	63	52.1	63	1072	48.5	118
162	0.0	54.8	78	542	55.0	95
75	6	54.1	80	523	54.5	108
Mean of Selected families	42	54.3	84	669	53,1	128
Pop. Mean	140	54.7		331	54.9	
Checks Mean	245	51.3		420	52.6	

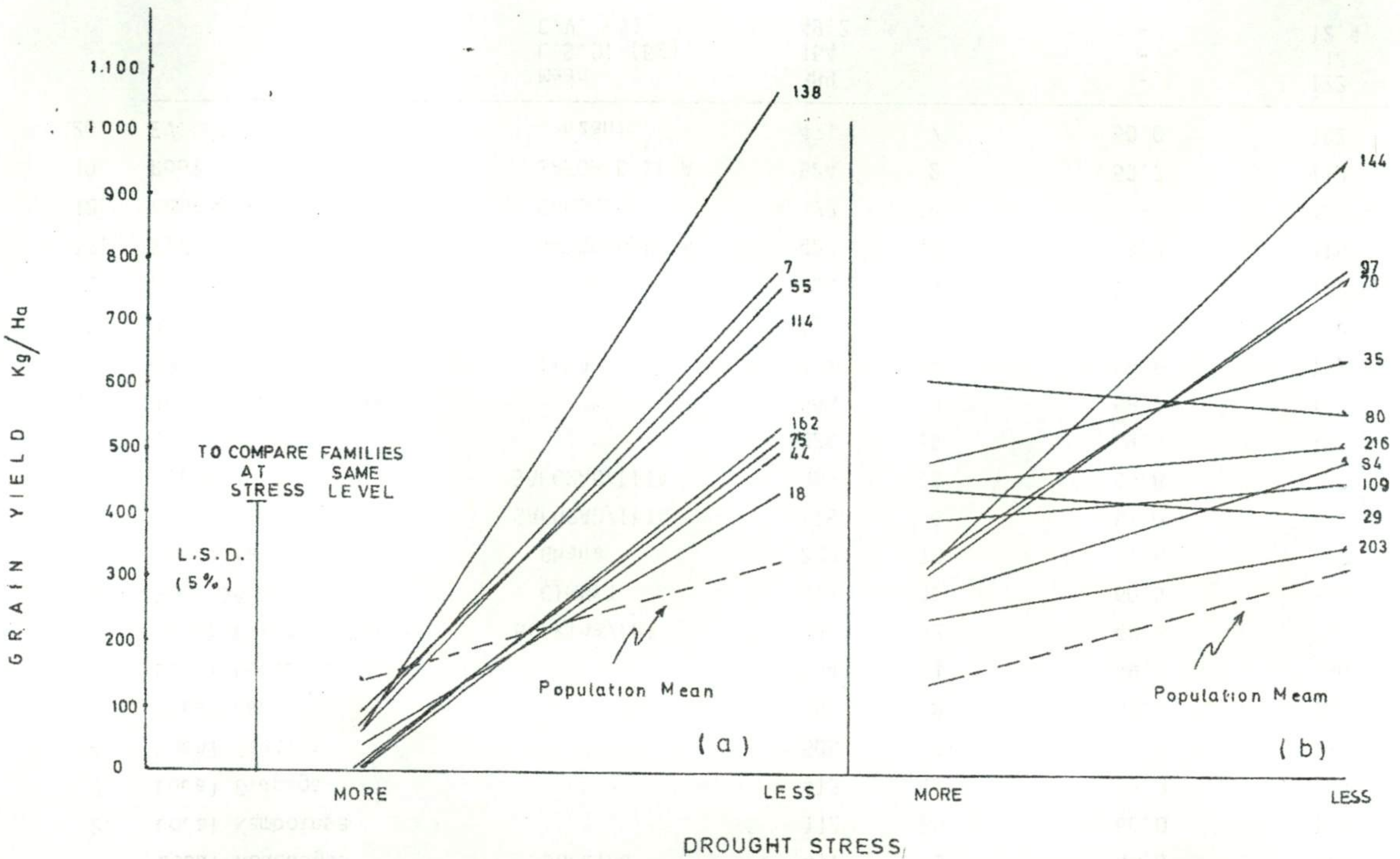


FIG 1, (a) Maize grain yield of 8 selected full sib families performing below and above the population mean under more and less drought stress conditions, respectively.

(b) Maize grain yield of 10 selected full-sib families performing above the population mean under both stress conditions population pool 16 (219 families) Kamboinsé (BURKINA FASO), 1984.

Table 17: Mean grain yield, days to flowering and plant height of 20 maize varieties, Stress trials, Kamboinse, 1984.

	Entry	Origin	Grain Yield kg/ha	Grain Yield Rank	50% silking days	Plant Height (cm)
1.	Local Koudougou	Burkina	491	5	48.0	118
2.	Local Kamboinse	"	112	20	60.0	115
3.	Local Diapaga	"	413	11	53.8	123
4.	Local Raytiri	"	505	4	47.2	132
5.	Local Pabre	"	459	8	53.2	121
6.	Local Loumbila	"	534	1	49.0	136
7.	Jaune Flint de Saria	Burkina/IRAT	394	12	48.6	116
8.	Pool 34 QPM	CIMMYT	317	16	60.5	114
9.	Early Yellow	Ghana	220	18	61.0	113
10.	Safita-104	SAFGRAD/IITA	475	6	51.0	120
11.	TZE-4	SAFGRAD/IITA	389	13	53.8	122
12.	Safita-2	"	320	15	59.5	126
13.	Temp x Tropical 42	"	508	3	58.7	132
14.	DMR-Y	IITA	422	9	58.6	132
15.	TZESR(W)	IITA	273	17	52.5	148
16.	Pirsabak(1) 7930	CIMMYT	355	14	57.5	122
17.	TZE 16 Across-W	SAFGRAD/IITA	422	10	53.2	115
18.	Composite 77 BD	Senegal	177	19	-	107
19.	Pool 18 (SAFGRAD)	SAFGRAD/IITA	524	2	53.7	112
20.	EV. 8188	Tanzania	471	7	50.0	122
		Mean	389		-	122
		L.S.D. (5%)	154		-	12
		C.V. (%)	49.2		-	12.4

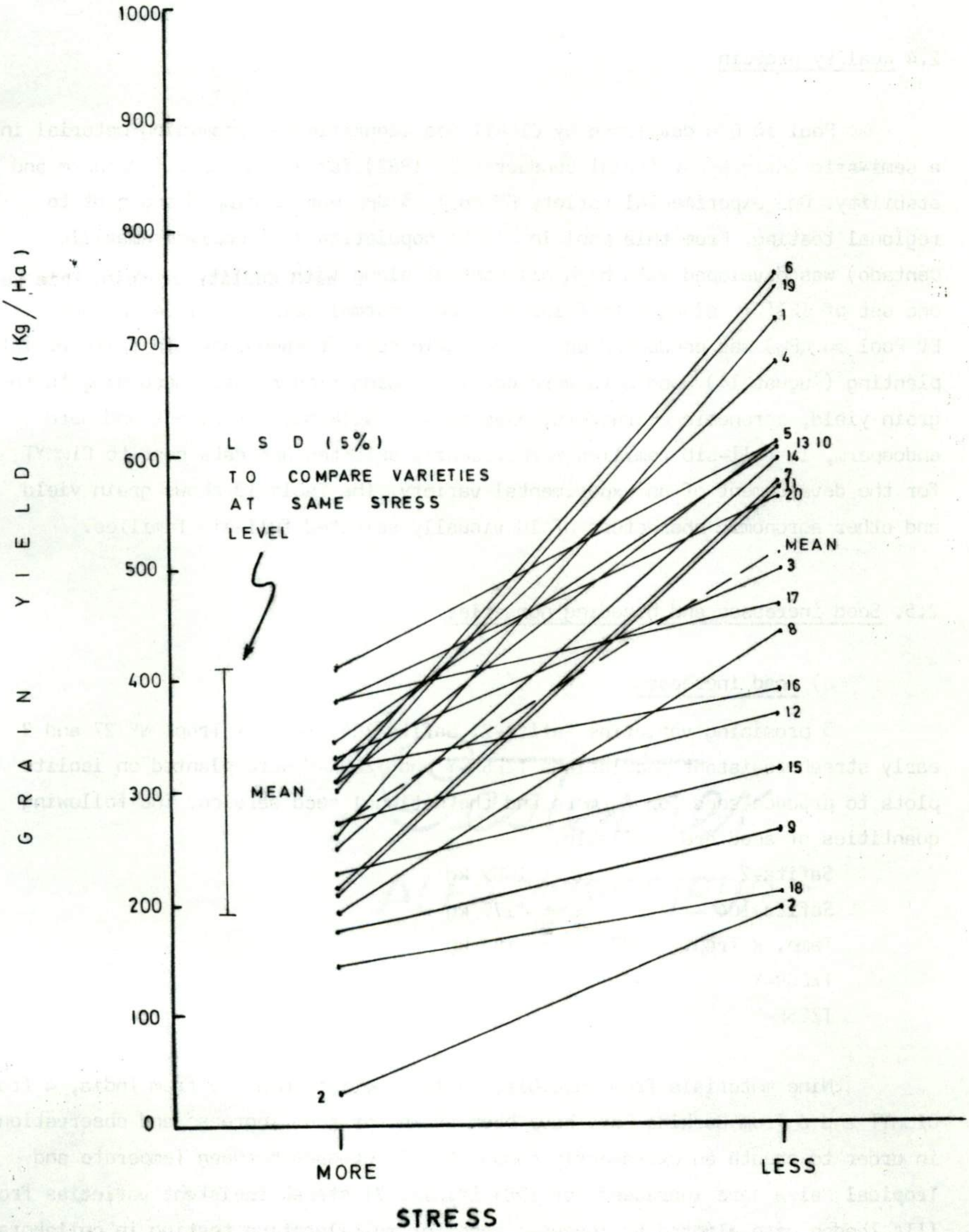


FIG 2. GRAIN YIELDS OF 20 MAIZE VARIETIES UNDER 2 DROUGHT STRESS LEVELS. KAMBOINSE (BURKINA FASO) 1984.

silk and grain yield under more stress. This experiment will be conducted again in 1985 to verify the 1984 results.

2.4 Quality protein

Pool 34 QPM developed by CIMMYT was identified as promising material in a semi-arid environment (trial conducted in 1982) for yield, hard endosperm and stability. One experimental variety EV Pool 34 QPM was developed and sent to regional testing. From this pool in CIMMYT population 70 (Templado Amarillo Dentado) was developed with high oil content along with quality protein. This year one set of IPTT 70 along with 6 local checks (normal maize, Pool 34 QPM and EV Pool 34 QPM) was conducted on hydromorphic soil at Kamboinse. In spite of late planting (August 14) good data were obtained using tied ridges. According to the grain yield, agronomic characters, days to 50 % silking, ear aspect and hard endosperm, 10 full-sib families were visually selected and data sent to CIMMYT for the development of an experimental variety. The Table 18 shows grain yield and other agronomic characters of 10 visually selected full-sib families.

2.5. Seed increases and breeding nurseries

a) Seed increases

3 promising varieties Safita-2, Safita-104, Temp. x Trop. N° 27 and 2 early streak resistant populations TZESR-Y and TZESR-W were planted on isolite plots to produce seed for farmers and the national seed service. The following quantities of seed are available.

Safita-2	: 1089 kg
Safita-104	: 179 kg
Temp. x Trop. N° 27	: 143 kg
TZESR-Y	: 136 kg
TZESR-W	: 300 kg.

Nine materials from Colombia, 25 from Soviet Union, 3 from India, 4 from CIMMYT and 6 from Burkina Faso have been grown for seed increase and observations in order to create an extra-early composite. 73 crosses between Temperate and Tropical Maize were increased for 1985 trials. 21 streak resistant varieties from IITA Ibadan were planted to increase seed for multilocation testing in collaboration with the national program of Burkina Faso. 26 varieties intended for regional testing (RUVT) were increased. 3 materials with the latente gene were grown for seed increase and observations for drought resistance work. 10 crosses between

Table 18. Grain yield and other agronomic characters of 10 visually selected full-sib families from IPTT 70 at Kamboinsé, Burkina Faso 1984.

Family	Grain Yield (Kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (Nº)	Ear aspect (1-5)	Hard endosp. (1-5)
26	2765	52	143	63	0.0	1.5	12	3.0	2.5
91	2466	56	133	70	2.0	0.0	11	3.0	2.5
111	3277	53	140	70	0.0	1.5	20	3.0	2.5
123	3689	52	128	60	0.0	2.5	14	2.5	2.0
160	2673	52	148	58	0.0	2.5	11	3.5	3.0
207	2655	58	140	65	1.0	0.5	12	2.0	2.5
226	2874	55	118	43	0.5	2.5	13	3.0	2.5
228	2764	53	120	63	0.5	2.5	13	3.5	3.0
229	3385	53	130	60	0.0	0.0	15	2.0	2.5
235	2971	56	128	45	0.0	1.0	11	3.0	2.5
Means									
Sel.Families	2952	54	133.0	60	0.4	1.5	13	3.0	2.6
Population	1845	56	133	66	*	*	11	3.7	3.1
Best check	2233	52	117	57	*	*	16	4.2	-
All checks	1865	57	124	62	*	*	14	4.3	-
L.S.D.(5 %)	ns	7	34	24	ns	ns	ns	ns	ns
C.V.(%)	40	6	12.0	18.0	155.0	129	36	22	35

* Affected by missing data

Best check EV Pool 34 QPM

Other checks Pool 34 QPM, Temp. x Trop. Nº 27

- Normal maize.

inbred lines from IITA and perenial maize were increased for termite resistance work in collaboration with the SAFGRAD Agronomist and Entomologist.

b) Breeding nurseries

Thirty six improved varieties of various origin (CIMMYT, IITA, national programs of SAFGRAD member countries) were crossed with Jaune Flint de Saria (Local improved variety well adapted in our area) in order to combine yield, earliness, root lodging and foliaire disease resistance.

The remnant seed of 219 full-sib families of Pool 16 tested in drought trial were planted and crossed with Pool 16 streak resistant from IITA Ibadan to combine drought and streak resistance in this promising pool developed by CIMMYT.

3. SEMI-ARID REGIONAL ADAPTATION TESTING

In 1984, IITA/SAFGRAD organized and coordinated 3 regional variety trials grouped in : (1) RUVT-1 (early maturity) ; (2) RUVT-2 (intermediate maturity) and (3) SAFGRAD Adaptation Trial (SAT). The entries of RUVT-1 and RUVT-2 were nominated by the national programs of SAFGRAD member countries and regional or international institutions. The early and intermediate promising pools and populations from CIMMYT and IITA were evaluated in SAT.

Twenty seven sets of RUVT-1 were sent to 17 countries and 26 sets of RUVT-2 to 15 countries whereas 7 sets of the SAT were sent to 4 countries.

Because of different cropping season and other logistic problems, at the time of writing this report, data from 5 locations for RUVT-1, 6 locations for RUVT-2 and 4 locations for SAT were available. Data from remaining locations will be reported in a complementary report.

3.1 Regional uniform early variety trial (RUVT-1)

The tables (19, 20, 21, 22, 23) show the grain yield and other agronomic characters of varieties tested in RUVT-1 at Sekou (Benin), Kaedi (Mauritania), Gampela, Saria (Burkina Faso) and Broukou (Togo). On table 24, data across 4 locations are reported.

Table 19. Grain yield and other agronomic characters of varieties tested in RUVT-1 at Sekou, Benin, 1984 (yield at 15 % moisture).

	Variety name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (no)	Stem lodging (no)	Ears harvested (no)	Streak attack (no)
1	Synth. C	4261	53	209	103	10.0	1.8	41	1.3
2	EV Gusao 81 Pool 16	3858	50	181	75	2.3	1.3	36	0.3
3	Safita 2	3665	50	198	86	2.8	2.0	40	1.8
4	TZESR-W	3589	52	210	95	5.3	3.0	38	0.3
5	Pirsaback(1) 7930	3571	50	188	84	9.0	3.5	36	0.5
6	EV Kamb. TZE 12	3503	51	181	93	9.0	3.0	39	0.8
7	Temp x Trop nº 42	3425	53	200	95	6.5	2.0	36	1.0
8	NCP 80 (check)	3362	50	191	98	2.8	0.5	42	1.0
9	Temp x Trop nº 3	3150	54	204	90	4.0	1.8	35	0.3
10	EV Pool 34 QPM	3146	51	185	75	5.8	1.0	42	1.3
11	EV 8188	3043	47	166	65	5.0	2.0	39	0.5
12	Pop Senegal O.	2745	50	209	98	23.0	6.5	34	2.0
13	Safita 104	2412	48	175	81	12.3	2.0	35	0.0
	Mean	3364	51	192	88	7.6	2.3	38	0.9
	L.S.D. (5 %)	485	2.0	18	ns	5.0	2.0	5	ns
	C.V. (%)	10	3	6	19	50.0	57.0	10	163

Table 20. Grain yield and other agronomic characters of varieties tested in RUVT-1 at Kaedi, Mauritania 1984.
(Yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Stem lodging (Nº)	Ears harvested (Nº)
1. Pop Senegal Oriental	1226	56	166	104	3.5	60
2. Synth C	1179	53	152	77	2.3	56
3. EV. Kamboinse TZE-12	1095	50	126	56	3.3	53
4. Pirsaback (1) 7930	1095	52	141	71	2.5	59
5. Temp. x Trop. Nº 42	1083	53	134	73	3.8	62
6. EV Pool 34 QPM	1060	50	149	70	2.8	53
7. EV 8188	1048	48	128	52	2.5	53
8. EV. GUSAU 81 Pool 16	1012	49	145	84	4.0	55
9. TZESR.W	964	51	150	90	2.8	51
10. SAFITA-2	845	53	147	77	3.8	43
11. SAFITA-104	845	47	130	48	5.0	49
12. Check variety	798	54	132	85	3.3	57
13. Temp x Trop. Nº 3	774	54	154	79	2.3	49
Mean	1002	52	143	74	3.2	54
L.S.D. (5%)	ns	5	20	16	ns	ns
C.V. (%)	36	7	10	15	65	24

Table 21. Grain yield and other agronomic characters of varieties tested in RUVT-1 at Gampela, Burkina Faso, 1984 (yield at 15 % moisture).

	Variety name	Grain yield (kg/ha	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (no)	Stem lodging (no)	Plants harvested (no)	Ears harvested (no)
1	TZESR-W	1147	65	158	54	2.0	10.0	80	75
2	Temp x TROP N°3	996	64	146	42	5.5	9.5	70	68
3	Synth. C	908	68	139	35	5.8	14.5	63	57
4	Temp x Trop n°42	895	65	138	33	5.8	12.5	69	58
5	EV Gusao 81Pool16	832	60	122	30	3.8	10.8	73	67
6	Safita 2	807	66	129	41	5.5	7.3	72	68
7	Safita 104	782	63	116	29	4.0	10.3	66	63
8	Check variety (J.F.S.)	744	62	129	30	7.3	13.5	71	61
9	Pop Senegal O.	718	48	145	45	2.5	8.3	57	47
10	EV Kamb. TZE 12	706	66	134	38	5.5	9.8	60	55
11	EV Pool 34 QPM	643	68	116	25	3.3	7.8	72	69
12	Pirsaback(1) 7930	429	61	119	33	5.8	13.8	62	53
13	EV 8188	403	60	118	26	3.0	13.0	57	52
Mean		770	63	131	35	4.6	10.9	67	61
L.S.D. (5 %)		352	ns	19	17	ns	ns	ns	ns
C.V. (%)		32	15	10	33	73	68	18	19

Table 22. Grain yield and other agronomic characters of varieties tested in RUVT-1 at Saria, Burkina Faso, 1984.
(Grain yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silk	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (n°)
1. Temp x Trop. N°3	1740	61	123	54	0.0	1.8	53
2. EV Pool 34 QPM	1727	57	100	33	0.7	1.0	66
3. Synth. C	1689	62	118	46	1.6	1.6	55
4. Temp. x Trop. N° 42	1450	61	109	39	0.6	0.4	60
5. Pop Senegal Oriental	1324	59	131	53	0.5	1.6	48
6. EV Kamboinse TZE 12	1324	57	114	41	0.0	0.6	46
7. SAFITA-104	1235	52	98	33	0.0	0.8	54
8. EV 8188	1223	51	101	29	0.5	1.7	48
9. SAFITA-2	1192	60	110	41	0.0	0.0	47
10. TZESR (W)	1185	61	110	41	0.0	1.2	44
11. Pirsaback (1) 7930	1134	59	101	34	0.2	1.4	56
12. EV GUSAU 81 Pool 16	1122	59	96	35	0.8	0.9	43
13. J.F. de Saria (Check)	807	55	108	34	0.0	2.5	40
Mean	1319	58	109	39	0.4	1.2	51
L.S.D. (5%)	502	3	15	13	ns	ns	20
C.V. (%)	26	4	9	24	280	124	27

Table 23 . Grain yield and other agronomic characters of varieties tested in RUVT-1 B at Broukou, Togo, 1984 (yield at 15 % moisture).

	Variety name	Grain yield (kg/ha)	Days to 50 % silk ing	Plant height (cm)	Ear height (cm)	Root lodging (No)	Stem lodging (no)	Ears harvested (no)	Streak attack (no)
1	Check variety	5929	53	195	105	0.5	0.8	92	1.5
2	TZESR(W)	5036	50	182	80	2.0	1.3	98	1.0
3	EV 8330 SR	5024	47	153	68	1.8	0.5	99	1.3
4	Temp x Trop n° 42	4250	48	150	58	0.7	1.3	94	1.8
5	Safita 2	3893	51	128	66	1.3	1.5	87	1.5
6	Pirsaback(1) 7930	3786	49	140	59	1.0	0.8	91	1.8
7	Local x Imp (bulk)	3286	42	164	78	2.8	2.0	85	1.3
8	EV 8188	3119	41	135	44	1.0	1.3	90	1.5
9	Pop Senegal O.	3036	50	176	84	3.8	2.0	82	1.3
10	EV Pool 34 QPM	2964	50	124	47	0.5	1.8	89	1.3
11	EV Kamb. TZE 12	2619	49	135	58	1.3	1.3	91	1.8
12	Safita 104	2452	42	133	57	1.0	0.8	80	1.0
13	TZE 16 Across(white)	2381	44	122	49	3.3	1.5	84	1.3
Mean		3675	47	149	66	1.6	1.3	89	1.4
L.S.D. (5 %)		842	3	27	22	ns	ns	11	ns
C.V. (%)		16	5	13	23	130	91	8	50

Table 24. Grain yield and other agronomic characters of varieties tested in RUVT-1 at 4 locations (Sekou-Bénin, Kaedi-Mauritanie, Gampela-Burkina Faso, Saria-Burkina Faso). 1984.

Variety name	Grain yield kg/ha at 15 % moisture				Mean	Mean		
	Sekou Bénin	Kaedi Mauritania	Gampela Burkina	Saria Burkina		Days to 50 % silking	Plant height (cm)	Ear height (cm)
1 Synth. C.	4261	1179	908	1689	2009	59	155	65
2 TZESR-W	3589	964	1147	1185	1721	57	157	70
3 Temp x Trop n° 42	3425	1083	895	1450	1713	58	145	60
4 EV Gusao 81 Pool 16	3858	1012	832	1122	1706	55	136	56
5 Temp x Trop N° 3	3150	774	996	1740	1665	58	157	66
6 EV Kamb. TZE 12	3503	1095	706	1324	1657	57	145	56
7 EV Pool 34 QPM	3146	1060	643	1727	1644	57	142	55
8 Safita 2	3665	845	807	1192	1627	57	146	61
9 Pirsaback (1) 7930	3571	1095	429	1134	1557	56	137	56
10 Pop Senegal Oriental	2745	1226	718	1324	1503	53	163	75
11 EV 8188	3043	1048	403	1223	1429	52	128	43
12 Check varieties	3362	798	744	807	1428	55	140	62
13 Safita 104	2412	845	782	1235	1319	53	130	48
Mean	3364	1002	770	1319	-	-	-	-
L.S.D. (5 %)	485	ns	352	502	-	-	-	-
C.V. (%)	10	36	32	27	-	-	-	-

Table 25. Grain yield and other agronomic characters of varieties tested in RUVT-2 at SANGUERE, Cameroon, 1984. (Yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears Harvested (Nº)
1. TZB GUSAU	5273	63	205	111	72
2. IRAT 178	5094	63	171	108	64
3. Check variety	4664	64	196	113	61
4. Elite x E. Mex. Comp.	4619	63	194	103	63
5. TUXP. DR.	4426	61	185	103	66
6. Temp. x Trop. Nº 27	4334	60	185	88	59
7. TZSR-1 (Y)	4090	65	189	95	55
8. Poza Rica 7843	3923	65	169	91	58
9. Fereke 7622	3914	62	195	109	60
10. SAFITA-102	3287	64	176	78	57
11. EV 8176	3127	56	191	96	59
12. ATK 82ZR	2786	62	193	90	39
Mean	4128	62	187	99	59
LS.D. (5%)	1323	3.00	ns	ns	15
C.V. (%)	22	3	10	17	18

Table 26 Grain yield and other agronomic characters of varieties tested in RUVT-2 at Touboro, Cameroon, 1984 (yield at 15 % moisture).

Variety name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Root lodging (cm)	Stem lodging (%)	Ears harvested (nº)
1 Safita-102	4112	69	240	2.7	2.7	71
2 Fereke 7622	4062	70	255	3.6	1.2	74
3 IRAT 178	3952	70	215	1.8	2.5	75
4 TZB Gusau	3730	72	255	4.0	1.4	78
5 Tuxp. DR	3507	67	230	3.9	3.7	69
6 Elite x E. Mex. Comp.	3478	68	205	1.9	2.8	71
7 ATK 82 ZR	3413	69	250	5.4	0.5	54
8 Temp. x Trop. Nº 27	3386	67	235	0.7	4.8	72
9 Poza Rica 7843	3359	68	260	2.6	1.8	66
10 Check variety	3339	67	230	6.8	2.6	69
11 TZSR-1 (Y)	2969	70	300	6.1	4.7	67
12 EV 8176	2658	55	200	7.6	6.6	61
Mean	3497	67	240	3.9	2.9	69
L.S.D. (5 %)	706	4	10	ns	ns	9
C.V. (%)	14	4	0.06	94	127	9

Table 27. Grain yield and other agronomic characters of varieties tested in RUVT-2 at Farako-Bâ, Burkina Faso, 1984. (yield at 15 % moisture)

Variety Name		Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (n°)	Streak attack (n°)
1	Temp x Trop N° 27	3379	61	177	85	4.2	1.3	76	3.5
2	Poza Rica 7843	3488	66	191	108	3.5	1.4	73	9.3
3	IRAT 178 (check)	3303	65	200	89	3.9	1.4	77	8.8
4	TZB Gusau	3298	66	183	96	2.8	1.2	75	3.3
5	Elite x E. Mex Comp.	3146	65	178	95	5.4	1.7	76	5.8
6	Tuxp. DR	2997	64	154	74	4.0	1.5	72	11.3
7	EV 8176	2930	55	169	88	4.5	2.1	69	9.8
8	ATK 82 ZR	2615	66	189	99	4.0	1.0	65	2.8
9	Fereke 7622	2552	68	156	76	4.3	1.4	67	8.8
10	TZSR-1 (Y)	2446	65	189	101	3.5	1.5	64	0.3
11	Safita-102	2258	67	160	83	3.2	0.7	68	11.8
12	Jaune Flint de Saria	1625	52	144	66	4.8	1.1	61	4.3
Mean		2853	63	174	88	4.0	1.4	70	6.6
L.S.D. (5 %)		902	3	ns	ns	ns	ns	9	5.0
C.V. (%)		22	3	16	24	43	69	9	53

Table 2 8 Grain yield and other agronomic characters of varieties tested in RUVT.2 at Loumbila, Burkina Faso, 1984.
(Yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (Nº)
EV 8176	1874	62	165	70	6.4	2.3	45
IRAT 178	1810	67	173	75	15.1	2.0	45
Poza Rica 7843	1669	66	183	84	15.0	3.0	42
TZSR-1 (Y)	1553	67	179	74	3.4	0.0	39
Elite x E.Mex. Comp.	1540	66	165	75	21.0	2.2	41
Temp x Trop. Nº 27	1527	64	164	65	8.8	1.5	36
Tuxp D.R.	1450	64	155	59	8.0	0.8	36
Fereke 7622	1361	64	154	59	15.3	3.1	35
Check variety (J.F.S)	1335	50	166	70	8.1	8.1	44
TZB GUSAU	1219	64	170	71	14.1	4.5	34
SAFITA-102	1142	70	151	68	3.9	2.2	34
ATK 82 ZR	975	66	174	71	3.9	0.0	28
Mean	1455	64	167	70	10.3	2.5	38
L.S.D. (5 %)	ns	6	ns	ns	ns	3.0	ns
C.V. %	43	6	10	20	116	87	35

Table 29. Grain yield and other agronomic characters of varieties tested in RUVT.2 at SARIA, Burkina Faso, 1984. (Yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Root lodging (N°)	Stem lodging (N°)	Ears harvested (N°)
IRAT 178	1733	67	124	54	0.0	0.5	52
TUXP. D.R	1527	65	106	46	0.0	0.3	47
Temp x Trop. N° 27	1463	61	113	39	0.8	0.8	49
Elite x E. Mex.Comp.	1412	64	129	54	0.0	1.3	44
SAFITA-102	1412	68	114	43	0.0	0.5	58
ATK 82-ZR	1386	67	119	43	0.0	0.8	43
TZB GUSAO	1348	68	135	60	0.3	0.3	50
Poza Rica 7843	1348	67	125	53	0.5	0.0	38
Fereke 7622	1322	67	111	44	0.0	0.0	42
TZSR-1 (Y)	1155	65	126	51	0.3	0.5	38
EV 8176	950	61	106	38	0.0	0.5	35
Check variety (JFS)	655	56	99	30	0.0	0.5	27
Mean	1309	65	117	46	0.2	0.5	44
L.S.D. (5%)	493	4	16	16	ns	ns	15
C.V. (%)	26	4	9	24	393	142	25

Table 30. Grain yield and other agronomic characters of varieties tested in RUVT-2 at Kaedi, Mauritania, 1984 (yield at 15 % moisture).

Variety Name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Stem lodging (N°)	Ears harvested (N°)
Fereke 7622	1188	57	146	84	2.5	48
Elite x E. Mex. Comp.	1151	58	163	100	4.5	56
Check variety	1067	55	140	82	4.0	40
Safita-102	1054	58	154	88	2.5	44
Poza Rica 7843	982	56	150	88	2.5	39
TZSR-1 (Y)	909	59	161	94	4.3	48
TZB Gusau	800	57	152	98	2.3	42
IRAT 178	776	57	157	96	2.5	48
EV 8176	764	52	142	71	3.8	44
ATK 82 ZR	751	54	155	92	3.3	42
Tuxp. D.R	739	56	126	62	2.8	41
Temp. x Trop. N° 27	667	55	164	93	4.3	43
Mean	904	56	151	87	3.3	45
L.S.D. (5 %)	ns	4	19	ns	ns	ns
C.V. (%)	34	5	9	20	61	26

Table 3 1. Grain yield and other agronomic characters of varieties tested in RUVT-2 at six (6) locations, 1984.

Variety name	Grain yield (kg/ha, at 15 % moisture) Sanguere (Cameroon)	Touboro (Cameroon)	Farako-Bâ (Burkina Faso)	Loumbila (Burkina Faso)	Saria (Burkina Faso)	Kaedi Mauritania	Mean	Mean Days to 50 % silking	Mean Plant height (no)	Mean Ear height (no)
1 IRAT 178	5094	3952	3303	1810	1733	776	2778	65	173	84
2 TZB Gusao	5273	3730	3298	1219	1348	800	2611	65	183	87
3 Elite x E. Mex. C.	4619	3478	3146	1540	1412	1151	2558	64	172	85
4 Poza Rica 7843	3923	3359	3488	1669	1348	982	2462	65	171	85
5 Temp Trop nº 27	4334	3386	3379	1527	1463	667	2459	61	173	74
6 Tuxp. DR	4426	3507	2997	1450	1527	739	2441	63	149	69
7 Fereke 7622	3914	4062	2552	1361	1322	1188	2400	65	170	74
8 Safita 102	3287	4112	2258	1142	1412	1054	2211	66	166	72
9 TZSR(1)-Y	4090	2969	2446	1553	1155	909	2187	65	191	85
10 Check varieties	4664	3339	1625	1335	655	1067	2114	57	163	72
11 EV 8176	3127	2658	2930	1874	950	764	2051	57	162	73
12 ATK 82 ZR	2786	3413	2615	975	1386	751	1988	64	180	79
Mean	4128	3497	2853	1455	1309	904	-	-	-	-
L.S.D. (5 %)	1323	706	902	ns	493	ns	-	-	-	-
C.V. (%)	22	14	22	43	26	34	-	-	-	-

Table 32. Grain yield and other agronomic characters of varieties tested in RUVT-2A at Broukou, Togo, 1984 (Yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Stem lodging (Nº)	Ears harvested (Nº)	Streak attack (Nº) plants
1. TZB GUSAU	5418	61	179	89	0.5	76	1.3
2. TZSR-1 (Y)	5284	60	164	100	0.3	72	1.5
3. ATK 82 ZR	4824	60	172	83	0.8	72	1.8
4. Poza Rica 7843	4787	61	171	90	0.3	75	2.8
5. Temp. x Trop. Nº. 27	4763	52	184	78	0.3	74	1.5
6. Check variety	4739	63	215	145	0.0	74	2.3
7. EV 8331 SR	4484	46	145	53	0.5	76	1.0
8. TUXP. DR	4266	57	134	64	0.5	74	3.0
9. Elite x E. Mex. Comp.	4084	58	171	89	0.8	73	2.8
10. IRAT 178	3963	61	163	84	0.8	66	3.8
11. SAFITA-102	3600	60	143	69	1.3	71	3.0
12. EV 8176	3030	48	156	65	0.8	60	2.3
Mean	4437	57	166	84	0.6	72	2.3
L.S.D (5%)	651	2	23	21	ns	8	1.0
C.V. (%)	10	3	10	18	177	7	31

At Sekou (Benin), in terms of yield Synth. C and EV Gusau 81 Pool 16 performed significantly better than the local check (NCP 80), but Synth. C is highly susceptible to root lodging compare to the check and EV Gusau 81 Pool 16. Population Senegal Oriental is the variety most susceptible to root and stem lodging after Safita-104.

Synthetic C, Temperate x Tropical N° 42, Temperate x Tropical N° 3 are significantly later than the other varieties. EV 8188 and Safita-104 are the earliest varieties.

At Kaedi (Mauritania) the F test (5 % level) was not significant with a large experimental error. The latest variety was population Senegal Oriental and the earliest Safita-104 and EV Gusau 81 Pool 16. At Gampela (Burkina Faso), TZESR-W was significantly high yielding than the local check.

At Saria the plant stand was severely affected by the drought, the F test (5 % level) for ears harvested was significant. Temperate x Tropical N° 3, EV Pool 34 QPM and Synthetic C yielded significantly higher than the local check, but the harvested ears of the local check were lower than all tested varieties.

At Broukou (Togo) a late material was chosen as check and the rainfall was good, therefore the check variety yielded significantly higher than the best variety (TZESR-W). The yield was affected also by the harvested ear (F test significant).
At this locality EV 8188, Safita-104 and Local x Imp (Bulk) were the earliest varieties.
Across locations, Synthetic C, TZESR-W, Temp. x Trop. N° 42 and EV Gusau 81 Pool 16 seemed promising.

3.2. Regional uniform intermediate variety trial (RUVT-2)

The tables (25, 26, 27, 28, 29, 30, 31) show the grain yield and other agronomic characters of varieties tested in RUVT-2 at Sanguere, Touboro (Cameroon), Farako-Bâ, Loumbila, Saria (Burkina Faso), Kaedi (Mauritania) Broukou (Togo). On table 32 data are reported across 6 locations.

At Sanguere, the yield was affected by the ears harvested (F test 5 % was significant). Less ears were harvested for ATK 82 ZR and TZSR-1(Y). No significant difference was observed between the best entry TZB Gusau and the local check. The earliest varieties were EV 8176 and Temp. x Trop. N° 27.

At Touboro the F test (5 % level) for ears harvested was significant. The yield of ATK 82 ZR was affected. Safita-102 and Fereke 7622 yielded significantly higher (21-23 %) than the check variety. The F test for days to silk was significantly, the latest entry was TZB Guşau and the earliest EV 8176.

At Farako-Bâ the F test for yield, days to 50 % silking ears harvested and number of attacked plants by streak was significant. No significant difference in yield was observed between the best entry (Temp. x Trop. N° 27) and the local check (IRAT 178). The latest variety was Ferke 7622 and the earliest : Jaune Flint de Saria. Safita-102, Tuxpeno DR, Poza Rica 7843, IRAT 178 and Fereke 7622 are more susceptible to streak than the other tested variety. TZSR-1 (1) was almost immune.

At Loumbila, the F test (5 % level) for yield was not significant with a large experimental error.
Safita-102 was the latest entry and Jaune Flint de Saria the earliest. In terms of stem lodging, where the F test was significant, Jaune Flint de Saria was the most susceptible and ATK 82 ZR, TZSR-1 (Y) the more resistant varieties.

At Saria, the yield was severely affected by the number of harvested ears. For the check variety only 27 ears instead of 88 were harvested. IRAT 178 and Tuxp. DR seem promising at this locality. Safita-102 and TZB Gusau were the latest entries, whereas Jaune Flint de Saria was earlier than all tested varieties.

At Kaedi no significant difference in yield between tested varieties was recorded. Safita-102, Elite x E. Mex. Comp. and TZSR-1 (Y) were later than others. EV 8176 was the earliest entry.

At Broukou, the F test for ears harvested was significant for EV 8176 less ears were harvested. In terms of yield TZB Gusau yielded significantly higher (14 %) than the local check which was the latest of the group. EV 8331 SR and EV 8176 were the earliest. Regarding the streak attack, EV 8331 was more resistant and IRAT 178, Tuxp. DR, Safita-102 more susceptible.

The highest mean location yield (6) was given by IRAT 178 and TZB Gusau, but IRAT 178 showed high susceptibility to streak at Farako-Bâ and Broukou. The earliest entry across locations was EV 8176.

3.3 SAFGRAD adaptation trial (SAT)

Given the big progress made by CIMMYT and IITA in germplasm development, it was decided to conduct a special trial (SAT) regrouping the early and intermediate pools and populations developed by CIMMYT and IITA.

In Burkina Faso this trial was conducted at four locations : Loumbila, Kamboinse, Saria and Farako-Bâ. The tables 33, 34, 35, 36, 37 show the yield performance and other agronomic characters of 18 entries and 2 local checks (Temp. x Trop. N° 27 and Safita-2).

At Loumbila the plant stand was severely affected by the drought, less ears were harvested for Jaune Flint de Saria. In the group of 55 to 61 days to silking DMR-ESR-W, DMR-ESR-Y and population 49 yielded significantly higher than the best check Temp. x Trop. N° 27 from 47 to 61 %. In the group of 50 to 55 days to silk, Compuesto Selection Precoz was the best in terms of yield and earliness. The earliest entries were Compuesto Selection Precoz, Pool 29, Pool 27, Jaune Flint de Saria and Pop 46.

At Kamboinse, the F test (5 % level) was not statistically significant. Pool 29, Pop 46, Compuesto Selection Precoz and Pool 16 (IITA) were the earliest materials.

At Saria, among the later materials, Temp. x Trop N° 27 was the highest yielding. Pop 35 and Temp. x Trop. N° 27 yielded significantly higher than Pool 16 from 40 to 55 %. In the group of the earliest materials, Across 8131 was the most promising entry, whereas population 46, Pool 27, Pool 28, Pool 29, Compuesto Selection Precoz, Jaune Flint de Saria were the earliest.

At Farako-Bâ, in the group of the latest entries none of them yielded significantly higher than the local check Temp. x Trop. N° 27. DMR-ESR-W was the best promising material in this group. In the group of earliest materials, Across 8131 was the top yielding variety followed by Compuesto Selection Precoz.

The earliest materials were Pool 29 and Pop 46. Across locations, (Table 37) Compuesto Selection Precoz had the higher mean. In terms of earliness, plant type, ear aspect and yield, Compuesto Selection Precoz seems very promising for semi-arid zones of West Africa.

Table 33. Grain yield and other agronomic characters of varieties tested in "SAFGRAD ADAPTATION TRIAL" at Loumbila, Burkina Faso, 1984.
(Yield at 15% moisture).

Variety Name	Grain yield (Kg/ha)	Days to 50% silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (N°)
1. DMR.ESR.W.	2722	57	160	69	10.5	4.9	31
2. DMR.ESR.Y.	2670	57	176	88	9.7	5.7	30
3. Pop. 49	2516	58	136	56	19.0	0.6	34
4. Pop CSP	2490	50	150	48	16.0	3.2	31
5. Across 8131	2336	57	161	73	6.1	1.7	28
6. TZESR.W	2208	56	163	75	14.0	5.0	27
7. BP. 30	2080	56	165	73	20.0	9.0	31
8. Pop. 46	2028	50	156	44	19.0	13.0	29
9. Pool 28	2003	52	151	51	32.5	6.1	25
10. Pop 35	1900	60	153	58	25.6	9.4	28
11. Pool 16 (IITA)	1797	52	156	59	18.1	27.1	21
12. Pool 18	1797	55	161	61	13.7	13.4	22
13. Pool 17	1772	57	148	58	16.4	3.8	25
14. Pool 29	1746	48	149	53	24.9	9.4	23
15. Temp x Trop N° 27(Check)	1695	61	160	70	19.4	4.6	22
16. Pool 27	1515	51	151	58	14.5	3.6	20
17. Pool 16 (CIMMYT)	1489	57	160	71	36.0	4.6	20
18. SAFITA-2 (Check)	1463	58	144	58	50.5	6.1	21
19. J.F. de Saria	1258	50	159	60	23.4	9.2	21
20. Pool 15	1053	58	146	51	21.9	6.0	17
Mean	1927	55	155	62	20.6	7.3	25
LSD (5%)	818	5	18	17	ns	ns	7
C.V. (%)	30	7	8	19	97	168	21

Table 34. Grain yield and other agronomic characters of varieties tested in SAFGRAD ADAPTATION TRIAL at Kamboinsé, Burkina Faso, 1984 (yield at 15 % moisture).

	Variety name	Grain yield kg/ha	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (n°)	Stem lodging (n°)	Ears harvested (n°)
1	Pop CSP	1438	44	166	80	0.00	1.50	28
2	Pool 16 (IITA)	1078	44	168	74	0.00	1.00	25
3	Pool 29	1052	42	166	70	0.00	0.50	31
4	Jaune Flint de Saria	1001	45	166	84	0.00	1.00	23
5	Pop 46	1001	43	164	74	0.00	0.50	28
6	Pool 28	924	45	168	73	0.00	0.80	24
7	Pool 17	899	45	185	94	0.00	0.80	27
8	Pool 18	898	49	179	89	0.00	1.80	20
9	Pool 16 (CIMMYT)	796	51	185	101	0.00	1.00	17
10	Pool 27	745	47	174	85	0.30	0.80	24
11	Across 8131	719	49	180	98	0.00	0.30	21
12	Safita(2) check	693	53	153	75	0.00	0.30	18
13	Pool 15	642	50	174	81	0.30	1.30	20
14	DMR-ESR-W	539	50	185	98	0.00	0.50	12
15	TZESR-W	539	49	183	93	0.00	1.00	15
16	Pop 30	436	51	175	93	0.30	1.00	15
17	Pop 49	385	54	161	83	0.00	0.00	12
18	Temp x Trop N° 27(check)	334	55	184	93	0.00	0.30	8
19	DMR-ESR-Y	308	53	188	103	0.00	0.50	8
20	Pop 35	282	54	176	93	0.00	1.50	11
Mean		756	49	174	86	0.04	0.80	19
L.S.D. (5 %)		ns	5	19	22	ns	ns	11
C.V. (%)		65	7	8	18	513	124	41

Table 35. Grain yield and other agronomic characters of varieties tested in SAFGRAD ADAPTATION TRIAL at Saria, Burkina Faso, 1984 (yield at 15 % moisture).

	Variety name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (Nº)	Stem lodging (Nº)	Ears harvested (Nº)
1	Temp. x Trop. Nº 27	2740	57	131	49	0.00	0.00	37
2	Pop 35	2585	54	110	44	1.00	0.50	39
3	Across 8131	2475	51	103	36	0.00	0.30	39
4	DMR-ESR-Y	2471	55	106	43	0.30	1.30	40
5	Pool 17	2327	53	100	41	0.00	1.00	40
6	TZESR-W	2318	53	109	36	0.00	0.30	36
7	Safita-2	2301	53	104	45	0.00	0.50	39
8	Pool 15	2224	51	118	44	0.00	1.30	41
9	Pop 30	2221	54	105	38	0.00	1.00	42
10	DMR-ESR-W	2220	56	110	48	0.00	1.30	37
11	Pool 27	2202	47	88	26	0.00	0.00	40
12	Pop 46	2201	46	98	31	0.30	1.30	42
13	Pop 49	2152	56	101	33	0.00	0.30	40
14	Pool 28	2057	49	100	34	0.00	0.80	41
15	Pop CSP	2006	49	99	26	0.00	0.80	36
16	Pool 29	1894	48	96	26	0.30	0.30	41
17	Jaune Flint de Saria	1827	49	101	35	0.00	1.00	36
18	Pool 18	1796	51	103	43	0.00	1.00	36
19	Pool 16 (IITA)	1771	54	100	34	0.00	0.50	32
20	Pool 16 (CIMMYT)	1768	54	100	35	0.00	1.50	35
Mean		2178	52	104	37	0.10	0.70	38
L.S.D. (5 %)		806	3	16	14	ns	ns	ns
C.V. (%)		20	4	11	27	554	120	11

Table 36. Grain yield and other agronomic characters of varieties tested in SAFGRAD ADAPTATION TRIAL at Farako-Bâ, Burkina Faso, 1984 (yield at 15 % moisture).

	Variety name	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Root lodging (%)	Stem lodging (%)	Ears harvested (no)	Streak attack (no)
1	Across 8131	3273	52	136	58	2.5	1.9	36	4.0
2	DMR ESR-W	3248	58	149	78	2.5	1.2	35	0.0
3	DMR ESR-Y	3070	55	206	89	3.4	1.5	29	0.0
4	Pool 18	3045	57	142	65	4.7	1.4	34	1.0
5	Pop CSP	3045	52	133	52	2.8	2.5	35	0.8
6	Pool 16 (CIMMYT)	3020	56	141	63	3.7	1.5	31	1.5
7	Pop 49	2995	59	123	48	2.6	1.2	32	2.3
8	Pop 30	2994	57	143	59	4.0	1.9	37	2.3
9	Pool 15	2969	53	164	76	3.7	1.9	35	1.8
10	Pool 16 (IITA)	2944	54	148	61	3.6	1.9	34	1.5
11	Pop 35	2842	58	164	76	4.2	1.7	28	2.0
12	Pool 17	2766	55	146	58	4.0	1.7	36	0.8
13	Pool 29	2740	50	128	51	3.3	2.8	39	0.3
14	Pop 46	2563	49	127	44	3.1	3.2	39	0.3
15	Pool 27	2461	52	130	44	2.4	2.3	37	1.5
16	Temp x Trop n°27 (check)	2335	61	159	63	2.4	1.1	24	2.8
17	Pool 28	2233	51	135	45	3.1	2.7	35	0.8
18	TZESR-W	2182	57	146	56	2.9	1.8	26	0.0
19	Safita 2 (check)	1954	54	123	56	4.6	1.7	24	3.5
20	Jaune Flint Saria	1269	53	151	61	3.1	3.0	26	1.3
Mean		2697	55	145	60	3.3	1.9	33	1.4
L.S.D. (5 %)		972	4.0	27	17	1.6	0.9	9	2.0
C.V. (%)		25	6	13	20	33	31	19	105

Table 37. Grain yield and other agronomic characters of varieties tested in SAFGRAD Adaptation Trial at four locations (Loumbila, Kamboinse, Saria, Farako-Bâ), Burkina Faso, 1984. (Yield at 15% moisture.)

Variety Name	Grain yield Kg/ha					Average			
	Loumbila	Kamboinse	Saria	Farako-Bâ	Mean	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears harvested (N°)
1. Pop. CSP	2490	1438	2006	3045	2245	49	137	51	32
2. Across 8131	2336	719	2475	3273	2201	52	144	66	31
3. DMRESR-W	2722	539	2220	3248	2182	55	151	73	29
4. DMR ESR-Y	2670	308	2471	3070	2130	55	170	80	27
5. Pop. 49	2516	385	2152	2995	2012	56	130	55	29
6. Pop. 46	2028	1001	2201	2563	1948	57	136	48	34
7. Pool 17	1772	899	2327	2766	1941	52	145	63	32
8. Pool 30	2080	436	2221	2994	1933	55	147	65	31
9. Pop. 35	1900	282	2585	2842	1902	56	150	68	26
10. Pool 16(C_2IITA)	1797	1078	1771	2944	1898	51	142	57	28
11. Pool 18	1797	898	1796	3045	1884	53	146	64	28
12. Pool 29	1746	1052	1894	2740	1858	47	135	50	33
13. TZESR-W	2208	539	2318	2182	1812	54	150	65	26
14. Pool 28	2003	924	2057	2233	1804	49	139	51	31
15. Tem x Trop.27	1695	334	2740	2335	1776	58	158	68	23
16. Pool 16(CIMMYT)	1489	796	1768	3020	1768	54	146	68	26
17. Pool 27	1515	745	2202	2461	1731	49	134	53	30
18. Pool 15	1053	642	2224	2969	1722	53	150	63	28
19. SAFITA-2(Check)	1463	693	2301	1954	1603	54	131	58	25
20. J.F. de Saria	1258	1001	1827	1269	1339	49	144	60	26
Mean	1927	756	2178	2697					
L.S.D. (5 %)	818	NS	806	972					
C.V. (%)	30	65	20	25					

MAIZE AGRONOMY

M. Rodriguez

I. 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 on the Sudan Savanna (600-900 mm rainfall) at the Kamboinse and Saria Research Stations and on-farm trials. Research in the Northern Guinea Savanna (900-1200 mm rainfall) at the Farako-Bâ Station was again started in 1983.

Most of the research results in the Sudan Savanna are applicable to regions in the 600-900 mm belt where there are ferruginous tropical soils (Alfisols) 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 600-900 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 Kamboinse 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 casè 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, 30 % silt and 58 % sand ; (3) 1 % organic matter ; (4) a C/N of 11 : (5) a pH-H_2O of 6 ; (6) exchangeable bases (me/100 g) : Ca = 2.3, Mg = 0.8, K = 0.21 and Na = 0.11 ; (7) 12 ppm of available P (Olsen) ; (8) total P contents of 80-160 ppm.

The soils at the Farako-Bâ Station (1100 mean annual rainfall) 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.

The annual rainfall at Farako-Bâ was 815.1 mm and, although still below the long-term average (1100 mm), it was better distributed than in 1983. There were only 414 mm of rainfall at Kamboinsé in 1984. All trials planted in July had to be wholly replanted in August, but only 252.3 mm fell in the period August to October.

When discussing the results of the trials no mention will be made of final plant densities (at harvest), except in those cases, if any, where 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 :

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

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

(3) To help in the training of national researchers of the SAFGRAD Member countries.

(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 :

(1) Research trials conducted directly by the SAFGRAD/IITA Maize Agronomist in Burkina Faso.

(2) Research trials conducted in SAFGRAD Member countries in collaboration with local researchers.

(3) Regional Maize Agronomy Trials (REMAT) in which :

a) cultural practices that have been proven successful in Burkina Faso 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.

(4) In-service training of national researchers through their direct participation in the cropping season activities in Burkina Faso.

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

(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

This experiment already conducted in 1983, was again planted in the same plot in 1984. It consisted of a factorial combination of 4 planting dates, 2 management levels and 2 varieties, arranged in a split-split-plot arrangement with 5 replications. The planting dates were : (1) June 24, (2) July 9, (3) July 24, and (4) August 8. 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 :

Year	Level	14-23-15	+	Urea	=	Total
1983	F1	100		50		37-23-15
	F2	300		250		157-69-45
1984	F1 & F2	100		50		37-23-15

The fertilizer applied in 1984 was the same in both F1 and F2 plots counting on a residual effect of the fertilizer applied in 1983 (and given that there was no crop residue removal in 1983). The planting dates and varieties were rerandomized in 1984. Soil preparation was by hand-hoeing. The 14-23-15 was applied at planting and the urea was split in 2 equal applications at 30 and 55 DAP (days after planting).

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)

The effect of planting date on maize grain yield (Table 1) was highly significant (P = 0.01). The first planting date gave the highest yields (1660 kg/ha for June 24) and successive planting dates gave lower and lower yields, with only 410 kg/ha for the Aug. 8 planting date. The average decrease in yield per day was 28 kg/ha for plantings after June 24. The decrease in yield was close to 50 kg/ha per day in planting after June 22 in the 1983 trial. The Management x Date interaction was significant in 1983 but not in 1984 ; nevertheless, the same yield trend of 1983 was observed in 1984, showing a better response to improved management at the earlier planting dates. SAFITA-2 was significantly better than SAFITA-102 at all planting dates and at both management levels. Differently from 1983, the Date x Variety interaction was not statistically significant.

Although there was a significant (P = 0.05) response to management level, the yields at M1 and M2 were only 990 VS 1255 kg/ha, with a high yield of 1850 kg/ha for the June 24 planting date at the high management level (M2) VS 3030 kg/ha for the June 22 planting in 1983. These results suggest that although there was an apparent significant residual effect of the fertilizer applied in 1983, the response to management level in 1984 would have been greater if more fertilizer had been applied at the M2 lefel.

Table 1. Planting date trial. FARAKO-BA (Burkina Faso), 1984.
Maize grain yield (kg/ha at zero percent moisture).

Management level (*)	Variety (**)	Planting date (**)				Mean
		June 24	July 9	July 24	August 8	
M1	SAFITA-2	1680	1320	1060	590	1165
	SAFITA-102	1260	1115	650	235	815
	Mean	1470	1220	855	410	990
M2	SAFITA-2	2075	1815	1230	545	1415
	SAFITA-102	1620	1720	765	270	1095
	Mean	1850	1765	1000	410	1255
Variety	SAFITA-2	1880	1570	1145	570	1290
	SAFITA-102	1440	1415	710	250	955
MEAN		1660	1495	925	410	1125

Management x Date	(ns)	C.V. (%)	Main plot	36.1
Management x Variety	(ns)		Sub-plot	41.2
Date x Variety	(ns)		Sub-sub-plot	23.5
Management x Date x Variety	(ns)			

*, ** : Significant at 5 and 1%

ns : Non significant

L.S.D.'s at 5%

Varieties	120.2
Dates	302.1
Management levels	251.6
Varieties at same Date	240.4
Varieties at same Management level	170.0
Dates at same Management level	427.3
Varieties at same Date and Management level	340.1

Total rainfall in Farako-Bâ in 1984 was 815.1 mm, higher than in 1983 (755.3 mm) and better distributed. The rains ended early October. As in 1983, part of the date of planting effect on grain yield can be attributed to lack of enough moisture at the end of the season and part to streak virus attack which increased markedly with later plantings : 19.5, 42.8, 59.4 and 89.5 % of plants attacked for the June 24, July 9, July 24 and August 8 plantings, respectively.

Stem borer damage was not evaluated in 1984. Given that no plant showed "dead-heart" symptoms, and that stem lodging was not serious, it can be assumed that borers were not of major importance.

3.2 Density trial

This experiment, already conducted in 1983, was again carried out in 1984 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). The following densities and arrangements were used :

	Density (plants/ha)	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 24 in 6-row plots, 5 m long and replicated 5 times. Soil preparation was by hand-hoeing. The fertilizer applied was 200 kg of 14-23-15/ha at planting, and 150 kg of urea/ha, applied in 2 equal splits at 30 and 55 DAP. The fertilizer applied amounts to 97-46-30 kg/ha of N-P_2O_5-K_2O. The experiment was carried out in the same plot as in 1983, but both varieties and densities were re-randomized. The effective plant densities at harvest time were very close to the intended ones, as follows : 17,300, 36,100, 50,500, 76,700, and 105,900 for SAFITA-2 and 17,500, 38,100, 53,300, 77,200 and 100,700 plants/ha for SAFITA-102.

As shown in Fig. 1, the highest grain yields in 1984 were obtained at a density of about 80,000 plants/ha for SAFITA-2 and 53,000 plants/ha of SAFITA-102. These results confirm those of 1983. However, the stability of yield at densities above the optimum did not show the same trend as in 1983.

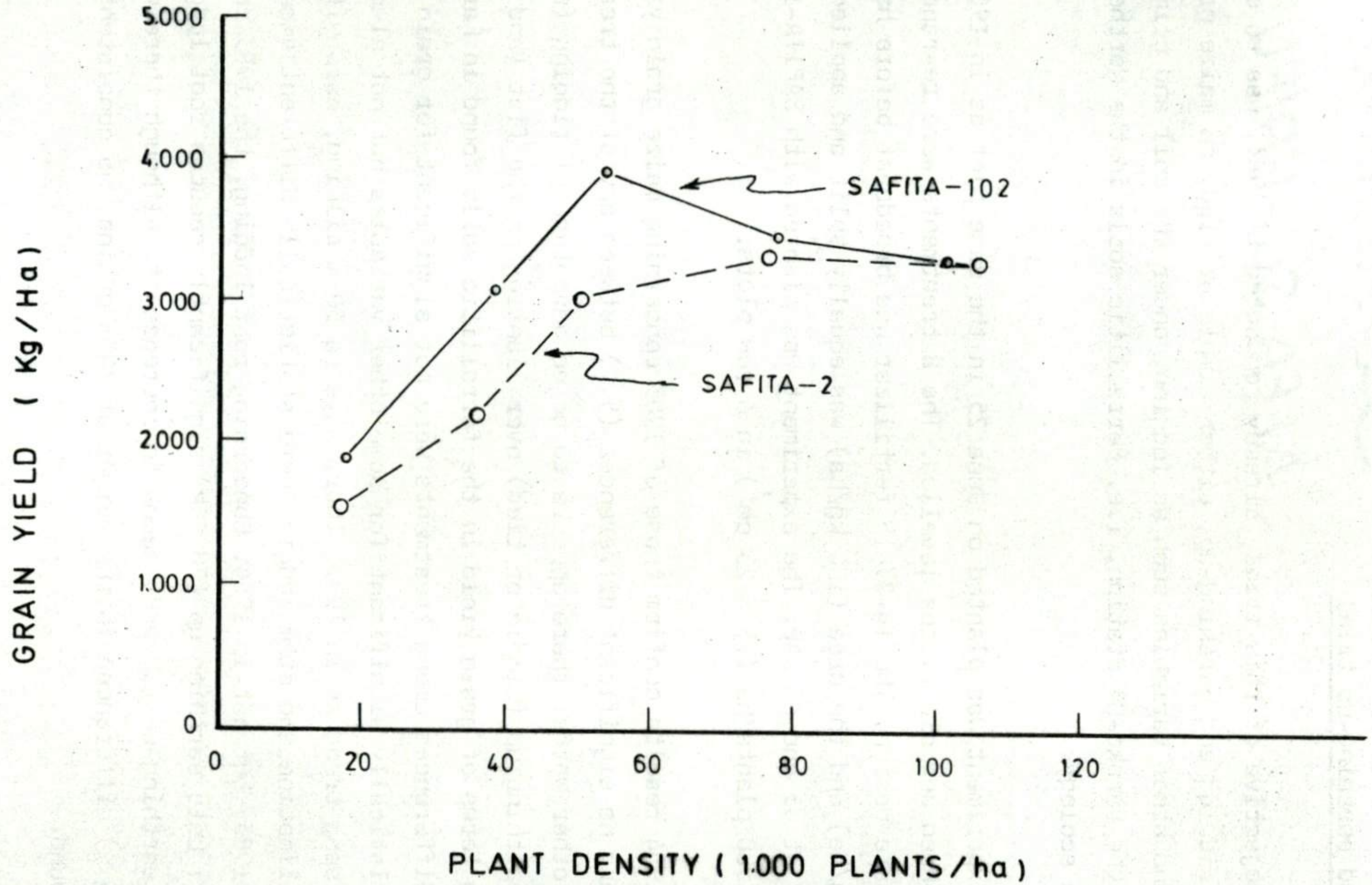


FIG. 1. THE EFFECT OF PLANT DENSITY ON THE MAIZE GRAIN YIELD OF 2 MAIZE VARIETIES.
DENSITY TRIAL. FARAKO-BA (BURKINA FASO), 1984.

SAFITA-102 gave a mean grain yield significantly (1.4 %) higher than that of SAFITA-2 (3120 VS 2670 kg/ha) and a higher maximum yield as well. The rainfall distribution pattern in 1984 was better suited to the requirements of the intermediate maturity variety (SAFITA-102) than in 1983 when the rains ceased too soon.

3.3 Ridging and earthing-up trial

The objective of this trial, already conducted in 1983, was to evaluate the effect of ridging and earthing-up, either simple or tied, on maize growth, grain yield, and other variables such as lodging, under the soil and climate conditions of the Farako-Bâ Station, i.e. Ferrallitic soils in the Northern Guinea Savanna ecology.

The experiment was planted on June 25 in the same plot as in 1983. The plot was hand-hoed and old ridges levelled. The 8 treatments were re-randomized in a latin square design. The 14-23-15 fertilizer was broadcast before hand-hoeing (200 kg/ha) and the urea (100 kg/ha) was equally split and applied (incorporated) at 35 and 60 DAP. The experiment was planted with SAFITA-102 at a density of 53,300 plants/ha (75 X 25 cm^2) in 6 row plots.

The 1984 results confirm those of 1983 concerning maize grain yield since there were no significant differences (5 %) between any of the treatments (Table 2). In other words, there appears to be no advantage 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 in the ferrallitic soils found in Farako-Bâ. Although the differences among treatments were not significant for grain yield, they were statistically significant for some other variables but not always following the same trend as in 1983. Thus, days to 50 % silking, ears with incomplete pollination and stem lodging were statistically different among treatments in 1983, but not in 1984. Concerning root lodging, the 1983 results are confirmed : Late earthing up (70 DAP) significantly reduces root lodging whereas early earthing-up (35 DAP) seems to increase it. Although there were significant (5 %) differences in the weight of 1000 grains, no consistent pattern was found.

3.4. Maize-cowpea rotation and relay-cropping trial

This experiment started in 1983 having as main objectives to evaluate : (1) the effect of rotating maize and cowpea in ferrallitic soils, (2) the effect

Table 2. Ridging and earthing-up trial. FARAKO-BA (Burkina Faso), 1984. Maize grain yield (at zero percent moisture), lodging (after the arcsine transformation) and other crop parameters.

TREATMENT	Yield grain kg/ha (ns)	Days to 50 % silking (ns)	Ears with incomplete pollination % (ns)	Stem lodging % (ns)	Root lodging % (**)	Weight (g) 1000 grains (*)	Grains per m^2 (ns)
T1. Planting on the flat	3380	64.4	9.9	3.4	30.4	190	1765
T2. Planting on the flat Earthing-up 35 DAP.	3380	63.9	8.1	4.5	34.4	184	1840
T3. Planting on the flat Earthing-up 70 DAP	3140	64.9	9.2	6.5	13.3	179	1750
T4. Planting on the flat Earthing-up + ridge-tying every other furrow 35 DAP	3480	64.1	7.3	5.5	31.9	186	1875
T5. Planting on the flat Earthing-up 35 DAP. Ridge-tying of every other furrow at 70 DAP.	3100	65.5	9.4	6.1	34.6	178	1735
T6. Planting on ridges	3350	63.8	7.6	5.8	27.7	188	1780
T7. Planting on ridges Earthing-up 35 DAP	2960	66.1	12.6	3.8	32.5	180	1635
T8. Planting on ridges tied every other furrow. Earthing-up 35 DAP	3220	62.9	9.0	4.1	31.4	175	1840
MEAN	3250	64.4	9.1	5.0	29.5	182	1780
C.V. (%)	15.8	3.2	55.3	116.5	30.6	5.5	12.6
L.S.D. (5%)	520	2.1	5.1	5.8	9.1	10.0	225

*, ** : Significant at 5 and 1%   ns : Non significant

of furadan applications on maize yield, (3) the effect of maize cowpea relay cropping on the yield of maize the following year, and (4) the interaction cowpea genotype x crop rotation effect (see IITA/SAFGRAD Annual Report 1983).

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 plots had 3 rows (5 m long) of which the central one was harvested.

The management levels for maize were : (1) low and (2) high. The former included low fertilizer level (28-46-30 kg $N-P_2O_5-K_2O$/ha), and low density (44,400 plants/ha). The high management included high fertilizer level (74-46-30) and high density (59,300 plants/ha). The fertilizer was applied as 14-23-15 (at planting) and urea (sidedressed at 35 and 60 DAP) ; the 1984 rates were lower than those applied in 1983. Maize (variety SAFITA-102) was planted on June 24. Cowpea (variety TVx 3236) was planted on June 24 (monocrop) and on August 31 (relay-cropped 68 DAP maize), at a density of 118,500 plants/ha.

The crop rotations are as follows (M = maize ; C1 = cowpea variety 1 (TVx 3236) ; C2 = cowpea variety 2 (local Logofrousso); M-C = cowpea 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 : (1) No Furadan ; (2) 1.5 g Furadan 5 G/plant applied both at planting (maize and cowpea) and 60 DAP (maize only). The cowpea was protected weekly with insecticide sprays starting 37 DAP. There was no tractor plowing in 1984, only hand-hoeing before planting.

3.4.1 Maize grain yields

Maize grain yields (Table 3) showed significant differences between rotations (P = 0.01), a significant (P = 0.01) response to Furadan application (2200 VS 3120 kg/ha), and a significant (P = 0.05) response to the high

Table 3. Maize-cowpea rotation and relay-cropping trial. FARAKO-BA (Burkina Faso), 1984. Maize grain yield (kg/ha, at zero percent moisture).

ROTATION (**)	Furadan (**)	Management (*) M1	Management (*) M2	Mean
R1 = 1983/M = 1984/M	F1	2300	2490	2390
	F2	2340	3440	2890
	Mean	2320	2960	2640
R3 = C1 - M	F1	2060	3380	2720
	F2	3740	4370	4050
	Mean	2900	3880	3390
R4 = M/C1 - M/C1	F1	980	1910	1440
	F2	1940	3160	2550
	Mean	1460	2530	2000
R5 = M/C1 - M	F1	1310	1960	1640
	F2	1840	2960	2400
	Mean	1580	2460	2020
R6 = M - M/C1	F1	1960	2890	2430
	F2	3030	3630	3330
	Mean	2500	3260	2880
R7 = C2 - M	F1	2800	3500	3150
	F2	3160	4740	3950
	Mean	2980	4120	3550
R8 = M/C2 - M	F1	1420	1910	1660
	F2	2040	3200	2620
	Mean	1730	2560	2140
Furadan	F1	1830	2580	2200
	F2	2590	3640	3120
MEAN		2210	3110	2660

Management x Rotation	(ns)			
Management x Furadan	(ns)	C.V.	Main plot	43.9
Rotation x Furadan	(ns)	(%)	Sub-plot	21.5
Management x Rotation x Furadan	(ns)		Sub-sup-plot	20.6

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

Furadan levels	209
Rotations	424
Management levels	702
Furadan levels at same Rotation	552
Furadan levels at same Management	295
Rotations at same Management	580
Furadan levels at same Rotation and Management	781

management level (2210 VS 3110 kg/ha). None of the interactions was statistically significant (P = 0.05).

The rotation in which maize followed maize (R1) gave a yield significantly lower (P = 0.05) than the rotations where maize was planted after TVx 3236 (R3) or the local Logofrousso cowpea (R7). These 3 rotations had mean maize yields of 2640, 3390, and 3550 kg/ha, respectively (L.S.D. = 424, at P = 0.05). Although the yield difference between R3 and R7 was not statistically significant, the R7 plots were easily identified by eye as showing better crop growth and vigour than R3 plots. This indicates that the positive rotation effect of cowpeas on maize varies with the cowpea variety. However, no elements are yet available to indicate the characteristics associated with the interaction cowpea genotype x rotation effect.

It is also interesting to note that the positive cowpea rotation effect was larger at the high than at the low management level (920 VS 580 kg/ha for R3, and 1160 VS 660 kg/ha for R7). This agrees with the findings of the rotation trial conducted in Saria (Sudan Savanna) since 1979 and suggests that symbiotic N fixation is not the main factor involved in the positive cowpea rotation effect (see IITA/SAFGRAD Annual Report 1982).

Regarding the third main objective of the experiment, i.e. The evaluation of the effect of maize-cowpea relay-cropping on the yield of maize the following year, the results indicate that such an effect was negative. There was a significantly lower maize yield (P = 0.05) when maize followed maize-cowpea in relay cropping (R5 and R8) than in R1 when maize followed maize (2020, 2140, and 2640 kg/ha, respectively. L.S.D. = 424). Thus, such yield loss in the maize yield the second year should be taken into account in the yield and economic evaluation of results obtained in the first year of a maize-cowpea relay-cropping system. The explanation for this negative effect (yield loss) is not clear, but it could be related to the more intensive exploitation of soil resources, in particular nutrients and water, under a relay-cropping system than under monocrop rotation systems.

Results from other experiments show that in these soils there is a maize yield response to 75 or more kg P_2O_5/ha. Both in 1983 and 1984 the applied P_2O_5 was below this level (50-57.5 and 46 kg P_2O_5/ha, respectively). Thus, the yield loss described above could maybe be eliminated by applying more P fertilizer. The positive monocrop cowpea rotation effect and the negative relayed-cowpea rotation effect on maize yield are very interesting and need to be elucidated.

The contrasts R1 (M-M) VS R6 (M-M/C1) and R5 (M/C1-M) VS R4 (M/C1-M/C1) give very small maize yield differences (-240 and 20 kg/ha, respectively) indicating that TVx 3236 relay-cropped with maize did not bring about any reduction in the maize monocrop yield under the 1984 experimental conditions.

3.4.2 Cowpea yields

Cowpea yields (Table 4) were not affected by the management level (1095 and 1156 kg/ha), nor by the Furadan level (1079 and 1172 kg/ha), but were significantly (P = 0.01) different between rotations. All the interactions were significant (P = 0.05), except the Management x Rotation interaction which was significant only at the 8.5 % level.

The highest grain yield was obtained with monocrop TVx 3236 (R2) which gave 2239 kg/ha. When cowpea (TVx 3236) was grown relay-cropped with maize, yields were significantly lower (P = 0.01) both when the previous (1983) crop was monocrop maize (R6 = 520 kg/ha) and when it was a maize-cowpea relay cropping system (R4 = 617 kg/ha). These cowpea yields are higher than those observed in 1983 (when the rains stopped very early in mid-september), but they are still much smaller than those under monocrop cowpeas. Rainfall pattern in 1984 was better than in 1983 but October was a droughty month. The relatively low cowpea yields (under relay-cropping),could be attributed to lack of enough moisture at the end of the season since cowpea pests were well controlled by periodic insecticide applications.

3.5 Timing of N application trial

This experiment was first conducted in 1983 and, given that there were no significant differences between the several timings of N application, it was reconducted in the same plot in 1984, but using only ½ of N rates used in 1983. The experiment consisted of a factorial combination of 2 Nitrogen levels and 5 timings of N application in a split-plot arrangement with 5 replications. There were 2 additional treatments : one without added N and another with 50 kg N/ha.

The N levels in 1984 were 25 and 75 kg/ha. The timings of N application are given in Table 5. The additional treatment with 50 kg N/ha received the T5 split application. The main plots (N levels) were superimposed on the previous (1983) main plots. The subplots (timings of N application) were rerandomized, with the exception of, those for the additional treatments.

Table 4. Maize-cowpea rotation and relay-cropping trial. Farako-Bâ (Burkina Faso), 1984. Cowpea grain yield (kg/ha, at 9% moisture).

ROTATION (**)		Furadan (ns)	Management (ns) M1	Management (ns) M2	Mean
R2 =	1983 - 1984 M - Cl	F1	1701	2405	2053
		F2	2476	2374	2425
		Mean	2088	2390	2239
R4 =	M/Cl - M/Cl	F1	602	680	641
		F2	607	581	594
		Mean	605	631	617
R6 =	M - M/Cl	F1	594	495	544
		F2	593	398	496
		Mean	594	446	520
Furadan		F1	965	1193	1079
		F2	1225	1118	1172
MEAN			1095	1156	1125

Management x Rotation	(ns)			
Management x Furadan	(**)	C.V.	Main plot	12.8
Rotation x Furadan	(**)	(%)	Sub-plot	23.0
Management x Rotation x Furadan	(*)		Sub-sub-plot	14.9

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

Furadan levels	102
Rotations	200
Management levels	132
Furadan levels at same Rotation	176
Furadan levels at same Management	144
Rotations at same Management	282
Furadan levels at same Rotation and Management	249

Table 5. Timing of nitrogen application trial. FARAKO-BA (Burkina Faso), 1984. Maize grain yield (kg/ha, at zero percent moisture).

Timing of application (* at P = 5.8%)				Nitrogen level (*) kg/ha (1984)		Mean
	DAP			25 (Low)	75 (High)	
	12	36	54			
T1.	1/1	-	-	1315	1645	1480
T2.	1/2	1/2	-	1415	2025	1720
T3.	1/2	-	1/2	1640	1870	1755
T4.	-	1/2	1/2	1810	2140	1975
T5.	1/3	1/3	1/3	1995	2100	2050
	MEAN			1635	1955	1795

N level X Timing (ns)	C.V.	Main plot	17.0
	(%)	Sub-plot	24.8

* : Significant at 5 %

ns : Non significant

L.S.D.'s at 5%

Nitrogen level	240
Timings	407
Timings at same Nitrogen level	575
Timings at different Nitrogen levels	564

The experiment was planted on June 25, at a density of 53,300 plants/ha (75 x 25 cm^2),,with the variety SAFITA-102. Land preparation was with the hand-hoe hoe. No additional P or K fertilizer was applied in 1984.

Whereas in 1983 there was a significant yield increment to N applications of 50,100 and 150 kg N/ha, in 1984 the yield increase was significant (P = 0.05) only for the first increment (25 kg N/ha in 1984). Note, however, that since the N levels applied in 1984 were only ½ of those applied in 1983 (same main plots), strictly speaking the 1984 results alone do not measure N response. Nevertheless, the total yield obtained in both years can be plotted against the total N applied in 1983 and 1984 to show the global yield response to N (Fig. 2). The global yield response taking the total yield and total N applied in both years show about 13.4 kg grain/kg of added N (when going from 0 to 225 kg N/ha), which, of course, is equal to the mean yield increase per year if the mean N application per year is considered. This is about 11 % below the mean yield increase increase / kg added N observed in 1983 and can be attributed to the non application of P in 1984. In effect, the potential residual effect of P applied in 1983 was overestimated and crop growth in 1984 was rather stunted because of apparent P deficiency.

When the timings of N application were compared, they were statistically different at the 5.8 % level. The difference between the N levels (low and high) was small but statistically significant (P = 0.05). The N level x Timing interaction was not statistically significant. The lowest mean yield was obtained when all the N was applied 12 DAP (1480 kg grain/ha), and the highest when the N was split in 3 equal applications (2050 kg grain/ha ; L.S.D. = 407, at 5 %). It would appear that if only grain yield is considered, : (1) it is not recommended to apply **all** N at or soon after planting ; (2) 2-3 split applications are better than one single application at planting. However, since no differences were observed in 1983 between the different timings of N application, and given the low rainfall observed in 1983 and 1984, more results are needed before general conclusions are drawn. The timing of N application had no effect on grain size, but it gave the smallest number of grains per square meter when all the Nitrogen was applied 12 DAP.

3.6 Nitrogen and phosphorus response and residual fertilizer effect trial

This experiment started in 1983 when the N and P response curves were evaluated. The experiment was again planted in the same plots in 1984 but without any additional fertilizer application in order to evaluate the residual fertilizer effect.

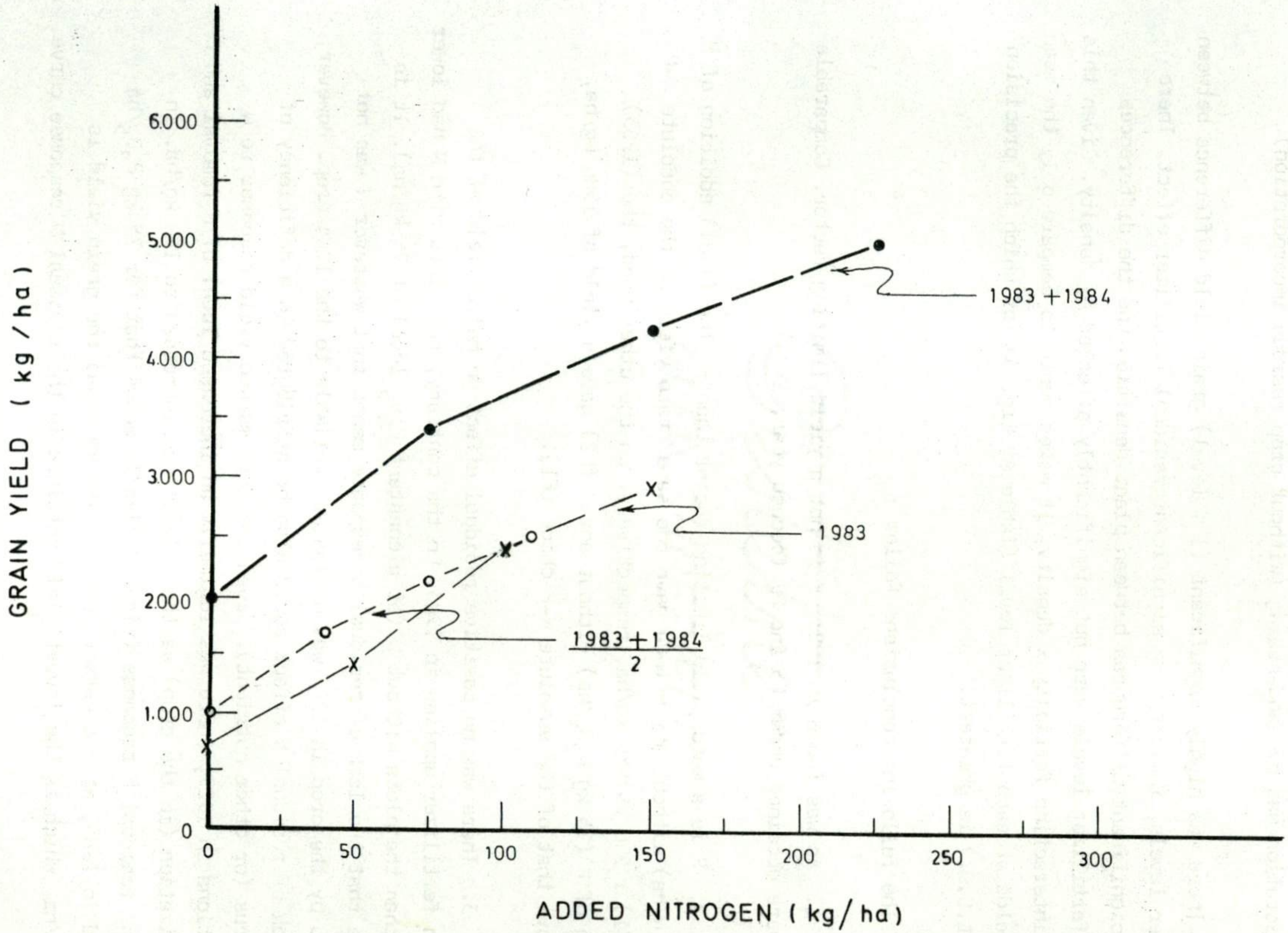


FIG. 2. THE EFFECT OF NITROGEN FERTILIZER ON MAIZE GRAIN YIELD. TIMING OF NITROGEN APPLICATION TRIAL. FARAKO-BA (BURKINA FASO). 1983 AND 1984.

The experiment consists of a factorial combination of 9 NP levels x 3 plant densities in a split-plot arrangement with 4 RCB. The plant densities were the same as in 1983 ; actual plant densities at harvest were very close to the target densities. The trial was planted on June 26 with the variety SAFITA-102. Soil preparation was by hand-hoeing (without crop residue incorporation).

There was highly significant (1 % level) grain yield difference between fertilizer levels, indicating a significant residual fertilizer effect. There were no significant differences between plant densities and the differences between fertilizer levels were not significantly affected by density. Given this lack of interaction fertility x density, it makes sense to compare only the mean grain yields at each fertilizer level (Table 6, Fig. 3) for which the precision (lowest L.S.D.) is greatest.

The following conclusions follow :

1. As was found in 1983, K is not a yield limiting factor. Comparable yields were obtained under F5 and F9 (second year, 1984).

2. P is a more yield limiting factor than N. The (1983) addition of N (150 kg N/ha) without any P (F8) gave the same grain yield as the absolute N-P check (F1) : 500 VS 555 kg/ha, respectively. On the other hand, the (1983) addition of P (75 kg P_2O_5/ha) without any N (F2) gave a yield of 1580 kg/ha, well above that of the absolute N-P check (F1).

3. There was no positive residual effect on maize yield of the nitrogen fertilizer applied in 1983. On the contrary, the plots with N had lower yields than the plots without N (at a constant P_2O_5 level of 75 kg/ha). It is possible that the lack of residual N response means that whatever N was not taken up by the crop in 1983 was no longer available to the 1984 crop. However, such lack of residual N effect could also be attributed to a deficiency of phosphorus (or other nutrient). Given the very marked yield response to N applications in 1983, there was logically an increased level of P removal and P immobilization (in the crop) as the N level was increased to 150 kg/ha. In fact, the residual P response (Fig. 3) clearly shows that for 75 kg P_2O_5/ha (applied in 1983, at a constant level of 150 kg N/ha) the grain yield is 1070 kg/ha, which is the lowest yield obtained in the residual N response curve.

4. There was a significant residual effect of the P applied in 1983. Grain yield increased from 500 to 1070 kg/ha as P_2O_5 applied in 1983 went from 0 to 75 kg/ha (L.S.D. = 270, at 5 % level).

Table 6. Nitrogen and phosphorus response and residual fertilizer effect trial. Farako-Bâ (Burkina Faso), 1984. Maize grain yield (kg/ha, at zero percent moisture).

Fertilizer level (**)				Density (ns) plants / ha			Mean
				26,700	44,400	66,700	
	N	P_2O_5	K_2SO_4				
F1.	0	0	80	595	545	525	555
F2.	0	75	80	1575	1800	1365	1580
F3.	50	75	80	950	1240	1505	1230
F4.	100	75	80	1240	1455	1525	1405
F5.	150	75	80	750	1255	1210	1070
F6.	150	50	80	890	1050	955	965
F7.	150	25	80	1045	765	705	840
F8.	150	0	80	445	655	400	500
F9.	150	75	0	1320	1320	1290	1310
Mean				980	1120	1050	1050
Fertilizer level x Density (ns)					C.V. (%)	Main plot	30.4
						Subplot	30.7

*, ** : Significant at 5 and 1 %
ns : Non significant

L.S.D.'s at 5 %

Fertilizer levels	270
Densities	153
Densities at same fertilizer level	458
Densities at different fertilizer levels	461

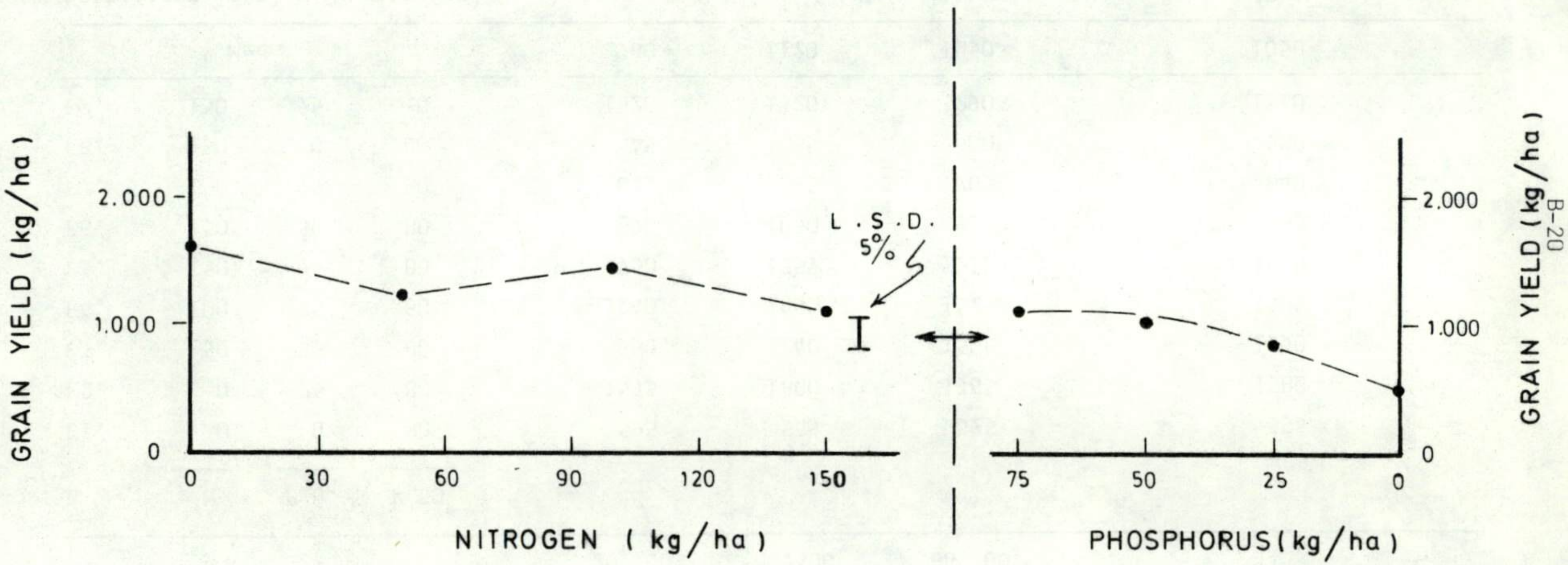


FIG. 3. THE RESIDUAL EFFECT OF NITROGEN AND PHOSPHORUS ON MAIZE GRAIN YIELD (MEANS OF 3 PLANT DENSITIES). NITROGEN AND PHOSPHORUS RESPONSE AND RESIDUAL FERTILIZER EFFECT TRIAL. FARAKO-BA (BURKINA FASO), 1984.

3.7 Genotype x Fertility level interaction trial

Collaborative work between the Maize Agronomy and Maize Breeding Programs.

M. Rodriguez and A. O. Diallo

This experiment was initiated in 1984 with the objective of evaluating : a) the performance of several local and improved varieties of maize under low and high fertility conditions ; b) the interaction genotype x fertility level.

Twelve maize genotypes were planted at 3 fertility levels (main-plots) in a split-plot design with 4 replications. The plots had 4 rows, 5 m long, of which the central 2 were used to estimate grain yield. The trial was planted on June 26 at a uniform density of 44,400 plants/ha. The plot had been under a grassy fallow for several years and was tractor plowed. The crop received Furadan 5G (0.3 g/hill) at planting and also at 50 DAP.

The 3 fertility levels were a low P level (F1), a low N level (F2) and a high N and P levels (F3). No absolute check was included in the test. However, previous (1983) research in the same block of land had shown that the P check treatment (F1) was equivalent to the absolute (NP) check in terms of crop growth and grain yield, P being the most limiting yield factor. The 3 fertility levels were established with the following fertilizer rates (Kg/ha).:

	N	P_2O_5
F1	150	0
F2	0	75
F3	150	75

The P_2O_5 was applied as SSP before planting. The N (urea) was split into 2 equal applications at 8 and 35 DAP.

The maize genotypes were :

V1 : Massayomba (intermediate local variety improved by IRAT by mass selection)

V2 : Jaune de Fo (early to intermediate local variety improved by IRAT by mass s selection)

V3 : Koudougou local (very early)

V4 : Jaune Flint de Saria JFS (early local improved by IRAT by mass selection)

V5 : Diapaga local (early local variety)

V6 : Raytiri local (very early variety)

V7 : SAFITA-102 (intermediate improved SAFGRAD variety)

V8 : SAFITA-104 (very early improved SAFGRAD variety)

V9 : TZE-4 (early improved SAFGRAD variety)

V10 : Temp. x Tropical 27 (intermediate improved SAFGRAD variety)

V11 : IRAT-178 (intermediate improved IRAT hybrid)

V12 : SAFITA-2 (early improved SAFGRAD variety).

The grain yield results (Table 7) show highly significant (P = 0.1 %) differences between fertility levels and between varieties as well as a differential performance of varieties at the fertility levels under test.

The lowest mean yield was obtained under F1 (150-0 kg $N-P_2O_5$/ha), followed by that under F2 (0-75 kg $N-P_2O_5$/ha) ; the highest yield was obtained under F3 (150-75 kg $N-P_2O_5$/ha), as expected (400, 715, 2985 kg grain/ha, respectively ; L.S.D. = 207 kg, at P = 5 %).

There were large differences between mean variety grain yields, going from a low of 1020 to a maximum of 1725 kg/ha, for an L.S.D. (5 %) of 203. The 3 lowest yielding varieties were Raytiri local (V6 = 1020 kg/ha), Koudougou local (V3 = 1150), and Massayomba (V1 = 1210). The 4 highest yielding varieties were SAFITA-2 (V12 = 1725 kg/ha), TZE-4 (V9 = 1580), and Temp. x Tropical 27 and SAFITA-102 (V10 and V7, both with 1470 kg/ha).

The statistically significant (P = 0.1 %) interaction Genotype x Fertility level reflects the differential yield performance of the varieties at the 3 fertility levels (Fig. 4). Although SAFITA-2 (V12) had the highest yield at all 3 fertility levels, its performance under F1 was statistically (P = 5 %) superior to that of most other varieties ; this suggests that maybe it can tolerate low P conditions better than the other varieties tested. Koudougou local (V3) was the second best variety under low P fertility, but the second to the last (in yield) under high P (F3).

The performance of the 12 varieties under F2 (no added N) shows that SAFITA-2 (V12) significantly (P = 5 %) outperformed Massayomba (V1). Raytiri local (V6) was among the best under F2 but had the lowest yield under F3. On the other hand, Temp. x Tropical 27 (V10) had the second lowest yield under F2 but the second highest under F3. These results suggest that there is a difference between varieties for adaptation (ability to give grain yield) to low N conditions.

Under F3 conditions (high N and P), the most striking feature is the performance of Koudougou local (V3) and Raytiri local (V6), significantly (P= 5%)

Table 7. Genotype x Fertility level interaction trial. Farako-Bâ (Burkina Faso), 1984. Maize grain yield (kg/ha, at zero percent moisture).

VARIETY (***)	Fertility level (***)			Mean
	F1	F2	F3	
	--------Kg	N-P_2O_5/ha------		
	150-0	0-75	150-75	
V1. Massayomba	225	515	2895	1210
V2. Jaune de Fo	395	700	3210	1435
V3. Koudougou local	525	775	2150	1150
V4. JFS	340	785	2775	1300
V5. Diapaga local	285	750	3065	1365
V6. Raytiri local	270	810	1985	1020
V7. SAFITA-102	405	625	3385	1470
V8. SAFITA-104	365	635	3000	1335
V9. TZE-4	460	855	3430	1580
V10. Temp. x Tropical 27	390	590	3440	1470
V11. IRAT-178	345	625	2975	1315
V12. SAFITA-2	795	890	3490	1725
Mean	400	715	2985	1365

Variety x Fertility level (***)	C.V. (%)	Main plot	30.3
		Sub-plot	18.4

*** : significant at 0.1 %

L.S.D.'s at 5%

Fertility levels	207
Varieties	203
Varieties at same fertility level	352
Varieties at different fertility levels	394

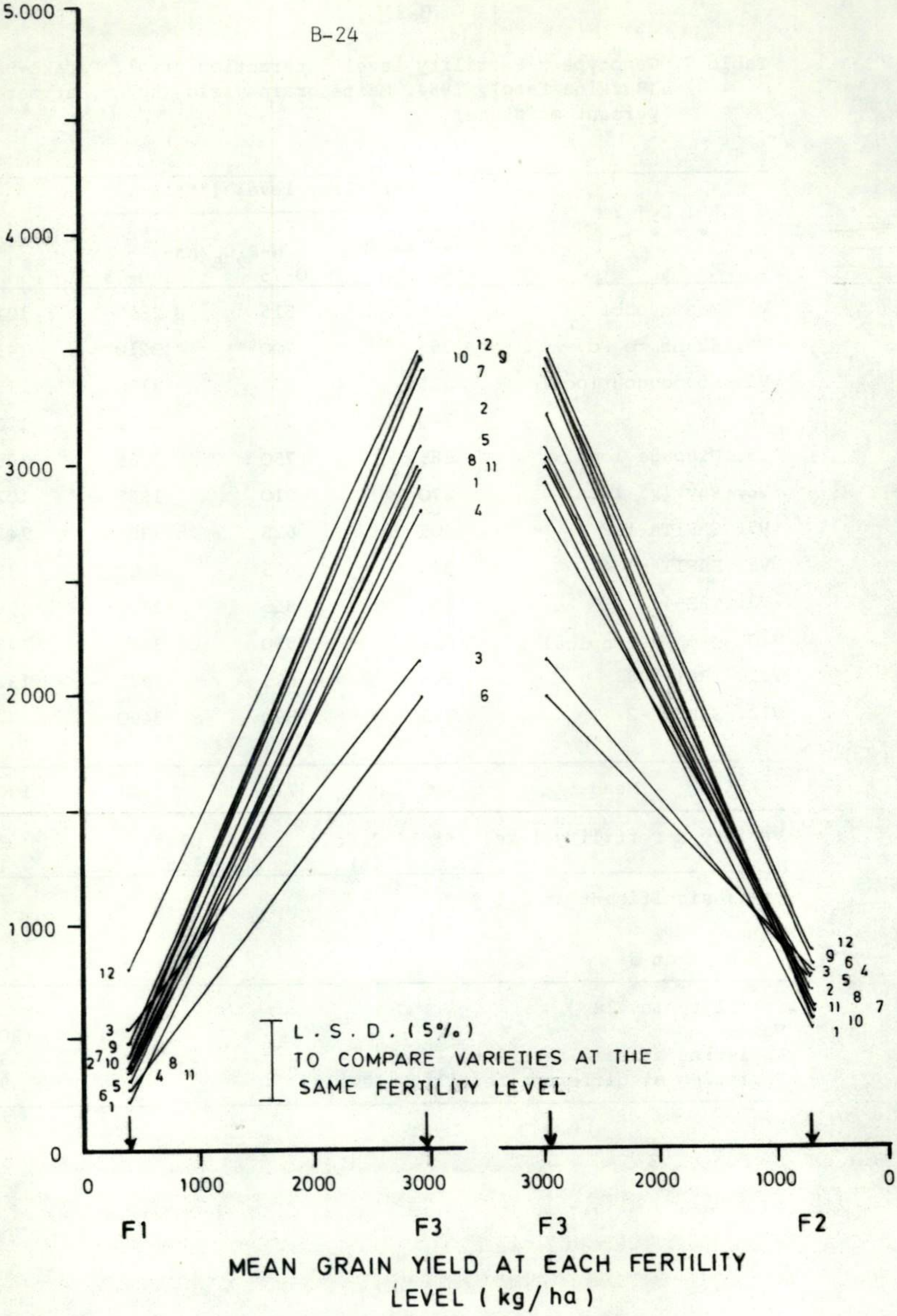


FIG. 4. GRAIN YIELD OF 12 MAIZE VARIETIES AT 3 LEVELS OF FERTILITY (F). GENOTYPE X FERTILITY LEVEL INTERACTION TRIAL. FARAKO-BA (BURKINA FASO), 1984.

below that of the other varieties. This is, nevertheless, explainable given that V3 and V6 are very early varieties (about 82 days to maturity) and, therefore, having a lower yield potential than varieties having a longer cycle. By the same token, the performance of SAFITA-104 (V8) under F3 is of interest given that it is also a very early variety (85 days) ; the data suggests that SAFITA-104 has either a high yield potential in relation to its early cycle or a better adaptation to the growing conditions at Farako-Bâ than Raytiri local and Koudougou local. It is also interesting to note that among the 4 top yielding varieties under F3 there were 2 early ones (V12 = SAFITA-2 and V9 = TZE-4) and 2 intermediate ones (V10 = Temp. x Tropical 27 and V7 = SAFITA-102).

An important conclusion follows from these results : it is not correct to say that local varieties are necessarily better adapted to low P or low N fertility conditions than improved varieties. The improved IITA/SAFGRAD varieties did not do less well under low fertility than the local ones.

The authors do not support the general statement that improved varieties will do as well or better than local ones under low management conditions. But, under the specific conditions of this experiment and for the varieties under test, the varieties improved by IITA/SAFGRAD did as well if not better than the local ones under low management (low fertility) conditions.

The 3 highest and the 3 lowest yielding varieties at each of the 3 fertility levels are presented in Table 8, together with their characteristics (cycle, and whether local or improved). Without drawing any general conclusions, but based on the present data, the following observations follow :

a) Under low P
   i) The 3 highest yielding entries were early or very early, and improved or local.
   ii) The 3 lowest yielding entries were early, very early or intermediate, and local or local improved by mass selection.

b) Under low N
   i) The 3 highest yielding entries were early or very early, and improved or local.
   ii) The 3 lowest yielding entries were all intermediate, and improved or local improved by mass selection.

c) Under high N and P
   i) The 3 highest yielding entries were early or intermediate, and all improved.

Table 8. Genotype x Fertility level interaction trial. Farako-Bâ (Burkina Faso), 1984. Three highest and 3 lowest yielding varieties and their characteristics under each low phosphorus, low nitrogen, and high nitrogen and phosphorus conditions.

	Low P (F1)	Low N (F2)	High N and P (F3)
Highest yielding varieties (and characteristics)*	V12 = SAFITA-2 (E, Im)	V12 = SAFITA (E, Im)	V12 = SAFITA-2 (E, Im)
	V3 = Koudougou local (VE, L)	V9 = TZE-4 (E, Im)	V10 = Temp. x Trop. 27 (I, Im)
	V9 = TZE-4 (E, Im)	V6 = Raytiri local (VE, L)	V9 = TZE-4 (E, Im)
Lowest yielding varieties (and characteristics)	V1 = Massayomba (I, Li)	V1 = Massayomba (I, Li)	V6 = Raytiri local (VE, L)
	V6 = Raytiri local (VE, L)	V10 = Temp. x Trop. 27 (I, Im)	V3 = Koudougou local (VE, L)
	V5 = Diapaga local (E, L)	V11 = IRAT-178 (I, Im)	V4 = JFS (E, Li)
		V7 = SAFITA-102 (I, Im)	

* Characteristics :

E = early ; VE = very early ; I = intermediate

L = local ; Li = local improved by mass selection ; Im = improved.

ii) The 3 lowest yielding entries were very early or early, and local or local improved by mass selection.

This experiment will be repeated and continued in order to validate the above results.

4. TRIALS AT KAMBOINSE (SUDAN SAVANNA)

4.1 Toposequence trial

Given the marked differences that exist between soils along a toposequence and the strong toposequence effect on maize grain yield, it can be asked whether different maize varieties have or not the same relative adaptation to the different soils in a toposequence. In order to explore the interaction genotype x position on the toposequence, an experiment was started in 1984 involving a factorial combination of 6 genotypes and 5 positions on the toposequence. The trial was arranged in a split-plot arrangement with 6 replications.

Due to the low rainfall and its bad distribution at Kamboinse in 1984, the experiment was planted only on August 4 (Note that normally the rains are expected to cease by mid-September). The trial was planted on old tied ridges (of the 1983 toposequence trial, where all the ridges were tied since the end of the 1983 season). No fertilizer was used in 1984 (nor in 1983). The density was 44,400 plants/ha and the plot size 3.75 m x 3.15 m (5 row plots, 3.15 m long ; 0.75 m between rows ; the central 3 rows were harvested).

As shown in Table 9, there were statistically (P = 0.1 %) significant grain yield differences between positions on the toposequence and between varieties. The Genotype x Position interaction was not significant (P = 5 %).

The mean grain yields varied from 89 to 762 kg/ha for the different positions along the toposequence, but only the latter yield, obtained in the bottommost position (hydromorphic soil), was statistically superior to those obtained in the other 4 positions. The highest yielding varieties were Raytiri local (365 kg/ha), Koudougou local (340 kg) and J.F.S. (274), followed by TZE-4 (225 kg), Kamboinse local (165 kg) and SAFITA-2 (119 kg), for and L.S.D. of 96.0 kg at 5 % level. These results show that, under the 1984 conditions, earliness was the key factor determining maize grain yield. Raytiri local and Koudougou local are the earliest among the 6 varieties tested, followed by JFS.

Table 9. Toposequence trial. Kamboinsé (Burkina Faso), 1984.
Maize grain yield (kg/ha, at zero percent moisture)

GENOTYPE (* * *)	Plateau P1	Upper slope P2	Mid slope P3	Lower slope P4	Hydromorphic soil P5	Mean
	Position along the toposequence (***)					
V1. SAFITA-2	18	99	72	42	365	119
V2. Raytiri local	124	233	293	168	1007	365
V3. TZE-4	72	97	125	63	768	225
V4. JFS	116	51	181	152	871	274
V5. Koudougou local	174	214	252	194	864	340
V6. Kamboinsé local	32	28	42	23	700	165
Mean	89	120	161	107	762	248
Genotype x Position (ns)		C.V. (%)	Main plot			244.5
			Sub-plot			75.7

*** : Significant at 0.1%
ns : Non significant

L.S.D.'s at 5%

Positions on the toposequence	298.6
Genotypes	96.0
Genotypes at the same position	214.7
Genotypes at different positions	357.1

The number of days to 50 % silking in the hydromorphic position for the 3 varieties was : 44.2, 44.8, and 52.5 days, respectively. For the other 8 varieties (normally around 50 days to 50 % silking), many of the plots never reached 50 % silking, even in the hydromorphic soil. The grain yield of local Raytiri in the latter position was 1007 kg/ha. Although the total rainfall at Kamboinse in 1984 was 414 mm, only 227.4 mm fell between planting and harvest of this trial.

4.2 Earthing-up trial

This is a long term experiment started in 1980. The latest review was presented in the 1982 IITA/SAFGRAD Annual Report. The objectives of the experiment are to : (1) estimate the effect of simple earthing-up VS tied earthing-up on maize grain yield, under a traditional hand-hoeing soil preparation system ; (2) to measure the effect of tying the ridges either every other furrow or in all furrows ; (3) to evaluate the usefulness of tied ridges from one season to the next.

The experiment involves a factorial combination of 2 management levels and 4 earthing-up systems, replicated 5 times. The management levels are : 1) low fertilizer level and low density (33,300 plants/ha), and 2) high fertilizer level and high density (44,400 plants/ha). These plant densities are lower than those normally used, but, given the late planting date (August 2), it was considered appropriate to use lower densities. The fertilizer rates used in the past were 37-23-15 (low) and 97-46-30 (high) kg of $N-P_2O_5-K_2O$/ha. In 1984, however, all plots received the blanket low fertilizer application (100 kg of 14-23-15 and 50 kg of urea/ha). The variety was Koudougou local.

The 4 earthing-up systems were :

1. Planting on the flat. No earthing-up.
2. Planting on the flat. Earthing-up 30 DAP.
3. Planting on ridges tied every second furrow.
4. Planting on ridges tied every furrow.

The plots are re-randomized within systems (1) and (2) every year. In systems (3) and (4) the ridges were made in 1980 (30 DAP) and are built up every year at the time of earthing up. The soil is prepared every year by hand-hoeing, but in systems (3) and (4) only furrows are hoed (without destruction of ridges or ties).

Although the grain yields were low, as expected for such poor season, there were statistically significant differences between management levels and earthing-up systems. The interaction Management x System was also significant (P = 1 %). The mean grain yield under the low management level was 145 kg/ha as opposed to 231 kg for the high level (Table 10). There was no yield difference between no earthing-up and simple earthing-up (15 VS 14 kg/ha, respectively), but yields for planting on ridges tied every second furrow (245 kg/ha) and on ridges tied every furrow (479 kg/ha) were significantly higher (L.S.D. = 68.5 kg, at P = 5 %). The yield increase between tying the ridges every second furrow and tying the ridges every furrow as also significant and was more pronounded at the high (602 VS 295 kg) than at the low (357 VS 195 kg) management level, which accounts for the significant Management x System interaction.

It takes 27 man-days/ha to make both ridges and ties (25 cm tall, 0.75 m between ridges and 1 m between ties) with a hand-hoe. Taking an opportunity cost of labor of 50 F CFA/hour, the cost of making tied ridges is 10.800 CFA. At a maize price of 90 CFA/kg, this equals 120 kg of maize/ha.

In a system where the crop is planted on old tied ridges, the labour input required for maintaining the old tied ridges is a function of the soil type, the rainfall distribution pattern and the protection given by the canopy. At Kamboinsé, and under the experimental conditions tested, the degree of destruction of the ridges from one season to the next has been estimated at about 50 %. Therefore, it takes about 13.5 man-days/ha to maintain old tied ridges by hand from one year to the next, or the equivalent of 60 kg of maize/ha. The yield increase obtained by tying all the ridges (furrows) in 1984 was 335 at the low and 595 kg/ha at the high management level. Greater yield increases were obtained in the previous years (same trial).

The practice of establishing tied ridges and keeping them from year to year can be recommended for the compound plots, where it is most likely that there is a minimum of fertility such that there can be a response to tied ridges, even without chemical fertilizer applications. This was in fact supported by the FSU/SAFGRAD on-farm tests in 1983.

4.3 Plants per hill trial

The objective of this experiment is to determine if, for a given plant density, the number of plants per hill has an effect on maize grain yield (under semi-arid conditions). The experiment consisted of a factorial combination of 2

Table 10. Earthing-up trial. Kamboinsé (Burkina Faso). 1984.

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

Earthing-up system (***)	Management level(*) M1	M2	Mean
1. Planting on the flat No earthing-up	22	7	15
2. Planting on the flat Earthing-up 30 DAP.	9	19	14
3. Planting on ridges tied every second furrow. Earthing-up 30 DAP.	195	295	245
4. Planting on ridges tied every furrow. Earthing-up 30 DAP	357	602	479
Mean	145	231	188

Earthing-up system x	C.V.	Main plot	47.5
Management level (**)	(%)	Sub-plot	39.3

*,**,*** : Significant at 5,1, and 0.1 %

L.S.D. 's at 5 %

Management levels	78.6
Earthing-up systems	68.5
Earthing-up systems at the same management	96.8
Earthing-up systems at different managements	113.8

densities (maize plots) and 4 plant arrangements in a split-plot design with 8 replications.

The densities were :

D1 : 44,400 plants/ha
D2 : 66.700 plants/ha

The plant arrangements were :

A1 : 1 plant/hill
A2 : 2 plants/hill
A3 : 3 plants/hill
A4 : 4 plants/hill.

The row spacing was 75 cm. The spacing between hills from A1 to A4 was, respectively, 30, 60, 90, and 120 cm for D1, and 20, 40, 60 and 80 cm for D2. The trial was planted on August 11 with the variety local Saria (about 84 days to maturity). No fertilizer was applied in 1984. The plots had 4 rows of which the central 2 were harvested. The trial was planted on old tied ridges (on the side of the ridges).

Data from replication 2 was **deleted** from the analysis because of missing plots.

In order to obtain the target densities and plant arrangements, the number of seeds/hill was 2-3 times above the minimum requirement. At thinning time, although some hills did not have the intended number of plants, there was no compensation from one hill to another for the missing plants. Therefore, the ratio of densities at harvest to intended densities gives an indication of the degree to which the target plant arrangements were achieved. The ratios for A1 to A4 were, respectively, as follows : 0.972, 0.961, 0.993, and 0.926 for D1 (44,400 plants/ha), and 0.909, 0.931, 0.899 and 0.931 for D2 (66,700 plants/ha). These values indicate that the intended densities and arrangements were obtained to a satisfactory degree. The grain yield results (Table 11) indicate no significant difference between plant densities (230 and 212 kg/ha), but show a significant (P = 1 %) effect of plant arrangement. Grain yields tended to decrease as the number of plants/hill increased from 1 to 4 (276 VS 175 kg/ha, respectively ; L.S.D. = 58.6, at 5 %). There appears to be no statistically significant nor important grain yield difference between 1 and 2 plants/hill. However, 3 and 4 plants per hill lead to lower grain yields, especially so, it

Table 11. Plants per hill trial. Kamboinsé (Burkina Faso), 1984
Maize grain yield (kg/ha, at zero percent moisture).

Plant Arrangement (* *)	Plant density (ns) D1	D2	Mean
1) 1 plant/hill	257	295	276
2) 2 "	271	229	250
3) 3 "	223	142	183
4) 4 "	169	181	175
Mean	230	212	221
Arrangement x Density (ns)	C.V.	Main plot	74.1
	(%)	Sub-plot	34.5

* * : Significant at 1 %
ns : Non significant

L. S. D.' s at 5 %	
Densities	107.3
Arrangements	58.6
Arrangements at the same density	82.8
Arrangements at different densities	128.6

seems, at the high density,although the Density x Arrangement interaction was not statistically significant. This experiment will be reconducted in 1985.

4.4. New cultivation trial

This experiment has as objective to evaluate the effectiveness of cultivations (scarifications) for breaking the soil crust and increasing soil water infiltration, as reflected in maize grain yields. This trial (long term) is conducted in a soil with tendency to surface crusting.

The following 6 treatments are compared in a CRB design with 5 replications :

C1 : No cultivation after planting

C2 : 2 cultivations, at ± 2 and 4 WAP

C3 : 3 cultivations, at ± 2, 4 and 6 WAP

C4 : 4 cultivations, at ± 2, 4, 6 and 8 WAP

C5 : 2 cultivations, at ± 2 and 4 WAP. At the time of the first cultivation small holes (± 40 cm long x 20 cm wide x 10 cm deep) are dug between the maize rows (without earthing up). The holes are about 20 cm apart from each other.

C6 : 2 cultivations, at ± 2 and 4 WAP. The second cultivation coincides with the earthing-up and tying of the ridges.

The plot was tractor plowed, and harrowed twice. The fertilizer applied was 200 kg 14-23-15/ha and 100 kg urea/ha. All the plots were planted on the flat on August 4, at a density of 44,400 plants/ha (variety Jaune Flint de Saria). All the plots received pre-emergent herbicide (Primextra) and, in addition, weeds were pulled out by hand, as often as necessary, to keep all plots weed free.

There were highly significant (P = 0.1 %)differences in grain yield between the cultivation treatments (Table 12). The treatment without any cultivations after planting did not produce any yield. Treatments with 2, 3 or 4 cultivations gave yields below 100 kg/ha. The best grain yields were obtained when holes were dug between rows (278 kg) or, better still, when there was a tied earthing-up (481 kg/ha ; L.S.D. = 205.1 kg, at 5 % level). This data confirms previous results indicating that the digging of small holes or ditches between the rows and/or the use of tied ridges are more effective alternatives than repeated cultivations to the problem of increasing soil water infiltration in crusting soils.

Table 12. Cultivation trial, Kamboinsé (Burkina Faso), 1984.
Maize grain yield (kg/ha, at zero percent moisture).

Cultivation system (***)	Grain yield
C1. No cultivation after planting	0
C2. 2 cultivations (± 2 and 4 WAP)	90
C3. 3 cultivations (± 2, 4 and 6 WAP)	16
C4. 4 cultivations (± 2, 4, 6 and 8 WAP)	27
C5. 2 cultivations (± and 4 WAP) + holes	278
C6. 2 cultivations (± 2 and 4 WAP) + tied ridges	481

*** : Significant at 0.1%

Mean	149
C.V.(%)	104.4
L.S.D.(5%)	205.1

4.5 Seed size trial

Seed size is a factor affecting germination and seedling vigor. Thus, it could be of importance for crop growth and grain yield under drought conditions. This trial was set up to determine the importance of seed size on the growth and yield of 3 local and 3 improved varieties.

The experiment consisted of a factorial combination of 6 varieties x 2 seed sizes in a split-plot design with 4 replications. Seed size was the sub-factor.

The 6 varieties were :

V1 = Pool 16, V2 = Koudougou local, V3 = Diapaga local, V4 = Saria local, V5 = SAFITA-2, and V6 = SAFITA-104. The cycles of the above varieties are respectively, 90, 82, 90, 84, 90 and 85 days from planting to maturity.

The seed sizes were : S1 = small, and S2 = large. The seed sizes were not the same for each variety. The procedure was to take seed of the same source for a given variety and separate it into 3 groups : large, medium and small (but rejecting the very small or broken grains). The large and small seed groups were then selected for the experiment. This gave the following weights (g) of 1000 grains (at 9 % moisture) for each variety and size :

		Seed size		Ratio
Variety		Small	Large	Small/large
V1		123	232	0.53
V2		99	199	0.50
V3		112	202	0.55
V4		102	194	0.53
V5		142	265	0.54
V6		111	193	0.58
	Means	115	214	0.54

The trial was planted on old tied ridges at a uniform spacing of 75 cm between rows and 30 cm between hills. Although the target density was uniform (44,400 plants/ha), the number of grains per hill was 5 for the small seed size and 3 for the large one. The reason for this was to eliminate differences in plant density as a factor in any eventual grain yield differences between treatments (since lower germination was expected in the small size). The fertilizer used was 100 kg/ha of each 14-23-15 and urea. The trial was planted on August 13 and thinned to 1 plant/hill on August 31.

Grain yields (Table 13) were significantly (P = 5 %) different between varieties but not between seed sizes. The interaction Variety x Seed size was not significant. The 3 lowest yielding varieties were Pool 16 (72 kg/ha), SAFITA-2 (169 kg), and Diapaga local (252 kg), which are the latest varieties tested (90 days to maturity). The 3 highest yielding ones were Koudougou local (577 kg), SAFITA-104 (381 kg), and Saria local (330 kg), which are earlier than the former (82-85 days). These results are not surprising given the rainfall distribution pattern in 1984. They show, nevertheless, the importance of very early materials and the need to develop extra-early maize varieties. Althouth the grain yield differences between varieties were only about 500 kg or less, for a farmer -under the 1984 harsh conditions- even a 100-200 kg/ha difference between varieties could make the difference between starvation and survival.

The mean yield for the small and large seed sizes was 260 and 333 kg/ha (L.S.D. = 128.3 at 5 % level). Although seed size had no significant effect on grain yield, it had a highly significant (P = 0.1 %) effect on germination : 61.9 % VS 78.4 % for small and large seed sizes, respectively (L.S.D. = 3.0, at 5 %). The effect of seed size on germination was not reflected on the grain yields under the experimental conditions since there was overplanting and later thinning to 1 plant/hill. In effect, final plant densities fluctuated from 43,137 to 44,444 plants/ha for all treatment combinations. However, under the growing conditions of a farmer who does not overplant in order to thin later on, the effect of seed size on germination could result on important differences in final plant density and grain yield. It follows as well that the effect of seed size on germination and maybe on seedling vigor has to be considered in varietal tests. In particular, tests that compare "improved" VS "local" (or "non-improved") varieties often involve a seed selection and rejection of the smaller seeds of the "improved"varieties" but no such seed selection is applied to the local varieties in many cases. This introduces on in-built bias in such tests (to be added to others like, e.g. chemical seed treatment of improved varieties but not of local ones in many cases).

4.6 Other trials conducted at Kamboinsé

Many other trials were conducted at Kamboinsé in 1984. Among them, long-term trials evaluating the effect on grain yield of factors such as :

Table 13. Seed size trial. Kamboinsé (Burkina Faso), 1984. Maize grain yield (kg/ha, at zero percent moisture).

Variety (*)	Seed size (ns) Small	Large	Mean
V1. Pool 16	58	85	72
V2. Koudougou Local	689	465	577
V3. Diapaga local	262	242	252
V4. Saria local	291	368	330
V5. SAFITA-2	83	255	169
V6. SAFITA-104	177	585	381
Mean	260	333	297

Variety x Seed size (ns)	C.V. (%)	Main plot	87.1
		Sub-plot	71.2

* : Significant at 5%

ns : Non significant

L.S.D.'s at 5%

Varieties	275.9
Seed sizes	128.3
Seed sizes at the same Variety	314.2
Seed sizes at different varieties	354.2

- Planting dates
- Soil preparation methods
- Seedbeds
- Crop residue managements
- Timings of N application
- Plant density
- Maize-cotton association.

The results will not be presented in this report. In general, grain yields were low, reflecting the bad rainfall distribution pattern observed in 1984. The results, however, show that, for plantings between August 2 and August 17, grain yields tended to fluctuate between 0 and 200 kg/ha without tied ridges and between 300 and 600 kg/ha tied ridges were used.

5. OVERVIEW OF THE MAIN AGRONOMIC PROBLEMS FOR GROWING MAIZE IN THE SEMI-ARID TROPICS OF WEST AFRICA AND POSSIBLE SOLUTIONS.

Given the wide variability in soils and climate found in the SAT of West Africa and the limited available information, it is difficult and risky to generalize. Nevertheless, it is better to have a general picture 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 300 to 1200 mm. Maize has been moving northwards, from the forest to the Savanna, slowly replacing sorghum and millet as the main cereal crop. Today, in general, in the 900-1200 mm belt, maize can be grown as an open field crop, i.e. in fields that to not necessarily receive intensive management from the point of view of manure or crop residue applications. In the 600 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 African countries maize is already a major cereal crop in the 900-1200 mm belt in terms of acreage or production. In the 600-900 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 600-900 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 : termite damage, streak virus, weeds, *Striga*, soil acidity, lodging.

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 iron 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 600-900 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 risk of drought stress, soil fertility and 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 :

Soil fertility

Nitrogen : chemical fertilizer and/or legume rotations (or other cropping systems involving legumes).

Phosphorus : chemical fertilizer and/or 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 6 years has shown that in ferruginous tropical soils (Alfisols) 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.

6. TIED-RIDGING WITH ANIMAL POWER (TRAP) PROJECT

J. Wright and M. Rodriguez

Tied ridges, introduced by the Maize Agronomy Program, have been identified by SAFGRAD Scientists as a very effective agronomic practice in the predominant soils of the 600-900 mm rainfall zone of Burkina Faso. Tied Ridges reduce rainfall runoff, soil erosion, and moisture stress thereby increasing yields. However, one of the major constraints to widespread adoption of tied-ridges by Burkinabè farmers is the amount of labor required to make them by hand. The SAFGRAD/IITA Maize Agronomy Program has developed an attachment for animal traction ridgers that eliminates the labor required to make tied ridges by hand.

It takes up to 27 man-days/ha to make both 25 cm high ridges (18 man-days) and the ties (9 man -days) using only the traditional hand-hoe (daba). To offset this labour cost, a yield increase of about 120 kg/ha would be required. Yield increases of this magnitude and greater have been obtained in farmers fields. However, if tied ridges are to be made early in the season, this would come when there can be serious labour constraints for other farm operations like soil preparation, planting, weeding. The labour requirements for making tied ridges can be reduced to less than 12 man-days/ha if the ridges are made with animal traction and the ties with the hand-hoe. Further reductions in labour requirements are to be expected if both the ridges and ties are all made by animal traction.

An informal survey was conducted about the animal traction systems available in Burkina Faso. What emerged from this preliminary work was a set of design criteria that were necessary, if not sufficient, for a ridge tyer in Burkina. The device should be : (1) Small enough to be used by a donkey or, otherwise, by oxen. Donkeys are the most common traction animals for Burkinabè farmers. They are easy to train and maintain and represent 80 % of all traction animals. (2) Easy to transport by bicycle and mobylette. (3) Easy to attach to all ridging equipement available in Burkina. These include ox ridgers manufactured by two local companies and the houe Manga, a scarification tool used for marking fields before planting and for weeding. (4) durable since repairs are difficult away from urban areas. (5) simple to operate and maintain and use readily available components. (6) able to make ties that are at least 12 cm high, every 2 m or less. Tied ridges of these dimensions will fully trap a rainstorm of up to about 60 mm. (7) not too expensive. It should cost less than 20.000 CFA. Burkinabè farmers have very little capital available for equipment purchases.

Ridge tying technologies from Africa and the United States (where over 500,000 hectars are under tractor tied-ridge cultivation) were investigated with an eye towards their adaptability to these design criteria. As a result, 4 ridge tyers were constructed from photographs and plans for testing under Burkina conditions at the Kamboinsé Research Station.

The design that performed the best in these tests was one by Lyle and Dixon of the American Society of Agricultural Engineers. It was originally designed for use behind tractors. It was scaled down to fit behind an ox ridger and its hydraulic tripping mechanism was replaced by one activated by a bicycle break lever assembly. It consistently made ties 14 cm high and spacing of the ties could be controlled by the operator. It is very compact (only 65 cm long) and therefore fits easily behind ridgers available in Burkina Faso.

This model has 4 shovels that roll on an axis. This rolling is controlled by a catch mechanism activated by a bicycle break lever. When attached behind a ridger one of the shovels pulls loose soil along the furrow until the operator activates the catch mechanism. When he does this, the next shovel rolls over the pile of soil which is slightly packed between the 2 shovels into a tie. The catch mechanism stops the roll and the process begin again.

Two versions of this "Tripping Shovel Device" are currently being testing. One is for donkey traction and row spacings of 50-65 cm. It weighs 11 kg and has shovels that are 40 cm wide at the top tapering to 16 cm at the bottom. Production cost is expected to be about 13.000 CFA. The other is for oxen traction and row spacings of 65 to 80 cm. It weighs 17 kg and has shovels that are 55 cm wide at the top tapering to 20 cm at the bottom. Production cost is expected to be about 15.000 CFA.

The Maize Agronomy Program tried to assess the agronomic and economic effectiveness of making tied ridges using animal power and the new Tripping Shovel Device (TSD). Cooperators in this effort were the Soil-Water Management Team of ICRISAT, the Centre National d'Equipement Agricole and the Centre National d'Entrainement à la Mécanisation Agricole at Boulbi. Research sites were at Boulbi, 12 km south of Ouagadougou, and at the Kamboinsé research station 12 km north of Ouagadougou.

The treatments tested were comparisons of tied ridges made by hand-hoe (daba), donkey (houe Manga) and oxen traction using Maize as a test crop. Data were collected on the effective working depth of each tool and the time spent performing each management option. For ridging and ridge tying the height of the ridge and the tie were noted at the time of construction and after 100 mm of rainfall. Ridge tying by the animals was performed by the Tripping Shovel Device. Results of ridging and ridge tying are summarized below :

Tied Ridging Method	Height (cm) at construction		Time man-days/ha	Height (cm) after 100 mm of rainfall	
	Ridge	Tie		Ridge	Tie
Hand (daba)	20	20	25.0	14	14
Donkey w/TSD	13	13	8.8 (+1 Donkey)	5	5
Oxen w/TSD	17	15	4.0 (+2 Oxen)	10	9

Given that the hand-made ridges were considerably higher than those made by the animals, if the height of the former is adjusted to 15 cm, then it can be considered that it would take 18.5 man-days/ha to make them ; their height after 100 mm of rainfall would be reduced to about 9 cm. These results show that, to make tied ridges of a roughly comparable height (about 15 cm), the use of one donkey or 2 oxen reduces the number of man-days/ha required from 18.5 to 8.8 or 4.0 respectively.

In addition to the formal research, informal off-station testing was carried out to get feedback from farmers on this new technology and investigate possible cultural limitations to acceptance of the device. Ten farmers used the device for a couple of hours each. They all responded favorable to how well it made ties. They liked the size of the device and they liked being able to control the spacing of the ties. Things they did not like were the difficulty of leaning over the device to operate the houe Manga and they did not like the cost at that time estimated at 16.000 CFA. The device did not work at all behind a horse since its fast pace threw the loose soil from the furrow and there was none left to form a tie. These off-station tests pointed out some of the limitations of this technology and its applicability, but also showed that farmers who are familiar with tied ridges and who have access to animal traction are interested in using animals to make tied ridges.

An extensive on-farm research effort is going to be carried out in the 1985 growing season. One hundred Tripping Shovel Devices will be made available to farmers and researchers for on-farm trials. Cooperators in this effort will be FSU, ICRISAT, IRAT, The World Bank, Centre National d'Equipement Agricole, several O.R.D.'s and state training farms.

7. ACKNOWLEDGEMENTS

The IITA/SAFGRAD Maize Agronomist expresses his gratitude to his brother, Sergio Rodriguez, for his unfailing help in the conduction of the Maize Agronomy Program during 1984. S. Rodriguez is a 5th year agronomy student at the National University in Medellin, Colombia, and was the main assistant of the Maize Agronomist from May to December 1984.

MAIZE ENTOMOLOGY

1. SCREENING OF MAIZE FOR RESISTANCE TO TERMITES

J.B. Suh, M. Rodriguez, and A.O. Diallo

Maize production in the Semi-Arid African Tropics is greatly limited by low fertility and drought. Diseases and damage from millipedes, termites, stem borers and armyworms are additional factors reducing grain yield. Termites are considered a major insect pest problem because they attack different stages and parts of the maize plant : roots, stem, cob and grain. Moreover because termite injury to the roots occurs underground, often with no visible (termite) activity above ground, it invariably either goes unnoticed or the ensuing yield loss is attributed to other causes. Work to date has included assessment of yield loss associated with various pest species as well as preliminary evaluation of cultivars for termite resistance.

An experiment was undertaken to continue evaluation of the response of some improved and local (L) cultivars to natural field infestation of termites at Kamboinse. Twenty varieties (12 improved, 8 local) of two maturity groups (15 early, 5 intermediate, Table 5), were planted on three 5 m long rows (density 53,333 plants/ha) in a randomized block design with 6 replications. One of two pest control treatments were instituted to determine intensity and effects of pestilence : no protection, and protection (split application of Carbofuran 5 g at 2.5 kg a.i./ha ; 1 kg at emergence and 1.5 kg 40 days after emergence). Observations were taken on plant development traits (stand establishment, lodging, tillering, silking), disease (streak) and insect pest incidence (Armyworms, Stemborers, Termites). The trial received 3 small irrigations (about 5-15 mm each) to try to insure some grain production.

Stand establishment was uniformly low in all varieties i.e. similar response to prevailing unfavourable growing conditions. However insecticide treatment resulted in a striking improvement (P = 0.001) in plant stand of all cultivars, presumably because of suppression of pre-emergence and seedling root pestilence. Between 60 and 70 per cent silking had occurred at 47 DAP in JFS, Local Raytiri and Composite Jaune, followed by 28 to 46 per cent in Safita 104, Safita 102, Local Pabre and TZSR-Y. This was substantially higher than in Massayomba, TZESR-W, Local Kamboinse and Pirsaback (1) 7930 (20-26 per cent). Lodging was assessed at 37, 45, 60 and 70 DAP, before termite activity on roots became intense. Safita-2, Local Raytiri, and JFS suffered considerable lodging damage (25 per cent) compared to Local Kamboinse, TZESR-W and IRAT 178 (12 to 15 per cent, Table 1). The incidence of streak and armyworms are reported in Table 2. Differences in varietal response to streak were highly significant (p = 0.001) and local cultivars (Raytiri, Pabre, Kamboinse etc) appeared to be markedly susceptible. However treatment with Furadan R effectively reduced incidence presumably through suppression of the vectors (Cicadulina Spp). IRAT 178, Local Kamboinse, Safita 102 and Massayomba suffered significantly higher damage (16 to 21 per cent) by the armyworm, Mythimnia unipuncta compared to TZESR-W, JFS, Composite J. (Senegal) and Local Pabré (8 to 11 per cent). Insecticide treatment evoked a highly favourable response (50 per cent reduction in incidence) in all varieties. The stem borers infesting stems and cobs, Sesamia and Eldana, caused only mild damage (less than 6 per cent). Termite injury was higher (27 to 35 per cent) on roots than stems (10 to 24 per cent) but in either case, no significant differences occurred among cultivars (Table 3).

Termite injury on cobs and grain is given in Table 4. Grain damage in general was higher than cob damage especially in early maturing cultivars. Injury was substantially higher in cobs of Local Raytiri, JFS, Composite J. (Senegal) and Local Koudougou in relation to TZSR-Y, TZESR-W, IRAT 178 and Pool 34 QPM. The pattern of grain damage was similar to that of cobs, but was more severe in L. Raytiri, JFS, Local Koudougou and Composite J. compared to Pool 34 QPM, TZSR-Y, TZESR-Y and Safita 102. Cob and grain injury particularly in the heavily infested varieties was significantly reduced by insecticide treatment. Conversely pest control had little or no effect on grain damage in less infested varieties.

It appears that early varieties suffered higher termite damage (cobs, grain) than intermediate ones. This is presumably because these cultivars mature and lodge earlier and the ears are thus more easily attacked by termites. Although not done in 1984, the harvest should be differential in this sort of experiment. Grain yield (Table 5) was miserable primarily because of poor rainfall. TZESR-W, Local Raytiri and JFS produced about 0.75 ton/ha on insecticide protected plots (compared to 200-400 kg/ha on untreated plots). Safita-102, TZSR-Y, IRAT 178 and Temp. x Trop. 27 yielded a little more or less than 100 kg/ha on insecticide protected plots. These are later maturing (intermediate) cultivars which were just tasseling when the rains stopped. Grain yield differences among varieties were highly significant and gave a very strong favourable response (P = 0.001) to pest suppression. These results show that the different cultivars, differ in their ability to cope with the stress and pestilence of the semi-arid environment. The objective is to harness these inherent qualities and, in adjunct with sensible pest suppression, increase and sustain economic maize production.

Table 1. Per cent lodging of selected maize varieties tested under field Termite Infestation at Kamboinse, Burkina Faso, 1984.

Variety	Protected	Unprotected	Mean
Safita 2	23.43	27.39	25.41
L. Raytiri	22.65	26.46	24.55
JFS	26.55	22.51	24.53
Pirsaback (1) 7930	22.89	22.06	22.48
Temp x Trop 27	12.80	16.53	14.67
L. Kamboinse	13.92	15.18	14.55
TZESR-W	12.06	15.20	13.63
IRAT 178	13.16	11.71	12.44
Mean		18.72	
L.S.D. (10 %)		4.544	
C.V. (%)		21.20	

Table 2. Incidence (%) of Armyworm and Streak on selected maize varieties tested at Kamboinse, Burkina Faso, 1984.

Variety	Protected	Unprotected	Mean
I. STREAK			
L. Raytiri	8.37	16.12	12.24
L. Pabre	10.02	12.05	11.04
L. Kamboinse	7.75	13.96	10.85
Composite Jaune	10.17	11.53	10.85
Pool 34 QPM	6.45	7.90	7.18
Temp x Trop 27	2.83	9.00	5.91
TZESR-W	5.88	5.74	5.81
TZSR-Y	3.12	3.72	3.42
Mean	8.67		
L.S.D. (5 %)	4.52		
C.V. (%)	45.5		
II. ARMYWORM			
IRAT 178	14.01	26.55	20.28
L. Kamboinse	10.88	22.13	16.51
Safita 102	12.46	20.35	16.41
Massayomba	10.55	19.82	15.19
L. Pabre	5.86	15.24	10.55
Composite Jaune	8.86	12.01	10.43
JFS	5.68	10.35	8.01
TZESR-W	4.11	11.51	7.81
Mean	13.10		
L.S.D. (5 %)	3.820		
C.V. (%)	25.50		

Table 3. Termite incidence (%) on roots and stems of selected varieties of maize tested under field termite infestation at Kamboinse, Burkina Faso, 1984.

Cultivars	Protected	Unprotected	Mean
I. ROOT DAMAGE			
TZESR-Y	35.75	40.15	37.95
Temp x Trop 27	37.08	37.41	37.25
L. Kamboinse	34.92	36.61	35.76
L. Koudougou	34.80	34.61	34.71
L. Raytiri	31.09	27.98	29.53
TZE 4	24.70	34.08	29.39
Safita 2	26.56	28.28	27.42
IRAT 178	26.37	27.92	27.14
Mean	32.27		
L.S.D. (5 %)	N.S.		
II. STEM DAMAGE			
Safita 102	23.34	24.32	23.83
JFS	18.95	24.89	21.92
L. Pabre	20.70	19.93	20.31
TZSR-Y	19.06	21.17	20.11
Safita 104	15.73	14.01	14.87
Pool 34 QPM	17.62	11.55	14.58
TZESR-W	10.46	12.85	11.65
TZESR-Y	11.27	9.45	10.35
Mean	17.02		
L.S.D. (5 %)	N.S.		

Table 4. Percent maize cob and grain damage by termites on selected maize varieties at Kamboinse, Burkina Faso, 1984.

Variety	Protected	Unprotected	Variety Mean
I. COB DAMAGE			
L. Raytiri	20.66	41.00	30.83 a
JFS T14 K81	21.18	31.23	26.29 b
Comp. Jaune	13.84	26.26	20.05 abc
L. Koudougou	7.00	23.03	15.40 bcd
TZSR-Y	0.00	6.54	3.27 def
TZESR-W	0.00	5.11	2.56 ef
IRAT 178	0.00	4.43	2.21 ef
Pool 34 QPM	0.00	2.74	1.37 f
Mean	9.83		
L.S.D. (5 %)	10.355		
C.V. (%)	91.90		
II. GRAIN DAMAGE			
L. Raytiri	42.10	43.50	42.80 a
JFS	28.20	37.80	33.00 ab
L. Koudougou	21.00	36.20	28.60 bc
Comp. Jaune	14.20	30.70	22.50 bcd
Pool 34 QPM	4.4	0.0	2.20 ef
TZESR-Y	3.9	0.0	2.00 ef
TZSR-Y	0.0	0.0	0.00 f
SAFITA 102	0.0	0.0	0.00 f
Mean	12.70		
L.S.D. (5 %)	13.333		
C.V. (%)	91.50		

Table 5. Grain yield (kg/ha) of 20 maize varieties under natural termite infestation at Kamboinse, Burkina Faso, 1984.

Variety	Cycle (days)	Protected	Unprotected	Variety Means
TZESR-W	95	744.00	402.00	573.00 a
L. Raytiri	82	762.00	343.00	553.00 a
L. Koudougou	82	665.00	284.00	474.00 ab
JFS	86	725.00	193.00	459.00 abc
Composite Jaune	78	475.00	271.00	373.00 abcd
SAFITA-104	86	519.00	215.00	367.00 abcd
L. Kamboinsé	92	403.00	311.00	357.00 abcd
L. Diapaga	90	540.00	118.00	329.00 bcde
Temp x trop.42	90	343.00	216.00	280.00 bcdef
SAFITA-2	92	364.00	167.00	266.00 bcdef
Pool 34 QPM	90	363.00	149.00	256.00 bcdef
TZE-4	90	400.00	112.00	256.00 bcdef
L.Pabre	90	260.00	232.00	246.00 cdef
TZESR-Y	95	296.00	174.00	235.00 cdef
Pirsaback (1) 7930	90	256.00	162.00	209.00 def
Massayomba	110	270.00	107.00	189.00 def
TZSR-Y	110	157.00	97.00	127.00 ef
SAFITA-102	110	112.00	84.00	98.00 f
IRAT 178	110	96.00	97.00	96.00 f
Temp x trop. 27	110	66.00	61.00	64.00 f
Mean			290.00	
L.S.D. (5%)			190.609	
C.V. (%)			57.3	

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

COWPEA BREEDING

V. D. Aggarwal

1. INTRODUCTION

The cowpea breeding program of IITA in support of the SAFGRAD project is headquartered at Kamboinse, Burkina Faso, with funding provided by the International Development Research Centre (IDRC) of Canada. The overall objective of the project is to develop or identify cowpea varieties that combine high yield, resistance to important insect-pests and diseases including Striga, desirable seed and plant characters, and are adapted to different agroclimatic conditions prevailing in the semi-arid areas, particularly of West Africa.

2. RESIDENT RESEARCH

2.1 Locations and Rainfall

In 1984 the cowpea trials in Burkina Faso were planted at five locations -Farako-Bâ, Kamboinse, Loumbila, Pobé and Saouga. Farako-Bâ represents the Northern Guinea Savanna (900 - 1200 mm rainfall), Kamboinse and Loumbila, the Sudan Savanna (600 - 900 mm), and Pobe and Saouga, the Sahel (300 - 600 mm). This year, the rainfall at all these sites was far below the annual average. In addition, except at Farako-Bâ and to a certain extent at Loumbila, its distribution was highly erratic resulting into several large dry spells. For example at Kamboinse, the whole month of July was almost dry, and plantings could not be carried out until 1st of August when the first good rain came. They pratically stopped after 10th of September, resulting into a growing season of only about 40 days. This coupled with poor soils caused severe drought conditions. Likewise at Pobé, the month of July was reasonably wet, but the situation worsened when very little rain came in the month of August. Overall the 1984 crop season was considered to be the worst in recent memory. The drought considerably affected the performance of different trials, a fact reflected by poor and highly variable yields. The data, therefore should be interpreted with great care.

2.2 Breeding for resistance to drought

The overall objective was to identify or develop varieties suitable for those areas where drought is a serious problem. Two experiments were conducted in 1984 to fulfill this objective. One was a regional variety trial (RCTD) whose results are reported under the Regional Program. The second was the evaluation of F_2 breeding material, the results of which are reported below :

20 F_2 populations originating from various crosses were grown at Kamboinse and Pobé. The main objective was to identify promising drought tolerant plants. The test material was planted in such a way that each row of it was alternated with Suvita-2, a variety consistently performing better in the dry areas. The length of each test row was 4 m, and the number varied depending upon the seed quantity. The trial at Pobé was planted on 19 th of July, and at Kamboinse on 2nd of August. Because of late plantings at Pobé, this trial, as compared to others, managed to escape serious drought conditions in the month of August. However, it underwent a sufficient drought stress at Kamboinse after 10th of September when the rains virtually stopped.

Observations were recorded for flowering and yield estimates. Individual plants were harvested separately from the F2 populations to estimate their yields. In case of SUVITA-2, the single plant yield (gm) in comparison to that of SUVITA-2 is given in Table 1. Between location differences were highly significant both for F2 populations and SUVITA-2. The yields at Pobé were high as compared to at Kamboinse, indicating influence of differences in drought stress at the two locations discussed as before.

The mean yields of F2 plants and SUVITA-2 at Kamboinse were similar. But at Pobé the mean yield of SUVITA-2 was significantly higher than that of F2 plants, suggesting little scope in selecting material superior to SUVITA-2 for that location. However, a closer look at the individual plant yields of the F2 plants, both at Kamboinse and Pobé, showed that many plants produced higher yield than that of SUVITA-2. These plants (transgressive segregates) are currently being advanced to a higher generation for tests next year, and it is hoped that some of them might produce higher and more stable yields than the currently known drought tolerant varieties.

Table 1. List of crosses, their pedigree and average plant yield of different F_2 populations in comparison to SUVITA-2 at two locations in Burkina Faso, 1984.

Cross	Pedigree	Plant Weight (gm) Kamboinsé F_2	Kamboinsé SUVITA-2	Pobé F_2	Pobé SUVITA-2
KVx 60	TVx 3236 x SUVITA-2	9.2	10.0	10.0	26.5
KVx 177	TN 88-63 x 58-57	7.0	8.3	14.9	20.9
KVx 192	SUVITA-2 x IT82E-32	10.5	7.0	10.4	31.4
KVx 218	1-2-1 x TN 88-63	7.8	8.7	11.3	24.5
KVx 222	2-13-4 x SUVITA-2	7.3	8.5	12.3	23.6
KVx 226	2-13-4 TVx 3236	10.3	8.7	9.5	24.6
KVx 231	3-4-11 x TVx 3236	9.1	7.2	12.1	22.5
KVx 235	3-4-13 x TN 88-63	10.8	10.4	9.1	19.4
KVx 241	8047 x TN 88-63	7.6	10.4	9.5	27.2
KVx 243	8047 x TVx 3236	10.4	7.4	11.2	29.8
KVx 245	SUVITA-2 x 58-57	6.8	8.6	10.1	22.5
KVx 246	SUVITA-2 x Mougne	7.0	9.1	7.0	18.7
KVx 247	SUVITA-2 x TN 88-63	9.0	7.8	12.2	18.4
KVx 249	58-57 x TVx 3236	10.8	8.8	10.6	22.6
KVx 250	58-57 x Mougne	9.5	10.2	10.8	21.8
KVx 252	TN 88-63 x TVx 3236	9.8	8.7	14.3	22.6
KVx 255	TVx 3236 x Mougne	8.2	8.7	8.5	22.9
KVx 256	TVx 3236 x IT82D-952	9.3	10.5	10.9	26.7
KVx 257	Mougne x IT82D-952	9.6	8.4	13.2	19.6
KVx 268	KVx 30-309-6G x SUVITA-2	10.9	8.7	15.8	22.8
Trial Mean		9.0	8.8	11.2	23.5
C.V. %		32.0	27.6	21.0	22.7
L.S.D %		5.8	5.1	4.8	10.9

2.3 Breeding for resistance to Striga

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

The 1984 Striga program was considerably expanded, but because of bad growing conditions (rainfall) and other unknown factors, the level of Striga emergence was poor as compared to in the previous years. This seemed to have influenced the performance of varieties and breeding materials. All the trials were conducted at Kamboinse in artificially re-infested Striga sick plots. Except for the Regional Cowpea Striga Trial (RCST), whose results are reported under Regional Program, the results of other trials are reported here.

2.3.1 Development and screening for Striga resistant varieties

a) An advanced yield trial consisting of 20 F5 families, originating from the cross of SUVITA-2 x KN-1, were planted to select plants or families combining resistance to Striga and diseases with desirable seed and plant characters. The trial had two replications and the plot size was a single row 4 m long. A severe infestation of bacterial blight was observed. This helped in eliminating a lot of susceptible families and plants, and in the end only four individual plants were selected which combined resistance to this disease with other desirable traits. These selections are currently being advanced to the next generation for yield tests next year.

b) Another trial consisting of F5 generation material originating from the cross of SUVITA-2 x TVx 3236 was planted. It consisted of 28 families originating from single plants selected in 1983. This trial also had two replications, but the plot size was 4 rows, 4 m long. Based on resistance to Striga, diseases, uniformity of seed and plant type, maturity and yield, only 9 bulk populations were selected. Yield estimates ranged from 438 to 988 kg/ha. An especially promising selection, KVx 61-74, showed zero Striga infestation in both the replications and produced an average yield of 881 Kg/ha. In addition, 28 promising individual plants were selected. All this material is currently being multiplied for further tests.

c) Another trial consisting of F5 generation material originating from the crosses of SUVITA-2 with KN-1 and TVx 3236 was planted. It consisted of 24 families originating from individual plants. These selections had been made early in the 1983/84 dry season so that they could be tested at another location (in Kano, Nigeria) and thus, were not included with the material mentioned above. At the time of this write up, the results weren't yet available from Kano. The material was planted in single rows, 4 meters long. 21 of these were rejected due to high levels of Striga infestation and bacterial blight. Of the remaining 3 families, 5 bulk selections were made based on resistance to Striga, absence of bacterial blight and uniformity of seed colour and plant type. These selections are currently being multiplied.

d) During the 1983-84 dry season a number of new crosses were made involving SUVITA-2 and 16 other promising lines, including IT 82 D-716, a bruchid and multiple disease resistant variety developed at IITA. The main objective was to combine resistance to Striga with the most desirable characters of these varieties. F2 populations of these 16 crosses were evaluated for resistance to Striga, diseases, podding, maturity and plant characters. 10 F2 families were completely rejected because of high level of Striga, diseases (bacterial blight and pod blotch) and poor plant type. Out of the remaining six families, a total of only nine single plants were selected. They represented material from crosses of SUVITA-2 with IT82E-18, IT82D-716, IT82D-652, IT82D-847, IT82D-889, TVx 4659-13C-1K. All of these are currently being advanced to a higher generation.

e) In a continuing effort to screen established (fixed) lines for Striga resistance, 136 lines originating from IITA, Ibadan were grown. The plots were single rows, with SUVITA-2 and IT82E-60 surrounding each variety as checks. As mentioned earlier, the Striga emergence this year was poor, and therefore, the infestation was not uniform. Of the 136 varieties, 34 showed zero Striga emergence, which was rather very high. These 34 varieties are currently being screened in pots to confirm their resistance.

f) Several years ago, TVu 2027 was crossed with SUVITA-2 to incorporate resistance to bruchids in this variety. As a result, some promising advanced generation (F7) selections were identified which combined resistance to bruchids, desirable seed type and reasonable yield. These selections were evaluated to find out if, by chance, any of them had resistance to Striga. A total of 13 of these selections were evaluated in a trial replicated twice. The plot size was 4 rows, 4 m long. The performance of the promising selections (cultivars) is shown in Table 2. Two of these KVx30-G172-1-6K and KVx 30-G467-5-10K, showed zero Striga emergence in both replications. Thus these two cultivars seemed to combine resistance to Striga and bruchids. The other two, KVx 30-G183-3-5K and KVx 30-G200-1-2K, had a favourable yield but showed 2 percent Striga emergence, because a single plant of Striga was observed in one of the replications. These results will be further confirmed in the pot experiments as well as in the field next year.

Table 2. Performance of the promising bruchid resistant cultivars in a Striga infested plot at Kamboinse, 1984.

Cultivars	DFF	Percent infestation	Yield Kg/ha
KVx 30-G172-1-6K	57	0	812
KVx 30-G183-3-5K	53	2	1027
KVx 30-G200-1-2K	53	2	1255
KVx 30-G467-5-10K	54	0	832
Controls			
SUVITA-2	52	0	1059
Kaya Local	59	36	491
Trial Mean	54	6	848
C.V. %	2.2	105.4	40.0
L.S.D. 5%	2	13	694

DFF = Days to 5% flowering.

2.3.2 Relationship of Striga infestation with maturity and plant type

The same trial as conducted in 1983, consisting of six varieties, two of them early (IT82E-60 and KVu 69), two medium (KN-1 and TVx 3236), one late photo-sentivity (Kaya Local) and one resistant (SUVITA-2), was planted at two different dates. The idea was to find out how the results obtained this year will compare with those of last year with regard to relationship of Striga resistance with maturity and plant type and possible escape mechanisms. The plot was 4 rows, 4 m long replicated four times. The central two rows were used for observations. Unfortunately the growing conditions in 1984 were very different from those in 1983. For example, because of late arrival of reliable rains, dates of planting this year were 2nd and 14th August as compared to 29th June and 13th July last year. In addition the rainfall distribution was scattered. This coupled with other factors resulted in poor and late Striga emergence, thus affecting the performance of the varieties. The results obtained in 1984 are reported in Table 3. In the susceptible varieties, the mean Striga,emergence in the first date of planting (D1), more or less coincided with their mean flowering date, but was earlier in the second date of planting (D2). The percent Striga infestation was relatively higher at D1 than at D2. The mean yields however, did not always seem to be related to Striga infestation, namely in the case of Kaya Local and TVx 3236 in D2. This could possibly be attributed to poor rainfall coinciding with their flowering and podding. These results, therefore, differed considerably from those in 1983. The experiment, therefore, will be repeated next year.

2.4 Breeding for insect resistance

2.4.1 Bruchids

The objective was to test promising resistant cowpea cultivars for yield, other agronomic traits and level of resistance. And also develop or identify new bruchid resistant varieties.

Following trials were conducted in 1984 to achieve these objectives :

IITA/SAFGRAD Advanced Yield Trial (AYT)-2

IITA/Advanced Variety Trial (ADVT)-4

IITA/SAFGRAD Preliminary Yield Trial (PYT)-1.

The AYT-2 included 10 promising varieties selected from last year's trials in Burkina Faso, and was planted at Farako-Bâ (F), Kamboinse (K) and Pobe (P). The ADVT-4 had 20 varieties and was received from IITA, Nigeria.

Table 3. Performance of cowpea varieties varying in plant type and maturity in a Striga infested plot at Kamboinse, 1984.

Varieties	DFF		Days first Striga emergence		% Striga infestation		Mean Striga number per plant		Mean Striga height (cm)		Yield (Kg/ha)	
	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2
IT82E-60	41	39	48	37	40	36	11	9	5.7	3.2	316	444
KVu 69	40	38	51	39	22	21	6	9	2.2	3.1	283	452
KVx 3236	47	50	48	35	64	27	12	10	5.0	3.1	581	453
KN-1	52	46	51	37	58	37	9	7	6.3	3.1	414	644
Kaya Local	61	55	50	37	56	43	12	7	4.3	4.0	527	397
SUVITA-2	54	48	151*	151	0	0	0	0	0	0	717	652
Trial Mean	49	46	66(50)**	56(37)	40	27	8	7	3.9	2.8	473	507
C.V. %	4.6	4.6	4.0	4.2	37.9	29.4	50.2	36.7	42.7	49.2	28.2	31.4
L.S.D 5%	3	3	4	3	22	12	6	4	2.4	2.0	195	233

* - Number of days counted upto 31st December to facilitate data analysis.

** - Average without considering SUVITA-2.

D1 and D2 - First and second dates of planting respectively.

It was planted at Loumbila (L). All the varieties of these trials were photo-insensitive. The PYT-1 contained 30 photosensitive varieties, and was planted at Kamboinse. The number of replications were four for the AYT-2 and ADVT-4, but two for the PYT-1. Length of the rows was 4 m in the case of AYT-2 and ADVT-4, but two in the case of PYT-1. The distance between the rows was 0.75 m for all the trials. The distance within the rows was 0.40 m for the PYT-1, but 0.20 m for the AYT-2 and ADVT-4. The data were recorded on yield, diseases and flowering. After harvest, a sample from each variety was tested in the laboratory for bruchid resistance. The results are reported in Tables 4 (AYT-2), 5 (ADVT-4) and 6 (PYT-1).

Several varieties were found to combine a good level of bruchid resistance with yield and other desirable plant characters. Examples : IT82D-716 (AYT-2 and ADVT-4), KVx 30-G171-1-6K (AYT-2), IT82D-453-2 and IT82D-713 (ADVT-4), all photoinsensitive, and KVx 30-400-6K and KVx-30-301-2K (PYT-1), both photosensitive.

2.4.2 Aphids

The main objective was to test aphid resistant varieties for yield and other agronomic characters across environments. To accomplish this objective a trial consisting of 15 varieties was planted at Farako-Bâ, Kamboinse and Pobe. Because of drought, the trial did not perform well at Kamboinse and Pobe. But good results were obtained at Farako-Bâ. The yields (kg/ha) at the three locations are reported in Table 7. Amongst the aphid resistant varieties, some still seemed to segregate for resistance. One of the most promising selections, KVx 165-14-1 whose plant type and other characters resemble that of KN-1, for example is not yet 100 % of pure for resistance. Special efforts have been undertaken in collaboration with the entomology program to purify this variety so that a completely resistant prototype is made available as soon as possible. The entomology program is also testing the resistance in this and other varieties at flowering and podding stage as well.

2.5 Yield trials - Plant type, maturity and seed quality

The objective was to evaluate cowpea varieties differing in their photoperiod response, plant type, maturity and seed characters at different locations, and identify promising material.

Table 4. Performance of bruchid resistant varieties in the IITA/SAFGRAD Advanced Yield Trial-2 planted at different locations in 1984.

Varieties	Yield (Kg/Kg/ha)			% bruchid infestation 60 DAI
	F	K	P	
Resistant				
IT81D-988	1044	317	13	70
IT81D-994	1276	384	13	50
IT82D-716	1642	332	159	50
KVx 30-G246-2-K	1159	202	213	50
KVx 30-G172-1-6K	1139	393	159	40
KVx 30-G200-1-3K	776	468	330	40
KVx 30-G183-3-5K	511	420	167	50
Susceptible				
SUVITA-2	1241	571	326	100
TVx 3236	1985	588	113	100
KN-1	2622	269	21	100
TVx 2027	-	-	-	40
Trial Mean	1336	394	151	
C.V %	36.0	45.5	48.8	
L.S.D. %	693	260	107	

Table 5 Performance of different varieties in the IITA Advanced Variety Trial-4 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 seed weight (gm)	% bruchid infestation 60 DAI
IT82D-638	38	4.5	1115	12	100
IT82D-640	43	3.8	822	19	100
IT82D-641	42	4.5	918	17	100
IT82D-713	40	4.5	1069	13	60
IT82D-453-2	42	4.0	900	16	70
IT82D-544-4	42	5.0	563	15	100
IT82D-542-2	41	5.0	367	18	90
IT82D-504-4	46	2.5	1263	18	100
I882D-516-5	41	4.8	1087	19	100
IT82D-716	39	4.5	900	13	80
IT82D-699	43	4.5	1211	12	100
IT81D-1189-81	44	4.5	1008	15	100
IT81D-1206-179	45	4.5	1078	14	100
IT81D-897	49	3.5	728	25	90
IT81D-1137	45	3.8	908	24	100
IT81D- 981	49	3.8	323	11	100
IT81D-975	41	3.0	1326	16	100
IT81D-709	39	3.5	772	18	60
IT81D-1186-699	45	3.8	998	12	100
TVx 3236	43	4.2	1523	10	100
TVu 2027	–	–	–	–	60
Trial Mean	43	4.1	944	–	–
C.V. %	5.6	19.1	38.0	–	–
L.S.D. 5%	3	1	509	–	–

Table 6. Performance of promising photosensitive bruchid resistant varieties in the IITA/SAFGRAD Preliminary Yield Trial-1 at Kamboinse, 1984.

Varieties	Yield (Kg/ha)	% bruchid infestation 60 DAI
KVx 30-301-2K	809	50
KVx 30-56-6K	694	50
KVx 30-400-6K	679	30
KVx 30-29-2K	516	40
KVx 30-4K	504	50
KVx 30-337-1K	858	50
Control		
Kaya Local	1009	100
Ouahigouya Local	504	100
TVu 2027	-	40
Trial Mean	750	-
C.V. %	7.7	-
L.S.D. 5%	116	-

Table 7. Yields of different varieties in the Advanced Yield Trial-1 planted at different locations in 1984.

Varieties	Yield (Kg/ha)		
	F	K	P
KVx 145-99-1	1711	240	76
KVx 145-27-4	3110	239	115
KVx 145-23-2	1361	322	175
KVx 146-13-3	2613	286	142
KVx 146-44-1	2524	356	136
KVx 146-49-3	2108	168	142
KVx 146-21-3	1979	218	71
KVx 146-27-4	2747	248	295
KVx 146-14-3	2580	312	251
KVx 165-14-1	2424	447	246
TVx 6484-51B_1-K	1783	129	113
TVu 36	3079	130	296
SUVITA-2	1540	244	367
TVx 3236	2797	416	209
KN-1	2575	169	96
Trial Mean	2329	261	182
C.V. %	20.0	63.0	45.5
L.S.D 5%	640	239	118

To accomplish this objective a total of 17 variety trials were conducted in 1984. The material evaluated can be classified into two main categories listed as below :

(a) Photosensitive Cowpeas

IITA/SAFGRAD Uniform Yield Trial (UYT)-4.
IITA/SAFGRAD Advanced Yield Trial (AYT)-3.

(b) Non-photosensitive Cowpeas

IITA/SAFGRAD Uniform Trials (UYT)-1, 2 and 3.
IITA/SAFGRAD Advanced Yield Trial (AYT)-4.
IITA Advanced Variety Trials (ADVT)-1, 2, 3, 5 and 6.
IITA Preliminary Variety Trials (PVT)-1, 2, 3, 4 and 5.

The important findings from these trials are described as below :

The photosensitive cowpea variety trials, UYT-4 and AYT-3, were planted at Farako-Bâ and Kamboinse. They contained 10 and 15 varieties, respectively selected in 1983 for their superior performance. All of these varieties had the most preferred seed characters i.e. large, white grains with rough seed coat. The trials consisted of 4 replications, and the plot size was 4 rows, 4 m long with 0.75 m distance both within and between plants. The data were recorded on flowering, diseases and yield. Central two rows were harvested, and the yields are reported in Tables 8 and 9.

The yields at Kamboinse were extremely low as compared to at Farako-Ba. These low yields were caused by late plantings (2nd August) and short growing season. Logfrousso Local practically did not produce any yield at Kamboinse. This variety originated in the Farako-Bâ area, where the crop season is long (about 5 months) and therefore is late in maturity. On average over both the trials at Farako-Bâ and Kamboinse, TVx 6486-36B1-K as in 1983, maintained its high yield (1264 kg/ha) this year. Several other varieties also maintained their good yields of previous years. Notable examples were KVu 22-1 (1352 kg/ha) and TVx 6486-12B1-K (1420 kg/ha) in the UYT-4. Another variety, KVu 144 (1403 kg/ha), was found to be promising in the AYT-4.

In the non-photosensitive group, there were 14 trials. Four of these (UYT-1, 2, 3 and AYT-4) were formulated by IITA/SAFGRAD in Burkina Faso on the basis of maturity and seed quality. The UYT-1 contained 15 medium maturing -rough seeded ; the UYT-2, 10 medium maturing - smooth seeded ; the UYT-3, 15 early maturing - different seeded ; and the AYT-4, 20 medium maturing - different

Table 8. Yields of different varieties in the IITA/SAFGRAD Uniform Yield Trial-4 at different locations in 1984.

Varieties	Yield (kg/ha)		Seed Characters	
	F	K	100 Seed weight(gm)	Colour & Texture
TVx 6486-36B1-K	2201	222	23	Wr
TVx 6486-12-B1-K	2619	220	18	Wr
KVu 20-2	2214	363	21	Wr
KVu 12-2	1725	238	21	Wr
KVu 18-1	1829	332	22	Wr
KVu 22-1	2388	316	23	Wr
KVu 9-2-1	1842	281	15	Wr
Ouahigouya Local	1960	278	21	Wr
Kamboinsé Local	2124	454	24	Wr
Logfrousso Local	1290	1	17	Wr
Trial Mean	2019	270		
C.V. %	27.0	52.3		
L.S.D 5%	794	205		

Table 9. Yields of different varieties in the IITA/SAFGRAD Advanced Yield Trial-3 planted at different locations in 1984.

Varieties	Yield (Kg/ha)		Seed Characters	
	F	K	100 Seed weight(gm)	Colour & Texture
KVu 93	1714	412	15	Wr
KVu 130	1546	353	20	Wr
KVu 132	1726	419	19	Wr
KVu 134	1942	314	22	Wr
KVu 135	1729	324	19	Wr
KVu 136	1411	357	19	Wr
KVu 139	1726	449	14	Wr
KVu 140	1941	270	15	Wr
KVu 144	2215	590	17	Wr
KVu 157	1340	489	19	Wr
Titao-1	1766	362	18	Wr
TVx 6486-36B$_1$-K	2193	444	22	Wr
Ouahigouya Local	1210	438	20	Wr
KVu 20-2	1482	335	20	Wr
Local	2008	264	25	Wr
Trial Mean	1730	388		
C.V. %	29.0	39.0		
L.S.D. 5%	728	213		

seeded varieties. All these trials, except for UYT-3, which instead of at Kamboinse was planted at Loumbila, were planted at Farako-Bâ, Kamboinse and Pobe. Each had four replications, and the plot size was 4 rows, 4 m long with 0.20 m distance within the rows. The distance between the rows was 0.50 m for UYT-3 and 0.75 m for the other trials. The data were recorded from the central two rows on flowering, diseases and yield. The mean yield of promising varieties are reported in Tables 10, 11, 12 and 13. The yields were low for all the trials at Kamboinse and Pobe due to drought. In addition, the coefficient of variability at these locations was high, making it difficult to establish the significance of the data. Nevertheless, there were certain varieties which seemed to be performing better in the drought stress conditions. For example KVx 30-230-2G (493 kg/ha) in the UYT-1 and KVx 30-164-8G (576 kg/ha) in the AYT-4 at Pobé. Both these lines are derivatives of SUVITA-2 which produced an average yield of 420 kg/ha for the two trials. The yields at Farako-Bâ and Loumbila, however, were more reliable, basically, because the rains were good at Farako-Bâ and were relatively better distributed at Loumbila. The most promising varieties in different trials at these locations were IT 82D-847 (2266 kg/ha) in UYT-2 at Farako-Bâ ; IT 82D-847 (1924 kg/ha), IT 82E-32 (1762 kg/ha), IT 82E-16 (1926 kg/ha) and KVu 150 (1818 kg/ha) in UYT-3 as an average over two locations ; and TVx 6484-7082-K (2539 kg/ha) at Farako-Bâ.

The rest of the 10 trials in the non-photosensitive group were received from IITA, Nigeria. Five of these were classified as Advanced Yield Trials (ADVT-1, 2, 3, 5, and 6) the other five as Preliminary Variety Trials (PVT-1, 2, 3, 4 and 5). The main criteria of grouping different varieties into these trials was seed colour and texture. Each of these trials contained 20 varieties and were planted at Loumbila. Each ADVT had 4 replications while PVT 3 replications. The plot size was 4 row, 4 m long for all the trials, and the distance between and within the rows was 0.50 m and 0.20 m, respectively. The varieties were evaluated for maturity, reaction to different diseases and grain yield. The results of the promising varieties in different trials are reported in Tables 14 through 23.

In general, the yields were reasonably good because of better moisture conditions at Loumbila. The incidence of bacterial blight was very high, which helped in screening the varieties resistant to this disease. Although a large number of them were susceptible, there were several which had a high level of resistance combined with high grain yield. Based on disease resistance (score of less than 2 on a scale of 1-5 where 1 was resistant and 5 most susceptible) and high yield, the promising varieties in different trials were IT82D-752 (816 kg/ha) in ADVT-2 ; IT82D-875 (1231 kg/ha) and IT82D-881 (1478 kg/ha) in ADV-3 ; TVx 4659-03E (1505 kg/ha) in ADVT-5 ; IT83D-208 (1389 kg/ha) and

Table 10. Yields of different varieties in the IITA/SAFGRAD Uniform Yield Trial-1 planted at different locations 1984.

Varieties	Yield Kg/ha F	Yield Kg/ha K	Yield Kg/ha P	Seed Characters 100 Seed weight(gm)	Seed Characters Seed Colour & Texture
KVx 30-309-6G	1585	263	376	22	Wr
KVx 30-230-2G	1401	272	493	20	Wr
ITD81D-1189-81	1927	205	67	18	Wr
IT82D-707	1767	323	384	15	Tr
IT82D-703	1853	311	330	17	Wr
IT82D-716	1322	277	263	13	WBr
SUVITA-2	1341	212	434	20	Br
TVx 3236	2561	217	305	11	WBr
KN-1	2259	255	92	13	Ts
TN 88-63	1008	202	301	11	Wr
Trial Mean	1655	260	276		
C.V. %	22.0	66.8	36.6		
L.S.D. 5%	531	248	144		

Note: W = White; B = Brown; T = Ten; r = Rough; s = Smooth

Table 11. Yield of different varieties in the IITA/SAFGRAD Uniform Yield Trial-2 planted at different locations in 1984.

Varieties	Yield Kg/ha			Seed Characters	
	F	K	P	100 Seed weight(gm)	Seed Colour & Texture
IT82D-847	2266	448	84	15	Ts
IT81D-1205-174	1734	265	75	18	Ts
TVx 4654-44E	1543	348	134	15	Ts
KVx 145-99-1	1597	324	58	22	Ts
KN-1	1968	307	17	16	Ts
TVx 1999-01F	2112	281	159	16	Ts
Trial Mean	1450	337	106		
C.V. %	23.5	46.2	83.2		
L;S.D. 5%	494	226	127		

Table 12. Yields of promising varieties in the IITA/SAFGRAD Uniform Trial-3 planted at different locations 1984.

Variety	Yield (Kg/ha)			Seed Characters	
	F	L	P	100 grain weight(gm)	Colour & Texture
IT82E-32	2403	1120	128	13	R
IT82E-16	2690	1161	259	14	R
IT82E-18	1601	1394	125	15	Ts
IT82D-641	1622	1151	413	19	Wr
IT82D-871	2246	1601	350	10	R
IT82D-889	1125	598	300	13	R
KVu 150	1778	1857	188	18	Wr
KVx 165-14-1	2069	1304	353	14	B
TVx 4659-13C-1K	1535	1133	200	14	Ts
IT82E-60	729	962	313	19	W
Trial Mean	1718	1124	268		
C.V. %	30.0	48.4	85.4		
L.S.D. 5%	720	778	327		

Note: R = red

Table 13. Yields of promising varieties in the IITA/SAFGRAD Advanced Yield Trial-4 planted at different locations 1984.

Varieties	Yield (Kg/ha)			Seed Characters	
	F	K	P	100 grain weight(gm)	Seed colour & Texture
KVx 30-164-8G	1049	446	576	21	Br
TVx 6484-6B1-K	2211	334	75	25	Bs
TVx 6484-70B2-K	2539	572	259	17	Bs
KVx 30-35-2K	1291	458	547	23	Br
KVx 30-44-2K	1661	654	330	22	Br
SUVITA-2	997	524	405	17	Br
KN-1	2374	744	150	15	Ts
TVx 3236	2118	724	267	10	WBr
Trial Mean	1436	477	234		
C.V. %	32.0	47.1	46.4		
L.S.D. 5%	630	318	154		

Table 14. Performance of promising varieties in the IITA Advanced Variety Trial-1 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & Texture
IT82D-511-3	41	4.5	762	16	Wr
IT82D-513-1	42	4.3	1552	20	Wr
IT82D-702	34	4.8	904	15	Wr
IT82D-649	43	4.0	985	13	Wr
IT82D-952	43	3.8	1164	15	Wr
IT82D-716	40	5.0	691	14	WBr
Trial Mean	42	4.7	856		
C.V. %	13.2	7.2	34.1		
L.S.D. 5%	8	0.5	414		

Table 15. Performance of promising varieties in the ITTA Advanced Variety Trial-2 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & Texture
IT82D-484-5	39	3.8	859	16	Br
IT82D-450-4	43	2.3	1024	21	Br
IT82D-847	43	1.8	551	17	Ts
IT82D-752	41	1.8	816	16	Bs
Ife Brown	37	4.8	643	16	Br
TVx 3236-6-1	39	3.3	1131	15	Br
Trial Mean	41	3.5	718		
C.V. %	5.7	20.9	41.6		
L.S.D. 5%	3	1.0	424		

Table 16. Performance of promising varieties in the IITA Advanced Variety Trial-3 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & Texture
IT82D-885	36	5.0	984	14	Rs
IT82D-874	43	3.0	1405	17	Rs
IT82D-881	38	1.8	1478	14	Rs
IT82D-872	32	1.0	1082	12	Rs
IT82D-875	43	1.3	1231	14	Rs
Ife Brown	41	4.5	1343	17	Br
IT82D-716	39	5.0	1137	14	WBr
Trial Mean	40	3.9	936		
C.V. %	12.8	13.5	46.1		
L.S.D. 5%	7	0.8	611		

Table 17. **Performance of promising varieties in the IITA Advanced Variety Trial-5 at Loumbila, 1984.**

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & texture
IT82D-699	43	2.5	1541	12	Wr
IT83D-225	43	2.3	1646	19	Wr
IT83D-224	42	2.8	1421	19	Wr
IT83D-219	44	3.0	1591	16	Wr
IT83D-223	43	2.5	1415	17	Wr
IT83D-716	40	3.5	1205	16	BCr
TVx 3236	43	4.0	1124	14	WBr
TVx 4659-03E	42	1.5	1505	18	BCs
IT82E-60	38	5.0	519	19	Ws
Trial Mean	43	3.1	1127		
C.V. %	3.9	33.9	33.2		
L.S.D. 5%	2	1.5	531		

Table 18. Performance of promising varieties in the IITA Advanced Variety Trial-6 at Loumbila, 1984.

Varietis	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & texture
IT83D-217	44	1.5	1337	18	Br
IT83D-216	44	1.5	1334	18	Br
IT83D-232	47	1.0	1027	17	Ts
IT83D-208	42	1.0	1389	19	Br
IT83D-226	42	1.5	1241	21	Br
IT83D-206	43	2.0	1387	22	Wr
IT83D-198	40	3.0	1594	17	Ts
IT83D-235	42	2.5	1628	22	Wr
TVx 3236-6-1	40	1.8	1194	12	Br
TVx 3236	44	1.0	948	14	WBr
Trial Mean	43	1.9	1054		
C.V. %	3.7	37.7	40.4		
L.S.D. 5%	2	1.0	603		

Table 19. Performance of promising varieties in the IITA Preliminary Variety Trial-1 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & texture
IT83S-796	41	1.7	833	23	Wr
IT83S-808	41	3.0	1205	16	Wr
IT83S-961	41	3.7	1296	16	Wr
IT82D-699	46	1.7	710	14	Wr
IT82D-716	41	2.7	1013	16	WBr
TVx 3236	43	3.0	1456	12	WBr
Trial Mean	42	2.9	819		
C.V. %	4.8	26.9	39.5		
L.S.D. 5%	3	1.3	535		

Table 20. Performance of promising varieties in the IITA Preliminary Variety Trial-2 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & texture
IT83S-821	40	1.0	618	17	Ws
IT83S-823	43	1.0	416	14	Ts
IT83S-825	42	1.0	708	12	Ws
IT83S-832	42	1.3	763	13	WBs
IT83S-944	49	1.0	513	18	Ws
IT83S-947	41	3.7	1047	16	Wr
IT82D-716	40	2.7	751	15	WBr
TVx 3236	43	1.3	1339	14	WBr
Trial Mean	41	2.2	660		
C.V. %	4.8	38.0	45.6		
L.S.D. 5%	2	1.4	498		

Table 21. Peformance of promising varieties in the IITA Preliminary Variety Trial-3 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & texture
IT83S-844	38	4.3	1104	14	Bs
IT83S-852	39	3.7	1348	15	Br
IT83S-853	40	4.3	1157	17	Br
IT83S-854	43	3.3	1212	18	Br
IT83S-875	38	2.3	1215	19	Ts
Ife Brown	42	3.0	1255	18	Br
TVx 3236	43	3.3	1452	14	WBr
Trial Mean	40	3.9	926		
C.V. %	7.0	23.5	38.8		
L.S.D. 5%	4	1.5	595		

Table 22. Performance of promising varieties in the IITA Preliminary Variety Trial-4 at Loumbila, 1984

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight (gm)	Seed colour & texture
IT83S-990	41	1.0	1251	14	Ts
IT83S-991	39	1.7	1937	14	Ts
IT83S-992	39	1.3	1915	19	Ts
IT83S-892	37	1.3	1538	13	Rs
IT83D-375	37	1.3	1507	13	WBs
IT83D-378	39	2.0	1589	12	Ws
IT83D-379	40	1.3	1585	10	W
Ife Brown	40	1.3	1318	16	Br
IT82D-789	36	1.7	1268	16	Bs
IT82D-889	35	2.7	1218	12	Rs
Trial Mean	37	1.7	1346		
C.V. %	3.0	42.1	30.6		
L.S.D. 5%	2	1.2	681		

Table 23. Peformance of promising varieties in the IITA Preliminary Trial-5 at Loumbila, 1984.

Varieties	DFF	BB	Yield (Kg/ha)	100 Seed weight(gm)	Seed colour & texture
IT83S-866	40	1.0	1114	21	Ts
IT83S-878	38	1.0	1118	22	Ts
IT83S-937	40	1.0	1398	18	WBs
IT83S-938	40	1.0	1322	24	WBs
Ife Brown	41	1.3	1533	17	Br
TVx 1948-01F	41	1.7	1469	14	Ts
IT82D-789	34	2.3	1093	16	Bs
IT82E-18	40	2.0	1423	18	Ts
Trial Mean	40	1.2	1080		
C.V. %	4.3	46.4	25.1		
L.S.D. 5%	3	1.3	448		

IT83D-226 (1241 kg/ha) in ADVT-6 ; IT82D-699 (710 kg/ha) in PVT-1 : IT83S-991 (1937 kg/ha) and IT83S-992 (1915 kg/ha) in PVT-4 ; and IT83S-937 (1398 kg/ha) and IT83S-938 (1322 kg/ha) in PVT-5. In comparison to these varieties, the average yields of the mostly commonly used check varieties were IT82D-716 (899 kg/ha), Ife Brown (1218 kg/ha) and TVx 3236 (1270 Kg/ha), and their disease score were 3.9, 3.0, and 2.7 respectively.

3. REGIONAL PROGRAM

The objective of the regional program was to evaluate varieties of cowpea originating from different national, regional and internationsl programs across a wide range of environments in the semi-arid areas of Africa.

In 1984 the following different trials were coordinated by the IITA/SAFGRAD Project.

- Regional Cowpea Trial for Drought (RCTD).
- Regional Cowpea Striga Trial (RCST).

The RCTD comprised 10 varieties contributed by IITA, IITA/SAFGRAD and Niger. It had four replications, and the plot size was 4 rows, 4 m long with a distance of 0.75 m and 20 m between and within rows, respectively. 29 sets of this trial were sent to 21 countries. The participating countries were Benin, Burkina Faso, Botswana, Cameroon, Cape Verde, Ethiopia, Gambia, Ghana, Guinea, Kenya, Mali, Mauritania, Niger, Nigeria, Rwanda, Senegal, Somalia, Tanzania, Togo, Zambia and Zimbabwe. Data were collected on flowering, diseases and grain yield. At the time of this write up, results were available from 14 locations in nine countries. The mean yields are reported in Table 24. Because of drought, the yields at several places were low. Still several varieties looked promising which produced higher yields than those of SUVITA-2 and TN 88-63, the two varieties consistently performing well for several years in the dry areas. Particularly interesting were KVx 30-470-3G, KVx 30-305-3G IUd KVx 30-309-6G which produced an average yield of 1033, 992, and 924 kg/ha, respectively across the 14 locations. All these varieties are derivates of SUVITA-2. IT82D-952 also performed equally good. It was one of the high yielders last year in the dry areas (Pobe) in Burkina Faso.

The second regional trial, RCST, contained 12 varieties. Of these 9 were selections, two susceptible (Mougne and Local), and one resistant (SUVITA-2)

Table 24. Yields of different varieties in the Regional Drought Resistant Variety Trial (RCTD) at different locations in 1984

Varieties	Origin	Yield Kg/ha						
		Kamboinse Burkina Faso	Pobé Burkina Faso	Bema Mali	Koporo Mali	Massantola Mali	Nisouli Benin	Broukou Togo
KVx 30-309-6G	IITA/SAFGRAD	626	481	1467	1170	199	1461	959
KVx 30-305-3G	"	793	227	1446	1584	374	1752	666
KVx 30-470-3G	"	693	390	963	1337	498	1619	828
TVx 5050-02C-K	"	384	265	342	734	270	1224	581
SUVITA-2	"	359	420	1598	1578	560	1432	581
IT82D-716	IITA/NIGERIA	501	465	444	767	350	1237	728
IT82D-952	"	392	470	494	1258	245	1235	557
TVx 3236	"	409	364	650	1027	164	1141	714
IN 88-63	Niger	434	551	1151	1654	457	1083	506
Local	-	159	460	0	329	270	1063	768
Trial Mean		475	409	855	1144	339	1324	689
C.V. %		35.2	35.0	25.0	34.0	61.0	18.0	50.0
L.S.D. 5%		243	208	316	561	296	337	490
Rainfall (mm)		413.0	274.0	366.1	450.5	413.5	985.4	1159.1

Table 24 (contd.)

Varieties	Origin	Yield (Kg/ha)						
		Selibaby Mauritania	Kano Nigeria	Bakura Nigeria	Samaru Nigeria	Sapu Gambia	Serrado-Santiago Cape Verde	Bordo Guinea
KVx 30-309-6G	IITA/SAFGRAD	278	293	1840	1667	261	1031	1214
KVx 30-305-3G	"	282	280	2158	1889	246	853	1346
KVx 30-470-3G	"	373	602	1605	1482	316	1043	1737
KVx 5050-02C-K	"	244	639	982	1637	136	677	1028
SUVITA-2	"	315	100	858	1377	392	668	1085
IT82D-716	IITA/NIGERIA	294	226	554	1219	315	627	847
IT82D-952	"	330	527	1591	1963	294	1165	1274
IVx 3236	"	313	664	429	1827	364	737	1210
TN 88-63	Niger	355	421	816	1135	399	1432	712
Local	-	288	801	775	2345	0	1525	609
Trial Mean		307	455	1160	1654	272	976	1106
C.V. %		25.0	27.0	46.0	19.0	68.0	37.0	33.0
L.S.D. 5%		111	176	908	447	268	524	525
Rainfall (mm)		263.8	507.3	390.8	888.0	595.8	506.9	1050.6

control. The plot size was 3 rows, 3 m long, and all the three rows were included for observations. The distance between the rows was 0.75 m and within the rows 0.20 m. Three sets of this trial were sent to Nigeria, one each to Mali and Niger and two remained in Burkina Faso. At Kamboinse it was planted in an artificially infested Striga plot. However, it was planted under natural conditions at other locations. Data were recorded for percent cowpea plants infested with Striga, yield, diseases and other plant characters. Results were available from all the locations except in Niger, and are reported in Table 25. There was no infestation of Striga at Samaru, Nigeria, and therefore only the yield data from that location is reported. Of the 9 selections, several showed as good level of Striga resistance as the resistant variety, SUVITA-2 in Burkina Faso, thus confirming the earlier findings. Although susceptible, the level of resistance of SUVITA-2 and its derivates varied in other countries. Everything was highly susceptible at Bakura, Nigeria. This further supported our earlier conclusion regarding the presence of different strains or biotypes of Striga.

Regarding yield, it was highly variable across locations. Amongst the cultivars, KVx 100-2, KVx 100-1 and KVx 61-2 seemed to be promising. Surprisingly, the yields at Bakura were highest in spite of high Striga infestation. This requires verification.

Table 25. Performance of different varieties included in the Regional Cowpea Striga Trial (RCST) at different locations in 1984.

Varieties	Kamboinse, Burkina Faso		Ouahigouya, Burkina Faso		Kano, Nigeria	
	Yield (Kg/ha)	% cowpea infested with Striga	Yield (Kg/ha)	% cowpea infested with Striga	Yield (Kg/ha)	% cowpea infes-with Striga
KVx 30-166-3G	801	3.5	372	0.0	857	10.4
KVx 30-183-3G	583	1.0	405	0.0	264	13.5
KVx 100-1	977	0.0	243	0.7	1373	11.1
KVx 100-2	988	0.7	335	0.0	1067	12.9
KVx 68-1	657	22.7	260	4.3	1003	33.8
KVx 68-2	569	0.0	190	25.7	889	35.6
KVx 61-1	779	6.8	233	5.0	361	34.3
KVx 61-2	1077	2.2	327	0.0	637	15.1
KVx 61-3	523	25.3	196	22.0	1049	17.6
SUVITA-2	1053	0.0	360	0.0	309	12.5
Mougne	443	33.7	219	15.3	613	34.8
Local	276	64.0	63	20.3	1437	39.1
Trial Mean	725	16	267	7.8	821	22.6
C.V. %	28.7	77.5	50.7	178.0	19.0	59.0
L.S.D. 5%	345	21	230	24.0	263	22.7

Table 25 (contd).

Varieties	Bakura, Nigeria		Kaporo, Mali		Samaru, Nigeria
	Yield (Kg/ha)	% cowpea infes-ted with Striga	Yield (Kg/ha)	% cowpea infes-ted with Striga	Yield (Kg/ha)
KVx 30-166-3G	2494	49.4	355	13.6	1752
KVx 30-183-3G	3234	51.0	365	0.0	1171
KVx 100-1	2445	32.2	543	8.9	1531
KVx 100-2	2815	37.1	741	16.7	1577
KVx 68-1	1506	71.7	469	13.8	1709
KVx 68-2	1852	44.2	321	54.8	1533
KVx 61-1	1383	54.7	420	21.3	2173
KVx 61-2	2814	38.7	141	15.9	2179
KVx 61-3	1679	56.5	839	38.7	2252
SUVITA-2	3383	51.5	400	17.8	1365
Mougne	815	79.6	765	32.4	1838
Local	938	46.9	692	13.5	3975
Trial Mean	2113	52.8	504	20.8	1917
C.V. %	30.0	47.0	70.0	82.0	17.0
L.S.D. 5%	1091	42.1	602	29.0	562

COWPEA AGRONOMY

N. Muleba

The objectives of the cowpea agronomy research program of SAFGRAD 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, a vast area that includes 27 countries. So, to accomplish its objectives the program has concentrated its main efforts in Burkina Faso, in three agroclimatic zones : Northern Guinea Savanna (at Farako-Bâ station), Sudan Savanna (at Kamboinse) and the Sahel Savanna (at Djibo/Pobe), representative of the West African semi-arid zone.

1. NORTHERN GUINEA SAVANNA

(900-1200 mm rainfall, from June to October).

1.1 Maize/cowpea relay-cropping

The objective of maize/cowpea relay cropping system is to enable farmers to obtain full maize yield and some cowpea yield, as a bonus, in the same land during the same crop season. This kind of double cropping is very crucial for farmers to use more efficiently the scarce moisture and inputs in this agroclimatic zone. As observed in the past five years, experiments conducted during 1984 have again demonstrated that : –cowpea can be relay cropped under maize one month after planting without a great detrimental effect on maize yield ;- early, prostrate, daylength sensitive cowpeas appear to be more adapted than daylength insensitive ones, particularly when planted one month after maize ; - early maturing, short, less leafy and high yielding maize cultivars tend to be better adapted in relay-cropping with cowpeas as compared to medium maturing, tall and leafy maize cultivars.

1.1.1 Response of cowpeas in maize-cowpea relay-cropping system

The experiment evaluating cowpeas of two plant types (daylength sensitive and insensitive) initiated in 1983 at Farako-Bâ, was repeated in 1984. A 90 days to maturity maize cultivar was planted on 19 June. Maize plants received NPK at planting and N one month after planting during the rapid growth stage of maize. Seven cowpea cultivars, of which three (Kaya local, Logofrousso local and Ouahigouya local) are daylength sensitive and four (TVx 1999-01F, TVx 3236, VITA-5 and KN-1) are insensitive, were planted at two dates : 18 July, one month after maize, and 17 August, ten days after maize planting. Maize and cowpeas were planted in alternating rows. Cowpea plants were not fertilized, but were sprayed twice with insecticides during the growing season. The experiment had a split plot design, with cowpeas as main treatments and planting dates as sub-treatments, and was replicated four times.

As observed in 1983, cowpeas, planting dates and their interaction had no significant effect on maize physiological (flowering and maturity dates) and morphological (ear and plant heights) traits. In contrast to the 1983 results, maize grain yield was not significantly affected by any of main effects nor their interaction. This confirmed, thus, that the 8 % yield reduction observed in 1983 with cowpeas planted one month after maize planting was related to the drought stress that occured during grain filling that year. An average maize grain yield of 3136 kg/ha was observed for the 1984 season. This relatively low yield can be attributed to high streak virus incidence this season and a severe lodging that occured as maize plants were approaching the end of grain filling stage.

Cowpeas TVx 3236 and Kaya local yielded similarly but significantly greater than Ouahigouya local, KN-1 and Logofrousso local ; the other cultivars were intermediate between the two groups (Table 1). Yield of cowpeas planted on 17 August was significantly reduced as compared to that of 18 July planting ; this was probably due to a combination of epidemics of bacterial and web blight diseases and drought stress in October (12.6 mm rainfall). The performance of cultivars Ouahigouya Local (particularly very sensitive to bacterial and web blights) and Logofrousso local (which flowered in October) may well illustrate yield reduction due to the two calamities (Table 1). As it was the case in 1983, the advantage of daylength-sensitive cultivars observed in 1981 and 1982 was not verified. It is, however, interesting to note that Kaya local (early daylength sensitive and less sensitive to the diseases) tended to yield higher than the best daylength-insensitive cultivar, TVx 3236, in the first date of planting. The results did, nevertheless, clearly demonstrate the appropriateness of planting cowpeas under maize one month after planting and the use of early maturing, disease resistant and daylength-sensitive cowpeas in maize-cowpeas relay cropping system.

Table 1. Seed yield and flowering dates of cowpeas in a maize cowpea relay-cropping system, Farako-Bâ, Burkina Faso, 1984.

Cultivars	Seed Yield			Flowering dates		
	18 July	17 August	Mean	18 July	17 August	Mean
	----------kg/ha---------			---------kg/ha----------		
Kaya local	530	390	460	69	56	62
Logofrousso local	62	31	46	81	66	74
Ouahigouya local	378	173	275	57	55	56
TVx1999-01F	272	375	324	43	54	48
KN-1	328	205	266	43	52	48
TVx3236	475	470	472	43	50	47
Vita-5	401	214	308	47	50	49
Mean	349	265	307	55	55	55

Comparison of means	Seed Yield		Flowering dates	
	LSD(5%)	C.V.(%)	LSD(5%)	C.V.(%)
Cultivars	179	39	3	3
Dates	60	35	2	5
Date for the same cultivar	NS		4	
Date for diff. cultivars	NS		6	

1.1.2 Effect of maize cultivar differences in maturity on seed yield of relay-cropped cowpeas

The experiment studying the effects of maize cultivars (of different maturity groups) and row-spacings on the performance of relay-cropped cowpeas conducted at Farako-Bâ in 1983 was repeated in 1984. Two early (90 days to maturity) maize cultivars : SAFITA-2 and "Jaune de Fo", and two medium maturing (105 days) maize cultivars : SAFITA-102 and IRAT 81, were planted on 20 June at two row-spacings (0.75 m x 0.25 m and 1 m x 0.25 m). All the cultivars were open-politinated except IRAT 81, which was an hybrid. Two cowpea cultivars : Ouahigouya local and TVx 3236, described in the previous experiment were planted under maize on 20 July and 19 August, respectively. The experiment had a split plot design, with maize cultivars as main-treatments and a factorial combination of two row-spacings and two cowpea cultivars as sub-treatments, and was replicated four times.

Yields of SAFITA-2 and IRAT 81 was significantly reduced when row-spacings were increased from 0.75 m to 1 m (Table 2). IRAT 81 significantly out-yielded all the cultivars at both spacings, except "Jaune de Fo" and SAFITA-102 at 1 m spacing ; the other cultivars did not significantly differ from one another. The prevalance of maize streak virus and severe lodging during grain filling were responsible for the observed low maize yield.

IRAT 81 significantly depressed cowpea yields more than any other cultivars ; "Jaune de Fo" and SAFITA-102 had a similar effect, and both significantly reduced cowpea yield as compared to SAFITA-2 (Table 3). The four maize cultivars differed in physiological and morphological traits and lodging as shown in Table 3. Inspite of high sensitivity to lodging exhibited by early maturing cultivars (which could be suspected to increase shading and, hence, reduce yield of relay-cropped cowpeas) the yield of relay-cropped cowpeas appeared to be more associated with LAI of maize cultivars than to any other traits (Table 3). So, as observed in 1983, SAFITA-2, which had the least LAI, also depressed the least yield of relay-cropped cowpeas.

Increasing maize row-spacing from 0.75 m to 1 m significantly increased cowpea yield from 556 to 673 kg/ha (LSD (5 %) = 79 kg/ha and C.V. (%) = 25).

The reduction of cowpea yield by tall, medium maturing maize cultivars, in this experiment, agrees with the 1981, 1982 and 1983 results. From the results of the relay-cropping experiment discussed above and those of this and previous years' experiments, it can be concluded that : - (1) maize growers in

Table 2. Effect of row spacings on grain yield of maize cultivars in a maize/cowpea relay-cropping system, Farako-Bâ, Burkina Faso, 1984.

Cultivars	Row spacings	
	(0.75 x 0.25m)	(1 x 0.25m)
	------------kg/ha--------	
SAFITA-2	2889	1713
JAUNE DE FO	2714	2547
SAFITA-102	2492	2310
IRAT 81	3689	2946

Comparison of means:	LSD(5%)	C.V.(%)
Row spacing same cultivar	546	20
Row spacing different cultivar	937	

Table 3. Cowpea seed yield and maize physiological and morphological traits in a maize/cowpea relay cropping system, Farako-Bâ, Burkina Faso, 1984.

Maize Cultivars	Cowpea Seed Yield (kg/ha)	Maize physiological and Morphological Traits					
		Flowering date (D A P)	Maturity date (D A P)	Plant height (C M)	Ear height (C M)	LAI	Lodging (%)
SAFITA-2	808	61	91	141	76	1.52	74
JAUNE DE FO	613	62	91	186	113	1.70	77
SAFITA-102	589	70	105	152	88	2.01	64
IRAT 81	449	71	106	180	103	2.37	50
LSD(5%)	108	2	1	10	10	0.44	Ns
C.V.(%)	11	2	0.4	4	7	14.4	20

the Northern Guinea Savanna may make better use of scarce available moisture and inputs by relay-cropping maize and cowpea ; - (2) the optimum time for planting cowpeas under maize is one month after maize planting ; - (3) delaying cowpea planting up to one week after 50 % maize silking may reduce cowpea yields, particularly during years when rains end in early to mid-September ; - (4) early, prostrate, disease resistant and daylength sensitive cultivars are more suitable to relay-cropping with maize than late daylength sensitive and daylength-insensitive cultivars ; - and (5) high yielding, short, less leafy and early maturing maize cultivars appear more suitable for maize/cowpea relay-cropping system than the tall, more leafy and medium maturing ones.

1.2 Sorghum-cowpea intercropping

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

1.2.1 Performance of cowpeas in an intercropping system with sorghum

Seven cowpea cultivars of different growth habit were intercropped with sorghum to study : (1) their performance in intercropping with sorghum, and (2) their effect on intercropped sorghum, cv. "Framida". The cowpea cultivars used were : IT82E-32, determinate, intermediate maturing and up-right ; KVu-69, extra-early and spreading ; TVx 3236, IT 82D-716, KN-1 and TVx 1999-01F, all of them spreading, medium maturing and daylength-insensitive ; and Ouahigouya local, early, prostrate and daylength-sensitive. Both cowpea and sorghum crops were sown simultaneously on 25 June in alternate solid rows. The spacings for sorghum were 1 m between rows and 0.25 m between plants within each row and for cowpeas, 1 m between rows and 0.20 m between plants within each row. Three sole crop treatments : two for cowpeas using KN-1 and TVx 3236, and one for sorghum, were included for comparison. All plots (6 m x 6 m each) were fertilized with NPK at planting. Sorghum plants, in intercrop and sole crop treatments, received an additional N one month after planting. One intercrop treatment using cowpea TVx 3236 and sole crop sorghum, both unfertilized, were also included for comparison. Cowpea plants were sprayed with insecticide twice. The experimental design used was randomised complete blocks replicated six times.

Sorghum grain yield was significantly reduced in intercropped as well as in unfertilized plots as compared to fertilized sole crop sorghum plots (Table 4). Intercropping cowpea with sorghum in unfertilized plots further reduced sorghum yield as compared to unfertilized sole crop sorghum.

Cowpea cultivars had different competitive ability in intercropping with sorghum. KN-1 and Ouahigouya local significantly depressed sorghum yield as compared to TVx 1999-01F, KVu-69 and IT82D-716 ; they induced a sorghum yield that was insignificantly different from that of unfertilized sole crop sorghum. The other cultivars were intermediate between the two groups.

The high competitive ability of KN-1 and Ouahigouya local appears to be related to mineral nutrition as they induced sorghum flowering, plant height and grain yield that were intermediate between those of fertilized and unfertilized sole crop sorghum treatments (Table 4). This is also well illustrated, in sorghum flag leaf N and P contents at flowering particularly for Ouahigouya local; sorghum intercropped with this cultivar had low flag leaf N and P contents (Table 4). Intercropping sorghum with cowpeas in unfertilized plots also affected sorghum N and P nutrition detrimentally (Table 4).

TVx 3236 and KN-1 yielded similarly in sole crop treatments but significantly higher than any intercrop cowpea treatment, except for intercropped KN-1 for which grain yield was not significantly different from that of sole crop TVx 3236 (Table 5). Intercrop KN-1 significantly out-yielded intercrop IT82D-716 and Ouahigouya local, in fertilized plots, and TVx 3236, in unfertilized plots.

Yield of unfertilized intercrop cowpea was not drastically reduced in relation to that of fertilized intercrop cowpea treatments as it was the case for sorghum (compare Table 4 and 5). This suggests that cowpea uses native soil nutrients more efficiently than sorghum.

Yield performance of cowpeas in intercropping with sorghum appeared to not be associated with the competitive ability of cowpea cultivars. KN-1 and Ouahigouya local, which were highly competitive, yielded differently. Also, KN-1 yielded similarly to less and intermediate competitive cultivars, exept IT82D-716.

With the exception of Ouahigouya local, cowpea dates of flowering and maturity appeared to not be associated with cowpea as well as sorghum yield performances in intercropping system (compare TVx 1999-01F, KVu-69 and IT82D-176, Tables 4 and 5). However, too late cowpea flowering and maturity appeared to have detrimental effect on yields of both cowpea and sorghum intercrops. This could be related to a strong competition for soil water and nutrients and light among the crops, due to a long overlap growth period. Indeed, as shown on Table 4, Ouahigouya local interfered strongly with sorghum N and P nutritions. Also, since sorghum was taller than cowpea and considering that Ouahigouya local and sorghum flowered almost at the same time and Ouahigouya local reached maturity during sorghum grain filling (sorghum plants had reached full plant height and leaf area by this time), the latter might have exerted a strong shading on the former. Sorghum shading might have reduced the photosynthetic capacity of Ouahigouya local, during a very critical period of grain fill and thus, drastically reduced grain yield.

Plant type-up-right versus spreading-appeared to not influence the competitive ability of cowpea cultivars. The four less competitive cowpeas included both plant types, with the least competitive cultivars TVx 1999-01F being spreading and not up-right plant types (see IT82E-32).

A land equivalent ratio greater than 1 was obtained by different contributions by each of component crop (see KN-1, KVu-69 and TVx 1999-01F intercrop, Table 5). Since sorghum is a staple crop, TVx 1999-01F appeared best adapted in sorghum-cowpea intercrop system as it affected the least sorghum yield, but still yielded enough to provide a combined (cowpea + sorghum) LER greater than 1 ; KVu-69 was the next well adapted and KN-1, the least adapted as it reduced drastically sorghum yield (Table 4).

Sole crop cowpea date of planting experiments conducted in 1983 and 1984 have shown TVx 3236, KN-1 and TVx 1999-01F to have an equal high yielding ability ; whereas KVu-69 to have a low yielding ability. Also cowpea breeding regional trials have shown TVx 3236, TVx 1999-01F and KN-1 to have a wide geographic and rainfall (ranging from above 1200 to 450 mm rainfall, except for KN-1 which performed poorly under 600 rainfall) agro-climatic zone adaptation. The fact that the three cultivars differed in their competitive ability and adaptability in intercropping system ; considering also that KVu-69 was the second adapted in sorghum-cowpea intercropping system ; it can thus, be concluded that : there is no relationship between a cowpea cultivar performance in sole crop and its performance in intercropping system. Therefore, the recommendation of a cowpea cultivar for use in intercropping system should be based on yield tests. And cowpea breeders should emphasize breeding under intercropping conditions for cultivars to be used in this cropping system.

Table 4. Effect of cowpea cultivars on sorghum performance in sorghum-cowpea intercropping, Farako-Bâ, Burkina Faso, 1984.

Treatments	Grain Yield (Q/ha) 1/	Flowering date 1/ (DAP)	Plant height 1/ (cm)	LER 2/	Flag leaf nutrient content Total N (%)	Total P (%)
1) Cowpea-sorghum intercrop						
a) Fertilized plots						
IT82E-32	24.6 bcd	75 c	184 ab	0.51	3.6	0.19
IT82D-716	27.1 bc	74 c	190 ab	0.56	3.1	0.16
TVx3236	20.4 cde	75 c	178 ab	0.42	3.4	0.17
KN-1	19.0 de	76 bc	189 ab	0.39	3.1	0.17
KVu-69	27.3 bc	75 c	182 ab	0.56	3.6	0.19
TVx1999-01F	29.1 b	74 c	193 ab	0.60	3.8	0.23
Ouahigouya local	19.2 de	76 bc	174 b	0.40	2.8	0.16
b) unfertilized plots						
TVx3236	5.1 f	80 a	129 d	(0.32)	3.0	0.10
2) Sole Crop						
a) fertilized sorghum	48.3 a	74 c	193 a	1.00	3.9	0.20
b) unfertilized sorghum	15.9 e	78 ab	148 c	(1.00)	3.6	0.14
LSD (5%)	7.4	2	18	-	-	-
CV (%)	27	2	9	-	-	-

1/ Means followed by the same letter are not statistically different at 5% probability level.

2/ The land equivalent ratio (LER) in parentheses was calculated based on unfertilized sole crop sorghum yield.

Table 5. Performance of cowpeas in a sorghum-cowpea intercropping system, Farako-Bâ, Burkina Faso, 1984.

Treatments	Grain Yield (kg/ha) 1/	FLowering date 1/ (DAP)	Maturity date 1/ (DAP)	L E R Partial Cowpea	L E R Combined 2/ (cowpea + soghum)
1) Cowpea-Sorghum intercrop					
a) Fertilized plots					
IT82E-32	605 cd	45 d	66 c	0.46	0.97
IT82D-716	518 d	46 cd	67 bc	0.39	0.95
TVx3236	701 cd	47 bc	67 bc	0.53	0.95
KN-1	873 bc	48 b	67 bc	0.66	1.05
KVu-69	600 cd	41 e	58 d	0.46	1.02
TVx1999-01F	634 cd	48 b	68 b	0.48	1.08
Ouahigouya local	434 d	67 a	90 a	0.32	0.72
b) Unfertilized plots					
TVx3236	535 d	48 b	68 b	0.41	0.73
2) Sole Crop Cowpeas					
TVx3236	1178 ab	46 cd	67 bc	-	-
KN-1	1457 a	47 bc	67 bc	-	-
Mean of the 2 checks	1317	-	-	1	1
LSD (5%)	319	1	1	-	-
C.V. (%)	36	2	1	-	-

1/ Means followed by the same letter are not statistically different at 5% probability level.

2/ This combined cowpea-sorghum land equivalent ratio (LER) was calculated by adding partial LER for cowpea and sorghum (see Table 4).

1.2.2 Effect of plant populations on performance of sorghum and cowpea in intercropping system

The sorghum cultivar, Framida, and the cowpea cultivar, TVx 3236, were sown simultaneously at Farako-Bâ, on 26 June, in alternate rows. Three row spacings and plant densities were used to study the effect of row-spacings and plant densities on the performance of cowpea and sorghum, an intercropping system. The row-spacings and plant densities used were : 1 m x 0.25 m (40,000 plants/ha), 1.25 m x 0.25 m (32,000 plants/ha)and 1.50 m x 0.25 m (26,667 plants/ha) for sorghum and 1 m x 0.20 m (50,000 plants/ha), 1.25 m x 0.20 m (40,000 plants/ha) and 1.50 m x 0.20 m (33,333 plants/ha) for cowpea. Sole crop sorghum and cowpea treatments were included using their optimum spacings and densities, 0.75 cm x 0.25 cm (53,333 plants/ha) for sorghum and 0.75 m x 0.20 m (66,667 plants/ha) for cowpea for comparison. The experimental design used was randomized complete blocks replicated six times. All agronomic practices used were as described in the sorghum-cowpea intercropping experiment discussed above.

Intercropping sorghum and cowpea significantly reduced grain yield of both crops as compared to sole crop treatments (Table 6). Increasing row-spacings and reducing plant densities had no significant effect among cowpea intercrop treatments, but it further significantly reduced yield of intercropped sorghum. The two intercrop treatments : the combination of 1 m x 0.25 m, for sorghum, and 1 m x 0.20 m for cowpea ; and that of 1.25 m x 0.25 m for sorghum, and 1.25 m x 0.20 m for cowpea gave similar land equivalent ratios that were greater than 1. Whereas the intercrop treatment 1.50 m x 0.25 m, for sorghum, and 1.50 m x 0.20 m, for cowpea, had a LER lower than 1 (Table 6). Thus, farmers will get a greater combined intercrop yield than combined sole crop yield by using any of the former two treatments than the latter.

1.3 Date of planting

Two experiments : one involving five daylength-sensitive cultivars and one check,daylength-insensitive (KN-1),and the other six daylength-insensitive cultivars, were conducted to determine the optimum planting date and to identify environmental factors (drought, diseases and parasites other than insect pests) that limit cowpea yields. The experimental design used for each experiment was a split plot, with planting dates as main treatments and cultivars as sub-treatments ; the experiments were replicated four times. All plots received P_2O_5 as rockphosphate and two insecticide treatments.

Table 6. Effect of plant populations on the performance of sorghum and cowpea in intercropping system, Farako-Bâ, Burkina Faso, 1984.

Treatments				Seed Yield		L E R		
Spacings		% Sole Crop density						
Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea	Sorghum	Cowpea	Combined
				-----kg/ha----				
(0.75x0.25m)	-	100	0	4356 a	-	1.00	0	1.00
-	(0.75x0.20m)	0	100	-	1579 a	0	1.00	1.00
(1.00x0.25m)	(1.00x0.20m)	75	75	2888 b	772 b	0.66	0.49	1.15
(1.25x0.25m)	(1.25x0.20m)	60	60	2544 bc	879 b	0.58	0.56	1.14
(1.50x0.25m)	(1.50x0.20m)	50	50	2014 c	821 b	0.46	0.52	0.98
LSD (5%)				614	286	-	-	-
C.V.(%)				17	24	-	-	-

1/ Means followed by the same letter are not statistically different a 5% probability level.

The crop season received a total of 815.1 mm rainfall (74% of the longterm average). Rains were more or less well distributed throughout the crop season, except in August and September, during which excessive rainfalls and overcast weather occured. They ended at the end of September, which was earlier than normal, mid to end of October.

The crop season experienced three epidemic diseases : bacterial blight, web blight and scab, due to excess of rains and overcasted weather in August and September. Plots where daylength sensitive cultivars (including KN-1) were tested showed more disease symptoms than those of daylength insensitive cultivars.

In contrast to the 1983 results, dates of planting x cultivars interaction had no significant effect on seed yield of both cowpea plant types. Dates of planting significantly affected seed yield of daylength-insensitive cultivars only (Table 7). 25 June planting significantly out-yielded 15 July and 4 August plantings but yielded similarly with 9 June planting. 4 August planting drastically reduced seed yield of daylength-insensitive cultivars as compared to any other dates ; however its seed quality and that of 15 July planting were better than those of the two early dates of planting.

As observed in 1983 early maturing daylength sensitive cultivars (which flower in late August to end of September) yielded similarly to the check daylength insensitive KN-1, but significantly higher than the late maturing (which flowersin mid-October) daylength sensitive, Logofrousso local (Table 8). KVu 20-2 was intermediate between the two former groups.

Medium maturing daylength-insensitive cultivars, KN-1, TVx 1999-01F and TVx 3236 significantly out-yielded early maturing IT82E-18 and IT82D-716 (Table 8). The latter two cultivars significantly out-yielded the extra-early KVu-69.

Inspite of a relatively good distribution of rainfall in 1984 as compared to 1983, seed yieldsin 1984 are lower than in 1983. This could be related to the disease out-break in August and September, which caused important defoliations that is reflected in poor ground cover (Table 8).

From these results and those of previous years, it can be concluded that in Northern Guinea Savanna : (1) cowpeas either daylength sensitive or insensitive should be planted in mid-July to achieve high and good quality seed yield ; (2) medium maturing daylength insensitive cultivars appear better adapted than the very early ones, especially when planted in mid-July ; (3) some

Table 7. Effect of dates of planting on seed yields of daylength-sensitive and insensitive cowpeas, Farako-Bâ, Burkina Faso, 1984.

Date of planting	Cowpea daylength 1/	
	Sensitive	Insensitive
	---------kg/ha---------	
9 June 1984	687 a	1157 ab
25 June 1984	725 a	1234 a
15 July 1984	761 a	1035 b
4 August 1984	509 a	586 c
LSD (5%)	NS	198
CV (%)	36	26

1/ Mean followed by the same letter are not statistical different at probability level 5%.

Table 8. Performance of cowpeas at Farako-Bâ, Burkina Faso, 1984.

Cultivars	Seed Yield 1/ (kg/ha)	Flowering date 1/ (DAP)	Maturity date 1/ (DAP)	Ground cover 1/ (%)
		Daylength sensitive		
KN-1	794 ab	50 d	66 d	74 bc
Ouahigouya local	721 ab	66 bc	85 c	73 c
TVx6486-36B1-K	799 ab	63 c	83 c	83 ab
KVu-12-2	870 a	66 bc	85 c	79 abc
KVu-20-2	637 b	70 b	90 b	75 bc
Logofrousso local	202 c	85 a	110 a	86 a
LSD (5%)	184	4	4	9
C.V. (%)	39	9	7	14
		Daylength insensitive		
IT82E-18	880 b	41 c	61 a	50 bc
IT82D-716	844 b	43 b	61 a	45 cd
TVx3236	1167 a	45 a	63 a	58 b
KN-1	1276 a	45 a	64 a	78 a
TVx1999-01F	1206 a	45 a	63 a	70 a
KVu-69	644 c	38 d	57 b	38 d
LSD (5%)	198	1	3	8
C.V. (%)	26	4	7	21

1/ Means followed by the same letter are not statistically different at 5% probability level.

early maturing daylength sensitive cultivars, such as "Ouahigouya local" yield about as well as improved daylength insensitive ones, particularly when not planted very early in the crop season ; (4) planting in mid to late June could lead to poor seed quality (seed rotting, which occurs if protracted cloudy cover and rainy conditions establish themselves in August and/or September, harvesting periods for these plantings) or to severe disease damages in August and September for daylength sensitive cultivars ; (5) planting late maturing daylength sensitive cultivars could reduce seed yields drastically, particularly in years when rains end early in crop season or epidemic diseases occur in August or September ; and (6) when planted early, daylength sensitive cowpeas provide better ground cover than the insensitive ones.

1.4 Plant population

The plant population experiment for semi-erect, early cultivars was repeated in 1984 at Farako-Bâ. It included two cultivars : KN-1, medium maturing, spreading and daylength insensitive ; and IT82E-32, determinate, early maturing, semi-erect and daylength insensitive. They were sown at two-spacings : 0.75 m and 0.50 m, and three plants populations : 50,000, 75,000 and 100,000 plants per hectare. The experimental design used was randomized complete blocks replicated four times. Each plot received the equivalent of 60 kg/ha of P_2O_5 as single super phosphate ; cowpea plants were sprayed four times.

Cowpea seed yield was significantly affected by cowpea cultivars only. KN-1 significantly out-yielded IT82E-32 (1014 kg/ha versus 854 kg/ha, LSD (5 %) = 109 kg/ha, CV (%) = 20). So, as observed in 1982 and 1983 at Farako-Bâ, it appears that row-spacings and plant populations are not the major yield limiting factors for semi-erect early cultivars.

1.5 Soil and soil-water management

1.5.1 Effect of seed-bed preparation methods on seed yield of cowpeas on a medium slope oxisol

The experiment comparing the effect of seed-bed preparation methods on seed yield of cowpea cultivars : KN-1 (daylength insensitive) and Logofrousso local (daylength sensitive), conducted in 1983 at Farako-Bâ, was repeated in 1984. The four seed bed preparation methods used were : (1) planting on flat, (2) planting on flat converted to untied ridges three weeks after planting, (3) planting on tied ridges, and (4) planting on flat converted to tied ridges three weeks after planting. The experimental design used was a factorial combination of four seed-bed preparation methods and two cultivars in randomized complete blocks replicated four times. All agronomic practices used were as described in the plant population experiment discussed above.

Cowpea seed yield was significantly affected by cultivars only. KN-1 significantly out-yielded Logofrousso local (1460 kg/ha versus 507 kg/ha, LSD (5 %) = 228 kg/ha, CV (%) = 31). Thus, in contrast to the results obtained in Sudan Savanna on alfisol, seed bed preparation methods had no effect on cowpea seed yields. From this year's results and those of 1981, 1982 and 1983, it can be concluded that : in oxisol, which have a good soil water infiltration rate, tied ridges are not required to improve soil water infiltration to replenish soil water reservoir and, hence, ensure high and/or stable grain yield.

1.5.2 Effect of zero-tillage with in-situ mulch on the performance on maize and cowpea in a relay cropping system.

Conventional tillage, whether done by hand hoeing or plowing with draft animals or tractor, is a high energy demanding cultural practice. It can constitute a bottle-neck in expanding cultivated area by farmers, either because of labor shortage (hand hoeing) or lack of financial resources (draft animal and tractor plowing). Also by denuding the soil, it exposes it to lashing rains, water runoff, erosion and high temperature and evaporation; all of which contribute to a reduced soil water reservoir and deterioration of soil physical and chemical properties. The consequences of this practice may be : reduced crop yield at short term, particularly during years protracted dry spells occur, and/or reduced soil fertility at long term. The zero-tillage with in-situ mulch technique, by not denuding the soil, may be a soil conservation measure particularly suited to semi-arid regions ; therefore it is imperative to study its effect on crop performance in the semi-arid zones.

Zero-tillage with in-situ mulch was tested against hand hoeing and tractor plowing, at Farako-Bâ, to study its effects on maize and cowpea performances in a relay cropping system. The in-situ mulch was provided by grasses (that included Imperata cylindrica) after a five year's fallow. The grasses were killed with the herbicide "Glyphosate" and left in the field in no-tilled plots, whereas they were plowed-under in tilled plots. Fertilizer treatments, comprising two levels of N (100 and 167.5 kg/ha) and three levels of P_2O_5 (60,85, 110 kg/ha), were also included to determine if there exists a tillage method x fertility interaction. Maize cultivar SAFITA-2 was sown on 10 July and the cowpea cultivar "Kaya local" relay-cropped under maize one month after planting. Maize was harvested in early-October and cowpea in late-October. The experimental design used was a split plot with tillage methods as main treatments and fertility levels as subtreatments. The experiment was replicated four times. All agronomic practices used were as described in the maize-cowpea relay-cropping experiments discussed above.

Maize flowering and maturity dates, ear and plant heights and seed yield were not significantly affected by any of the main effects nor their interaction, except for seed yield. Seed yield was significantly affected by N levels only ; plots that received 167.5 kg of N/ha significantly out-yielded those that received 100 kg of N/ha (3004 kg/ha versus 2333 kg/ha ; LSD (5 %) = 287 kg/ha and CV (%) = 23). The lack of significant effect due to tillage methods on the afore mentioned traits suggests that plowing was not required to improve soil physical properties to ensure proper growth and development of maize crop.

None of the main effects and their interactions affected significantly cowpea flowering and maturity dates, except N ; high N level significantly reduced flowering and maturity dates for one day. N levels, tillage methods and tillage methods x P_2O_5 levels interaction significantly affected cowpea seed yield (Table 9). Zero-tillage with in-situ mulch significantly out-yielded both hand hoeing and tractor plowing ; the latter two did not significantly differ from each other. Increasing levels of P_2O_5, at each tillage method, had no significant effect on cowpea seed yield, except for tractor plowing for which 110 kg/ha of P_2O_5 significantly reduced seed yield.

Since cowpea flowered in mid-October and reached maturity at the end of October, considering also that the month of October was dry (12.6 mm rainfall most of them between the 6 th and the 7th), the high seed yield exhibited by zero-tillage with in-situ mulch suggests that mulch, by intercepting solar radiations, was effective in reducing soil water evaporation. It, thus, enabled to store sufficient moisture in the soil and that prevented drastic yield loss inspite of the dryness of the month of October.

From the experimental results it appears that zero-tillage with in-situ mulch is as good as conventional tillage in ensuring cowpea seed yield in oxisol with good ground cover from natural grasses. It can even be more advantageous than the latter, particularly during years protracted dry spells occur at a critical growth stage (such as grain filling period). This is because it can reduce soil water evaporation and so help conserving soil moisture, which is crucial for crop maturation under residual moisture.

1.5.3 Response of cowpeas to soil applied P_2O_5

The experiment comparing the effect of P_2O_5 levels from two phosphatic fertilizer sources on six cowpea cultivars conducted at Farako-Bâ in 1983 was repeated in 1984 with some modifications. The levels of rock phosphate, Burkina phosphate 26.7 % (BP) (formerly Volta phosphate), was increased from one to two (100 and 200 kg of P_2O_5/ha), and those of single super phosphate 18 % (SSP) reduced from two to one (50 kg of P_2O_5/ha), giving thus a total of four treatments : 0 kg/ha, 100 kg/ha and 200 kg/ha of P_2O_5, from BP, and 50 kg/ha of P_2O_5, from SSP. The six cultivars used were : three daylength sensitive (i.e., Ouahigouya local, Logofrousso local and Kamboinse local rouge) and three daylength insdnsitive (IT82D-716, TVx 3236 and KN-1). The experiment was planted on 5 July using a split plot experimental design with P_2O_5 levels as main treatments and cowpea cultivars as subtreatments ; it was repeated four times. Cowpea cultivars were sprayed four times. All agronomic practices used were as described in plant population experiment discussed above.

Soil P test taken 50 days after cowpea planting is shown on Table 10. Application of 50 kg/ha of P_2O_5 from SSP tended to increase soil available P as compared to other treatments. 100 and 200 kg/ha of P_2O_5 from BP had no appreciable effect in soil available P. It is, however, interesting to note that two daylength sensitive cultivars, Ouahigouya local and Logofrousso local, tended to maintain high levels of soil available P in their plots which did not receive soluble phosphatic fertilizer.

Cowpea seed yield was significantly affected by cultivars and cultivars x P_2O_5 levels interaction. Table 11 shows the effect of interaction cultivars x P_2O_5 levels. KN-1 was the only cultivar that responded positively to P_2O_5 levels. Its seed yield increased significantly with the first increment of P_2O_5 from BP and reached a plateau. Seed yield induced, in this cultivar by 100 kg/ha and 50 kg/ha of P_2O_5, respectively, from BP and SSP were not significantly different. Seed yield of Logofrousso local reached its maximum at 0 kg/ha and 100 kg/ha of P_2O_5 from BP. It was significantly reduced at 200 kg/ha and 50 kg/ha of P_2O_5, respectively, received from BP and SSP. Seed yields of Logofrousso local at 0 kg and 100 kg/ha of P_2O_5 from BP was not significantly different from those of KN-1 at all levels of applied P_2O_5. Other cultivars did not respond to P_2O_5 applications.

The experimental results contrast with those of 1983, particularly for Ouahigouya local, TVx 3236 and Logofrousso local, and tend to agree with those of 1981 and 1982 for Logofrousso local.

Table 9. Effect of interaction of P_2O_5 levels x tillage methods on seed yield of cowpeas in a maize-cowpea relay cropping system, Farako-Bâ, Burkina Faso, 1984.

Tillage methods	P_2O_5 levels (kg/ha)			Mean
	60	85	110	
	kg/ha			
-Zero-tillage with in-situ mulch	514	486	557	519
-Hand hoeing	400	427	338	389
-Tractor plowing	438	447	280	388
Mean	451	453	392	432

Means comparison	LSD (5%)	CV (%)
Tillage methods	85	11
P_2O_5 levels	NS	26
P_2O_5 at same level of tillage	117	26

Table 10. Soil P test taken 50 days after planting, Farako-Bâ, Burkina Faso, 1984.

Cultivars	P_2O_5 levels (kg/ha)				Mean
	Check	Burkina Phosphate		S.S.Phosphate	
	0	100	200	50	
	PPM				
Ouahigouya local	3.29	3.32	2.21	3.81	3.16
IT82D-716	2.84	2.07	2.73	3.16	2.70
TVx3236	2.84	2.21	2.88	3.25	2.79
Logofrousso local	4.18	2.07	3.25	3.02	3.13
KN-1	2.17	1.77	2.88	3.32	2.53
Kamboinsé local rouge	2.17	2.07	2.07	2.14	2.22
Mean	2.99	2.25	2.67	3.12	2.76

Table 11. Effect of P_2O_5 levels on seed yield of cowpea cultivars, Farako-Bâ, Burkina Faso, 1984.

Cultivars	P_2O_5 levels (Kg/ha)			
	Check	Burkina Phosphate		S.S. Phosphate
	0	100	200	50
	----------------kg/ha----------------			
Ouahigouya local	620	880	712	804
IT82D-716	748	881	919	809
TVx3236	833	849	907	1226
Logofrousso local	1147	1374	700	885
KN-1	922	1402	1344	1542
Kamboinse local R.	855	877	954	953

Means comparison	LSD (5%)	CV(%)
Two means at same level of P_2O_5	344	25
Two means at diff. levels of P_2O_5	398	

The occurence of disease epidemics : bacterial blight, web blight, scab and rust (in plots where P_2O_5 levels experiment was conducted) might have prevented cowpeas from expressing their full yield potential and, hence, altered their response to P_2O_5 levels observed in 1983. KN-1 showed susceptibility only to web blight as did TVx 3236, but it suffered less damage as compared to the latter. This explains its best performance in this experiment. Logofrousso local delayed diseases establishment more than other cultivars and it had exhibited better tolerance to disease, particularly to rust. This also explains its best performance in this experiment at 0 kg/ha and 100 kg/ha of P_2O_5 from BP. Its yield drop at 200 kg/ha and 50 kg/ha of P_2O_5, respectively, from BP and SSP, could be related to excessive vegetative growth favoured by high availability of P_2O_5 commonly observed with daylength sensitive cultivars. As observed in 1981 and 1982, Logofrousso local demonstrated again its ability to utilize, when planted early in the crop season, more efficiently native soil P and gave high seed yields equal to that of fertilized improved daylength-insensitive cultivars. The expression of this ability was prevented in 1983 by early cessation of rains in mid-September and by Sericothrips damages.

From these results and those of 1983, 1982 and 1981, it can be concluded that varietal differences exist in utilization of native soil P.

1.5.4 Residual effect of P_2O_5 levels from two different sources on maize grain yield

The study of P_2O_5 levels from single super phosphate 18 % (SSP) and rock phosphate, Burkina phosphate 26.7 % (BP), formerly Volta phosphate, conducted in 1983 had shown cowpea yield to increase with 50 kg/ha of P_2O_5 from SSP and reach a plateau, whereas the 100 kg/ha of P_2O_5 from BP had no significant effect on cowpea yield. Since BP is less soluble than SSP, one would expect it to have a strong resitual effect in years subsequent to its application than the latter. To test this hypothesis, an experiment was conducted in 1984 with two levels of P_2O_5 from SSP (25 and 50 kg/ha of P_2O_5) and three levels of P_2O_5 from BP (50, 75 and 100 kg/ha). An unfertilized treatment was included as a check. The six treatments were applied as sub-treatments to each of the plots which received either : 0, 50 or 100 kg/ha of P_2O_5 from SSP, or 100 kg/ha of P_2O_5 from BP in the 1983 crop season on cowpeas. These were main-treatments in a split plot experimental design. In addition to the afore mentioned P_2O_5 levels, maize plants received uniformly 22.5 kg/ha of N at planting and 90 kg/ha of N one month after planting.

Maize dates of flowering and maturity were not significantly affected by any of treatment effects. Maize plant and ear heights were significantly increased only in plots that received P_2O_5 levels from SSP on cowpea in 1983 and on maize in 1984. Ear leaf P content in plots that received BP in 1983 (Table 12) was equal to or tended to be higher than in plots that received 50 kg of P_2O_5 from SSP in the same year. This was, however, not reflected in grain yield (Table 13).

Maize grain yield was significantly affected by P_2O_5 levels applied on cowpeas in 1983 as well as on maize in 1984 and by their interaction. With the exception of plots that received 75 kg/ha of P_2O_5 from BP and 50 kg/ha of P_2O_5 from SSP in 1984, maize grain yield was significantly increased only by P_2O_5 levels, particularly 100 kg/ha, from SSP applied on cowpeas in 1983 (Table 13). Only 50 kg/ha of P_2O_5 from SSP applied in 1984, in plots that received 0 kg/ha of P_2O_5 on cowpeas in 1983, and 25 and 50 kg/ha of P_2O_5 from SSP applied in 1984 in plots that received 50 kg/ha of P_2O_5 from SSP or 100 kg/ha of P_2O_5 from BP on cowpeas in 1983, significantly affected maize grain yield. Maize grain yield in plots that received 100 kg/ha of P_2O_5 from SSP in 1983 was unaffected by none of P_2O_5 levels from both phosphatic carriers applied in 1984.

From experimental results, BP appeared to not have immediate as well as residual effects on maize yield ; whereas SSP had both strong immediate as well as residual effects. It appeared, thus, to achieve 3 T/ha of maize grain yield under Farako-Bâ conditions : - farmers who apply 100 kg/ha of P_2O_5 from SSP on cowpea are not required to add a supplement of P_2O_5 to maize crop in the subsequent year ; - those who apply 50 kg/ha of P_2O_5 from SSP on cowpeas will have to apply a supplement of 25 kg/ha of P_2O_5 from SSP on maize ; - those who apply 100 kg/ha of P_2O_5 from BP on cowpea will have to apply 25 to 50 kg/ha of P_2O_5 from SSP on maize ; - and those who do not apply phosphatic fertilizer at all will have to apply 50 kg/ha of P_2O_5 from SSP on maize.

1.5.5 Soil improvement

With the availability of rock phosphate, Burkina phosphate (BP), in Burkina Faso, one would expect the combination of cowpea's N fixing capacity with this fertilizer to reduce fertilizer requirements for achieving a given level of yield of cereal crops, such as maize, in a rotational sequence. If this is so, farmers can then be encouraged to use this fertilizer on cowpea crops, even though it may appear at first costly, but knowing that they will recover part of the cost in the subsequent season through increased maize or other cereal yields. On the other hand, it is always better to compare this practice to some other possible alternatives : e.g., cowpea and other legumes as green manure, to quantify the beneficial effect farmers can get. Six treatments involving cowpea and <u>Crotalaria</u> were established in 1983 to study the effect of cowpea production

Table 12. Ear leaf P content of maize plants in an experiment of residual effect of P_2O_5 levels applied to cowpeas, Farako-Bâ, Burkina Faso, 1984.

P_2O_5 levels applied on maize in 1984 (kg/ha)	P_2O_5 levels applied on cowpeas in 1983(kg/ha)1/				Mean
	0	50 SSP	100 SSP	100 BP	
	------------------------- % -------------------------				
0	0.123	0.132	0.170	0.177	0.150
50 BP	0.156	0.163	0.170	0.168	0.164
75 BP	0.165	0.142	0.149	0.172	0.157
100 BP	0.140	0.132	0.176	0.178	0.156
25 SSP	0.121	0.140	0.160	0.174	0.149
50 SSP	0.135	0.184	0.246	0.172	0.184
Mean	0.140	0.149	0.178	0.173	0.160

1/ SSP= single super phosphate 18%; BP = Burkina Phosphate, a natural rock phosphate (26.7% of P_2O_5).

Table 13. Residual effect of P_2O_5 levels applied on cowpeas on maize grain yield, Farako-Bâ, Burkina Faso, 1984.

P_2O_5 levels applied on maize in 1984 (kg/ha)	P_2O_5 levels applied on cowpeas in 1983 (kg/ha)			
	0	50 SSP	100 SSP	100 BP
	---------------kg/ha---------------			
0	1383	2215	3403	907
50 BP	1139	2161	3731	1160
75 BP	2046	2145	2988	937
100 BP	1905	2854	3715	1367
25 SSP	1907	3194	4283	2729
50 SSP	3001	3258	3408	3646

Mean comparison	LSD (5%)	CV (%)
means at same level P_2O_5 (1983)	969	28
means at diff. levels P_2O_5 (1983)	1203	

for grain or green manure using Burkina phosphate (BP) on grain yield of the subsequent crop of maize. The treatments were :

(1) cowpea for grain production + 60 kg/ha of P_2O_5 from single super phosphate (SSP) ;

(2) the same as (1) + 60 kg/ha of P_2O_5 from BP ;

(3) cowpea green manure without fertilizer application ;

(4) the same as (3) + 60 kg/ha of P_2O_5 from BP ;

(5) Crotalaria green manure without fertilizer application ;

(6) the same as (5) + 60 kg/ha of P_2O_5 from BP.

Two sorghum treatments : sorghum + 100 kg/ha of N + 60 kg/ha of P_2O_5 from SSP and sorghum + 100 kg/ha of N + 60 kg/ha of P_2O_5 from BP, were also included for comparison. In 1984 three NPK fertilizer level treatments : 0:0:0, 36.5:25:14 and 73:50:28, were applied to each of afore mentioned 8 treatments. The experimental design used was a split plot with the eight 1983 treatments as main-treatments and the three fertilizer levels as sub-treatments. Cowpea and Crotalaria green manure treatments were plowed under slightly after their flowering ; whereas crop residues from other treatments were plowed under slightly before planting. The agronomic practices used were as described in maize/cowpea relay cropping experiments discussed above.

Soil tests done slightly after maize silking in 1984 did not show any definite tendency for any of the eight main-treatments to influence soil pH, organic matter, and N and P contents. The P test was greater than 3 ppm for all treatments.

Maize ear leaf P and N contents, determined at the same time as the soil tests, showed the tendency of unfertilized cowpea and Crotalaria green mamure treatments and the sorghum treatment that received BP to reduce ear leaf P content ; whereas the same treatments, except sorghum, tended to increase N content as compared to other treatments (Table 14). However, these tendencies were not reflected in maize seed yield. Maize seed yield was not significantly affected by the main treatments.

Increasing levels of fertilizer applied to each main treatment significantly increased both P and N in maize ear leaf (Table 14). This increase was reflected in maize flowering and maturity dates and seed yield, which were significantly reduced and increased, respectively (Table 15).

Table 14. Ear leaf P and N contents of maize plants in a soil improvement experiment, Farako-Bâ, Burkina Faso, 1984

Treatments	P: Fertilizer levels (NPK) 0:0:0	36.5:25:14	73:50:28	Mean	N: Fertilizer levels (NPK) 0:0:0	36.5:25:14	73:50:28	Mean
	%							
Cowpea grains + 60kg SSP (1)	0.121	0.121	0.174	0.139	1.72	1.69	2.14	1.85
Cowpea grains + 60kg BP (2)	0.108	0.153	0.176	0.146	1.88	1.47	2.11	1.82
Cowpea green manure	0.114	0.132	0.154	0.133	1.66	2.04	2.39	2.03
Cowpea green manure + 60kg BP	0.140	0.150	0.162	0.151	1.59	1.85	1.88	1.77
Crotalaria green manure	0.121	0.132	0.126	0.126	2.20	2.11	2.25	2.19
Crotalaria green manure + 60kg BP	0.136	0.135	0.163	0.145	2.11	1.68	1.77	1.85
Sorghum + 45kg N + 60kg SSP	0.100	0.135	0.180	0.138	1.60	1.68	2.13	1.80
Sorghum + 45kg N + 60kg BP	0.106	0.130	0.155	0.130	1.57	1.85	1.74	1.72
Mean	0.118	0.136	0.161	0.138	1.79	1.80	2.05	1.88

(1) 60kg SSP = 60 kg/ha of P_2O_5 from single super phosphate 18 %

(2) 60kg BP = 60 kg/ha of P_2O_5 from Burkina phösphate 26.7 %

Table 15. Effect of fertilizer levels on flowering and maturity dates and Seed yield of maize in a soil improvement experiment, Farako-Bâ, Burkina Faso, 1984.

Fertilized levels (kg/ha)	Flowering date 1/ (DAP)	Maturity date 1/ (DAP)	Seed Yield 1/ (kg/ha)
0	63 a	92 a	1416 c
36:5:25:14	61 ab	91 ab	2520 b
73:50:28	59 b	90 b	3169 a
LSD (5%)	2	1	268
CV (%)	5	2	22

1/ Means followed by the same letter are not statistically different at 5 % probability levels.

The lack of significant effect due to main treatments could be attributed to P alimentation. This element showed very little variation in both soil and leaf tissue due to main treatments. It is possible that by growing efficient native soil P user materials : Logofrousso local (indigenous cowpea cultivar, very efficient user of native soil P, see IITA/SAFGRAD annual report, 1981, 1982 and 1983), Crotalaria (indigenous species to the area), and sorghum (more efficient user of native soil P than maize), and by plowing them under either as green manure or crop residues, they might have contributed to increased available soil P as the product of the decomposition of organic matter.

From experimental results, it appears that under conditions where crop residues are plowed under : legume green manure either fertilized with rock phosphate or not have no significant residual effect as compared to fertilized cowpea and sorghum grown for seed production. It should be noticed, however, that the present findings might be peculiar to the conditions of this experiment, where we used efficient native soil P user materials.

2. SUDAN SAVANNA

(600-900 mm rainfall, from mid-June to mid-September)

2.1 Date of planting

As in Northern Guinea Savanna, two dates of planting experiments were conducted at Kamboinse in 1984. The first compared five daylength sensitive cowpeas (i.e., Kaokin local, Ouahigouya local, TVx 6486-36B1-K, KVu-12-2 and KVu-20-2) and one daylength-insensitive cultivar, KN-1, as a check, at four dates of planting (i.e., 8 July, 25 July, 2 August and 12 August). The second compared six daylength-insensitive cultivars (i.e., IT 82E-18, IT 82D-716, KN-1, TN 88-63 and TVx 1999-01F) at the same aforementioned dates of planting. All agronomic practices were as described in the date of planting experiments conducted in Northern Guinea Savanna discussed above.

The 1984 crop season in Sudan Savanna was characterized by insufficient rainfalls and several dry spells throughout the season. A total of 414 mm rainfall (or 52 % of the long term average) was received.

Seed yield of daylength sensitive as well as insensitive cowpeas as affected by dates of planting is shown on Table 16. In contrast to

Table 16. Seed yield of cowpeas at Kamboinsé, Burkina Faso, 1984.

Cultivars	Date of planting				Mean
	8 July	25 July	2 August	12 August	
	---kg/ha---				
a) Daylength sensitive					
Kaokin local	539	501	492	178	427
Ouahigouya local	390	145	155	146	209
KN-1	382	213	120	161	219
TVx6486-36B1-K	194	149	122	39	126
KVu-12-2	276	212	206	139	208
KVu-20-2	292	189	190	86	189
Mean	346	235	214	125	230
b) Daylength insensitive					
IT82E-18	288	568	369	201	357
IT82D-716	166	382	485	247	320
TVx3236	268	564	260	158	312
KN-1	355	158	110	51	168
TN88-63	502	458	361	227	387
TVx1999-01F	336	230	84	131	195
Mean	319	393	278	169	290

Mean comparison	Daylength-sensitive		Daylength-insensitive	
	LSD (5%)	CV(%)	LSD (5%)	CV (%)
Date of planting	125 kg/ha		NS	47
Cultivars	83 kg/ha		100 kg/ha	49
Cultivars same date	NS		200 kg/ha	
Cultivars diff. dates	NS		281 kg/ha	

the 1983 (during which long duration daylength sensitive cultivars were used) observations, the seed yield of early daylength-sensitive cultivars was significantly affected by dates of planting. 8 July planting significantly out-yielded the last two dates of planting (Table 16). Seed yield of daylength-insensitive was not significantly affected by dates of planting this crop season. This could be due to poor stand establishment at first date of planting for all cultivars, and second date of planting, particularly for IT 82D-716. Plantings done at those dates were after a 7.6 and 12.0 mm rainfall, respectively, and they were followed by more than six day dry spells. Stands of daylength sensitive cultivars were also reduced at the same dates ; but because of their high branching ability, they were able to compensate for the missing plants.

Three types of response to dates of planting were observed among cowpeas : (1) cultivars for which grain yield declined with delayed planting, this included all daylength sensitivars and KN-1 ; (2) cultivars for which grain yield increased with the second (IT 82E-18 and TVx 3236) or the third (IT 82D-716) dates of planting ; and (3) cultivars for which grain yield was not significantly affected by dates of planting (TN 88-63 and TVx 1999-01F) (Table 16). Yield decline observed in these experiments were associated with flowering under drought stress conditions, except for cultivars in group (2) for which flowering occured around 14 September under no drought stress. Their low yield at the first two or three dates of planting could be associated with poor stand establishment and their inability to compensate for missing plants by increased branching.

"Kaokin local" and TN 88-63 were the best drought tolerant ; whereas KN-1 was the least drought tolerant ; and the other cultivars were either intermediate between the latter and former two cultivars or suffered from severe drought stress because of their lateness (daylength sensitive) (Table 17). Compared to KN-1, "Kaokin local" flowered and matured at the same time with KN-1 and produced less flowers but yielded higher than KN-1 (Table 17). Whereas TN 88-63 flowered and matured earlier and produced more flowers and yielded higher than KN-1. It should also be noted that KN-1 provided a ground cover similar to that of TN 88-63. Compared to other daylength insensitive cowpeas, KN-1 tended to produce less flowers. It appears, thus, that the drought intolerance of KN-1 could be associated with both : its inability to flower profusely and to set pods under drought conditions.

The experimental results agree with those of 1983 and previous years. They stress on the need for : (1) planting in early to mid-July as soon as the rains become well established ; and (2) using high branching and drought

Table 17. Flowering (FD) and maturity (MD) dates, flowering period (FP), flowers per day per m² (FDM) and maximum flowers per day per m² (MFDM) of daylength sensitive cowpeas at Kamboinsé, Burkina Faso, 1984.

Cultivars	FD 1/ (DAP)	MD 1/ (DAP)	FP 1/ (Days)	FDM 1/ (nº)	MFDM 1/ (nº)
a) Daylength sensitive					
Kaokin local	53 b	71 c	14 b	11 a	24 ab
Ouahigouya local	62 a	73 b	14 b	4 b	10 c
KN-1	49 b	72 bc	21 a	13 a	38 a
TVx6486-36B1-K	61 a	77 a	14 b	4 b	11 c
KVu-12-2	62 a	75 ab	10 b	3 b	6 c
KVu-20-2	62 a	74 ab	12 b	3 b	8 c
LSD (5%)	4	3	5	2	6
CV (%)	9	6	50	57	52

1/ Means followed by the same letter are not statistically different at 5% probability level.

tolerating cultivars, which can be daylength insensitive (such as TN 88-63) or early daylength sensitive (such as "Kaokin local").

As far as cultivars are concerned, based on the findings of this year and those of 1983 and previous years, it can be concluded that TVx 3236 is better adapted in Sudan Savanna than KN-1. Indeed, it can yield better than or as much as the latter during dry or rainy years, respectively. Consequently, it should be recommended for use by farmers.

2.2 Soil and soil water mamagements

2.2.1 Response of cowpeas to seed-bed preparation methods

Experiments conducted in previous years in alfisol at Kamboinse have shown tied ridges to increase cowpea yields, particularly in late planting, on tilled upper slope soil in the toposequence as compared to planting on flat beds. Soil-water content monitored in 1983 during a 9 day dry spell has shown tied ridges to increase soil water reservoir by eliminating rain water runoff as compared to flat seed-beds. Date of planting experiments, have, on one hand, shown TVx 3236 and "Suvita-2" to be more tolerant to drought stress than KN-1, and on the other hand, "Suvita-2" to be less tolerant to excess of moisture than KN-1. Thus, since tied ridge techniques can influence soil water reservoir, one would think of using them to differentiate cultivars for drought resistance and/or tolerance to excess of moisture. To test this hypothesis we compared TVx 3236, "Suvita-2", KN-1 and "Ouahigouya local" (the only daylength sensitive cultivar) at three different seed-bed preparation methods (i.e., (1) planting on flat seed-beds, (2) planting on flat seed-beds converted to tied ridges three weeks after planting, and (3) planting on tied ridges). The experiment was established at five positions in the toposequence (i.e., (1) upper slope, (2) upper to medium slope, (3) medium slope, (4) medium to lower slope, and(5)lower slope). The experimental design used was a factorial combination of three seed-bed preparation methods and four cowpea cultivars in randomized complete blocks replicated twice at each position in the toposequence. The experiment was established on 2 August 1984, which was a late planting. All agronomic practices used were as described in plant populations experiment conducted at Farako-Bâ above discussed.

Seed bed preparation methods had no significant effect on floral bud initiation, flowering and maturity. TVx 3236 and KN-1 initiated floral buds, flowered and matured significantly earlier than "Ouahigouya local". "Suvita-2" was intermediate between the former two and the latter cultivars. Cowpea seed yield was significantly affected by cultivars, seed-bed preparation methods, seed bed preparation methods x positions interaction and seed bed preparation methods x cultivars interaction only. Both tied ridge techniques increased cowpea seed yield at all positions, except at upper to medium slope and lower slope (Table 18). At these two positions cowpea seed yield increased singificantly with tying ridges three weeks after planting and reached a plateau. Also seed yield of all cowpea cultivars was increased by both tied ridge techniques, except for Suvita-2 (Table 19). The seed yield of this cultivar significantly increased with tying ridges three weeks after planting and reached a plateau.

"Suvita-2" and TVx 3236 significantly out-yielded KN-1 and "Ouahigouya local" at all seed-bed preparation methods ; they did not differ from each other, except on plots planted on flat but converted to tied ridges three weeks after planting. On these plots, "Suvita-2" significantly out-yielded TVx 3236. KN-1 significantly out-yielded "Ouahigouya local" only on plots where planting was done on tied ridges.

The poor performance exhibited by "Ouahigouya local" was due to severe defoliation caused by bacterial pustule disease ; (this disease affected only "Ouahigouya local"). Whereas that of KN-1 was due to its low tolerance to drought. "Suvita-2" and TVx 3236 appeared, thus, to have high tolerance to drought, with "Suvita-2" requiring lower level of soil water management than TVx 3236 to achieve the same yield (Table 19). These results confirm the 1983 and 1984 date of planting experiments "observations and the cowpea breeding regional trials" results. Consequently, the cowpea breeding program may use late planting and tied ridge techniques on alfisol at Kamboinse to screen for drought resistance. As far as tolerance to excess of moisture was concerned, it was not possible to assess it in this experiment because of lower rainfall than normally observed throughout the crop season.

2.2.2 Soil tillage methods

Soil tillage method experiments were conducted at Loumbila with the same overall objectives as in Northern Guinea Savanna.

Soil tillage experiments conducted in 1981 and 1982 have shown zero-tillage without mulch to affect cowpea seed yield detrimentally on alfisol at Kamboinse. Whereas tractor plowing, by plowing deeply the soil, increased cowpea seed yield several fold as compared to zero-tillage without mulch and significantly out-yielded oxen plowing and hand hoeing. The advantage of conventional

Table 18. Effect of seed-bed preparation mathods and positions in the toposequence on seed yield of cowpeas, Kamboinse, Burkina Faso, 1984.

Positions in the toposequence	Seed-bed preparation methods			Mean
	Flat	Tied ridges 3 weeks after planting	Tied ridges at planting	
	----------------------kg/ha----------------			
Upper slope	82	154	312	182
Upper to medium slope	129	381	461	324
Medium slope	101	270	497	289
Medium to lower slope	38	181	334	184
lower slope	174	338	363	292
Mean	105	265	393	254

Mean comparison	LSD(5%)	CV(%)
Positions	NS	28
Seed-bed preparation methods	42 kg/ha	37
Seed-bed pre. meth. same position	94 kg/ha	37

Table 19. Effect seed-bed preparation methods and cultivars on cowpea seed yield, Kamboinse, Burkina Faso, 1984.

Cultivars	Seed-bed preparation methods: Flat	Tied ridges 3 weeks after planting	Tied ridges at planting	Mean
	---------------------kg/ha			----------------
Suvita-2	163	460	519	380
TVx3236	177	295	502	325
KN-1	63	190	342	199
Ouahigouya local	16	115	210	114
Mean	105	265	393	254

Mean comparison	LSD (5%)	CV (%)
Cultivars	48 kg/ha	37
Seed-bed preparation methods	42 kg/ha	
Cultivars x seed-bed prep.meth.	94 kg/ha	

Table 20. Effect of soil tillage methods on soil water content measured, on 10 August, after a 8 day dry spell, Loumbila, Burkina Faso, 1984.

Tillage methods	Soil water content at depth 1/: 0 - 10 cm	11 - 30 cm
	----------%	---------
- Zero-tillage with *in-situ* mulch	4.5 a	5.9 a
- Oxen plowing	4.0 a	4.3 b
- Tractor plowing	4.3 a	4.4 b
LSD (5%)	NS	0.7
CV (%)	30	13.0

1/ Means followed by the same letter are not statistically different at 5% probability level.

tillage over zero-tillage without mulch was because : the conventional tillage broke down the crusting, loosened the soil to reduce its compaction and improve its porosity, and create irregularity on soil surface to retain rain water and so reduce its runoff. All these resulted in increased soil water infiltration rate and consequently increased soil water reservoir. A great soil water reservoir is crucial in reducing drought stress, in order to maintain proper crop growth and development during protracted dry spells. Since mulch does create irregularity on soil surface, which, can reduce rain water runoff ; considering that it enhances soil biological activities, particularly termite burrowing, which not only improve soil porosity but also soil structure ; and considering also that by intercepting solar radiation it can lower soil water evaporation (so reduce soil water reservoir depletion) and soil temperature, both of which are very important in maintaining proper crop growth and development during protracted dry spells ; one would expect mulch to improve crop performance under zero tillage treatment. To test this hypothesis the following experiments were conducted.

2.2.2.1 Effect of P_2O_5 levels and tillage methods on cowpea performance

Since most of crop residues are left on soil surface when using zero-tillage with <u>in-situ</u> mulch, one would expect this treatment to require more fertilizer application than conventional tillage. This is because conventional tillage by plowing-under crop residues, it favors their rapid decomposition and the subsequent release of nutrients which they contain. The nutrients so released can improve the mineral nutrition of crops and, consequently, reduce their fertilizer requirement. Therefore it is imperative to study the interaction of fertilizer levels with tillage methods.

Two experiments were conducted to study the effect of the interaction of tillage methods and different levels P_2O_5 in alfisol in Sudan Savanna.

<u>Experiment 1</u>

. The experiment compared zero-tillage with <u>in-situ</u> mulch to two conventional tillage methods : plowing by oxen and plowing by tractor, using three levels of single super phosphate 18 % fertilizer (i.e., 0, 50, 100 kg/ha of P_2O_5). The <u>in-situ</u> mulch was provided by a crop of <u>Crotalaria</u> that was established in June 1983 in a plot that was plowed by tractor prior to <u>Crotalaria</u> seeding. The <u>Crotalaria</u> crop was cut in June 1984 to leave 10 cm height stubbles. In plots that received zero-tillage with <u>in-situ</u> mulch, the stubbles were killed with the herbicide "paraquat" and the residues left on soil surface as mulch ; whereas they were plowed-under in plots that were conventionally tilled. The experiment was planted on July 14, 1984. The experimental design used was a'split plot' with tillage methods as main treatments and P_2O_5 levels as sub-treatments. The experiment was replicated four times. Plots that were conventionally tilled were regularly scarified to break down crusting and improve rain water infiltration, whenever necessary, throughout the crop season. All other agronomic practices used were as described in plant population experiment conducted in Northern Guinea Savanna above discussed.

Tillage methods affected significantly soil moisture content in 11-30 cm soil layer (Table 20). Within this layer, zero-tillage with in-situ mulch maintained a soil moisture content significantly higher than both conventional tillage methods.

Zero-tillage with in-situ mulch increased significantly stem length and branch length, which resulted in greater shoot dry weight than that induced by any of the conventional tillage methods except tractor flowing (Table 21). Increasing levels of P_2O_5 (from single super phosphate) also increased significantly stem length, shoot dry weight and root dry weight and to some extent branch length (Table 21).

Cowpea seed yield induced by zero-tillage with in-situ mulch was significantly greater than that induced by both conventional tillage methods (Table 22). The latter two tillage methods did not induce a seed yield that was significantly different. Also cowpea seed yield increased significantly with the first P_2O_5 level increment only (Table 22). However, the effect of zero-tillage with in-situ mulch alone was by far greater than that of increasing levels of P_2O_5 on conventionally tilled plots. Zero-tillage with in-situ mulch improved, thus, the P use efficiency of cowpea.

Experiment 2

This experiment compared zero-tillage with in-situ mulch to plowing by oxen at three levels of rock phosphatic fertilizer, Burkina phosphate (26.7 % P_2O_5), a naturally occuring phosphatic fertilizer with low solubility. The three levels of rock phosphatic fertilizer used were : 0, 100 and 200 kg/ha of P_2O_5. The experimental design used was a factorial combination of three levels of P_2O_5 and two tillage methods in randomized complete blocks replicated five times. All agronomic practices used were as described in the single super phosphate levels' experiment above discussed, except that Crotalaria had a very good growth and, consequently, provided mulch over twice greater than that

Table 21. Effect of soil tillage methods and levels of single super phosphate on cowpea morphological and physiological traits, Loumbila, Burkina Faso, 1984.

Tillage methods	Stem lenght 1/ (cm)	Branch lenght 1/ (cm)	Shoot dry weight 1/ (G/plant)	Root dry weight 1/ (G/plant)
		a) Soil tillage methods		
- Zero-tillage with in-situ mulch	23 a	23 a	24 a	1.63 a
- Oxen plowing	16 b	11 b	11 b	1.05 a
- Tractor plowing	17 b	11 b	15 ab	1.29 a
- LSD (5%)	2	10*	8*	NS
- CV (%)	10	46	36	30
		b) levels of single super phosphate		
- 0 kg/ha of P_2O_5	16 c	13 a	12 b	1.05 b
- 50 kg/ha of P_2O_5	19 b	14 a	17 ab	1.33 ab
- 100 kg/ha of P_2O_5	21 a	18 a	21 a	1.59 a
- LSD (5%)	1	NS	6	0.32
- CV (%)	9	44	44	29

1/ Means followed by the letter are not statistically different at 5% probability level.

* The significance is at 10% probability level.

of the afore mentioned experiment. The experiment was planted on July 18, 1984.

The soil texture in 0-10 cm layer was sandy loam (Sand : 61.7 % ; Silt : 32.8 % ; and clay : 5.5 %) with the clay content increasing in deep soil layers. Soil moisture contents, measured in two soil layers (i.e., 0-10 cm and 11-30 cm) on 11 August and 28 October, respectively, after 8 and 10 day dry spells, are shown on Table 23. Plots that received zero-tillage,with in-situ mulch maintained a soil moisture content, in both soil layers at both sampling dates, significantly greater than that of plots that were plowed with oxen. Also soil temperature measured at 5 cm depth did not differ markedly between both tillage methods during the morning hours, but during the hotest period of the day (12:00 and 15:00 hours) (fig. 1). Soil temperature tended to increase markedly in oxen plowed plots as compared to zero-tilled plots with in-situ mulch during the noon hours. The increase was more evident as the dry spell progressed. Thus, mulch by intercepting solar radiation, not only reduced soil water evaporation and so, helped conserve soil moisture, but also reduced soil temperature. Soil chemical properties did not differ markedly between both tillage methods, though there was tendency for zero-tillage with in-situ mulch to have high organic matter content and pH and low total N in both soil layers as compared to plowing by oxen (Table 24). Increasing levels of Burkina Phosphate did not increase soil available P, this illustrated very well its low solubility.

Cowpea performance reflected more soil physical properties than soil chemical properties (Table 25). Floral bud initiation and flowering occured much earlier in zero-tilled plots with in-situ mulch than in oxen plowed plots ; but the cropsmatured at the same time in plots under both tillage methods. Thus, the generative growth duration was much greater in zero-tilled plots with in-situ mulch than in oxen plowed plots. Also zero-tillage with in-situ mulch induced great root dry weight, long stem with numerous long branches as compared to oxen plowing. All these resulted in greater shoot dry weight and seed yield for the former than for the latter tillage method (Table 25).

In contrast to what one would have expected, zero-tillage with in-situ mulch required less fertilizer application to achieve a given level of cowpea sedd yield than the conventional tillage under the conditions both experiments were conducted (i.e., low rainfall 475.7 mm, 59.5 % of the long term average, with poor distribution). It created soil physical conditions (high soil moisture content and low soil temperature, below physiological limits 40°C, as compared to conventional tillage) proper for continued crop growth and development under dry spells. This explains the high P use efficiency exhited in the first

Table 22. Effect of soil tillage methods and single super phosphate levels on cowpea seed yield, Loumbila, Burkina Faso, 1984.

Tillage methods	Single super phosphate levels			Mean
	0 kg/ha of P_2O_5	50 kg/ha of P_2O_5	100 kg/ha of P_2O_5	
	kg/ha			
- Zero-tillage with in-situ mulch	883	1002	1202	1029
- Oxen plowing	385	538	503	475
- Tractor plowing	176	485	507	389
Mean	481	675	737	631

Mean comparison	LSD (5%)	CV(%)
Tillage	377 kg/ha	34
P_2O_5 levels	189 kg/ha	35
Tillage * P_2O_5 levels	NS	

Table 23. Soil moisture contents measured on 11 August and 28 October after, respectively, 8 and 10 day dry spells, Loumbila, Burkina Faso, 1984.

Tillages methods	11 August 1/		28 October 1/	
	0-10cm	11-30cm	0-10cm	11-30cm
	%			
- Zero-tillage with in-situ	6.2 a	7.7 a	5.7 a	5.7 a
- Plowing by Oxen	4.8 b	5.8 b	4.4 b	4.3 b
LSD (5%)	1.3	1.7	0.7	1.0
CV (%)	28	30	17	23

1/ Mean followed by the same letter are not statistically different at 5% probability level.

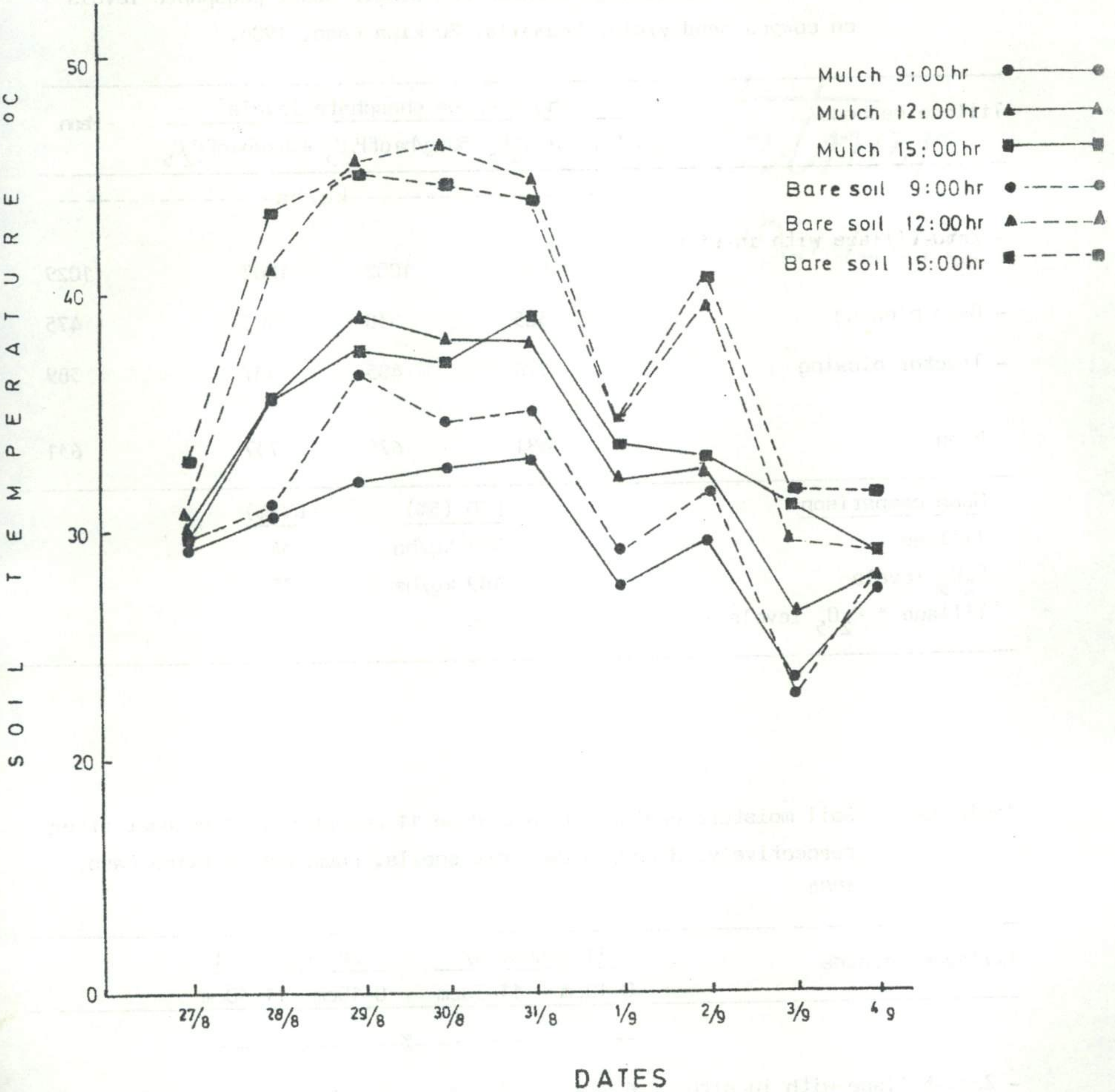


FIG. 1. Soil temperature monitored at 5 cm soil depth in late August to early September, Loumbila, BURKINA FASO, 1984. (the soil t°c monitoring was initiated after a 6.7mm rainfall on 26/8; a 18.0 mm and 29.0 m rainfall was received on the night of 31/8 and 2/9, respectively, which explains soil t°c drop the following day).

Table 24. Soil chemical properties as affected by tillage methods in a rock phosphate tillage methods experiments.

Tillage methods	Organic matter(%)	pH	Available P (ppm)	Total N (%)
	0 - 10 cm layer			
- Zero-tillage with in-situ mulch	0.73	6.98	2.563	0.029
- Oxen plowing	0.67	6.78	2.863	0.036
	11 - 30 cm layer			
- Zero-tillage with in-situ mulch	0.58	6.28	1.767	0.023
- Oxen plowing	0.46	6.17	1.590	0.034

Table 25. Effect of soil tillage methods on cowpea morphological and physiological traits, Loumbila, Burkina Faso, 1984.

Tillage methods	Floral bud initiation 1/ (DAP)	Flowering dates 1/ (DAP)	Maturity dates 1/ (DAP)	Number of branches 1/	Stem length 1/ (cm)	Branch length 1/ (cm)	Shoot dry weigth 1/ (G/plant)	Root dry weight 1/ (G/plant)	Nodule dry weight 1/ (mg)	Seed yield 1/ (kg/ha)
Zero-tillage with in-situ mulch	40 b	46 b	69 a	4.3 a	27 a	39 a	33 a	2.05 a	57 a	1026 a
Oxen plowing	43 a	50 a	70 a	3.7 b	17 b	13 b	15 b	1.52 b	47 a	386 b
LSD (5%)	1	1	1	0.4	3	8	5	0.4	ns	272
CV (%)	3	3	1	13	16	37	26	26	86	45

1/ Means followed by the same letter are not statistically different at 5% probability level.

experiment and the better cowpea performance in the second experiment despite the lack of marked differences in soil chemical properties between both tillage methods. Therefore, farmers should be encouraged to use zero-tillage with in-situ mulch in Sudan Savanna as this practice may reduce yield loss during protracted dry spells.

2.2.2.2 Effect of interaction of preceding crop treatments and soil tillage methods on cowpea performance

This experiment compared six preceding crop treatments under four soil tillage methods (i.e., zero-tillage, traditional hand hoeing, oxen plowing and tractor plowing). The six preceding crop treatments used were : (1) maize crop residues removed from the field slightly after harvesting (M) (this practice is commonly done in semi-arid zone) ; (2) Crotalaria pure crop cut slightly after its flowering to leave 10 cm height stubbles (CF) ; (3) Crotalaria pure crop cut slightly before cowpea seeding (in the crop season following its seeding) to leave 10 cm stubbles (CP) ; (4) maize intercropped with Crotalaria, the latter was planted one month after maize and cut slightly after its flowering (M + CF) ; (5) the same as (4) but Crotalaria was cut slightly before cowpea seeding (M + CP) ; and (6) maize crop residues left in the field (MM). It should be noted that the preceding crop treatments were established during the 1983 crop season. Maize pure and intercrop treatment received NPK at planting and N one month after planting. Maize crop residues in treatments M, M + CF and M + CP were removed from the field slightly after harvesting ; whereas crop residues in other treatments were left in the field up to the time of soil preparation in June 1984 before cowpea planting. So, crop residues for all treatments constituted in-situ mulch for the zero-tillage treatment. The experimental design used was split plot with tillage methods as main-treatments and preceding crop as sub-treatments. The experiment was replicated six times. All plots received 60 kg/ha of P_2O_5 as single super phosphate fertilizer. All agronomic practices used were as described in the two soil tillage method experiments discussed above.

The soil texture in 0-10 cm was sandy loam (sand : 62.1 %, silt : 31.3 % ; and clay : 6.6 %) ; the clay content did no show an increase with soil depth up to the 30 cm depth layer as it was the case for the site where the preceding two soil preparation experiments were conducted. Soil chemical properties are shown on Tables 26 and 27. Plots hand hoed tended to have more organic matter and higher pH, total N and available P than no-tilled plots and plots plowed by oxen or tractor (Table 26). Zero-tillage tended to have higher organic matter, pH and total N but lower available P than tractor plowing.

Table 26. Soil chemical properties as afffected by soil tillage methods, Loumbila, Burkina Faso, 1984.

Tillage methods	% Organic matter		pH		Total N		Available P	
	0-10cm	11-25cm	0-10cm	11-25cm	0-10cm	11-25cm	0-10cm	11-25cm
	%		pH		%		ppm	
Zero-tillage	0.76	0.62	6.3	6.2	0.032	0.022	6.56	1.39
Hand hoeing	0.86	0.67	6.5	6.4	0.030	0.028	6.75	1.93
Oxen plowing	0.77	0.62	5.8	5.8	0.028	0.024	6.37	1.96
Tractor plowing	0.72	0.56	6.0	6.0	0.024	0.027	6.61	1.84

The observed effect of tractor plowing on the afore mentioned soil chemical properties could be ascribed to the tendency of this practice to thoroughly mix crop residues with soil and, hence, favoring their rapid decomposition. This contrasts, respectively, with the tendency of hand-hoeing to poorly mix crop residues with soil and that of zero-tillage to accumulate crop residues on soil surface. Also, since soil sampling was done slightly after cowpea flowering, one would expect some nutrient uptake by plants and movements within the soil profile to have taken place, particularly if crop residue decomposition was rapid.

Pure crop Crotalaria cut at flowering tended to increase soil organic matter, pH and total N than any other preceding crop treatments; but its' P was lower than that of most treatments except pure crop Crotalaria cut at cowpea planting (Table 27). Plots for which Crotalaria was intercropped with maize had similar total N with plots for which maize crop residues were removed, but higher organic matter and available P, and lower pH than the latter.

Inspite of the afore mentioned differences in soil chemical properties due to soil tillage methods as well as preceding crop treatments, cowpea performance appeared to not be influenced by these differences. Cowpea floral bud initiation, flowering and maturity dates and seed yield were not significantly affected by soil tillage methods, but by preceding crop treatments (Table 28). Maize crop residues not removed from the field induced early floral bud initiation, flowering and maturity as compared to maize crop residues removed from the field. The other treatments were intermediate between the former and the latter. Cowpea seed yield appeared to be positively associated with the amount of crop residues left in the field. Plots for which all crop residues were not removed and either left as in-situ mulch or plowed-under before cowpea planting significantly out-yielded all the others ; whereas plots for which all crop residues were removed yielded the lowest. And plots for which crop residues were partially removed (intercropped maize crop residues removed) were intermediate between the two afore mentioned groups.

Since differences in soil chemical properties were not reflected in cowpea performance, one would think of soil physical properties to have played a major role in cowpea growth and development, as it was the case for the preceding two soil preparation methods experiments. It should be noted that soil organic matter account only for crop residues that have undergone decomposition. But all remaining debris, though not part of the soil, can influence markedly soil physical properties. Indeed, because of their high water absorption capacity, they may greatly influence soil water holding capacity and

Table 27 Soil chemical properties as affected by preceding crop treatments in a soil tillage method experiment, Loumbila, Burkina Faso, 1984.

Preceding crop Treatments	% Organic matter		pH		Total N		Available P	
	0-10cm	11-25cm	0-10cm	11-25cm	0-10cm	11-25cm	0-10cm	11-25cm
	--------%-------		------pH-------		-------%-------		------pH-------	
- Maize crop residues removed after hervesting	0.71	0.59	6.2	6.4	0.028	0.025	6.32	1.85
- Crotalaria cut at flowering (pure crop)	0.84	0.67	6.4	6.3	0.030	0.027	6.12	1.74
- Crotalaria cut at cowpea planting (pure crop)	0.76	0.60	6.3	6.0	0.030	0.024	4.28	1.31
- Crotalaria cut at flowering (intercrop with maize)	0.81	0.64	6.0	5.9	0.027	0.024	6.68	1.72
- Crotalaria cut at planting (intercrop with maize)	0.78	0.61	5.9	6.0	0.028	0.027	6.98	2.09
- Maize crop residues not removed	0.76	0.59	6.1	5.9	0.028	0.023	9.06	1.51

soil temperature (a soil with high water content requires large amont of energy to increase its temperature). Also, all debris on soils surface, by intercepting solar radiation, cut down energy load required for soil water evaporation, and, consequently, help conserving soil water. Also it should be noted that the soil at the site of the present experiment had twice less clay in 11-30 cm layer than the soil in the two soil preparation experiments discussed above. Therefore, with the soil scarification done regularly to break down crusting, soil water infiltration in deep soil layer in this experiment was less impeded than in the preceding two experiments. So, the combination of a relatively great soil water reservoir and low temperature, during dry spells may explain the early floral bud initiation and flowering and the high seed yield in plots for which crop residues were not removed Table 28.

From the results of the three soil preparation method experiments it can be concluded that : (1) dependent on soil physical properties (particularly soil water infiltration rates) and climatic conditions, zero-tillage with in-situ mulch can be as good as or even much better than conventional tillage methods ; (2) leaving all crop residues in the field for either incorporation in the soil through tillage or being used as in-situ mulch is crucial in maintaining soil productivity, probably through their beneficial effect on soil physical properties (reduced soil water evaporation and soil temperature, increased soil water holding capacity, etc.) ; and (3) farmers in semi-arid zones of Africa are accelerating soil degredation by removing crop residues from the fields.

2.3. Striga resistance

Experiments conducted in 1982 and 1983 with daylength-sensitive cultivars at different dates of planting under Striga infestation have shown significant cultivars x dates of planting interaction effect. Some daylength-sensitive cultivars suffered severe Striga damages when Striga emerged on their plots longtime before their critical photoperiod, but gave acceptable yield when Striga emerged on their plots by the time they were flowering. This was possible only when they were planted closely to their critical photoperiod. Since daylength-insensitive cowpeas do not have a critical photoperiod, and considering also that past observations have shown the earliest Striga emergence to occur thirty days after planting, one would expect early daylength-insensitive cowpeas to suffer less Striga damages as compared to the late ones. To verify this hypothesis, we tested three daylength-insensitive cowpeas of different maturity groups (viz. TVx 3236, TN 88-63 and IT 82E-32) against two daylength-

Table 28. Effect of preceding crop treatments on cowpea performance in a soil tillage methods experiment, Loumbila, Burkina Faso, 1984.

Preceding crop treatments	Floral bud initiation 1/	Flowering date 1/ (DAP)	Maturity date 1/ (DAP)	Seed Yield 1/ (kg/ha)
-Maize crop residues removed after harvesting	39.3 a	48.1 a	71.2 a	436 c
-Crotalaria cut at flowering (pure crop)	37.9 b	46.2 bc	69.5 bc	887 a
-Crotalaria cut at cowpea planting (pure crop)	38.1 b	46.8 abc	69.2 bc	918 a
-Crotalaria cut at flowering (intercrop with maize)	38.2 b	47.4 ab	69.9 b	673 b
-Crotalaria cut at cowpea planting (intercrop with maize)	37.8 b	47.2 abc	70.2 ab	704 b
-Maize crop residues not removed	37.7 b	45.7 c	68.5 c	921 a
LSD (5%)	1.0	1.6	1.0	175
CV (%)	5	6	2.5	40

1/ Means followed by the same letter are not statistically different at 5 % probability level.

insensitive (viz. "Suvita-2", a Striga resistant, and KN-1, which has a low level of tolerance to Striga) and one daylength-sensitive (viz. "Ouahigouya local", a Striga susceptible when planted longtime before its critical photoperiod, and Striga escaping when planted closer to its critical photoperiod) cultivars of known Striga resistance characteristics at three dates of planting. The three dates used were : 8 July, 25 July and 2 August 1984. The experimental design used was split plot with dates of planting as main treatments and cultivars as sub-treatments. The experiment was replicated four times. All agronomic practices used were as described in plant population experiment conducted in Northern Guinea Savanna above discussed.

Date of planting had no effect on cowpea seed yield, Striga density and cowpea flowers per m^2 (Table 29). But early planting significantly delayed flowering, Striga emergence, plant senescence and maturity dates as compared to the two late planting dates. The last two dates of planting did not differ significantly from each other for the afore mentioned attributes, except for Striga emergence and maturity dates. Striga emerged much earlier for the 25 July planting as compared to the 2 August planting, which did not differ significantly from 8 July planting. Cowpea planted on 2 August matured much earlier than those planted on 25 July. The delayed flowering, Striga emergence, senescence and maturity dates observed in early planting could be attributed to severe drought in July. Indeed from 8 July planting to end of July, the crop received only 27.1 mm rainfalls, which were poorly distributed with 12 mm received on 25 July. Seedling growth was impeded by the drought stress. It should be noted that flowering and Striga emergence for all dates of planting occured between 4 and 26 September, following a period of good and well distributed rainfalls from late August to mid-September. Also, the early Striga, emergence observed for the 25 July planting could be attributed to this date of planting having benefited from good and well partitioned rainfalls than early and late plantings. Thus, as observed in 1982, Striga emergence is not only dependent on cowpea cultivar, but also on soil moisture conditions. So, the dryer the soil the greater the delay in Striga emergence and vice-versa.

"Ouahigouya local" yielded significantly lower than any other cultivar except IT 82E-32 (Table 30). Since it flowered and matured the latest, considering that it was the only cultivar susceptible to bacterial pustule and its plants initiated senescence process longtime before its flowering and immediately after Striga emerged from its plots, considering also that Striga emerged from its plots earlier than for other cultivars and it produced the lowest flowers per m^2 ; its low yield could be attributed to Striga as well as to drought and bacterial pustule damage (Table 30). Thus, its' Striga damage

Table 29. Effect of dates of planting on seed yield; days to flowering, first *Striga* emergence, senescence and maturity; *Striga* density; and total number of flowers per m^2 of cowpeas under *Striga* infestation; Kamboinse, Burkina Faso, 1984.

Date of planting	Seed Yield 1/ (kg/ha)	Flowering dates 1/ (DAP)	*Striga* emergence dates 1/ (DAP)	Senescence dates 1/ (DAP)	Maturity dates 1/ (DAP)	*Striga* density 1/ (plants/m^2)	Flowers per m^2 1/
8 July	266 a	64 a	61 a	72 a	84 a	1.4 a	186 a
25 July	228 a	49 b	41 b	53 b	66 b	2.2 a	144 a
2 August	231 a	44 b	55 a	49 b	61 c	0.5 a	161 a
LSD (5%)	NS	6	10	4	3	NS	NS
CV (%)	28	6	11	4	3	56	25

1/ Means followed by the same letter are not statistically different at 5% probability level.

Table 30. Seed yield; days to flowering, first Striga emergence, senescence and maturity; Striga density; and total number of flowers per meter square of cowpeas under Striga infestation; Kamboinse, Burkina Faso, 1984.

	Seed Yield 1/ (kg/ha)	Flowering dates 1/ (DAP)	Striga emergence dates 1/ (DAP)	Senescence dates 1/ (DAP)	Maturity dates 1/ (DAP)	Striga density 1/ (plants/m²)	Flowers per m² 1/
Suvita-2	304 ab	51 b	75 a	59 ab	72 b	0.04 b	184 bc
TVx3236	237 bc	51 b	52 b	56 b	71 bc	1.8 a	151 bc
TN88-63	381 a	48 b	50 bc	62 ab	69 bcd	1.4 a	268 a
Ouahigouya local	92 d	62 a	44 c	49 c	78 a	1.9 a	35 d
IT82E-32	161 cd	49 b	48 bc	56 b	66 d	1.6 a	138 c
KN-1	276 b	52 b	46 bc	65 a	68 cd	1.5 a	207 ab
LSD (5%)	91	4	7	6	3	0.7	65
CV (%)	38	9	17	13	5	56	25

1/ Means followed by the same letter are not statistically different at 5% probability level.

escaping behavior exhibited in 1982 and 1983 could not be expressed this crop season. IT 82E-32 did not differ with TVx 3236, TN 88-63 and KN-1 in most of studied attributes other than seed yield and flowers per m^2, except for senescence dates with KN-1 and for maturity dates with TVx 3236. Its low yield could be attributed to Striga damages. This is even well supported by the fact that, unlike "Ouahigouya local" this cultivar was not susceptible to bacterial pustule and flowered at all dates of planting between the 6 and 13 September under no drought stress. Thus, IT 82E-32 suffered severe Striga damages despite the fact that it flowered about the same time Striga plants were emerging from its plots. It was, thus susceptible to Striga damagds. Its behavior contrasted with that of KN-1, which flowered six days after Striga emerged from its plots, but still yielded similarfy with "Suvita-2", a Striga resistant cultivar. Thus KN-1 exhibited again its tendency, already expressed in 1982, to tolerate Striga infestation. "Suvita-2" confirmed its resistance to Striga observed in 1981, 1982 and 1983. It not only delayed Striga emefgence up to its maturity but also restricted significantly its density. TN 88-63, inspite of being similar to IT 82E-32 in most of studied attributes, except seed yield, maturity and flowers per m^2, yielded significantly higher than any other cultivar, except Suvita-2. It also produced the largest number of flowers and was among the latest cultivars to initiate senescence. It was, thus tolerant to Striga infestation. TVx 3236 was intermediate between IT 82E-32 and KN-1.

From the experimental results it can be concluded that : earlyness and flowering at same time with Striga emergence were not sufficient to reduce Striga damages ; the cultivar should have some level of tolerance to Striga infestation.

3. SAHEL SAVANNA

(300-600 mm rainfall from late-June to mid-September)

At Pobe/Djibo dry spells occured during the crop season. A total of 274 mm rainfall (68.5 % of long term average), poorly distributed, particularly in June, August and September (viz. 34.5, 48.5 and 57.5 mm, respectively) was received. All experiments conducted at this site had to be discarded except the date of planting experiment.

3.1 Date of planting

Six daylength-insensitive cowpea cultivars were tested at three dates of planting (viz. 29 June, 8 July and 20 July) with the same overall objectives as for the dates of planting experiments conducted in Northern Guinea Savanna. The experimental design and all agronomic practices used are as described in the dates of planting experiments conducted in Northern Guinea Savanna discussed above.

Cowpea seed yield was significantly affected by cultivars and cultivars x dates of planting interaction only. "Suvita-2" was the only cultivar for which seed yield increased significantly from 213 and 2140kg/ha for the 29 June and 8 July dates of planting, respectively, to 371 kg/ha for the 20 July planting (Table 31). At the latter date, its yield was significantly greater than that of IT 82E-18, IT 82D-716 and 58-57. IT 82E-18 consistently maintained a lower yield than any other cultivar at all dates of planting.

Since all the cultivars flowered (Table 31) under severe drought stress (insufficient rainfalls) and high air temperature, considering that IT 82E-18 was not markedly different to most of cultivars in number of flowers produced per m^2, except "Suvita-2" that tended to produce lower number of flowers (Table 32), the lower yielding ability exhibited by IT 82E-18 could be ascribed to its inability to set pods under drought stress and high heat conditions. So, as observed in 1983, the results underline the importance of using drought and heat tolerant cultivars to obtain acceptable yield during dry years in the Sahel.

4. REGIONAL TRIALS

4.1 Regional cowpea management trials

Only Mali requested regional cowpea management trial. The objectives of this experiment were to study the effect of dates of planting, cowpea cultivars and seed-bed preparation methods on cowpea performance in Sudan Savanna in other countries than Burkina Faso. The dates of planting intended to be used were : D1 = begining of rainy season, D2 = intermediate between D1 and D3, and D3 = six weeks before the anticipated end of rainy season. The actual dates used were : D1 = 13 July, D2 = 26 July, and D3 = 10 August ; the 13 July planting coincided more with mid-season than early season planting. This is because 21.3 mm and 24.6 mm rainfalls were received, respectively, on 26 June and 3 July. They could

Table 31. Cowpea seed yield and dates of flowering as affected by cultivars and dates of planting, Pobe/Djibo, Burkina Faso, 1984.

Cultivars	Seed Yield Dates of planting 29 June	 8 July	 20 July	Dates of Flowering Dates of planting 29 June	 8 July	 20 July
	---------kh/ha---------			------------dates------------		
IT82E-18	150	73	181	14 Aug.	21 Aug.	5 Sep.
IT82D-716	212	294	232	14 Aug.	19 Aug.	5 Sep.
TVx3236	188	247	276	16 Aug.	25 Aug.	5 Sep.
SUVITA-2	213	214	371	18 Aug.	27 Aug.	5 Sep.
TN 88-63	242	303	304	17 Aug.	24 Aug.	5 Sep.
58-57	239	284	271	18 Aug.	24 Aug.	5 Sep.

Mean Comparison	Seed Yield LSD(5%)	 CV(%)	Dates of flowering LSD(5%)	 (CV %)
means same dates	77 kg/ha	23	2 days	1
means diff. dates	96 kg/ha		3 days	

Table 32. Number of flowers per m² as affected by cowpea cultivars and dates of planting, Pobe/Djibo, Burkina Faso, 1984.

Cultivars	Dates of planting		
	29 June	8 July	20 July
	flowers/m²		
IT82E-18	195	164	108
IT82D-716	270	151	229
TVx3236	132	86	120
SUVITA-2	85	132	82
TN 88-63	106	361	210
58-57	123	218	131

Mean comparison	LSD (5%)	CV (%)
means same dates	76	33
means diff. dates	78	

have served as early planting. Cowpea cultivars used were : TVx 3236, KN-1, "Suvita-2" and the best local check. The seed bed preparation methods used were : planting on flat-beds after plowing and planting on tied ridged beds. The experimental design used was split-plot with dates of planting as main-treatments and the factorial combination of 4 cultivars and 2 seed-bed preparation methods as sub-treatments. The experiment was established on sandy loam (clay content less than 10 %, and silt : between 12 and 24 %) alfisol with 1 % slope. Cowpea plants received 11 kg/ha of P_2O_5 at planting from single super phosphate, and were sprayed once with insecticides.

Cowpea cultivars did not differ in flowering and maturity dates. Cowpea seed yield was significantly affected by date of planting, cultivars and their interaction only. Delaying planting significantly reduced seed yield (Table 33). However, the observed drastic yield reduction could be due more to improper insect protection than climatic conditions only. This is substantiated by the fact thet only one insecticide spraying was done on 23 August. The local check yielded similarly to TVx 3236 but significantly higher than the two other cultivars at all dates of planting except 26 July and 10 August. At 26 July planting, it yielded similarly to KN-1, whereas it did not significantly differ from other cultivars at 10 August planting. Fodder yield of the local check was significantly lower than that of other cultivars (local check 912 kg/ha vs 1342 kg/ha, for TVx 3236 ; 1535 kg/ha, for KN-1 ; and 1431 kg/ha, for "Suvita-2" ; LSD (5 %) = CV (%) = 43). The latter did not differ significantly from one another. Tied ridges significantly increased cowpea fodder yield as compared to planting on flat (1679 kg/ha, for tied ridges vs. 930 kg/ha for flat ; LSD (5 %) = 339 kg/ha; CV (%) = 43).

From experimental results it appears that vegetative growth took advantage of tied ridges than the generative growth. But since flowering occured in late-August, mid to late-September, and October, respectively, for the first, second and third dates of planting (periods that coincided with dry spells) ; considering also that cowpea were sprayed only once, on 23 August ; it is possible that the generative growth might have been hampered by improper insect protection. Thus, with generative growth hampered, the vegetative growth might have taken advantage of increased moisture in tied ridge beds to continue. This is well illustrated by the local check that produced the highest seed yield but the lowest fodder yield. This experiment is to be repeated for better conclusions.

Table 33. Effect of cultivar * dates of planting interaction on cowpea yield, Cinzana, Mali, 1984.

Cultivars	Dates of planting			Mean
	13 July	26 July	10 August	
	kg/ha			
TVx 3236	596	192	37	275
KN-1	282	121	14	139
SUVITA-2	421	91	17	176
Local Check	603	254	75	311
Mean	475	164	36	225
Mean comparison	LSD (5%)		CV (5%)	
Dates	56 kg/ha		41	
Cultivars	78 kg/ha		60	
Cultivars same date	135 kg/ha			
Cultivars diff. dates	367 kg/ha			

5. VERIFICATIVE RESEARCH

5.1 Maize-cowpea relay cropping system

Two plots, one 20 m x 40 m fertilized and the other 20 m x 20 m unfertilized, were established at three villages around the Farako-Bâ station, in Northern Guinea Savanna. The fertilized plots received N, P_2O_5 and K_2O (35, 62.5 and 35 kg/ha, respectively) at planting and N (67.5 kg/ha) one month after planting. The maize cultivar, SAFITA-2, was planted in early June, and the cowpea cultivar, "Kaya local" or "Ouahigouya local", planted one month after maize. The agronomic practices used were as described in maize-cowpea relay cropping experiments discussed above.

Seed yields of maize and cowpea are shown on Table 34. Use of fertilizers increased maize yield more than cowpea yield. It should be noted that the plot at the Lesso village was gravely lateritic with high P fixing capacity. Maize is not traditionally grown on this type of soil (this is the sorghum or millet crop land). This explains the low seed yield obtained for maize at that village. So, with the exception of the village Lesso, yields of fertilized maize approaching those of the experiment station were obtained. Farmers in Northern Guinea Savanna should, therefore, be encouraged to use maize-cowpea relay cropping system.

5.2 Effect of improved cowpea cultivar, P_2O_5 levels and seed bed preparation methods on cowpea performance under farmers' conditions in Sudan Savanna

Cultivars : TVx 3236 (improved daylength-insensitive to be released) and "Kamboinse local rouge" (unimproved daylength-sensitive actually used by farmers) were tested at : (i) two P_2O_5 levels (0 and 50 kg/ha of P_2O_5 from single super phosphate 18 %) and (ii) five seed bed preparation methods (viz. (1) tillage + planting on tied ridges, (2) tillage + planting on flat converted to tied ridges three weeks after planting, (3) tillage + planting on flat, (4) no-tillage + planting on flat converted to tied ridges three weeks after planting and (5) no-tillage + planting on flat) at three villages under farmers' conditions. The objective of this experiment, initiated in 1983, was to verify the applicability of the technologies developed in experiment station (cultivar, P_2O_5 level and tied ridge techniques) under farmers' conditions. The experimental design used was a split-plot, with P_2O_5 levels as main-treatments, seed bed preparation methods and soil tillage as sub-treatments, and cultivars as sub-subtreatment. The experiment was replicated two times at each site. 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 are shown on Table 35.

Though rainfall data were not recorded at the three sites, it rained more, with good distribution, at both the Pabre sites than at the Oipassi site. As observed in 1983, the cultivar TVx 3236 significantly out-yielded "Kamboinse local" at all the sites (seed yield of 631 kg/ha for TVx 3236 vs 461 kg/ha for Kamboinse local ; LSD (5 %) = 63 kg/ha and CV (%) = 31) and the application of 50 kg of P_2O_5/ha significantly increased seed yield of cowpea as compared to the 0 kg of P_2O_5/ha treatment (767 kg/ha for 50 kg of P_2O_5 vs 325 kg/ha for 0 kg P_2O_5/ha ; LSD (5 %) = 202 kg/ha and CV (%) = 36). It appeared, thus, that the use of improved cowpea cultivar and 50 kg of P_2O_5/ha were crucial in increasing cowpea seed yield.

Cowpea seed yield was also significantly affected by villages (Table 36). Whereas seed bed preparation methods and the interaction seed bed preparations method x village were significant only at 10 % probability level. The two Pabre villages, which received relatively more and well distributed rainfall than Oipassi, induced seed yield significantly greater than the latter. They did not significantly differ from each other. At Oipassi, planting on tied ridges significantly increased seed yield as compared to planting on flat without tilling the land. The other treatments were intermediate between the afore mentioned two groups. At Pabre 2, seed bed preparation methods did not affect seed yield even at 10 % probability level. Whereas at Pabre 1, all tied ridge techniques out-yielded significantly planting on flat whether the land was tilled or not. There was no significant difference among tied ridge techniques as well as among planting on flat techniques at this village (Table 36). Thus, as observed in 1983, the response to tillage and tied ridges appeared to be related to clay content. The villages Oipassi and Pabre I, had a clay content greater than 10 %, they respectively responded to tillage and tied ridges techniques as compared to Pabre 2 (Table 35).

From the experimental results and those of 1983, it can be concluded that the superiority of technologies developed at the experiment station is also applicable under farmers' fields. Therefore, the cultivar TVx 3236, the application of 50 kg/ha of P_2O_5 and use of tied ridge techniques should be recommended for use by farmers. However, as far as tied ridge techniques are concerned planting on tied ridges should be recommended on highly compacted soil with clay content greater than 10 %. Whereas planting on flat converted to tied ridges three weeks after planting can be done in less compacted soil with less than 10 % clay content without a detrimental effect on seed yield. Land tillage is highly recommended in addition to tied ridges techniques on highly compacted soil.

Table 34. On-Farm seed yield of maize and cowpea in a relay-cropping system in Northern Guinea Savanna, Farako-Bâ, Burkina Faso,1984.

FARM	FERTILIZED PLOTS		UNFERTILIZED PLOTS	
	Maize	Cowpea	Maize	Cowpea
	kg/ha			
Kouadeni	3685	525	2875	650
Lesso	1822	704	338	569
Baya	2034	327	1049	329

Table 35. Soil characteristics (0-30 cm surface layer) at the sites the experiment was conducted. 1984.

Soil Characteristics	Oipassi	Pabre 1	Pabre 2
Clay (2µ) %	14.8	12.0	9.5
Silt (20-50µ)%	23.3	16.9	29.1
Sand (40-2000µ)%	61.9	71.1	61.4
Organic matter %	0.82	0.74	0.53
pH (H_2O, 1:2½ susp)	5.2	6.0	6.0
Available P(Bray P_1) ppm	3.78	1.21	0.98
CEC me/100 g	2.5	3.0	3.0
Exch. base saturation %	60.8	47.0	41.7

Table 36. Effect of seed-bed preparation methods and site on cowpea seed yield on farmers' field, Kamboinse, Burkina Faso, 1984.

Seed-bed preparation	Villages			Mean
	Oipassi	Pabre 1	Pabre 2	
-Tillage planting on tied ridges	358	875	568	600
-Tillage, planting on flat converted to tied ridges 3 weeks after planting.	202	919	727	616
-Tillage, planting on at flat	214	514	585	438
-Zero-tillage, planting on flat converted to tied ridges 3 weeks after planting.	121	1003	749	627
-Zero-tillage, planting on flat	50	553	741	448
- Mean	191	773	674	546

Mean comparison	LSD(5%)	CV(%)
Villages	407	23
Seed bed preparation 1/	169	36
Seed bed pre. x tillage at same village 1/	239	

1/ LSD was calculated at 10 % probabitlity level.

COWPEA ENTOMOLOGY

J. B. Suh

I. INTRODUCTION

The objective of the Entomology component of IITA/SAFGRAD is to compliment Agronomists and Breeders in a team effort to develop and test improved production technologies for increased and stable cowpea and maize yields in the semi-arid regions of Africa. The most realistic approach is through an integrated management system based on a vigorous resistance breeding programme for the major pest problems (Aphids, Bruchids, Maruca, Thrips and Hemipterous Pod Sucking Bugs on cowpea ; and, Termites, Cicadulina, Armyworms and Lepidopterous Borers on maize) which is agronomically acceptable, economically sound and environmentally safe.

Our activities were carried out in the three ecological zones of Burkina Faso : the Northern Guinea Savanna in the South, the Sudan Savanna in the Centre and the Sahel Savanna in the North. These included : Resistance studies on major cowpea and maize insect pests (Aphids, Bruchids, Maruca and Termites) ; Studies of plant-pest interactions in Mixed Cropping Systems (Inter-cropping, Strip Cropping etc) ; Minimum Insecticide Protection of Cowpea ; and Standardized Sampling Studies.

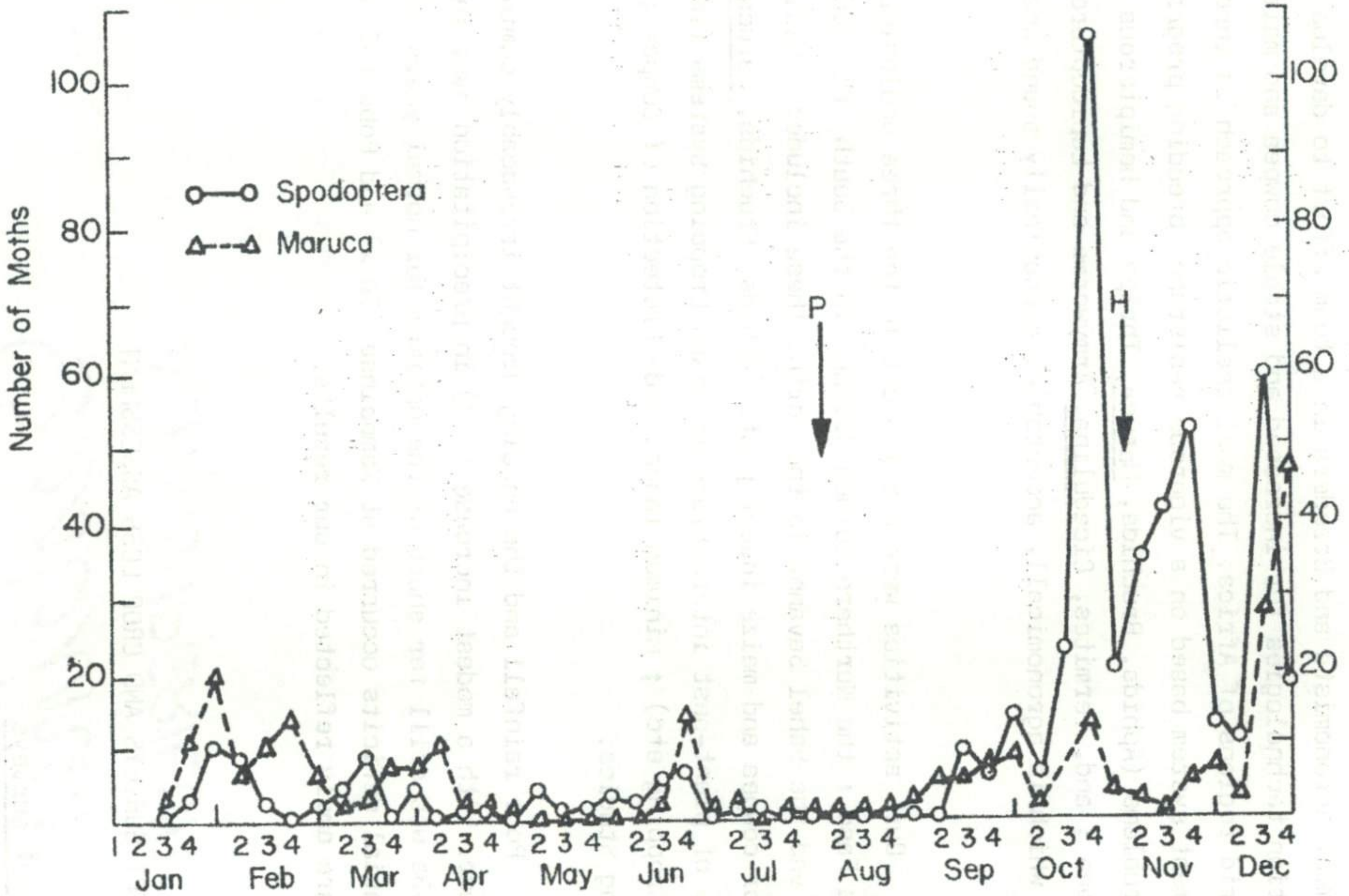
Poor rainfall and the ensuing drought irrevocably dominated our work this year. With a modest increase (9 %) in precipitation over last year, Farako-Bâ was still far short of the optimum for normal years (815 mm vs 1100 mm). Substantial deficits occurred at Kamboinse (38 %) and Pobe (35 %), the impact of which are amply reflected in our results.

2. INSECT SURVEYS AND CROP LOSS ASSESSMENT

2.1 Insect surveys

In addition to the four major field insect pests of cowpea there are several secondary species which if not properly managed could be elevated to primary pest status. A fluorescent light trap was operated throughout the year at

Fig. 1: Numbers of Spodoptera And Maruca Moths From A Fluorescent Light Trap At Kamboinse, Burkina Faso. 1984



Kamboinse Station to monitor adult activity of Lepidopterous species associated with cowpea. Light traps are a useful pest management tool : they can be used to improve timing of insecticide application and also in predicting potential pest outbreaks. The trap was serviced daily and weekly collections (Spodoptera and Maruca only) are summarised in Figure 1. Two species of Spodoptera were active : S. littoralis which was dominant, and an unidentified species, presumably S. exempta. S. littoralis has been reported to aause severe damage to late maturing cowpea in the area. But for a marked break in August (due to late rains) Spodoptera was active year round. However, such activity was mild between January and June, and sustained by alternate host plants and an irrigated cowpea crop. Flight intensified from September through December, following cultivation of the main cowpea crop. Three generations were completed during this period as last year but the late rains and a considerable irrigated crop at the Station extended activity beyond normal harvest time. There were mild flights of Amsacta sp (Arctiidae) between June and December. Amsacta is an important cowpea seedling pest in Senegal and other Sahelian countries. The Pod Borer, Maruca testulalis was also active throughout the year. Flight was quite intense in March and April, presumably because of the irrigated cowpea seed crop. The spurt in activity in June is probably due to availability of weed hosts following preliminary showers. Flight picked up again between September and December, coinciding with the cowpea season. The rise in activity in December is associated with irrigated seed multiplication plots at the Station.

2.2 Yield loss assessment : Pod Borer M. Testulalis

Two plots each 625 m2 were established at Kamboinse and Farako-Bâ and planted with KN-1 (Vita 7) to monitor fluctuations in Maruca larval population; and assess potential effect on yield. Both plots were treated with Monocrotophos (400 g a.i./ha) at raceme initiation to suppress flower thrips. Subsequently one plot received applications of Decamethrin (15 g a.i./ha) at intervals of 10-14 days from flowering for Maruca control, while another was treated with Monocrotophos at the same interval, to suppress flower thrips and Pod Sucking bugs. Flower samples (100 flowers/plot) were taken every 4th day for counts of Maruca larvae, and yield information was taken at crop maturity. Results from the Kamboinse trial are given in Table 1. Insecticide treatment did not reduce Maruca population levels significantly. This is most probably due to a low uneven distribution in Maruca larval population resulting from low flower production (poor rainfall, poor crop development). The high relative variations of our samples amply illustrate this situation (high imprecision ascribed to low, poorly distributed larval population). Grain yield was predictably low, but insecticide

Table 1. Yield and Maruca populations densities in cowpea at Kamboinse, Burkina Faso, 1984.

Sampling date	Maruca larvae per 10 flowers	
	Protected	Unprotected
September 16	3.20	3.60
" 19	3.10	1.40
" 22	2.00	2.40
" 25	1.90	3.50
" 28	0.50	0.00
Means (± S.E.)	2.14 ± 1.096	2.18 ± 1.513
C.V. (%)	51.25	69.44
Grain yield (kg/ha)	494.12	157.10
Yield loss (%)	65.33	

protection produced a significant yield increase equal to a 65 % loss in the unprotected crop. This study will be repeated at both locations next season.

3. PLANT RESISTANCE TO APHIDS

Aphids are a serious problem on cowpea in the dry Sahelian conditions. Incidence is often early (10-20 DAE), builds up quickly and overwhelms drought stressed crops. Insecticide protection is relatively expensive and hazardous, and in the long term may build up resistance in the pest population. Resistant varieties offer the best long term solution for coping with crop pest problems by farmers and are a strong foundation for building a viable integrated pest control system. This experiment is a compliment to on-going work by the Cowpea Breeder in developing resistance to the groundnut aphid, Aphis craccivora. Twenty three cultivars including a resistant (TVu 36) and susceptible (KN-1) check were evaluated in the screenhouse at Kamboinse. Six rows each with 10 to 12 cowpea plants were grown in wooden trays. Each tray contained one susceptible and a resistant check as well as four cultivars assigned randomly in a randomized block design replicated four times. Five days after emergence i.e. approximately 10 DAP (when first trifoliate leaf appears) 5 last instar aphid nymphs were transferred unto each seedling with the aid of camel hair brushes. The source of aphids was a screenhouse colony established earlier from collections taken at Loumbila. Plants were assessed 10 and 15 days after infestation and counts made of healthy seedlings per row of each tray. Results are given in Table 2. At 10 days after infestation, the cultivars A-99-1, D-13-3, D-44-1 and D-53-2 performed as well as TVu 36 the resistant check and had significantly more healthy plants than C-14-1, C-36-1, C-33-1, C-32-1, D-14-3, C-28-3 and the susceptible check, KN-1. Five days later (15 DAI) only D-13-3 and TVu 36 (closely followed by A-99-1, D-44-1, A-23-2 and A-27-4) had a full compliment of vigorous seedlings, in marked contrast with C-14-2, C-14-1, C-32-1, C-28-3 and KN-1 (susceptible check). It appears that at the seedling growth stage the cultivars D-13-3, A-99-1, D-44-1, A-23-2, A-27-4 and D-53-2 are highly resistant to aphids. A-27-6, D-49-3, D-19-1, D-27-4, A-34-1, A-5-1, D-39-1 and D-21-3 are resistant while C-14-2, C-14-1, C-36-1, C-33-1, C-32-1, D-14-3 and C-28-3 are moderately resistant. Seedlings from the resistant and highly resistant groups have been grown singly in pots to obtain seed for confirmatory tests.

Table 2. Performance of improved cowpea lines artificially infested with aphids (A. Craccivora) at he seedling growth stage in the Screenhouse at Kamboinse, Burkina Faso, 1984.

Nº	Cultivar	Per cent healthy plants	
		10 DAI	15 DAI
1	TVu-36	100.00 a (1)	100.00 a (1)
2	D-13-3	100.00 a	100.00 a
3	A-99-1	100.00 a	97.50 ab
4	D-44-1	100.00 a	97.50 ab
5	D-53-2	100.00 a	70.25 abcde
6	A-23-2	98.25 a	94.50 abc
7	A-27-4	94.25 ab	90.00 abcd
8	A-27-6	92.50 ab	82.50 abcd
9	D-49-3	92.50 ab	87.50 abcd
10	D-19-1	92.25 ab	77.00 abcde
11	D-27-4	90.00 ab	87.50 abcd
12	A-34-1	85.25 abc	77.00 abcde
13	A-5-1	85.00 abc	65.00 bcde
14	C-39-1	85.00 abcd	80.00 abcde
15	D-21-3	82.50 abcd	77.50 abcde
16	C-14-2	77.75 bcd	57.50 de
17	C-14-1	75.00 bcd	54.25 e
18	C-36-1	75.00 bcd	65.00 cde
19	C-33-1	72.50 bcd	70.00 abcde
20	C-32-1	70.00 bcd	57.50 de
21	D-14-3	65.00 cd	60.00 cde
22	C-28-3	61.50 d	48.00 e
23	KN-1	0.00 e	0.00 f
Means		82.36 $\pm$ 14.87	73.85 $\pm$ 19.87
L.S.D. (5 %)		21.03	28.10
C.V. (%)		18.06	26.91

(1) Significant at p = 0.05 (Duncan's Multiple Range Test of Arcsin Transformations).

Treatment means with the same letter are not significantly different.

4. CULTURAL CONTROL OF COWPEA PESTS

4.1. Effect of sorghum-cowpea intercropping on cowpea pest and grain yield

The experiment was initiated in 1981 with the objective of studying the effect of intercropping cowpea with sorghum on cowpea thrips population and grain yield. Results showed that intercropping provided no protection from thrips and yield data were conflicting. In 1981, cowpea yields under intercropping were higher than monocrop and were reversed in 1982. In these experiments, insects other than thrips wete controlled using appropriate insecticides. In 1983 the experiment was slightly modified to observe the effect of intercropping vs. monocrop without pest protection, and minimum protection : two insecticide applications Decamethrin (Decis R), 15 g a.i./ha at raceme initiation stage, and Endosulfan at the rate of 500 g a.i./ha at pod formation stage. Also, an additio additional factor of plant density was added. Monocrop had 66,666 cowpea plants/ha, while two intercrop densities (33,333 plants of cowpea and 26,666 plants of sorghum/ha (D1) and 50,000 plants of cowpea and 40,000 plants of sorghum/ha (D2) were used. In 1984, the experiment was repeated in its modified form. No insect pest population samples were taken because of poor crop development resulting from low rainfall. Thus only agronomic data are reported for Research Station (Kamboinse) Trial. Cowpea grain yield was significantly affected by insecticide applications, cropping systems and their interaction only. Insecticide applications significantly increased seed yield of both cowpea cultivars ; whereas intercropping and increased intercropping densities significantly reduced cowpea grain yield (Table 3).

The cultivar TVx 3236 (moderatly resistant to thrips) did not yield significantly higher than KN-1 (susceptible to thrips) under no protection in intercropping with sorghum as observed in 1983. Since the crop experienced a severe drought stress when cowpeas were flowering, it is possible that under such stress conditions, low level of thrips resistance is not sufficient to protect cowpeas against severe yield loss.

This trial was repeated on a farmer's field in Kamboinse village, and pest incidence recorded despite poor crop performance. Results are given in Tables 4, 5.

Rainfall was late, sporadic and insufficient and adversely affected plant development and yield. Insecticide application had no significant effect on the low pest populations (Table 4). Thrips density on racemes, Maruca larvae in flowers and Pod Sucking Bugs per meter of row were not substantially

Table 3. Effect of sprayings and intercropping systems on seed yield of cowpea, Kamboinse, Burkina Faso, 1984.

Cropping system		SRAYING REGIME	
Sorhgum (plants/ha)	Cowpea (plants/ha)	Nº SPRAYING	TWO SPRAYINGS
		--------------kg/ha--------------	
0	66,666	53	414
26 666	33,333	23	229
40 000	50,000	13	93

LSD (5%) = 65 kg/ha ; CV (%) = 47

Table 4. Effect of pest control, cowpea variety and cropping system on pest incidence at Kamboinse, Burkina Faso, 1984.

Treatment	Thrips per 10 racemes(1)	Thrips per 10 flowers(2)	Maruca per 25 flowers(3)	PSB 25 per 2 m row(4)
A. PEST CONTROL				
Protected	12.04	137.50	0.39	1.50
Unprotected	15.04	166.65	0.58	1.50
L.S.D (5%)	N.S	N.S	N.S	N.S
B. CULTIVAR				
TVx3236	14.75	124.70	0.48	1.30
KN-1	12.33	179.30	0.58	1.70
L.S.D.(5%)	N.S	2.789	N.S	N.S
C.V. (%)	–	19.90		
C. CROPPING SYSTEM				
Monocrop cowpea	13.81	140.90	0.61	1.76
Sorghum + Cowpea (D1)	12.56	172.70	0.36	1.08
Sorghum + Cowpea (D2)	14.25	142.30	0.58	1.74
L.S.D .(5%)	N.S	1.325	N.S	N.S
C.V. (%)		5.00		

(1) Mean of 6 observations

(2) " " 5 "

(3) " " 5 "

(4) " " 6 "

Table 5. Effect of interactions of Cropping Systems Cowpea Variety and Pest Control on Flower production and Grain Yield at Kamboinse, Burkina Faso, 1984.

System	Pest Control	TVx3236	KN-1
I. FLOWER PRODUCTION (1)			
Monocrop	Protected	2.80	1.98
	Unprotected	0.65	1.92
Sorghum + Cowpea (D1)	Protected	0.90	3.77
	Unprotected	0.50	1.33
Sorghum + Cowpea (D2)	Protected	1.13	0.95
	Unprotected	1.02	0.25
II. GRAIN YIELD (KG/HA)			
Monocrop	Protected	330	111
	Unprotected	91	93
Sorghum + Cowpea (D1)	Protected	185	206
	Unprotected	100	143
Sorghum + Cowpea (D2)	Protected	203	157
	Unprotected	127	46

1) Means of 5 observations (number of flowers per m of row).

different between TVx 3236 and KN-1. However, thrips population in TVx 3236 flowers was markedly lower than in KN-1. Pest population levels were comparable among cropping systems (mono, intercrop) but Thrips density in flowers was considerably higher in the D1 intercrop, unlike previous years probably because of the low pest density levels rather than due to a cropping system effect. Last year Pod Sucking Bugs were significantly reduced by intercropping, and a decrease in flower Thrips population levels occurred only in the D2 intercrop. The extent of the drought on crop performance is amply reflected in low flower production and miserable grain yield (Table 5). The number of flowers produced per meter of row was negligible and unlike last year, not affected by pest suppression, cowpea cultivar or cropping system. Similarly, differences in grain yield due to variety and cropping system were statistically insignificant, regardless of pest control. Interactions between pest control + cultivar, pest control + cropping system, as well as cultivar + cropping system had no marked effect on pest population densities. Although pest suppression in general elicited favourable reactions (reduced pest incidence, moderate grain yield increase) potentially complementary responses due to varieties, cropping system and their interactions were virtually overshadowed by the overwhelming drought. These studies will be repeated under more auspicious circumtances hopefully, in attempts to gain better insights into the pest-plant interactions in mixed cropping.

4.2 Cereal - Cowpea strip cropping (Row intercropping)

This is a modification of intercropping where strips of cereals and cowpea in different combinations alternate with each other. Because of our small treatment plot size (30 m^2) row intercropping might be more appropriate. At the present time cowpea grain production is almost impossible in Africa without pest suppression which in mixed cropping could be highly cumbersome. Strip or row intercropping, in addition to optimizing plant densities also lends itself well to pesticide utilization. Maize (vars. SAFITA-2, Jaune de Fo) - cowpea (var. TVx 3236 and sorghum (var. Framida) - cowpea were established at Loumbila and Farako-Bâ, and a millet - cowpea (var. SUVITA-2) crop was planted at Pobé, to study plant-pest interactions with emphasis on pest incidence and yield. The crop arrangement were : Cereal monocrop (S1), Cowpea monocrop (S2) and five cereal + cowpea combinations ; 1 row cereal + 2 rows cowpea (S3), 2 rows cereal + 2 rows cowpea (S4), 2 rows cowpea + 3 rows cowpea (S5), 3 rows cereal + 4 rows cowpea cowpea (S6) and 3 rows cereal + 5 rows cowpea (S7). Cereal and cowpea densities on 8 row plots were 20,000 and 41,667 plants/ha respectively in S3 and S7, and 26,667 and 33,333 plants/ha respectively in S4, S5 and S6 combinations. Cowpea received one of two pest control treatments : minimum insecticide protection (two applications - Decamethrin, 15 g a.i./ha at raceme initiation, and Endosulfan,

Table 6. Effect of Cereal + Cowpea Strip Cropping on Pest Incidence and grain yield at Pobe, Loumbila and Farako-Bâ, Burkina Faso, 1984.

Treatment	Thrips per 10 racemes	Thrips per 10 flowers	Maruca per 20 flowers	PSBs per 2 m row	Yield (kg/ha) Cowpea	Yield (kg/ha) Cereal
I. MILLET + COWPEA			POBE(1)			
Protected	4.35	7.90	0.08	0.28	163.4	41.0
Unprotected	3.90	11.00	0.13	0.33	77.9	27.9
Means	4.40	9.50	0.10	0.31	120.7	34.5
L.S.D. (5 %)	NS	NS	NS	NS	34.585	NS
I. MAIZE + COWPEA			LOUMBILA(2)			
Protected	23.50	164.40	0.31	6.92	1652.0	3383.0
Unprotected	29.40	183.80	0.73	22.60	1236.0	2848.0
Means	26.50	174.10	0.52	14.76	1444.0	3115.0
L.S.D. (5 %)	1.178	NS	NS	NS	NS	NS
II. SORPHUM + COWPEA						
Protected	8.10	54.90	0.59	2.64	1067.0	566.0
Unprotected	29.60	116.60	0.96	3.60	803.0	664.0
Means	18.90	85.70	0.76	3.12	935.0	615.0
L.S.D. (5 %)	NS	NS	NS	NS	NS	NS
I. MAIZE + COWPEA			FARAKO-BA(3)			
Protected	2.94	8.94	3.64	0.14	947.0	1934.0
Unprotected	2.67	10.61	3.42	0.19	1051.0	1915.0
Means	2.81	9.78	3.54	0.17	999.0	1924.0
L.S.D. (5 %)	NS	NS	NS	NS	NS	NS
II. SORGHUM + COWPEA						
Protected	5.44	10.28	1.54	50.20	565.0	1315.0
Unprotected	4.06	11.72	2.17	41.40	480.0	1300.0
Means	4.75	11.00	1.86	45.80	522.0	1307.0
L.S.D. (5 %)	NS	NS	NS	NS	NS	NS

(1) Vars : millet (local, cowpea (Suvita-2)
(2) Maize (Safita-2), sorghum (Framida), cowpea (TVx 3236, white large grain)
(3) Maize (Jaune de Fo), sorghum (Framida), cowpea (TVx 3236, brown, large grain).

Table 7. Performance of Cereal + Cowpea Strip Cropping Trial at Loumbila and Farako-Bâ, Burkina Faso, 1984.

Crop Combination(1)		Yield (Kg/ha)		Cereal LER	Cowpea LER	Inter Crop LER
		Cereal	Cowpea			
			LOUMBILA			
Maize Monocrop	(S1)	3220	-			
Cowpea Monocrop	(S2)	-	1363			
1 Maize + 2 Cowpea	(S3)	3634	1495	1.13	1.10	1.12
2 Maize + 2 Cowpea	(S4)	3111	1480	0.97	1.09	1.03
2 Maize + 3 Cowpea	(S5)	3006	1438	0.93	1.06	1.00
3 Maize + 4 Cowpea	(S6)	2990	1488	0.93	1.09	1.01
3 Maize + 5 Cowpea	(S7)	2730	1398	0.85	1.03	0.94
						1.02
Sorghum Monocrop	(S1)	523	-			
Cowpea Monocrop	(S2)	-	864			
1 Sorghum + 2 Cowpea	(S3)	610	805	1.17	0.93	1.05
2 Sorghum + 2 Cowpea	(S4)	610	1100	1.17	1.28	1.23
2 Sorghum + 3 Cowpea	(S5)	632	929	1.21	1.08	1.15
3 Sorghum + 4 Cowpea	(S6)	649	876	1.24	1.02	1.13
3 Sorghum + 5 Cowpea	(S7)	668	1036	1.28	1.20	1.24
						1.16
			FARAKO-BA			
Maize Monocrop	(S1)	2141	-			
Cowpea Monocrop	(S2)	-	895			
1 Maize + 2 Cowpea	(S3)	1639	860	0.77	0.96	0.87
2 Maize + 2 Cowpea	(S4)	2283	1254	1.07	1.40	1.24
2 Maize + 3 Cowpea	(S5)	1445	1111	0.67	1.24	0.96
3 Maize + 4 Cowpea	(S6)	2134	994	1.00	1.11	1.06
3 Maize + 5 Cowpea	(S7)	1897	880	0.89	0.98	0.94
						1.01
Sorghum Monocrop	(S1)	1189	-			
Cowpea Monocrop	(S2)	-	611			
1 Sorghum + 2 Cowpea	(S3)	1199	591	1.01	0.97	0.99
2 Sorghum + 2 Cowpea	(S4)	1265	521	1.06	0.85	0.96
2 Sorghum + 3 Cowpea	(S5)	1278	523	1.07	0.86	0.97
3 Sorghum + 4 Cowpea	(S6)	1322	277	1.11	0.45	0.78
3 Sorghum + 5 Cowpea	(S7)	1591	611	1.34	1.00	1.17
						1.08

(1) Number of cereal rows followed by number of cowpea rows.

500 g a.i./ha at podding), and no protection. Results are given in Tables 6 and 7. Insect pest populations were much higher on the Loumbila cowpea crop than at Pobé and Farako-Bâ. Pest incidence (Thrips, Maruca and Pod Sucking Bugs) was similar on protected and unprotected plots at Pobé. Cowpea and millet yields were low because of premature cessation of the rain. However, despite virtual crop failure, pest suppression caused a significant increase in cowpea yield. Flower thrips were markedly reduced by pest control in the sorghum-cowpea association at Loumbila. Maruca incidence was very low and comparable between insecticide treated and untreated crop. Pod Sucking Bug density levels were considerably reduced by pest suppression in the maize-cowpea relative to the sorghum-cowpea combination. Maize-cowpea grain yields were satisfactory, and despite a mild depression in maize LER, overall or relative productivity was favourable (Table 7). Sorghum-cowpea grain yields were lower than maize-cowpea : Sorghum appeared to be stressed in this mixture in relation to cowpea but relative production was also favourable. The best combinations were S3 and S4, and S4, S5 and S7 for maize-cowpea, and sorghum-cowpea associations respectively. At Farako-Bâ although Maruca and Pod Sucking Bug populations were considerably higher than at Loumbila, pest incidence (Thrips, Maruca, Pod Sucking Bugs) in general was similar on treated and untreated crop. Maize-cowpea yields were lower than at Loumbila. Maize was more stressed than cowpea presumably because of late planting (July 15) at Farako-Bâ. In the sorghum-cowpea association, sorghum, probably taking advantage of high rainfall at Farako-Bâ, fared much better than at Loumbila. However cowpea suffered considerable yield decrease in this association presumably because of the marginal soil on these plots. Relative productivity was favourable (LER 1.0, Table 7) for both maize-cowpea and sorghum-cowpea combinations. The best maize-cowpea associations were S4 and S6, and S3 and S7 for sorghum-cowpea. The favourable response of the S4 maize-cowpea association, as well as S7 sorghum-cowpea combination at both locations might be interesting to pursue. There appears to be an intriguing though not significant difference in Flower Thrips response in the sorghum-cowpea association, and Pod Sucking Bugs in maize-cowpea combination to pest suppression at Loumbila compared to Farako-Bâ which requires further elucidation. This study will therefore be repeated on large sized plots (100 m^2) at same locations next season.

5. MINIMUM INSECTICIDE PROTECTION OF COWPEA

Heavy pest pressures are one of the constraints currently limiting increased production of especially cowpea grain in Africa. Pesticide protection is mandatory particularly in monocultures (where cowpea is a high risk crop) if reasonable/decent yields are expected. At the same time alternative uses of cowpea (vegetables, fodder), high pesticide cost, low literacy of local farmers and a very delicate Sahelian environment demand extreme caution in choicd and use of pesticides especially at the peasant production level. This study was initiated as a SAFGRAD Regional Activity to evaluate cultivars which can produce reasonable yields with minimal pesticide protection. Nine improved entries from IITA and National Research Programmes have been tested in different localities of the Sahel since 1979. This year, trials were sent to Senegal, Ghana, Burkina Faso, Niger, Togo, Nigeria, Cameroon, Kenya and Ethiopia. Results are reported from 9 locations : 6 in Burkina and one each in Ghana, Togo and Nigeria. Minimum insecticide protection was provided by two applications : Decamethrin, 15 g a.i./ha at flower bud initiation (30-35 DAE) and Endosulfan, 500 g a.i./ha at podding (45-55 DAE). In most locations in Burkina Faso, a third application (Dimethoate, 400 g a.i./ha) was necessary to suppress severe aphid outbreaks early in the season (2 to 3 weeks after emergence).

Flower Thrips infestations were low to moderate, with considerable differences among varieties. In Burkina Faso the lowest population levels were found in Local Kamboinse, TVx 3236, KN-1 and often TN 88-63, Mougne, IT 82E-60 and SUVITA-2. In Ghana, Togo and Nigeria substantial differences in Thrips densities were observed among varieties : TVx 3236, Local checks, TN 88-63, TVx 1999 and SUVITA-2, had low Thrips populations. Maruca incidence was quite low in all locations most probably because of poor flowering rather than effectiveness of pesticide treatment alone. Consequently the only marked varietal differences were obtained at Farako-Bâ where Maruca density on Local Kamboinse was significantly lower than on TVx 1999, Bambey 21, Mougne and IAR-48. Local Kamboinse possesses moderate resistance to Maruca. Pod Sucking Bug incidence was even lower than that of Maruca, in part due to less than optimal podding. In Farako-Bâ and Gampela, Pod Bug infestation of Local Kamboinse was substantially lower than in other varieties. Local Kamboinse is a late photo-sensitive variety and may have escaped infestation.

Grain yields are given in Table 8. Production was lowest (100-300 kg/ha) at Pobe, Ouahigouya and Saria because of drought. However indigenous drought tolerant cultivars IAR 48, TN 88-63, Mougne, SUVITA-2, thrived. At Gampela the effects of the drought were accentuated by late planting (August 13). Yields at Kamboinse, Nyankpala (Ghana) and Ilorin (Nigeria) were moderate (600-700 kg/ha). TVx 1999 and KN-1 took advantage of higher moisture to produce about 1 ton of grain/ha. The highest yields were obtained at Farako-Bâ and Davie (Togo), where over half the entries produced between 1 and 2 tons/ha. Across locations TVx 1999,

Table 8. Grain yield (Kg/ha) of cowpea under minimum protection from insect Pests in Burkina Faso, Ghana, Togo and Nigeria, 1984.

Treatments	Kamboinse Burkina	Gampela Burkina	Saria Burkina	Ouahigouya Burkina	Pobe Burkina	Farako-Bâ Burkina	Nyankpala Ghana	Davie Togo	Ilorin Nigeria	Mean
TVx 1999-10F	691	453	470	294	65	1148	1254	1913	1047	815
IAR-48	897	558	372	301	235	1146	878	1355	869	734
KN-1	363	430	286	145	49	1176	1271	1509	827	673
TN 88-63	836	488	300	366	143	1325	468	723	976	625
MOUGNE	833	351	388	208	166	1237	557	1073	693	612
SUVITA-2	993	528	187	232	231	824	540	1041	873	605
TVx 3236	673	384	350	201	117	661	512	1328	556	529
Local (checks)	58	525	130	78	---	1524	706	1020	---	449
IT82E-60	736	403	155	149	212	731	657	340	553	437
Bambey-21	272	250	76	164	77	1069	317	359	531	346
Mean	635.19	436.93	271.25	213.91	129.40	1084.26	715.70	1065.96	690.42	582.56
L.S.D.	284.70	296.24	126.90	124.56	96.55	388.38	326.12	487.33	265.67	339.12
C.V.	30.89	46.73	32.24	40.13	51.42	24.69	31.40	31.51	26.52	41.32

IAR 48, KN-1, TN 88-63, Mougne and SUVITA-2 showed widest adaptation relative to yield response (600-800 kg/ha), followed by TVx 3236, IT 82E-60 and local checks (400-600 kg/ha). Local varieties in Pobe and Ilorin did not set pods because the rains stopped prematurely. Sambey 21 appears to be the least adapted entry.

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