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SEMI-ARID FOOD GRAIN RESEARCH AND DEVELOPMENT

S A F G R A D

and

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

I I T A

IITA/SAFGRAD PROJECT

A N N U A L   R E P O R T

1987

Funded by:

USAID, United States Agency for International Development.

IDRC, International Development Research Center, Canada.

IITA/SAFGRAD
01, B.P. 1783
Ouagadougou, 01
Burkina Faso

C O N T E N T S

ABBREVIATIONS

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

PREFACE

This report summarizes the activities of the IITA/SAFGRAD collaborative project for the period January to December, 1987 which represented the final year of resident research for the project. Following acceptance of the recommendations of SAFGRAD II Design Team, resident research was phased out while project activities concentrated on the establishment and organization of collaborative Research Networks.

During the year, the maize and cowpea collaborative Research Networks for West and Central Africa were launched and became fully operational. Steering Committees were elected, research agendas and modalities for their execution were formulated. Regional trials were also distributed at the request of national agricultural research programs. These activities are thus the beginning of project program implementation in SAFGRAD Phase II.

ACKNOWLEDGEMENTS

The IITA/SAFGRAD Project is grateful to the Government of Burkina Faso for its continued support of project activities. In particular, the assistance of the Ministry of Higher Education and Scientific Research in providing land and other Stations, and the Ministry of Agriculture for land at Loumbila, Pobe (Djibo) and Gorom-Gorom, is greatly appreciated. Excellent co-operation of the Director of the Institut National d'Etudes et de Recherche Agricoles (INERA), the Directors of the "Direction des Services Agricoles" (DSA), and the Station Directors contributed immensely to the success of the 1987 season activities.

Excellent cooperation received from CIMMYT, IRAT, F.S.U. and IDR (University of Ouagadougou) and from many ORD Directors, ACPOs, US Peace Corps and USAID/BF in 1987 is gratefully acknowledged.

Active participation of researchers at National Maize and Cowpea Programs of SAFGRAD member countries has been a key element in developing and improving the Regional Maize and Cowpea Networks promoted by SAFGRAD, and the support of National Governments has been largely responsible for the successful operation of these Networks.

The resident IITA/SAFGRAD Team in Burkina Faso continued to receive effective administrative and technical backstopping from IITA Headquarters at Ibadan, Nigeria, which considerably facilitated work and enabled the project to achieve set objectives.

Finally, the project received financial assistance from the United States Agency for International Dēvelopment (USAID) and the International Development Research Centre (IDRC) of Canada. We are deeply indebted and grateful to these organizations for this support throughout the duration of the project.

Ouagadougou
Burkina Faso
July, 1988

Joseph B. Suh
Entomologist
and Project Leader

DECLARATION

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

DEDICATION

This Report is dedicated to the loving memory of Miss Rose Z. Somé, former Project Secretary, who was well known for her exemplary dedication, hardwork and kindness. Her untimely, brutal and violent demise is a tragic and needless loss to the Project, Institute and Burkina Faso, and especially to her family to whom most sincere condolences are extended. May She Rest in Perfect Peace.

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INTRODUCTION

The Semi-Arid Food Grain Research and Development Project, SAFGRAD, was launched in 1977 by the Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC) and the United States Agency for International Development (USAID). The Project, sometimes referred to as OAU/STRC Joint Project 31, covers 26 countries in the semi-arid zone of Africa. The Project is administered from a Coordination Office in Ouagadougou headed by an International Coordinator. The major objective of this Project is to improve production of maize, sorghum, millet and cowpea in the semi-arid Africa. The International Institute of Tropical Agriculture (IITA) accepted responsibility for regionally oriented research, development and training activities for maize and cowpeas, in order to promote improved maize and cowpea varieties in addition to cultural practices which are compatible with small-scale farming systems in the semi-arid tropics (SAT).

The IITA/SAFGRAD Project became fully operational in June, 1979 with the arrival of four USAID-Funded scientists in Ouagadougou. This research team consisted of a maize breeder, as Project Leader, a maize agronomist, a cowpea agronomist (soil fertility specialist) and an entomologist. Under a separate agreement between the host Government and IDRC of Canada, an IITA cowpea breeder was based in Ouagadougou from 1977 to develop the National Cowpea Improvement Program. In addition to his national program responsibilities, this cowpea breeder provided technical support to USAID/SAFGRAD scientists.

Later, in 1983, the IDRC/IITA Cowpea Breeding Program was expanded into a full regional activity within the IITA/SAFGRAD Project activities. Thus, from the start, the five IITA scientists worked in two teams; namely, (a) a maize team, consisting of a breeder, an agronomist and an entomologist; and (b) a cowpea team, also consisting of a breeder, an agronomist and an entomologist. The Project also included soil and water management research which was conducted under an ICRISAT/SAFGRAD contract arrangement. IITA later assumed responsibility for the soil and water management research and consequently, a sixth IITA/SAFGRAD scientist joined the research team in April, 1985.

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

The major objectives of the IITA/SAFGRAD Project were defined as follows:

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

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

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

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

The strategy adopted for achieving these objectives included:

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

b) Regional Research conducted by IITA/SAFGRAD scientists in collaboration with national programs in 26 SAFGRAD member countries.

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

d) Training of national staff on maize and cowpea production technologies on site at Burkina Faso and at IITA Headquarters in Ibadan, Nigeria.

Mid-term and end-of-project evaluations of the entire SAFGRAD Project, and in particular the IITA component, concluded that implementation had produced many useful results which contributed to the achievement of project objectives. On this basis, the end-of-project evaluation team recommended extension of the project into SAFGRAD Phase II to last 5 years. The major activity for SAFGRAD II will be to increase the efficiency and effectiveness of national agricultural research by developing the capacity and initiative of national scientists to assume increasing decision-making roles in maize and cowpea collaborative research Networks.

The International Institute of Tropical Agriculture (IITA) accepted responsibility for establishing the Maize and Cowpea Collaborative Research Networks, initially in West and Central Africa. Under this arrangement, IITA was expected to:

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

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

c) Assist in the establishment of Steering (Advisory) Committees for each network, with responsibility to coordinate, provide leadership and direction for networks through setting up agendas for annual meetings, monitoring tours and workshops, and allocating research responsibilities to participating member countries.

Research experience over the last 8 years has enabled IITA/SAFGRAD scientists to develop, introduce, and test improved maize and cowpea varieties and management practices for their production under semi arid conditions. Salient results of the 1987 activities are presented in this report.

RESEARCH AND DEVELOPMENT ACTIVITIES

Physical Environment: Climate and Soils of Experimental Sites.

Three main ecologies can be recognized in the West African Semi-Arid Tropics (WASAT); these are: the Sahel, the Sudan, and the Northern Guinea Savannas, characterized by a unimodal rainfall pattern. There is considerable variability among different authors in the terminologies and parameters used to define these ecologies. In this report, the ecologies have been defined on the basis of annual rainfall and length of the rainy season as follows (see Table 1.1).

Table 1.1. Characterization of Ecologies in the SAT of West Africa.

Ecological Category	Annual Rainfall (mm)	Duration of Rainy Season (months)
Sahel Savanna	300 - 600	2 - 3
Sudan Savanna	600 - 900	3 - 4
Northern Guinea Savanna	900 - 1200	4 - 5

There is considerable variability in total annual rainfall and its distribution in the West African SAT, therefore the classification scheme presented in Table 1.1. should not be interpreted rigidly.

All these ecologies are represented in Burkina Faso, thus the sites selected have permitted IITA/SAFGRAD to conduct regionally oriented resident research with potential applicability to much of the West African Semi-Arid Tropics.

The main resident research sites selected, and area cropped by IITA/SAFGRAD during 1987 are described below, and indicated in Figure 1.1.

a) Sahel Savanna:

- Saouga, Gorom-Gorom (Ministry of Agriculture), located about 300 km north of Ouagadougou. Mean annual rainfall: 400 mm.
- Pobe (Ministry of Agriculture), located about 200 km north of Ouagadougou. Mostly ferruginous tropical soils (Haplargids and Cambiorthids). Mean annual rainfall: 450 mm. Area: 6 hectares.

b) Sudan Savanna:

- Kamboinse Research Station (INERA), located 14 km north-east of Ouagadougou. Ferruginous tropical, hydromorphic and some ferralitic soils (Palenstalfs, Plithustalfs and Ustochrepts). Mean annual rainfall: 800 mm. Area: 17 hectares.
- Loumbila (Ministry of Agriculture), located 15 km north of Ouagadougou. Mostly ferruginous tropical soils (Hapludalfs, Plinthustalfs, Ustorthents and Haplustalfs). Mean annual rainfall: 800 mm. Limited irrigation facilities are available. Area: 2 hectares.
- Gampela (ISP) located about 20 km east of Ouagadougou. Mostly ferruginous tropical soils. Mean annual rainfall: 700 mm. Area: 3 hectares.

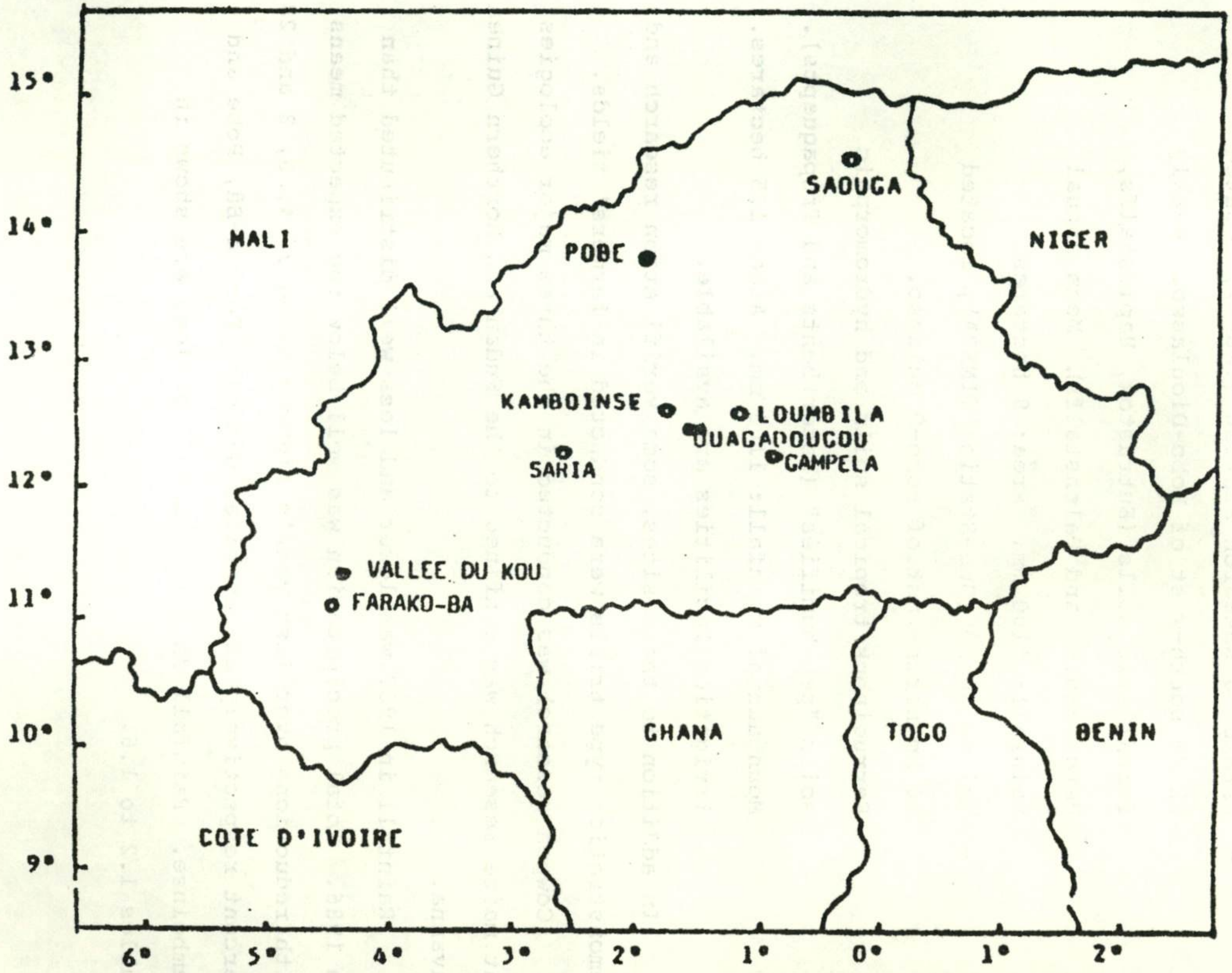

Fig.1.1 MAP OF BURKINA FASO SHOWING MAIN RESEARCH SITES OF IITA/SAFGRAD

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

c) Northern Guinea Savanna:

- Farako-Bâ Research Station (INERA), located 12 km south-west of Bobo-Dioulasso. Weakly ferrallitic soils (Eutrustox, Haplustalfs, Ustorthents, and Palenstalfs). Mean annual rainfall: 1100 mm. Area: 8 hectares.
- Vallee du Kou Sub-Station (INERA), located 20 km north-east of Bobo-Dioulasso. Ferruginous tropical soils and hydromorphic soils "peu humifiés" (Ustorthents and Tropaquepts). Mean annual rainfall: 1100 mm. Area: 1.5 hectares. Irrigation facilities are available.

In addition to these sites, some verification research and demonstration type trials were conducted in farmers' fields.

Cowpea research was conducted in the three major ecologies, but maize research was confined to the Sudan and Northern Guinea Savanna.

Rainfall in 1987 was lower and less well distributed than in 1986. Total precipitation was well below the expected means with reductions over last year's figures being 2, 4, 6, 8 and 28 percent respectively at Loumbila, Gampela, Farako-Bâ, Pobe and Kamboinse. Rainfall data for these locations are shown in Tables 1.2 to 1.6.

Table 1.2. Location (Localité) : POBE/DJIBO

Daily rainfall (Tableau pluviométrique) mm

Year (Année): 1987

Date	J	F	M	A	M	J	J	A	S	O	N	D
1									11			
2							10					
3									18			
4						36						
5									2			
6						12						
7												
8						1.5				2.5		
9												
10							17		11			
11												
12												
13												
14						0.5						
15												
16												
17						18.0		4.5				
18												
19								24				
20									11			
21												
22												
23								36	12			
24												
25							22					
26								2.8				
27												
28												
29							18					
30												
31							33					
Total (mm)						68	100	67.3	65	2.5		
No. days (jours)						5	5	4	6	1		
Total cumul. (mm)						68	168	235.3	300.3	302.8		
No. days (jours) Cumul.						5	10	14	20	21		

Table 1.3. Location (Localité) : KAMBOINSE (STATION)
Daily rainfall (Tableau pluviométrique) mm

Year (Année): 1987

Date	J	F	M	A	M	J	J	A	S	O	N	D
1						1.1	12.0					
2							2.5	21.0	4.0	18.5		
3						11.0		2.8				
4									15.0			
5									4.6			
6					2.5	35.0						
7						19.0	7.5	21.5				
8												
9						0.4				0.8		
10							22.0		5.0			
11							6.5	10.5				
12							3.5					
13								3.2		4.6		
14							8.4	32.0	1.0			
15												
16									4.5			
17			0.3			0.2	6.5					
18			16.0									
19												
20						3.0		30.0				
21							6.2		13.4			
22					0.4				12.0			
23								13.0				
24							7.1	1.0				
25					6.5	35.0		3.0				
26							8.2		59.0			
27					1.4			2.2	9.5			
28						9.5	5.6					
29												
30							52.5	0.5				
31												
Total (mm)			16.3	0	10.8	114.2	148.5	140.7	128	23.9		
No. days (jours)			2	0	4	9	13	12	10	3		
Total cumul. (mm)			16.3	16.3	27.1	141.3	289.8	430.5	558.5	582.4		
No. days (jours) Cumul.			2	2	6	15	28	40	50	53		

Table 1.4. Location (Localité) : GAMPELA (STATION)
Daily rainfall (Tableau pluviométrique) mm

Year (Année): 1987

Date	J	F	M	A	M	J	J	A	S	O	N	D
1						7.9	13.7					
2								10.3				
3						4.2		34.2				
4												
5												
6						94.6						
7						3.2	3.8	30.5		2.9		
8									2.6			
9										3.3		
10							10.7		12.3	9.6		
11						9.4	26.9	5.5		2.5		
12												
13								2.6				
14							11.0	28.9	3.8			
15												
16												
17							7.1		1.3			
18												
19			15.3									
20						6.3		22.4				
21							2.9		28.2			
22									2.5			
23									3.6			
24							0.3	23.8				
25					5.4	20.0		3.7				
26							42.7					
27					14.1			7.4	31.0			
28									13.2			
29						11.7						
30							42.7					
31												
Total (mm)			15.3		19.5	157.3	161	182.3	100.5	22.0		
No. days (jours)			1	0	2	8	10	10	9	4		
Total cumul. (mm)			15.3	0	34.8	192.1	353.1	535.4	635.9	657.9		
No. days (jours) Cumul.			1	1	3	11	21	31	40	44		

Table 1.5. Location (Localité) : LOUMBILA
Daily rainfall (Tableau pluviométrique) mm

Year (Année): 1987

Date	J	F	M	A	M	J	J	A	S	O	N	D
1												
2							14.6		0.7			
3						3.3	1.0	18.9		15.0		
4												
5									3.7			
6						35.2		27.7				
7							7.8					
8						3.9						
9								0.7		1.7		
10									10.9			
11						1.9	14.9					
12							12.6	15.0				
13										3.1		
14						1.1	2.5	3.3	2.4			
15								52.1				
16									15.9			
17							9.4					
18												
19												
20						3.4		32.2				
21							4.2		8.2			
22									38.2			
23								6.3				
24								9.3				
25					2.0	27.2		9.0				
26							36.2					
27					10.7			10.9	31.4			
28							1.5					
29						17.7						
30								1.7				
31							46.2					
Total (mm)					12.7	93.7	150.9	187.1	111.4	19.8		
No. days (jours)					2	8	11	12	8	3		
Total cumul. (mm)					12.7	106.4	257.3	444.4	555.8	575.6		
No. days (jours) Cumul.					2	10	21	33	41	44		

Table 1.6. Location (Localité) : FARAKO-BA (STATION)

Daily rainfall (Tableau pluviométrique) mm

Year (Année): 1987

Date	J	F	M	A	M	J	J	A	S	O	N	D
1					3.0			23.5				
2							14.0					
3					2.0	21.7		43.2				
4								13.1				
5						16.7						
6						10.7				8.5		
7							39.4	39.6		12.3		
8						6.1						
9						18.5		13.1	14.8			
10									17.7	1.3		
11						15.7	1.8	22.0				
12							6.5					
13						13.0						
14				1.0			12.8	27.3	1.6			
15					0.2			6.1	14.8			
16						0.8		0.5				
17					0.5	1.8	9.2	3.1				
18												
19			0.7			2.5						
20			14.1			12.5		1.5	5.4			
21		10.9				0.4	9.5	48.8	8.7			
22								0.5	1.9			
23					6.2				2.5			
24							67.0					
25						9.0		13.3				
26						15.5	3.3	7.5				
27					15.3			73.5				
28												
29					15.7	5.6			6.7			
30							32.4	35.0				
31							2.9					
Total (mm)		10.9	14.8	1.0	42.9	150.5	198.8	371.6	74.1	22.1		
No. days (jours)		10.9	25.7	26.7	69.6	220.1	418.9	790.5	864.6	886.7		
Total cumul. (mm)		1	2	1	7	15	11	17	9	3		
No. days (jours) Cumul.		1	3	4	11	26	37	54	63	66		

SUPPORT TO NATIONAL PROGRAMS AND TRAINING

One of the important objectives of IITA/SAFGRAD is the strengthening of National Maize and Cowpea Programs. Thus, in addition to developing improved varieties and technologies and coordinating regional testing, the following additional activities were undertaken.

Annual Workshops

Annual Workshops which started in 1979 at Ouagadougou, Burkina Faso, have continued to be organized by IITA/SAFGRAD and the OAU/STRC/SAFGRAD Coordination Office. From 1984, annual workshops were held jointly by SAFGRAD and IITA/EEC High Yielding Varieties Technology Project (HYVT).

The purpose of these workshops was to:

- Evaluate progress/accomplishments by National Maize and Cowpea Programs, IITA/SAFGRAD and other organizations (EEC) through presentation and discussion of research results obtained in the previous season.
- Plan future research activities, including the following year's regional testing program. If the workshop took place in March, National Program Researchers not only nominated their own varieties for regional testing, but also personally delivered seeds of such entries to the IITA/SAFGRAD Team, for preparation and despatch to regional trials.
- Exchange information, promote friendship and a sense of common purpose among National and SAFGRAD Researchers.

A major accomplishment of the IITA/SAFGRAD project has been the breaking down of barriers between anglophone and francophone researchers, thus ensuring closer interaction between maize and cowpea scientists in the West African Semi-Arid Tropics.

The IITA/SAFGRAD component of SAFGRAD II was designed to increase the efficiency and effectiveness of National Agricultural Research Systems. In order to achieve this, IITA initiated the establishment of Maize and Cowpea Collaborative Research Networks in West and Central Africa, by organizing a meeting of the Directors of Agricultural Research, forming the Council of Research Directors, of the 26 SAFGRAD member countries, in Ouagadougou, Burkina Faso, from February 23-27, 1987. The Directors reviewed the achievements of SAFGRAD I, set directions for activities of SAFGRAD II, and also decided to organize and coordinate research networks for cowpea, maize, millet, and sorghum. To implement this decision, SAFGRAD, in collaboration with IITA, organized a workshop of national program scientists working on maize and cowpea in the 18 SAFGRAD member countries of West and Central Africa from March 23-27, 1987 at Ouagadougou, Burkina Faso. The objective of the workshop was to launch the collaborative research networks for maize and cowpea for the West and Central Africa sub-region. The workshop enabled national program scientists to identify and deliberate on the major and common constraints affecting maize and cowpea production in the sub-region. They elected Steering Committees to propose and elaborate details of Maize and Cowpea Research Networks in the region. Thirty nine national program researchers (19 cowpea scientists and 20 maize scientists) from 17 national agricultural research systems and several representatives from regional and international organizations, involved in maize and

and cowpea research and production in the region, also participated in the workshop.

Regional Testing

IITA/SAFGRAD coordinated a regional testing program for maize and cowpea with the following objectives:

a) Provide elite germplasm to researchers in the West African SAT for testing and use in their national programs. The elite materials originated from IITA/SAFGRAD, National, and Regional/International Organizations (IITA, CIMMYT, IRAT).

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

c) Enhance the exchange of germplasm between national programs.

d) Develop/select varieties possessing tolerance to special conditions in semi-arid areas for wide adaptation and stability.

e) Evaluate the economic importance and regional variation in diseases and insect pests affecting maize and cowpea.

f) Test improved management practices for maize and cowpea production.

The Network Coordinators prepared and despatched a total of 135 sets of trials requested by 16 National Programs in West and Central Africa as follows: 83 cowpea trials to 16 National Programs (Table 2.1) and 55 Maize trials to 15 National Programs (Table 2.2).

Table 2.1

COWPEA NETWORK REGIONAL TRIALS - 1987

Country	Number of Trials Requested						
	Drought tolerance	*Striga* resistance	Sorghum-Cowpea intercropping	Millet-Cowpea intercropping	Insect Resist. observation nursary	Maize-Cowpea relay cropping	Minimum Insecticide protection.
Benin	1		2		1		2
Burkina Faso	1	1			1		
Cameroon							1
Cape Verde					1		
Central Africa Rep.					2		
Côte d'Ivoire					1		
Gambia	1		1	2			1
Ghana	1	1	1				1
Guinea			1		3	2	1
Guinea Bissau	1		1		1		
Mali	2	2		2	1		
Niger	3	3		3	3		2
Nigeria	2	3	1		1	1	2
Senegal	2		1	1	3		2
Tchad	2			2	2	1	
Togo			2			1	
	16	10	10	10	20	5	12

Table 2.2 MAIZE NETWORK REGIONAL TRIALS - 1987

Country	Number of Trials Requested		
	Extra-early	Early	Intermediate
Cape Verde	2	-	-
Gambia	2	2	-
Togo	3	3	2
Burkina Faso	1	2	1
Senegal	1	2	2
Mali	1	-	1
Guinea Bissau	1	-	-
Tchad	2	1	-
Benin	2	2	2
Nigeria	-	2	1
Ghana	-	1	1
Camerron	-	1	1
Central African Republic	-	2	2
Guinea Conakry	-	3	2
Côte d'Ivoire	-	1	-
TOTAL	15	22	15

Monitoring Tours

Monitoring tours coordinated by IITA/SAFGRAD scientists and OAU/STRC/SAFGRAD Coordination Office were conducted during the growing season, to bring together national scientists from about 6 countries (per crop) as well as scientists from CIMMYT and IITA to visit national maize or cowpea programs in 4-6 countries. The objectives of monitoring tours were:

- to promote interaction among national programs in West, East and Southern African countries.
- evaluate performance of entries and/or management practices in the regional testing including any other maize, cowpea or agronomic trials, and
- to provide both national and IITA SAFGRAD Researchers a unique opportunity to learn first hand about the problems (edaphic, climatic, biotic or management) limiting maize and cowpea production in the SAT.

No monitoring tours were organized this year because it was decided that in SAFGRAD II, this activity would be organized in alternate years to coincide with the Network Workshops/Conferences.

Visits to National Programs

The Network Coordinators visited 10 national programs during the cropping season. The Cowpea Coordinator visited Mali, Mauritania, Niger, Nigeria, Senegal, Togo and Guinea-Conakry. The Maize Network Coordinator made two visits (the first at the beginning of the season and the second towards its end) to Mali, Guinea Conakry, and the Central African Republic; he also visited Togo and Benin. He also travelled extensively within Burkina Faso.

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

Training

The training in SAFGRAD II emphasized short-in-service training workshops focussing on specific production problem areas or research methods, such as, tied ridges, data processing/ interpretation, seed production/varietal maintenance. Three researchers from the Burkina Faso national program participated in the following IITA Group Training Courses in 1987:

- Statistics in Agricultural Experimentation;
- Maize Pathology, and Maize Research and Production;

their participation was sponsored by USAID, FAO and IITA.

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

MAIZE BREEDING

A.O. DIALLO

INTRODUCTION

Since 1984, the IITA/SAFGRAD Maize Breeding Program focussed attention on breeding for drought resistance and drought escape in the Sudan Savanna Zone. This involved improving the performance of materials under drought stress, identifying varieties which already have this ability and developing a drought resistant pool, and extra early maturing maize which can escape drought.

In collaboration with IITA (Ibadan), CIMMYT and National Programs of SAFGRAD member countries, the Program also attempted to identify early and intermediate streak resistant maize varieties for the Northern Guinea Savanna Zone. Regional testing aimed at enhancing germplasm exchange between SAFGRAD Resident Research and National Programs of SAFGRAD member countries.

RESIDENT RESEARCH

Four locations, namely, Farako-Bâ, in the Northern Guinea Savanna Zone; Kamboinse, Gampela and Loumbila, in the Sudan Savanna Zone, were used for the 1987 Resident Research. In the Sudan Savanna Zone, tied ridges were used to reduce the risk of drought stress. Fertilizer rates of 72-40-30 of $N-P_2O_5-K_2O$ kg/ha were applied in the Sudan Savanna Zone, while 108-60-45 kg/ha of $N-P_2O_5$-K20 was applied on trials of the Northern Guinea Zone. Population densities of 66,000 and

53,000 plants per hectare were established for extra early and early, and intermediate varieties, respectively.

Breeding for Extra-Early Maize (Drought Escape)

Although data for the past 7 years indicate disturbing rainfall variability, generally greater variability was usually observed at the beginning and towards the end of the rainy season. Extra early maize, which matures in less than 82 days after planting, is therefore useful in this kind of environment, where farmers are sometimes compelled to replant when erratic rainfall and drought cause failure of the first crop.

During the 1984 dry season, early and extra early germplasm collected from CIMMYT, Colombia, India, and Burkina Faso were planted out and observed for growth performance and seed production. Out of 80 materials, 48 were selected, and evaluated at three locations. Across locations, two varieties, viz., Bursanga tollo or Kamandaogo tollo (local yellow variety) and GUA 314 (white Colombian variety) flowered on the average of 42-43 days after planting (DAP) which was 7 days earlier than the local check. Mean yields were 2.4 and 2.5 t/ha, respectively. Because of the narrow genetic base of those varieties, the bad looking grain type and colour, and susceptibility to lodging, it was decided to cross them with other existing good early white and yellow improved varieties to develop composites combining extra earliness with other useful agronomic characters.

During the dry season of 1985-1986, 40 early white varieties were crossed with GUA 314 and advanced to F2 and 58 early yellow varieties crossed with Kamandaogo tollo and advanced to F2. During the 1986 growing season, the best F2 white and yellow crosses were evaluated in two trials at Kamboinse (Burkina Faso). Sixteen crosses reached the black layer stage, at 72-78 DAP with an average yield of 3.5 t/ha. The best 10 crosses were included in the Regional Uniform extra early variety trial (RUVT-3) for regional testing in SAFGRAD member countries.

During the dry season of 1986-1987 (October-December) the yellow crosses were backcrossed with the earliest yellow recurrent parent (Kamandaogo tollo) and the white crosses with the earliest white recurrent parent (GUA 314). During the same growing season (February-May, 1987) the best yellow and white backcrosses were recombined and the following composites were developed: TZEE-Y (Tropical Zea extra early yellow), TZEE-W-1 (Tropical Zea extra early white one), TZEE-W-2 (Tropical Zea extra early white two) and TZEE-W-3 (Tropical Zea extra early white three). In the 1987 season, 7 sets of trials including F2 crosses, backcrosses and composites were evaluated in two or three locations in Burkina Faso.

a) RUVT-3 Kamboinse:

This trial which included 11 extra early crosses intended for regional testing was planted at Kamboinse. Grain yield and other important agronomic characters are given in Table 3.1. Significant differences for yield and other important agronomic characters were observed.

Table 3.1 Grain yield and other agronomic characters of varieties tested in RUVT-3 at Kamboinse, Burkina Faso, 1987.

Entry Name	Grain Yield Kg/ha	Days to 50 % silking	Plant Stand (cm)	Plant Height (cm)	Ear Height (cm)	Plants Harvested No	Ears Harvested No	Moisture %	Ear Aspect Rate	Stem Lodging %	% Husk Cover
1. (Across 8131 x JFS x Local Rayitiri) F4	4938	44	55	166	79	53	52	19.1	2.7	2.8	5.6
2. Pop CSP Early	4800	42	55	135	55	53	55	19.8	1.7	0.0	4.5
3. Pool 27 x GUA 314 F4	4709	42	55	152	71	53	60	17.9	3.0	9.4	1.2
4. JFS (Check)	4661	46	55	176	73	53	54	19.6	3.7	0.9	9.6
5. CSP x L. Rayitiri F2	4209	47	56	155	69	53	51	21.3	3.2	4.2	6.0
6. Pool 28 x GUA 314 BC1 F2	4146	44	55	154	81	53	55	16.8	3.0	6.5	4.0
7. Early 84 TZESR-W x GUA 413 BC1 F2	4055	42	54	152	73	53	60	17.2	3.2	4.7	2.8
8. (DMR-ESR-Yx JFSx K.T.)F4	3933	41	55	145	59	53	55	15.9	3.2	8.0	6.5
9. (Pool 29 x K. Tollo) F4	3804	40	55	147	61	53	57	16.1	3.0	2.3	6.3
10. Pop 30 x GUA 314 F4	3678	44	55	150	75	53	54	18.4	2.7	15.5	3.2
11. WIR 17215 x K. T. BC1 F2	3641	39	55	142	57	53	57	16.3	4.2	28.3	14.9
12. Pop 46x K. Tollo F4	3550	39	55	144	67	54	57	17.7	3.5	10.2	7.3
Overall Mean	4177	43	55	152	68	53	56	18.0	3.1	7.7	6.0
LSD 5 %	834.0	2.4	2.0	16.0	16.0	1.3	5.6	3.6	0.9	9.3	5.8
Prob of F.	0.009	0.000	0.785	0.001	0.028	0.893	0.045	0.097	0.002	0.000	0.005
CV (%)	13.8	3.9	2.6	7.3	16.1	1.7	6.9	13.9	20.9	83.2	57.2

Yields of 4.9 t/ha were recorded for (Across 8131 x JFS x LR)F4 which attained 50% silking 44 DAP. Pop CSP early and Pool 27 x GUA 314 F4 were also very promising with 42 DAP to 50% silking and yields of 4.7 t/ha. Pop 46 x Kamandaogo tollo F4 and W17215 x Kamandaogo tollo BC1 F2 were the earliest entries (39 DAP to 50% silking and 3.5 t/ha of grain yield). In terms of ear aspect Pop CSP early, Across 8131 x JFS x LR F4 and Pop 30 x GUA 314 F4 were the best. W17215 x Kamandaogo tollo BC1 F2 was highly susceptible to stem lodging and showed very bad husk cover.

b) Extra-Early-1: Kamboinse:

Fourteen extra-early materials together with 4 local checks were evaluated in this trial at Kamboinse. Results are shown in Table 3.2. Differences between the yields of varieties were not significant. Significant differences were recorded for DAP to 50% silking and moisture content at harvest. Tropical Zea extra-early yellow (TZEE-Y) was the earliest (40 DAP to 50% silking with 1.3 t/ha grain yield).

c) Extra-Early-2: Kamboinse:

In this trial, I4 extra-early crosses and 4 local checks were included. Significant differences in yield, days to 50% silking and other important agronomic characters were obtained (TAble 3.3). Differences between plants harvested are also significant. Pop CSP x Kamandaogo tollo F2 gave the highest grain yield (2.6 t/ha) and was as early as the earliest local check (Kamandaogo tollo) with a yield of 1.4 t/ha. Kamandaogo tollo also showed very high

Table 3.2 Grain yield and other agronomic characters of varieties tested in Extra-early-1 at Kamboinse, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %
1. Local Raytiri (check)	2333	56	47	120	54	54	44	16.5
2. Pop 31 x Kamandaogo Tollo F2	1967	55	42	113	34	55	48	15.5
3. Pool 28 x GUA 314 F2	1685	56	46	113	48	54	43	17.6
4. Pool 15 x GUA 314 F2	1652	55	45	113	44	53	44	20.8
5. Jaune Flint de Saria (check)	1523	56	46	120	53	54	37	19.0
6. Pop 35 x JFS x Kamandaogo T. F2	1454	55	45	117	53	53	36	16.3
7. Pop 30 x GUA 314 F2	1393	55	48	127	64	54	32	18.5
8. 8131 x JFS x Local Raytiri F2	1353	55	52	113	49	53	42	19.5
9. TZEE-Y	1273	55	40	110	37	53	41	13.0
10. Pool 16 IITA x GUA 314 F2	1227	56	51	103	62	55	39	17.1
11. Pool 27 x GUA 314 F2	1138	54	50	115	52	54	41	17.6
12. CSP x Local Raytiri F2	1056	55	50	92	39	53	40	19.9
13. TZESR-W x GUA 314 F2	926	56	54	114	60	55	35	21.6
14. SAFITA-104 x JFS x K. Tollo F2	851	56	47	110	50	56	37	14.9
15. EV 8188 x GUA 314 F2	824	55	52	92	36	54	39	21.5
16. D822 x GUA 314 F2	822	55	53	124	52	54	34	24.9
17. SAFITA-104 (check)	752	56	53	104	44	54	32	23.2
18. GUA 314 (check)	680	55	45	105	59	54	35	13.4
Overall Mean	1273	55	48	111	49	54	39	18.4
LSD 5%	1018	1.1	6.4	29.3	21.1	1.9	13.1	5.6
Prob of F.	0.106	0.238	0.001	0.606	0.141	0.256	0.602	0.003
C.V. (%)	56.2	1.3	9.4	18.5	29.9	2.5	23.7	21.6

Table 2.3 Grain yield and other agronomic characters of varieties tested in Extra-early-2 at Kamboinse, Burkina Faso, 1987.

Entry	Grain Yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %	Stem lodging %
1. CSP x Kamandaogo Tollo F2	2651	55	43	147	53	53	50	18.9	6.2
2. EV8131 x JFS x L. Raytiri F2	2531	51	46	157	66	47	44	18.3	6.5
3. TZSR-y x JFS x Kamandaogo Tollo F2	2304	53	44	136	54	48	40	15.0	4.2
4. L. Raytiri x Kamandaogo Tollo F2	2238	55	46	131	40	51	48	10.4	12.9
5. Local Raytiri (check)	2208	55	49	159	58	54	48	18.3	14.2
6. CSP x Local Raytiri F2	2202	54	50	143	51	50	38	19.1	2.4
7. Pop 46 x Kamandaogo Tollo F2	2035	53	47	124	48	48	40	15.8	7.3
8. Jaune Flint de Saria (check)	2010	52	51	145	56	47	43	19.5	2.7
9. Pool 29 x Kamandaogo Tollo F2	1983	55	46	132	51	54	48	16.8	5.1
10. SAFITA-104 (check)	1929	55	53	129	51	51	40	23.5	0.0
11. Pool 29 x JFS x Kamandaogo T. F2	1901	54	44	127	46	51	45	13.9	7.9
12. Kaïchan x Kamandaogo Tollo F2	1842	53	44	122	46	49	46	15.7	8.8
13. WIR 15253 x Kamandaogo Tollo F2	1787	48	41	121	41	43	41	13.2	10.8
14. Pool 17 x Kamandaogo Tollo F2	1756	52	49	120	51	47	45	18.1	4.9
15. WIR 17215 x Kamandaogo Tollo F2	1545	48	42	129	45	44	40	17.5	3.9
16. D765 x Kamandaogo Tollo F2	1542	53	43	115	38	49	45	16.0	7.5
17. Kamandaogo Tollo (check)	1412	52	40	102	32	49	49	8.3	16.4
18. JFS x Kamandaogo Tollo	881	33	44	108	37	27	26	12.9	2.2
Overall Mean	1931	52	46	130	48	48	43	16.2	6.8
LSD 5%	819.0	6.6	3.6	18.6	18.5	7.5	8.4	4.4	6.9
Prob. of F.	0.019	0.000	0.000	0.073	0.000	0.000	0.000	0.000	0.000
C.V. (%)	29.8	8.9	5.5	10.0	27.0	11.1	13.8	19.1	70.7

susceptibility to stem lodging compared to other varieties tested in this trial.

d) <u>Extra-early-yellow BC1-1: Kamboinse-Gampela</u>:

This trial consisted of 11 yellow F2 backcrosses and 3 local checks. Tables 3.4 and 3.5 present grain yields and the main important agronomic characteristics of varieties recorded. There were significant differences at Kamboinse for days to silk and moisture content at harvest. SAFITA-104 x JFS x Kamandaogo tollo BC1 and Pool 29 x K. tollo BC1 flowered at 37-36 DAP with a very low moisture content at harvest. The experimental error for yield was large. At Gampela, the differences between varieties for days to silk, moisture content, ear rot, ears harvested and plants and ear heights were significant. Local Rayitiri (local check) was among the earliest and yielded 2.6 t/ha. Across 2 locations, Kaichan x K. tollo BC1 flowered 39 DAP and yielded 2.1 t/ha (Table 3.6).

e) <u>Extra-Early Yellow BC-1-2:Kamboinse and Gampela</u>:

Seven extra-early yellow materials were tested against 4 local checks at Kamboinse and Gampela. At Kamboinse, there were no significant differences between varieties for yields, whereas the differences for days to silk, ear height, plant harvested and moisture content at harvest were significant. Yields of 2.7 t/ha were recorded for Pop 35 x JFS x K. tollo BC1 F2 which reached 50% silking 40 days after planting (DAP) (Table 3.7).

Table 3.4 Grain yield and other agronomic characters of varieties tested in Extra-early-yellow BC1-1, at Kamboinse Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %
1. SAFITA-104 x JFS x K. T. BC1 F2	2248	55	37	110	38	54	49	11.7
2. Pool 29 x K. Tollo BC1 F2	1945	56	36	104	41	53	44	13.3
3. SAFITA-104 x K. Tollo BC1 F2	1794	56	46	136	69	54	37	18.7
4. Jaune Flint de Saria (check)	1753	56	47	132	68	53	41	17.3
5. Kaïchan x Kamandaogo Tollo BC1 F2	1730	55	37	121	45	53	43	12.3
6. WIR 17215 x Kamandaogo T. BC1 F2	1619	55	37	119	41	52	41	14.2
7. Pop 29 x JFS x K. Tollo BC1 F2	1577	56	36	120	48	55	43	12.6
8. Pop 46 x Kamandaogo T. BC1 F2	1572	56	39	104	39	54	36	11.1
9. Pop 31 x Kamandaogo T. BC1 F2	1494	55	39	101	36	53	44	14.0
10. CSP x Kamandaogo Tollo BC1 F2	1463	54	39	102	30	53	41	12.0
11. D765 x Kamandaogo Tollo BC1 F2	1433	55	35	121	46	54	44	10.8
12. JFS x Kamandaogo Tollo BC1 F2	1125	55	42	113	38	51	33	12.4
13. Kamandaogo Tollo (check)	1046	56	35	103	37	54	46	8.8
14. Local Raytiri (check)	893	55	51	123	53	52	32	17.0
Overall Mean	1549	55	40	115	45	53	41	13.3
LSD 5%	1107	1.2	7.0	25.7	14.5	2.7	13.2	4.1
Prob. of F	0.595	0.067	0.000	0.120	0.000	0.342	0.381	0.001
C.V. (%)	49.8	1.5	12.3	15.6	22.5	3.6	22.4	21.9

Table 3.5 Grain yield and other agronomic characters tested in Extra-early-yellow BC1-1-1 at Gampela, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %	Ear rot %
1. Local Raytiri (check)	2629	56	40	127	54	53	52	14.6	0.0
2. Pop 46 x Kamandaogo Tollo BCl F2	2591	56	40	139	63	53	56	11.3	0.9
3. Kaïchan x Kamandaogo Tollo BCl F2	2556	55	40	136	59	53	53	14.1	0.5
4. JFS x Kamandaogo Tollo BCl F2	2508	56	40	141	60	50	50	14.5	0.5
5. SAFITA-104 x K. Tollo BCl F2	2402	56	43	149	63	51	51	14.2	0.0
6. Jaune Flint de Saria check	2402	55	43	127	56	52	53	11.2	0.0
7. Pool 29 x Kamandaogo T. BC1 F2	2394	55	46	170	69	45	38	17.7	1.4
8. WIR 17215 x Kamandaogo T. BC1 F2	2332	56	41	134	60	52	52	16.0	1.5
9. CSP x Kamandaogo Tollo BCl F2	2288	55	40	135	58	52	50	13.4	0.9
10. Pop 31 x Kamandaogo T. BC1 F2	2274	56	41	140	64	52	53	13.0	1.9
11. Pool 29 x JFS x K. T. BC1 F2	2237	56	46	188	92	48	46	15.5	1.7
12. Kamandaogo Tollo (check)	2129	56	47	164	79	50	49	16.5	1.5
13. SAFITA-104 x JFS x K. T. BC1 F2	2096	56	44	123	55	49	46	11.0	0.0
14. D765 x Kamandaogo Tollo BCl F2	1729	56	41	109	39	50	52	10.2	0.0
Overall Mean	2326	56	42	142	62	51	50	13.8	0.8
LSD 5%	607	1.0	0.6	14.5	11.6	4.7	5.4	3.7	1.4
Prob. of F.	0.289	0.505	0.000	0.000	0.000	0.069	0.000	0.003	0.057
C.V. (%)	18.2	1.3	1.1	7.2	13.0	6.6	7.5	18.7	134.2

Table 3.6 Grain yield (kg/ha) and days to 50% silking of varieties tested in Extra-early yellow BCl-1, Across 2 locations, 1987.

Entry	Gampela (Burkina F.)	Kamboinse (Burkina F.)	Means	Mean days to 50% silking
1. SAFITA-104 x JFS x K T. BC1 F2	2096	2248	2172	40
2. Pool 29 x Kamandaogo T. BC1 F2	2394	1945	2169	41
3. Kaïchan x Kamandaogo T. BC1 F2	2556	1730	2143	39
4. SAFITA-104 x JFS x K. T. BC1 F2	2402	1794	2098	44
5. Pop 46 x K. Tollo BCl F2	2591	1572	2082	40
6. Jaune Flint de Saria (check)	2402	1754	2078	45
7. WIR 17215 x K. Tollo BCl F2	2332	1619	1975	39
8. Pool 29 x JFS x K. Tollo BCl F2	2237	1577	1907	41
9. Pob 31 x K. Tollo BCl F2	2274	1494	1884	40
10.CSP x K. Tollo BCl F2	2288	1463	1876	40
11. JFS x K. Tollo BCl F2	2508	1125	1817	41
12. Local Raytiri (check)	2629	893	1761	46
13. Kamandago Tollo (check)	2129	1046	1587	41
14. D765 x K. Tollo BCl F2	1729	1433	1581	38
Location Mean	2326	1549		
C.V. (5%)	18	50		
LSD 5%	607	1107		
Prob. of F	0.2896	0.5959		

Table 3.7 Grain yield and other agronomic characters of varieties tested in Extra-early-yellow (BCl)-2 at Kamboinse, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %
1. Pop 35 x JFS K. Tollo, BCl, F2	2751	40	154	62	50	44	16.5
2. SAFITA-104 (check)	2350	38	119	37	53	46	15.1
3. WIR 15253 x K. Tollo, BCl, F2	2090	37	109	49	47	46	15.2
4. Pool 17 MP x Kamandago Tollo BCl,F2	2067	34	121	43	54	50	15.0
5. CJP 75 x Kamandaogo Tollo BCl, F2,	1958	45	134	66	53	41	20.2
6. Jaune Flint de Saria (check	1536	36	101	47	49	44	13.7
7. Local Raytiri (check)	1522	48	115	49	51	39	23.3
8. Kamandaogo Tollo (check)	1318	34	106	34	48	42	9.6
9. Local Raytiri x K. Tollo BCl, F2	1256	36	106	39	51	43	10.8
10. DMR-ESR-Y x JFS x K. Tollo BCl, F2	1147	37	103	36	49	42	14.1
11. TZEE-Y	684	38	96	40	52	44	9.5
Overall Mean	1698	39	115	46	51	44	14.8
LSD 5%	1397.0	5.2	36.0	20.0	4.2	10.7	4.1
Prob. of F	0.169	0.000	0.106	0.030	0.032	0.818	0.000
C.V. (%)	56.9	9.4	21.6	29.8	5.7	16.9	19.1

At Gampela, significant differences were recorded for yield, days to 50% silking and other important characters (moisture, husk cover, etc.). TZEE-Y (New extra-early composite) and Kamandaogo tollo were the earliest entries (39 DAP to 50% silking). TZEE-Y significantly outyielded Kamandaogo tollo (40%). These two entries also showed bad husk cover compared to other varieties tested in the same trial (Table 3.8). Across two locations, a yield of 2.6 t/ha was recorded for Pop 35 x JFS x K. tollo BC1 F2 which reached 50% silking 41 days after planting (Table 3.9).

f) Extra-Early White BC1: Kamboinse and Gampela:

Eight extra-early white backcrosses and 4 local checks were tested at 2 locations in Kamboinse and Gampela. At Kamboinse the differences in yields, days to silk and other important agronomic characters were significant (Table 3.10). Pool 16 IITA x GUA 314 BC1 F2 and GUA 314 (original extra-early material) were similar in terms of maturity. This new prolific combination also flowered 8 days before SAFITA-2 with a similar yields. It, however, showed susceptibility to stem lodging. At Gampela, yield differences between varieties were not significant (Table 3.11).

Across the two locations, EV8188 x GUA 314 BC1 F2 seemed to be the earliest entry (43 days to 50% silking) with grain yields of 2.2 t/ha (Table 3.12).

Table 3.8 Grain yield and other agronomic characters of varieties tested in Extra-early-yellow (BC1)-2, Gampela, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %	Husk cover %
1. Local Raytiri (check)	2621	54	46	152	61	53	47	20.5	4.0
2. Pop 35 x JFS x K.T. BC1,F2	2571	55	42	155	64	55	49	18.1	4.0
3. J. Flint de Saria (check)	2545	55	46	164	62	52	46	21.8	1.7
4. TZEE-y	2525	55	39	147	56	51	50	15.4	6.0
5. L. Raytiri x K. T. BC1, F2	2512	55	40	140	57	55	52	16.0	5.1
6. Pool 17 MP x K. Tollo BC1,F2	2504	54	41	139	51	53	52	17.9	5.7
7. WIR 15253 x K. Tollo BC1,F2	2041	54	41	150	59	51	50	19.0	5.6
8. CJP 75 x K. Tollo BC1, F2	1987	54	41	148	52	53	50	16.9	3.9
9. DMR-ESR-y x JFS x K.T. BC1,F2	1980	53	42	149	55	52	46	17.6	4.3
10. Kamandaogo Tollo (check)	1800	54	39	147	50	52	48	13.7	7.7
11. SAFITA-104-RE (check)	1797	54	44	151	67	53	37	28.6	3.3
Overall Mean	2262	34	42	149	58	53	48	18.7	4.7
LSD 5%	451	2.9	0.4	18.9	19.2	3.6	6.4	3.7	3.2
Prob. of F	0.000	0.829	0.000	0.410	0.719	0.539	0.004	0.000	0.068
C.V. (%)	13.8	3.7	0.8	8.7	22.9	4.8	9.2	13.9	47.5

Table 3.9 Grain yield (kg/ha) and mean of days to 50% silking of varieties tested in Extra-early yellow (BC1)-2 Across two locations Burkina Faso, 1987.

Entry	Gampela	Kamboinse	Means	Mean Days to 50% silking
1. Pop 35 JFS x Kamandaogo Tollo BC1,F2	2571	2751	2661	41
2. Pool 17 MP x K. Tollo BC1, F2	2504	2067	2285	38
3. SAFITA-104 RE (check)	1797	2350	2074	41
4. Local Raytiri (check)	2621	1522	2072	47
5. WIR 15253 x K. Tollo BC1, F2	2041	2090	2066	39
6. Jaune Flint de Saria (check)	2545	1536	2040	41
7. CJP 75 x Kamandaogo Tollo BC1,F2	1987	1958	1973	43
8. Local Raytiri x K. Tollo BC1, F2	2512	1256	1884	38
9. Extra-early Comp. yellow	2525	684	1604	39
10. DMR-ESR-y x JFS x K. Tollo BC1, F2	1980	1147	1564	40
11. Kamandaogo Tollo (check)	1800	1318	1559	37
Location Mean	2262	1698		
C.V. (%)	14	57		
LSD (5%)	451	1397		
Prob. of F.	0.000	0.169		

Table 3.10 Grain yield and other agronomic characters of varieties tested in Extra-early-white (BC1) at Kamboinse, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moist. %	Ear aspect	Stem lodging %	Ear rot %
1. SAFITA-2 RE (check)	4534	56	53	176	84	105	101	26.8	2	0.0	0.4
2. Local Raytiri (check)	4481	55	48	171	75	102	98	16.5	3	2.4	0.0
3. Pool 16 IITA x GUA 314 F2	3840	56	44	146	72	105	114	15.0	2	6.9	0.4
4. D822 w x GUA 314 BC1, F2	3805	54	45	159	65	99	107	17.8	3	3.9	0.0
5. Pool 27 x GUA 314 BC1, F2	3800	55	44	152	83	105	113	15.8	3	2.6	0.2
6. Jaune Flint de Saria (check)	3778	55	49	172	82	96	95	17.7	3	1.0	2.1
7. E-TZESR-w x GUA 314 BC1, F2	3593	55	47	160	85	103	110	16.6	3	4.3	0.2
8. Pool 28 FP x GUA 314 BC1, F2	3522	55	44	144	65	105	108	16.7	3	5.3	0.2
9. Pop 30 Early x GUA 314 BC1, F2	3417	55	45	146	64	102	109	15.5	4	7.3	0.9
10. EV 8188 x GUA 314 BC1, F2	3360	54	42	147	72	99	104	16.8	3	4.5	0.0
11. Pool 15 x GUA 314 BC1, F2	3285	54	45	156	70	95	101	17.2	3	3.5	0.5
12. GUA 314 (check)	3070	54	43	150	80	96	107	15.1	3	7.7	3.9
Overall Mean	3707	55	46	157	75	101	106	17.3	3	4.1	0.7
LSD 5%	746.0	1.9	2.3	15.8	18.5	9.8	9.8	2.7	0.6	4.5	1.3
Prob. of F	0.008	0.451	0.000	0.000	0.173	0.277	0.005	0.000	0.000	0.025	0.000
C.V. (%)	13.9	2.4	3.6	7.0	17.2	6.8	6.5	11.2	15.5	75.7	121.0

Table 3.11 Grain yield and other agronomic characters of varieties tested in Extra-early-white (BC1) at Gampela Burkina Faso, 1987

Entry	Grain yields kg/ha	Plant stand No.	Days 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %	Root lodging %	Ear rot %
1. Jaune Flint de Saria (check)	1747	52	47	160	63	49	38	22.1	1.0	0.5
2. Local Raytiri (check)	1484	51	48	154	63	48	33	23.5	3.9	4.7
3. Pop 30 Early x GUA 314 BC1, F2	1408	54	44	142	63	53	43	18.8	1.4	0.0
4. GUA 314 (check)	1383	52	45	142	71	48	42	16.7	2.1	2.4
5. Pool 28FP x GUA 314 BC1, F2	1242	52	44	143	61	51	41	14.4	4.2	1.1
6. D822W x GUA 314 BC1, F2	1199	52	44	136	71	50	40	23.2	0.9	0.6
7. Pool 15 x GUA 314 BC1, F2	1143	53	46	133	61	51	38	18.0	6.2	2.7
8. EV 8188 x GUA 314 BC1, F2	1088	52	44	138	62	51	39	19.9	1.4	2.0
9. E. TZESR-W x GUA 314 F2	1064	53	44	136	55	50	37	23.2	3.5	0.0
10. Pool 27 x GUA 314 BC1 F2	775	52	46	126	53	49	33	21.8	0.9	0.6
11. Pool 16 IITA x GUA 314 F2	721	50	46	133	54	46	32	14.4	0.8	0.5
12. SAFITA-2 RE (check)	653	46	56	138	68	45	22	45.5	5.9	0.0
Overall Mean	1159	52	46	140	62	49	36	21.8	2.7	1.2
LSD 5%	782.0	6.5	0.4	17.6	17.7	7.6	10.9	6.3	3.7	2.3
Prob. of F	0.194	0.598	0.000	0.033	0.485	0.697	0.023	0.000	0.033	0.005
C.V. (%)	46.8	8.9	0.6	8.7	19.7	10.8	20.7	20.1	96.2	126.6

Table 3.12 Grain yield (kg/ha) and mean of days to 50% silking of varieties tested in Extra-early-white (BCl) Across 2 locations, Burkina Faso, 1987.

Entry	Gampela	Kamboinse	Means	Mean days to 50% silking
1. Local Raytiri (check)	1485	4482	2983	48
2. Jaune Flint de Saria (check)	1747	3778	2763	48
3. SAFITA-2 RE (check)	653	4534	2594	54
4. D822W x GUA 314 BCl, F2	1199	3805	2502	45
5. Pop 30 Early x GUA 314 BCl, F2	1408	3417	2413	45
6. Pool 28 FP x GUA 314 BCl, F2	1242	3522	2382	44
7. E-TZESR-W x GUA-314 BCl, F1	1064	3593	2329	46
8. Pool 27 x GUA 314 BCl, F2	776	3800	2288	45
9. Pool 16 IITA x GUA 314, F2	721	3840	2280	45
10. GUA 314 (check)	1383	3071	2227	44
11. EV 8188 x GUA 314 BCl, F2	1088	3360	2224	43
12. Pool 15 x GUA 314 BCl, F2	1144	3285	2214	46
Location mean	1159	3707		
C.V. (%)	47	14		
LSD 5%	782	746		
Prob. of F	0.194	0.008		

g) Extra-Early Composites Kamboinse, Loumbila and Gampela:

During the 1987 dry season (February-May), 4 extra early composites were developed using the best yellow and white backcrosses. These 4 composites (TZEE-Y, TZEE-W-1, TZEE-W-2 and TZEE-W-3) were tested along with 6 local checks during the 1987 growing season at three locations: Kamboinse, Loumbila and Gampela. At Kamboinse, significant differences between varieties were observed for yields, days to 50% silking and other important agronomic characters (Table 3.13). TZEE-W-1 and TZEE-W-3 were as early as the recurrent parent GUA 314 with similar grain yields. TZEE-W-1 was significantly earlier than TZEE-4, local Rayitiri and SAFITA-2 with similar grain yields (4 t/ha) but showed very high susceptibility to stem lodging. Its husk cover was good. TZEE-Y was similar to Kamandaogo tollo (recurrent parent) in terms of days to 50% silking but was significantly superior in terms of grain yield (30%) and stem lodging resistance.

At Loumbila, significant differences were observed for days to silk and other agronomic characters but not for yields (Table 3.14). At this location, the new composites were among the earliest entries with more than 3 t/ha of grain yield but showed high susceptibility to stem lodging.

At Gampela, significant differences were obtained for grain yields, days to silk and other important agronomic characters. The new composites were among the earliest entries with susceptibility to stem lodging. TZEE-Y was the earliest and the highest yielding composite (Table 3.15).

Table 3.13 Grain yield and other agronomic characters of varieties tested in extra-early composites at Kamboinse, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant. Stand No	Days to 50 % silking	Plant height (cm)	Ear Height (cm)	Plants Harvested (cm)	Ears harvested (cm)	Moisture %	Ear Aspect	Stem lodging %	Husk cover %
1. TZE-4 (check)	4239	56	50	173	87	54	56	17.6	3	1.8	0.8
2. Local Rayitiri (check)	4218	56	47	173	69	54	58	15.8	4	0.0	3.4
3. SAFITA-104 (check)	4064	56	46	171	73	54	59	16.1	3	0.0	2.4
4. TZEE-w-1	4024	55	44	138	68	54	56	14.4	3	18.4	0.7
5. TZEE-Y	3876	55	40	137	55	54	63	11.7	4	7.7	6.5
6. TZEE-W-3	3758	55	40	151	69	54	63	12.9	2	0.0	1.2
7. TZEE-W-2	3463	56	43	149	64	54	62	13.2	3	4.1	0.4
8. SAFITA-2 (check)	3383	55	49	167	72	54	56	17.1	2	0.0	0.9
9. GUA 314 (check)	3164	55	42	151	70	54	62	13.5	4	5.5	1.6
10. Kamandaogo Tollo (check)	2972	52	40	116	44	51	56	8.9	4	33.5	8.6
Overall Mean	3716	55	45	152	67	54	59	14.1	3.0	7.1	2.7
LSD 5 %	753	2.0	2.7	15.9	15.9	2.3	9.6	2.9	0.9	16.7	4.9
Prob of F.	0.01	0.02	0.00	0.00	0.00	0.20	0.55	0.00	0.00	0.00	0.02
CV (%)	13.9	2.6	4.2	7.2	16.3	2.9	11.2	14.1	19.9	161.9	124.5

Table 3.14 Grain yield and other agronomic characters of varieties tested in Extra-early composites at Loumbila, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moist. %	Ear aspect (rate)	Stem lodging %	% husk cover
1. TZE-4 (check)	3839	51	50	185	96	44	42	20.6	2	5.4	7.4
2. TZEE-y	3715	56	39	161	78	52	55	20.4	3	22.1	9.6
3. Local Raytiri(check)	3586	55	46	189	95	49	49	25.3	2	10.8	10.0
4. TZEE-w-2	3539	56	44	164	91	52	54	21.4	2	11.7	3.1
5. SAFITA-104 (check)	3533	56	46	175	89	48	46	19.5	3	5.9	7.3
6. SAFITA-2 (check)	3483	52	45	181	86	48	48	22.2	1	9.3	3.6
7. GUA 314 (check)	3460	55	42	164	89	54	59	20.1	3	11.6	4.6
8. TZEE-w-3	3424	56	44	173	92	50	52	20.8	2	13.5	2.8
9. TZEE-w-1	3380	56	43	164	83	52	55	25.2	3	13.1	4.0
10. Kamandaogo Tollo(check)	2920	56	37	132	54	53	55	16.5	3	20.5	6.4
Overall Mean	3488	55	44	169	85	50	51	21.2	3	12.4	5.9
LSD 5%	251.0	2.2	1.3	14.0	17.0	3.6	3.9	4.5	0.8	9.5	4.3
Prob. of F	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
C.V. (%)	10.3	2.8	2.1	5.7	13.7	4.9	5.2	14.7	23.3	52.7	50.6

Table 3.15 Grain yield and other agronomic characters of varieties tested in Extra-early Composites at Gampela, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Moisture %	Stem lodging %
1. Local Raytiri	3106	54	47	176	75	50	52	18.4	8.9
2. TZE-4 (check)	2709	51	49	174	90	46	46	20.2	2.3
3. TZEE-Y	2468	53	40	135	60	49	51	11.8	13.3
4. SAFITA-104 (check)	2467	51	45	157	73	43	43	20.0	1.0
5. Kamandaogo Tollo (check)	2163	51	37	125	48	48	49	10.3	12.2
6. SAFITA-2 (check)	1951	47	48	162	75	42	42	16.9	10.0
7. TZEE-W-3	1845	55	44	161	83	52	52	16.6	12.4
8. TZEE-W-1	1820	53	43	166	88	49	45	13.2	6.9
9. GUA 314 (check)	1499	53	42	132	70	50	46	11.9	13.3
10. TZEE-W-2	1483	53	44	144	71	45	46	14.2	11.2
Overall Mean	2151	52	44	153	73	47	47	15.3	9.2
LSD 5%	689.0	4.8	1.7	19.1	13.8	6.7	8.8	2.9	8.2
Prob. of F	0.00	0.14	0.00	0.00	0.00	0.08	0.22	0.00	0.03
C.V. (%)	22.0	6.4	2.8	8.6	12.9	9.7	12.8	13.2	61.8

Across locations, TZEE-Y reached 50% silking 40 days after planting and yielded 3.3 t/ha, TZEE-W-1. TZEE-W-2 and TZEE-W-3, reached 50% silking 44 days after planting with yields of 3.0, 3.0, and 2.8 t/ha respectively (Table 3.16).

<u>Breeding for Early Maturity (90-95 days to maturity)</u>:

In 1984, it became necessary to develop new early yellow population using local and improved germplasm. Therefore, 36 improved varieties of various origins (CIMMYT, IITA, National Programs of SAFGRAD member countries) were crossed with Jaune Flint de Saria (JFS) (local improved variety well adapted in Sudan Savanna of Burkina Faso) in order to combine high yields, earliness, root lodging and resistance to foliar disease. In the 1985 dry season, these crosses were advanced to F2 and then tested in the rainy season at three locations in Burkina Faso. The best yellow crosses together with local Rayitiri (good local variety) were diallel crossed to give a new population TZEF-Y (Tropical Zea Early Flint Yellow). This population was included in Regional Uniform Variety Trials (RUVT-1) in 1987 and also tested at two locations, Kamboinse and Farako-Bâ, in Burkina Faso.

<u>RUVT-1 Kamboinse and Farako-Bâ</u>:

This trial consisted of promising varieties nominated by SAFGRAD Maize Breeding Resident Research Program, Ghana National Program and IITA-CIMMYT Program. Materials were tested by National Program of SAFGRAD member countries as well as the Resident Program in Burkina Faso.

Table 3.16 Grain yield and days to 50% silking of extra-early composites across three locations in Burkina Faso.

Locations	Gampela	Kamboinse	Loumbila	Means	Mean days to 50% silking
1. Local Raytiri (check)	3106	4218	3586	3637	47
2. TZE-4 (check)	2709	4239	3840	3596	50
3. SAFITA-104 (check)	2467	4063	3533	3355	46
4. TZEE-y	2469	3876	3715	3353	40
5. TZEE-W-1	1820	4024	3381	3075	44
6. TZEE-W-3	1845	3758	3424	3009	44
7. SAFITA-2 (check)	1951	3383	3483	2939	47
8. TZEE-W-2	1483	3463	3539	2828	44
9. GUA 314 (check)	1499	3164	3460	2708	42
10. K. Tollo (check)	2164	2972	2920	2685	38
Location Mean	2151	3716	3488	3118.8	44
C.V. (%)	22	14	10		
LSD (%)	689	754	521		
Prob. of F.	0.005	0.145	0.1098		

a) RUVT-1 Kamboinse:

At Kamboinse, differences between varieties were not significant: Pool 16 DR C1 seemed promising. Capinopolis 8245 was highly susceptible to root lodging (Table 3.17).

RUVT-1: Farako-Bâ:

Significant varietal differences in grain yields, days to silk, and other agronomic characters were obtained (Table 3.18). SAFITA-2, Capinopolis 8285 and Kawanzie, were very promising. They significantly outyielded (80%) the local check (Jaune Flint de Saria). But they were also significantly late maturing. Pop CSP, TZEF-Y and the local check were the earliest entries. Pop CSP, Kamboinse (1) 8433 and the local check showed the highest degree of susceptibility to ear rot at Farako-Bâ.

b) EVT 16 A:

14 early subtropical varieties developed by CIMMYT along with two local checks were tested at Loumbila. Significant differences were recorded for yield, days to 50% silking and other important agronomic characters (Table 3.19). Across 8445 and Kamboinse 8433 significantly outyielded SAFITA-2 (local check) by 80% and 65% respectively. But they were not significantly different from the check 1 (Kamboinse 86 pool 16 DR). Across 8445 showed a high percentage of bad husk cover compared to other varieties. Varieties developed from populations 46 and 48 showed higher susceptibility to root lodging. SAFITA-2 (local check) was also highly susceptible to root lodging.

Table 3.17 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Kamboinse, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Ear aspect rate	Root lodging %
1. Pool 16 DR C1	4449	56	48	169	93	55	53	2	16.3
2. Capinopolis 8245	4024	56	51	195	105	54	46	4	39.1
3. Pool 16 DR CO	3577	54	49	165	78	52	52	2	30.0
4. TZEF-Y F_3	3521	56	44	171	75	54	52	3	16.4
5. Early 84 TZESR-W	3481	54	47	156	77	52	53	2	6.6
6. Kawanzie	3442	56	50	171	81	54	48	1	23.9
7. EV 8431 SR	3363	55	46	170	81	52	47	3	6.0
8. Kamboinse (1) 8433	3347	54	47	147	72	53	49	3	8.4
9. Kamboinse(1) 84 TZESR-W	3304	65	47	171	92	53	47	2	6.0
10. Pop CSP	3110	56	47	158	71	53	49	3	3.3
11. SAFITA-2 RE	2868	56	50	175	89	55	47	2	17.7
12. Pop 30 SR Early	2861	54	47	161	70	53	48	3	20.9
13. Local check	2803	54	45	169	77	52	48	3	10.8
Overall Mean	3396	55	48	168	82	53	49	3	15.8
LSD 5%	1227.0	2.3	2.9	16.3	20.2	1.9	8.1	0.8	21.9
Prob. of F	0.336	0.330	0.001	0.000	0.036	0.006	0.719	0.000	0.063
C.V. (%)	25.1	2.9	4.3	6.7	17.2	2.6	11.5	21.8	96.4

Table 3.18 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant stand No.	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	No. of rotten ears (%)
1. SAFITA-2 RE	5119	54	55	181	101	49	57	0.5
2. Capinopolis 8245	5048	55	56	184	94	51	54	12.4
3. Kawanzie	4881	53	56	167	84	47	54	2.1
4. EV 8431 SR	4786	51	55	157	69	49	53	2.0
5. Kamboinse (1) 84 TZESR-W	4500	52	56	177	81	48	54	2.6
6. Early 84 TZESR-W	4429	51	56	172	80	51	53	3.9
7. Pool 16 DR C1	4262	52	56	151	70	51	56	4.9
8. Pop 30 SR Early	4071	52	56	169	87	51	53	3.4
9. Pop CSP	3976	48	56	152	66	47	51	20.4
10. Pool 16 DR CO	3952	53	55	157	79	51	54	3.4
11. TZEF-y F3	3809	47	56	156	74	49	50	19.7
12. Kamboinse (1) 8433	3548	51	56	136	70	51	54	20.1
13. Local check	2714	49	56	162	74	44	45	15.6
Overall Mean	4238	51	56	163	79	49	53	8.5
LSD 5%	792.2	1.7	0.7	22.1	20.9	5.1	6.6	10.4
Prob of F.	0.000	0.000	0.787	0.004	0.049	0.224	0.174	0.000
C.V. (%)	13.0	2.4	0.9	9.4	18.4	7.3	8.7	84.9

Table 3.19 Grain yield and other agronomic characters of varieties tested in EVT-16A at Loumbila, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Root lodging %	Husk cover %
1. Across 8445	5297	52	188	96	44	43	16.2	22.5
2. Kamboinse 8433	4849	49	170	80	43	45	16.9	12.7
3. Cravinhos 8445	4357	51	182	87	43	43	10.9	14.5
4. Udairpur 8433	4322	51	182	90	43	44	24.4	10.1
5. La Esperanza 8433	4293	51	167	88	43	42	16.5	18.2
6. Tlaltizapan 8546	4233	50	180	86	43	44	23.0	11.2
7. Across 8346	4130	46	167	76	43	45	35.1	11.7
8. Across 8433	4111	51	181	100	44	43	21.1	8.2
9. Yousafawala 8433	4054	51	186	98	44	44	18.7	6.8
10. Across 7748 RE	3959	49	192	96	44	41	33.7	13.6
11. Kamboinse 86 Pool 16 DR	3933	51	183	90	43	42	20.8	7.5
12. Across 8448	3675	50	180	84	44	43	56.7	11.0
13. Dholi 8448	3667	50	182	87	43	43	51.2	14.9
14. Across 7845 RE	3666	54	184	90	43	41	10.9	17.9
15. Tlaltizapan 8433	2975	53	179	97	43	41	17.9	12.8
16. SAFITA-2	2930	53	187	102	41	41	48.0	3.6
Overall Mean	4028	51	181	90	43	43	26.4	12.3
LSD 5%	1254.0	1.2	13.0	13.0	1.1	3.8	29.6	8.0
Prob. of F.	0.058	0.000	0.008	0.007	0.034	0.506	0.047	0.003
C.V. (%)	21.8	1.9	5.0	9.9	1.9	6.3	78.8	45.6

c) EVT-ESR-W:

This trial comprised 8 early streak resistant varieties from IITA-CIMMYT along with two local checks and was planted at Farako-Bâ. Significant differences were observed between varieties for yield, days to 50% silking and other important agronomic characters (Table 3.20). None of the tested varieties significantly outyielded the local checks. DMR ESR-W and Kamboinse 86 pool 16 DR) gave the highest grain yields of 5.4 t/ha.

Breeding for Intermediate Maturing Varieties:

Intermediate maize streak resistant varieties (96-110 days to maturity) are useful in the Northern Guinea Savanna Zone (900-1200 mm rainfall). SAFGRAD Annual Regional Program included intermediate maturing varieties in RUVT-2, and also evaluated varieties from CIMMYT and IITA in order to identify good materials for distribution to national programs of SAFGRAD member countries.

a) RUVT-2, Farako-Bâ:

Varieties used in this trial were nominated by SAFGRAD Resident Research Program, National Program of Ghana, IITA-CIMMYT. Significant differences were recorded for yield and important agronomic characters (Table 3.21). EV8422 SR and Kamboinse (2) 83TZUT-W yielded 5.8 t/ha and 5.7 t/ha respectively. The local check was highly susceptible to stem lodging and ear rot.

Table 3.20 Grain yield and other agronomic characters of varieties tested in EVT-EST-W at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant Stand No	Days to 50 % silking	Plant height (cm)	Ear Height (cm)	Plants harvested No	Ears harvested No
1. DMR-ESR-White	5434	43	53	196	115	41	44
2. Kamboinse 86 Pool 16 DR	5352	44	52	181	95	43	44
3. Samaru 84 TZESR-W	5184	44	51	171	82	44	46
4. Across 84 Pool 16	5099	44	50	177	90	41	44
5. Guebi 84 Pool 16	4970	43	50	172	87	41	41
6. Across 84 TZESR-W	4926	44	51	181	96	42	44
7. Farako-Bâ 86 Pool 16 HD	4858	44	50	171	91	43	44
8. EV 84 30-SR BC4	4547	44	50	179	87	41	43
9. Ikenne84 Pool 16	4371	43	50	164	85	44	43
10.Gusau 81 Pool 16 (RE)	4112	44	50	159	89	42	42
Overall Mean	4885	44	51	175	92	42	44
LSD 5 %	627.8	0.7	1.2	17.1	19.1	2.4	3.0
Prob of F.	0.002	0.111	0.000	0.010	0.092	0.139	0.146
CV (%)	8.8	1.2	1.7	6.7	14.3	4.0	4.8

Table 3.21 Grain yield and other agronomic characters of varieties tested in RUVT-2 at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Stem lodging %	No of rotten ears(%)
1. EV 8422 SR	5876	43	62	190	102	43	43	3.4	0.0
2. Kamboinse (2) 83TZUT-W	5766	44	59	197	105	42	42	1.7	1.8
3. Across 83TZUT-W	5670	44	59	194	99	42	42	4.7	2.2
4. EV 8428 SR	5647	43	59	195	105	42	43	4.0	1.1
5. Loumbila 84TZUT-y	5626	44	55	177	92	41	42	4.8	2.9
6. EV8443-SR	5511	44	61	210	112	41	39	6.2	0.6
7. Farako-Bâ 85 TZSR-W1	5227	44	62	217	119	43	42	6.9	1.1
8. Samaru 83 TZSR-Y-1	5162	44	60	199	114	43	40	5.2	1.9
9. EV 8449 SR	4855	43	57	162	77	42	43	1.1	4.0
10. SAFITA-102 (RE)	4729	44	53	164	94	41	44	4.8	3.4
11. Aburotia	4430	44	60	147	75	41	43	1.1	2.4
12. D822	4009	43	54	169	90	42	43	15.2	12.2
Overall Mean	5209	44	58	185	99	42	42	4.9	2.8
LSD 5%	751.3	0.7	2.4	26.8	20.1	2.3	3.6	5.1	5.3
Prob. of F	0.000	0.327	0.000	0.000	0.001	0.578	0.444	0.000	0.009
C.V. (%)	10.0	1.2	2.9	10.0	14.1	3.8	5.9	72.4	131.1

b) EVT-ISR White Farako-Bâ:

Eight(8) varieties from IITA-CIMMYT Maize Program together with two local checks were evaluated in this trial at Farako-Bâ. Significant differences were obtained for yield and important agronomic characters. Very high yields were recorded (Table 3.22). None of the tested varieties significantly outyielded the best check SR-22. IKE83TZUT-W and EV8540-SR BC4 were very promising. However, IKE 83TZUT-W was susceptible to ear rot and had bad ears. IKE (1) 8149 SRBC5 were highly susceptible to root lodging at this location.

c) EVT-ISR Yellow Farako-Bâ:

Five (5) yellow intermediate streak resistant varieties from IITA-CIMMYT program and two local checks were evaluated in this trial, which produced significant differences for yields and other important agronomic characters. TZSYN6 SR-Y and Pop 66-SR-BC3 were the latest entries (Table 3.23). None of the earliest varieties significantly outyielded the best local check (Farako-Bâ 86 Pool 16 DR) - Bert-82TESR-Y developed bad ears.

d) ELVT 18B Farako-Bâ:

Ten (10) early and intermediate varieties from CIMMYT along with two local checks were tested in this trial. The differences between varieties were significant for yield and other agronomic characters (Table 3.24). SR22 (local check) was the latest and gave the highest yield of 5.9 t/ha. Only two varieties (Los Bânos (1) 8232 and Across 8223) significantly outyielded the worse check (Farako-Bâ pool 16 HD) which was significantly early maturing.

Table 3.22 Grain yield and other agronomic characters of varieties tested in EVT-ISR-White at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Ear aspect rate	Rotten ears No.	Root lodging %
1. Ikemé 83 TZUT-W	6743	44	58	212	104	42	40	4.7	4	0.6
2. EV 8540-SR BC4	6686	43	59	212	122	41	41	1.7	1	4.7
3. Kamboinse 83 TZUT-W	6606	43	57	207	115	42	42	4.7	3	9.1
4. Ilonga 83 TZUT-W	6472	44	57	210	112	42	42	4.5	3	9.6
5. SR 22	6379	43	61	200	113	42	40	1.5	1	0.6
6. Samaru 83 TZUT-W	6330	43	57	217	104	41	39	5.0	3	6.6
7. Across 83 TZUT-W	6142	42	58	210	105	41	40	4.0	2	1.7
8. TZSYN-1 SR-W	5424	44	59	200	109	43	41	3.5	2	2.8
9. Ikenne(1) 8149 SR BC5	5407	44	56	179	91	42	42	2.0	2	31.7
10. SAFITA-102	4954	43	53	196	109	41	42	3.7	2	11.4
Overall Mean	6114	43	58	204	108	42	41	3.5	2	7.9
LSD 5%	755.1	1.4	1.4	22.0	14.8	2.4	3.1	1.0	1.7	9.0
Prob. of F	0.000	0.326	0.000	0.052	0.022	0.531	0.689	0.000	0.027	0.000
C.V. (%)	8.5	2.2	1.6	7.4	9.4	4.0	5.2	20.8	47.7	78.1

Grain yield and other agronomic characters of varieties tested in EVT-E-ISR-yellow at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height No.	Plants harvested No.	Ears harvested No.	Ear aspect rate
1. TZSYN 6 SY-y	6112	44	58	204	117	42	45	3.2
2. DMR-ESR-yellow	5410	44	53	195	110	43	42	2.5
3. Bertoua 82 TZESR-y	5142	44	54	194	97	42	43	4.7
4. Farako-Bâ 86 Pool 16 HD	5054	43	51	184	96	42	42	2.7
5. Pop 66 SR BC3	5037	44	56	200	107	43	44	2.7
6. Kamboinse 86 Pool 16 DR	5028	43	52	181	89	41	43	3.5
7. EV 8431-SR BC4	4650	44	50	170	86	42	43	3.5
Overall Mean	5205	44	54	190	100	42	43	3.2
LSD 5%	441.8	0.7	1.5	15.7	22.2	2.3	2.6	0.8
Prob. of F	0.000	0.455	0.000	0.003	0.071	0.757	0.197	0.000
C.V. (%)	5.7	1.1	1.9	5.6	14.8	3.7	4.1	17.1

Table 3.24 Grain yield and other agronomic characters of varieties tested in ELVT-18B at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Ear aspect rate	Root lodging %	No.of ear rot(%)
1. SR 22	5934	44	62	196	101	44	40	2.5	11.3	7.0
2. Los Banos (1) 8232	5897	43	59	186	100	43	43	1.7	5.1	1.1
3. Across 8223	5856	44	56	196	110	43	44	3.7	18.9	8.9
4. Suwan 8331	5152	44	52	185	97	42	42	3.2	19.8	11.2
5. Across 8331	5148	44	52	176	91	41	42	3.2	20.2	10.6
6. Poza Rica 8349	5096	44	55	151	66	43	44	2.0	36.9	1.6
7. Masaya 8349	5047	43	55	165	77	42	42	2.7	40.0	1.7
8. Pirsabak (1) 7930 (RE)	5045	44	51	179	96	42	46	3.5	24.2	8.6
9. Across 7726 RE	5031	44	56	200	107	43	43	3.2	6.9	12.7
10. Sanguere 8330	5015	44	52	177	96	41	45	2.5	25.9	6.5
11. Poza Rica 8326	4863	44	55	177	79	43	45	2.7	30.9	2.4
12. Farako-Bâ 86 Pool 16 DR	4859	44	53	164	86	42	45	3.2	26.0	6.5
Overall Mean	5245	44	55	179	92	43	44	2.8	22.2	6.5
LSD (5%)	801.4	0.4	1.3	19.7	15.2	2.4	4.0	0.7	21.0	5.3
Prob. of F	0.049	0.206	0.000	0.000	0.000	0.318	0.162	0.000	0.035	0.000
C.V. (%)	10.6	0.7	1.8	7.6	11.4	3.9	6.3	18.5	65.4	56.4

Varieties from populations 49 and 26 showed high susceptibility to root lodging. Populations 31 and 26 are susceptible to ear rot.

Breeding for Drought Resistance:
A.O. Diallo; M.S. Rodriguez

The main objectives of this program were (i) improvement of Pool 16 (early white tropical white dent pool) developed by CIMMYT and adapted to the Sudan Savanna of West Africa (ii) identification of drought resistant germplasm within available materials to develop a drought resistant pool and (iii) development of extra-early maize varieties which escape the drought stress occuring during the beginning or the end of the season.

Agronomic research at IITA/SAFGRAD since 1979 showed very marked response of maize to tied ridges on the ferruginous tropical soils common in the Sudan Savanna. By growing sets of varieties using both simple and tied ridges as main plots and varieties or families as split plots, the performance of the genotypes under two drought stress conditions (more and less stress) could be evaluated. Simple and tied ridges were used as new methods for families and for varietal evaluation of resistance to drought stress.

a) Population Improvement:

In 1982, Pool 16 was identified as resistant to drought compared with other materials tested with it under irrigation at Loumbila and Vallée du Kou (Burkina Faso). In 1983, this pool was structured in full sib (FS) families as well as SAFITA-2 (experimental variety derived from it).

In the 1984 growing season, 219 FS (from Pool 16 and SAFITA-2) were tested under more and less stress conditions at Kamboinse. The remaining seeds of FS families were planted in a breeding nursery and crossed with Pool 16 SR BC4 (streak resistant version handled at IITA Ibadan). From the trials, 26 FS which performed better than the population mean at each stress level were selected as drought resistant. The seeds from the breeding nursery of those selected families were planted for recombination to form Pool 16 drought resistant cycle one (Pool 16 DR C1). The balanced bulk of the 219 FS (from the breeding nursery) was recombined to form Pool 16 drought resistant cycle zero (Pool 16 DR CO). Two experimental varieties: Kamboinse 84 Pool 16 DR (drought resistant) and Kamboinse Pool 16 DS (drought susceptible i.e. low yielder under more stress and high yielder under less stress conditions) were developed. In 1985, Pool 16 DR C1 was restructured again in FS families and tested at three locations in Burkina Faso and at one location in Mexico in collaboration with CIMMYT.

The Burkina Faso trials were conducted at Kamboinse and Gampela using tied and simple ridges and at Farako-Bâ using high density. Thirty one FS families were selected across three locations and recombined to form Pool 16 DR C2. From the recombination block 514 half sib families (HS) were harvested and replanted for selfing. More than 600 S1 families were selected and will be crossed with Pool 16 DR handled at CIMMYT Mexico for testing during the 1988 growing season. Four experimental varieties (Kamboinse 86 Pool 16 DR, Kamboinse 86 Pool 16 DS, Farako-Bâ 86 Pool 16 HD and

Early Pool 16 DR) were developed and tested with the different varieties, Across 86 Pool 16 DR was also developed from 11 FS families found to be drought resistant in Mexico and at Kamboinse. These new drought resistant experimental varieties will be tested in 1988. Tables 3.25 to 3.29 give grain yields and other important characters of varieties tested in EV Pool 16 DR at four locations in Burkina Faso.

EV Pool 16 DR - Kamboinse Block-K:

Ten entries including 2 varieties selected for drought resistance, 2 varieties selected for drought susceptibility, one variety selected for drought resistance and earliness, and SAFITA-2 (reference entry) were tested in a split plot design using tied and simple ridges as main plots and entries as split plots. Plots of 3 rows (5 m x 0.75 m) were used with 53000 plants ha. There were 6 replications. All the three rows were harvested. This trial was planted on July 2, 1987.

Table 3.25 shows the relative performance of varieties in terms of grain yield under more and less stress conditions and the mean number of days to 50% silking. For yields significant differences were not recorded for ridging systems, varieties and ridging system x variety interaction.

EV Pool 16 DR - Kamboinse Block F4:

The same varieties, same design and same plant population densities as in Block K were used. This trial was planted on July 13, 1987. Significant differences were not observed for yield (Table 3.26). For days to 50% silking, significant differences were recorded between ridging systems and between varieties; differences between

Table 3.25 Grain yield and other agronomic characters of varieties tested in EV-Pool 16 DR under two drought stress levels at Kamboinse, Block K, Burkina Faso, 1987.

Variety	Grain Yields Kg/ha		Mean	Rank	Mean days to 50% silking
	More stress	Less stress			
1. Pool 16 DR C1	1292	2120	1706	6	52.2
2. Kamb. 84 Pool 16 DR	1321	2018	1670	9	51.9
3. FB 86 Pool HD	1379	2250	1815	5	51.2
4. SAFITA-2 RE	1118	2236	1677	8	52.2
5. Kamb. 86 Pool 16 DS	1670	2367	2018	2	50.3
6. Kamb. 84 Pool 16 DS	1481	1902	1691	7	50.6
7. Kamb. 86 Pool 16 DR	1771	2047	1909	3	50.0
8. Early 86 Pool 16 DR	1655	2047	1851	4	51.2
9. Pool 16 DR CO	1292	1786	1539	10	51.0
10. Pool 16 DR C2	1655	2497	2076	1	50.7
Mean	1463	2127	1795		51.2
C.V. (%)	28				4
Prob. of F. for					
- Ridging system	0.48				0.81
- Varieties	0.21				0.07
- Ridging system x varieties	0.60				0.51
LSD 5% for					
- Means	409				1.7
- Ridging x varieties					

Table 3.26 Grain yield and other agronomic characters of varieties tested in EV Pool 16 DR at Kamboinse Block F 4, Burkina Faso, 1987.

Variety	Grain Yields Kg/ha More stress	Grain Yields Kg/ha Less stress	Mean	Rank	Mean days to 50% silk.	No. ear/ 100 plants
1. Pool 16 DR C2	1176	2192	1684	3	49.2	80.5
2. Farako-Bâ 86 Pool 16 DR HD	1234	2091	1662	4	48.3	81.3
3. Kamb. 86 Pool 16 DS	1164	2149	1655	7	48.9	78.2
4. Early 86 Pool 16 DR	1234	2091	1662	4	48.1	82.4
5. Kamb. 86 Pool 16 DR	1121	2192	1657	6	48.9	82.2
6. SAFITA-2 RE	1002	1858	1430	9	50.0	71.7
7. Kamb. 84 Pool 16 DR	958	1902	1430	9	50.2	67.1
8. Kamb. 84 Pool 16 DS	1190	2105	1648	8	48.4	82.1
9. Pool 16 DR Cl	1249	2236	1742	1	49.6	78.9
10. Pool 16 DR CO	1176	2236	1706	2	49.0	74.4
Mean	1150	2105	1627		49.0	77.9
C.V. (%)	19				2	1.3
Prob. of F. for						
- Ridging system	0.14				0.06	0.12
- Varieties	0.2				0.04	20.01
- Ridging x varieties	0.99				0.43	0.48
LSD for						
- Means	258				1.6	8.2
- Ridging x varieties						

the number of ears/plant (prolificacy) in the varieties were significant.

SAFITA-2 and Kamboinse 84 Pool 16 DR were the latest entries whereas Early 86 Pool 16 DR was the earliest. SAFITA-2 was significantly later than Early 86 Pool 16 DR. Early 86 Pool 16 DR gave the highest number of ears/plant, and was significantly higher than SAFITA-2.

EV Pool 16 DR - Loumbila:

This trial was similar to EV Pool 16 DR-Kamboinse Block K and F4 except that at this location, 4 rows plots were used and two central rows were harvested. The trial was planted on July 14, 1987. Significant differences between varieties were recorded for yields, days to silk, shelling percentage, number of grain/m² and synchronization. Also the varieties x drought stress levels interactions were significant for prolificacy and synchronization (Table 3.27). Farako-Bâ 86 Pool 16 HD gave the highest yield, significantly higher than SAFITA-2 and the cycle 1. SAFITA-2 was the latest and Kamboinse 86 Pool 16 DS the earliest. SAFITA-2 was significantly later than Early 86 Pool 16 DR. Under more stress conditions, Early 86 Pool 16 DR, Pool 16 DR C1 and Pool 16 DR CO gave significantly higher number of ears/ plant than SAFITA-2. Under less stress conditions Farako-Bâ 86 Pool 16 HD gave the highest number of ears/plant. For the cycle 2 and SAFITA-2, the number of ears/plant was significantly reduced by drought stress.

Farako-Bâ Pool 16 HD and Kamboinse 84 Pool 16 DR showed the highest shelling percentage and the cycle 1 and 2 were the lowest. The highest number of grain/m² were

Table 3.27 Grain yield and other agronomic characters of varieties tested in EV Pool 16 DR under two levels of drought stress at Loumbila, Burkina Faso, 1987.

Variety	Grain yields Kg/ha More stress	Grain yields Kg/ha Less stress	Grain yields Kg/ha Mean	Rank	Mean days to 50% silking	Prolific More stress	Prolific Less stress	Prolific Mean	Sh.% Mean	NSQM Mean	Synchronization More stress	Synchronization Less stress	Synchronization Mean
1. Kamb. 84 Pool 16 DR	2593	3029	1811	2	48.2	93.5	97.3	95.4	85.3	1376	0.7	1.0	0.8
2. Kamb. 86 Pool 16 DS	2899	2659	2779	3	47.3	94.2	98.8	96.5	84.9	1434	0.7	0.0	0.3
3. Pool 16 DR C1	2768	2680	2724	7	49.2	96.8	98.4	97.6	82.8	1356	0.5	0.7	0.6
4. Pool 16 DR C2	2637	2877	2757	5	48.8	93.1	99.6	96.3	82.9	1372	1.0	0.0	0.5
5. Kamb. 84 Pool 16 DS	2615	2659	2637	8	48.3	96.6	96.4	96.5	84.8	1287	1.0	1.2	1.1
6. Farako-Bâ 86 Pool 16 HD	2964	3116	3040	1	48.6	96.6	100.4	98.5	85.5	1436	0.0	0.5	0.2
7. Early 86 Pool 16 DR	2833	2397	2615	9	48.2	99.6	92.7	96.2	84.0	1320	0.0	0.5	0.2
8. Pool 16 DR CO	2811	2746	2779	3	48.6	97.7	96.0	96.9	84.1	1489	0.3	1.0	0.7
9. SAFITA-2 RE	2245	2441	2342	10	49.9	90.4	98.8	94.6	83.1	1149	0.5	0.8	0.7
10. Kamb. 86 Pool 16 DR	2593	2899	2746	6	48.7	93.9	99.2	96.5	84.9	1377	0.2	0.3	0.2
Mean	2696	2750	2723		48.6	95.2	97.8	96.5	84.2	1360	0.5	0.6	0.5
C.V. (%	13.8				1.9	54			2.3	11	115.9		
Prob. of F. for													
- Ridging system	0.9				0.07	0.47			0.84	0.96	0.46		
- Varieties	0.01				<0.01	0.88			0.003	<0.01	0.017		
- Ridging x varieties	0.16				0.62	0.03			0.18	0.38	0.03		
LSD 5% for													
- Means	307				0.76	4.3			1.6	126	0.6		
- Ridging x varieties						6.1					0.7		

recorded for Farako-Bâ 86 Pool 16 HD, the cycle O and Kamboinse 86 Pool 16 DS. SAFITA-2 and Kamboinse 84 Pool 16 DS gave the lowest number of grain/m². Under less stress conditions Fārako-Bâ 86 Pool 16 HD, Early 86 Pool 16 DR and Kamboinse 86 Pool 16 DR showed the better synchronization between silking and anthesis. The difference between the two drought stress levels in terms of synchronization was significant for the cycle O.

EV Pool 16 DR - Kamboinse Block E:

Same as the trials planted at Loumbila except the plant density was 33000 plants/ha. The trial was planted on July 27, 1987. Because the trial was planted late, supplementary irrigation was supplied from September 15 in order to assure plant survival. For yield and 1000 SWT (Thousand Seed Weight) significant differences were observed between ridging systems. The differences between thousand seed weights of varieties were significant. The drought stress levels x varieties interaction was not significant for 1000 SWT (Table 3.28). SAFITA-2 and Kamboinse 86 Pool 16 DR were the latest and Kamboinse 84 Pool 16 DS and Early 86 Pool 16 DR the earliest. SAFITA-2 was slightly later than early 86 Pool 16 DR. The highest means of 1000 SWT were recorded for Kamboinse 84 Pool 16 DS the cycle 1 and the cycle 2. The lowest was for the cycle O.

EV Pool 16 DR - Farako-Bâ:

This trial was planted at Farako-Bâ in the Northern Guinea Savanna Zone (900-1200 mm rainfall) to evaluate the varieties under better moisture conditions. A complete randomized block design 4 replications, 4-row plot

Table 3.28 Grain yield and agronomic characters of varieties tested in EV Pool 16 DR at Kamboinse Block E 10, Burkina Faso, 1987.

Variety	Grain Yields Kg/ha More stress	Grain Yields Kg/ha Less stress	Mean	Rank	Mean days to 5% silking	1000 SWT (2) More stress	1000 SWT (2) Less Stress	Mean
1. F.B 86 Pool 16 HD	1947	2354	2150	3	50.7	222	222	222
2. SAFITA-2 RE	1363	2170	1766	10	52.0	204	233	219
3. Early 86 Pool 16 DR	1840	2332	2086	4	50.0	211	234	223
4. Kamboinse 86 Pool 16 DS	1309	2247	1778	9	50.8	196	236	216
5. Pool 16 DR C2	1917	2488	2203	2	50.7	220	236	228
6. Pool 16 DR CO	1337	2319	1828	8	51.3	203	222	213
7. Pool 16 DR C1	2262	2458	2360	1	50.1	233	237	235
8. Kamboinse 86 Pool 16 DR	1177	2696	1936	6	52.1	196	237	217
9. Kamboinse 84 Pool 16 DR	1412	2283	1848	7	50.5	217	229	223
10. Kamboinse 84 Pool 16 DS	1391	2632	2011	5	49.6	224	246	235
Mean	1595	2398	1997		50.8	213	233	223
C.V. (%)	30				4	8		
Prob. of F. for								
- Ridging system	0.015				0.6	0.013		
- Varieties	0.2				0.07	0.02		
- Ridging x varieties	0.2				0.27	0.078		
- LSD 5% for								
- Means	487				1.7	14		
- Ridging x varieties						20		

Table3.29 Grain yield and other agronomic characters of varieties tested in EV Pool 16 DR at Farako-Bâ, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.
1. Pool 16 DR C2	5093	55	52	156	80	54	54
2. Kamboinse 84 Pool 16 DR	4974	56	52	155	91	54	54
3. Kamboinse 86 Pool 16 DR	4965	56	52	152	74	52	54
4. Early 86 Pool 16 DR	4898	56	52	154	85	53	53
5. Kamboinse 86 Pool 16 DS	4895	55	51	161	80	53	54
6. Kamboinse 84 Pool 16 DS	4819	55	52	157	80	53	54
7. Pool 16 DR CO	4699	56	52	157	72	54	55
8. Pool 16 DR C1	4692	56	52	159	80	53	54
9. SAFITA-2	4462	56	54	146	69	53	53
10. FARAKO-BA 86 Pool 16 HD	4208	55	52	159	86	52	53
Overall Mean	4770	56	52	156	80	53	54
LSD 5%	1121	0.8	1.3	24.1	19.7	4.0	3.4
Prob. of F.	0.876	0.147	0.101	0.981	0.468	0.722	0.868
C.V. (%)	16.1	1.0	1.8	10.7	17.0	5.2	4.4

5.20 x 0.75 m was used with a population density of 66000 plants/ha. Fertilizer $N-P_2O_5-K_2O$ was applied at the rate of 108-60-45 kg/ha. Analysis by means of F test showed that the differences in yield and other important agronomic characters of varieties were not significant. The relative performance of the cycle 2 was better than the cycle 0, cycle 1 and SAFITA-2. Early 86 Pool 16 DR was among the earliest and SAFITA-2 the latest. Across 5 trials, a trend of improvement from cycle to cycle was observed. A mean of 6% progress was recorded from cycle to cycle under more stress conditions and 5% under medium stress conditions. There was also some improvement under less stress conditions (4.7% per cycle) (Table 3.30). Pool 16 DR C2 seemed better than SAFITA-2 by 28.9%, 15.5% and 14.4% under three decreasing levels of drought stress i.e. more, medium and less stress conditions. Kamboinse 86 Pool 16 DR and Early 86 Pool 16 DR were promising. Early 86 Pool 16 DR was earlier than SAFITA-2 in all trials.

b) Varietal Evaluation:

For population improvement, tied and simple ridges were used to test different genotypes under two drought stress conditions (more and less). Four trials were conducted this year, but data from only two trials (EVT 10E and RUVT-3 DR) were available for analysis and presentation at the time this report was prepared.

EVT 10E - Kamboinse:

15 materials of various origin were tested in this trial at Kamboinse. A split plot design used with simple and tied ridges as main plots and different entries as split

Table 3.30 Means of grain yield and days to 50% silking of varieties tested in EV Pool 16 DR (5 trials) in Burkina Faso, 1987.

Variety	Sudan Savanna More stress * Kg/ha	Sudan Savanna Less stress *	North. G. Sav. **	Mean	Mean days to 50% silking
1. Pool 16 DR CO	1654	2272	4699	2875	50.5
2. Pool 16 DR Cl	1893	2374	4692	2986	50.6
3. Pool 16DR C2	1846	2514	5093	3151	50.3
4. Kamboinse 84 Pool 16 DR	1571	2308	4974	2951	50.6
5. Kamboinse 84 Pool 16 DS	1670	2325	4819	2938	49.7
6. Kamboinse 86 Pool 16 DR	1666	2459	4965	3030	50.2
7. Kamboinse 86 Pool 16 DS	1760	2356	4895	3004	49.7
8. Farako-Bâ 86 Pool 16 HD	1881	2453	4208	2847	50.3
9. Early 86 Pool 16 DR	1103	2217	4898	3006	49.9
10. SAFITA-2 RE	1432	2176	4462	2690	51.7

* Mean of 4 trials.

** Data from one trial.

plots, 3 rows plot 5 m x 0.75 m, 6 replications, 53000 plants/ha. All three rows were harvested. Table 3.31 shows the grain yields and other important characters of varieties tested. The differences between ridging systems and varietal differences in grain yields, days to 50% silking, ears/plant, 1000 SWT, shelling percentage and number of grain/m² were significant. Variety x stress levels interaction was significant only for shelling percentage (Table 3.30). In the group of 47-48 days to 50% silking, the yield of differences between Pool 16 (C14) and Pool 17 were not significant. In the group of 50-52 days to 50% silking, Pool 16 IITA significantly outyielded TZESR-W and Pop 61 QPM and had similar yield with DMR-ESR-W. In the latest maturing group 53-54 days to 50% silking, the yields of different entries were similar. These data confirm the good performance of Pool 16 under relative drought conditions compared to other materials of the same maturity.

JFS (local check), Pool 17 and Pool 16 IITA had the highest number of ears/plant, significantly higher than TZESR-Y. Pool 16 IITA, BUES-W and Pool 17 had the highest 1000 SWT and Pop 61 QPM the lowest. For shelling percentage, variety x stress level interaction was significant. Pool 18 (C14), Pool 16 IITA TZESR-Y, and JFS recorded the highest mean of shelling percentage. The shelling percentage was significantly reduced (due to drought stress) for Pool 18 (C14), Pool 15, Pool 17, Pool 16 (C14) Pop 31 and Pop 30. This character was not affected by drought for Pool 16 IITA, DMR-ESR-W, DMR-ESR-Y, Pop 61 QPM. The highest number of grain/m² was recorded for JFS, Pool 17, Pool 16 IITA,

Table 3.31 Grain yield and other agronomic characters of varieties tested in EVT 10E under two stress levels, Kamboinse, Burkina Faso.

Varieties	Grain yields Kg/ha			Rank	Days to 50 % silking	No ears/ 100 plants	1000 S WT	% Shelling			NSQM
	More stress	Less stress	Mean					More stress	Less stress	Mean	
1. Pop 61 QPM	778	2381	1580	13	52	73	124	79	79	79	1212
2. Pool 18 (C14)	782	2759	1771	9	50	71	157	80	83	82	1036
3. Pool 15	1082	2323	1702	11	51	79	154	77	79	78	1051
4. DMRESR-Y	878	2192	1535	15	53	70	152	82	81	81	942
5. DMRESR-W	1005	3034	2020	4	50	82	149	80	81	81	1273
6. Pool 16 IITA	1452	2933	2192	2	50	85	169	82	92	82	1241
7. BUES-W	987	2817	1902	6	53	81	160	82	80	81	1138
8. Pool 17	1016	3093	2054	3	47	86	160	79	81	80	1231
9. Pool 16 (C14)	1002	2875	1938	5	48	83	153	78	81	79	1194
10. TZESR-Y	868	2367	1617	12	53	65	143	83	82	82	1070
11. Pop 31	1060	2555	1808	8	51	77	152	78	81	79	1139
12. TZESR-W	958	2192	1575	14	51	74	129	80	81	81	1171
13. Pop 30	865	2773	1819	7	52	75	156	82	84	83	1121
14. JFS	1568	2991	2279	1	45	89	155	80	81	81	1425
15. Pop 49	987	2425	1706	10	54	77	146	78	79	79	1134
Mean											
C.V. (%)	30			4		17	13	2.8			24.9
Prob of F											
Ridging System	<0.01			0.03		<0.01	<0.01	0.01			<0.01
Varieties	0.01			<0.01		<0.01	<0.01	<0.01			0.03
Ridging x varieties	0.59			0.24		0.78	0.64	0.04			0.54
LSD 5 %											
Mean	439			1.6		11	16	1.9			234
Same ridging System								2.6			

DMRESR-W and Pop 61 QMP and the lowest for DMRESR-Y and Pool 15.

<u>RUVT-3 DR:</u>

12 extra-early varieties (maturing in less than 82 days) of various origin were evaluated for the second year under two drought level conditions. The design and other special arrangements were the same as EVT 10E. Significant differences were recorded between genotypes for yields, days to silk, number of grain/m² and synchronization betweeen days to silk and days to anthesis. For yield, variety x drought stress levels interaction was marginal but significant at 1% level for number of grain/m² (Table 3.32). In the group of 42-44 days to 50% silking, Kaichan and local Koudougou significantly outyielded GUA 314 (mean yield). In the group of 46-48 days to 50% silking, the yield of SAFITA 104 was significantly higher than those of Pop 31 Early and Kito. Composite D significantly outyielded Local Rayitiri in the latest group. Under more stress conditions, the varieties of the first group were similar in yield, but local Koudougou gave significantly higher yield than GUA 314 and CSP early. In the second group of maturity, SAFITA 104 was significantly better than Kito, under both stress conditions. Composite D and Local Rayitiri of the latest group had similar yield levels under more stress conditions but Composite D was significantly better than Rayitiri under less stress conditions.

Local Koudougou and Kaichan gave the highest number of grain/m² under both stress conditions and Kito the lowest. Except for Kamandaogo Tollo, JFS and CSP Early,

Table 3.32 Grain yield and other agronomic characters of varieties tested in RUVT-3 DR under two drought stress levels at Kamboinse , Burkina Faso, 1987.

Variety	Grain yield kg/ha			Rank	Days to 50 % silking	No Grain/m2			Synchro
	More stress	Less stress	Mean			More stress	Less stress	Mean	
Local Rayitiri	1142	1527	1334	7	49	841	1523	1182	2.5
Kito	885	2041	1463	12	46	573	1220	897	0.92
Kaïchan	1527	2784	2155	2	44	1327	1864	1596	2.5
K. Tollo	1214	1799	1507	11	39	865	1027	946	1.42
Comp. D	1122	2484	1803	8	49	836	1681	1258	2.75
Local Koudougou	1470	2883	2177	1	44	1214	1838	1526	1.75
GUA 314 x VEN 389	1954	2100	2027	10	44	672	1337	1004	1.75
Pop 31SR Early	1013	2198	1606	8	48	723	1351	1037	2.25
JFS	1713	2412	2063	4	47	1134	1394	1264	1.83
CJP 75	1270	2455	1863	5	42	911	1364	1137	1.17
CSP Early	1713	2013	1863	6	44	1141	1241	1191	1.25
SAFITA-104	1342	2883	2113	3	46	914	1792	1353	0.83
Mean	1281	2382			45	929	1469	1199	1.74
CV (%)	26				4	24			74
Prob of F.									
- Ridging syst.	0.18				0.49	0.18			0.25
- varieties	0.01				0.01	0.01			0.01
- Ridging x Varieties	0.06				0.8	0.013			0.93
LSD 5 % for Comp.									
- Mean	392				1.6	231			1.04
- Same Ridging System	554				-	328			-

the number of grain/m² of other varieties was significantly affected by drought.

Seed Increase and Breeding Nurseries:

a) Dry Season:

31 F.S. Families selected from Pool 16 DR were recombined.

4 experimental varieties selected for drought resistance from Pool 16 were developed.

4 extra-early composites were formed.

75 extra-early, early and intermediate varieties intended for national programs and 1988 crop season trials were multiplied by bulk sibbing.

42 F.S. Families from Pool 16 were multiplied for agronomic trials.

b) Rainy Season:

38 early and extra-early varieties were planted at Kamboinse for seed multiplication.

10 early drought resistant varieties were planted at Farako-Bâ for seed increase.

24 early, extra-early varieties were planted at Farako-Bâ for seed increase.

514 H.S. Families from Pool 16 DR were planted for selfing.

Extra-early composite yellow and extra-early composite white-1 were planted for recombination.

11 F.S. drought resistant families selected from Pool 16 DR across locations were planted for experimental variety formation.

REGIONAL TESTING

To enhance the exchange of germplasm between resident research and national programs of SAFGRAD member countries, IITA/SAFGRAD maize breeding program organized and coordinated Regional Uniform Varieties Trials. Varieties were nominated by national programs, Resident Research and International Organizations (IITA and CYMMYT). This year only Ghana included two varieties in the regional trials. 52 sets of RUVT-1 (early varieties), RUVT-2 (intermediate varieties) and RUVT-3 (extra-early varieties) were sent to 16 countries.

Regional Uniform Early Variety Trial (RUVT-1):

This trial comprised 12 entries and a local check. One variety (Kawanzie) was nominated by the Ghanaian national program. Grain yield and the most important agronomic characters of varieties tested in this trial at Nyankpala (Ghana), Broukou (Togo), Gampela (Burkina Faso), Kolo (Niger), Ibadan (Nigeria), Sapu (Gambia), Sinthiou, Nioro (Senegal), Kilissi, Pita, Bordo (Guinea) and Farako-Bâ (Burkina Faso) are given in Tables 3.33 to 3.34.

At Nyankpala (Ghana), significant varietal differences were observed for days to 50% silking, stem lodging, ear rot, streak, rust and Curvularia attack (Table 3.33). Pop CSP and TZEF-Y F3 were susceptible to streak, rust and ear rot. The local check and TZEF-Y-F3 showed high susceptibility to stem lodging. Early 84 TZESR-W and EV 8431 SR were promising Nyankpala conditions.

At Broukou (Togo), the varietal differences in yield, streak attack, ear rot, plants and ears harvested were significant (Table 3.34). EV 8431 SR was significantly

Table 3.33 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Nyankpala, Ghana, 1987.

Entry	Grain yield kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Streak virus No.	Rust rate	Curvula-ria rate	Stem lodging %	Ear rot %
1. Early 84 TZESR-w	4121	100	50	141	70	100	99	1	1.2	1.7	3.9	7.3
2. EV8431-SR	3527	96	50	142	66	96	85	2	2.0	2.2	3.3	8.1
3. Capinopolis 8245	3427	104	54	166	85	104	77	4	1.7	2.5	4.9	13.2
4. Pop 30 SR early	3165	103	51	132	63	103	91	2	1.7	2.2	3.6	4.5
5. Kamboinse(1) 8433	3061	106	51	123	63	106	97	4	2.2	3.7	8.7	26.2
6. Pool 16 DR CO	3030	96	51	134	62	96	92	2	1.0	2.5	5.9	4.9
7. Pool 16 DR C1	2989	105	50	141	76	105	94	3	1.5	2.7	7.1	8.7
8. Pop CSP	2944	102	47	123	57	93	90	4	2.0	3.2	8.7	15.2
9. Local check	2934	97	54	161	89	97	74	4	1.0	2.2	12.1	7.5
10. Kawanzie	2748	103	53	141	72	103	87	3	1.5	2.2	5.4	9.2
11. Kamboinse(1) 84 TZESR-W	2657	102	53	139	73	102	79	2	1.5	2.0	6.6	4.9
12. SAFITA-2 (RE)	2555	105	53	139	77	105	76	4	1.2	2.5	11.0	9.4
13. TZEF-y-F3	2553	102	47	131	65	96	93	3	2.2	3.0	12.5	24.5
Overall Mean	3055	102	51	139	71	101	87	3	1.6	2.5	7.2	11.0
LSD 5%	1180.8	9.9	2.2	16.5	10.5	10.4	12.0	1.3	0.7	0.6	6.1	6.0
Prob. of F	0.365	0.466	0.000	0.000	0.000	0.166	0.000	0.000	0.005	0.000	0.036	0.000
C.V. (%)	26.9	6.8	3.1	8.3	10.3	7.2	9.6	31.0	30.7	17.5	59.3	38.1

Table 3.33 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Nyankpala, Ghana, 1987.

Entry	Grain yield kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Streak virus No.	Rust rate	Curvula-ria rate	Stem lodging %	Ear rot %
1. Early 84 TZESR-w	4121	100	50	141	70	100	99	1	1.2	1.7	3.9	7.3
2. EV8431-SR	3527	96	50	142	66	96	85	2	2.0	2.2	3.3	8.1
3. Capinopolis 8245	3427	104	54	166	85	104	77	4	1.7	2.5	4.9	13.2
4. Pop 30 SR early	3165	103	51	132	63	103	91	2	1.7	2.2	3.6	4.5
5. Kamboinse(1) 8433	3061	106	51	123	63	106	97	4	2.2	3.7	8.7	26.2
6. Pool 16 DR C0	3030	96	51	134	62	96	92	2	1.0	2.5	5.9	4.9
7. Pool 16 DR C1	2989	105	50	141	76	105	94	3	1.5	2.7	7.1	8.7
8. Pop CSP	2944	102	47	123	57	93	90	4	2.0	3.2	8.7	15.2
9. Local check	2934	97	54	161	89	97	74	4	1.0	2.2	12.1	7.5
10. Kawanzie	2748	103	53	141	72	103	87	3	1.5	2.2	5.4	9.2
11. Kamboinse(1) 84 TZESR-W	2657	102	53	139	73	102	79	2	1.5	2.0	6.6	4.9
12. SAFITA-2 (RE)	2555	105	53	139	77	105	76	4	1.2	2.5	11.0	9.4
13. TZEF-y-F3	2553	102	47	131	65	96	93	3	2.2	3.0	12.5	24.5
Overall Mean	3055	102	51	139	71	101	87	3	1.6	2.5	7.2	11.0
LSD 5%	1180.8	9.9	2.2	16.5	10.5	10.4	12.0	1.3	0.7	0.6	6.1	6.0
Prob. of F	0.365	0.466	0.000	0.000	0.000	0.166	0.000	0.000	0.005	0.000	0.036	0.000
C.V. (%)	26.9	6.8	3.1	8.3	10.3	7.2	9.6	31.0	30.7	17.5	59.3	38.1

Table 3.34 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Broukou, Togo, 1987.

Entry	Grain yield kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Streak virus %	Rotten ears %
1. EV 8431-SR	4003	52	192	97	98	89	32.9	5.8
2. Pop 30 SR Early	3723	54	178	93	102	95	43.5	0.8
3. Kamboinse (1) 84 TZESR-w	3570	53	190	95	107	100	46.1	4.2
4. Early 84 TZESR-w	3481	54	185	89	107	102	47.9	2.2
5. Pool 16 DR CO	3373	55	180	89	101	91	60.5	5.0
6. Pool 16 DR C1	3059	53	171	85	103	94	65.7	7.4
7. Capinopolis 8245	2897	51	208	104	100	77	78.2	14.6
8. Pop CSP	2665	53	146	62	106	91	66.7	1.0
9. SAFITA-2 (RE)	2563	54	168	84	105	87	86.2	11.4
10. Kawanzie	2438	55	154	72	104	86	74.4	6.1
11. TZEF-y F3	2283	54	159	78	103	88	69.4	0.0
12. Kamboinse (1) 8433	2172	54	144	56	104	81	81.0	13.4
13. Local check	1706	51	175	90	98	69	89.8	4.4
Overall Mean	2918	53	173	84	103	89	64.8	5.9
LSD 5%	221	4.5	19.0	16.0	4.5	12.9	12.8	6.8
Prob. of F.	0.000	0.814	0.000	0.000	0.001	0.000	0.000	0.000
C.V. (%)	15.1	5.9	7.8	13.0	3.0	10.1	13.7	79.9

better than other varieties tested (135% better than the local check). Streak attack was very severe; all varieties were affected - EV 8431 SR was the most resistant and the local check the most susceptible. Capinopolis 8245, SAFITA-2 RE and Kamboinse (1) 8433 were susceptible to ear rot.

At Gampela (Burkina Faso) the yield was very low and the experimental error very large (Table 3.35).

At Kolo (Niger) the trial was variable and yield was low (Table 3.36).

At Ibadan, significant varietal differences were recorded for yield, days to 50% silking and ear rot (Table 3.37). EV 8431 SR and Kamboinse (1) 84 TZESR-W gave the highest grain yield. All entries were susceptible to ear rot. Pool 16 DR C1 was the most resistant and TZEF-Y-F3 the most susceptible.

At Sapu (Gambia) differences between varieties were not significant for grain yield and for stem lodging. Kawanzie and Pool 16 DR C1 were promising. Pool 16 CO and Pop 30 SR early were the most susceptible varieties to root lodging (TAble 3.38).

At Sinthiou (Senegal), significant varietal differences were observed for grain yield, days to 50% silking, plant and ear heights (Table 3.39). Capinopolis 8245 and Early 85-TZESR-W significantly outyielded the local check by 54% and 29% respectively and were significantly earlier than the local check. The earliest entries were Pop CSP and TZEF-Y which reached 50% silking in 43 days after planting (DAP).

At Nioro (Senegal) the varietal yield differences were not significant but were significant for days to 50%

Table 3.35 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Gampela, Burkina Faso, 1987.

Entry	Grain yield kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Stem lodging %
1. Kamboinse (1) 8433	1833	49	124	58	103	65	0.9
2. Early 84 TZESR-w	1336	50	125	62	92	50	0.2
3. Local check	1313	47	144	66	89	56	0.0
4. Capinopolis 8245	1301	54	145	79	94	36	0.0
5. Kamboinse (1) 84 TZESR-w	1294	53	122	69	100	39	1.0
6. TZEF-y F3	1287	48	137	67	102	46	0.0
7. Pop 30 SR Early	1253	48	144	72	96	42	0.0
8. Pool 16 DR C1	1187	53	125	68	94	41	0.0
9. EV 8431 SR	942	49	127	54	90	28	0.0
10. SAFITA-2 (RE)	912	54	132	70	102	33	0.0
11. Pop CSP	802	49	121	52	94	39	0.0
12. Pool 16 DR CO	723	51	140	59	91	22	0.8
13. Kawanzie	693	54	132	64	93	23	0.0
Overall Mean	1144	51	132	65	96	40	0.2
LSD 5%	937.8	4.7	22.0	15.7	10.6	31.4	0.6
Prob. of F.	0.511	0.034	0.231	0.075	0.141	0.257	0.007
C.V.(%)	57.0	6.5	11.6	16.9	7.8	54.7	203.1

Table 3.36 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Kolo, Niger, 1987.

Entry	Grain yield kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Streak virus %
1. Pool 16 DR	741	57	135	51	52	35	1.9
2. Pop 30 SR Early	740	59	125	47	39	1.5	1.5
3. Local check	685	65	138	71	52	21	14.5
4. TZEF-y F3	670	50	135	47	45	33	6.9
5. Kamboinse (1) 8433	661	55	110	45	51	26	3.6
6. EV 8431 SR	606	56	122	46	37	28	1.2
7. SAFITA-2 (RE)	549	62	125	58	49	28	15.4
8. Pop CSP	508	55	117	47	50	32	5.3
9. Capinopolis 8245	504	63	128	54	40	19	6.1
10. Pool 16 DR C1	486	57	127	55	40	24	3.1
11. Early 84 TZESR-w	482	58	125	34	56	25	0.4
12. Kamboinse (1) 84 TZESR-w	425	61	124	53	53	22	2.0
13. Kawanzie	316	59	115	46	38	17	8.6
Overall Mean	567	58	125	50	46	26	5.4
LSD 5%	268.3	3.7	28.3	7.6	13.8	10.8	55.2
Prob. of F.	0.076	0.000	0.787	0.000	0.077	0.039	0.000
C.V. (%)	32.2	4.4	15.8	10.6	20.7	28.8	66.8

Table3.37 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Ibadan, Nigeria, 1987.

Entry	Grain yield kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Rotten ears No.
1. EV 8431 SR	2044	45	45	177	77	45	41	19.2
2. Kamboinse (1) 84 TZESR-w	2021	42	46	170	76	42	40	15.5
3. Local check	1925	50	47	173	78	50	44	16.7
4. Early 84 TZESR-w	1727	45	45	158	62	45	40	19.2
5. SAFITA-2 (RE)	1682	47	48	166	89	46	40	22.7
6. Pool 16 DR CO	1658	43	47	170	77	43	35	14.7
7. Pool 16 DR Cl	1572	41	47	159	65	41	35	13.2
8. TZEF-y F3	1570	44	40	163	75	44	40	27.2
9. Pop 30 SR Early	1499	43	45	162	75	43	40	22.5
10. Capinopolis 8245	1447	43	49	181	95	42	32	22.5
11. Pop CSP	1283	45	43	134	43	44	36	17.7
12. Kawanzie	1258	40	46	153	62	41	31	16.2
13. Kamboinse (1) 8433	1212	44	45	140	60	44	33	20.7
Overall Mean	1607	44	46	162	72	44	37	19.0
LSD 5%	465.0	6.2	2.2	16.9	15.5	6.2	6.3	6.5
Prob. of F.	0.006	0.221	0.000	0.000	0.000	0.293	0.002	0.005
C.V. (%)	20.1	9.8	3.5	7.3	15.0	9.9	11.8	23.9

Table 3.38 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Sapu, Gambia, 1987.

Entry	Grain yield kg/ha	Plant height (cm)	Ear height (cm)	Plants harvested No.	Root lodging %
1. Kawanzie	5143	183	55	47	6.1
2. Pool 16 DR C1	5048	193	76	49	8.7
3. Pool 16 DR CO	5000	189	64	48	11.2
4. SAFITA-2 (RE)	4976	196	75	49	8.7
5. POP CSP	4833	175	42	47	7.0
6. TZEF-y, F3	4809	190	66	48	10.9
7. Kamboinse (1) 84 TZESR-w	4619	179	50	48	3.5
8. Local check	4571	248	109	47	0.9
9. Early 84 TZESR-w	4399	180	59	47	5.2
10. Kamboinse (1) 8433	4095	169	47	50	5.4
11. EV 8431 SR	4000	192	65	43	8.7
12. Capinopolis 8245	3905	210	71	44	9.7
13. POP 30 SR Early	3524	169	64	46	11.0
Overall Mean	4532	190	65	47	7.5
LSD 5%	1103.0	20.3	15.2	6.0	6.4
Prob. of F	0.092	0.000	0.000	0.452	0.062
C.V. (%)	16.9	7.4	16.3	8.9	59.7

Table 3.39 **Grain yield and other agronomic characters of varieties tested in RUVT-1 at Sinthiou Nalene, Senegal, 1987.**
Cooperator : Mr. A. NDIAYE.

	Entry	Grain yield (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)
1.	CAPINAPOLIS 8245	4717	46	201	98	96	81
2.	E84 TZESR-W	3962	44	166	84	78	78
3.	Pool 16 DR C0	3829	44	174	86	84	82
4.	Kamboinse(1) 8433	3795	44	154	76	80	82
5.	EV. 8431 SR	3772	44	163	76	86	72
6.	Kamboinse(1) 84 TZESR-W	3725	44	179	88	92	91
7.	Pool 16 DR C1	3612	44	176	84	87	76
8.	SAFITA 2 RE	3530	48	184	99	96	81
9.	POP CSP	3442	43	152	68	80	83
10.	POP 30 SR (E)	3229	44	170	86	78	72
11.	Local check	3064	48	170	89	84	74
12.	Kawanzie	3062	45	171	86	85	76
13	TZEF-Y F3	2771	43	162	76	76	70
	Overall mean	3578	45	171	84	85	78
	L.S.D. 5 %	862	1.0	13.5	9.2	22.1	12.7
	Prob. of F.	0.0101	0.0000	0.0000	0.0000	0.6995	0.0873
	C.V. %	16.8	1.5	5.5	7.6	18.1	11.3

silking, -Helminthosporium attack, ear rot and plant height (Table 3.40). SAFITA-2 and Capinopolis 8245 yielded 6 t/ha and 5.8 t/ha respectively i.e. 30% and 20% higher than the local check with the same maturity days. Pop CSP was the earliest maturing variety. Kamboinse (1) 8433 was the most susceptible to Helminthosporium attack and ear rot. TZEF-Y, Capinopolis 8245 and Pop CSP were equally susceptible to ear rot whereas Kawanzie and Kamboinse (1) 84-TZESR-W were the most resistant.

At Kilissi (Guinea) significant varietal differences were obtained for grain yield, days to 50% silking and other important agronomic characters. The differences between plants and ears harvested were also significant (Table 3.41). The local check was significantly the highest yielding entry with 3.9 t/ha in contrast with 3 t/ha for SAFITA-2. However, it was very late maturing and not in the same maturity group as all tested entries. EV 8431-SR, Pop 30-SR, POP CSP and TZEF-Y were the earliest maturing varieties. All entries showed susceptibility to stem lodging and ear rot. TZEF-Y was the most susceptible to stem lodging, Capinopolis 8245 and Kamboinse (1) 9433 to ear rot. TZEF-Y showed bad husk cover.

At Pita (Guinea) (Table 3.42), the differences between entries in grain yields and other important agronomic characters as well as plants and ears harvested were significant. The grain yield of some of the entries, like the local check, must have been affected by the low plant population density. Kawanzie and Pool-16-DR-C1 were promising at this location. Percent ear rot, root and stem lodging were high. TZEF-Y was the most susceptible entry

Table 3.40 **Grain yield and other agronomic characters of varieties tested in RUVT-1 at NIORO DU RIP, Senegal, 1987.**
Cooperator : Mr. A. NDIAYE.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Helm. Maydis	Ear rot (%)
1.	SAFITA 2 RE	6062	49	192	91	102	106	1.8	3.4
2.	Capinapolis 8245	5804	50	191	84	86	99	1.2	7.5
3.	Kamb.(1) 84 TZESR-W	5462	48	174	80	90	102	1.7	1.2
4.	EV 8431 SR	5397	46	178	80	93	95	2.7	4.7
5.	Kamb.(1) 8433	5102	47	159	74	91	99	2.7	12.9
6.	KAWANZIE	5088	48	180	81	84	95	2.0	1.6
7.	E 84 TZESR-W	5087	47	172	78	92	98	2.0	2.5
8.	Pool 16 DR CO	4992	46	175	86	100	96	2.5	2.2
9.	TZEF-Y-F3	4937	46	177	85	89	96	2.0	9.6
10.	POP CSP	4877	45	159	70	97	103	2.0	7.0
11.	Local Check	4774	50	182	81	93	97	1.7	2.1
12.	Pool 16 DR C1	4636	48	170	81	98	95	2.0	3.4
13.	POP 30 SR (E)	4342	48	154	68	85	89	2.5	5.3
	Overall mean	5119	48	174	80	92	98	2.1	4.9
	L.S.D. 5 %	1502	2	19	15	18	14	0.9	4.5
	Prob. of F.	0.6492	0.0001	0.0045	0.1752	0.6238	0.6187	0.0557	0.0001
	C.V. %	20.4	2.9	7.6	13	13.4	9.7	29.9	63.8

Table 3.41. Grain yield and other agronomic characters of varieties tested in RUVT-1 at Kilissi, Guinea, 1987. Cooperators, Messrs. Malick Soumah, Pathe Diallo, Seydouba Sylla.

Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Stem lodging (%)	Ears rot (%)	Husk cover (%)
1. Local check	3905	59	156	56	108	85	8.1	6.9	3.5
2. SAFITA 2 RE	3083	50	123	43	103	76	7.8	9.7	3.4
3. POP 30 SR (E)	2893	47	159	61	104	80	9.9	5.8	4.6
4. KAWANZIE	2321	51	154	69	106	86	13.4	4.4	5.4
5. EV 8431 SR	2226	46	131	51	87	61	7.3	12.6	3.4
6. Pool 16 DR CO	2214	52	136	52	102	78	10.1	7.7	4.8
7. Kamb.(1) 84 TZESR-W	2048	53	122	45	101	71	8.4	8.6	4.1
8. Capinopolis 8245	2048	50	155	73	95	51	10.6	25.7	5.0
9. Pool 16 DR C1	2036	50	123	42	102	67	12.9	14.3	6.2
10. E 84 TZESR-W	1821	50	157	65	90	72	15.9	4.9	7.5
11. POP CSP	1643	47	129	46	103	75	15.4	7.6	7.5
12. Kamb.(1) 8433	1286	51	123	42	96	50	16.0	24.5	8.7
13. TZEF-Y-F3	1262	47	140	57	92	56	27.2	12.7	13.3
Overall mean	2214	50	139	54	99	70	12.5	11.2	6.0
L.S.D. 5 %	512	2.4	22	17	9.2	10.3	8.0	10.1	4.0
Prob. of F.	0.0000	0.0000	0.0008	0.0037	0.0005	0.0000	0.0011	0.0009	0.0006
C. V. %	16.1	3.3	11.0	21.0	6.4	10.5	44.6	63.0	46.8

Table 3.42 Grain yield and other agronomic characters of varieties tested in RUVT-1 at Pita, Guinea, 1987. Cooperator : DNRA.

	Entry	Grain yields (kg/ha)	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Root lodging (%)	Stem lodging (%)	Ears rot (%)
1.	KAWANZIE	3119	147	76	67	72	21.5	2.6	6.8
2.	Pool 16 DR C1	3000	137	76	60	63	19.7	6.2	10.6
3.	Kamb.(1) 84 TZESR-W	2833	148	74	70	74	13.1	3.9	11.0
4.	POP 30 SR (E)	2738	129	70	66	71	14.4	7.8	17.5
5.	E 84 TZESR-W	2476	134	55	57	64	17.5	4.8	7.4
6.	SAFITA 2 RE	2452	136	69	53	57	15.6	6.4	9.8
7.	Pool 16 DR CO	2262	118	57	53	58	29.8	22.5	11.7
8.	POP CSP	2178	126	55	46	52	28.3	17.9	13.3
9.	Capinopolis 8245	2083	142	66	48	54	21.5	5.2	22.8
10.	Kamb.(1) 8433	1893	132	55	52	56	19.6	13.2	10.6
11.	EV 8431 SR	1810	128	50	42	45	39.8	12.6	19.4
12.	TZEF-Y-F3	1440	128	60	40	44	58.0	36.7	21.1
13.	Local check	1333	170	95	44	49	27.6	30.2	16.5
	Overall mean	2278	136	66	54	58	25.1	13.1	13.7
	L.S.D. 5 %	782	22	17	14.5	15	20.2	17.2	6.6
	Prob. of F	0.0003	0.0048	0.0003	0.0010	0.0015	0.0045	0.0029	0.0001
	C.V. %	23.9	11.0	18	18.8	18	56.1	92.0	33.6

to ear rot, root and stem lodging. Capinopolis 8245 was also very susceptible to ear rot.

At Bordo (Guinea) grain yield differences between entries were not significant, whereas significant differences were observed for days to 50% silking, ear rot, plant and ear heights. The grain yields were generally high, ranging from 5.8 t/ha and 5.4 t/ha for Capinopolis 8245 and Safita-2 respectively (Table 3.43). Pop CSP and TZEF-Y were the earliest entries, while the local check was the latest. The local check was unsatisfactory terms of maturity at that location. TZEF-Y was most susceptible to ear rot.

At Farako-Bâ (national program) yield differences between varieties were not significant (Table 3.44), whereas significant differences were observed for Helminthosporium and streak attack, ear rot, days to 50% silking, plant and ear heights. At this location, TZEF-Y and Pop CSP were also the earliest entries and Capinopolis 8245 and Early 84 TZESR-W the most promising in terms of grain yields. Kawanzie and TZEF-Y were the most susceptible to streak attack, while Kamboinse (1) 8433 was susceptible to Helminthosporium attack and ear rot.

Table 3.45 shows mean grain yields and days to 50% silking of varieties tested in RUVT-1 across 14 locations. The 1987 data confirmed the 1985 and 1986 results regarding the good yield performance of Capinopolis 8245 in the Sudan Savanna Zone of West Africa. This variety is however susceptible to streak attack and ear rot. Pop CSP and the new population TZEF-Y were the earliest entries but were susceptible to stem lodging and ear rot. These varieties are therefore, not suitable for the moist savanna zone but

Table 3.43. **Grain yield and other agronomic characters of varieties tested in RUVT-1 at Bordo-Kankan, Guinea, 1987.**
Cooperator : Mr. Lansana Toure.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Ears rot (%)
1.	Capinepolis 8245	5884	50	218	105	94	94	1.9
2.	SAFITA 2 RE	5429	50	197	99	110	112	2.9
3.	Local check	5393	60	214	127	89	90	1.6
4.	KAWANZIE	5232	49	183	86	104	104	2.3
5.	E 84 TZESR-W	5202	48	184	80	108	109	3.2
6.	POOL 16 DR CO	5167	49	182	91	106	106	3.9
7.	POOL 16 DR C1	4833	48	193	102	108	109	3.4
8.	POP 30 SR (E)	4690	48	170	78	98	98	2.8
9.	EV 8431 SR	4595	46	175	74	105	105	4.5
10.	KAMB.(1) 84 TZESR-W	4417	49	186	94	106	106	2.8
11.	KAMB.(1) 8433	4131	48	161	82	103	102	4.2
12.	POP CSP	4048	44	158	68	105	105	4.8
13.	TZEF-Y-F3	3964	44	172	74	105	105	5.9
	Overall mean	4845	49	184	89	103	104	3.4
	L.S.D. 5 %	1994	1.4	31	20.6	15.9	16.4	2.4
	Prob. of F.	0.7016	0.0000	0.0074	0.0001	0.3314	0.3698	0.0478
	C.V. %	28.6	2.0	11.6	16.1	10.7	11.0	49.8

Table 3.44 **Grain yield and other agronomic characters of varieties tested in RUVT-1 at Farako-Bâ, Burkina Faso, 1987.**
Cooperator : Mr. Sanou Jacob.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Helm. Maydis	Rotten Ears (%)	Streak attack (%)
1.	Capinapolis 8245	4847	56	190	86	82	78	2.0	3.5	0.9
2.	E 84 TZESR-W	4696	52	168	68	82	89	2.2	2.2	0.0
3.	Kamb.(1) 84 TZESR-W	4684	52	162	81	82	84	2.0	2.3	0.3
4.	POP 30 SR (E)	4668	52	166	80	85	86	2.0	1.1	0.0
5.	POOL 16 DR CO	4411	52	171	79	82	82	2.0	1.2	1.8
6.	KAWANZIE	4407	53	174	71	86	86	2.2	1.4	5.2
7.	POOL 16 DR C1	4342	52	161	78	80	81	2.2	2.1	3.0
8.	TZEF-Y-F3	4291	48	172	75	84	88	3.0	4.0	5.1
9.	SAFITA 2 RE	4141	54	170	78	86	86	2.0	1.7	4.6
10.	EV 8431 SR	4063	51	169	72	80	82	2.0	2.2	0.3
11.	POP CSP	4051	49	151	58	83	81	2.0	1.8	3.3
12.	Local check	4002	59	198	109	81	81	2.0	2.5	1.2
13.	KAMB.(1) 8433	3478	52	141	49	81	75	3.0	5.8	4.8
	Overall mean	4314	52	169	76	82	83	2.2	2.4	2.3
	L.S.D. 5 %	1121	2.9	22.0	17.1	7.2	10.3	0.3	1.4	3.5
	Prob. of F.	0.5424	0.0000	0.0016	0.0000	0.7626	0.3357	0.0000	0.0000	0.0084
	C.V. %	18.0	3.9	9.1	15.8	6.1	8.7	10.8	38.8	105.2

Table 3.45. **Mean grain yield and days to 50 % silking of varieties tested in RUVT-1 Across 14 locations, 1987.**

	Entry	Grain yield kg/ha	**Days to 50 % silking**
1.	Capinopolis 8245	3424	52
2.	Early 84 TZESR-W	3336	50
3.	SAFITA-2 RE	3280	52
4.	Kamboinse(1) 84 TZESR-W	3254	51
5.	POOL 16 DR C1	3251	50
6.	EV 8431 SR	3224	49
7.	POOL 16 DR CO	3209	51
8.	KAWANZIE	3153	51
9.	POP 30 SR	3100	50
10.	Local check	2937	53
11.	POP CSP	2883	47
12.	Kamboinse (1) 8433	2830	50
13.	TZEF-Y-F3	2798	47

could play an important role where extra-early Maize is needed. Progress of 1.3% across 14 locations was recorded from the cycle 0 to cycle 1 of Pool 16 DR currently under improvement for drought tolerance.

Regional Uniform Intermediate Variety Trial (RUVT-2)

Eleven varieties together with a local check were tested in this trial. One variety (ABUROTIA) was nominated by the national program of Ghana. Grain yield and other important agronomic characters of varieties tested in this trial at Broukou (Togo), Nyankpala (Ghana), Sinthiou, Nioro (Senegal), Kilissi, Bordo (Guinea), Farako-Bâ (Burkina Faso) and Sotuba (Mali) are given on Tables 3.46 to 3.53.

At Broukou (Togo) there were significant varietal differences in grain yields, streak attack, root and stem lodging. The differences for plants and ears harvested were also significant (Table 3.46). EV 8422 SR, EV 8443 SR and Across 83 TZUT-W were the highest yielding varieties. EV 8422 SR was significantly better than the local check by 117%. The number of plants with streak attack was high for all tested entries. EV 8443 SR was the most susceptible variety to root and stem lodging. SAFITA-102 and EV 8449 SR showed better resistance to root and stem lodging.

At Nyankpala (Ghana) significant differences were recorded for grain yields and other important agronomic characters (Table 3.47). EV 8422 SR and Farako-Bâ 85 TZSR-W-1 were the latest entries, Loumbila 84 TZUT-Y and SAFITA-102 the earliest. The yield differences between the highest yielding variety and the local check was not significant. EV 8428 SR and Kamboinse (2) 83 TZUT-W were the best yielding varieties. EV 8428 SR, EV 8422 SR,

Table 3.46 Grain yield (kg/ha) and other agronomic characters of varieties tested in RUVT-2 at Broukou, Togo, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Streak virus No.	Root lodging %	Stem lodging %
1. EV 8422 SR	4865	62	204	114	86	79	51	4.9	16.2
2. EV8443 SR	4491	61	220	117	86	71	49	7.7	23.4
3. Across 83 TZUT-w	4229	61	203	106	86	71	56	6.6	17.6
4. EV 8449 SR	3899	59	137	72	82	73	51	0.6	5.1
5. EV 8428 SR	3654	59	206	118	88	79	59	5.9	14.2
6. Kamboinse(2) 83 TZUT-w	3421	60	197	100	86	67	59	3.8	14.3
7. Farako-Bâ 85 TZSR-w	3318	60	194	110	87	75	63	6.3	19.5
8. Loumbila 84 TZUT-y	2994	57	170	79	86	69	55	3.4	11.3
9. Samaru 83 TZSR-w	2929	59	209	106	87	73	63	4.5	12.3
10. Local check	2241	60	190	122	82	52	79	5.8	21.9
11. SAFITA-102 (RE)	1915	61	117	61	83	70	74	1.2	5.1
12. Aburotia	1876	61	112	56	83	70	80	1.2	4.5
Overall Mean	3319	60	180	97	85	71	62	4.3	13.8
LSD 5%	909.0	5.4	44.0	28.0	2.9	9.5	11.2	3.8	6.7
Prob of F	0.000	0.894	0.000	0.000	0.000	0.000	0.000	0.005	0.000
C.V. (%)	18.9	6.3	17.0	19.9	2.4	9.3	12.6	60.8	34.1

Table 3.47 Grain yield (kg/ha) and other agronomic characters of varieties tested in RUVT-2 at Nyankpala,Ghana, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested (No.	Streak virus No.	Curvula-ria (rate)	Root lodging (%)	Rotten ears(No) (%)
1. EV 8428 SR	5086	85	58	177	95	85	78	1	3.0	22.3	3.5
2. Kamboinse(2) 83 TZUT-w	4599	76	58	176	93	76	65	3	2.5	25.6	14.4
3. EV 8422 SR	4149	83	62	168	92	83	66	2	3.0	31.3	14.8
4. Samaru 83 TZSR-w-1	3773	89	60	181	90	89	64	2	3.7	34.6	8.1
5. Local check	3751	73	57	147	77	73	62	3	2.0	23.3	7.9
6. EV 8443 SR	3711	82	59	182	99	82	56	2	2.7	20.8	11.3
7. Farako-Bâ 85 TZSR-w-1	3441	88	62	185	108	88	68	1	3.0	20.9	5.7
8. EV8449 SR	2929	74	58	130	68	74	58	3	2.2	20.1	13.5
9. Loumbila 84 TZUT-y	2910	84	56	168	83	84	62	4	2.2	32.1	16.7
10. Across 83 TZUT-w	2814	86	60	167	88	86	61	3	2.5	27.5	15.4
11. Aburotia	2398	79	59	132	70	79	65	3	2.5	9.1	10.3
12. SAFITA-102 (RE)	2353	81	56	141	73	81	67	3	2.7	33.0	14.1
Overall Mean	3493	82	59	163	86	82	64	3	2.6	25.0	11.3
LSD 5%	1571.0	9.3	2.2	20.0	14.0	9.3	16.4	1.0	0.8	13.5	8.7
Prob. of F.	0.023	0.019	0.000	0.000	0.000	0.019	0.532	0.042	0.016	0.027	0.070
C.V. (%)	31.2	7.9	2.6	8.6	11.2	7.9	17.7	26.6	21.5	37.4	53.4

SAMARU 83 TZSR-Y-1 showed susceptibility to Curvularia attack and root lodging. Loumbila 84 TZUT-Y and Across 83 TZUT-W were susceptible to ear rot.

At Sinthiou (Senegal) significant differences were observed for grain yield, days to 50% silking, *Helminthosporium maydis* attack, plant and ear heights (Table 3.48). Yield differences between the highest yielding variety (EV 8422-SR) and the local check were not significant (5522 kg/ha against 4971 kg/ha). Across 83 TZUT-W and SAMARU 83 TZSR-Y-1 were most susceptible to *Helminthosporium* attack.

At Nioro (Senegal) very high yields were obtained with significant differences between varieties (Table 3.49). The differences in days to 50% silking, plants and ears harvested, as well as plant and ear heights were also significant. The local check and Farako-Bâ 85 TZSR-W-1 were the highest yielding entries while ABUROTIA was the lowest.

At Kilissi (Guinea) significant varietal differences were recorded for grain yields, days to 50% silking, *Helminthosporium* attack and other important agronomic characters. The differences for plants and ears harvested were also significant (Table 3.50). Farako-Bâ 85 TZSR-W-1 and EV 8428 SR were the highest yielding entries and performed significantly better than the local check (40% and 33%), respectively. The local check was however significantly earlier. Farako-Bâ 85 TZSR-W-1 was the most susceptible to *Helminthosporium* attack while Kamboinse (2) 83 TZUT-W was susceptible to ear rot. Across 83 TZUT-W was also susceptible to ear rot. These two varieties showed bad husk cover at this location.

Table 3.48. Grain yield and other agronomic characters of varieties tested in RUVT-2 at SINTHIOU NALENE, Senegal, 1987.
Cooperator : Mr. A. NDIAYE

	Entry	Grain yields (kg/ha)	Days to 50 % Silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	H. Maydis
1.	EV 8422 SR	5522	52	206	116	78	70	1.0
2.	Across 83 TZUT-W	5001	50	218	120	81	70	1.8
3.	Local check	4971	49	198	104	74	78	1.5
4.	Loumbila 84 TZUT-Y	4953	48	198	104	82	70	1.0
5.	EV 8428 SR	4931	52	204	116	79	80	1.0
6.	EV 8443 SR	4813	51	218	125	75	70	1.0
7.	Kamboinsé(2) 83 TZUT-W	4504	50	207	113	79	70	1.0
8.	ABUROTIA	4459	49	162	91	72	69	1.0
9.	Farako-Bà 85 TZSR-w-1	4439	53	222	130	72	66	1.0
10.	EV 8449 SR	4150	46	162	88	71	70	1.0
11.	SAFITA-102 (RE)	3661	46	183	101	76	68	1.2
12.	SAMARU 83 TZSR-Y-1	3455	53	214	125	82	72	1.8
	Overall mean	4572	50	199	111	77	71	1.2
	L.S.D. 5 %	967	1.1	14	12	14	14	0.4
	Prob. of F.	0.0056	0.0000	0.0000	0.0000	0.7856	0.7607	0.0013
	C.V. %	14.7	1.5	4.8	7.4	12.6	13.7	26.2

Table 3.49 **Grain** yield and other agronomic characters of varieties tested in RUVT-2 at NIORO DU RIP, Senegal 1987.
Cooperator : Mr. A. NDIAYE.

Entry		Grain Yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)
1.	Local check	7078	52	209	98	82	84
2.	Farako-Ba 85 TZSR-W-1	6624	56	234	120	82	94
3.	Across 83 TZUT-W	6560	53	219	107	79	76
4.	EV 8428 SR	6468	54	206	107	84	89
5.	SAMARU 83 TZSR-W-1	6383	56	225	116	82	83
6.	EV 8443 SR	6358	54	224	115	85	88
7.	Loumbila 84 TZUT-Y	6164	52	209	96	75	75
8.	Kamboinse(2) 83 TZUT-W	5775	54	216	102	80	82
9.	EV 8449 SR	5355	52	174	82	78	80
10.	SAFITA-102 RE	5335	50	195	92	83	85
11.	EV 8422 SR	5210	56	202	99	75	69
12.	ABUROTIA	4221	54	154	73	71	72
	Overall mean	5961	54	206	101	80	81
	L.S.D. 5 %	1280	1.4	17	13	8	13
	Prob. of F	0.0042	0.0000	0.0000	0.0000	0.0470	0.0138
	C.V. %	14.9	1.8	5.6	9.0	7.2	11.0

Table 3.50 Grain yield and other agronomic characters of varieties tested in RUVT-2 at Kilissi, Guinea, 1987.
Cooperators :Messrs: Malick Soumah, Pathe Diallo, Seydouba Sylla.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Helmin-thospo-rium(%)	Ears rot (%)
1.	Farako-Bâ 85 TZSR-W-1	3455	64	201	84	80	70	4.2	1.1
2.	EV 8428 SR	3297	62	172	75	69	67	2.5	2.6
3.	EV 8422 SR	2994	70	176	76	73	59	2.2	3.4
4.	SAMARU 83TZSR-Y-1	2982	62	186	83	76	64	3.0	4.3
5.	EV 8443 SR	2836	64	188	69	64	58	3.8	2.7
6.	ABUROTIA	2812	63	155	58	69	58	3.0	1.7
7.	Kamboinse(2) 83 TZUT-W	2691	65	187	73	70	50	3.2	7.2
8.	Local check	2461	59	171	71	68	59	3.0	1.6
9.	SAFITA-102 (RE)	2291	64	150	47	60	56	2.0	1.8
10.	Across 83 TZUT-W	2121	62	188	78	68	46	3.5	7.3
11.	EV 8449 SR	1976	63	140	48	61	48	2.2	5.6
12.	Loumbila 84 TZUT-Y	1745	63	166	62	64	52	3.0	4.9
	Overall mean	2638	63	173	69	68	57	3.0	3.7
	L.S.D. 5 %	402	2.3	23	14	10	10	1.1	4.1
	Prob. of F.	0.0000	0.0000	0.0001	0.0000	0.0114	0.0004	0.0059	0.0288
	C.V. %	10.6	2.5	9.1	14.1	10.5	12.2	25.3	76.7

At Bordo (Guinea) the differences between varieties for yield, days to 50% silking, plant and ear heights, as well as plants and ears harvested were significant. Across 83 TZUT-W, EV8443 SR and EV 8422 SR were quite promising at this location (Table 3.51). They significantly outyielded the local check by 120%, 115% and 110%, respectively. Plant population density was very low for the local check, which might have affected the grain yield. The local check was the latest entry.

At Farako-Bâ (national program) significant differences were recorded for yield and other important agronomic characters (Table 3.52). Varietal differences for plants and ears harvested were significant. The differences in performance between the highest yielding variety (Kamboinse (2) 83 TZUT-W and the local check were not significant. Across 83 TZUT-W and SAFITA 102 were the most susceptible entries to *Helminthosporium* attack. SAFITA-102 and EV 8428 SR were also susceptible to stem lodging.

At Sotuba (Mali) varietal yield differences were significant with a very large experimental error (Table 3.53). The differences for root lodging, plants and ears harvested were also significant. Across 83 TZUT-W significantly outyielded the local check and was 6 days (to 50% silking) earlier. SAFITA-102 and EV 8443 were the most susceptible entries to root lodging.

Table 3.54 shows mean grain yields and days to 50% silking of varieties tested in RUVT-2 across 9 locations. The 1987 results confirmed our 1985 and 1986 data regarding the good performances of TZUT-W and population 22 for the

Table 3.51 Grain yield and other agronomic characters of varieties tested in RUVT-2 at Bordo-Kankan, Guinea, 1987.
Cooperator : Mr. Lansana Toure.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)
1.	Across 83 TZUT-W	7261	56	211	118	86	87
2.	EV 8443 SR	7103	56	225	124	87	89
3.	EV 8422 SR	6909	58	210	108	86	88
4.	Loumbila 84 TZUT-Y	6873	54	202	104	88	88
5.	Farako-Bâ 85 TZSR-W-1	6400	61	206	106	86	87
6.	EV 8428 SR	5758	58	207	104	86	86
7.	Kamboinse(2) 83 TZUT-W	5661	57	106	96	84	84
8.	EV 8449 SR	4788	54	154	71	82	83
9.	ABUROTIA	4703	56	164	82	83	84
10.	SAFITA-102(RE)	4582	52	181	92	83	84
11.	SAMARU 83 TZSR-Y-1	4455	60	204	118	73	74
12.	Local check	3297	62	234	132	71	72
	Overall mean	5649	57	200	105	83	84
	L.S.D. 5 %	2068	1.8	32.0	25.4	10.1	10.8
	Prob. of F.	0.0048	0.0000	0.0005	0.0012	0.0279	0.0483
	C.V. %	25.4	2.3	11.1	16.9	8.5	8.9

Table 3.52. Grain yield and other agronomic characters of varieties tested in RUVT-2 at Farako-Bâ, Burkina Faso, 1987.
Cooperator : Mr. Sanou Jacob.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant stand	Plant height (cm)	Ear height (cm)	Plants Harv. (no)	Ears Harv. (no)	H. Maydis	Stem lodging (%)	Streak attack (%)
1.	Kamboinse (2) 83 TZUT-W	5666	60	83	209	104	82	78	1.8	3.7	0.6
2.	Local check	4856	58	88	210	108	88	85	1.8	3.7	0.6
3.	Farako-Ba 85 TZSR-W-1	4284	66	86	216	108	82	78	1.0	3.3	0.0
4.	Across 83 TZUT-W	4135	60	83	194	84	76	65	2.0	7.9	0.0
5.	EV 8443 SR	4126	64	77	209	104	68	68	1.5	2.6	0.9
6.	SAMARU 83 TZSR-Y-1	3704	64	82	215	101	78	72	1.5	7.1	0.0
7.	SAFITA 102 (RE)	3684	58	80	185	96	72	70	1.0	16.5	6.0
8.	EV 8428 SR	3555	62	81	191	90	72	72	2.0	13.1	0.0
9.	Loumbila 84 TZUT-Y	3456	58	82	192	86	73	65	1.8	2.4	0.7
10.	EV 8449 SR	3324	60	82	154	66	76	68	1.2	11.3	0.8
11.	EV 8422 SR	3319	64	82	196	86	74	70	1.8	10.3	0.0
12.	ABUROTIA	2775	64	84	144	71	76	67	1.5	3.6	3.7
	Overall mean	3907	62	82	193	92	76	71	1.7	7.2	1.1
	L.S.D. 5 %	1249	1.7	5.6	16	15	8.6	10	0.6	9.5	2.2
	Prob. of F.	0.005	0.0000	0.0466	0.0000	0.0000	0.0035	0.0072	0.0143	0.0520	0.0001
	C.V. %	22.2	1.9	4.7	5.7	11.6	7.8	9.9	26.6	91.9	142.5

Table 3.53. Grain yield and other agronomic characters of varieties tested in RUVT-2 at Sotuba, Mali, 1987.
Cooperator : Mr. Cheik Omar Keita.

	Entry	Grain yields (kg/ha)	Days to 50 % silking	Plant height (cm)	Ear height (cm)	Plants harvested (no)	Ears harvested (no)	Root lodging (%)
1.	Across 83 TZUT-W	2812	54	201	92	47	52	2.3
2.	Farako-Bâ 85 TZSR-W-1	2085	58	201	94	44	46	5.7
3.	Kamboinse(2) 83 TZUT-W	2000	56	185	86	31	36	0.0
4.	EV 8422 SR	1903	58	191	89	43	43	5.6
5.	Loumbila 84 TZUT-Y	1867	53	199	91	34	34	10.8
6.	Local check	1830	60	220	118	30	36	0.6
7.	ABUROTIA	1673	55	161	74	36	40	4.3
8.	EV 8443 SR	1503	58	188	91	34	37	14.3
9.	EV 8428 SR	1224	58	178	82	28	30	2.5
10.	EV 8449 SR	1188	55	152	66	29	32	7.8
11.	SAMARU 83 TZSR-W-1	1079	59	200	91	30	31	8.9
12.	SAFITA 102 (RE)	1018	52	172	82	25	25	56.3
	Overall mean	1682	56	187	88	34	37	9.9
	L.S.D. 5 %	746	2.3	14	15	14.3	14.6	18.2
	Prob. of F.	0.0010	0.0000	0.0000	0.0001	0.0703	0.0436	0.0000
	C.V. %	30.8	2.9	5.3	12.0	28.9	27.5	127.3

Table 3.54. **Mean grain yield and days to 50 % silking of varieties tested in RUVT-2 Across 9 locations, 1987.**

	Entry	Grain yield kg/ha	Days to 50 % silking
1.	EV 8422 SR	4527	62
2.	ACROSS 83 TZUT-W	4511	57
3.	EV 8443 SR	4494	59
4.	Kamb. (2) 83 TZUT-W	4453	58
5.	EV 8428 SR	4402	58
6.	Farako-Bâ 85 TZSR-W-1	4364	60
7.	Loumbila 84 TZUT-Y	4065	55
8.	Local check	3832	57
9.	SAMARU 83 TZSR-Y-1	3769	59
10.	EV 8449 SR	3607	56
11.	SAFITA 102 (RE)	3285	55
12.	ABUROTIA	3261	58

the Northern Guinea Savanna of West Africa. However, TZUT-W was susceptible to ear rot and had very poor husk cover. Farako-Bâ 85 TZSR-W-1 was susceptible to *Helminthosporium* attack.

Regional Uniform Extra-Early Variety Trial (RUVT-3):

Eleven (11) extra-early varieties and a local check were tested at Broukou (Togo), Ibadan (Nigeria), Kolo (Niger), Gampela (Burkina Faso), Sapu (Gambia) and Nioro du Rip (Senegal). The results of this trial are presented in Tables 3.55 to 3.60).

At Broukou (Togo) significant varietal differences were recorded for ear height, ears harvested and ear rot. The experimental error for yield was very large (Table 3.55).

At Ibadan (Nigeria) the differences between varieties in grain yields, days to 50% silking and rotten ears were significant. (Pop CSP x Local Rayitiri) F2 significantly outyielded the local check (36%). All tested varieties were very susceptible to ear rot (Table 3.56), the most resistant was Pop CSP early.

At Kolo (Niger) grain yields were very low with a very high experimental error (Table 3.57).

At Gampela (Burkina Faso), the differences between varieties for days to 50% silking and root lodging were significant (Table 3.58). Pool 29 x Kamandaogo Tollo F4 and WIR 17215 x Kamandaogo Tollo BC1 F2 were the earliest entries whereas (Pop CSP x Local Rayitiri) F2 was the latest and the most resistant to root lodging. (Pop 46 x Kamandaogo Tollo) F4 was the most susceptible to root lodging.

At Sapu (Gambia) significant varietal differences were obtained for grain yield (Table 3.59). (Across 8131 x JFS x Local Rayitiri) -F4 with 5.1 t/ha significantly yielded

Table 3.55 Grain yield (kg/ha) and other agronomic characters of varieties tested in RUVT-3 at Broukou, Togo, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Rotten ears %	Streak virus %
1. Pop CSP Early	2080	49	156	68	94	83	2.7	80.3
2. Pool 28 x GUA 314 BC1,F2	1956	49	167	92	104	88	1.1	93.6
3. Early 84 TZESR-w x GUA 314 BC1, F2	1863	49	145	73	102	99	2.6	69.3
4. Pop 30 SR Early x GUA 314 F4	1764	50	147	73	100	87	3.8	93.6
5. Pool 27 x GUA 314 F4	1698	47	147	70	100	93	7.2	96.5
6. Pool 29 x Kamandaogo Tollo F4	1697	47	157	77	95	85	8.7	93.9
7. (DMR-ESR-y x JFS) x K. Tollo F4	1649	51	151	65	103	88	18.2	89.7
8. (Pop 46 x Kamandaogo Tollo) F4	1487	48	128	58	101	84	20.5	101.3
9. Local check	1407	46	187	98	100	72	1.5	118.7
10. (Across 813 x JFS) x Local Raytiri F4	1277	53	150	78	92	84	9.8	101.1
11. (Pop CSP x Local Raytiri) F2	1234	46	157	68	87	72	5.3	114.8
12. WIR 17215 x K. Tollo BC1, F2	1195	44	145	68	101	77	21.3	96.6
Overall Mean	1609	48	153	74	98	84	8.6	95.8
LSD 5%	856.2	7.3	30.0	17.1	14.8	13.9	9.6	36.6
Prob. of F	0.483	0.473	0.095	0.004	0.438	0.019	0.000	0.386
C.V. (%)	31.4	9.0	11.6	13.6	8.9	9.7	65.9	22.5

Table 3.56 Grain yield (Kg/ha) and other agronomic characters of varieties tested in RUVT-3 at Ibadan, Nigeria, 1987.

Entry	Grain yields kg/ha	Plant stand No.	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Rotten ears %
1. (Pop CSP x Local Raytiri) F2	1494	39	40	141	54	39	36	70.0
2. Pop CSP Early	1411	39	40	130	47	39	35	43.4
3. Pool 29 x Kamandaogo Tollo F4	1397	41	36	117	32	41	40	59.1
4. Pop 30 SR Early x GUA 314 F4	1314	42	40	150	63	39	40	58.5
5. Early 84 TZESR-w x GUA 314 BC1, F2	1262	38	38	145	73	38	38	61.5
6. (DMR-ESR-y x JFS) x K. Tollo F4	1194	44	36	120	45	42	40	75.9
7. Local check	1096	41	40	141	49	40	39	68.2
8. Pool 28 x GUA 314 BC1, BC2	1087	42	39	142	60	41	37	53.4
9. Pool 27 x GUA 314 F4	1087	40	39	138	62	39	35	52.7
10. (Across 8131 x JFS) x Local Raytiri F4	1052	43	40	137	53	42	37	66.7
11. (Pop 46 x Kamandaogo Tollo) F4	904	44	36	124	43	42	36	61.3
12. WIR 17215 x Kamandaogo Tollo BC1, F2	630	39	35	118	35	38	30	59.3
Overall Mean	1161	41	38	134	51	40	37	60.8
LSD 5%	385	5.8	1.2	18.0	14.9	5.1	7.6	16.5
Prob. of F.	0.004	0.426	0.000	0.004	0.000	0.649	0.340	0.031
C.V (%)	23.0	9.9	2.4	9.4	20.1	8.9	14.3	18.9

Table 3.57 Grain yield (kg/ha) and other agronomic characters of varieties tested in RUVT-3 at Kolo, Niger, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears harvested No.
1. Pool 27 x GUA 314, F4	677	50	113	35	52
2. Pop 30 SR Early x GUA 314, F4	538	50	115	43	42
3. (Pop 46 x Kamandaogo Tollo), F4	455	49	93	34	44
4. (DMR-ESR-y x JFS) x K. Tollo, F4	444	48	103	33	38
5. Early 84 TZESR-w x GUA 314 BCl, F2	385	50	107	41	40
6. Pool 29 x K. Tollo, F4	382	49	94	27	41
7.(Pop CSP x Local Raytiri) F2	382	52	113	35	34
8.(Across 8131 x JFS) x Local Raytiri,F4	360	52	109	40	39
9. Pool 28 x GUA 314 BCl, F2	270	51	94	35	36
10. Pop CSP Early	269	51	95	29	31
11. Local check	232	60	122	62	38
12. WIR 17215 x K. Tollo BCl, F2	230	49	100	34	33
Overall Mean	385	51	105	37	39
LSD 5%	200.4	1.4	24.3	12.4	17.1
Prob. of F.	0.002	0.000	0.253	0.000	0.545
C.V. (%)	36.0	2.0	16.1	23.2	30.4

Table 3.58 Grain yield (kg/ha) and other agronomic characters of varieties tested in RUVT-3 at Gampela, Burkina Faso, 1987.

Entry	Grain yields kg/ha	Days to 50% silking	Plant height (cm)	Ear height (cm)	Plants harvested No.	Ears harvested No.	Root lodging %
1. (Across 8131 x JFS) x L. Raytiri F4	1696	44	136	53	82	78	4.4
2. (DMR-ESR-y x JFS) x K. Tollo F4	1640	40	106	43	86	84	10.2
3. (Pop CSP x Local Raytiri) F2	1637	45	120	42	89	68	2.4
4. Pool 29 x Kamandaogo Tollo F4	128	39	112	41	90	83	9.2
5. Pool 28 x GUA 314 BC1, F2	1564	44	118	46	78	77	4.2
6. Pool 27 x GUA 314 F4	1532	43	102	42	97	80	4.9
7. Early 84 TZESR-w x GUA 314 BC1, F2	1473	44	120	52	83	78	5.3
8. Pop 30 SR Early x GUA 314 F4	1438	44	121	51	86	71	8.3
9. Pop CSP Early	1428	44	101	38	91	76	8.9
10. Local check	1428	44	120	59	82	82	2.6
11. (Pop 46 x K. Tollo) F4	1336	40	92	38	80	75	11.6
12. WIR 17215 x K. Tollo BC1, F2	1276	39	92	48	91	72	9.9
Overall Mean	1506	43	112	46	86	77	6.8
LSD 5%	572.0	1.9	15.0	8.0	13.5	18.4	5.7
Prob. of F	0.926	0.000	0.000	0.000	0.240	0.812	0.017
C.V. (%)	26.3	3.2	9.5	13.2	10.9	16.6	57.8

Table 3.59 Grain yield (kg/ha) and other agronomic characters of varieties tested in RUVT-3 at Sapu, Gambia, 1987.

Entry	Grain yields kg/ha	Plant height (cm)	Ear height (cm)	Plants harvested No.
1. (Across 831 x JFS) x L. Raytiri, F4	5143	203	71	45
2. (Pop CSP x Local Raytiri) F2	4809	199	64	48
3. Pop CSP Early	4524	175	44	43
4. (DMR-ESR-y x JFS) x K. Tollo, F4	4286	187	61	45
5. Pool 28 x GUA 314 BC1, F2	4190	186	69	43
6. (Pop 46 x K. Tollo) F4	4190	177	56	41
7. Local check	4155	220	89	46
8. WIR 17215 x K. Tollo BC1, F2	4143	175	45	47
9. Pool 29 X K. Tollo, F4	4095	180	52	45
10. Pop 30 SR Early x GUA 314, F4	4048	188	68	44
11. Pool 27 x GUA 314, F4	4000	177	51	42
12. Early 84 TZESR-w x GUA 314, BC1,F2	3809	189	64	42
Overal Mean	4283	188	61	44
LSD 5%	689.0	18.0	18.0	5.0
Prob. of F	0.024	0.000	0.000	0.201
C.V. %	11.1	6.5	19.9	7.9

higher than the local check which gave 4.1 t/ha).

At Nioro du Rip (Senegal), significant varietal differences were recorded for grain yields and other important agronomic characters. The differences for plants and ears harvested were also significant. Four varieties of the same maturity group, 42-44 days to 50% silking, as the local check significantly outyielded the local check (Table 3.60).

Pop CSP early, (Across 8131 x JFS x L. Rayitiri) F4, (Pop 30 x GUA 314) F4 and (Pool 27 x GUA 314) F4 outyielded the local check by 40%, 29% and 23% respectively. (Pop 46 x Kamandaogo Tollo) F4 reached 50% silking stage 40 days after planting and gave grain yield of 3.3 t/ha. It was the earliest entry. The extra-early Maize showed susceptibility to *Helminthosporium* stem lodging and ear rot. (WIR 17215 w Kamandaogo Tollo) BC1 F2 was the most susceptible entry to *Helminthosporium* attack, stem lodging and ear rot.

Table 3.61 shows mean grain yield and days to 50% silking of varieties tested in RUVT-3 Across 7 locations.

The yield potential of the extra-early maize varieties (41-44 days to 50% silking) tested in this trial was 2.5 t/ha.

<u>CONCLUDING REMARKS</u>:

The Maize Improvement Program of extra-early germplasm evaluated for grain yields, stem lodging and ear rot should be continued. This kind of material would probably be most useful to Senegal and the Gambia in the future.

Table 3.60 Grain yield and other agronomic characters of varieties tested in RUVT-3 at Nioro du Rip, Senegal, 1987.
Cooperator : Mr. A. NDIAYE.

Entry name	Grain Yields (kg/ha)	Days to 50 % silking	Plant Height (cm)	Ear Height (cm)	Plants harvested (no)	Ears harvested (no)	H. Maydis	Stem lodging (%)	Ear rot (%)
1. Pop CSP Early	4675	42	154	65	96	91	2.2	10.0	5.8
2. A 8131 x JFS x L.Raytiri F4	4473	44	182	89	78	96	2.5	21.7	9.5
3. CSP x Local Raytiri F2	4307	45	152	67	88	95	2.0	14.9	22.6
4. POP.30 x GUA 314 F4	4116	43	165	82	100	102	2.8	18.0	2.4
5. Pool 27 x GUA 314 F4	4104	42	146	72	97	98	2.0	15.9	6.2
6. PL 28 x GUA 314 BC1 F2	3976	42	165	81	86	93	2.5	23.3	10.2
7. ESR-W x GUA 314 BC1 F2	3522	44	146	72	91	92	2.8	17.0	2.5
8. Pool 29 x K. Tollo F4	3342	41	143	64	75	91	3.0	17.5	15.1
9. Local check	3334	42	154	69	86	84	3.5	23.2	17.9
10. POP 46 x K. Tollo F4	3299	40	156	71	82	88	2.8	19.6	14.7
11. W17215 x K. Tollo BC1,F2	2570	41	148	63	72	86	3.5	36.3	20.8
12. DMR-ESR-Y x JFS x K.Tollo F4	2499	43	135	56	74	66	3.8	17.9	17.9
Overall mean	3685	42	154	71	85	90	2.8	19.6	12.1
L.S.D. (5 %)	678	1.9	14	8	13.7	14.2	0.6	11.8	8.6
Prob. of F	0.0000	0.0003	0.0000	0.0000	0.0008	0.0033	0.0000	0.0219	0.0001
C.V. (%)	12.8	3.1	6.2	7.8	11.1	10.9	14.07	41.7	49.2

Table 3.61. **Mean grain yield and days to 50 % silking of varieties tested in RUVT-3 across 7 locations, 1987.**

	Entry	Grain yield (kg/ha)	Days to 50 % silking
1.	POP CSP Early	2741	45
2.	Across 8131 x JFS x L. Raytiri F4	2705	46
3.	CSP x Local Raytiri F4	2582	46
4.	Pool 27 x GUA 314 BC1 F2	2544	44
5.	Pool 28 x GUA 314 BC1 F2	2456	45
6.	POP 30 x GUA 314 BC1 F2	2414	45
7.	TZESR-W x GUA 314 BC1 F2	2338	45
8.	Pool 29 x Kamandaogo Tollo F4	2335	42
9.	Local check	2330	46
10.	DMR-ESR-Y x JFS x K. Tollo F4	2235	43
11.	POP 46 x Kamandaogo Tollo F4	2175	42
12.	WIR 17215 x K. Tollo BC1 F2	1955	41

MAIZE AGRONOMY

Mario Rodriguez

Introduction

The IITA/SAFGRAD Maize Agronomy Program was initiated in 1979 to identify and help solve agronomic problems constraining maize production in the Semi-Arid Tropics (SAT) of Africa.

Objectives

The specific objectives of the IITA/SAFGRAD Maize Agronomy Program were:

a) To assess the relative importance of the different soil, climatic and management factors affecting maize production in the Northern guinea and Sudan Savanna Zones.

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

c) To participate in the formulation and execution of a maize improvement program designed for growing conditions in the SAT, with particular emphasis on increasing drought resistance in maize.

Most of the research efforts have been concentrated in the Sudan Savanna Zone of Burkina Faso, at the Kamboinse, Saria and Loumbila research stations. Some on-farm trials were also conducted. The trial zone is characterized by a total rainfall of 600-900 mm, with 3-4 months when rainfall is greater than half the potential evapotranspiration. Research in the Northern Guinea Savanna Zone (900-1200 mm rainfall, with 4-5 months when rainfall is greater than half the potential evapotranspiration) was conducted at the Farakô-Ba station.

Some of the research results obtained in the Sudan Savanna and reported here are applicable to regions in the 600-900 mm belt where there are Ferruginous tropical soils (Alfisols) and associated soils with low water infiltration, soil compaction, tendencies toward surface sealing or crusting, and where dry periods occur during the growing season.

Soils

Under the French Soil classification System, soils at the Kamboinse and Saria stations fall into two main categories : "Sols Ferrugineux Tropicaux" and "Sols Hydromorphes" (in the lower parts of the toposequence). The USDA Soil Taxonomy Classification equivalents include : Paleustalfs, Plinthustalfs and Haplustalfs in the former case, and Ustochrepts in the case of hydromorphic soils. Sometimes Weakly Ferrallitic Soils are found in the upper parts of the toposequence (Paleustalfs, Ustorthents and Eutrustox).

Soils at the Kamboinse station (except the hydromorphic soils) typically possess the following characteristics : (1) loam to sandy loam texture: (2) approximately 12% clay, 30% silt, and 58% sand ; (3) 1% or less organic matter ; (4) C:N of 11 ; (5) soil-water pH of 6.0 ; (6) exchangeable bases (meq/100g) consisting of Ca = 2.3, Mg = 0.8, K = 0.21, and Na = 0.11; (7) 12 ppm of available P (Olsen) ; and (8) 80-160 ppm total P. Soil bulk densities are often between 1.4 and 1.5 g/cm^3, and tend to increase with depth. Final water infiltration rates are usually in the order of 2-5 cm/hour.

Soils at the Farako-Ba station (1100 mm mean annual rainfall) are classified as "Sols Ferrallitiques faiblement desatures" (Weakly Ferrallitic soils) or as Eutrustox, Haplustalfs, Ustorthents and Hapludalfs under the USDA Soil Taxonomy System.

Rainfall :

Total annual rainfall in 1987 was 582.4 mm at the Kamboinse Station, 575.6 mm at Loumbila, and 886.7 mm at the Farako-Ba Station, compared with long-term averages of 800 mm and 1000 mm, respectively. Rainfall distribution enabled crop planting in late June/early July at Kamboinse and Loumbila, and during early June at Farako-Ba. The crops experienced marked drought stress periods throughout the season, especially in July-August at Kamboinse and in July and September at Loumbila and Farako-Ba.

Crop Management

The IITA/SAFGRAD Maize Agronomy Research Program was usually conducted under low and high management levels. The low level was a combination of low plant density (approximately 44,000 plants/ha) and low fertilizer rates (approximately 37-23-15 kg/ha $N-P_2O_5K_2O$). This allowed for grain yields approaching 2-2.5 t/ha in the Sudan Savanna when rainfall was not limiting. The high management level consisted of a high plant density (approximately 59,000 plants/ha) and high fertilizer rates (approximately 97-46-30 kg/ha $N-P_2O_5-K_2O$), allowing for grain yields of up to 4-5 t/ha. These management levels also involved application of S and B_2O_3 as follows : 6-1 and 12-2 kg/ha at the low and high fertility levels, respectively, since sulfur and boron are included in the compound fertilizer of Burkina Faso ($14N-23P_2O_5-15K_2O-6,5'-1B_2O_3$).

When discussing yield results no mention will be made of plant density at harvest, except when they were markedly lower than the target densities. All grain yield results are expressed on a 0% moisture basis.

TRIALS AT FARAKO-BA (Northern Guinea Savanna)

Fertility level x Pool 16 DR Family interaction trial
(In collaboration with the Maize Breeding Program)

A previous experiment conducted from 1984-86 comparing 12 local and improved varieties, under 3 fertility levels, indicated that there were significant interactions between varieties and N levels and between varieties and P levels. the variety SAFITA-2 showed consistently good performance under low P, whereas SAFITA-2 and TZE-4 were among the best performance under low N. In 1987, it was decided to evaluate if such fertility level x genotype interactions could be detected within Pool 16, the population from which SAFITA-2 was developed.

The experiment involved 42 full sib families of Pool 16 DR Cycle 1, selected at randon out of 194, in a factorial arrangement with 3 fertility levels (main plots) and 4 replications (RCB's). The trial was established on the same plots of the 1986 trial where 12 varieties were compared. A bulk of the 42 families was used as common border in the outside of each replication. The following amounts of fertilizer were applied in 1987.

F1	:	150 N - 10 P_2O_5 kg/ha
F2	:	23 N - 75 P_2O_5 "
F3	:	150 N - 75 P_2O_5 "

The fertilizers were SSP applied before planting, and are split in 2 halves at 12 and 40 DAP, banded and incorporated.

The crop was planted on June 22 at a density of 53,300 plants/ha and in single-row plots, 5 m long and 75 cm apart. Harvest was at 98 DAP, discarding 3 border hills at each side of the row.

Field observations suggested that performance of the Pool 16 DR families was probably affected by the preceding variety planted in 1986 in 4-row plots. This hypothesis was tested by performing a covariance analysis, one at a time on the previous varieties (presence or absence). Results showed that 5 varieties had a statistically significant ($P<0.05$) effect on grain yields from 1987 crop, and other plant parameters such as days to silking and plant height. These varieties were : V3 = Local Koudougou, V5 = Local Diapaga, V6 = Local Raytiri, V9 = TZE-4, and V11 = IRAT-178, the first 3 of which had positive covariance regression coefficients for yield (426 kg/ha, 407 kg/ha and 323 kg/ha, respectively) while the last two had negative coefficients (-188 kg/ha and -323 kg/ha, respectively). Grain yields (and other plant variables affected) were adjusted for the covariates.

As shown in Table 3.62, there were highly significant ($P<0.001$) differences in grain yields between fertility levels F1, F2 and F3. Yield differences between families were significant ($P = 0.069$) and the Fertility x Family interaction was significant at $P = 0.062$. The relative yield performance of families was statistically different under low and high P conditions ($P = 0.083$) and also under low and high N conditions ($P = 0.061$).

The differential family performance under the 3 fertility levels was also indicated by the small rank correlation coefficients : -0.019 between ranks under F1 and F3, 0.099 under F2 and F3, and -0.006 under F1 and F2.

Table 3.62 : Fertility x family interaction trial.
Farako-Bâ, Burkina Faso, 1987.

Rank and maize grain yields (kg/ha, at zero percent moisture ; means adjusted for covariates).

Family (0.069)+	Fertility level (P < 0.001)						Mean	
	F1		F2		F3			
	Rank	Yield kg/ha	Rank	Yield kg/ha	Rank	Yield kg/ha	Rank	Yield kg/ha
1	7	1884	32	1928	22	3197	22	2336
2	41	1247	27	2053	35	2972	41	2091
3	21	1619	42	1743	33	3044	37	2136
4	15	1763	29	2017	19	3251	21	2344
5	5	2011	30	1991	24	3187	15	2397
6	9	1851	34	1903	29	3153	26	2302
7	2	2087	28	2040	1	3876	1	2668
8	35	1364	22	2152	21	3198	32	2238
9	18	1677	8	2466	10	3457	8	2534
10	20	1642	11	2402	9	3513	10	2519
11	29	1503	26	2057	20	3218	29	2259
12	42	1160	13	2309	26	3167	35	2212
13	36	1351	16	2248	14	3372	25	2324
14	17	1731	4	2550	5	3684	2	2655
15	33	1420	40	1783	2	3867	20	2357
16	38	1320	41	1782	6	3674	30	2259
17	8	1873	12	2366	25	3181	11	2474
18	31	1454	36	1855	3	3796	17	2368
19	30	1487	20	2178	11	3406	19	2357
20	12	1793	38	1840	39	2768	38	2134
21	34	1402	10	2402	23	3188	23	2331
22	27	1511	3	2588	28	3159	14	2419
23	3	2064	31	1967	40	2688	31	2240
24	25	1530	25	2080	38	2770	39	2126
25	4	2020	37	1848	31	3107	24	2325
26	6	2000	2	2631	36	2958	9	2530
27	40	1279	23	2151	18	3281	33	2237

Table 3.62 (Cont'd) : Fertility x family interaction trial.
Farako-Bâ, Burkina Faso, 1987.

Rank and maize grain yields (kg/ha at zero percent moisture ; means adjusted for covariates).

Family (0.069)[+]	Fertility level (P< 0.001)						Mean	
	F1		F2		F3			
	Rank	Yield kg/ha	Rank	Yield kg/ha	Rank	Yield kg/ha	Rank	Yield kg/ha
28	14	1783	19	2197	15	3370	13	2450
29	1	2092	9	2419	16	3351	3	2620
30	32	1430	7	2471	42	2617	36	2173
31	37	1342	15	2253	32	3096	34	2230
32	16	1759	21	2176	4	3770	6	2568
33	28	1504	24	2092	8	3526	16	2374
34	19	1673	1	2828	27	3163	7	2554
35	22	1591	14	2291	37	2913	28	2265
36	24	1540	18	2228	17	3315	18	2361
37	39	1304	33	1924	41	2634	42	1954
38	10	1843	35	1856	30	3150	27	2283
39	13	1788	17	2238	13	3375	12	2467
40	23	1572	39	1828	34	2974	40	2125
41	26	1522	5	2538	7	3657	5	2572
42	11	1799	6	2519	12	3401	4	2573
Mean		1633		2171		3249		2351

Family x Fertility	(0.062)		
Family x (F1 VS F2)	(0.162)	C.V. Main plots	: 10.8
Family x (F1 VS F3)	(0.083)	(%) Subplots	: 20.9
Family x (F2 VS F3)	(0.061)		
Covariates	(P< 0.001)		

+ Values in parentheses give probabilities of F.

Standard errors of differences of means (SED) and LSD's (P = 0.05)

	SED	LSD
Fertility	179.6	440.5
Family	201.7	397.3
Families at same level of Fertility	352.6	694.5
Families at different levels of Fertility	386.6	796.3

The grain yields of 26 contrasting families out of the 42 tested have been plotted in Fig. 3.2. It appeared that some families performed well only under low or high N (or P) conditions, whereas others performed well under both low and high N (or P).

If the 42 families had been tested only under high NP conditions, as is the normal practice in standard breeding programs, many of the best performing families under low N or low P conditions could neither have been identified nor selected. Assuming that the 10 top families for grain yields under high NP would be selected to create an experimental variety, these families (Nos. 7, 15, 18, 32, 14, 16, 41, 16, 41, 33, 10 and 9) would include only 1 family (No. 7) of the 10 best performing families under low P (F1), and only 3 families (Nos. 14, 41 and 9) of the 10 best families under low N (F2).

Trials at Kamboinse (Sudan Savanna)

Surface management trial
(In collaboration with ICRISAT's socio-economics program)

This experiment was designed to :

(a) compare the efficiencies of tied ridges and small inter-row ditches made by animal traction with tied ridges made by using the hand-hoe (daba); and
(b) to evaluate the residual effect of the ridging systems established in 1986.

The experiment consisted of a factorial combination of 2 surface management systems and 5 ridging systems, replicated 4 times in randomized complete block split-plot design, with the ridging systems as subplots.

The following ridging systems had been tested in 1986 :

R1 : No earthing up (check).

R2 : Tied earthing up by hand hoe at 35 DAP.

R3 : Tied earthing up at 35 DAP with the IITA/SAFGRAD TRAP ridge-tier (donkey version).

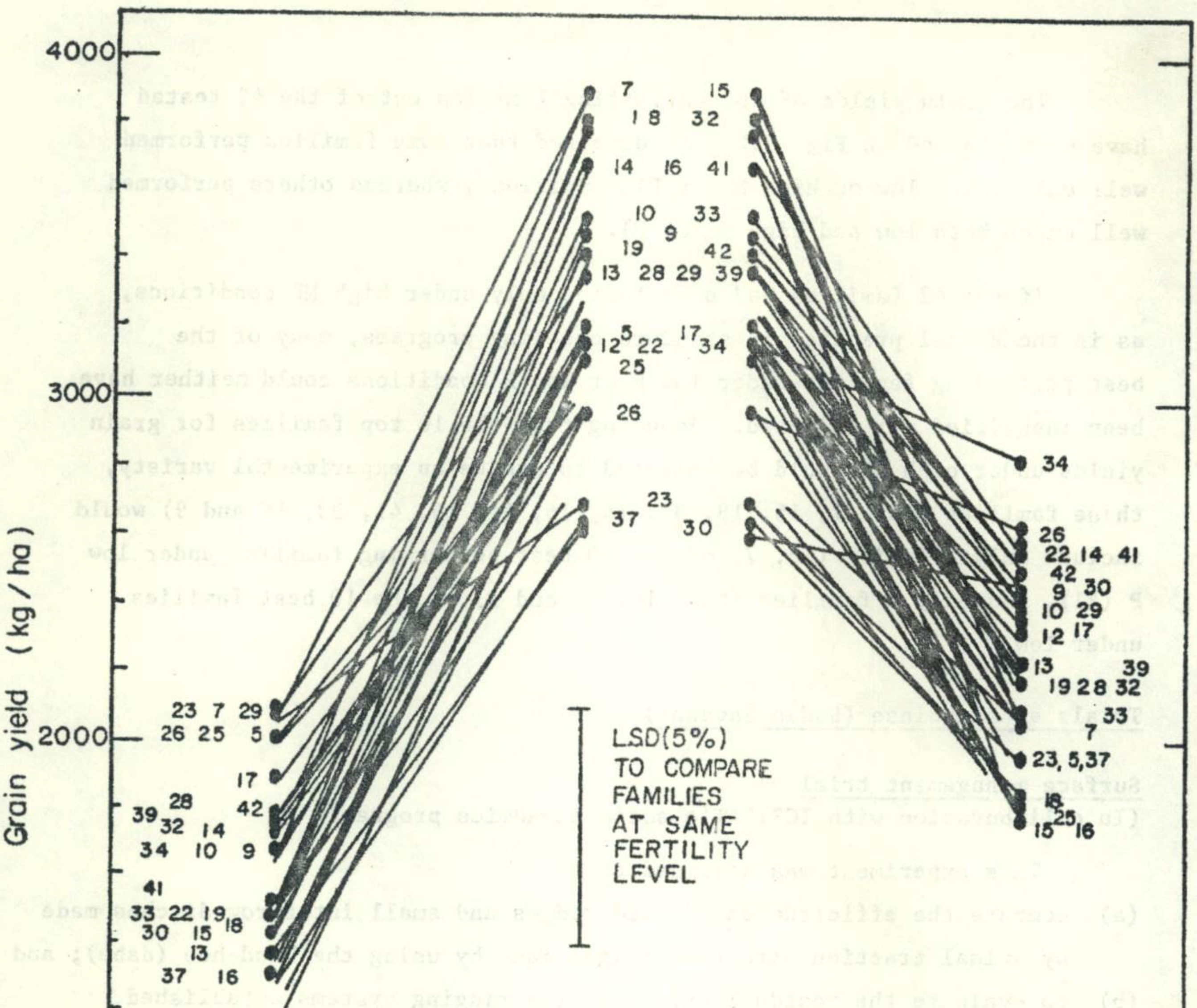

FIG. 3.2. GRAIN YIELD OF SELECTED POOL 16 DR FULL SIB FAMILIES AT 3 FERTILITY (F) LEVELS (ADJUSTED FOR COVARIATES). FERTILITY x FAMILY INTERACTION TRIAL. FARAKO-BA, BURKINA FASO. 1987.

R4 : Digging of small ditches between rows at 35 DAP with the oval wheel and "houe-manga" (for donkey traction). Ditches were about 15 cm deep in the middle and 1.8 m long.

R5 : Digging of larger ditches between rows at 35 DAP with the over-wheel and the ridger ("butteuse") for oxen traction. Ditches were about 18 cm deep in the middle and 2.0 m long (due to the lack of appropriate harnessing equipment, the implement was pulled by 2-3 people).

All the 1986 treatments involved planting on the flat, (following the traditional cultivation system). The oval wheel (Figure 3.3), developed by ICRISAT's socio-economics program, lifts the ridger above the ground at every revolution, to make holes or ditches separated by hard ground.

The surface management systems imposed in 1987 consisted of:

M1 : Disk harrowing to destroy the ridging systems established in 1986 and soil packing with a press (February 1987).

M2 : Planting without destruction of the 1986 ridging systems.

The 1987 ridging systems were applied to M1 as described above for 1986 ; plots were hand-hoed cultivated before planting. Under the M2 management systems, plots were also hand-hoe cultivated before planting but without destruction of old ridges and ditches ; 43 days after planting, plots were earthed up or ditches were dug between rows as required by the ridging systems. R2 plots were, however, not earthed up because the 1986 tied ridges were in such good condition that it was unnecessary to re-make them. Plots were weeded and cultivated at 15 and 36 DAP (only the furrows in R2) and weeded again at 59 DAP.

The fertilizer applied was 97-46-30 kg/ha of N-P_2O_5-K20, with the compound fertilizer (14-23-15) broadcast before planting and were banded and incorporated during the second weeding at 36 DAP.

The trial was planted on June 26 to maize (variety Local Koudougou) intercropped with cotton (varety HCB-475), but many hills had to be replanted on July 11. Each crop was planted at a density of 41,700 plants/ha with alternating hills of each crop with 2 plants/hill. Row distance was 80 cm with hills 30 cm apart. Plots had 6 rows, 5 m long. Alleys 4.5 m long separated the plots to allow working space for the donkey along the rows.

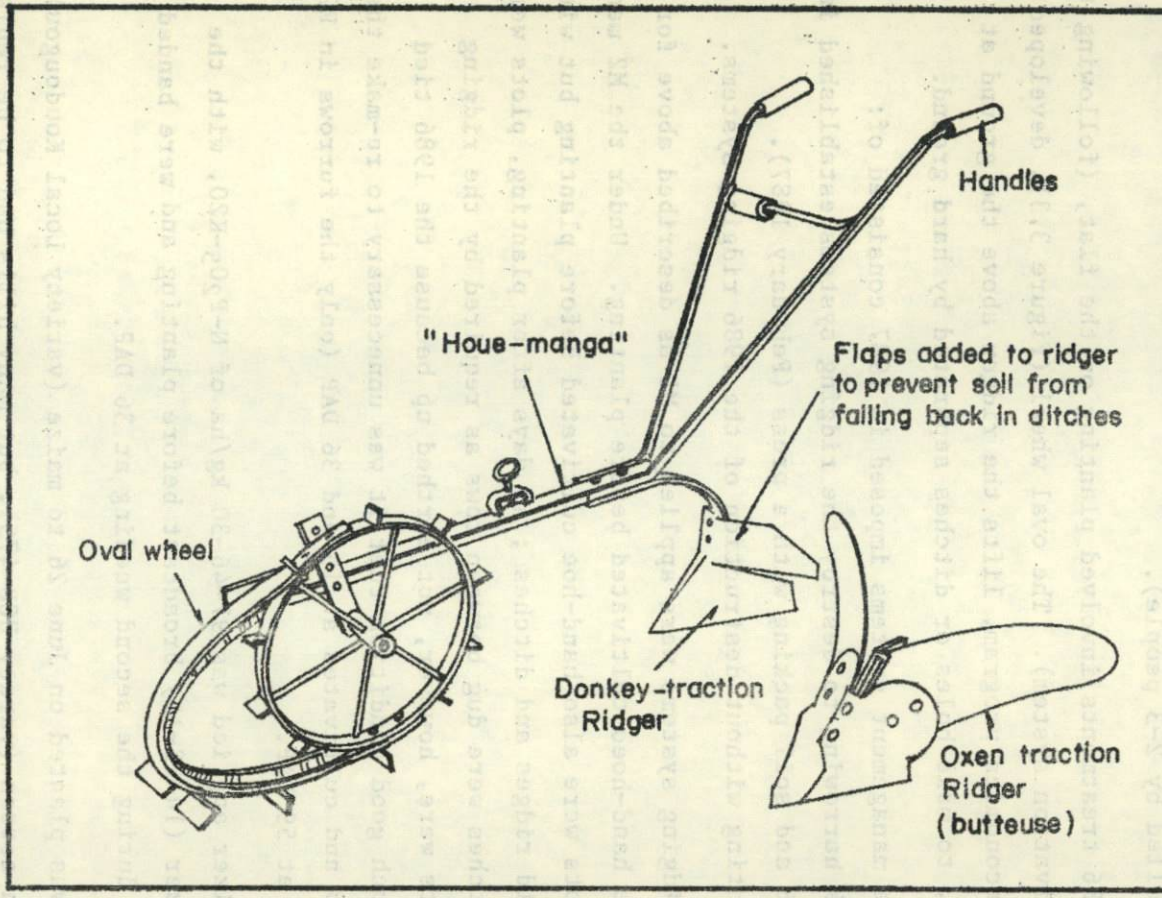

Fig. 3.3. The oval wheel for digging inter-row ditches, shown attached to a "houe-manga" for donkey traction. Larger ditches are made with the ridger for oxen traction on the right.

Cotton was sprayed with Decis at 1.5 l/ha 5 times, starting at 36 DAP and every 12-15 days thereafter.

Maize was harvested (4 central rows) at 81 DAP and 91 DAP while cotton was harvested (4 central rows, discarding the first and last hills of each row) starting 111 DAP until 140 DAP. Cotton stalks were cut to estimate dry matter and to test their suitability as fuel wood for cooking.

Maize germination counts 10 DAP showed a significant difference P = 0.01 between M1 and M2 (52.2% and 63.2%, respectively), but no significant difference between ridging systems and no significant interaction. There were no significant differences in cotton germination between surface management systems and ridging systems (overall mean = 35.9%).

Although the maize and cotton were overplanted (5 maize seeds/hill and 10 cotton seeds/hill), drought conditions early in the season and the very sandy nature of the topsoil casued poor stands. Missing hills were therefore replanted 15 DAP.

Plant densities at harvest were slightly below the target for maize but good for cotton. For maize, the only significant (P = 0.035) differences recorded were between surface management systems (29,300 plants/ha for M1, and 35,100 plants/ha for M2). Densities ranged from 29,600 plants/ha for R1 to 35,600 plants/ha for R3. These small differences in stand, and the variability in individual plants development within treatments, were partially responsible for high coefficient of variation (C.V.) for maize yields. There were no significant differences in cotton plant densities between surface management systems. Although statistically (P = 0.032) significant differences were noted between ridging systems, such differences were of no practical importance since the range was 39,200 plants/ha (R3) to 41,600 plants/ha (R2).

Maize grain yields (Table 3.63) were 690 kg/ha under M1 and 1110 kg/ha under M2; these differences were significant at P = 0.101. The differences in grain yields between ridging systems were large and highly significant (P<0.001), whereas surface management x ridging interaction was significant at P = 0.063. The lowest mean yield was obtained with the check treatment = no earthing up (410 kg/ha) and the highest with R2 (tied earthing up by

Table 3.63 Surface management trial. Kamboinse, Burkina Faso, 1987.
Maize grain yield (kg/ha)

Ridging system (P<0.001)+	Surface Management (0.01) M1	M2	Mean Yields kg/ha
R1 . No earthing up (check)	290	540	410
R2 : Tied earthing up by hand-hoe 43 DAP (M1) or old tied ridges (1986) by hand-hoe	850	1750	1300
R3 : Tied earthing up 43 DAP with the TRAP ridge-tier (donkey version)	1110	1220	1160
R4 : Small inter-row ditches 43 DAP with oval wheel and houe-manga (donkey traction)	310	1050	680
R5 : Larger inter-row ditches 43 DAP with with oval wheel and ridger (for oxen traction)	910	1000	950
Mean	690	1110	900
Surface manag. x Ridging (0.063)	C.V. (%)	Main plot / sub-plot	28.1 / 36.9

+ Values in parenthesis give probabilities of F

Standard errors of means (SE) and LSD's (P=0.05)

	SE	LSD
Surface management (SM)	127	570
Ridging system (RS)	118	344
RS at same level of SM	166	486
RS at different levels of SM	195	701

hand-hoe or direct planting on old tied ridges) which gave 1300 kg/ha. Intermediate yields were obtained with the oval wheel and donkey traction (R4 = 680 kg/ha), the oval wheel and the oxen ridger (R5 = 950 kg/ha), and the IITA/SAFGRAD TRAP donkey ridge-tier (R3 = 1160 kg/ha ; LSD = 344, at P = 0.05).

Seed, cotton yields (Table 3.64), were not significantly different between surface management systems (850 VS 950 kg/ha for M1 and M2, respectively). There were, however, highly significant (P<0.001) differences between ridging systems. The lowest mean yield was that of the check (520 kg/ha) while the highest yield was obtained with R2 (1370 kg/ha). Intermediate yields were obtained with R4 (810 kg/ha), R5 (870 kg/ha) and R3 (920 kg/ha ; LSD = 214, at P = 0.05). The interaction ridging x surface management systems was not significant.

The 1987 results showed that yields of both maize and cotton in association can be significantly improved over the traditional flat cultivation method by either (i) planting directly on old tied ridges (hand made) or tied earthing-up by hand at 43 DAP or (ii) using animal traction for making the tied ridges or digging inter-row ditches. The highest yield increases were obtained with hand made tied ridges (R2) followed by R3, R5 and R4.

It seemed that yield ranking of the different ridging systems was related to the amount of rain-water that could be trapped by them. In this respect, it should be noted that in a year like 1987 with below average and poorly distributed rainfall, it was important to retain all the rainwater. This was most efficiently done by hand-made tied ridges. However, tied ridges only capture water falling in situ; they cannot capture runoff water from alleys or surrounding fields which can be captured by inter-row ditches.

The satisfactory results obtained by planting directly on tied ridges made in 1986, should be noted. This was the best treatment for both maize and cotton yields (1750 and 1450 kg/ha respectively), inspite of the fact that no raising or remolding of the ridges was done in 1987. Average ridge and tie heights of M2R2 plots were 13.6 cm and 11.8 cm on November 18, 1987 at the end of the season.

Table 3.64 Surface management trial. Kamboinse, Burkina Faso, 1987.
Seed cotton yield (kg/ha)

Ridging system($P < 0.001$)+	Surface Management (0.266)		Mean Yield kg/ha
	M1	M2	
R1 : No earthing up (check)	490	540	520
R2 : Tied earthing up by hand-hoe 43 DAP (M1) or old tied ridges (1986) by hand hoe	1290	1450	1370
R3 : Tied earthing up 43 DAP with the TRAP ridge-tier (donkey version)	910	920	920
R4 : Small inter-row ditches 43 DAP with oval wheel and houe-manga (donkey traction)	670	950	810
R5 : Larger inter-row ditches 43 DAP with oval wheel and ridger (for oxen traction	870	860	870
Mean	850	950	900
Surface manag. x Ridging (0.603)	C.V. (%)	Main plot	11.6
		Sub-plot	23.1

+ Values in parenthesis give probabilities of F

Standard errors of means (SE) and LSD's ($P = 0.05$)

	SE	LSD
Surface management (SM)	52	235
Ridging system (RS)	73	214
RS at same level of SM	103	302
RS at different levels of SM	106	351

When the residual effects of the ridging systems established in 1986, were considered, M2 gave significantly better maize germination than M1, but the differences in maize and cotton yields between M1 and M2 were not statistically significant. Nevertheless, M2 gave generally higher yields than M1, particularly in maize grown on hand-made tied ridges. This can be better appreciated when the average relative yields of maize and cotton are considered (Table 3.65).

Dry matter of cotton stalks (Table 3.66) was significantly ($P<0.001$) different between ridging systems. The check treatment (R1) produced an average of 540 kg/ha, which increased to 1670 kg/ha, 1060 kg/ha and 1030 kg.ha for R2 to R5, respectively ($LSD = 368$, at $p = 0.05$).

Tests were conducted in December 1987, with 3 families to evaluate the usefulness of cotton stalks as fuelwood for cooking. Family 1 was composed of 9 persons (5 adults, i.e. > 14 years old, and 4 children), Family 2 of 5 persons (2 adults and 3 children), and family 3 of 6 persons (4 adults and 2 children). Each family received 17.9 kg of cotton stalks at 11% moisture, i.e. 15.9 kg at 0% moisture, for use exclusively as fuelwood for all household needs. Cotton stalks lasted for 3, 6 and 5.5 days for families 1, 2, and 3, respectively. Therefore, 15.9 kg of cotton stalks dry matter were equivalent to 27, 30, and 33 person-days of fuelwood, which gives an average of 1.88 person-days of fuelwood per kg of cotton stalks dry matter.

Average cotton stalks dry matter yields were 540 kg/ha for R1 (check) and 1670 kg/ha for hand-made tied ridges (R2), equivalent to 1010 and 3150 person-days of fuelwood/ha, respectively. Therefore, if a household of 10 members cultivated 1 ha of a maize-cotton association and obtained cotton stalks dry matter yields equivalent to those obtained in this trial, their fuelwood needs would be satisfied for about 101 to 315 days depending on the ridging systems employed. The use of cotton stalks as fuelwood is an additional advantage of the proposed maize-cotton association.

Table 3.65 Surface management trial. Kamboinse, Burkina Faso, 1987. Relative Maize grain and cotton yields (kg/ha).

Ridging system		Surface Management M1	Surface Management M2	Mean Yield (kg/ha)
R1 : No earthing up (check)	Maize	100	186	141
	Cotton	100	110	106
	$\bar{X}$	100	148	124
R2 : Tied earthing up by hand hoe 43 DAP (M1) or old tied ridges (1986) by hand hoe	Maize	293	603	448
	Cotton	263	296	280
	$\bar{X}$	278	450	364
R3 : Tied earthing up 43 DAP with TRAP ridge-tier (donkey version)	Maize	383	421	400
	Cotton	186	188	188
	$\bar{X}$	284	304	294
R4 : Small inter-row ditches 43 DAP with oval wheel and houe-manga (donkey traction)	Maize	107	362	234
	Cotton	137	194	165
	$\bar{X}$	122	278	200
R5 : Larger inter-row ditches 43 DAP with oval wheel and ridger (for oxen traction)	Maize	314	345	328
	Cotton	178	176	178
	$\bar{X}$	246	260	253
Mean	Maize	238	383	310
	Cotton	173	194	184
	$\bar{X}$	206	288	247

Table 3.66 Surface management trial. Kamboinse, Burkina Faso, 1987.
Cotton stalks dry matter (kg/ha, at 0% moisture)

Ridging system($P < 0.001$)+	Surface Management (0.112) M1	M2	Mean yield kg/ha
R1 : No earthing up (check)	560	520	540
R2 : Tied earthing up by hand hoe 43 DAP (M1) or old tied ridges (1986) by hand hoe	1370	1980	1670
R3 : Tied earthing up 43 DAP with the TRAP ridge-tier (donkey version)	1050	1070	1060
R4 : Small inter-row ditches 43 DAP with oval wheel and houe-manga (donkey traction)	690	1070	880
R5 : larger inter-row ditches 43 DAP with oval wheel and ridger (for oxen traction)	1040	1020	1030
Mean	940	1130	1040
Surface manag. x Ridging (0.30)	C.V. Main plot		11.6
	(%) Sub-plot		34.4

+ Values in parenthesis give probabilities of F

Standard errors of means (SE) and LSD's ($P = 0.05$)

	SE	LSD
Surface management (SM)	60	271
Ridging system (RS)	126	368
RS at same level of SM	178	520
RS at different levels of SM	170	531

Tied ridges trial on gravelly soil (plateau)

This experiment evaluated the effect of several systems of ridge-tying on maize grain yields under low and high nitrogen fertilizer levels. The trial consisted of a factorial combination of 4 ridge-tying systems and 2 management levels in a gravelly plateau soil. The trial had a split-plot arrangment with ridging as the main plots with 8 replications.

the ridge-tying systems were :

- R1 : Simple ridges
- R2 : Ridges tied every furrow
- R3 : Ridges tied every other furrow
- R4 : Ridges tied every furrow from before planting until early August. On August 6 (40 DAP) ridges were opened at every other furrow until August 20 (54 DAP) when all furrows were again tied.

The management levels consisted of a combination of low fertility and low plant density (M1) and high fertility and high plant density (M2). The fertility levels were 0-50-0 (low) and 92-50-0 (high) kg/ha of $N-P_2 O_5-K20$. Phosphorus (SSP) was applied before tractor plowing and the nitrogen (urea) applied 18 DAP. Plant densities were 44,400 and 59,300 plants/ha.

The trial was planted to SAFITA-2 variety on June 27 in plots 5 m long and consisting of 4 rows (except for R1 which had only 3 rows), 75 cm apart. The plot had been disk-plowed (10-15 cm depth) 9 days before planting (DBP), tractor ridged and then ridge-tied 5 DBP.

Maize was harvested on September 21, i.e. 86 DAP. Although SAFITA-2 normally reaches full black layer formation at 95 days, many ears had already showed black layer at 81 DAP due to the dry weather conditons in September.

There were highly significant ($P< 0.001$) differences in grain yields between management levels and between ridging systems, with management x ridging interaction significant at $P = 0.006$.

The lowest yields (Table 3.67) for M1 and M2 were obtained with ridges (460 kg/ha and 860 kg/ha, respectively). Significant ($P = 0.05$) yield increases were obtained over R1 by tying every other furrow (R3), and over R3 by tying every furrow (R2). The yield increase from R3 to R2 was larger under M2 than M1 (980 kg/ha and 460 kg/ha, respectively) which explains the significant M x R interaction. The greater amount of rainfall captured by tying the ridges every furrow could be better utilized under the high management (fertility) level.

The rationale for R4 was to avoid excess moisture which could occur during August which is normally the wettest month in the Sudan Savanna. Grain yields under R4 were below those of R2 although the differences were not significant. Therefore, under dry conditions as prevailed in 1987 at Kamboinse with an August rainfall of only 140.7 mm, there was no yield advantage of reopening every other furrow from 6-20 August when rainfall was 67.2 mm.

The mean grain yields under M1 and M2 were 1210 kg/ha and 2000 kg/ha, respectively. The grain yield (1720 kg/ha) obtained by tying the ridges every furrow under M1 was rather high when it is realized that this treatment had not received any nitrogen fertilizer for 4 years and that tied ridges had been used continuously for 8 years. This suggests that in this type of soil, the use of tied ridges does not necessarily result in high nitrogen losses by leaching or volatilization.

Grain yield under R2M2 was 2740 kg/ha which represented an increase of 1020 kg/ha over M1, due to the application of 92 kg N/ha (not taking into account residual effects of post fertilizer application).

The yield increases resulting from the use of tied ridges were due mainly to increases in grain numbers (485 against 1376 grains/m^2 for R1 and R2, respectively; LSD = 203 at P = 0.05) and smaller increases in grain size (120 against 160 g/1000 kernels for R1 and R2, respectively; LSD = 11.7 at P = 0.05).

<u>Extra-early maize plant density trial</u>

The objective of this experiment was to evaluate the plant density response of extra-early maize varieties developed by the breeding program. The trial consisted of a factorial combination of 2 varieties and 5 plant densities, as subplots in 4 randomized complete blocks (RCB).

The varieties were : V1 = Pop. 46 x Kamandaogo Tollo F4, (yellow variety) and V2 = TZESR (early 84) W x GUA 314 BC1 F2, (white variety).

Table 3.67. Tied ridges trial on gravelly soil : Kamboinse, Burkina Faso, 1987. Maize grain yield (kg/ha at zero percent moisture)

Ridging systems (P= 0.001)+		Management level (P= 0.001)		Mean yield kg/ha
		Low	High	
R1	Simple ridges	460	860	660
R2	Ridges tied every furrow	1720	2740	2230
R3	Ridges tied every other furrow	1260	1760	1510
R4	Ridges tied every furrow from 0-40 DAP and after 54 DAP ; tied every other furrow 40-50 DAP	1410	2650	2030
	Mean	1210	2000	1610

Ridging system x Management level (0.006)	C.V. (%)	Main plot	21.2
		Sub-plot	22.2

+ Values in parenthesis give probabilities of F.

Standard errrors of means (SE) and LSD's (P = 0.05)

	SE	LSD
Ridging system (RS)	120	355
Management level (ML)	63	183
ML at same level of RS	126	366
ML at different levels of RS	150	439

The following plant densities, hill distances and plants/hill arrangements were used:

Density	Plants/ha	Hill distance (cm)	Plants/hill
D1	53,300	25	1
D2	80,000	25	1-2-1-2
D3	106,700	12.5	1
D4	133,300	10	1
D5	160,000	12.5	1-2-1-2

Plots had 4 rows, 5 m long with rows 75 cm apart, of which the central 2 were harvested for yield.

The plot received 200 kg/ha of 14-23-15 broadcast before plowing, and 150 kg/ha of urea banded and incorporated at 31 days after planting DAP.

The trial was planted on July 13 on plots ridge-tied 12 days before planting (DBP).

Leaf area was estimated 56 DAP in 2 replications by measuring length and width of all leaves from 10 plants/plot. Varieties 1 and 2 were harvested at 75 and 77 DAP respectively, at full black layer stage.

Under the dry conditions of 1987, V1 and V2 gave the highest yields of 3270 kg/ha and 2750 kg/ha, respectively at densities of 80,000 plants/ha (Table 3.68): V1 showed a more stable yield under the highest densities whereas yields of V2 dropped markedly.

Days to 50 % silking were significantly (P = 0.002) different between varieties. V1 silked at 38.8, 40.0 and 41.8 days under D1, D2 and D5, respectively, while V2 silked at 42.8, 42.5 and 44.8 days under the same densities. V1 seemed to be a few days earlier than V2 and it was likely that the black layer development of V2 and probably V1 was hastened by the dry weather conditions in September. The relative earliness of V1 in relation to V2 may explain its higher grain yields.

There were no significant differences in Leaf Area Index (LAI) between varieties (1.99 and 2.14 for V1 and V2, respectively), but LAI was significantly (P = 0.009) affected by density. LAI, from D1 to D5, were 1.50, 1.58, 2.10, 2.33 and 2.44 for V1, and 1.54, 1.99, 1.92, 2.70

and 2.56 for V2. therefore, both varieties gave the highest grain yields at LAI's below 2.0.

Both varieties showed similar root lodging characteristics. The arcsine transformed data were 19.8 and 16.6 for V1 and V2, respectively.

Trials at Loumbila (Sudan Savanna)

Extra-early maize plant density trial

The objectives and methods adopted in this experiment were similar to the extra-early maize/plant density trial described in the previous section. The following modifications were however made for the Loumbila trial:

a) Varieties : V1 = Pop 46 x Kamandaogo Tollo F4 (same as at Kamboinse), V2 = Pop 30 early x GUA 314 F4 (a white variety).
b) Fertilizer : 300 kg/ha of 14-23-15 before disk-harrowing and application of 120 kg/ha of urea.
c) Planting date : June 27, on plots ridge-tied 4 DBP.
d) Harvest : 76 and 81 DAP for V1 and V2, respectively.

Maize grain yields of V1 increased consistently from D1 to D5, i.e. from 3020 kg/ha to 3900 kg/ha. Those of V2 increased from 3040 kg/ha at D1 to 3290 kg/ha at D4 (Table 3.69).

Variety 1 was significantly earlier ($P<0.001$) than V2 in days to 50% silking: 42.0 against 46.3 days, which increased from 40.0 to 44.2 days for V1 at D1-D5, and from 43.0 to 49.5 days at D1-D5 for V2. From these data, V2 did not qualify to be regarded as an extra-early maize variety. These results are inadequate for making any firm recommendations on planting densities for extra-early maturing maize varieties. More trials and other factors, including seed, planting and harvesting costs and consumer acceptability, need to be considered before recommendations can be confidently made.

Table 3.68. Extra-early maize plant density trial. Kamboinse, Burkina Faso, 1987. Maize grain yield (kg/ha).

Plant density (0.114)+ plants/ha				Variety (0.256)		
	Target	Effective				Mean Yields kg/ha
		V1	V2	V1	V2	
D1	53,300	51,100	50,200	2900	2350	2620
D2	80,000	76,200	75,200	3270	2750	3010
D3	106,700	102,400	104,100	2670	2780	2720
D4	133,300	126,800	124,800	2730	2540	2630
D5	160,000	162,300	150,200	2750	2030	2390
		Mean		2860	2490	2680

Variety x Density (0.367)	C.V.	Main plot	14.1
	(%)	Sub-plot	16.4

+ Values in parenthesis give probabilities of F.

Standard errors of means (SE) and LSD's (P = 0.05)

	SE	LSD
Variety (V)	188	848
Plant density (D)	155	452
D at same level of V	219	640
D at different levels of V	272	1000

Table 3.69. Extra-early maize plant density trial. Loumbila, Burkina Faso, 1987.

Maize grain yield (kg/ha).

Plant density (0.005)+ plants/ha				Variety (0.076)		Mean Yields kg/ha
Target		Effective				
		V1	V2	V1	V2	
D1	53,300	52,700	52,700	3020	3040	3030
D2	80,000	77,800	78,700	3430	3170	3300
D3	106,700	103,100	104,100	3490	3190	3340
D4	133,300	124,500	125,500	3760	3290	3530
D5	160,000	58,000	157,700	3900	3110	3510
		Mean		3520	3160	3340

Variety x Density (0.05)	C.V.	Main plot	5.7
	(%)	Sub-plot	7.6

+ Values in parenthesis give probabilities of F.

Standard errors of means (SE) and LSD's (P = 0.05)

	SE	LSD
Variety (V)	95	430
Plant density (D)	90	262
D at same level of V	127	371
D at different levels of V	148	530

Maize-cotton intercropping trial

This experiment was set up in Loumbila to test the maize-cotton association system developed for the Sudan Savanna and which had only been tested at the Kamboinse station.

The experiment consisted of 5 cropping systems in 4 RCB as follows:

	Cropping System	Density (each crop) plants/ha	Planting Dates
C1	Maize	88,900	D1 (June 27)
C2	Cotton	88,900	D1 "
C3	Maize-cotton	88,900	D1 "
C4	Maize-cotton	44,400	D1 "
C5	Maize-cotton	44,400	D2 (July 11)

The plot received 300 kg/ha of 14-23-15 broadcast before disk-harrowing and 150 kg/ha of urea, banded and incorporated at 30 DAP. Tractor-made ridges were tied by hand-hoe 4 DBP. Varieties tested were Koudougou local for maize, and HCB-475 for cotton.

Plots had 6 rows, 5 m long and 75 cm apart. Hill distance was 30 cm, except for C3 which had 15 cm between hills. There were 2 plants/hill. Plots with maize-cotton intercropping had alternating hills of each crop.

Decis (1.5 l/ha) was sprayed in all plots with a knapsack sprayer at 30, 42, 59, and 72 DAP to protect the cotton crop from insect damage.

Maize planted on D1 was harvested 76 DAP at black layer; with the stalks cut and left in situ as mulch. Date-2 maize D2 was harvested 75 DAP. Cotton was harvested 3 times between 109 and 156 DAP. Cotton stalks were cut to estimate their suitability as fuelwood for cooking.

In inspite of the low and erratic rainfall in 1987, good maize and cotton yields were obtained in this trial, especially when both crops were intercropped as in treatments C3 and C4 (Table 3.70).

Table 3.70. Maize-cotton intercropping trial. Loumbila, Burkina Faso, 1987. Seed-cotton and maize grain yields and plant densities.

Cropping system	Yield (kg/ha)		Density at harvest (plants/ha)	
	Cotton	Maize	Cotton	Maize
C1 Maize	-	3070	-	88,200
C2 Cotton	3090	-	90,900	-
C3 Maize-cotton	1140	2940	86,300	87,700
C4 Maize-cotton	1490	2310	44,400	44,300
C5 Maize-cotoon (Date 2)	1330	1320	43,100	43,700
Mean	1760	2410	66,200	66,200
Probability of F	<0.001	<0.001	<0.001	<0.001
SE of means	126	106	1091	356
LSD (P = 0.05)	403	340	3497	1142
C.V. (%)	14.3	8.8	3.3	1.1

Similar maize yields were obtained under monocropped maize (C1, 3070 kg/ha), and intercropped maize-cotton at high density (C3, 2940 kg/ha). Significantly lower maize yields were obtained when maize and cotton were intercropped at low density (C4, 2310 kg/ha), particularly at the second planting date (C5, 1320 kg/ha : LSD = 340 kg/ha, at ($P = 0.05$).

Seed-cotton yields were highest under monocropped cotton (C2, 3090 kg/ha) and were significantly lower under all intercropped systems. Maize-cotton intercropping at low densities (44,400 plants/ha) gave cotton yields superior but not significantly higher than those of intercropping at high densities (88,900 plants/ha).

Maize yields for the second planting date (C5) were affected not only by drought conditions late in the season, but also by high maize mottle virus attack (24.8% of plants severely attacked, but no attack for Date 1 (D1) This, probably reduced the competition from maize and allowed better cotton yields than expected under Date 2 (D2).

Maize-cotton intercropping gave a LER = 1.33 at the high density (C3), 1.23 at the low density (C4), and 0.86 at the late planting low density (C5).

Tests with the cotton stalks as fuelwood for cooking indicated that 1 kg of stalks (at 0 % moisture) could satisfy the normal needs of one person for 2.25 days. Based on stalk dry matter production per ha, the following fuelwood person-days were estimated for C2 to C5: 8283, 2795, 2880, and 2832, respectively (LSD = 483 days, at $P = 0.05$). It thus appears that it would be advantageous to adopt a maize-cotton intercropping system for the Sudan Savanna.

<u>Improvement of the Animal Traction Ridge-tiers</u>

(In collaboration with the Farm Manager)

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

Several modifications of blade thickness and width, frame size and type, stabilizer for facilitating lifting of the implements, and a new tripping mechanism (donkey-ridge-tier) have been introduced. The latest model donkey ridge-tier has 3 mm thick blades, which are 10 cm wide at the outer edge, increasing to 39 cm at the axel. Blade height was increased to 20 cm. The weight was reduced to 8 kg. Tube rather than angled iron was used for the frame (Fig. 3.4).

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

Production costs of these new ridge ties are not yet available and the model has not been widely tested so their limitations are unknown.

OVERVIEW OF MAJOR AGRONOMIC FACTORS WHICH CONSTRAIN MAIZE PRODUCTION IN THE WEST AFRICAN SEMI-ARID TROPICS (WASAT) AND POSSIBLE SOLUTIONS

The issues discussed in this overview are applicable mainly to the predominant soils found in the WASAT, namely Ferrugionous Tropical Soils (Alfisols) and associated soils, and are particularly relevant to the Sudan Savanna.

Traditionally, maize has been an important crop more in the Humid Forest and Derived Savanna areas than in the Semi-Arid Savanna Zones of West Africa, where sorghum and millet are the traditionally important crops. Maize has been increasingly cultivated northwards from the Forest to the Savanna Zone, slowly replacing sorghum and millet as the main crop. In the Northern Guinea Savanna Zone, maize is generally grown in fields which do not receive intensive management in terms of animal manure or crop residue applications. It may be grown in pure culture or intercropped in the Northern Guinea Savanna whereas it is mostly grown as a monocrop in the Sudan Savanna Zone. Maize has gradually become the major cereal (in Northern Guinea Savanna) in countries such as Nigeria and Ghana. In the Sudan Savanna Zone, maize tends to be grown mostly as a compound crop in fields adjacent to homesteads and sometimes on hydromorphic soils. It is important as an early crop to fill the hungry period before sorghum or millet are harvested.

The importance of maize in the Sudan Savanna Zone is likely to increase in the future. Total rainfall is sufficient for a 80-90 day crop if we consider that the potential evapotraspiration is 4-6 mm/day during the growing season. However, the occurrence of dry spells during the rainy season can cause serious drought stress. It seems that farmers' ability to use improved

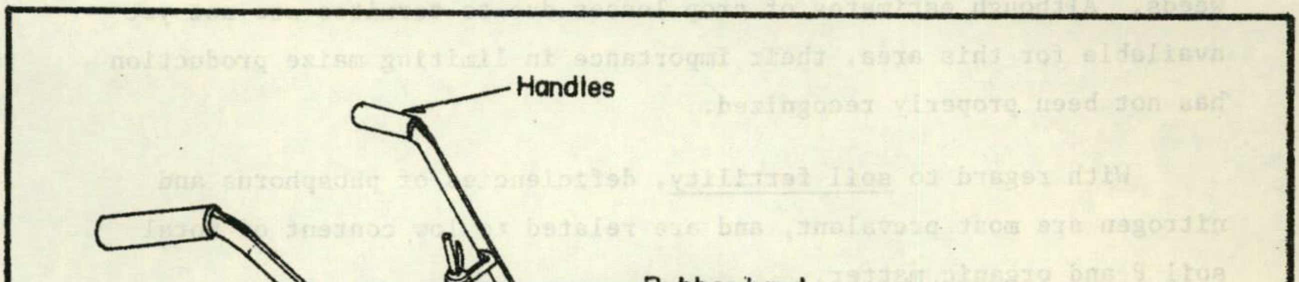

Fig. 3.4. The IITA/SAFGRAD TRAP ridge tier (donkey version) with a new tripping system and other modifications (shown attached to a "houe-manga").

soil fertility and soil-water management practices will determine the extent to which maize will become important in this ecology.

For the remainder of this overview, references to maize culture in the WASAT will be confined to the Sudan and Northern Guinea Savana Zones. Although some maize is grown under very special soil or management conditions in the Sahel Savanna Zone, the areas are small compared to those of millet and sorghum.

The main agronomic problems affecting maize production are low soil fertility, high soil compaction, and drought stress. Other factors of lesser importance or of more localized nature include: maize streak virus, termite damage, the parasitic weed Striga, lodging and other weeds. Although estimates of crop losses due to termites are not yet available for this area, their importance in limiting maize production has not been properly recognized.

With regard to soil fertility, deficiencies of phosphorus and nitrogen are most prevalent, and are related to low content of total soil P and organic matter.

The problem of high soil compaction is mainly a function of:

a) mineralogy: high content of quartz and kaolinite, and low content of amorphous iron and aluminium oxides; b) low organic matter; c) systematic crop residue removal; d) lack of tillage, and e) impact from intense rainfall.

The risk of drought stress is high, particularly in the Sudan Savanna Zone. This is mainly attributed to:

a) low rainfall. Rainfall is equal to or greater than evapotranspiration in only 2 to 4.5 months of the year.

b) erratic rainfall distribution patterns. Dry periods of 1-2 weeks or longer during the growing season are common and unpredictable. Moreover, rains may be established late or cease earlier than expected.

c) soil surface sealing and/or crusting. The consequences are lower infiltration rates and increased runoff losses. This problem is aggravated in areas of high population density and advanced soil degradation.

d) soil or subsoil compaction. Infiltration and percolation rates are reduced.

e) low available soil moisture. This is the result of shallow soils and low available water capacities (low clay organic matter contents).

Farmers in the Northern Guinea Savanna Zone have successfully reduced severity of compaction and soil fertility problems through soil tillage and fertilizer application. The solution generally adopted by farmers in the Sudan Savanna Zone is to grow maize as a compound crop. Hand-hoeing before planting and adding household, animal, or crop refuse as soil amendments reduces the risk of drought stress as well as soil fertility and compaction problems. This solution works fairly well in small areas, but limited availability of these amendments tends to restrict the area under production.

The IITA/SAFGRAD Maize Agronomy Program has shown that the following cultural practices were effective for partially overcoming the major factors identified as constraining maize production in the Sudan and Northern Guinea Savanna Zones of West Africa.

Soil Fertility

1) Nitrogen

a) Application of 60-150 kg N/ha.

b) Leguminous-maize crop rotations. Maize following either cowpea or groundnuts produced maize yield increases from 150 kg/ha to 1000 kg/ha. The data suggest, however, that factors other than symbiotic N fixation alone could be involved in this rotation effect.

c) Timing of nitrogen application. Experiments in the Sudan Savanna Zone with Alfisols showed no consistent differences in grain yields between single and split nitrogen applications. On Ferralitic Soils in the Northern Guinea Savanna Zone, split nitrogen applications generally produced higher yields than one single N application at or soon after planting.

2) Phosphorus

a) Application of 50-100 kg of soluble P_2O_5/ha. Results have shown marked residual effects of soluble P applications.

b) Use of local rock phosphate. Using the local phosphatic rock (Burkina phosphate), experimental results indicated minor maize yield response after 3 years of application.

Soil Compaction

Soil compaction affects maize growth and yield in at least two ways: reduced root growth, with its related effects on water uptake and mineral nutrition, and reduced water infiltration. Tillage and crop residues were shown to reduce these negative effects.

a) Soil tillage: Soil preparation by tractor, oxen, donkey or hand-hoe without tied ridges usually gave higher maize grain yields than zero tillage. Generally, grain yield was positively correlated with depth of soil tillage and tillage methods could be ranked as tractor > oxen > donkey = hand-hoe for their effects on maize grain yield.

b) Residues: Crop residues help to maintain soil organic matter levels and promote a higher level for biological activity. In particular, termite activity at or near the soil surface was greatly enhanced by the presence of crop residues. As a result, infiltration rates and soil aeration were improved. Marked effects on maize grain yield occurred only when the amount of residue was at least 3.5-4 tons of dry matter/ha. Under the traditional hand-hoeing and flat cultivation system, with continuous removal of crop residues, the response to fertilizer application was sometimes minimal or non-existent.

Drought Stress

Research conducted during the past 9 years has shown that on Ferruginous Tropical Soils (Alfisols) and associated soils, the risk of drought stress can be reduced by the following practices either alone or in combination: a) soil tillage, b) tied ridges, c) shallow ditches, d) cultivation, e) planting on lower slopes and hydromorphic soils, f) use of crop residues as mulch, g) use of varieties whose maturities are suited to the length of the growing season, and h) appropriate planting dates.

a) Soil tillage: Tractor, oxen, donkey and hand-hoe tillage methods improve infiltration and soil water storage. Deep tillage is generally better than shallow tillage. The effect of soil tillage is only temporary and is insufficient to ensure improved soil water infiltration rates throughout the growing season.

b) Tied ridges. The IITA/SAFGRAD Maize Agronomy Program evaluated tied ridges and demonstrated that tied ridges were very effective in increasing infiltration and decreasing runoff losses. This was particularly true in soils which had low infiltration rates due to surface sealing, crusting or compact subsoil layers. The yield response to tied ridges was more consistent in the Sudan than in the Northern Guinea Savanna Zone. Long term trials also showed that it was feasible for farmers to plant directly into old tied ridges without prior soil preparation, except furrow cultivation. This option is more viable in the Sudan than in the Northern Guinea Savanna Zone because the longer dry season lessens the problem of weed control. Results from 1985 and 1986 seasons showed that if wet conditions prevailed during the early part of the rainy season, maize growth could be adversely affected if it were planted in old tied ridges without furrow cultivation, but not when the soil was plowed and ridge-tied.

No yield response to tied ridges was found in the Weakly Ferrallitic Soils at Farako-B. These are typical Forest Zone Soils, however, which are not common in the West African Savanna. At Saria (Sudan Savanna) only on poorly or imperfectly drained lower slope soils, tied ridges produced negative effects on maize growth and yield in most years.

The grain increases obtained on-station using tied ridges were as high as 2000 kg/ha when soil fertility was not a yield limiting factor. Yield increases of 1000 kg/ha were more common. On-farm tests have given yield increases of up to 500 kg/ha. The labor costs of making tied ridges (20 cm high) by hand was estimated at 27 man-days/ha or 10,800 CFA/ha (opportunity cost of labor at 50 CFA/hour). At a maize price of 45 CFA/kg such labor costs equal 240 kg maize/ha.

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

It was concluded that the risk of drought stress could be reduced by small holes, catchments, basins, or terrain irregularities that slow down water runoff and conserve rain water.

d) Cultivations (scarifications) for breaking a crusted or sealed soil surface. Crusting and/or surface sealing are soil characteristics frequently encountered in the WASAT. The results are poorer soil aeration and reduced water infiltration, leading to a greater risk of drought stress. In these circumstances, even in the absence of weeds, cultivations after planting led to improved grain yields. In general, grain yield increased the number of cultivations. Cultivations were not as effective as digging small ditches or ridge-tying for increasing maize yields. Moreover, cultivations may cause root pruning and/or exposure of moist soil to dessication, thereby depressing yields.

e) Planting of maize on lower slopes or hydromorphic soils: There is a very marked toposequence effect on maize grain yield. Yields are lowest on plateau soils and increase toward lower slope and hydromorphic soils. The differences in grain yield were in the order of 2 to 5 fold; the former were found when improved soil water management practices (such as tillage and tied ridges) and fertilizer were used.

f) Use of residues as a mulch: Maize crop residues had a marked effect on maize grain yield. Although farmers need crop residues for fuel, fodder and construction materials, the current practice of systematic crop removal from the field is counter-productive in the long run. It is one of the major factors responsible for current degradation of the soil resource base.

g) Use of varieties whose maturity fits the length of the growing cycle. Under "average" rainfall conditions and simple maize monocropping systems, early varieties (82-95 days) should be used in the Sudan Savanna Zone and intermediate varieties (96-110 days) in the Northern Guinea Savanna Zone. Late varieties (up to 120 days) can be used in the better soils or the wetter parts of this Zone. There is a demonstrated need to develop extra-early maize varieties (less than 82 days to maturity) for the Sudan Savanna Zone for years when maize cannot be planted at the normal times or has to be replanted when the remaining part of the growing season is too short for planting an early variety.

h) Appropriate planting dates. When rainfall conditions permit, it appeared that the optimum planting dates for maize were June 16-30 in the Sudan Savanna Zone and June 1-20 in the Northern Guinea Savanna Zone. However, because of the high variability of rainfall distribution pattern from year to year there were years when high maize yields were obtained from maize planted outside the optimum times specified above.

MAIZE ENTOMOLOGY

Joseph B. Suh

CHEMICAL SUPPRESSION OF MAIZE INSECT PESTS

Systemic Insecticide Trial:

Two granular systemic insecticides, Carbofuran (Furadan 5G) and Fonofos (Dyfonate 5G) were assessed for insect pest control on two early maize varieties SAFITA-104, Jaune Flint de Saria (JFS) at Gampela IDR (University of Ouagadougou) farm. Three doses (0; 1; kg a.i./ha; 2 kg a.i./ ha) of each compound were tested in a split application, 0.25 kg; 0.25 kg; 0.5 kg and 0.5 kg, 1.0 kg respectively for doses of 1 kg a.i/ha and 2 kg a.i/ha respectively at planting, 30 and 60 DAP. Treatments were assigned at random to trial plots (6 rows 0.75 m apart) in a split-split plot design with insecticides as main treatments and insecticide dose and maize varieties as sub-treatments, with 4 replications. Three to four grains were sown per hill (0.25 m between hills) and thinned to 2 plants per stand 2 to 3 weeks after planting. Engrais cotton (NPK: 14:23:15) was applied (200 kg/ha) at planting followed by a split application (side dressing) of urea (90 kg/ha) 30 DAP and at flowering. Observations were taken on stand establishment, incidence of lodging, streak, insect pests (Armyworms, Lepidopterous borers, Termites) and number of days to 50% silking.

Stand establishment improved significantly with increase in insecticide dose (scores were 3.5, 4.5 and 4.1 at 0, 1 kg a.i/ha and 2 kg a.i/ha respectively, on a scale of 1 to 5: where 1 = poor, 3 = moderate, 5 = good stand establishment). Differences between varieties and insecticides were negligible. Insecticide dose also resulted in considerable improvement in root lodging at harvest, although differences were not statistically significant. Termite damage to stems of standing crop was significantly higher in SAFITA-104 (7 per cent) than Jaune Flint de Saria (3 per cent), and markedly reduced by insecticide dose (8%, 6% and 1% at 0, 1, and 2 kg a.i/ha. respectively). However, armyworm and Lepidopterous borer infestations, termite infestation of roots of standing crop, as well as damage to roots, stems cobs and grains of lodged maize were low and similar between varieties and insecticides, irrespective of dose.

Grain yields were moderate and similar between varieties (JFS: 3.5 t/ha; SAFITA-104: 3.6 t/ha) and insecticides (Carbofuran: 3.5 t/ha; Fonofos: 3.6 t/ha). Significant differences emerged in respect of insecticide dose - 3.0, 4.0 and 3.5 t/ha, respectively at 0, 1 and 2 kg a.i/ha; (Table 3.71).

Seed Treatment Trial

Carbosulfan (Marshal ^{R}) powder was evaluated as seed treatment at 3 doses (1, 2, 3 kg/100 kg seed) along with Carbofuran (Furadan 5G) and Fonofos (Dyfonate 5G) at 1 kg a.i/ha at planting, using 4 local and improved early maize varieties, namely Jaune Flint de Saria (JFS), SAFITA-104, SAFITA-2 and TZESR-W. Each treatment was supplemented by a single application of Carbofuran (0, or 0.5 kg a.i/ha) at 30-35 DAP. Treatment plots (4 rows 0.75 m, 5 m long) were arranged in split plot design with insecticides as main plots and maize varieties as sub plots with 4 replications. Three to four seeds were planted per hill and thinned to 2 plants per stand 2 to 3 weeks after planting. Fertilization included 200 kg NPK: 14:23:15 (engrais cotton) at planting, and a split application (side dressing) of urea (90 kg/ha) 30 DAP and at flowering. Observations were made on stand establishment, lodging, streak, insect pests (Termites, Armyworms, Lepidopterous borers) and Days to 50% silking.

Neither seed treatment nor systemic insecticides caused significant improvement in crop establishment and development, insect pest incidence or grain production. However, marked varietal differences occurred in stand establishment, root lodging due to wind and termite injury, defôliation by Armyworms (Mythimnia sp.) and seed yield (TAble 3.72). Despite modest yields (0.4 t/ha to 1.2 t/ha) owing presumably to severe drought stress, soil and nutrient problems, TZESR-W outperformed other varieties. It would be useful to repeat this trial using a flowable or slurry formulation of Carbosulfan to obtain more information on insecticide dose.

Table 3.71Grain yield (Kg/ha) of Two Local and Improved Early Maize Varieties protected with two systemic granular insecticides (three doses) at Gampela, Burkina Faso, 1987.

Insecticide Dose kg a.i/ha	SAFITA-2		Jaune Flint de Saria		Mean
	Carbofuran	Fonofos	Carbofuran	Fonofos	
0	3085	2699	3553	2975	3078
1	3943	4288	3664	4007	3975
2	3532	3855	3275	3483	3536
	3520	3610	3497	3488	3530

Comparisons	L.S.D (5%)	C.V. (%)
Dose	1132	14.9
Insecticide	NS	-
Variety	NS	-

Table 3.72 Performance of four local and improved early maize varieties protected with seed treatment and systemic insecticides at Kamboinse, 1987.

Early-Maize Varieties	Plant stand *		Lodging (%)*		Armyworm**, *** Damage (%)	Yield (Kg/ha)
	8 Aug. (21 DAP)	13 Oct. (86 DAP)	14 Sept. (57 DAP)	13 Oct. (86 DAP)		
Jaune Flint de Saria(JFS)	4.3	1.9	5.5	60.8	17.0	1073
SAFITA-104	4.8	1.8	6.7	53.7	20.0	941
SAFITA-2	4.8	1.5	8.9	54.7	16.3	366
TZESR-W	4.8	3.5	3.3	33.3	17.5	1170
Means	4.7	2.2	6.1	50.6	17.7	887
LSD (5%)	0.4	0.5	4.0	11.6	3.8	337
C.V. (%)	14.0	52.8	101.6	35.3	33.1	58.5

* Scores 1 to 5; 1 = poor, 3 = moderate, 5 = good.

** Arcsin transformations from 2 middle rows per plot.

*** Means of four samples on August 20, September 2, 18 and 25.

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

COWPEA BREEDING

V.D. Aggarwal

INTRODUCTION

The Cowpea Breeding Program funded by IDRC in support of the IITA cowpea improvement activities in the IITA/SAFGRAD Project was terminated in 1987. Although program objectives remained the same as in previous years, the 1987 activities concentrated on evaluating cowpea varieties previously developed for adaptation to dry areas, and those combining resistance to Striga and to major insect pests. As in previous years, the work was divided into two components, namely, resident research and regional trials.

RESIDENT RESEARCH

Location and Rainfall

Trials were conducted only at Kamboinse and Pobe, representing Sudan Savanna (600-900 mm) and Sahel Savanna (300-600 mm) Zones, respectively. Although total rainfall was fairly good, it was highly erratic, particularly early in the growing season and during pod filling stage. Thus, there were drought stress periods, resulting in low grain yields. The highest grain yields recorded at Kamboinse did not exceed 1500 kg/ha and at Pobe 800 kg/ha, which were considerably low compared to previous years.

Drought Resistance

Work done in 1987 included an Advanced Yield Trial and some breeding materials.

Advanced Yield Trial (AYDT)

The main objective of this trial was to evaluate promising drought tolerant cowpea varieties identified from the previous year's preliminary yield trials. The trial contained 15 varieties mostly originating from the material developed by this project. It was planted at Kamboinse (L1) and Pobe (L2) at two planting dates D1, July 11 and D2, July 25 at Kamboinse; and July 10 and 25 at Pobe, respectively. Plot size was 4 rows 4 m long with 0.75 m and 0.20 m, between and within the plants respectively. Records were made on the central two rows for days to 50% flowering, (DFF) diseases (pod blotch and bacterial blight), yield (grain and forage) and seed characters. The results are presented in Table 4.1.

Significant differences were observed on performance of varieties at the two locations. As in previous years, yields at Kamboinse were higher because of higher rainfall, but were lower than expected due to frequent drought stress periods during the growing season. No significant differences were observed between the two dates of planting in mean grain and forage yields at the two locations, but the differences were greater at Pobe. Among the varieties, two sister lines KVx 249-P37-IR and KVx 249-P37-IN produced the highest grain and forage yields at Kamboinse, their performance at Pobe was also reasonably good. KVx 249-P37-IN was particularly good in producing high grain and forage yields at both the locations.

Table 4.1 Performance of different cowpea varieties in the Advanced Yield Trial for Drought at two dates (D1 and D2 at Kamboinse (L1) and Pobe (L2) in Burkina Faso, 1987.

Varieties	DFF				BB				PB				Yield (Kg/ha)				Dry plant weight(Kg/ha)			
	L1		L2		L1		L2		L1		L2		L1		L2		L1		L2	
	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2
KVx 177-KO7-2	40	37	45	36	2.0	3.0	3	2	2.3	1	1	1	1113	1160	681	477	593	501	178	166
KVx 192-P11-1-1	44	41	47	44	3.3	2.3	3	3	1.0	1	1	1	973	1003	526	492	821	655	289	239
KVx 249-P37-30-1R	42	41	46	44	1.7	2.7	2	2	1.3	1	1	1	1370	1283	680	435	1145	880	289	267
KVx 249-P37-30-1N	42	42	46	41	1.3	1.7	1	2	1.3	1	1	1	1353	1157	763	475	1306	1016	483	450
KVx 252-K32-7-1	46	44	46	43	1.3	1.7	2	2	1.0	1	1	1	700	673	664	390	1451	1215	334	261
KVx 257-K21-3B	43	41	45	41	2.3	2.7	3	2	1.0	1	1	1	1220	1157	527	478	1081	734	289	255
KVx 396-4	43	42	46	42	1.7	2.7	2	2	1.0	1	1	1	1190	1037	553	485	630	507	139	161
KVx 396-11	46	42	47	42	1.7	2.0	3	2	1.3	1	1	1	883	693	543	526	1044	536	266	322
KVx 396-18	45	42	47	43	1.7	2.3	2	2	1.7	1	1	1	1017	1000	782	643	883	706	322	300
KVx 396-27	43	41	47	43	2.3	3.0	3	2	1.0	1	1	1	1173	1113	505	430	798	546	211	244
KVx 241-P15-5	41	37	43	35	2.7	2.7	3	2	1.0	1	1	1	1130	1060	691	476	1022	556	161	195
IT83S-796	43	41	47	43	1.3	2.7	3	2	1.0	1	1	1	1110	807	681	557	630	436	161	305
KVx 30-305-3G	49	45	48	43	2.3	2.0	3	2	1.0	1	1	1	767	743	716	682	931	983	200	372
SUVITA-2	45	44	49	44	2.0	2.3	3	2	1.0	1	1	1	1267	870	560	426	1042	658	261	239
KN-1	44	42	47	45	2.0	1.0	1	2	1.0	1	1	1	573	917	268	113	1473	832	550	450
Mean	44	41	47	42	1.9	2.3	3	2	1.2	1	1	1	1053	978	609	473	990	751	276	282
C.V. (%)	2.3	2.9	3.2	4.2	28.3	28.1	18.2	16.6	34.2	0	0	0	15.8	23.2	38.2	39.5	27.4	37.4	44.9	34.0
LSD (5%)	1.7	1.9	2.6	2.9	0.9	0.3	0.9	0.6	0.7	0	0	0	278	379	382	363	454	470	207	161

DFF = Days to 50% flowering; BB = Bacterial blight; PB = Pod blotch.

They were also among the best yielders in 1986. At Pobe which was the drier site, KVx 396-18 and KVx 30-305-3G were the two highest grain yielders. KVx 30-305-3G had previously been selected for its high yield in the dry areas, thus confirming its superiority. All of these varieties combine the most preferred seed type characteristics. Among the poorly adapted varieties in dry areas, KN-1 produced the lowest grain yield at Pobe but produced the highest forage yield, which could be considered a useful character of this variety in these areas.

Breeding Materials

Several new crosses, particularly to incorporate resistance to bacterial blight and pod blotch in backgrounds of preferred seed types, were initiated in 1986. YBc 357-K21-3 and KVx 250-K27-18 were used as donor parents. F2 of these crosses were screened at Kamboinse and Pobe to make single plant selections for adaptation, good podding, seed type, and resistance to diseases. The numbers of plants selected in each cross at the two locations are given in Table 4.2. Most of the plants selected combined good seed characters and resistance to diseases. These plants will be further evaluated in the coming years.

Striga Resistance

The 1987 work included experiments on the following:

- Evaluation of materials combining aphid, bruchid and *Striga* resistance.
- Evaluation of materials combining bruchid and *Striga* resistance.
- Inheritance studies.

Table 4.2 Screening of F_2 populations of crosses combining disease resistance and adaptability to dry areas.

Crosses	Pedigree	F_2 plants selected Kamboinse	F_2 plants selected Pobe	Seed characters
KVx 408	SUVITA-2 x KVx 257-K21-3	22	12	Medium brown rough
KVx 417	TN88-63 x KVx 257-K21-3	29	32	Small white-speckled rough
KVx 418	KVx 30-305-3G x KVx 257-K21-3	14	0	Medium white-speckled rough
KVx 419	KVx 396-4 x KVx 257-K21-3	20	23	Medium white-speckled rough
KVx 420	TN88-63 x KVx 250-K27-18	50	38	Small white rough
KVx 421	KVx 30-305-3G x KVx 250-K27-18	19	12	Medium white rough
KVx 422	KVx 396-4 x KVx 250-K27-18	48	21	Medium white rough
KVx 423	SUVITA-2 x KVx 250-K27-18	34	6	Medium brown rough
KVx 424	KVx 257-K21-3 x KVx 250-K27-18	49	36	Medium white rough

- Breeding materials, and
- Confirmation of resistance in multiple strain resistant varieties.

The results obtained are as follows:

Evaluation of materials combining aphid, bruchid and Striga resistance:

Two trials were conducted; the first contained 7 most promising selections originating from the materials tested previously combining resistance to aphids, bruchids and Striga. (IITA/SAFGRAD Annual Report, 1986). These selections were yield tested and evaluated for resistance to Striga and diseases along with 3 check varieties i.e. SUVITA-2 (Striga resistant), KN-1 (susceptible), and KVx 30-G172-1-6K (bruchid and Striga resistant). The experiment was laid out in a Striga infested plot at Kamboinse. There were three replications, and the plot size was 4 rows, 4 m long with a distance of 0.75 m and 0.20 m between the rows and plants respectively. Varieties were also evaluated for resistance to aphids and bruchids in the screenhouse and in the laboratory. Results obtained are reported in Table 4.3. KVx 295-2-124-51 was the most outstanding. It best combined the different resistances including those for diseases and possessed high grain yield and preferred seed type.

The second trial contained those entries which, could not be included in the first due to shortage of seed. Ten such entries including 5 check varieties were planted in a 2 row

Table 4.3. Performance of newly developed cowpea varieties combining resistance to Striga, aphids and bruchids (Trial 1).

Varieties	Days to 50% flowering	Bacterial blight	Pod blotch	Per cent cowpea plants infested with Striga	Aphid resis-tance	Per cent bruchid resistant seeds (45 DAI)	Yield (kg/ha)	100 seed wt. (g)	Seed colour and texture
New varieties									
KVx 293-114-27	42	2.3	1.0	38.0	R	70.0	1251	18	White rough
KVx 295-2-124-51	46	2.0	1.0	0.0	R	75.0	1489	18	White rough
KVx 295-2-124-52	44	2.7	1.0	8.0	R	70.0	1355	21	White rough
KVx 295-2-124-99	42	3.0	1.3	16.7	R	65.0	1020	20	White rough
KVx 295-2-124-121	45	2.3	1.0	34.3	R	65.0	1024	21	White rough
KVx 305-118-31	47	1.3	1.0	4.0	MS	95.0	1254	18	Brown rough
KVx 305-118-32	42	2.7	1.0	14.3	NT	90.0	1067	18	White brown rough
Check varieties									
KN-1	44	2.0	1.0	79.3	S	0.0	762	15	Cream smooth
KVx 30-G172-1-6K	48	3.7	1.3	0.0	S	75.0	1018	22	White rough
SUVITA-2	47	2.3	1.0	1.7	S	0.0	1191	17	Brown rough
Mean	45	2.4	1.0	19.6	-	-	1143		
C.V. %	3.6	31.4	22.4	84.9	-	-	16.8		
LSD (5%)	2.8	1.3	0.1	28.5	-	-	330		

R = Segregation for susceptibility between 0-3 %.
MS = Segregation between 3-10%.
NT = Not tested due to lack of seeds.
S = More than 85% susceptible.

plot replicated twice in a Striga infested plot at Kamboinse. These varieties, were also evaluated for aphid and bruchid resistance. Results obtained are given in Table 4.4. Several interesting observations were made. The varieties KVx 294-119-61 recorded the highest seed weight ever reported and combined high levels of bruchid resistance, but produced a low grain yields. The three sister lines from the cross of KVx 293 seemed to be the most promising in terms of bruchid, aphid and Striga resistance and high yields.

Evaluation of Material Combining Bruchid and Striga Resistance.

The trial had 10 entries, 5 promising selections and 5 check varieties. The objective was to identify promising aphid and bruchid resistant varieties that combined reasonable levels of disease resistance with reasonable yields. The trial was planted in a Striga infested plot at Kamboinse. It was replicated three times with a plot size of 4 rows, 4 m long and a distance of 0.75 m and 0.20 m between and within the rows, respectively. The material was also evaluated in the laboratory for bruchid resistance. Results are presented in Table 4.5. KVx 164-41-64 and KVx 291-47-224 appeared to be most promising for resistance to diseases, Striga and bruchids. Yield data revealed that KVx 164-41-62 was the highest yielder, but it was partially susceptible to diseases and Striga.

Inheritance Studies

During the past years, crosses of SUVITA-2 and 58-57, the two Striga resistant varieties in Burkina Faso, were studied to understand the mode of inheritance of resistance to Striga in these varieties. The results obtained indicated a single dominant gene responsible for resistance. Later, B301 was also

Table 4.4. Performance of newly developed cowpea varieties combining resistance to *Striga*, aphids and bruchids. (Trial 2)

Varieties	Days to 50% flowering	Bacterial blight	Pod blotch	% cowpea plants infested with *Striga*	Percent bruchid resistant seeds(45 DAI)	Aphid resistance	Grain yield (kg/ha)	100 Seed (g)	Seed colour and texture
KVx 293-114-12	44	2.5	2.0	6.0	85.0	MS*	1445	20	Brown rough
KVx 293-114-13	45	2.0	1.5	1.5	85.0	MS	1320	23	White rough
KVx 293-114-31	45	3.5	1.5	1.5	70.0	MS	1635	19	White rough
KVx 294-2-119-61	47	1.5	2.5	13.5	95.0	R	365	41	White rough
KVx 294-2-118-23	45	1.0	2.0	30.0	100.0	R	1255	22	Brown rough
TVx 3236	44	2.0	1.5	89.5	0.0	S	790	12	White brown rough
KVx 30-G172-1-6K	48	3.0	4.0	0.0	80.0	S	905	26	White rough
KN-1	45	2.0	1.0	88.5	0.0	S	375	14	Cream smooth
TVu 36	43	1.5	1.5	75.5	0.0	R	660	12	Cream smooth
SUVITA-2	46	2.5	2.5	0.0	0.0	S	1735	20	Brown rough
Mean	45.0	2.2	2.0	30.7	-	-	1098.5		
C.V. (%)	2.4	23.7	28.9	40.6	-	-	23.5		
LSD (5%)	2.4	1.6	1.3	8.0	-	-	584.9		

* MS = Segregation for susceptibility between 13-15%. R = Segregation for susceptibility 0%.

S = More than 85% susceptible.

Table 4.5. Performance of newly developed cowpea varieties resistant to *Striga* and bruchids.

Varieties	Days to 50% flowering	Bacterial blight	Pod blotch	Perccent cowpea plants infested with *Striga*	Per cent bruchid resistant seeds(45 DAI) *	Yield (kg/ha)	100 Seed (g)	Seed colour and texture
New varieties								
KVx 164-41-62	44	1.7	1.0	9.3	80.0	1114	19	Cream smooth
KVx 164-41-64	45	1.0	1.0	1.0	70.0	603	22	Cream smooth
KVx 164-65-5	45	1.0	1.0	12.7	90.0	956	19	Brown rough
KVx 291-47-222	47	1.0	1.0	17.0	95.0	729	20	Brown rough
KVx 291-47-224	48	1.0	1.0	1.0	95.0	642	22	Brown rough
Check varieties								
KVx 30-G467-5-10K	50	2.0	2.3	3.3	95.0	913	24	Brown rough
KVx 30-G246-2-5K	47	2.0	3.0	5.7	65.0	905	22	Brown rough
SUVITA-2	47	2.7	2.7	1.0	0.0	631	20	Brown rough
IT82D-716	46	1.7	1.0	77.0	80.0	243	13	White brown rough
KN-1	46	1.7	1.0	100.0	0.0	491	15	Cream smooth
Mean	47	2.0	1.5	22.8	-	722.7		
C.V. (%)	4.5	29.6	44.3	42.5	-	49.2		
LSD (5%)	3.6	1.0	1.1	16.6	-	609.5		

* DAI = Days after infestation.

identified to be resistant to Striga and crosses of this variety with the two susceptible varieties, TVx 3236 and IT 82D-60, were made in 1987 to study the mode of inherance of resistance in this variety (B301). Results obtained (Table 4.6) indicated that the resistance to Striga in B301 was also controlled by a single dominant gene.

Breeding Materials

In 1986, two varieties, i.e. IT82D-849, originating from our program identified to be resistant to Striga in Burkina Faso, and B301 from Botswana known to be resistant to Alectra vogelii, were observed to be showing resistance to Striga strains from Mali, Burkina Faso and Niger in collaborative studies conducted by Parker and Polniaszek in England. These varieties were therefore included in the 1987 Cowpea Regional Striga Trial for comparison of resistance in various countries. Variety B301 was also tested at Kamboinse to identify its resistance to the Burkina strain of Striga. B301 possessed a spreading plant type, a preferable character in the dry areas, whereas IT82D-849 had a short erect plant type. Because of this plant growth character, B301 was first crossed with other promising varieties to incorporate multiple strain resistance to Striga, while waiting confirmation of resistance to this and IT82D-849 in the region. Preliminary results, however, indicated that both were free of Striga infestation in Mali, Burkina Faso, Niger and Nigeria. The breeding material developed by crossing B301 was advanced and the F3 generation evaluated in 1987 in a Striga plot at Kamboinse. Different crosses studied and number of plants selected in each are given in Table 4.7. Seeds of these plants will be sent to Long Ashton in England for further evaluation

Table 4.6 Genetic segregation for resistance to Striga in cowpea at Kamboinse, 1987.

Cross and populations	Plants Resistant	Plants Susceptible	Segregation ratio Resistant		Segregation ratio Susceptible	X^2	Probability of a greater value
B 301	113	0	1	:	0	0.00	1.00-0.95
TVx 3236	10	101	0	:	1	0.90	0.50-0.25
F_1	110	0	1	:	0	0.00	1.00-0.95
F_2	205	75	3	:	1	0.48	0.50-0.25
BC_1	103	1	1	:	0	0.01	0.95-0.90
BC_2	55	65	1	:	1	0.84	0.50-0.25
B301	113	0	1	:	0	0.00	1.00-0.95
IT82E-60	18	91	0	:	1	2.97	0.10-0.03
F_1	107	0	1	:	0	0.00	1.00-0.95
F_2	211	55	3	:	1	2.44	0.25-0.10
BC_1	118	2	1	:	0	0.03	0.90-0.75
BC_2	75	33	1	:	1	16.33	0.00-1.00

Table 4.7. Evaluation of segregating F_3 populations originating from crosses of B 301 with other varieties for resistance to Striga at Kamboinse, 1987.

Cross	Pedigree	No. of F_3 Plants selected	Grain size color & texture
KVx 397	SUVITA-2 x B 301	25	Medium brown rough
KVx 399	TN88-63 x B 301	25	Small white brown smooth
KVx 400	58-57 x B 301	25	Small cream smooth
KVx 401	KVx 65-114 x B 301	25	Small cream rough
KVx 398	KVx 61-74 x B 301	25	Small cream rough
KVx 410	TVx 3236 x B 301	25	Small cream smooth
KVx 402	KVx 30-166-3G x B 301	25	Medium brown rough

and identification of single plants combining resistance to different Striga strains.

Confirmation of Resistance in Multiple Strain Striga Resistant Varieties:

Two varieties, IT82D-849 and B301 were identified to be resistant to Striga strains from Mali, Burkina Faso and Niger. To confirm this observation under field conditions, they were included in the Regional Cowpea Striga Trial. The results of this trial are reported under the Regional Program (see page D15). However, it is noteworthy that these two varieties have been confirmed to be Striga resistant at Kamboinse in Burkina, at Bakura in Nigeria, and at Magaria and Tarna in Niger. Preliminary observations made by the IITA/SAFGRAD Agronomist in Mali also indicated that these varieties were free of any Striga infestation in that country (personal communication). Furthermore, A.M. Emechebe at IAR, Samaru, Nigeria, confirmed B301 to be completely resistant (Zero number of Striga plants attached to cowpea roots) in pot experiments when compare with TVx 3236 which had 33-48 Striga plants attached to its roots (personal communication).

Miscellaneous Variety Trials

As in previous years, various advanced and preliminary yield trials from IITA were introduced inorder to provide IITA the necessary feedback on the performance of different varieties included in these trials, and to select promising ones suitable for semi-arid areas. In 1987, 4 Advanced and 6 Preliminary Yield Trials were planted at Kamboinse. All these trials had 20 entries each, but there were 4 replications in the Advanced and 3 in the Preliminary Trials. Plot size in all the trials was 4 rows, 4 m long with a distance between and within the plants of 0.75 m and 0.15 m, respectively. Records were made of days to 50% flowering (DFF), diseases-bacterial blight (BB) and pod blotch (PB), yield (kg/ha) and seed characters, i.e. 100 seed weight, seed colour and texture. Results for the Advanced Yield Trials are reported in Tables 4.8 to 4.11 and those of the preliminary Yield Trials in Tables 4.12 to 4.17.

Yields were generally low this year compared to the 1986 yields. The Disease incidence, especially bacterial blight was fairly high because a majority of the varieties tested were susceptible. In spite of these difficulties, several of the varieties in different trials looked promising. In terms of yield, disease resistance and seed characters, IT85F-3517-2 in the Advanced Trial-1, IT83D-328-1 in Advanced-2, IT86D-817 in Preliminary-2, and IT86D-911 in Preliminary-3 appeared most promising.

Regional Program

Two regional trials, one on Striga and another on drought, were the major regional activities in 1987.

Regional Cowpea Striga Trial (RCST)

The trial contained 15 promising cowpea varieties including susceptible checks and 13 sets distributed to 6 collaborating countries, as follows: Burkina Faso (3); Cameroon (1); Ghana (1); Mali (2); Niger (3); and Nigeria (3). The plot size was 4 rows with a distance between and within the rows of 0.75 m and 0.20 m respectively. Observations were recorded on the central two rows of levels of Striga infestation, flowering, diseases, yield and other characters. At the time this report was written, only

Table 4.8 Performance of cowpea varieties in the IITA Advanced Yield Trial-1 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
KN-1	44	2.5	1.0	873	13	Cs
IT82D-1026	42	2.8	1.3	1139	19	Ws
IT86D-901	42	2.8	1.0	1169	16	WBr
IT86D-929	42	4.5	1.0	833	11	Wr
IT84S-2114	43	3.3	1.0	1061	15	Ws
IT84S-2163	42	2.8	1.0	1129	17	Ws
IT85F-1002	42	2.3	1.0	1243	15	Wr
IT85F-2368	41	2.8	1.0	1495	14	Ws
IT85D-3428-4	43	2.8	1.0	1270	14	Ws
IT85D-3516-2	46	3.0	1.0	1174	15	WBs
IT85D-3545	41	3.0	1.0	917	13	WBr
IT85D-3550	45	2.5	1.0	1024	23	Ws
IT81D-1137	45	3.5	1.0	1090	20	Ws
IT85F-2865	43	3.0	1.0	990	14	Ws
IT85F-3517-2	45	3.0	1.0	1412	15	WBs
IT85F-1004-4	41	3.5	1.0	997	15	Wr
IT85F-968-3	43	2.0	1.0	1369	12	WBs
IT86S-769	40	3.8	1.0	947	16	WBs
IT82D-699	43	2.5	1.0	1311	13	Ws
IT81D-994	59	2.3	1.0	725	27	Wr
Mean Trial	44	3.0	1.0	1113.0	-	-
CV (%)	2.7	28.6	10.9	27.0	-	-
LSD (5%)	1.6	1.2	0.2	425.0	-	-

Table 4.9 Performance of cowpea varieties in the IITA Advanced Yield Trial-2 Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT85F-2687	42	3.3	1.0	745	15	Ws
IT83S-797	43	3.8	1.5	1115	16	Wr
IT84S-2049	42	4.0	1.0	900	16	Ws
IT83D-338-1	42	2.3	1.0	1149	18	Wr
IT84S-2137	43	3.5	1.0	785	19	Ws
IT83D-326-2	44	2.8	1.0	1001	11	Ws
IT85F-1992	42	2.8	2.3	743	14	Ws
IT83S-728-5	40	4.0	1.0	1014	13	Ws
IT85D-3577	44	4.0	1.3	595	18	Ws
IT85F-1003-5	42	4.3	1.0	877	16	Wr
IT85F-2694	42	3.0	1.0	1047	16	Wr
IT85F-1936	42	4.0	1.5	1038	14	Ws
IT85F-1988	44	2.8	1.5	930	13	Ws
IT83D-340-5	43	2.8	1.0	1415	17	Ws
IT83D-328-1	43	2.3	1.0	1251	20	Wr
IT84E-1-108	42	4.0	1.3	971	18	Ws
IT84S-2246-4	44	4.5	1.3	959	15	Br
TVx 3236	44	3.0	1.0	1231	10	WBr
IT83S-818	42	4.5	1.0	525	14	Ws
Mean Trial	43.0	3.0	1.0	967.0	-	-
C.V.(%)	3.3	18.5	37.0	13.4	-	-
LSD (5%)	2.0	0.78	0.5	183.9	-	-

Table 4.10 Performance of cowpea varieties in the IITA/Advanced Yield Trial-3 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT85F-3103	40	4.3	1.0	538	14	Br
IT85F-867-5	40	3.8	1.0	668	11	Rs
IT85F-3106	41	4.3	1.0	458	14	Br
IT85F-2805	41	3.8	1.0	694	10	Br
IT85F-2120	44	2.0	1.0	730	13	Br
IT85S-852	41	4.0	1.0	472	13	Cs
IT85F-3094	41	4.3	1.0	635	16	Br
IT83S-992	43	3.8	1.0	720	17	Cs
IT85-2816	42	4.5	1.0	535	13	Br
IT84S-853	42	4.5	1.0	582	15	Br
IT84S-2085	42	3.3	1.3	577	15	Rs
IT85F-2205	44	5.0	1.0	638	15	Br
IT85-1380	43	5.0	1.0	449	12	Cs
IT83S-725-18	42	4.0	1.0	627	18	Cs
IT84S-2246-4	45	4.0	1.3	796	15	Br
IT85F-2345	43	4.3	1.0	475	12	Br
IT85F-2202	43	4.5	1.0	767	16	Br
IT85F-2305	42	4.5	1.0	610	21	Cs
KN-1	43	2.3	1.0	666	14	Cs
IT85F-1517	38	5.0	1.0	491	13	Br
Mean Trial	42.0	4.0	1.0	606.0	-	-
CV (%)	3.4	14.9	15.1	37.7	-	-
LSD (5%)	2.0	0.8	0.2	323.3	-	-

Table 4.11 Performance of cowpea varieties in the IITA Advanced Yield Trial-4 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT84S-2118	43	2.0	1.0	801	15.	Br
IT83S-755-1	46	1.5	1.0	192	10	Rs
IT85D-3850-2	45	2.0	1.0	310	18	Rs
IT85F-2829	43	4.8	1.0	556	14	Cs
IT85F-1825	45	5.0	1.5	480	16	RWs
IT84D-718	44	4.3	1.0	509	20	Cs
IT85D-3850-1	47	2.0	1.0	321	19	Rs
IT83S-689-4	45	4.0	1.0	700	12	Rs
IT83S-680-9	44	3.0	1.0	646	15	Cs
IT84S-2140	44	2.3	1.5	666	15	Cs
IT85F-2018	44	4.5	1.0	775	19	Cs
IT85F-2258	44	4.8	1.0	463	19	Cs
IT83S-682-7	44	2.5	1.0	625	13	Cs
IT84S-2155	43	4.5	1.0	502	16	Br
IT85F-2264	45	2.5	1.0	795	13	Br
IT85F-2825	45	4.8	1.0	623	13	Br
IT85F- 966	46	1.8	1.0	893	14	Br
IT86S-769	45	4.5	1.0	493	21	Br
IAR-48	44	3.3	1.3	926	20	Br
Mean Trial	45.0	3.4	1.1	582.0	-	-
CV (%)	3.2	17.1	18.6	44.3	-	-
LSD (5%)	2.0	0.8	0.3	364.7	-	-

Table 4.12 Performance of cowpea varieties in the IITA Preliminary Yield Trial-1 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT86D-479	43	4.0	1.0	811	14	WBs
IT86D-585	44	3.3	1.0	924	10	Wr
IT86D-916	44	3.7	1.0	879	10	Wr
IT86D-917	45	3.7	1.0	836	13	Ws
IT86D-928	42	3.0	1.3	803	13	Wr
IT85D-3609-8	46	2.3	1.0	757	15	Ws
IT85D-3516-3	46	2.0	1.3	681	14	WBr
IT85-D3318-1	44	4.3	1.0	806	17	WBs
IT85D-3334-1	44	3.3	1.0	957	17	Ws
IT85D-3428-1	44	2.0	1.0	1151	16	Ws
IT85F-2269	44	4.3	1.0	764	20	Ws
IT85F-2716	41	3.0	1.0	704	15	Ws
IT85D-3550	44	2.3	1.0	1382	19	Ws
IT85D-3531	44	3.3	1.0	952	12	WBr
IT85D-3551	45	1.7	1.0	1172	19	Ws
IT85F-2282	43	1.0	1.0	1143	16	Wr
IT85D-3515-4	45	1.7	1.0	799	14	WBr
IT82D-669	44	2.7	1.0	1005	12	Wr
TVx 3236	44	3.0	1.0	1074	10	WBr
IAR-48	44	5.0	1.0	418	16	Cs
Mean Trial	44	3.0	1.05	898	-	-
CV (%)	1.2	25.3	19.5	29.7	-	-
LSD (5%)	1.1	1.5	0.4	538.1	-	-

Table 4.13 Performance of cowpea varieties in the IITA Preliminary Yield Trial-2 at Kamboinse.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT86D-400	41	2.3	1.0	1094	17	Cs
IT86D-422	43	2.3	1.0	1052	23	Cs
IT86D-466	45	2.0	1.0	736	17	Rs
IT86D-472	41	4.0	1.0	934	17	Bs
IT86D-473	43	3.3	1.0	1144	16	Bs
IT86D-486	45	2.0	1.0	521	16	Cs
TVx 3236	44	2.0	1.0	1318	12	WBr
IT86D-534	44	3.0	1.0	1173	15	Bs
IT86D-535	43	2.0	1.0	1177	14	Br
IT86D-537	43	2.3	1.0	1213	11	Br
IT86D-622	44	3.7	1.0	432	18	Cs
IT86D-633	42	2.7	1.0	1191	17	Bs
IT86D-634	43	2.3	1.0	887	18	Cs
IT86D-641	41	3.0	1.0	955	22	Rs
IT86D-643	42	3.0	1.0	683	20	Rs
IT86D-646	44	4.7	1.0	838	18	Rs
IT86D-817	45	3.3	1.0	1356	19	Br
IT86D-892	44	1.7	1.0	1166	18	RWs
IT86D-1013	44	4.0	1.0	783	17	RWs
KN-1	45	2.7	1.0	652	15	Cs
Mean Trial	43	3.0	1.0	965	_	_
CV (%)	2.2	23.8	0.0	21.6	_	_
LSD (5%)	1.9	1.4	0.0	422.1	_	_

Table 4.14. Performance of cowpea varieties in the IITA Preliminary Yield Trial-3 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT86D-326	44	2.7	1.0	920	16	Ws
IT86D-333	46	1.7	1.0	566	12	Wr
IT86D-335	42	4.0	1.0	1023	16	Ws
IT86D-336	42	1.7	1.0	1000	16	Ws
IT86D-446	39	1.7	1.0	969	14	WCs
IT86D-491	43	1.3	1.0	1139	11	Ws
IT86D-492	44	1.7	1.0	1201	12	Ws
IT86D-493	43	1.7	1.0	1015	12	Ws
KN-1	44	2.0	1.0	941	15	Cs
IT86D-668	41	2.3	1.0	969	19	Ws
IT86D-719	43	1.0	1.0	1315	12	Wr
TVx 3236	44	1.7	1.0	1552	14	Wr
IT86D-801	44	3.3	1.0	1113	11	Ws
IT86D-1008	42	1.0	1.0	1028	16	Ws
IT86D- 896	44	1.7	1.0	1253	16	Bs
IT86D- 964	44	2.0	1.0	1180	16	Br
IT84E-1-108	42	2.7	1.0	1178	18	Ws
IT86D-1010	42	1.3	1.0	1089	15	Ws
IFE Brown	43	2.7	1.0	1394	14	Br
Mean Trial	43	2.1	1.0	1109	-	-
CV (%)	1.8	33.6	0.0	16.2	-	-
LSD (5%)	1.6	1.4	0.0	362.8	-	-

Table 4.15 Performance of cowpea varieties in the IITA Preliminary Yield Trial-4 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT86D-424	43	3.3	1.3	1266	14	Bs
IT86D-447	40	4.3	1.0	693	13	Bs
IT86D-477	42	2.3	1.0	1105	15	Cs
IT86D-499	41	4.0	1.3	881	12	Bs
IT86D-503	40	4.0	1.3	1022	13	Bs
IT86D-518	43	3.3	1.0	1256	12	Br
IT86D-522	44	3.7	1.0	924	19	Cs
IT86D-543	40	5.0	1.7	660	15	Bs
IT86D-548	41	3.7	1.0	1098	15	Bs
IT86D-683	41	3.7	1.0	1128	14	Bs
IT86D-684	41	4.3	1.0	884	15	Bs
IT86D-756	41	3.3	1.0	1040	16	Bs
KN-1	45	2.3	1.0	678	15	Cs
IT86D-766	41	4.0	1.3	1102	14	Bs
TVx 3236	43	2.3	1.0	1330	12	Ws
KVx 145-27-6	40	2.0	1.3	1165	13	Ws
IT86D-1016	39	4.3	1.3	755	14	Bs
IT86D-898	42	3.7	1.3	1271	15	RWs
IT86D-810	40	2.7	1.0	768	21	Rs
IT84S-2246-4	44	4.0	1.0	1308	15	Bs
Mean Trial	42	3.0	1.2	767	-	-
CV (%)	3.4	1.9	179.7	32.2	-	-
LSD (5%)	2.9	1.1	4.3	498.3	-	-

Table 4.16 Performance of cowpea varieties in the IITA Preliminary Yield Trial-5 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT86D-314	42	4.3	1.0	813	15	Cs
IT86D-318	40	4.7	1.0	716	17	Cs
IT86D-319	41	4.7	1.0	803	17	Cs
IT86D-320	39	4.0	1.0	795	16	Cs
IT86D-321	41	3.7	1.7	1007	15	Cs
IT86D-343	42	3.0	1.0	720	15	Cs
IT86D-364	40	2.7	1.3	827	22	Cs
TVx 3236	46	2.3	1.0	583	13	Wr
IT86D-426	41	4.0	1.0	860	25	Bs
IT86D-453	50	2.7	1.0	372	15	Cs
IT86D-533	42	4.3	1.3	549	17	Cs
KN-1	44	2.7	1.0	620	17	Cs
IT86D-734	41	2.0	1.0	623	19	Cs
IT86D-360	39	3.0	1.0	1228	20	Rs
IT86D-368	46	1.7	1.0	642	14	Rs
IT86D-425	45	1.3	1.0	440	18	Rs
IT86D-428	42	3.3	1.0	1223	15	Rs
IT86D-612	39	2.0	1.7	766	22	Rs
IT86D-737	39	2.7	1.3	666	20	Rs
IT84S-2246-4	43	3.3	1.0	1088	16	Bs
Mean Trial	42	3.0	1.11	767	-	-
CV (%)	3.4	18.6	185.2	32.2	-	-
LSD (5%)	2.9	1.1	4.1	498.3	-	-

Table 4.17. Performance of cowpea varieties in the IITA Preliminary Yield Trial-6 at Kamboinse, 1987.

Variety	DFF	BB	PB	Yield (kg/ha)	100 Seed wgt (g)	Colour and texture
IT86D-345	40	3.0	1.0	521	12	Ws
IT86D-347	42	3.3	1.0	817	13	Ws
IT86D-348	42	2.7	1.0	521	15	Ws
IT86D-349	43	2.7	1.0	375	16	Ws
IT86D-383	39	4.0	1.0	691	12	Bs
IT86D-390	39	4.3	1.0	701	14	Bs
KN-1	43	2.0	1.0	609	16	Cs
IT86D-394	39	2.7	1.0	442	13	Bs
IT86D-401 AR	47	3.0	1.0	546	19	Ws
IT86D-403 AR	48	3.3	1.0	155	20	Cs
IT86D-409 BR	43	3.3	1.0	576	10	Ws
IT86D-410 BR	42	3.0	1.0	435	9	Wr
IT86D-510	43	3.0	1.0	512	18	Ws
IT86D-520 BR	40	3.7	1.0	360	15	Wr
IT86D-531	39	2.7	1.0	424	15	Bs
IT86D-564	42	3.3	1.0	285	15	Cs
IT86D-686 BR	41	4.7	1.0	757	14	Br
IT86D-795	42	3.3	1.0	501	12	Wr
IT86D-797	38	3.7	1.7	359	14	Bs
IT84S-2246-4	43	3.7	1.0	536	16	Br
Mean Trial	42	3.3	1.0	491	-	-
CV (%)	1.9	23.6	12.6	41.2	-	-
LSD (5%)	1.6	1.6	0.2	408.4	-	-

data were available from two locations in Burkina Faso, three locations in Nigeria, two locations in Niger, one location in Ghana and two locations in Mali (Table 4.18).

The most outstanding result was that the two varieties, IT82D-849 and B301 were free of Striga infestation in most of these countries. These same varieties were also reported free of Striga infestation in Mali, although actual data was not yet available. Yield performance of individual varieties, showed considerable variation. The highest yields were obtained at Magaria, followed by at Kano, Nigeria and Kamboinse, Burkina Faso.

These results are highly encouraging and are a step forward in solving the problem of Striga in West Africa.

Regional Cowpea Drought Trial (RDCT)

This trial comprised 20 varieties including the check varieties. 18 sets were distributed to 10 countries i.e. Benin (1); Burkina Faso (3); Chad (2); Gambia (1); Ghana (2); Guinea-Bissau (1); Nigeria (2); Mali (2); Niger (3); and Senegal (2). The plot size, as in RCST, was a 4 rows plot with a distance between and within the rows of 0.75 m and 0.20 m respectively. Records were made of grain yields, disease incidence and maturity time. At the time of this write up results were received from two locations in Burkina Faso, two in Nigeria, two in Niger, one in Mali and one in Ghana. Yield (kg/ha) data from these locations are reported in Table 4.19. The most promising varieties were KVx 30-305-3G, KVx 268-K03-3, and KVx 183-1. Of these KVx 30-305-3G was identified to be one of the most promising drought tolerant varieties.

Table 4.18 Performance of cowpea varieties in the Regional Cowpea Striga Trial at different locations in 1987.

Varieties	Origin	Burkina Faso, Kamboinse,		Pobe, Burkina Faso		Bakura, Nigeria		Magaria, Niger	
		Number of Striga plants	Yield kg/ha	Number of Striga plants	Yield kg/ha	Number of Striga plants	Yield kg/ha	Number of Striga plants	Yield kg/ha
KVx 61-1	IITA/SAFGRAD	2	1077	0	606	5	440	4	1377
KVx 61-2	"	2	856	0	714	1	790	2	1323
KVx 61-74	"	5	973	0	548	1	887	4	1282
KVx 65-114	"	1	760	0	628	3	855	3	1261
KVx 68-31-3	"	4	1290	0	543	2	918	7	1583
KVx 183-1	"	4	993	0	662	10	583	10	1515
B 301	Botswana	0	581	0	378	0	770	0	958
VITA-5	IITA	46	790	0	334	1	1023	6	875
IT82D-450-4	IITA	11	875	0	612	1	540	1	1200
IT82D-479-1	IITA	7	1038	0	582	5	1020	5	1198
IT82D-849	IITA	0	1044	0	323	0	1083	0	865
SUVITA-2	IITA/SAFGRAD	1	968	0	688	2	688	2	1596
TN 88-63	NIGER	141	576	1	661	3	898	8	1521
Mougne	SENEGAL	186	411	0	432	9	1063	12	1317
Local	-	153	670	1	367	2	373	2	1427
Trial Mean		37	856.9	0.1	538.0	3.0	766	3	1286
C.V. (%)		85.4	25.1	400.4	25.8	120.2	52.1	103.9	21.1
LSD (5 %)		48.7	306.8	0.6	198	5.2	569	6.4	387

Table 4.18 contd.

Varieties	Origin	Tarna, Niger: Number of *Striga* plants	Tarna, Niger: Yield kg/ha	Manga, Ghana: Number of *Striga* plants	Manga, Ghana: Yield kg/ha	Tomas Dan Batta, Nigeria: Number of *Striga* plants	Tomas Dan Batta, Nigeria: Yield kg/ha	Kano -Sada, Nigeria: Number of *Striga* plants	Kano -Sada, Nigeria: Yield kg/ha
KVx 61-1	IITA/SAFGRAD	3.5	327	No *Striga* infestation reported	275	3.3	792	0.5	1125
KVx 61-2	"	1.0	405		421	0.5	948	0.5	833
KVx 61-74	"	2.0	261		323	1.8	865	0.5	1000
KVx 65-114	"	4.0	223		554	0.8	396	0.3	1084
KVx 68-31-3	"	8.0	298		483	9.8	646	0.0	1250
KVx 183-1	"	5.0	442		373	2.3	969	0.3	1042
B 301	Botswana	0.0	267		371	0.0	866	0.0	917
VITA-5	IITA	15.3	218		225	0.8	568	0.5	792
IT82D-450-4	IITA	1.3	252		340	0.0	802	0.0	958
IT82D-479-1	IITA	8.5	305		413	1.0	917	0.0	1167
IT82D-849	IITA	0.0	279		206	0.3	677	0.0	1127
SUVITA-2	IITA/SAFGRAD	2.3	424		525	0.3	1083	0.0	958
TN 88-63	NIGER	-	349		156	9.0	980	0.0	1458
MOUGNE	SENEGAL	13.5	178		317	6.0	792	0.0	1209
LOCAL	-	1.3	114		363	1.0	71	1.3	1083
Trial mean		5.0	290		356	2.4	800	0.3	1067
CV (%)		144.0	25.4		38.0	167.2	26.3	222.5	13.1
LSD (5 %)		10	105		191	2.9	300.2	0.9	199.2

Table 18 contd.

Varieties	Origin	Cinzana, Mali: Number of *Striga* plants	Cinzana, Mali: Yield kg/ha	Koporo, Mali: Number of *Striga* plants	Koporo, Mali: Yield kg/ha
KVx 61-1	IITA/SAFGRAD	No *Striga* infestation reported	945	No *Striga* infestation reported	917
KVx 61-2	"		629		813
KVx 61-74	"		632		896
KVx 65-114	"		745		980
KVx 68-31-3	"		694		709
KVx 183-1	"		1099		748
B 301	BOTSWANA		423		792
VITA-5	IITA		331		438
IT82D-450-4	IITA		655		959
IT82D-479-1	IITA		679		854
IT82D-849	IITA		564		1146
SUVITA-2	IITA/SAFGRAD		1064		959
TN88-63	NIGER		294		834
Mougne	SENEGAL		409		750
Local	-		426		73
Trial Mean			639		811
C.V. (%)			37.1		33.8
LSD (5 %)			339		391

Table 19. Yields (kg/ha) of different varieties in the Regional Cowpea Drought Trial at different locations in 1987.

Varieties	Origin	Burkina Faso		Nigeria		Ghana	Mali	Niger	
		Kamboinse	Pobe	Bakura	Samaru	Manga	Koporo	Kolo	Gabougoura
KVx 30-305-3G	IITA/SAFGRAD	1633	472	1773	2157	879	1438	2408	556
KVx 60-K26-2	"	1148	449	1250	2678	594	1313	1124	348
KVx 60-P04-1	"	1018	609	1353	1368	702	1271	1356	485
KVx 61-1	"	1183	605	2003	2206	379	1646	2021	325
KVx 65-114	"	1173	682	1268	1679	646	1115	1807	250
KVx 183-1	"	1315	464	1233	2040	896	1375	1409	342
KVx 249-P37-30	"	930	364	1250	2449	725	1219	1629	375
KVx 250-K27-18	"	1080	461	1313	1412	660	1156	1845	371
KVx 257-K21-3	"	923	322	980	2271	640	1188	899	213
KVx 268-K03-3	"	1283	560	1833	2466	838	1333	1646	386
KVx 256-K17-11	"	1078	519	1688	2883	563	1042	1284	340
IT83S-343-5	IITA	1073	487	1398	2322	604	1208	1141	288
IT81D-994	"	245	415	695	2216	410	1011	318	344
IT82D-699	"	1023	525	1628	2156	181	1125	1265	256
IT82S-2246	"	980	104	1645	1725	633	1063	302	233
IT845-2137	"	953	257	1168	1520	408	958	470	86
IT83S-340-5	"	1000	394	1188	1791	509	1104	650	171
TN 88-63	NIGER	1225	540	1855	1267	740	1448	1665	515
SUVITA-2	IITA/SAFGRAD	1205	391	1668	1109	893	1229	2332	467
Local	-	738	361	395	2621	342	698	1932	715
Trial Mean		1060	449	1379	2004	612	1197	1375	353
C. V. (%)		22.7	37.0	40.2	20.2	26.0	18.6	23.2	53.6
LSD (5%)	430	340	235	785	574	226	314	451	268

Table 2.1

COWPEA NETWORK REGIONAL TRIALS - 1987

Country	Number of Trials Requested						
	Drought tolerance	*Striga* resistance	Sorghum-Cowpea intercropping	Millet-Cowpea intercropping	Insect Resist. observation nursary	Maize-Cowpea relay cropping	Minimum Insecticide protection.
Benin	1		2		1		2
Burkina Faso	1	1			1		
Cameroon							1
Cape Verde					1		
Central Africa Rep.					2		
Côte d'Ivoire					1		
Gambia	1		1	2			1
Ghana	1	1	1				1
Guinea			1		3	2	1
Guinea Bissau	1		1		1		
Mali	2	2		2	1		
Niger	3	3		3	3		2
Nigeria	2	3	1		1	1	2
Senegal	2		1	1	3		2
Tchad	2			2	2	1	
Togo			2			1	
	16	10	10	10	20	5	12

COWPEA AGRONOMY

N. MULEBA

The objectives of the IITA/SAFGRAD cowpea agronomic research are to develop new production technologies for achieving maximum economic yields of cowpea in the semi-arid zone of Africa, a vast area that includes 26 countries.

NORTHERN GUINEA SAVANNA

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

SORGHUM/GRAIN LEGUMES INTERCROPPING

Performance of Cowpea Cultivars in an Intercropping System with Sorghum.

Seven cowpea cultivars of different growth habits were sown at Farako-Bâ simultaneously with sorghum in alternate solid rows on 28 June, 1987. The spacings were 1 m between rows and 0.25 between hills in a row for sorghum and 1 m and 0.20 m for cowpea. Three pure-stand treatments were used for comparison: two for cowpea and one for sorghum. All plots received NPK fertilizer at sowing. Sorghum plants in intercrop and pure-stand treatments received an additional N fertilizer one month after sowing. An intercrop treatment using cowpea TVx 3236 and a pure-stand of sorghum, both without fertilizer application, were also included for comparison. Cowpea plants were sprayed with insecticide twice. Sorghum cultivar Framida was used in this trial.

Sorghum flowering and maturity dates were significantly delayed only in fertilizer free pure-stand and intercrop treatments (Table 4.20). Plant height and seed yields were significantly reduced in the fertilizer-free intercrop treatments (Table 4.20).

Cowpea cultivars differred significantly in flowering (from 34 to 63 days after sowing) and maturity (from 51 to 83 days after sowing) dates and seed yields (from 0.07 to 0.35 t/ha) (Table 4.20). Of the two cowpea checks, TVx 3236 and KN-1, only seed yields of TVx 3236 were significantly reduced in intercrop (0.25 t/ha) versus pure-stand (0.42 t/ha) treatments (Table 4.20). TVx 3236 yielded significantly higher and less than KN-1 in pure-stand and intercrop treatments, respectively.

Seed yields of both crops, particularly cowpea, were relatively lower in 1987 than in 1986. Dry spells in late September and early October, during sorghum grain fill, were probably responsible for the low seed yields, whereas excess rains in August may have drastically reduced cowpea seed yields. LER's were abnormally high during this crop season compared to previous years. This may be related to the effects of dry spells on sorghum grain fill, which probably prevented pure-stands treatments from expressing their yield potential.

In contrast with previous year's results, there were no differences in cowpea cultivar competitive ability with sorghum; early cultivars did not show better adaptation to intercropping with sorghum compared to intermediate ones, which exhibited a high LER (i.e. 1.34 for TVx 3236, 1.60 for KN-1 and 1.04 for TVx 1999-01F). These intermediate maturing cowpea cultivars and IT 82D-716 to some extent, appeared better adapted to intercropping with sorghum than the early

Table 4.20. Effect of cowpea cultivars on the performance of sorghum and cowpea in an intercropping system at Farako-Bâ, Burkina Faso, in 1987.

Cowpea cultivars	Sorghum					Cowpea				Combined Sorghum Cowpea LER**
	Flower-ing date*	Matu-rity date*	Plant height*	Seed yield*	Partial LER**	Flower-ing date*	Matu-rity date*	Seed yield*	Partial LER**	
	-----DAS-----		---cm---	--kg/ha--		-----DAS-----		--kg/ha--		
FERTILIZED PLOTS										
a) Intercrop										
Ouahigouya local	70 b	98 b	201 a	1280 ab	0.84	63 a	83 a	270 cd	0.64	1.48
TVx 1999-01F	70 b	99 b	195 a	1300 ab	0.85	43 d	62 d	80 e	0.19	1.04
KVu-69	71 b	98 b	204 a	1400 ab	0.93	34 f	51 f	90 e	0.21	1.14
TVx 3236	71 b	98 b	205 a	1140 ab	0.75	45 c	66 c	250 d	0.59	1.34
KN-1	70 b	98 b	200 a	1170 ab	0.77	48 b	69 b	350 ab	0.83	1.60
IT82E-716	71 b	98 b	205 a	1430 ab	0.94	40 e	57 e	100 e	0.24	1.18
IT82E-32	70 b	99 b	189 ab	1100 b	0.72	43 d	61 d	70 e	0.17	0.89
b) Pure Stand										
Sorghum	71 b	98 b	200 a	1520 ab	1.00	-	-	-	-	1.00
TVx 3236	-	-	-	-	-	46 c	66 c	420 a	1.00	1.00
KN-1	-	-	-	-	-	49 b	70 b	340 bc	(1.00)	(1.00)
UNFERTILIZED PLOTS										
a) Intercrop										
TVx 3236	76 a	102 a	175 b	510 c	(0.32)	45 c	68 bc	380 ab	(0.90)	(1.22)
b) Pure Stand										
Sorghum	76 a	103 a	192 ab	1580 a	(1.00)	-	-	-	-	-
L.S.D. (5%)	1	1	19	460	-	1	2	70	-	-
C.V. (%)	1	1	10	39	-	2	3	33	-	-

*Means followed by the same letter are not statistically different at 0.05 probability level

**LER = Land Equivalent Ratio; it was calculated on the basis of the best check.

and late maturing cultivars. Emphasis should, therefore, be placed on better adapted and intermediate maturing cowpea cultivars in an effort to improve seed yields of cowpea in an intercropping system with sorghum.

Effect of Soybean Cultivars on the Performance of Sorghum in an Intercropping System.

Eight soybean cultivars were simultaneously sown with sorghum in an intercropping system to study their effect on intercropped sorghum. Three soybean and one sorghum pure-stand treatments were included for comparison. The experiment was sown on 21 June, 1987. All agronomic practices were as described in the sorghum-cowpea intercropping experiment; except that soybean plants were not sprayed with insecticides.

In comparison with the sorghum pure-stand treatment:
(i) Cultivars TGx 536-02D and TGx 713-02D significantly delayed sorghum flowering date by about 2 days; other cultivars did not have any marked effects on the sorghum trait (Table 4.21);
(ii) None of the intercropped soybean cultivars had significant effect on sorghum maturity date nor plant height; and
(iii) Sorghum seed yield was significantly reduced only in intercrop treatments with soybean cultivars TGx 573-104G, TVx 297-192C, Alamo (or G200) and G121 (Table 4.21).

Except G121, soybean cultivars did not differ significantly in their competitive ability with sorghum. G 121 had a greater competitive ability with sorghum than TGx 536-02D and G 38. Since G 121 did not significantly delay sorghum flowering date like TG 536-02D and considering that both cultivars had insignificant effects on sorghum maturity date, G 121 reduced sorghum plant height compared to TGx 536-02D; the competitive effect observed, thus, appeared to be related to sorghum nutrition (water and nutrients) during the grain fill period.

Soybean cultivars differred significantly in their flowering as well as maturity dates as shown on Table 4.21. The three cultivars grown in both cropping systems reacted differently in their flowering and maturity dates: intercropping significantly delayed flowering and maturity dates of TGx 297-192D, but had no marked effect on the same traits of TGx 536-02D and ISRA 26/72 (or G 196) (Table 4.21).

Intercropping significantly reduced seed yields of the three checks; except Alamo (or G 200), which yielded less than most cultivars, seed yields of cultivars did not differ significantly in intercrop treatments. Similarly, seed yields of the three checks did not differ significantly in pure-stand treatments (Table 4.21).

As observed in 1986, there was an advantage in intercropping sorghum with soybean (LER 0.87 to 1.19) (Table 4.21). Cultivar TGx 536-02D confirmed its good adaptation in intercropping with sorghum as was observed in 1985 and 1986.

SOIL MANAGEMENT

Background Effect of P_2O_5 Levels from Two Sources on Sorghum

The background effect of P_2O_5 levels applied on cowpea in 1985 and the residual effect of P_2O_5 applied on maize in 1986 were studied on sorghum in 1987. P_2O_5 applied to cowpea in 1985 consisted of four levels: 0 Kg of P_2O_5/ha (a check), 50 and 100 kg of P_2O_5/ha from Single Superphosphate 18% (SSP)

Table 4.21 Performance of sorghum and soybean in an intercropping system at Farako-Bâ, Burkina Faso, in 1987.

Treatments (Soybean cultivars)	Sorghum Flowe-ring date*	Sorghum Matu-rity date*	Sorghum Plant height* cm	Sorghum Seed yield*	Sorghum LER**	Soybean Flowe-ring date*	Soybean Matu-rity date*	Soybean Seed yield*	Soybean LER**	Combined Sorghum-Soybean LER
	-----DAS-----		---cm---	Kg /ha--		-----DAS-----		Kg /ha--		
A) Intercrop treatments										
TGx 573-104 G	77 ab	106 a	188 a	1240 bc	0.73	51 f	87 c	670b	0.39	1.12
TGx 536-02D	78 a	107 a	186 a	1360 ab	0.80	56 ab	91 ab	590 b	0.34	1.14
TGx 713-09D	78 a	107 a	181 a	1320 abc	0.78	53 de	88 c	430 bc	0.25	1.03
TGx 297-192c	77 ab	107 a	174 a	1250 bc	0.73	53 de	88 c	460 bc	0.27	1.00
Alamo (ou G200)	76 b	106 a	185 a	1200 bc	0.71	55 bc	90 b	130 c	0.07	0.78
ISRA 26/72 (ou G 196)	76 b	107 a	189 a	1310 abc	0.77	52 ef	88 c	450 bc	0.26	1.03
G 38	77 ab	106 a	183 a	1360 ab	0.80	53 d	88 c	680 b	0.39	1.19
G 121	76 b	107 a	169 a	920 c	0.54	54 cd	90 b	570 b	0.33	0.87
B) Pure stand treatments										
Sorghum	76 b	107 a	181 a	1700 a	1.00	-	-	-	-	1.00
TGx 536-02D	-	-	-	-	-	57 a	92 a	1670 a	(1.00)	(1.00)
TGx 297-192D	-	-	-	-	-	49 g	85 d	1680 a	(1.00)	(1.00)
ISRA 26/72 (ou G 196)	-	-	-	-	-	51 f	87 c	1730 a	1.00	(1.00)
L.S.D. (5 %)	1	NS	NS	400	-	1	1	400	-	-
C.V. (%)	2	1	13	36	-	2	1	46	-	-

* Means followed by the same letter are not statistically different at 0.05 probability level.

** LER = Land Equivalent Ratio ; it was calculated on the basis of the best pure stand check.

and 200 kg of P_2O_5/ha from Burkina Phosphate 27% (BP), rock phosphate. In addition, each received six P_2O_5 levels -- viz., 0 kg of P_2O_5/ha (as a check), 25 and 50 kg of P_2O_5/ha from SSP; and 50, 75 and 100 kg of P_2O_5/ha from BP -- as sub-treatments on maize crop in 1986. The experiment was a split-plot design with the four 1985 P_2O_5 levels as main-treatments and the six 1986 P_2O_5 levels as sub-treatments; the experiment was replicated four times. The sorghum cultivar "Framida" was sown on 16 June, 1987 and received only 22.5 kg of N/ha at sowing and 45 kg of N/ha one month after sowing.

Flowering and maturity dates and plant height of sorghum were not affected by both P_2O_5 levels applied in 1985 and 1986. Seed yield of sorghum was, however, significantly affected by the background effect of P_2O_5 levels applied in 1985 only; yield increased by 4.1 t/ha on the average for the treatments which received 100 kg/ha of SSP in 1985 compared to the fertilizer free check. Other seed yield increases exhibited on Table 4.22 were not statistically significant.

Dry spells during the second half of September and early October probably prevented sorghum from expressing its full yield potential.

Soluble phosphatic fertilizer, SSP, confirmed its superiority over the insoluble rock phosphatic fertilizer, BP, even at dosages as high as 200 kg/ha of P_2O_5.

Throughout the three years of this experiment the background and residual effects of rock phosphate BP on sorghum appeared to depend on the growing conditions. The effects were positive, although less significant than those of soluble phosphate at the same P_2O_5 levels during rainy years and insignificant during dry years. Substitution of rock phosphatic fertilizer for the soluble ones in Oxisol in Northern Guinea Savanna, should therefore be done with considerable caution.

Background Effect of Liming in Oxisol.

The background effect of liming treatments applied on cowpea in 1985 was studied on sorghum in 1987. The liming treatments were: 0, 500, 1000 and 1500 kg/ha of finely ground lime; 50 kg of P_2O_5/ha from a soluble source (SSP) was included for comparison. Each liming treatment received two P_2O_5 levels -- viz. 25 and 50 kg/ha -- from a soluble P source in 1986. The experimental design was a factorial combination of two P_2O_5 levels applied in 1986 and 5 liming treatments applied in 1985 in randomized complete blocks replicated 4 times. The sorghum variety, Framida, was sown on 14 June, 1987. All agronomic practices were as described earlier in the "Background effect of P_2O_5 levels from two sources on sorghum".

As was observed on maize, liming treatments had no background effect two years after their application on sorghum flowering and maturity dates and plant height. The combination of 1500 kg/ha of lime, applied in 1985, and 50 kg/ha of P_2O_5 from SSP, applied in 1986, significantly induced seed yield, much more than any other treatment combination, except: 1000 kg/ha of lime in 1985, 25 kg/ha of P_2O_5 in 1986, 50 kg/ha of P_2O_5 in 1985 and 50 kg/ha of P_2O_5 in 1986 (Table 4.22). Liming per se, thus, had no residual and background effects under the conditions of this experiment.

Table 4.22. Background and residual effects of P_2O_5 on sorghum seed yield at Farako-Bâ, Burkina Faso, in 1987.

Residual effect of P_2O_5 levels applied on maize in 1986 (kg/ha)§	Background effects of P_2O_5 levels applied on cowpea in 1985§&				Mean
	0	50 SSP	100 SSP	200 B	
	kg/ha				
0	730 a	910 a	1440 a	850 a	980 a"
25 SSP	630 a	900 a	1050 a	1060 a	910 a"
50 SSP	830 a	1020 a	1230 a	1130 a	1050 a"
50 SSP	620 a	1070 a	1210 a	1170 a	1020 a"
75 BP	900 a	990 a	1190 a	860 a	980 a"
100 BP	930 a	1100 a	970 a	950 a	990 a"
MEAN	770 b'	1000 a'b'	1180 a'	1000 a'b'	990

Comparison of means	L.S.D. (5%)	C.V. (%)
1985 P_2O_5 levels means	250	8
1986 P_2O_5 levels means	N.S.	16
1986 P_2O_5 levels means at same or different levels of 1985 P_2O_5.	N.S.	32

§ SSP = Single Super Phosphate 18%; BP = Burkina Phosphate 27% (a rock phosphate).

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

Table 4.23. Background and residual effects of liming on sorghum seed yield at Farako-Bâ, Burkina Faso, in 1987.

P_2O_5 levels applied in 1986 (kg/ha)§	Lime levels applied in 1985§&				
	0	500	1000	1500	50 P_2O_5
	kg/ha				
25	990 b	990 b	1130 ab	910 b	760 b
50	730 b	800 b	810 b	1540 a	1030 ab
L.S.D. (5%)	520				
C.V. (%)	37				

§ The single superphosphate 18% fertilizer was used

& Mean followed by the same letter are not satistically different at 5% probability level.

Residual Effect of Soil Improvement Treatments.

The soil improvement experiment conducted in 1983-1985 was repeated in the period of 1985 to 1987. It consisted of studying the effect of preceeding crop treatments on maize crop in 1986 and the subsequent sorghum crop in 1987. The preceeding crop treatments established in 1985 were:

1) Cowpea grain production + 60 kg of P_2O_5/ha from phosphate 18% (SSP);
2) The same as (1) + 200 kg of P_2O_5/ha from Burkina phosphate 26.7 (BP);
3) Cowpea green manure;
4) Cowpea green manure + 200 kg of P_2O_5/ha from BP;
5) *Crotalaria* green manure;
6) *Crotalaria* green manure + 200 kg of P O /ha from BP.

The sorghum treatments: sorghum + 100 kg of N/ha and 60 kg of P_2O_5/ha from SSP and sorghum + 100 kg of N/ha and 200 kg of P_2O_5/ha from BP, were also included as checks. Unlike in 1984 when three levels of NPK fertilizers were applied on maize; in 1986, a factorial combination of two levels of N -- viz., 60 and 120 kg of N/ha -- and two levels of P_2O_5 -- viz., 0 and 50 kg of P_2O_5/ha from SSP -- were used as sub-treatments on maize for each of the preceeding crop treatments described earlier. The experimental design used was a split-plot, with preceeding crops as main-treatments and the factorial combination of two levels of N and two levels of P_2O_5 as sub-treatments. The cowpea and *Crotalaria* green manure treatments were plowed in slightly after they flowered. The experiment was replicated 4 times.

To study the background effect of preceeding crop treatments applied in 1985 and the residual effect of fertilizers applied in 1986, a trial was set up with the sorghum variety, Framida, sown on 4 July, 1987 and treated with 90 kg of N/ha fertilizer only during the crop season.

Preceding crop treatments had no significant effects on sorghum flowering and maturity dates, plant height and seed yields (Table 4.24). However, when compared to cowpea grain production from crops treated with SSP or BP, green manure treatments involving cowpea and fertilizer-free <u>Crotalaria</u>, tended to reduce sorghum plant height and seed yields (Table 4.24). Similar effects were noted with sorghum treatment that received 200 kg of P_2O_5/ha as BP (Table 4.24). Application of 50 kg in 1986 significantly hastened flowering and maturity dates, and increased plant height and seed yields (Table 4.25).

Increasing levels of N from 60 kg/ha to 120 kg/ha significantly delayed flowering and maturity dates, but had no effect on plant height or seed yields (Table 4.25). Unlike the 1983-85 experiment, the importance of phosphorous as an important limiting nutrient for crop growth and development was demonstrated in this experiment. Soluble phosphatic fertilizer had a residual and some background effect on crop performance. There was no evidence that legumes provided additional N required by the crops.

SUDAN SAVANNA

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

SORGHUM-COWPEA INTERCROPPING

<u>Performance of cowpea Cultivars in an Intercropping System with Sorghum</u>.

As in the Northern Guinea Savanna Zone, 7 cowpea cultivars were studied for their performance when intercropped with sorghum.

Table 4.24. Effect of preceeding crop treatments in 1985 on sorghum flowering and maturity dates, plant height and seed yield at FArako-Bâ, Burkina Faso, in 1987.

Preceeding crop treatments in 1985	Flowering date&	Maturity date&	Plant height&	Seed yield&
	---------DAS-------		---cm---	-kg/ha-
- Cowpea grain + 60 kg of P O /ha as SSP §	75 a	106 a	170 a	1360 a
- Cowpea grain + 200 kg of P_2O_5/ha as BP §	74 a	106 a	168 a	1250 a
- Cowpea green manure	74 a	106 a	164 a	860 a
- Cowpea green manure + 200 kg of P_2O_5/ha as BP.	74 a	106 a	160 a	900 a
- Crotalaria green manure	74 a	106 a	164 a	990 a
- Crotalaria green manure + 200 kg of P_2O_5/ha as BP.	74 a	106 a	167 a	1110 a
- Sorghum + 100 kg of N/ha and 60 kg of P_2O_5/ha as SSP.	74 a	106 a	172 a	1130 a
- Sorghum + 100 kg of N/ha and 200 kg of P O /ha as BP.	74 a	106 a	166 a	970 a
L.S.D. (5%)	NS	NS	NS	NS
C.V. (%)	0.2	0.4	5	35

§ SSP = Single Super Phosphate 18%; BP = Burkina Phosphate 27%; a rock phosphate.

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

Table 4.25. Residual effects of fertilizer levels applied as subtreatments in 1986 on Sorghum flowering and maturity dates, plant height and seed yields at Farako-Bâ, Burkina Faso, in 1987.

Fertilizer levels in 1986 §	Flowering date&	Maturity date&	Plant height&	Seed yield&
	----------DAS -------		---cm---	-kg/ha-
60:0:0	75 b	106 b	163 c	900 b
60:50:0	73 c	105 c	168 ab	1220 a
120:0:0	77 a	107 a	165 bc	950 b
120:50:0	72 d	105 c	169 a	1220 a
L.S.D. (5%)	0.1	0.5	3	140
C.V. (%)	0.4	1.0	4	26

§ 60:0:0 = N: P_2O_5 : K_2O kg/ha

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

They were, however, sown under sorghum after mid-July and harvested in late September under sunny and dry weather conditions, crucial for good quality grain. The experimental design and agronomic practices used were as described in the Northern Guinea Savanna experiment. Sorghum crop was planted on 29 June and cowpea on 27 July.

Cowpea cultivar Koakin Local significantly delayed flowering date of intercropped sorghum; other cultivars as well as soil fertilizer treatments had insignificant effects (Table 4.26). Relative to fertilizer treated sorghum pure-stands, intercropped cowpea significantly delayed sorghum maturity date in fertilizer free treatments; the effects of other treatments were intermediate between these treatments (Table 4.26). Cultivar IT 82D-716 significantly depressed plant height of intercropped sorghum compared to cultivar TVx 1999-01F. Otherwise, cowpea cultivars and soil fertilizer treatments had no significant effect on sorghum plant height. Sorghum seed yield was significantly depressed only by cultivar Koakin local (Table 4.26).

Relative to cowpea pure-stand treatments, intercropping significantly reduced seed yield of cowpeas in all treatments. Seed yield in the latter two treatments did not differ significantly (Table 4.26).

Cowpea cultivars significantly differred in their flowering and maturity dates, ground cover and seed yield in intercropped treatments. Cultivar IT 81D-994 had poor stand, flowered and matured latest, but had intermediate ground cover and yielded low and significantly less than cultivar Kaokin Local (Table 4.26). The latter cultivar, thus contrasted with

Table 4.26. Sorghum and cowpea performances as affected by cowpea cultivars in an intercropping system at Gampela Burkina Faso, in 1987.

Cowpea Cultivars	Sorghum: Flowering date§	Sorghum: Maturity date§	Sorghum: Plant height§	Sorghum: Seed yield§	Sorghum: Partial LER&	Cowpea: Flowering date§	Cowpea: Maturity date§	Cowpea: Ground cover	Cowpea: Seed yield	Cowpea: Partial LER&	Combined Sorghum-Cowpea LER&
	-----DAS-----		--cm--	---Kg/ha---		-----DAS-----		---%---	--Kg/ha--		
Fertilized Treatments											
a) Intercrop											
Koakin local	88a	114abc	181ab	800	0.60	48b	63b	65b	340	0.29	0.89
TVx 1999-01F	83ab	111abc	192a	1190	0.89	41de	60c	47cd	320	0.27	1.16
IT81D-994	84ab	113abc	182ab	980	0.74	53a	66a	40def	200	0.17	0.91
TVx 3236	84ab	111abc	182ab	1060	0.80	43cd	63b	38ef	280	0.24	1.04
KN-1	81b	109c	182ab	1250	0.94	44c	62bc	53c	320	0.27	1.21
IT82D-716	86ab	114abc	177b	1020	0.77	40e	62bc	35f	250	0.21	0.98
IT82E-32	84ab	112abc	181ab	1030	0.77	41de	61bc	45cde	230	0.19	0.96
b) Pure Stand											
Sorghum (Framida)	81b	110bc	182ab	1330	1.00	-	-	-	-	-	1.00
TVx 3236	-	-	-	-	-	42cde	63b	67b	1180	1.00	1.00
KN-1	-	-	-	-	-	43cd	62bc	97a	1100	(0.93)	(0.93)
Unfertilized Treatments											
a) Intercrop											
TVx 3236	86ab	116a	179ab	1140	(0.86)	43cd	63b	33f	230	(0.19)	(1.05)
b) Pure Stand											
Sorghum (Framida)	85ab	115ab	184ab	1030	(0.77)	-	-	-	-	-	-
L.S.D. (5 %)	5	5	13	350	-	2	2	8	120	-	-
C.V. (%)	6	5	7	34	-	5	3	16	29	-	-

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

LER = Land Equivalent Ratio ; it was calculated on the basis of the best pure stand check.

the former in that: although it was the next latest flowering and maturing cultivar, it had the best ground cover and the highest yield in intercropped treatments (Table 4.26). The respective seed yields of both cultivars did not, however, significantly differ from those of other cultivars in other intercrop treatments.

Insufficient and poorly distributed rainfall in late August, early and mid-September was probably responsible for the short height and low seed yields of sorghum plants. In spite of this, there was a seed yield advantage in intercropping sorghum with cowpea cultivar TVx 1999-01F, TVx 3236 and KN-1. The three cultivars contrasted with Kaokin Local, IT82D-716 and IT82E-32; they were better adapted in intercropping with sorghum, when sown three to four weeks after sorghum, as observed in 1986.

While the loss of yield advantage of Kaokin Local in intercropping with sorghum was due to its high competitive ability, which affected sorghum yields, those of IT82D-716 and IT82E-32 were apparently attributable to lack of adaptation to drought particularly, in intercropping with sorghum (Table 4.26). These results, therefore, confirm the importance of choosing an appropriate cowpea cultivars to ensure good yields of both crops in an intercropping system. Since Kaokin Local tolerates low plant populations and considering that it was planted at high plant population densities, its high competitive ability during a droughty year could be reduced by decreasing plant population.

Effect of Row-Spacings, Densities, and Dates of Sowing Cowpea on Sorghum-Cowpea Intercropping.

This study investigated different ways of alleviating the strong competition for P nutrient exerted on sorghum by intercropped cowpea, observed in 1984 and 1985. Three row-spacings --viz., (i) 1.50 m x 0.25 m and 1.50 m x 0.20 m; (ii) 1.25 m x 0.25 m and 1.25 m x 0.20 m; and (iii) 1.00 m x 0.25 m and 1.00 m x 0.20 m, respectively, for sorghum and cowpea and two cowpea dates of sowing viz. (i) sorghum and cowpea sown simultaneously and (ii) cowpea sown about 4 weeks after sorghum, were tested. Three pure-stand treatments: one for sorghum, one for cowpea sown at the same time with sorghum and one for cowpea sown about, 4 weeks after sorghum were included for comparison. The experimental design was a randomized complete block (with nine treatments replicated six times). All sorghum and cowpea treatments sown simultaneously with sorghum on 29 June. Cowpea second date of sowing treatments was on 27 July. Agronomic practices used were as in the preceeding intercrop experiment described earlier. Sorghum and cowpea cultivars used were Framida, and TVx 3236, respectively.

As observed in 1985, but contrary to the 1986 results, sorghum flowering and maturity dates were not significantly affected by row-spacings and by time of sowing cowpea treatments in 1987. Relative to the pure-stand treatment, sorghum plant height, was significantly reduced by row-spacing treatments: (1.50 x 0.25) m/(1.50 x 0.20) m and (1.25 x 0.25) m/(1.25 x 0.20) m when cowpea was sown four weeks after sorghum (Table 4.27). The two treatments did not significantly affect sorghum plant height compared to other intercrop treatments irrespective of the time cowpea was sown.

Intercropping significantly reduced sorghum seed yields compared to the pure-stand treatment (Table 4.27). In contrast to the 1985 and 1986 results, row-spacings and cowpea sowing time had no significant effect on sorghum seed yields (Table 4.27). Nevertheless, the general tendency of increased sorghum seed yield when cowpea sowing date was delayed by 3 to 4 weeks after sorghum was again evident. Sorghum yields were also reduced in the wide row-spacings when cowpea sowing was delayed. The results were, however, different when sorghum and cowpea were sown simultaneously: seed yields tended to decrease with reduced row-spacings (Table 4.27).

None of the treatments significantly affected cowpea flowering dates, whereas cowpea maturity dates were significantly delayed in the early compared to the late sowings (Table 4.27).

Intercropping and late sowing significantly reduced cowpea ground cover and seed yields (Table 4.27). The seed yields of pure-stand cowpea treatments were, however, not significantly affected by sowing dates (Table 4.27). Though, statistically insignificant, narrow row-spacings reduced cowpea seed yields on each sowing date (Table 4.27).

Dry spells in late August, early and mid-September probably caused low yields observed in both crops. They might have also exacerbated the competition between both crops, which further decreased seed yields in intercropped treatments particularly: under narrow row-spacings for cowpea, and for sorghum, only when both crops were sown simultaneously.

No seed yield advantage was observed in 1987 (Table 4.27) as was observed in 1985 and 1986. This suggests that even with wide spacings and delayed cowpea sowing relative to sorghum, severe seed yield losses due to intercropping can be expected during

Table 4.27 Sorghum and cowpea performances as affected by row-spacings/densities in an intercropping system at Gampela, Burkina Faso, in 1987.

Treatments				Sorghum					Cowpea					Combined Sorghum-Cowpea LER&
Spacing		% of												
Sorghum	Cowpea	Sorghum	Cowpea	Flowering date§	Maturity date§	Plant height§	Seed yield§	Partial LER&	Flowering date§	Maturity date§	Ground cover§	Seed yield§	Partial LER&	
				----DAS----		--cm--	--Kg/ha--		----DAS----		--%--	--Kg/ha--		
a) Sorghum and cowpea sown simultaneously														
1) Pure Stand Treatments														
(0.75 x 0.25)m	-	100	0	72a	101a	188a	1560a	1.00	-	-	-	-	-	1.00
-	(0.75x0.20)m	-	100	-	-	-	-	-	45a	76a	97a	1450a	1.00	1.00
2) Intercrop Treatments														
(1.50x0.25)m	(1.50x0.20)m	50	50	72a	101a	178abc	680b	0.44	47a	73a	69b	670b	0.46	0.90
(1.25x0.25)m	(1.25x0.20)m	60	60	75a	101a	183abc	670b	0.43	52a	73a	69b	690b	0.48	0.91
(1.00x0.25)m	(1.00x0.20)m	75	75	75a	103a	177abc	560b	0.36	45a	73a	84ab	590b	0.41	0.77
b) Cowpea sown four weeks after Sorghum														
1) Pure Stand Treatments														
-	(0.75x0.20)m	0	100	-	-	-	-	-	42a	63b	75c	1290a	(1.00)	(1.00)
2) Intercrop Treatments														
(1.50x0.25)m	(1.50x0.20)m	50	50	71a	100a	172c	800b	0.51	42a	64b	46d	270c	(0.21)	(0.72)
(1.25x0.25)m	(1.25x0.20)m	60	60	75a	101a	173bc	900b	0.58	46a	64b	47d	240c	(0.19)	(0.77)
(1.00x0.25)m	(1.00x0.20)m	75	75	73a	100a	184ab	920b	0.59	43a	63b	38d	190c	(0.15)	(0.74)
L.S.D. (5 %)				NS	NS	11	370	-	NS	3	15	230	-	-
C.V. (%)				8	5	7	47	-	13	4	22	33	-	-

§ Means followed by the same letter are not statistically different at 0.05 probability level.

& LER = Land Equivalent Ratio based on pure stand check. Those in parenthesis were calculated on the basis of the yield of the pure stand cowpea sown four weeks after sorghum.

years of severe drought. Since this was the case in 1984, adoption of sorghum cowpea intercropping should, not be considered for use in the Sudan Savanna Zone during drought years.

MANAGEMENT OF PURE-STAND COWPEA

Background Effect of P_2O_5 Levels from Two Different Sources on Sorghum.

The background effect of four P_2O_5 levels viz. 0 and 50 kg of P_2O_5/ha from single super phosphate (SSP) 18% and 100 and 200 kg of P_2O_5/ha from Burkina phosphate (BP) 26.7% -- applied on cowpea in 1984-85 were studied. The six additional P_2O_5 levels applied on sorghum in 1986 as subtreatments and all agronomic practices used were as in the similar experiment described earlier. The cowpea cultivar KVx 396-4 was sown on 25 July. Cowpea plants were sprayed with insecticides during the crop season; at flower bud formation and at the beginning of pod filling growth stages.

Flower bud formation and maturity dates were not affected by P_2O_5 levels applied in 1984/85 and in 1986. Application of P_2O_5 levels from both phosphatic sources in 1984/85 and in 1986 significantly hastened flowering compared to the fertilizer-free check treatment (Table 4.28). In fertilizer treated crops, flowering dates did not differ significantly due to P_2O_5 levels or phosphatic fertilizer sources (Table 4.28).

Seed yield was significantly affected only by P_2O_5 levels applied in 1984/85 as well as 1986. Seed yield increases were significant only for P_2O_5 treatment 200 BP applied in 1984/85 (Table 4.28). This indicated that: at 200 kg of P_2O_5/ha, the rock fertilizer BP had a strong background effect. Of the levels

Table 4.28 Flowering dates and seed yields of cowpea as affected by P_2O_5 levels applied in 1984/85 and P_2O_5 levels in 1986 at Oipasse/Kamboinse/Ouagadougou, Burkina Faso, in 1987.

P_2O_5 levels applied in 1986 (kg/ha)§	Flowering dates					Seed yields&				
	P_2O_5 levels applied in 1984/85 (kg/ha)§					P_2O_5 levels applied in 1984/85 (kg/ha)§				
	0	50SSP	100BP	200BP	Mean	0	50SSP	100BP	200BP	Mean
	DAS									
0	48 a	45 b	45 b	45 b	46 a"	150 a	300 a	430 a	550 a	360 c"
25 SSP	45 b	45 b	45 b	45 b	45 b"	290 a	470 a	490 a	530 a	450 b"
50 SSP	45 b	45 b	45 b	45 b	45 b"	430 a	590 a	580 a	620 a	550 a"
50 BP	45 b	44 b	45 b	45 b	45 b"	310 a	420 a	550 a	640 a	480 b"
75 BP	45 b	45 b	45 b	44 b	45 b"	390 a	510 a	470 a	650 a	500 a"b"
100 BP	45 b	45 b	45 b	45 b	45 b"	360 a	510 a	530 a	580 a	500 a"b"
Mean	46 a'	45 a'	45 a'	45 a'	45	320 b'	470 a'b'	510 a'b'	590 a'	470

Comparison of Means	Flowering dates L.S.D. (5 %)	Flowering dates C.V. (%)	Seed yields L.S.D. (5 %)	Seed yields C.V. (%)
- P_2O_5 levels applied in 1984/85	N.S	1.4	240	22
- P_2O_5 levels applied in 1986	0.5	1.5	60	19
- Same or different level of P_2O_5 applied in 1984/85	1.0		N.S	

§ SSP = Single Super Phosphate 18 % ; BP = Burkina Phosphate 26.7 %, a rock phosphate.

& Means followed by the same letter are not statistically different at 0.05 probability level.

applied in 1986, cowpea treated with 50 kg of P_2O_5/ha from SSP significantly out-yielded cowpea on all the other treatment levels and 50 kg of P_2O_5/ha from BP and 25 kg of P_2O_5/ha from SSP induced similar seed yield significantly greater than that of the fertilizer free check treatment (Table 4.28).

These results, suggest that unlike in Northern Guinea Savanna, the rock phosphatic fertilizer, Burkina phosphate (BP), and the single super phosphate (SSP) had strong residual and background effects. But the effects of SSP were much stronger than those of BP at the same levels of P_2O_5. The ratio of equivalence between the two fertilizers appeared to be around 1:2. Therefore, BP could be substituted for SSP at the above ratio in the Sudan Savanna.

Effect of Dates of Sowing on Cowpea Performance Under Striga Infestation.

This experiment, which had been conducted since 1984 at Kamboinse, was repeated in 1987 at Gampela to study the response of cowpea to dates of sowing under Striga infestation. Five day length neutral and one day length sensitive (Kaokin Local) cowpea cultivars were tested at three dates: i.e., 2 July, 25 July and 12 August, on a heavily Striga infested field plot. Striga seeds collected from the same field at the end of the previous crop season were mixed with wet soil, broadcast and plowed under before sowing cowpea. The experimental design was a split-plot, with sowing dates as main-treatments and cultivars as sub-treatments. The experiment was replicated 4 times. Cowpea plants were sprayed twice with insecticides.

The effect of Striga density on cowpea seed yield are, shown on Table 4.29, which gives data for flowering, Striga emergence, senescence, and maturity dates, flowers per square meter and ground cover. Cultivar Kaokin local flowered latest, but reached maturity at the same time with cultivars: SUVITA-2, TVx 3236 and TN88-63; all other cultivars flowered at the same time: IT82E-32 and KN-1 were the earliest maturing cultivars (Table 4.29). Except SUVITA-2, for which Striga emerged latest (82 days after sowing), Striga emerged at about the same time for all cultivars (33-36 days after sowing) well before cowpea plants flowered (46-53 DAS). All cultivars started senescing within ten days after Striga emerged from their plots and slightly before they flowered (Table 4.29). For IT82E-32, however, Striga emerged as it was initiating the senescence process: whereas Kaokin Local flowered about 9 days after its senescence process had began. TVx 3236, Kaokin Local, IT82E-32 and KN-1 had the largest number of Striga plants (21-32 plants) per square meter at cowpea maturity; TN88-63 had the next largest number (16 plants) but SUVITA-2 was free of Striga at its maturity. The few Striga plants that were in SUVITA-2 plots died shortly after emergence (Table 4.29). SUVITA-2, Kaokin Local and KN-1 had the best ground cover while IT82E-32 and TVx 3236 the poorest ground cover; TN88-63 had an intermediate ground cover.

SUVITA-2 out-yielded all other cultivars; IT82E-32 yielded the least and the other cultivars had seed yield intermediate between those of SUVITA-2 and IT82E-32 whose yields did not differ significantly from one another (Table 4.29).

Table 4.29 Performance of cowpeas under natural <u>Striga</u> infestation in a sowing dates experiment at Gampela/Ouagadougou, Burkina Faso, in 1987.

Cultivars	Flowering date§	Striga Emergence date§	Senescense date§	Maturity date§	Striga density§	Flowers per m^2§	Ground cover§	Seed yield§
	--------------DAS	--------------	--------------	--------------	--pl/m^2--	--fl/m^2--	--%---	--kg/ha--
Suvita-2	48 b	82 a	44 a	64 ab	0 c	271 a	64 ab	610 a
TVx 3236	47 b	33 b	44 a	65 a	32 a	174 a	44 c	440 ab
TN88-63	46 b	35 b	43 a	63 bc	16 b	262 a	56 b	490 ab
Koakin local	53 a	34 b	44 a	64 ab	26 ab	177 a	69 a	340 bc
IT82E-32	46 b	34 b	34 b	62 c	21 ab	62 b	40 c	200 c
KN-1	46 b	36 b	41 a	62 c	30 a	227 a	62 ab	480 ab
L.S.D. (5 %)	2	6	4	1	11	101	11	190
C.V. (%)	4	17	12	2	62	63	23	55

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

Striga infestation, thus, appeared to have prevented susceptible cultivars from attaining their yield potentials. Cultivars IT82E-32 and Kaokin Local appeared more susceptible than cultivars TN88-63, KN-1 and TVx 3236 since they experienced severe yield losses in spite of their relatively low *Striga* density. The yield losses seemed to be associated with damage to flowering. This was substantiated by the least numbers of flowers per square meter of IT82E-32 for which *Striga* emerged while it was flowering (Table 4.29). The relatively low numbers of flowers per square meter of TVx 3236 and Kaokin Local also support this observation.

THE SAHEL SAVANNA

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

MILLET-COWPEA INTERCROPPING

Responses of Cowpea Cultivars in Millet-Cowpea Intercropping.

As in the Northern Guinea and the Sudan Savanna Zones, 7 cowpea cultivars were studied for their performance in an intercropping system with the millet cultivar IKMV 8201. Both crops were sown simultaneously on 2 July. Except IT82D-716 and TVx 1999-01F, intercropped cowpea cultivars, particularly in fertilizer-free treatments, significantly delayed millet flowering date (Table 4.30). All intercrop treatments, particularly the fertilizer-free ones and the fertilizer-free millet-purestand treatment, significantly reduced millet plant height (Table 4.30). Because of severe drought in late September and early October, millet plants matured in all treatments at the same time. As a result, only millets in all the purestand treatments which flowered earliest, significantly out-yielded all intercrop treatments. Among intercrop treatments, the

Table 4.30 Millet and cowpea performances as affected by cowpea cultivars in a intercropping system at Pobé/Djibo, Burkina Faso, in 1987.

Cowpea cultivar	Millet: Flowering date§	Millet: Plant height§	Millet: Seed yield§	Millet: Partial LER&	Cowpea: Flowering date§	Cowpea: Maturity date§	Cowpea: Seed yield§	Cowpea: Partial LER&	Combined Millet and Cowpea LER&
	--DAS--	--cm--	--kg/ha		------DAS-----		--kg/ha		
1) Fertilized treatments									
a) Intercrop									
TVx 1999-01F	72abc	110bc	50 bc	0.36	59ab	74b	130 d	0.25	0.61
58-57	73ab	104bc	30 c	0.21	55c	74b	380 b	0.74	0.95
TN88-63	76a	96c	20 c	0.14	59ab	79a	320 bc	0.63	0.77
TVx 3236	71bc	116b	80 b	0.57	56bc	73b	230 cd	0.45	1.02
IT82D-716	71bc	114b	80 bc	0.57	54c	73b	190 d	0.37	0.94
SUVITA-2	73ab	105bc	40 bc	0.29	62a	80a	340 b	0.67	0.96
IT82E-32	73ab	105bc	40 bc	0.29	55c	73b	180 d	0.35	0.64
b) Pure Stand									
TVx 3236	-	-	-	-	55c	73b	380 b	0.74	(0.74)
SUVITA-2	-	-	-	-	60a	79a	510 a	1.00	1.00
Millet	68c	132a	140 a	1.00	-	--	-	-	1.00
2) Unfertilized treatments									
a) Intercrop									
SUVITA-2	74ab	97c	30 c	(0.21)	61a	79a	370 b	(0.72)	(0.93)
b) Pure Stand									
Millet	72abc	111bc	140 a	(1.00)	-	-	-	-	(1.00)
L.S.D. (5 %)	4	15	40	-	3	3	10	-	-
C.V. (%)	6	14	58	-	5	4	34	-	-

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

& LER = Land Equivalent Ratio ; it was calculated on the basis of the best (cowpea) pure stand check.

fertilizer-free and those that were planted to cowpea cultivars 58-57 and TN88-63, were the lowest yielders (Table 4.30).

The earliest flowering and maturing cowpea were 58-57, IT82D-716 and IT82E-32 in intercrop treatments and cultivar TVx 3236 in the purestand treatment; intermediate, for cultivars TVx 1999-91F and TVx 3236 in intercrop treatments; and latest, for cultivars TN88-63 and SUVITA-2 in both intercrop as well as pure-stand treatments (Table 4.30).

Seed yields of the two cowpea checks (i.e., TVx 3236 and SUVITA-2) were significantly reduced in fertilizer treated and fertilizer-free intercrop plots. Cultivar SUVITA-2 significantly out-yielded cultivar TVx 3236 in both pure-stands and intercrops (Table 4.30).

Seed yields were high for cultivars 58-57 and SUVITA-2 (in both fertilizer treated and fertilizer free intercrop plots); intermediate, for cultivars TN88-63 and TVx 3236; and, low, for cultivars TVx 1999-01F, IT82D-716 and IT82E-32 (Table 4.30).

Insufficient and poorly distributed rainfall in August, September and October may have caused the low seed yields of millet and cowpea. It might also have increased the competitive ability of cowpea against millet, particularly the drought resistant cultivars (i.e., 58-57, TN88-63 and SUVITA-2) in millet-cowpea intercropping system.

These results confirm those of the 1985 trials at the same station and show that the millet-cowpea intercropping system is unsuitable for the dry Sahel, where the crop season receives less than 300 mm rainfall, and is usually poorly distributed. Since rainfall in 1983 never exceeded 300 mm and that during the 1984 drought year, total crop failure occurred in millet-cowpea intercropping system, whereas some cowpea seed yield was harvested in pure-stand treatments, millet-cowpea intercropping should therefore, not be recommended to peasant farmers because it is a high risk cultural practice.

Effect of Row-Spacings, Densities and Dates of Sowing Cowpea on a Millet-Cowpea Intercropping System.

As in the Sudan Savanna Zone, row-spacings and densities and dates of sowing cowpea were studied for their effects on cowpea-millet intercropping. Millet CV. IKMV 8201 and cowpea SUVITA-2 were used in this study and the first sowing date was 2 July while the second sowing date was 25 July.

Intercropping cowpea with millet had no significant effect on millet flowering dates, except for the two narrow-row-spacings when millet and cowpea were sown simultaneously. The latter two treatments significantly delayed millet flowering compared to the millet pure-stand treatment (Table 4.31).

In the pure-stand treatment, millet plant heights were significantly reduced regardless of row-spacings only when millet and cowpea were sown simultaneously (Table 4.31). Millet seed yields were high in the pure-stand treatments; intermediate, regardless of row-spacing when cowpea sowing was delayed for about three weeks after millet; and, low, regardless of row-spacing when millet and cowpea were sown simultaneously (Table 4.31).

Cowpea sown late took few days from sowing to flower bud formation, flowering and ripening dates compared to cowpea sown early (Table 4.31). There were significant differences only for flowering dates within row-spacings, and between row-spacings and pure-stand treatments. The widest and the narrowest

Table 4.31. Millet and cowpea performances as affected by row-spacings and time of sowing cowpea in an intercropping system at Pobe/Djibo, Burkina Faso, in 1987.

Treatments: Spacings, Millet	Treatments: Spacings, Cowpea	% of Pure Stand: Millet	% of Pure Stand: Cowpea	Millet: Flowering date§	Millet: Plant height §	Millet: Seed yield§	Millet: Partial LER&	Cowpea: Flower bud formation date§	Cowpea: Flowering date§	Cowpea: Maturity date§	Cowpea: Seed yield§	Cowpea: Partial LER&	Combined Millet and Cowpea LER&
				--DAS--	--cm--	--kg/ha--		----------DAS----------			--kg/ha--		
a) Millet & Cowpea sown simultaneously													
1) Pure Stand													
(1.00x0.50)m	-	100	0	68c	128a	150 a	1.00	-	-	-	-	-	1.00
-	(0.75x0.30)m	0	100	-	-	-	-	50a	60b	74a	590 a	1.00	1.00
2) Intercrop													
(2.00x0.50)m	(2.00x0.20)m	50	56	71bc	113bc	50 c	0.33	50a	63a	81a	360 bc	0.61	0.94
(1.50x0.50)m	(1.50x0.20)m	67	67	75a	104d	30 c	0.20	51a	61b	77a	390 b	0.66	0.86
(1.25x0.50)m	(1.25x0.20)m	80	80	72ab	106cd	30 c	0.20	52a	63a	81a	280 cd	0.47	0.67
b) Cowpea sown three weeks after millet													
1) Pure Stand													
-	(0.75x0.30)m	0	100	-	-	-	-	33c	43d	63b	430 b	(1.00)	(1.00)
2) Intercrop													
(2.00x0.50)m	(2.00x0.20)m	50	56	71bc	127a	70 bc	0.47	35bc	44cd	62b	220 d	(0.51)	(0.98)
(1.50x0.50)m	(1.50x0.20)m	67	67	68c	122a	110 ab	0.73	35bc	44cd	64b	220 d	(0.51)	(1.24)
(1.25x0.50)m	(1.25x0.20)m	80	80	69bc	120ab	70 bc	0.47	38b	45c	63b	110 e	(0.26)	(0.73)
L.S.D. (5 %)				3	8	50	-	3	1	7	100	-	-
C.V. (%)				5	8	69	-	7	2	10	31	-	-

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

& LER = Land Equivalent Ratio ; LER's in parenthesis were calculated on the basis of the pure-stand cowpea sown after millet.

row-spacings flowered significantly after the pure-stand and the intermediate row-spacing treatments when millet and cowpea were sown simultaneously; whereas when cowpeas were sown after millet, only the narrowest row-spacing significantly flowered after the pure-stand cowpea treatment (Table 4.31).

Late sowing and intercropping treatments significantly reduced cowpea seed yields compared to early sowing and pure-stand treatments (Table 4.31). Narrow row-spacings further reduced seed yields of intercropped cowpea within sowing date treatments.

Competition for water and nutrients appeared to have affected millet growth and development, particularly when it was sown simultaneously with cowpea using narrow row-spacings. The same was true for cowpea, which could have suffered from an accrued competition for light when it was sown after millet.

These experimental results are in general agreement with those of 1985 and 1986. However, the seed yield advantage (LER greater than 1) observed in the previous two seasons when millet and cowpea were sown simultaneously was not observed in 1987. This suggested that during a drought year, there is no advantage in intercropping millet and cowpea sown simultaneously. This also apply to yield advantage (i.e., LER = 1.24) observed with the intermediate spacing when cowpea was sown 3 weeks after millet (Table 4.31); this advantage was not observed in 1985 when September and October were dry. Millet-cowpea intercropping is therefore, unsuitable for the dry Sahel because of the potential high risk of complete failure of both crops during droughty years. It should therefore not be recommended to peasant farmers.

MANAGEMENT OF PURE-STAND COWPEA

Response of Cowpea to Wind-Breaks.

Four cowpea cultivars were tested at two dates (i.e., 2 and 25 July) using 2 wind-break treatments (i.e., with and without wind-break). The wind-break consisted of a straw fence, 1 m high from ground level and 20 m long. The straw fence consisted of millet stalks; one stalk was removed at every five stalks to reduce the fence resisting the blowing wind and, thus, to prevent it falling down. The straw fence protected cowpea plants against eastern dominant winds in a strip 10 m wide along its length. The experimental design was a split-plot, with wind-breaks as main-treatments and a factorial combination of cultivars and dates of sowing as sub-treatments. The experiment was replicated 4 times and cowpea plants were sprayed with insecticides twice. Rainfall, soil temperatures recorded at 5 cm depth daily at 15.00 hours and soil moisture contents determined bi-weekly within the upper 45 cm layers are shown in figure 4.1. Two sand-blasts occurred during the crop season: the first in early July and the second in mid-July. Only three major-rain-storms occurred after the crop was sown; they were sparsely distributed. Soil temperatures decreased after rains to as low as 25°C, but increased to 46°C as dry spells progressed; they often oscillated around 35°C (Fig. 4.1). No major temperature differences were observed between wind protected and unprotected treatments, although wind protected treatments tended to be cooler than unprotected ones immediately after rains; but the trend reversed as dry spells progressed (Fig. 4.1). The early sown crop retained less water than the late sown one, this was particularly true during the August

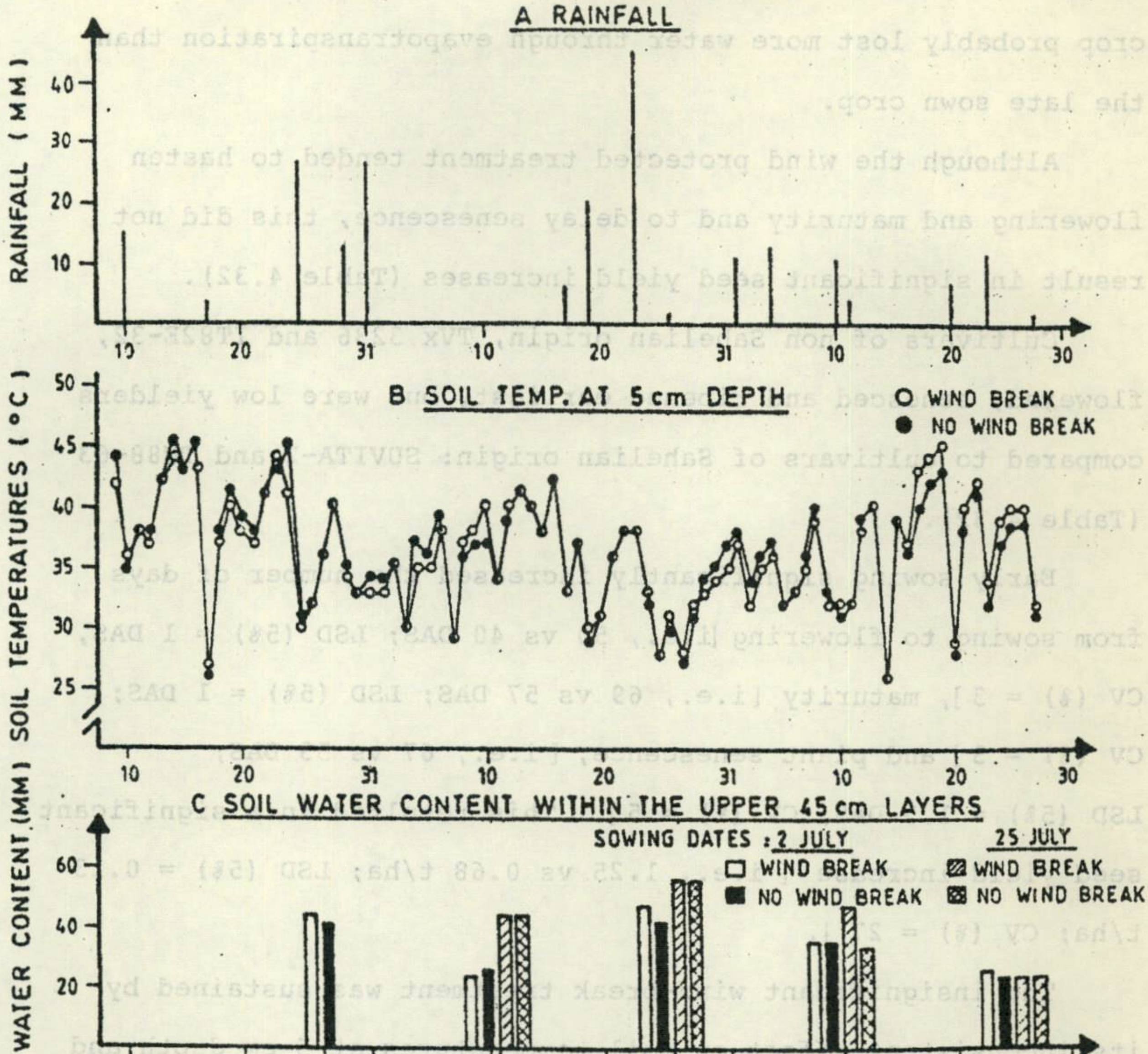

FIG. 4.1 RAINFALL (A), SOIL TEMPERATURES AT 5 cm DEPTH (B) AND SOIL WATER CONTENT WITHIN 0-45 cm LAYERS RECORDED BIWEEKLY (C) AT POBE / DJIBO, BURKINA FASO, IN 1987.

droughts; thus, with a large evaporative canopy, the early sown crop probably lost more water through evapotranspiration than the late sown crop.

Although the wind protected treatment tended to hasten flowering and maturity and to delay senescence, this did not result in significant seed yield increases (Table 4.32).

Cultivars of non Sahelian origin, TVx 3236 and IT82E-32, flowered, senesced and ripened earliest, but were low yielders compared to cultivars of Sahelian origin: SUVITA-2 and TN88-63 (Table 4.32).

Early sowing significantly increased the number of days from sowing to flowering [i.e., 50 vs 40 DAS; LSD (5%) = 1 DAS, CV (%) = 3], maturity [i.e., 69 vs 57 DAS; LSD (5%) = 1 DAS; CV (%) = 3] and plant senescence, [i.e., 67 vs 53 DAS; LSD (5%) = 1.5 DAS; CV (%) = 5]. This resulted in a significant seed yield increase [i.e., 1.25 vs 0.68 t/ha; LSD (5%) = 0.13 t/ha; CV (%) = 27].

The insignificant wind-break treatment was sustained by its inconsistent effect on soil temperatures at 5 cm depth and soil moisture content as dry spells progressed. Since the crop season received only few sparsely distributed rain storms, it appeared that there were insufficient occasions, particularly in August and early September, for the beneficial effects of wind-breaks to result in high seed yields.

Early planting, on the other hand, exposed cowpea plants to high temperatures while they were still in the vegetative growth stage (Fig. 4.1B). This reduced their growth and lengthened the period from sowing to flowering, senescence and maturity (Table 4.32). Thus, by the time soil temperatures were

Table 4.32 Effect of wind-break and cultivars on cowpea performance at Pobé/Djibo, Burkina Faso, in 1987.

Cowpea cultivars	Flowering date§			Maturity date§			Senescence date§			Seed yield§		
	Wind break	No wind break	Mean	Wind break	No wind break	Mean	Wind break	No wind break	Mean	Wind break	No wind break	Mean
	DAS									kg/ha		
SUVITA-2	47 a	47 a	47 a"	65 a	65 a	65 a"	62 a	61 a	61 a"b"	1200 a	1040a	1120 a"
TN88-63	46 a	47 a	47 a"	65 a	65 a	65 a"	61 a	63 a	62 a"	1230 a	1140a	1190 a"
IT82E-32	43 a	43 a	43 b"	60 a	60 a	60 c"	60 a	58 a	59 b"	680 a	670a	680 c"
TVx 3236	43 a	44 a	44 b"	62 a	63 a	62 b"	59 a	59 a	59 b"	820 a	940a	880 b"
MEAN	45 a'	45 a'	45	63 a'	63 a'	63	60 a'	60 a'	60	980 a'	950a'	970
Mean comparison	L S D (5 %)		CV (%)	LSD (5 %)		CV (%)	LSD (5 %)		CV (%)	LSD (5 %)		CV (%)
- Wind-Break	NS		1	NS		1.5	NS		1	NS		11
- Cultivars	1.0		3	1		3.0	2		5	190		27
- Wind-B. * Cult.	NS			NS			NS			NS		

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

reduced, making flowering possible, cowpea plants had sufficient vegetative growth to support the high demand for nutrients exerted by developping pods. This resulted in high seed yield for early sown cowpeas.

As observed in 1985 and 1986, early sowing of better adapted intermediate maturing cowpea cultivars appeared highly advantageous. In spite of the occurrence of two sand-blasts, during the crop season, wind-break treatments did not induce significant seed yield increases. This practice should be recommended to peasant farmers for use as "hedge-rows" since it also protects fields againsts wind erosion.

Integrated Crop Management.

An integrated crop management approach was studied by testing cowpea cultivars of different drought resistant characteristics using techniques which reduced water losses from soil and plants (i.e., mulching and wind-break). Mulching treatments consisted of: straw mulch, from millet crop residues (1.4 t/ha), and bare soil. Wind-break treatments were as described earlier in the "Response of cowpeas to wind-break" experiment. The experimental design was a split-plot, with wind-breaks as main-treatments and a factorial combination of cultivars and mulching as sub-treatments. The experiment was replicated 4 times, with cowpea plants sprayed twice with insecticides.

Soil temperatures were recorded at 5 cm depth daily at 15.00 hrs. and soil water content within the upper 45 cm was determined bi-weekly as shown in Figure 4.2. Soil temperatures oscillated around 35°C and increased to 43-45°C during dry spells in the bare soil treatment; whereas they often varied between

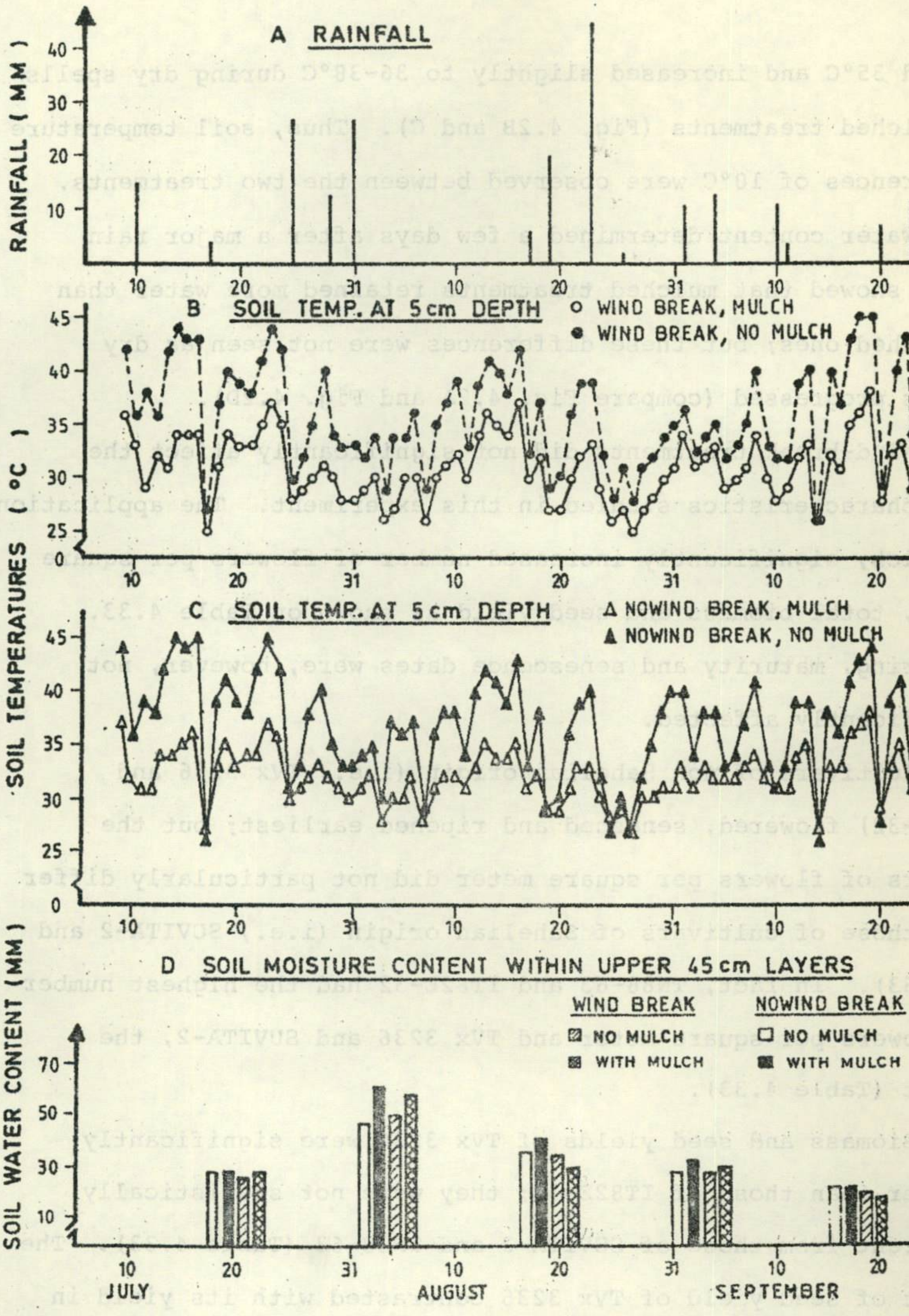

FIG.4.2 RAINFALL (A) SOIL TEMPERATURES AT 5 cm DEPTH OF WIND BREAK WITH MULCH VS WIND BREAK WITHOUT MULCH TREATMENTS (B); SOIL TEMP. AT 5 cm DEPTH OF NO WIND BREAK WITH MULCH VS NO WIND BREAK WITHOUT MULCH (C); AND SOIL WATER CONTENT WITHIN UPPER 45 cm LAYERS AT POBE/DJIBO, BURKINA FASO, IN 1987.

26 and 35°C and increased slightly to 36-38°C during dry spells in mulched treatments (Fig. 4.2B and C). Thus, soil temperature differences of 10°C were observed between the two treatments. Soil water content determined a few days after a major rain storm showed that mulched treatments retained more water than unmulched ones; but these differences were not seen as dry spells progressed (compare Fig. 4.2A and Fig. 4.2D).

Wind-break treatments did not significantly affect the crop characteristics studied in this experiment. The application of mulch, significantly increased number of flowers per square meter, total biomass and seed yield as shown on Table 4.33. Flowering, maturity and senescence dates were, however, not significantly affected.

Cultivars of non Sahelian origin (i.e., TVx 3236 and IT82E-32) flowered, senesced and ripened earliest; but the numbers of flowers per square meter did not particularly differ from those of cultivars of Sahelian origin (i.e., SUVITA-2 and TN88-63). In fact, TN88-63 and IT82E-32 had the highest number of flowers per square meter and TVx 3236 and SUVITA-2, the lowest (Table 4.33).

Biomass and seed yields of TVx 3236 were significantly greater than those of IT82E-32; they were not statistically different from those of SUVITA-2 and TN88-63 (Table 4.33). The result of seed yield of TVx 3236 contrasted with its yield in the "Response of cowpea to wind break" experiment (vide Table 4.32). It appeared, therefore, that high soil temperatures in that experiment (Fig. 4.1) and in bare soil treatments in the present experiment (Fig. 4.2) prevented TVx 3236 from expressing its yield potential. Whereas the low seed yield of IT82E-32 in

Table 4.33 Effect of mulch and cultivars on cowpea performance at Pobe/Djibo, Burkina Faso, in 1987.

Cowpea Cultivars	Flowering date§			Maturity date§			Senescence date§			Flowers/m²§			Biomass§			Seed yield§		
	No Mulch	With Mulch	Mean	No Mulch	With Mulch	Mean	No Mulch	With Mulch	Mean	No Mulch	With Mulch	Mean	No Mulch	With Mulch	Mean	No Mulch	With Mulch	Mean
	DAS									fl/m²			kg/ha					
SUVITA-2	54a	53a	53a"	72a	71a	71b"	70a	69a	70a"	123a	168a	145c"	1620a	2360a	1990a"	1280a	1510a	1390a"
TN88-63	54a	54a	54a"	74a	74a	74a"	72a	71a	72a"	176a	244a	210a"	1860a	2200a	2030a"	1240a	1410a	1320a"
IT82E-32	48a	47a	47b"	67a	66a	66c"	63a	64a	64b"	161a	233a	197a"b"	880a	1410a	1150b"	640a	900a	770b"
TVx 3236	48a	48a	48b"	68a	67a	67c"	66a	65a	66b"	158a	161a	160b"c"	1540a	1990a	1760a"	1090a	1330a	1210a"
Mean	51a'	50a'	51	70a'	69a'	70	68a'	68a'	68	154b'	201a'	178	1480b'	1990a'	1730	1060b'	1290a'	1170

Comparison of Mean	LSD(5%)	CV(%)	LSD(5%)	CV(%)	LSD(5%)	CV(%)	LSD(5%)	CV(%)	LSD(5 %)	CV(%)	LSD(5%)	CV(%)
Mulch	NS	3	NS	3	NS	4	32	36	300	33	140	24
Cultivars	1		1		2		46		430		200	
Mulch * Cultivars	NS		NS		NS		NS		NS		NS	

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

both experiments suggested that its lack of adaptation to both high soil and air temperatures prevented it from expressing its yield potential.

These results are consistent with those of 1986 and those of the "Response of cowpea to wind break" experiment in 1985, 1986 and 1987. It can, therefore, be concluded that in the Sahel, early sowing of better adapted intermediate maturing cultivars in mulched plots can produce high and stable cowpea yields in spite of the erratic, insufficient, and poorly distributed rainfall.

BREEDING FOR ADAPTATION TO SEMI-ARID ZONES

Introduction.

The erratic nature of rainfall in semi-arid zones imposes moisture shortage or excess moisture constraints on cowpea production, depending on the year, and/or period during a crop season. To insure a sustainable agricultural production in these agro-climatic zones, crop varieties should be well buffered against these climatic haphazards. To study this problem, a three way cross involving high yielding, Striga susceptible and water loving cultivars -- i.e., KN-1 and IAR 1696 -- and a drought and Striga resistant cultivar, SUVITA-2 was made in December 1982. Progenies were advanced to F-5 before being subjected to replicated yield trials at three dates of sowing in the Sahel Savanna Zone in 1985. Ten best lines, identified for high yield at each of the sowing dates in the 1986 trial, were tested in 1986 against the best parent and a common check at three dates at two locations: Pobe/Djibo, in the Sahel Savanna Zone, and at Loumbila, in the Sudan Savanna Zone.

Since lines were in F-6 and still segregating, 10 plants, from each line, were separately harvested in a breeding nursery and subjected to a purification selection. Plants segregating for leaf type or other traits, including those highly susceptible to disease and Striga were discarded. Adaptation studies in 1987 consisted of two trials: studies of purified lines and yield trials of promising F-5 lines to determine if progress was made in developing cultivars well buffered against variable environmental conditions. This information is crucial for cowpea breeders to adjust their breeding strategy in the semi-arid zones.

Adaptation Studies of Purified Lines.

Purified lines were sown at three dates in the three ecologies of the West African Semi-Arid Zones -- i.e., at Farako-Bâ, in the Northern Guinea Savanna; at Loumbila, in Sudan Savanna Zone; and at Pobe/Djibo, in the Sahel Savanna. The experimental design used was a split-plot with sowing dates as main-treatments, lines and cultivars as sub-treatments. The experiment was replicated twice. Cowpea plants were sprayed with insecticides twice.

At Farako-Bâ, the experiment was sown on a field plot with a known history of high disease incidence, particularly web blight and scab. The variety Kaya Local, was added at this location as a susceptible check to multiple diseases. It was sown around the experimental plots prior to the experiment; it, thus, served as a disease spreader, and contributed to increasing the inoculum of some disease agents. At Loumbila, in the Sudan Savanna Zone, the experiment was sown on a Striga infested plot. Two Striga susceptible cultivars -- i.e., IT82E-32 and TVx 3236 -- were included as checks.

Results at Farako-Bâ, Northern Guinea Savanna.

Rainfall during the crop season is shown on Fig. 4.3. Excess rains fell in early to mid-August. There were dry spells in September and October. Cowpea sown on 9 July flowered in late August, filled pods and ripened in early and mid-September, respectively. It thus experienced excess moisture in the vegetative growth, and dry spells in generative growth stages. Cowpea sown on 25 July flowered in early September, thus taking advantage of the few rains to fill pods and ripen in late September before the onset of the long dry spell in October. Cowpea sown on 12 August, on the other hand, flowered at the end of September and, thus, filled pods and ripened during the October dry spell.

Cowpea seed yield appeared to be influenced by climatic conditions that prevailed during the generative growth stages. Thus, the 25 July sown cowpea gave a high yield (1.48 t/ha), the 9 July sown cowpea, an intermediate yield (1.06 t/ha), although this was not significantly different from that of the 25 July sowing dates. 12 August sown cowpea gave a low yield of (0.62 t/ha) which was significantly different from those of the other two sowing dates (Table 4.34).

Lines KVx 396-18-9, KVx 396-18-10, KVx 396-4-2 and KVx 396-4-5 and cultivar TVx 3236 had the highest average seed yields across sowing dates (Table 4.34). Of these lines, KVx 396-4-2 and KVx 396-4-5 had significantly reduced seed yields only at the 12 August sowing date and KVx 396-18-10 and TVx 3236, at the 9 July and 12 August sowing dates (at these dates, the respective yields of the latter entries did not differ significantly). Cultivars KN-1, SUVITA-2 and Kaya Local,

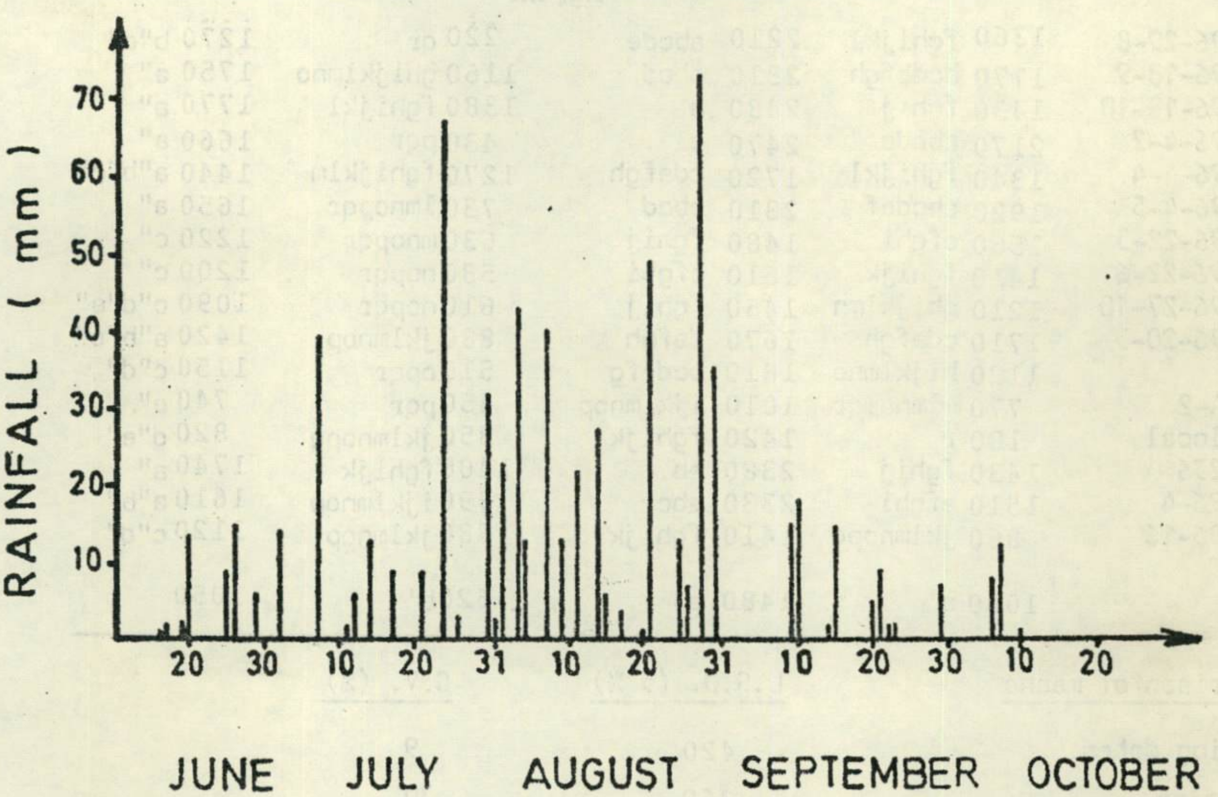

FIG.4.3 RAINFALL AT FARAKO – BA / BOBO-DIOULASSO

BURKINA FASO, IN 1987.

Table 4.34 Seed yield of the 10 best performing lines and the checks as affected by sowing dates at Farako-Bâ/Bobo-Dioulasso, Burkina Faso, in 1987.

Entries	Sowing Dates§						Mean	
	9 July		25 July		12 August			
	Kg/ha							
KVx 396-29-8	1360	fghijkl	2210	abcde	220	qr	1270	b"c"
KVx 396-18-9	1770	bcdefgh	2310	abcd	1160	ghijklmno	1750	a"
KVx 396-18-10	1430	fghij	2480	a	1380	fghijkl	1770	a"
KVx 396-4-2	2170	abcde	2470	a	430	pqr	1660	a"
KVx 396-4-4	1340	fghijkl	1720	cdefgh	1270	fghijklm	1440	a"b"c"
KVx 396-4-5	1920	abcdef	2310	abcd	730	lmnopqr	1650	a"
KVx 396-22-3	1560	efghi	1480	fghij	630	mnopqr	1220	c"
KVx 396-22-6	1410	fghijk	1610	efghi	580	nopqr	1200	c"
KVx 396-27-10	1210	ghijklmn	1450	fghij	610	nopqr	1090	c"d"e"
KVx 396-20-3	1710	cdefgh	1670	defgh	880	jklmnop	1420	a"b"c"
KN-1	1120	hijklmno	1810	bcdefg	510	opqr	1150	c"d"
SUVITA-2	770	klmnopqr	1010	ijklmnop	450	pqr	740	e"
Kaya local	180	r	1420	fghijk	850	jklmnopq	820	d"e"
TVx 3236	1430	fghij	2380	ab	1400	fghijk	1740	a"
KVx 396-4	1510	efghi	2330	abc	990	ijklmnop	1610	a"b"
KVx 396-16	860	jklmnopq	1410	fghijk	880	jklmnop	1120	c"d"
MEAN	1060	a'	1480	a'	620	b'	1050	

Comparison of means	L.S.D. (5 %)	C.V. (%)
- Sowing dates	420	9
- Entries	360	30
- Entries at same or different sowing dates	650	

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

Table 4.35 Flowering and maturity dates, ground cover and disease reaction of entries at Farako-Bâ/Bobo-Dioulasso, Burkina Faso, in 1987.

Entries	Flowering dates§	Maturity dates§	Ground cover	Diseases			
				Web Blight§	Scab§	Brown Blotch§	Viral Infection§
	-------DAS-----		---%---	-----(Scale 1-5)-----			--pl--
KVx 396-29-8	45 bc	63 bc	62 bc	1 b	1 c	1 a	4 ab
KVx 396-18-9	45 bc	63 bc	64 abc	2 a	2 b	1 a	2 b
KVx 396-18-10	45 bc	62 c	62 bc	2 a	2 b	1 a	2 b
KVx 396-4-2	44 cd	62 c	57 cd	2 a	2 b	1 a	4 ab
KVx 396-4-4	44 cd	62 c	60 bcd	2 a	2 b	2 a	3 b
KVx 396-4-5	44 cd	63 bc	66 ab	2 a	2 b	1 a	2 b
KVx 396-22-3	44 cd	62 c	61 bcd	1 b	2 b	1 a	3 b
KVx 396-22-6	44 cd	62 c	57 cd	1 b	1 c	1 a	2 b
KVx 396-27-10	45 bc	62 c	58 bcd	2 a	3 a	1 a	2 b
KVx 396-20-3	43 d	63 bc	65 abc	2 a	2 b	1 a	3 b
KN-1	46 b	64 b	66 ab	1 b	1 c	1 a	2 b
SUVITA-2	45 bc	64 b	53 d	2 a	2 b	1 a	6 a
Kaya Local	59 a	76 a	71 a	2 a	1 c	1 a	6 a
TVx 3236	44 cd	63 bc	63 abc	2 a	1 c	1 a	2 b
KVx 396-4	44 cd	62 c	59 bcd	2 a	2 b	1 a	3 b
KVx 396-16	45 bc	63 bc	57 cd	2 a	1 c	1 a	3 b
L.S.D. (5 %)	1	1	8	0.5	0.5	NS	2
C.V. (%)	2	1	12	29	28	30	5

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

line KVx 396-27-10 and F-5 line KVx 396-16 had the lowest yield accross sowing dates and were among the lowest yielders at each sowing date (Table 4.34) (SUVITA-2 and KN-1 are two of the three parents of the lines). Seed yields of other tested lines were intermediate between those of the other two groups. It should be noted that the seed yields of the F-5 line KVx 396-4 were similar to those of F-8 lines -- i.e., KVx 396-4-2, KVx 396-4-4 and KVx 396-4-5 extracted from it.

Except cultivars KN-1 and Kaya Local for flowering dates, and KN-1, SUVITA-2 and Kaya Local for maturity dates and viral diseases, the best seed yielding lines did not differ from check cultivars in flowering and maturity dates, and reaction to web blight, brown blotch and viral infection (Table 4.35).

It was concluded that the best lines, particularly, KVx 396-18-9 and KVx 396-18-10, and to some extent KVx 396-4-2 and KVx 396-4-5 (all extracted from the same F-3 plant) inherited genes to cope with environmental conditions of the Northern Guinea Savanna.

Results at Loumbila, in Sudan Savanna.

Rainfall was poorly distributed, particularly in July, mid-August, early to mid-September and October (Fig. 4.4). Cowpea sown on 11 July flowered in early September, filled pods and ripened in mid to late September, thus, experiencing dry spells during its generative growth stages. Due to relatively cool weather in August, cowpea sown on 25 July took about 9 days less from sowing to flowering than cowpea sown on the 11 July. They also flowered at about the same time and experienced similar climatic conditions during the generative growth stage as the July cowpea. Whereas, cowpea sown on

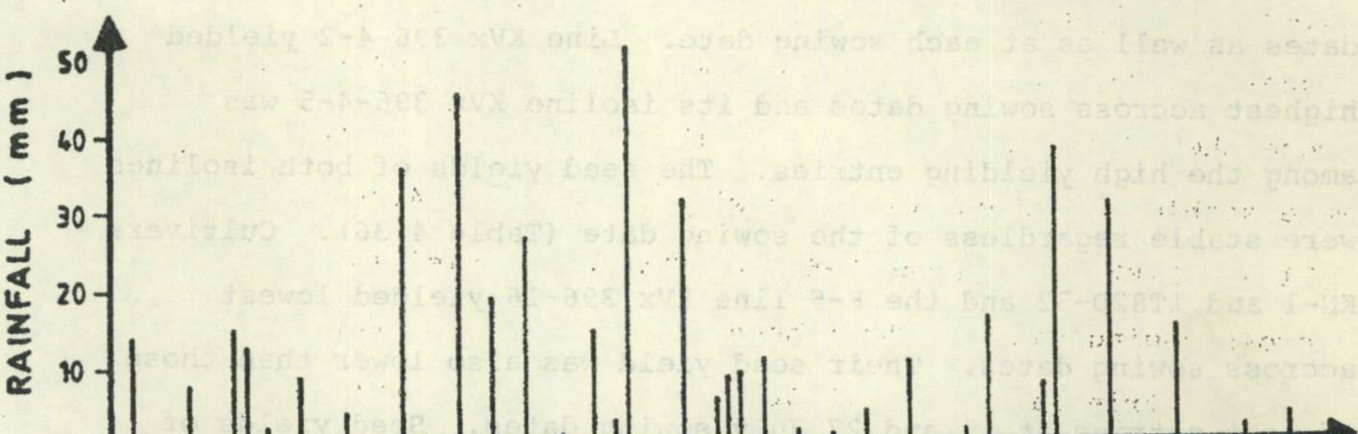

FIG. 4.4 RAINFALL AT LOUMBILA / OUAGADOUGOU, BURKINA FASO, IN 1987.

12 August flowered in late September, filled pods and ripened in early October. It thus experienced drought during late August to early September in the vegetative growth stages and again in late September to early October during the generative growth stages.

Average cowpea seed yields were not affected by sowing dates. They varied from 1.28 t/ha for the 11 July sown crop to 1.38 t/ha for the 12 August sown crop (Table 4.36).

Entries significantly differed in seed yield accross sowing dates as well as at each sowing date. Line KVx 396-4-2 yielded highest accross sowing dates and its isoline KVx 396-4-5 was among the high yielding entries. The seed yields of both isolines were stable regardless of the sowing date (Table 4.36). Cultivars KN-1 and IT82D-32 and the F-5 line KVx 396-16 yielded lowest accross sowing dates. Their seed yield was also lower than those of most entries at 11 and 27 July sowing dates. Seed yields of the remaining entries were intermediate between that of KVx 396-4-2 and those of KN-1, IT82E-32 and KVx 396-16 (Table 4.36).

The performance of entries accross sowing dates is shown on Table 4.37. Except cultivar IT82E-32 which was highly susceptible to bacterial blight disease and for which flower bud formation, flowering, Striga emergence, senescence and maturity dates were the earliest, the best and poorest yielding entries did not differ markedly (compare Tables 4.36 and 4.37).

The low seed yield of cultivars KN-1 and IT82E-32 and the F-5 line KVx 396-16 at the 11 and 27 July sowing dates suggested that these entries were poorly adapted to drought and high temperatures during the generative growth stages. Indeed, the flowering, pod fill and ripening of cowpea at both sowing dates

Table 4.36 Seed yield of the 10 best performing lines and the checks as affected by sowing dates under natural Striga infestation at Loumbila/Ouagadougou, Burkina Faso, in 1987.

Entries	Sowing Dates§ 11 July	27 July	12 August	Mean
	Kg/ha			
KVx 396-18-10	1430fghijklm	2260a	1500 defghijkl	1730 a"b"
KVx 396-8-5	2050abc	1360ghijklmn	1460 efghijkl	1620 a"b"
KVx 396-8-9	1970abcde	1570cdefghijk	1220 jklmn	1590 b"
KVx 396-7-1	1670bcdefghijk	1580cdefghijk	1340 ghijklmn	1530 b"
KVx 396-7-3	1790abcdefghi	1340ghijklmn	1540 cdefghijk	1560 b"
KVx 396-4-2	2150ab	1770abcdefghi	1820 abcdefghi	1910 a"
KVx 396-4-4	990lmn	2020abcd	1510 defghijkl	1510 b"
KVx 396-4-5	1440efghijklm	1640bcdefghijk	1770 abcdefghi	1620 a"b"
KVx 396-27-1	1430fghijklm	1520cdefghijkl	1470 efghijkl	1470 b"
KVx 396-20-3	1330ghijklmn	1900abcdef	1740 abcdefghij	1660 a"b"
KN-1	380o	1000lmn	1510 defghijkl	960 c"
SUVITA-2	1860abcdefgh	1370fghijklmn	1270 ijklmn	1500 b"
IT82E-32	1200klmn	920mn	1190 klmn	1100 c"
TVx 3236	1640bcdefghijk	1460efghijkl	1640 bcdefghijk	1580 b"
KVx 396-4	1400fghijklm	1320hijklmn	1800 abcdefghi	1510 b"
KVx 396-16	990lmn	850no	1440 efghijklm	1090 c"
MEAN	1280a'	1340a'	1380 a'	1330

Comparison of means	L.S.D. (0.05)	C.V. (%)
- Sowing dates	NS	4
- Entries	300	20
- Entries sowing dates	530	

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

Table 4.37 Performance of the 10 best lines and the checks under natural *Striga* infestation at Loumbila/Ouagadougou, Burkina Faso, in 1987.

Entries	Flower bud formation date§	Flowering date§	*Striga* emergence date§	Senescence date§	Maturity date§	*Striga* plants/m²§	Bacterial blight disease§	Virus infections§	Pythium root rot disease§	Fodder yield§	Biomass§
	DAS					pl/m²	(1-5)	n° of pl		Kg/ha	
KVx 396-18-10	34bc	46a	42e	65ab	64ab	1a	1c	3a	0a	2940 bcde	4670b
KVx 396-8-5	33c	43bc	64bcd	61cd	63bc	0a	1c	1a	0a	3000 bcde	4620b
KVx 396-8-9	34bc	45ab	44e	62bcd	62c	1a	2b	1a	0a	3170 bcde	4750b
KVx 396-7-1	34bc	44abc	42e	59d	63bc	1a	2b	0a	0a	3560 abcd	5090ab
KVx 396-7-3	34bc	46a	67b	62bcd	62c	0a	1c	0a	1a	2670 cde	4220b
KVx 396-4-2	33c	45ab	49de	64abc	63bc	1a	1c	4a	1a	2560 de	4470b
KVx 396-4-4	35ab	45ab	46e	66a	64ab	0a	1c	2a	0a	3440 abcde	4950ab
KVx 396-4-5	35ab	45ab	39e	62bcd	65a	1a	1c	0a	0a	3000 bcde	4620b
KVx 396-27-1	35ab	45ab	53bcde	59d	62c	0a	2b	0a	0a	3220 bcde	4700b
KVx 396-20-3	34bc	45ab	41e	66a	65a	1a	3a	2a	1a	4440 a	6100a
KN-1	35ab	45ab	44e	61cd	60d	1a	1c	0a	0a	3720 abc	4680b
SUVITA-2	36a	45ab	90a	65ab	63bc	0a	1c	8d	1a	3000 bcde	4500b
IT82E-32	33c	42c	47e	61cd	59d	1a	3a	0a	0a	2890 bcde	3990b
TVx 3236	34bc	45ab	51cde	62bcd	62c	0a	1c	0a	0a	2390 e	3970b
KVx 396-4	34bc	45ab	44e	65ab	64ab	1a	1c	1a	0a	3000 bcde	4510b
KVx 396-16	36a	45ab	65bc	61cd	64ab	0a	1c	0a	0a	3830 ab	4920b
MEAN	34	45	54	62	63	0.4	1.5	1.4	0.4	3310	4640
L.S.D. (5 %)	1	2	15	3	1	NS	0.7	NS	NS	1070	1170
C.V. (%)	5	3	24	4	2	206	4	129	226	28	22

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

occurred during late August to mid-September dry spells (Fig. 4.4). Nevertheless, cultivar IT82E-32, due to its earliness, apparently took advantage of late August rains to rapidly fill pods and yielded higher than KN-1 at the 11 July sowing date (Table 4.36) But, at the 27 July and 12 August sowing dates, its earliness was not favourable. It was exposed to severe drought and this explains its lower seed yield than that of KN-1 at the late sowing dates (Table 4.36).

The equal seed yields of most cultivars at all sowing dates, particularly the 11 July and 12 August sowing dates, suggested that dry and hot spells during vegetative growth stages followed by good rains during generative growth stages had very little impact on cowpea seed yields.

Cultivar SUVITA-2 showed high susceptibility to virus diseases (Table 4.37) which was conspicuous at the two late sowing dates. This may explain its very low seed yields in late than early sowing dates (Table 4.36).

Striga infestation did not appear to have seriously affected seed yielding ability, at least for the best lines and check cultivars. Lines KVx 396-7-1, KVx 396-4-4 and KVx 396-20-3 combined high seed and fodder yields (Tables 4.36, 4.37).

These results, suggest that, as observed in the Northern Guinea Savanna Zone, line KVx 396-4-2 inherited best genes that confered on it an adaptive advantage in the Sudan Savanna Zone. This adaptive advantage was also apparent in its sister line (with which it was extracted from the same F-3 plant). KVx 396-18-10 and in its isoline (with which it was extracted from the same F-7 plants) KVx 396-4-5.

Results at Pobe/Djibo, Sahel Savanna.

Rainfall received during the crop season was described in the wind-break experiment (see Fig. 4.1). Cowpea sown on 2 July flowered in late August, filled pods and ripened in early and mid-September respectively. Cowpea sown on 25 July flowered in early September, filled pods and ripened in mid and late September, whereas cowpea sown on 19 August, flowered, filled pods and ripened in October under severe drought conditions. Although the three crops were exposed to drought during the vegetative and generative growth stages, the overall drought intensity incurred by a crop, increased as the sowing date was delayed. This was very well illustrated in soil moisture content monitored weekly in a nearby yield trial experiment (see Fig. 4.6C). Late sown crops were also exposed to higher soil temperatures during dry spells than early sown crops (Fig. 4.6B).

Entries yielded consistently at each sowing date. As a result, the interaction: entries by sowing dates, was not significant (Table 4.38). Delayed sowing dates reduced cowpea seed yields although the difference was significant only for the 19 August sown crop, for which no yields were obtained (see Table 4.38).

The best performing entries, i.e., KVx 396-8-5, KVx 396-6-1 and KVx 396-4 as a group, did not particularly differ from the poorest performing ones, namely KVx 396-16-5, KVx 396-14-9 and KVx 396-16-1 (Table 4.39). This suggested an inherent ability to cope with environment conditions that prevailed during the experiment.

Table 4.38 Seed yield of entries as affected by sowing dates at Pobe/Djibo, Burkina Faso, in 1987.

Entries	Seed Yield§			
	2 July	25 July	19 August	Mean
	K/ha			
KVx 396-18-9	760 a	770 a	0 a	0b"c"d"e"f"
KVx 396-18-10	620 a	730 a	0 a	450c"d"e"f"
KVx 396-8-5	1350 a	980 a	100 a	810a"
KVx 396-8-9	520 a	600 a	90 a	410c"d"e"f"
KVx 396-16-1	340 a	330 a	40 a	230f"
KVx 396-16-5	630 a	260 a	0 a	300d"e"f"
KVx 396-16-8/2	750 a	770 a	0 a	510b"c"d"e"f"
KVx 396-16-10/1	1130 a	370 a	30 a	510b"c"d"e"f"
KVx 396-16-10/2	660 a	1010 a	0 a	510a"b"c"d"e"
KVx 396-6-1	1060 a	1200 a	0 a	750a"b"
KVx 396-6-10	960 a	400 a	0 a	450c"d"e"f"
KVx 396-14-4	560 a	680 a	0 a	410c"d"e"f"
KVx 396-14-9	560 a	230 a	30 a	270e"f"
TVx 3236	740 a	620 a	0 a	450c"d"e"f"
SUVITA-2	930 a	450 a	150 a	510b"c"d"e"f"
TN88-63	590 a	1020 a	90 a	570a"b"c"d"
KVx 396-4	1420 a	760 a	60 a	750a"b"
KVx 396-16	950 a	360 a	30 a	450c"d"e"f"
MOUGNE	920 a	420 a	20 a	460b"c"d"e"f"
BAMBEY 21	1010 a	600 a	0 a	540a"b"c"d"e"
TVu 1509	590 a	640 a	120 a	450c"d"e"f"
58-57	1020 a	780 a	0 a	600a"b"c"
IT82D-716	620 a	360 a	110 a	360c"d"e"f"
IT82D-699	620 a	830 a	30 a	490b"c"e"f"
IT84S-2246	720 a	560 a	70 a	450c"d"e"f"
MEAN	800 a'	630 a'	40 b'	409

Comparison of means	L.S.D. (5 %)	C.V. (%)
- Sowing dates	340	16
- Entries	290	52
- Entries at the same or different sowing date	NS	

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

Table 4.39 Performance of cowpea entries at Pobe/Djibo, Burkina Faso, in 1987.

Entries	Flowe-ring date§	Senes-cense date§	Matu-rity date§	Bacte-rial Blight Disease§	Plant type§	Fodder yield§	Biomass§
	----------DAS--------			--(1-5)--	-(1-4)-	----------kg/ha------	
KVx 396-18-9	46 bcd	65 bcde	57 de	1 c	3 a	480 fghi	990 cde
KVx 396-18-10	52 ab	67 abcd	59 bcd	2 bc	3a	620 cdefghi	1070 bcde
KVx 396-8-5	46 bcd	62 e	56 e	1 c	3 a	420 fghi	1230 abc
KVx 396-8-9	46 bcd	63 de	57 de	2 bc	2 b	370 hi	770 de
KVx 396-16-1	55 a	71 a	61 ab	1 c	3 a	990 ab	1220 abc
KVx 396-16-5	55 a	71 a	61 ab	1 c	3 a	790 abcde	1090 bcde
KVx 396-16-8/2	49 abcd	65 bcde	60 abc	2 bc	2 b	710 bcdefg	1220 abc
KVx 396-16-10/1	52 ab	65 bcde	61 ab	1 c	3 a	1060 a	1570 a
KVx 396-16-10/2	52 ab	69 ab	62 a	1 c	3 a	1040 a	1600 a
KVx 396-6-1	51 abc	66 bcde	59 bcd	2 bc	3 a	540 defghi	1300 abc
KVx 396-6-10	51 abc	66 bcde	60 abc	1 c	3 a	500 efghi	950 cde
KVx 396-14-4	50 abc	65 bcde	58 cde	1 c	2 b	790 abcde	1200 abcd
KVx 396-14-9	51 abc	65 bcde	60 abc	2 bc	3 a	790 abcde	1060 bcde
TVx 3236	51 abc	67 abcd	58 cde	2 bc	3 a	470 fghi	920 cde
SUVITA-2	51 abc	64 cde	58 cde	2 bc	3 a	720 bcdef	1230 abc
TN88-63	46 bcd	65 bcde	60 abc	1 c	3 a	670 cdefgh	1240 abc
KVx 396-4	52 ab	66 bcde	59 bcd	2 bc	3 a	360 i	1110 bcde
KVx 396-16	53 a	67 abcd	61 ab	1 c	3 a	820 abcd	1270 abc
MOUGNE	45 cd	62 e	56 e	2 bc	3 a	630 cdefghi	1090 bcde
BAMBEY 21	43 d	65 bcde	57 de	4 a	3 a	680 cdefgh	1210 abcd
TVu 1509	50 abc	62 e	56 e	3 ab	3 a	410 ghi	860 cde
58-57	51 abc	68 abc	59 bcd	2 bc	3 a	850 abc	1450 ab
IT82D-716	49 abcd	63 de	56 e	3 ab	2 b	340 i	710 e
IT82D-699	51 abc	67 abcd	59 bcd	2 bc	3 a	430 fghi	930 cde
IT84S-2246	45 cd	62 e	56 e	4 a	2 b	410 ghi	860 cde
L.S.D. (5 %)	6	4	2	1	0.4	300	440
C.V. (%)	10	5	3	30	12		

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

It should be noted that cultivars Bambey 21, TVu 1509, IT82D-716 and IT845-2246 were highly susceptible to bacterial blight disease while line KVx 396-16-10/2 and cultivar 58-57 combined high seed and fodder yields (compare Tables 4.38 and 4.39).

Conclusion.

The F-5 line KVx 396-4 and isolines extracted from it, particularly from KVx 396-4-2 and KVx 396-4-5 performed consistently well accross sowing dates at each location as well as accross locations. It also exhibited a good level of resistance to diseases accross locations, and appeared to have inherited the best genes to cope up with variable environmental conditions.

Yield Trials of Promising F-5 Lines.

This experiment was conducted in all the three agro-ecological zones of semi-arid West Africa, to ascertain progress made in breeding for better adaptation using sowing dates experiments. All agronomic practices were as described in "Adaptation studies of purified lines" except that plot size was increased from 3 to 4 rows and the experiment was replicated 4 times at each site. The experiment was conducted in field plots without any background of heavy disease or Striga infestations.

Results at Farako-Bâ, in Northern Guinea Savanna.

Rainfall received during the crop season at Farako-Bâ is described in Figure 4.3. Cowpea sown on 1 July flowered in mid to late August, filled pods and ripened in late August and early to mid-September, respectively. It, thus, experienced 10 days of dry spell, in late August to mid-September, during the generative growth stages. Cowpea sown on 20 July flowered in early September, filled pods and ripened in mid and late September, respectively. It, thus, filled pods under minimal but somewhat well distributed rainfall conditions. Cowpea sown on 8 August flowered in late September, filled and ripened in early and mid-October, respectively; thus benefitting from only three minor rains (Fig. 4.3) during generative growth stages.

Cowpea seed yields were high (841 to 2449 kg/ha), for the 20 July sown crop; intermediate (895 to 1978 kg/ha), for the 8 August sown crop; and, low, for (254 to 1940 kg/ha) for the 1 July sown crops (Table 4.40). Thus, the 10 day dry spell during pod filling and ripening growth stages, in spite of preceeding heavy rains, appeared to have caused more seed yield losses, than the few minor rains, which were well distributed during the generative growth stages of the 20 July sown crop.

Cultivar Kaya Local yielded higher than any other entry sown on 1 July. Cultivars TVx 3236 and KN-1 and lines KVx 396-4, KVx 396-11 and KVx 396-18, yielded significantly higher than the remaining entries sown on 20 July; and, similar to all entries except cultivar KN-1 sown on 8 August (Table 4.40). Its seed yields were significantly reduced by sowing dates in the following order 20 July, 1 July and 8 August. It, thus, contrasted with all entries, for which seed yields decreased in either of the following orders: 20 July, 8 August and 1 July or 8 August, 20 July and 1 July. Because it is daylength sensitive, it escaped the 10 day dry spell in early September when it was still in the vegetative growth stage.

Table 4.40 Seed yield (kg/ha) of promising lines at three dates of sowing at Farako-Bâ, in Northern Guinea Savanna, Burkina Faso, in 1987.

Entries	DATE OF SOWING		
	1 July	20 July	8 August
	kg/ha		
KVx 396-4	1284 hijkl	2298 ab	1607 defgh
KVx 396-11	788 m	2245 ab	1612 cdefgh
KVx 396-16	932 jklm	1356 hijk	1513 efgh
KVx 396-18	1445 fghi	2074 abc	1540 efgh
KVx 396-27	1003 jklm	1855 bcdefg	1470 fgh
KVx 396-29	942 jkl	1570 efgh	1544 efgh
KN-1	1362 hij	2046 abcd	1878 bcdef
TN88-63	254 n	841 lm	895 klm
TVx 3236	1327 hijk	2421 a	1411 ghi
Kaya local	1940 bcde	2449 a	1298 hijkl
SUVITA-2	697 mn	1468 fghi	934 jklm
IT82D-716	540 mn	1443 fghi	1640 cdefgh
L.S.D. (5 %)	± 466		
C.V. (%)	24		

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

Table 4.41 Performance of promising lines at Farako-Bâ, Burkina Faso, in 1987.

Entries	Flowering date§	Maturity date§	DISEASE: Brown Blotch§	Web Blight§	Scab§	Viral infection§	Ground cover
	DAS		(Scale 1-5)			pl	%
KVx 396-4	47 cd	67 cd	1.1 a	2.2 a	1.0 b	4 bc	65 bc
KVx 396-11	47 cd	68 c	1.2 a	2.2 a	1.3 ab	4 bc	59 cde
KVx 396-16	47 cd	66 de	1.2 a	2.5 a	1.3 ab	4 bc	60 cde
KVx 396-18	48 bc	66 de	1.2 a	2.1 a	1.2 b	4 bc	61 bcd
KVx 396-27	46 d	65 ef	1.5 a	2.2 a	1.1 b	4 bc	60 cde
KVx 396-29	48 bc	67 cd	1.2 a	2.1 a	1.0 b	4 bc	62 bcd
KN-1	49 b	71 b	1.0 a	1.9 a	1.1 b	3 bc	71 a
TN88-63	46 d	67 cd	1.2 a	2.9 a	1.6 a	25 a	35 f
TVx 3236	48 bc	68 c	1.0 a	2.2 a	1.3 ab	2 c	63 bc
Kaya local	65 a	86 a	1.1 a	1.5 a	1.2 b	5 b	75 a
SUVITA-2	48 bc	68 c	1.2 a	2.7 a	1.6 a	5 b	58 de
IT82D-716	46 d	64 f	1.2 a	2.2 a	1.6 a	4 bc	56 e
L.S.D. (5 %)	1	1	NS	NS	0.3	2	4
C.V. (%)	2	3	44	37	40	36	8

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

Lines KVx 396-4 and KVx 396-18 yielded similarly to their best parent at this location, KN-1, and the best check TVx 3236 at all sowing dates. They significantly out-yielded their second parent, SUVITA-2, and the checks TN88-63 and IT82D-716 at all sowing dates, except 8 August for IT82D-716 (Table 4.40). Cultivars SUVITA-2 and TN88-63 are of Sahelian origin.

Flowering and maturity dates, reaction to diseases and ground cover of entries are shown on Table 4.41. Except for reaction to virus diseases and ground cover, lines did not differ markedly from the best daylength sensitive checks, i.e., KN-1 and TVx 3236 for the other attributes studied. It should be noted that checks of the Sahelian origin were either significantly or appeared susceptible to diseases, particularly virus disease, compared to other checks, and lines; this explains their poor yields in this experiment.

Results at Gampela, in Sudan Savanna.

Climatic conditions - i.e. rainfall, shelter air temperatures, soil temperatures at 5 cm depth and weekly soil water content (except in mid-September) within the upper 45 cm layers, are shown on Fig. 4.5. Day and night temperatures fluctuated mostly around 35 and 25°C, respectively as dry spells progressed and after rains. Rainfall was poorly distributed throughout the crop season; dry spells occurred in early and mid to late July, mid-August, late August to late September and throughout October (Fig. 4.4A). Soil temperatures were recorded for the second and third sowing dates only, i.e., 25 July and 12 August. They increased above 35°C reaching 43°C during protracted dry spells and decreased below 35°C to 24°C after rains (Figure 4.5B).

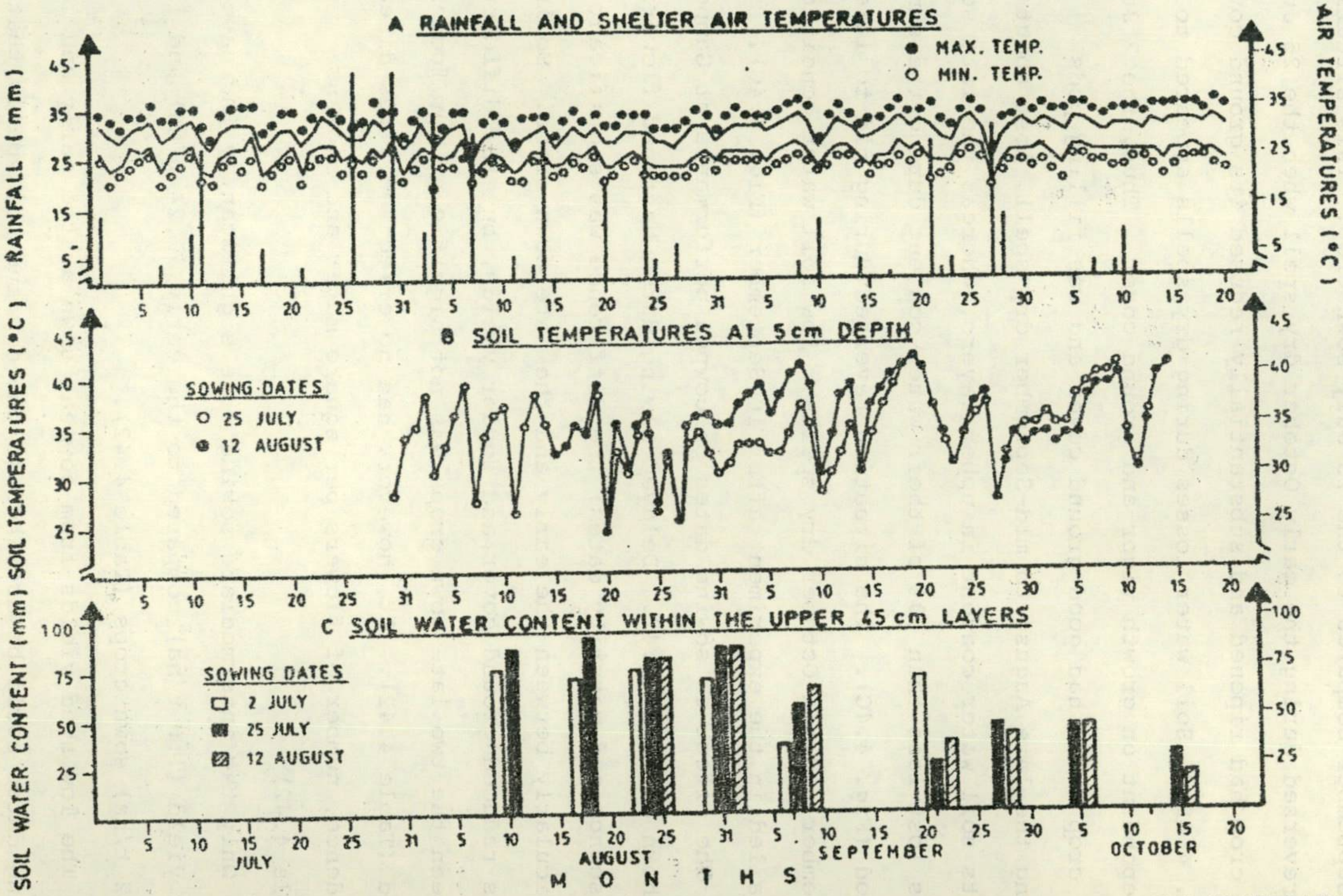

Fig. 4.5. RAINFALL, SHELTER AIR TEMPERATURES: MAXIMUM AND MINIMUM, AND EFFECTIVE DAY AND NIGHT TEMPERATURES, CALCULATED FROM THE MEAN OF DAILAY MEAN, DAILY MAXIMUM AND MINIMUM, RESPECTIVELY (A); SOIL TEMPERATURES AT 5 cm DEPTH AT 15.00 HRS (B); AND SOIL WATER CONTENTS WITHIN THE UPPER 45 cm LAYERS AT GAMPELA / OUAGADOUGOU, BURKINA FASO, IN 1987.

Because of poor ground cover, the 8 August sown crop experienced higher soil temperatures in late August to mid-September compared to the 25 July sown crop. This situation was reversed during the early October dry spell when the 25 July sown crop had ripened and substantially reduced its ground cover (Fig. 4.4B). Soil water losses during dry spells appeared to be dependent on growth vigor and ground cover. Thus, the 2 July sown crop which had good ground cover and was filling pods during the late August to mid-September dry spell, lost about 50% of its soil water content in upper layers, whereas the late sown crops lost less than 50% of their water content during the same period (Fig. 4.4C). The situation reversed during mid to late September and mid-October dry spells. Low soil water conditions prevailed in the experiment after 10 September (Fig. 4.4C).

The effect of sowing dates on cowpea performance at Gampela is shown on Table 4.42. Delayed sowing dates hastened flowering, senescence and maturity dates; the difference was significant particularly between the early and the late sown crops. Sowing dates reduced ground cover and fodder yields, but the difference between the two late sown crops was not significant for fodder yield (Table 4.42). It, however, had no effect on virus disease incidence, number of flowers per square meter and biomass (Table 4.42).

Only the intermediate sowing date significantly increased seed yield (1.6 t/ha) compared to the early (1.24 t/ha) and late (1.22 t/ha) sown crops (Table 4.42).

The low seed yields from cowpeas sown at the early and late sowing dates could be ascribed to the dry and hot spells that occurred in late August and in early and mid to late September,

Table 4.42 Effect of sowing dates on cowpea performance at Gampela/Ouagadougou, Burkina Faso, in 1987.

Sowing dates	Flowering date§	Senescense date§	Maturity date§	Ground cover§	Viral infection§	Flowers per m²	Seed yield§	Fodder yield§	Binmass§
	DAS			%	pl	fl/m²	K/ha		
2 July	52 a	49 a	71 a	74 a	4 a	388 a	1240b	4220 a	54.6
25 July	44 b	34 b	59 b	65 b	3 a	344 a	1560a	2640 b	42.1
12 August	42 c	32 b	58 b	44 c	3 a	351 a	1220b	2710 b	39.4
L.S.D.(5 %)	1	3	1	6	NS	NS	170	1400	NS
C.V. (%)	1	4	1	6	16	12	7	25	18

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

Table 4.43 Seed yield of entries at three dates of sowing at Gampela/Ouagadougou, in Sudan Savanna, Burkina Faso, 1987.

Entries	DATE OF SOWING: 2 July	25 July	12 August
	kg/ha		
KVx 396-4	1626 bcd	1613 bcd	1261 defghijklm
KVx 396-11	977 jklmno	1587 bcde	1087 ijklmn
KVx 396-16	1440 bcdefghi	2110 a	1093 hijklmn
KVx 396-18	1702 b	1684 b	1388 bcdefghi
KVx 396-27	1591 bcde	1467 bcdefghi	1292 cdefghijkl
KVx 396-29	941 lmno	1468 bcdefgh	1140 ghijklmn
KN-1	949 klmno	1576 bcdef	1323 bcdefghijk
TN88-63	693 o	1626 bcd	1488 bcdefg
TVx 3236	1651 bc	1487 bcdefg	1206 fghijklmn
KAOKIN LOCAL	887 mno	1281 cdefghijkl	1222 efghijklmn
SUVITA-2	1269 defghijkl	1533 bcdef	1285 cdefghijkl
IT82D-716	1143 ghijklmn	1340 bcdefghij	871 no
L.S.D. (5 %)	± 380		
C.V. (%)	19		

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

for the early sowing date, and in late September throughout October, for the late sowing date. This is because the periods referred to coincided with the generative growth stages of cowpeas at the respective sowing dates. Heavy rains before flowering followed by a protracted dry spells which occurred in the early sowing date, appeared to be less important than minor well distributed rains during the generative growth stages, even when preceded by a dry spell as was the case for the intermediate sowing date (Fig. 4.4A and Table 4.42).

Entries responded differently to sowing dates. Line KVx 396-16 out-yielded all entries at all sowing dates when it was sown on 25 July (Table 4.43); its seed yield was significantly reduced at the 2 July and 12 August sowing dates, at which it was similar to those of most entries. Lines KVx 396-4, KVx 396-18, and KVx 396-27 and cultivars TVx 3236 were high yielding. They gave similar yields at all sowing dates while seed yields were not significantly affected by sowing dates, except for TVx 3236. The seed yield of this cultivar was significantly reduced at the late compared to the early sowing date (Table 4.43). Lines KVx 396-11 and KVx 396-29 and cultivars KN-1, TN88-63 and Kaokin Local, at the 2 July sowing date, yielded significantly lower than other entries at the 25 July sowing date (Table 4.43). Cultivar IT82D-716 was the only entry that gave the lowest yield at the 12 August sowing date (Table 4.43). Seed yield of cultivar SUVITA-2 was not affected by sowing dates.

The low seed yield of cultivar KN-1 at the 2 July sowing date could be ascribed to its inability to tolerate hot and dry spells during generative growth stages. This appeared to be supported by the fact that KN-1 produced the highest biomass and fodder yield like line KVx 396-16, from which it did not differ, in all plant attributes except seed (Tables 4.43, 4.44). It was noted that KN-1 initiated senescence earlier which could also be considered in its inability to tolerate hot and dry weather. Lines KVx 396-11 and KVx 396-29 and cultivar IT82D-716 were also unable to tolerate hot and dry weather since they produced the lowest yields at the early and late sowing dates (Table 4.43).

The low seed yields of cultivar TN88-63 and Kaokin Local, was related to their high susceptibility to virus disease, which had a high incidence in early than late sowing dates (Table 4.42, 4.43, 4.44).

These results thus show that line KVx 396-4, KVx 396-18 and KVx 396-27 and to some extent KVx 396-16 inherited best genes that enabled them to cope with variable environmental conditions. They showed substantial yield improvements compared to their parents (KN-1 and SUVITA-2), particularly KN-1 at the 2 July sowing date.

Results at Pobe/Djibo, in the Sahelian Savanna.

Rainfall was poorly distributed during the crop season. Dry spells occurred in early and mid to late July, in early to mid-August, late August, mid and late September, and throughout October (Fig. 4.6A). Soil temperatures at 5 cm depth were recorded for all sowing dates. Recording for the 25 July sowing date was discontinued after 19 August (Fig. 4.6B). Soil temperatures increased above 40°C during dry spells and fell below this value and sometimes down to 30°C after rains. Prior to their ripening, early sown crops had relatively cooler soil

Table 4.44 Performance of promising lines at Gampela/Ouagadougou, Burkina Faso, in 1987.

Entries	Flowering date§	Senescense date§	Maturity date§	Ground cover§	Viral Infection Disease§	Flowers per m²	Fodder yield	Biomass§
	-----------	DAS	-----------	---%---	---pl---	--fl/m²--	-----K/ha	--------
KVx 396-4	46 c	40 a	64 ab	67 ab	3 bc	384 bc	2020 cd	3530 de
KVx 396-11	49 b	37 a	64 ab	62 bcd	3 bc	314 cd	4240 ab	5460 b
KVx 396-16	46 c	40 a	63 abc	67 ab	3 bc	323 cd	5040 a	6590 a
KVx 396-18	46 c	39 a	63 abc	55 d	4 ab	480 a	2330 cd	3920 de
KVx 396-27	42 d	37 a	62 bc	57 cd	3 bc	343 bcd	1580 d	3030 e
KVx 396-29	46 c	39 a	64 ab	61 bcd	2 c	359 bcd	3790 b	4970 bc
KN-1	44 cd	36 a	60 c	66 bc	4 ab	343 bcd	4550 ab	5840 ab
TN88-63	45 c	39 a	62 bc	67 ab	4 ab	426 ab	3720 b	4990 bc
TVx 3236	45 c	38 a	62 bc	56 d	2 c	345 bcd	2310 cd	3760 de
Kaokin local	52 a	39 a	66 a	76 a	5 a	277 d	4030 b	5160 b
SUVITA-2	46 c	39 a	64 ab	62 bcd	3 bc	338 cd	2690 c	4050 cd
IT82D-716	42 d	39 a	61 bc	35 e	3 bc	397 bc	2020 cd	3140 de
L.S.D. (5 %)	2	NS	3	9	1	84	960	980
C.V. (%)	5	12	5	18	36	29	37	2670

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

Table 4.45 Effect of sowing dates on cowpea performance at Pobé/Djibo, Burkina Faso, in 1987.

Sowing dates	Flowering date§	Senescence date§	Maturity date§	Ground cover	Diseases: Bacterial blight§	Diseases: Viral Infection§	Flowers per m²	Seed yield§	Fodder yield§	Biomass§
	-----------	DAS	-------	---%---	--Scale	(1-5)-	--fl/m²--	----------	K/ha	----------
2 July	54 a	70 a	71 a	46 a	2.3 b	1.1 a	188 a	9.1 a	550 a	1470 a
25 July	41 b	52 c	58 b	35 b	2.9 a	1.2 a	124 b	4.2 b	480 b	910 b
19 August	43 b	54 b	72 a	25 c	2.6 ab	1.1 a	63 c	0.3 c	360 c	400 c
L.S.D. (5 %)	2	1	3	5	0.4	NS	27	2.9	110	280
C.V. (%)	4	1	2	9	9	6	12	36	13	18

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

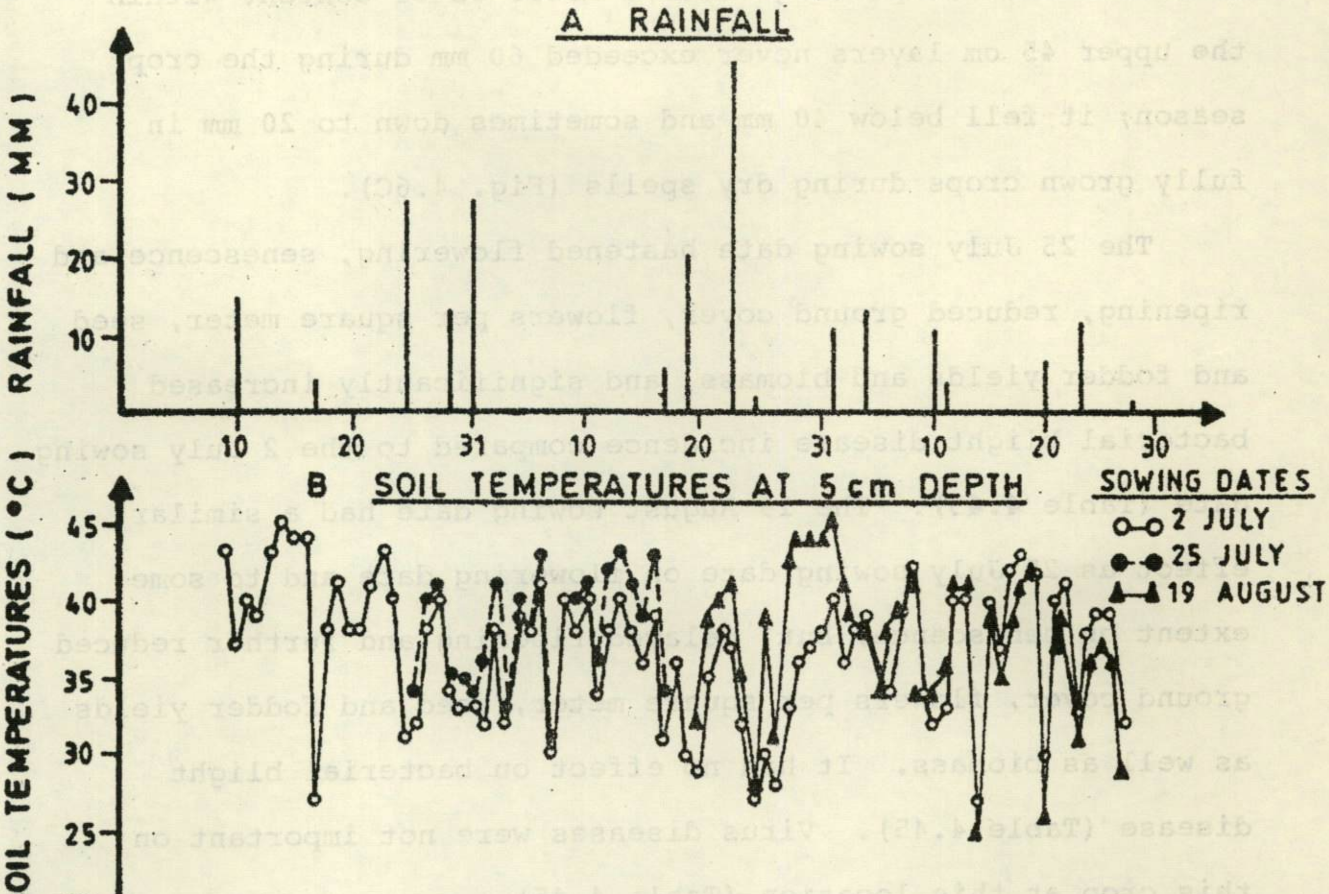

Fig. 4.6. RAINFALL (A), SOIL TEMPERATURES AT 5cm DEPTH AT 15 00 HRS (B); AND, SOIL WATER CONTENT WITHIN UPPER 45cm LAYERS AT POBE/DJIBO BURKINA FASO, IN 1987.

than late sown crops (Fig. 4.6B). Soil water content within the upper 45 cm layers never exceeded 60 mm during the crop season; it fell below 40 mm and sometimes down to 20 mm in fully grown crops during dry spells (Fig. 4.6C).

The 25 July sowing date hastened flowering, senescence and ripening, reduced ground cover, flowers per square meter, seed and fodder yields and biomass, and significantly increased bacterial blight disease incidence compared to the 2 July sowing date (Table 4.45). The 19 August sowing date had a similar effect as 25 July sowing date on flowering date and to some extent on senescence, but, delayed ripening and further reduced ground cover, flowers per square meter, seed and fodder yields as well as biomass. It had no effect on bacterial blight disease (Table 4.45). Virus diseases were not important on this crop at this location (Table 4.45).

Since the 2 and 25 July sown crops flowered at about the same time, namely, 2 and 4 September, respectively, the low yields of the latter crop compared to that of the former crop could not be attributed solely to dry spells and high temperatures in September (Fig. 4.6B). Growing conditions prior to flowering of the 25 July sown crop appeared to have contributed to the low seed yield. The long August dry spell, that occurred two weeks after this crop was sown, severely hampered its vegetative growth which was reflected in the poor ground cover, and low fodder yield at maturity (Table 4.45). Thus, from the time the dry spell ended in mid-August and flowering occurred in early September, this crop did not have sufficient time to gain enough vegetative and/or build up enough reserve metabolites to sustain rapid development of pods. The 19 August sown crop developed mainly under drought conditions in September and received no rainfall at all after flowering in early October. This explains the severe floral abscission experienced and the subsequent seed yield loss (Table 4.45).

Cultivar TN88-63 and line KVx 396-4 significantly out-yielded all other entries at all sowing dates, except lines KVx 396-18, and cultivars SUVITA-2 and 58-57 at the 2 July sowing date (Table 4.46). At the 25 July sowing date, line KVx 396-4 out-yielded all entries; but the difference was only significant for line KVx 396-11; TN88-63 out-yielded all entries at the 19 August sowing date.

The physiological traits and disease reaction of lines are shown on Table 4.47. Differences were observed between poor and best performing entries only for bacterial blight disease score, for which the poor performing entries, KVx 396-11, IT82E-32, Bambey 21 and IT82D-716 showed higher susceptibility than the best performing entries (Table 4.47). It should be noted that as observed in previous years, a strong interaction "entries x dates of sowing" was again observed for flower bud formation, flowering and maturity dates. This was mainly due to cultivar TN88-63 which was among the latest maturing entries in the early crops and the earliest maturing entry in the late sown crop, and accounted for its adaptive advantage in the Sahelian Savanna compared to other entries. Lines KVx 396-29, KVx 396-16 and 396-4 gave high fodder yields and biomass. Line KVx 396-4 combined both high seed and fodder yields (Tables 4.46, 4.47).

Table 4.46 Seed yields kg/ha of entries at three dates of sowing at Pobe/Djibo in the Sahel Savanna, Burkina Faso, 1987.

Entries	Date of sowing§		
	2 July	25 July	19 August
	kg/ha		
KVx 396-4	1213 ab	624 defg	0 l
KVx 396-11	800 cdef	273 hijkl	0 l
KVx 396-16	833 cde	310 ghijkl	47 kl
KVx 396-18	968 abc	492 fgh	0 l
KVx 396-27	896 bcd	546 efgh	40 l
KVx 396-29	894 bcd	313 ghijkl	0 l
SUVITA-2	1033 abc	459 fgh	0 l
TN88-63	1279 a	493 fgh	126 ijkl
58-57	979 abc	444 ghi	57 jkl
IT82E-32	609 defg	353 ghijk	29 kl
BAMBEY-21	870 cde	402 ghi	35 kl
IT81D-716	608 defg	388 ghij	42 kl
L.S.D. (0.05)	331		
C.V. (%)	27		

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

Table 4.47 Performance of promising lines at Pobe/Djibo, Burkina Faso, in 1987.

Entries	Flowering date§	Senescence date§	Maturity date§	Ground cover§	Diseases: Bacterial blight§	Diseases: Viral infection§	Plant type§	Flowers per m²§	Fodder yield§	Biomass§
	---DAS---			--%--	---(1-5)---		--(1-4)--	--fl/m²--	---K/ha---	
KVx 396-4	47 a	59 cd	71 ab	40 ab	2.0 e	1.1 a	3.0 a	129 a	560 ab	1180 a
KVx 396-11	48 a	61 ab	74 a	38 bc	2.9 c	1.2 a	3.0 a	81 a	480 b	830 cd
KVx 396-16	48 a	62 a	70 abc	39 abc	1.2 f	1.2 a	3.0 a	88 a	670 a	1070 ab
KVx 396-18	47 a	58 d	71 ab	40 ab	2.6 cd	1.1 a	3.0 a	155 a	420 bc	910 bc
KVx 396-27	45 b	58 d	66 bcd	33 cd	2.7 cd	1.2 a	3.0 a	110 a	320 cd	810 cd
KVx 396-29	47 a	59 cd	72 a	41 ab	2.5 cde	1.1 a	3.0 a	152 a	680 a	1080 ab
SUVITA-2	48 a	59 cd	72 a	30 d	2.3 de	1.3 a	3.0 a	106 a	480 b	980 abc
TN 88-63	45 b	60 bc	61 de	45 a	1.2 f	1.0 a	3.0 a	141 a	450 bc	1080 ab
58-57	45 b	59 cd	64 de	39 abc	2.5 c	1.2 a	3.0 a	151 a	490 b	980 abc
IT82E-32	44 bc	55 e	61 de	22 e	4.1 a	1.0 a	2.2 c	113 a	270 d	600 e
BAMBEY-21	43 c	58 d	65 cde	35 bcd	3.7 ab	1.0 a	3.0 a	139 a	500 b	940 bc
IT82D-716	44 bc	56 e	60 e	21 e	3.5 b	1.0 a	2.7 b	135 a	280 d	630 de
L.S.D. (5 %)	1	1	5	6	0.5	NS	0.15	NS	150	200
C.V. (%)	4	3	9	19	22	27	6	61	41	27

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

Conclusion:

It was concluded from these results that line KVx 396-4 performed better than the best parent and the best check in all three agro-ecologies as shown on Table 4.48 for seed yield, in spite of variable environmental conditions. This indicated that effective genes for wide adaptation were carried by the parents and inherited by line KVx 396-4. Sowing date experiments were, therefore, effective in identifying this line for adaptation to semi-arid zones.

COWPEA PHYSIOLOGY

In semi-arid West Africa, drought is often associated with high temperatures resulting from increased solar radiation. Either one or both of these factors may detrimentally affect cowpea growth and development. The reaction of cowpea to soil heat and soil moisture stresses was therefore studied to provide information which is crucial for improving cowpea performance during dry years.

Nine cowpea cultivars were subjected to two soil heat stresses, namely high and low stresses, and two soil moisture stresses, moisture stress and no moisture stress treatments.

The experimental design consisted of a factorial combination of 9 cultivars, 2 heat and 2 moisture stress treatments, in randomized blocks replicated 3 times. Cowpea plants were sprayed weekly with insecticides, to protect them from insect pests.

Table 4.48 Seed yields (kg/ha) of promising KVx 396 lines in the Sahel at Pobe/Djibo, Sudan Savanna at Gampela/Ouagadougou and Northern Guinea Savanna at Farako-Bâ/Bobo-Dioulasso in Burkina Faso in date of sowing experiments in 1987.

Entries	Seed Yield		
	Pobe/Djibo Sahel $	Gampela Sudan S.$	Farako-Bâ Northern Guinea Savanna $
	Kg/ha		
KVx 396-4	918 a	1500 ab	1730 a
KVx 396-11	536 ef	1217 de	1548 bcd
KVx 396-16	571 def	1548 ab	1242 ef
KVx 396-18	730 bc	1591 a	1686 abc
KVx 396-27	721 bc	1458 abc	1443 cde
KVx 396-29	603 de	1183 de	1352 de
SUVITA-2	746 b	1362 bcd	1033 f
TN88-63	886 a	1269 cde	663 g
IT82D-716	498 f	1118 e	1208 ef
TVx 3236§	-	1522 ab	1714 abc
KN-1 §	-	1283 cde	1763 ab
Kaokin local§	-	1130 e	-
Kaya local§	-	-	1896 a
IT82E-32 §	481 f	-	-
BAMBEY 21 §	636 cd	-	-
58-57 §	711 bc	-	-
MEAN	670	1348	1440
L.S.D. (0.05)	± 99	± 205	± 277
C.V. (%)	27	19	21

§ These cultivars were not tested in all three ecologies.

$ Means followed by the same letter are not statistically different at 5 % probability level at each location.

Of the cultivars used: SUVITA-2, TN88-63, 58-57, Mougne, BAMBEY 21 and TVx 3236 had been proved to be adapted to semi-arid zones; KN-1 was drought and heat susceptible and was used as a check. TVu 1509 and KVx 396-4 were also included; the former cultivar was one of the two parents of TVx 3236 and the latter cultivar was a selection from a three way cross involving SUVITA-2, KN-1, and IAR 1696. These cultivars were used to measure physiological changes due to selection that might be associated with better adaptation.

High soil heat treatments were induced by covering pots with transparent polyethylene sheets, while low heat treatment were obtained by covering pots with aluminium foil. Transparent polyethylene sheets permited incoming short wave radiation through and retained long wave back-radiation, which heated the pots. Aluminium foil however reflected most of the incoming radiation, thus, preventing or reducing back-radiation and heat building up in the pots.

Each pot consisted of 17.0 kg of soil substratum comprising of: 13.6 kg of dry sand and 3.4 kg of dry and well decomposed animal manure. Soil water holding capacity per pot was determined equal to 3.0 l. Pots were weighed every two or three days, depending on the growth vigor of the crop, and water replinished to full holding capacity throughout the duration of the experiment. In the soil moisture stress treatments, water supply was withheld for 10 days beginning on the 38th day after sowing but normal water supply was resumed after an 8 day transition period beginning on the 11th day of soil moisture stress. During this period, moisture stress pots received only 500 ml of water every

2 days, so that the moisture stress period lasted 17 days, extended from the 38th to 55th day after sowing.

Maximum and minimum shelter air temperatures, and effective day and night temperatures, are shown on Fig. 4.7A. Mid-to-late-May was very hot with maximum and minimum temperatures exceding 40°C and 28°C respectively. Though temperatures decreased in July, they were still high as maxima and minima were exceeding 35°C and 24°C respectively.

Soil temperatures, at 5 cm depth, recorded at 15.00 hrs, were higher in polyethylene covered pots; they reached sublethal levels of 45°C to 50°C, often in May, June and July. Aluminium foil covered pots reached such temperatures occasionally in May and June only (Fig. 4.7B). Thus, the two treatments were effective in inducing different soil heat stress regimes (Fig. 4.7B).

When water supply was withheld, no moisture stress polyethylene covered pots were hotter than the moisture stress treated pots. This relationship was not evident in aluminium foil covered pots (Fig. 4.8). Under continuous high soil heat regime, soil moisture may improve the transmission of heat waves in deep soil layers.

The combination of low soil heat stress and no soil moisture stress hastened flower bud formation and flowering, prevented wilting, and increased seed and fodder yields and biomass compared to other treatment combinations (Table 4.49). During morning hours, all cultivars, except SUVITA-2, TN88-63, TVx 3236 and KVx 396-4, wilted significantly under soil moisture stress treatments; whereas in mid-afternoon hours, under the same treatments, only SUVITA-2 and KVx 396-4 did not

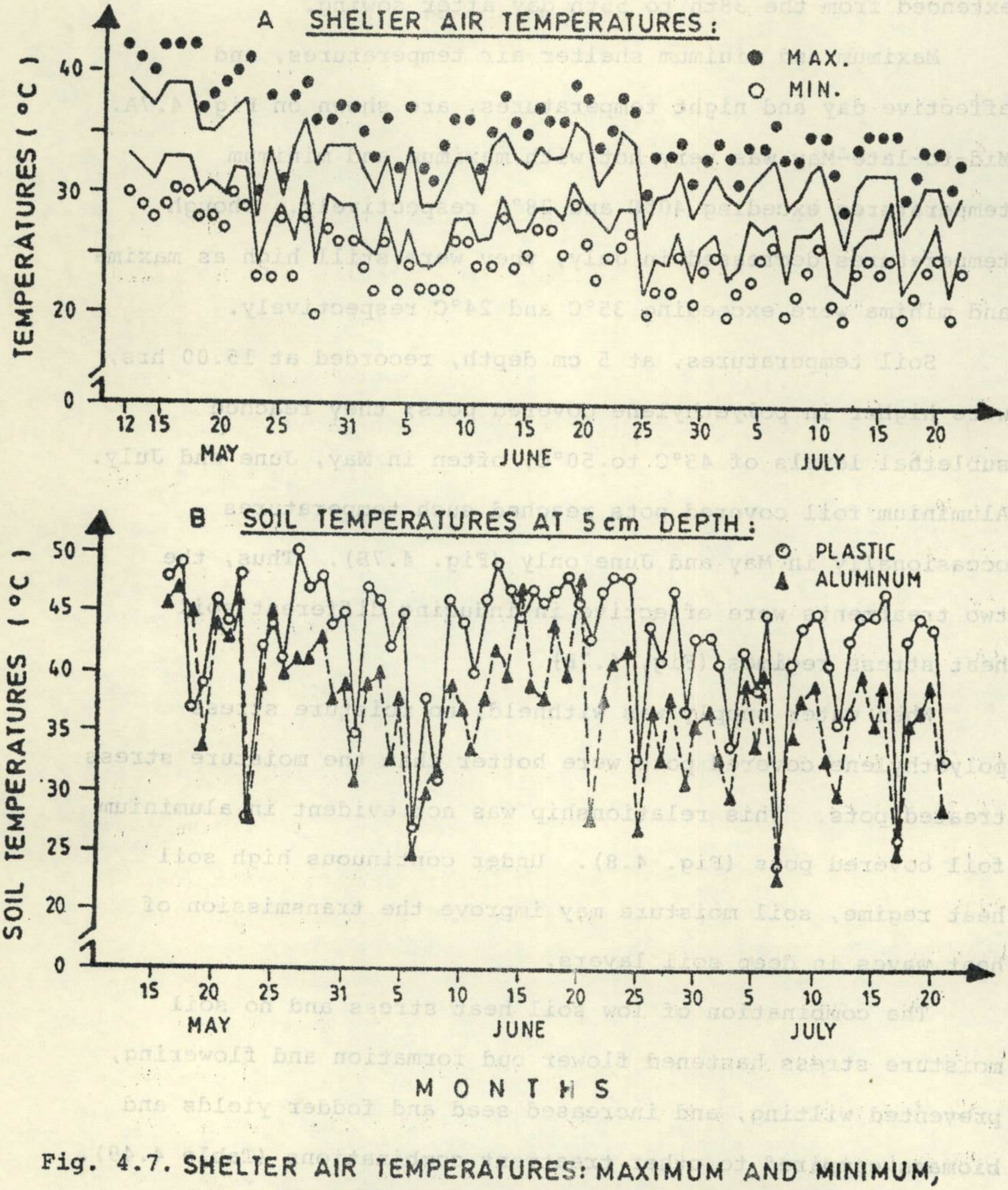

Fig. 4.7. SHELTER AIR TEMPERATURES: MAXIMUM AND MINIMUM, AND EFFECTIVE DAY AND NIGHT TEMPERATURES, CALCULATED FROM THE MEAN OF DAILY MEAN, DAILY MAXIMUM AND MINIMUM, RESPECTIVELY (A); AND, SOIL TEMPERATURES AT 5 cm DEPTH, RECORDED IN POTCULTURE DAILY AT 15.00 HRS (B) AT KAMBOINSE / OUAGADOUGOU, BURKINA FASO, IN 1987.

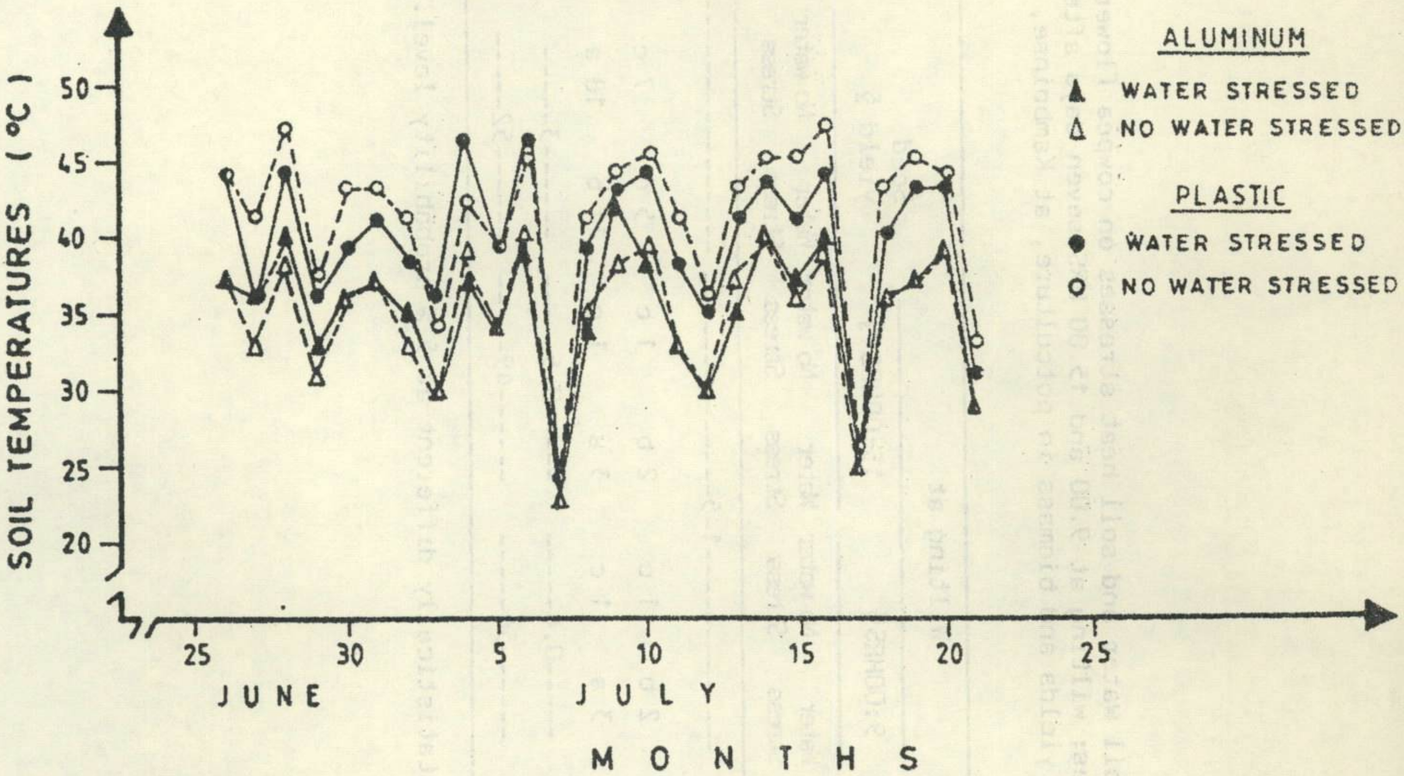

Fig. 4.8. SOIL TEMPERATURES OF WATER STRESSED POTS RECORDED AT 5 cm DEPTH DAILY AT 15.00 HRS AT KAMBOINSE / OUAGADOUGOU, BURKINA FASO, IN 1987.

Table 4.49. Effect of interaction of soil water and soil heat stresses on cowpea flower bud formation, flowering and maturity dates; wilting at 9.00 and 15.00 HRS seven days after water stress bigan ; seed and fodder yields and biomass in potculture, at Kamboinse, Burkina Faso, in 1987.

Soil heat stress	Flower bud formation date§		Flowering date§		Wilting at 9:00HRS§		Wilting at 15:00HRS §		Seed yield §		Fodder yield§		Biomass§	
	Water Stress	No Water Stress	Water Stress	No water Stress	Water Stress	No water Stress	Water Stress	No water Stress	Water Stress	No water Stress	Water Stress	No water Stress	Water Stress	No water Stress
	DAS				1-5				g/pot					
High	61 a	66 a	70 a	69 a	2 b	1 c	2 b	1 c	5 c	7 c	11 b	8 b	16 c	15 c
Low	49 b	42 b	60 b	50 c	3 a	1 c	3 a	1 c	11 b	18 a	18 a	21 a	29 b	39 a
LSD (5 %)	8		6		0.4		0.5		3		4		6	
CV (%)	27		19		54		49		52		49		42	

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

wilt (Table 4.50). Cultivars 58-57, Mougne, Bambey 21 and KN-1 were highly susceptible to wilting (Table 4.50). Seed yield of cultivars was, however, consistent at soil moisture stress treatments as shown on Table 4.50.

High seed and fodder yields and biomass under low soil heat stress treatments (Table 4.49) resulted from hastened flower bud formation, flowering and maturity (Tables 4.49, 4.51, 4.52), and also in increased root system, root nodule activities, number of branches in the shoot, length of branches and the stem and number of pods (Tables 4.51, 4.52). Low soil heat stress treaments thus enabled cowpea plants to express their seed yield potential.

Under low soil heat stress treatments, seed yields of SUVITA-2 were very high (21 g/pot). Yields of TN88-63, 58-57, Bambey 21, TVu 1509, TVx 3236 and KVx 396-4 were also high (15-17 g/pot) while that of Mougne was intermediate (12 g/pot); grain yields of KN-1 were very low (2 g/pot) (Table 4.52). Under high soil heat stress treatment, only seed yields of KVx 396-4 were high (16 g/pot). Other entries, except TN88-63, TVu 1509 and KN-1, had intermediate seed yields (5-9 g/pot); the latter entries had very low or no seed yields (0-2 g/pot) (Table 4.52).

The high seed yields of KVx 396-4 under both soil heat stress treatments were related to its ability to grow profusely, form flower buds, flower, set several pods and fill them, and mature earlier than any other cultivar (Tables 4.52, 4.53). This is well supported by its significant high biomass and fodder yield (Table 4.52). These traits of KVx 396-4 were not significantly decreased

Table 4.50 Effect of soil water on wilting at 9.00 and 15.00 HRS, seed yield and water consumption of cultivars in potculture at Kamboinse, Burkina Faso, in 1987.

	Wilting at				Seed Yield&		Water Consumed	
	9.00 HRS§		15.00 HRS§					
	Water Stress	No Water Stress	Water Stress	No Water Stress	Water Stress	No Water Stress	Water Stress	No Water Stress
	(1-5)				g/pot		l/pot	
SUVITA-2	1 c	1 c	1 c	1 c	11	16	21	31
TN88-63	1 c	1 c	2 bc	1 c	4	13	22	27
58-57	3 ab	1 c	3 ab	1 c	10	15	22	28
MOUGNE	4 a	1 c	4 a	1 c	9	7	21	21
BAMBEY-21	3 ab	1 c	4 a	1 c	11	13	23	23
TVu 1509	2 bc	1 c	2 bc	1 c	8	11	14	21
TVx 3236	1 c	1 c	2 bc	1 c	6	14	15	27
KN-1	3 ab	1 c	3 ab	1 c	0	2	20	19
KVx 396-4	1 c	1 c	1 c	1 c	14	18	34	41
L.S.D. (5 %)	1		1		NS			
C.V. (%)	54		49		52			

§ Means followed by the same letter are not statistically different at 5 % probability level.
& The interaction cultivars by soil moisture stress was not significant for seed yield.

Table 4.51 Effect of soil heat stress on cowpea performance in potculture at Kamboinse, Burkina Faso, in 1987.

Soil heat stress	Maturity date§	Number of branches§	Branches length§	Stem length§	Number of pods§	Root dry weight§
	DAS	No	cm		No	
High	77 a	2.2 b	7 b	16 b	7 b	4 b
Low	69 b	4.9 a	15 a	27 a	19 a	6 a
L.S.D. (5 %)	3	0.8	3	3	3	1
C.V. (%)	13	57	73	43	56	61

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

Table 4.52 Effect of soil heat stress on pods, fodder yiels, nodule dry weight, seed yield and water consumption of cowpea cultivars in potculture at Kamboinse, Burkina Faso, in 1987.

Entries	Number of Pods§		Fodder yield§		Nodule Dry Weight§		Seed Yield§		Biomass§		Water consumed	
	High Temp.	Low Temp.	High Temp.	Low Temp.	High Temp.	Low Temp.	High Temp.	Low Temp.	High Temp.	Low Temp.	High Temp.	Low Temp.
	Pods/pot		g/pot								l/pot	
SUVITA-2	6.0fghi	18.5bcd	8efg	21abc	0.05e	0.55b	6ef	21a	14ghi	42ab	21	30
TN88-63	1.0i	21.7b	10defg	29a	0.28bcde	1.37a	1h	16b	11hi	45a	16	34
58-57	9.2efgh	20.5bc	11defg	20bc	0.45bc	0.45bc	9de	16b	20fgh	35abcd	20	29
MOUGNE	6.5fghi	15.0bcde	8efg	17bcd	0.07de	0.28bcde	5fg	12cd	13ghi	29cdef	15	27
BAMBEY 21	10.8defg	17.8bcd	13cdefg	22ab	0.18cde	0.28bcde	8ef	15bc	22efgh	38abc	21	25
TVu 1509	4.7ghi	32.3a	5g	15bcdef	0.05e	0.12cde	2gh	17b	7i	32bcdef	10	25
TVx 3236	7.8efghi	19.3bc	7fg	16bcde	0.00e	0.23bcde	6ef	15bc	13ghi	31bcdef	17	25
KN-1	0.5i	2.0hi	7fg	23ab	0.27bcde	0.40bcd	0h	2gh	7i	25defg	12	27
KVx 396-4	13.2 cdef	20.0bc	17bcd	13cdefg	0.27bcde	0.23bcde	16b	16b	33abcde	29cdef	29	47
L.S.D. (5%)	8		8		0.33		3		12		-----	
C.V. (%)	56		49		95		52		42		-----	

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

under high soil heat stress compared to low soil heat stress as was the case for other cultivars, except Bambey-21, for number of pods, and KN-1, for number of pods and seed yield (Table 4.52). Bambey-21 and 58-57, were better adapted to high soil heat stress (Table 4.52).

Except perhaps cultivars TN88-63 and KN-1, subjected to soil moisture stress treatment only, low yielding cultivars consumed less water than high yielding cultivars, under soil moisture or soil heat stress treatments (Tables 4.50, 4.52).

Flowering and pod setting of TN88-63 and KN-1 were demonstrated in a similar experiment in 1985 to be hampered by either soil or air heat stress or both. TN88-63 was, however, less sensitive to these factors than KN-1. The 1985 findings were confirmed in this 1987 experiment. High soil heat stress and the super-imposition of soil moisture stress on high air heat stress drastically reduced seed yields of TN88-63. Similarly, high air heat stress prevented KN-1 from expressing its yield potential (Tables 4.50, 4.52 and Fig. 4.6). Other low yielding cultivars (viz. TVu 1509 and TVx 3236) behaved like TN88-63. In addition, their root metabolic activities were probably hampered by soil moisture stress, (Table 4.53), which could also be related to their small root system.

Under low soil heat stress, only SUVITA-2, TN88-63, 58-57 and KN-1 had high root nodule dry weight at maturity; the same was true under high soil heat stress only for 58-57 (Table 4.52). Thus, nodule activities were highly sensitive to soil heat stress. Nevertheless, nodule activity was presumably not associated with better performance, since high

Table 4.53 Flower bud formation, flowering and maturity dates, stem and branch lengths and rood dry weight of entries in potculture at Kamboinse, Burkina Faso, in 1987.

Entries	Flower bud formation Date§	Flowering date§	Maturity date§	Stem length§	Branch length§	Root dry weight§
	DAS			cm		g/pot
SUVITA-2	55 abc	62 bc	74 bc	19 bcd	7 b	5 ab
TN88-63	62 ab	70 ab	77 b	28 a	28 a	8 a
58-57	53 bc	61 bcd	72 bcd	26 ab	14 b	6 ab
MOUGNE	56 abc	64 abc	72 bcd	18 cd	12 bc	6 ab
BAMBEY 21	45 cd	57 cd	68 cd	23 abc	9 bc	6 ab
TVu 1509	58 ab	62 bc	73 bcd	13 d	6 c	3 b
TVx 3236	53 bc	60 bcd	72 bcd	17 cd	6 c	4 b
KN-1	66 a	73 a	85 a	26 ab	11 bc	5 ab
KVx 396-4	40 d	51 d	66 d	21 abc	7 bc	5 ab
L.S.D. (5 %)	12	10	7	7	7	3
C.V. (%)	27	19	12	43	73	61

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

yielding cultivars included also those with low nodule activities (Table 4.52).

These results, suggested that:

- Soil heat stress was far more critical than soil moisture stress for crop development, since the combination of low heat stress and soil moisture stress gave better crop performances compared to the combination of high soil heat stress and no soil moisture stress;
- Cultivars of Sahelian origin, namely, SUVITA-2, 58-57, Mougne and Bambey 21 performed satisfactorily under high soil heat stress treatments, unlike cultivar TN88-63. Cultivar TVx 3236, of non Sahelian origin, also performed satisfactorily under the same conditions;
- TN88-63, TVu 1509 and KN-1 performed poorly under high soil heat stress and soil moisture stress;
- Line KVx 396-4 inherited gene combinations, presumably from SUVITA-2, which enabled it to perform better under both high and low soil heat stress treatments as well as under soil moisture stress;
- The satisfactory performance of TVx 3236 under high soil heat stress did not seem to be inherited directly from its TVu 1509 parent.

The high level of field performance of TN88-63 was associated with its ability to tolerate soil and air heat stress, which enabled it to develop flower buds, and, flower, set and fill pods in time, to coincide with cool weather in late August and early to mid-September.

Conclusion.

High soil heat stress exacerbated drought damage to cowpea. Appropriate cultivars, or genetic manipulations, were shown to be effective in reducing soil heat effects and, hence, drought damage.

REGIONAL TRIALS

Maize-Cowpea Relay Cropping.

In 1987, maize-cowpea relay cropping trials were set up in the following countries: Burkina Faso, one set; Guinea Conakry, two sets; Nigeria, one set; Tchad, one set; and Togo, one set. As at May 20, 1988, all countries except Nigeria and Tchad had sent their data.

Two types of experiments were conducted. One tested the effects of different maize and cowpea cultivars, particularly maturity groups, and row-spacings on the performance of both crops; a second trial tested the effect of different cowpea cultivars on the performance of both crops.

Effect of Different Maize and Cowpea Cultivars and Row-Spacings on the Performance of both Crops in a Relay-Cropping System.

This experiment was conducted at Diebougou, Burkina Faso, and Broukou/Kara, Togo. It involved 2 maize cultivars, 3 cowpea cultivar treatments and 2 row-spacings. Maize cultivars used consisted of SAFITA-2, 90 days to maturity, less leafy with short plant stature; IRAT 171, 105 days to maturity, leafy with tall plant stature and La Posta, 110 days to maturity, leafy and tall plant stature. SAFITA-2 and IRAT 171 were used at Diebougou, and SAFITA-2 and La Posta, at Broukou. Cowpea cultivars consisted of Kaya Local, daylength sensitive; a local check.

A pure-stand maize treatment was used as check. There was no cowpea pure-stand treatment. The row-spacings were 0.75 m x 0.25 and 1.00 m x 0.25 m. Maize cultivars were sown at the onset of the crop season while cowpea cultivars were sown 4 weeks after maize. Maize plants received side-dressings of NPK fertilizer at sowing and N one month after sowing. Cowpea plants were sprayed with insecticides twice. The experimental design was a factorial combination of 2 maize cultivars, 3 cowpea cultivar treatments and 2 row-spacings in randomized complete blocks.

There were very little differences between seed yields of maize cultivars, SAFITA-2 and IRAT 171, under all cowpea cultivars and row-spacing treatments at Diebougou (Table 4.54). For cowpea, only the cultivar Diebougou Local gave seed yields which tended to increase as the row-spacing was increased from 0.75 to 1.00 m (Table 4.54). A dry spell in mid to late October was probably responsible for the very low cowpea seed yields (Table 4.54).

At Broukou, Togo, maize cultivar La Posta yielded significantly higher than maize cultivar SAFITA-2 (Table 4.55). Row-spacings had an insignificant effect on seed yield of both cultivars.

As observed for cowpea at Diebougou, only the local Broukou cultivar gave some seed yields (Table 4.55). Maize cultivar La Posta tended to depress cowpea seed yield compared to maize cultivar SAFITA-2 (Table 4.55). The effect of row-spacings on cowpea seed yields was not significant.

Severe virus disease infection and dry spells in October caused low seed yields of cowpeas.

Table 4.54 Seed yields of maize and cowpea as affected by row-spacings and cultivars in relay-cropping system at Diebougou, Burkina Faso, in 1987.

Cowpea cultivars	MAIZE CULTIVARS SAFITA-2 (0.75m x 0.25m)	SAFITA-2 (1.00m x 0.25m)	IRAT 171 (0.75m x 0.25m)	IRAT 171 (1.00m x 0.25m)
	Kg /ha			
1) Maize Seed Yield§				
Kaya local	1060 abcd	630 d	900 cd	1270 abc
Local (Diebougou)	1010 abcd	1130 abcd	890 cd	970 bcd
Maize pure stand	790 cd	1460 a	1520 a	1420 ab
L.S.D. (5 %)	5.0			
C.V. (%)	33			
2) Cowpea Seed Yield	Q/ha			
Kaya local	0	0	0	0
Local (Diebougou)	200	260	190	330
Maize pure stand	0	0	0	0
L.S.D. (5 %)	NS			
C.V. (%)	39			

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

Table 4.55 Seed yield of maize and cowpea as affected by row-spacings and cultivars in relay-cropping system at Broukou, Togo, in 1987.

Cowpea Cultivars	MAIZE CULTIVARS SAFITA-2 (0.75m x 0.25m)	SAFITA-2 (1.00m x 0.25m)	LA POSTA (0.75m x 0.25m)	LA POSTA (1.00m x 0.25m)
	Kg /ha			
1) Maize Seed Yield§				
Kaya local	2880 c	2570 c	4900 a	4240ab
Local (Broukou)	2750 c	2590 c	5000 a	4230ab
Maize pure stand	3100 bc	2550 c	4740 a	4520a
L.S.D. (5 %)	11.5			
C.V. (%)	22			
2) Cowpea Seed Yield§	Q/ha			
Kaya local	0	0	0	0
Local (Broukou)	230	230	130	140
Maize pure stand	0	0	0	0
L.S.D. (5 %)	NS			
C.V. (%)	55			

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

The depressing effect of La Posta, tall leafy, and late maturing maize cultivar, on seed yield of relay cropped cowpea agreed with the observations at Farako-Bâ, Burkina Faso in 1982, 1983, and 1984.

Effect of Cowpea Cultivars on Seed Yield of Relay Cropped Maize.

This experiment was conducted at Bordo/Kankan and Kilissi/Kindia, Guinea Conakry. It involved 8 cowpea cultivars of different growth habits. Agronomic practices and the experimental design were similar to row-spacing experiment, except that only one row-spacing, 0.75 m x 0.25 m, was used.

As observed at Farako-Bâ, Burkina Faso, cowpea cultivars relay-cropped 4 weeks after maize had an insignificant effect on maize seed yields at both locations (Table 4.56). Maize seed yields were lower at Bordo/Kankan (1.7 to 3.5 t/ha) than at Kilissi/Kindia (4.1 to 4.5 t/ha).

Seed yields of cowpea differed significantly at Kilissi/Kindia only (Table 4.56). Daylength neutral and sensitive cultivars KN-1 and Kaya Local, respectively, yielded similarly and significantly higher than any other cultivars at that location (Table 4.56). Cowpea seed yields were lower at Bordo/Kankan (0.0 to 0.1 t/ha) than at Kilissi/Kindia (0.4 to 1.2 t/ha).

A short crop season and poorly distributed rainfall at Bordo/Kankan compared to Kilissi/Kindia were believed to have caused the lower seed yields of both crops at the former than the latter locations (Table 4.56).

As observed in Burkina Faso in 1981, 1982, and 1984 and in regional testing trials in Togo, Gambia, Nigeria and Benin in 1983, 1984 and 1985, cowpea sown one month after maize did not

Table 4.56 Seed yields of maize and cowpea as affected by cowpea cultivars in relay-cropping at Bordo/Kankan and Kilissi/Kindia, Guinea Conakry, in 1987.

Cowpea Cultivars	SEED YIELD AT			
	Bordo/Kankan &		Kilissi/Kindia&	
	Maize	Cowpea	Maize	Cowpea
	/ha			
1) Maize pure crop	3720 a	-	4310	-
2) Cowpea cultivars				
a) Daylength neutral				
TN 88-63	2400 a	90 a	4470 a	810 c
IT81D-994	2300 a	20 a	4140 a	690 d
TVx 3236	3060 a	10 a	4250 a	440 e
KN-1	3270 a	20 a	4310 a	1140 a
b) Daylength-sensitive				
KVx 30-G172-16K	3530 a	20 a	4460 a	510 e
Kaya Local	1720 a	10 a	4200 a	1190 a
Kamboinse local R.	3000 a	0 a	4240 a	990 b
Local cultivar	2900 a	60 a	4440 a	810 c
L.S.D. (5 %)	N.S.	N.S.	N.S.	79
C.V. (%)	38	124	11	6

& Means followed by the same letter are not statistically different 5 % probability level.

have detrimental effects on maize seed yields. Cowpea performance under maize depended on environmental conditions (i.e., rainfall intensity and distribution and probably on disease incidence). Where environmental conditions were favourable up to October, cowpea yields greater than 700 kg/ha were obtained with some daylength sensitive and insensitive cultivars. Depending on crop management levels and environmental conditions good yields of maize and cowpeas, higher than 3.0 t/ha and 0.5 t/ha, respectively, were obtained at some sites.

Results of Regional Trials, in general, agreed with those obtained in Burkina Faso. They suggested that maize/cowpea relay-cropping system can be successfully extended to Northern Guinea Savanna in other West African countries.

Sorghum-Cowpea Intercropping.

Sorghum-cowpea intercropping trials were conducted at Oronkua/Diebougou, Burkina Faso; Tilli/Bolgatanga, Bordo/Kankan, Guinea Conakry; Maroua, Cameroun; and Broukou/Kara and Atekou/Kante, Togo in 1987, in order to test 3 cowpea cultivars: TVx 3236, KN-1 and a farmers' local cowpea, under two insecticide treatments, namely, no insecticide application and, 2 sprays, one at flower bud formation and the other, at the onset of pod filling to control flower thrips and other insect pests. TVx 3236 and KN-1 are daylength-neutral cultivars: the first has moderate levels of resistance or tolerance to flower thrips while the second is known to be susceptible to thrips attack. Experiments conducted in the Sudan Savanna at Kamboinse (Burkina Faso) from 1981 to 1985, have shown TVx 3236 to yield up to 300 kg/ha of seed without insecticide protection in inter-cropping. Whereas the same cultivar in pure-stand cropping gave no yields, just like KN-1 in both pure-stand and inter-croppings when insecticides are not applied to suppress flower thrips.

The sorghum cultivar Framida, was sown early in the crop season at all locations, except at Tilli/Bolgatanga, Ghana, and Maroua, Cameroon, using 1.25 m x 0.25 m spacings. Seedlings were thinned to one plant per hill within 3 weeks of sowing. Sorghum plants received NPK fertilizer at sowing and additional N fertilizer as side dressing one month after sowing. Cowpea was sown 2 to 3 weeks after sorghum in solid rows 1.25 m x 0.20 m apart, alternating with sorghum. Two seeds were sown and seedlings thinned to one plant per hill 2 weeks after sowing.

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

Sorghum seed yields were high at Oronkua/Diebougou, Burkina Faso and Broukou/Kara, Togo, intermediate at Maroua, Cameroon, Atekou/Kante, Togo; very low at Bordo/Kankan, and nil at Tilli/Bolgatanga, Ghana (Table 4.57). Late sowing, due to late establishment of rainfall and the early cessation of rains were responsible for the failure of the sorghum crop at Tilli/Bolgatanga and the low sorghum yields at Maroua. On the other hand, heavy rainfall and the ensuing water logging, drastically reduced sorghum seed yields at Bordo/Kankan, while a severe sorghum foliar disease reduced sorghum yields at Atekôu/Kante, Togo.

Intercropped cowpea reduced sorghum seed yields only at Oronkua/Diebougou, Burkina Faso and Maroua, Cameroon (Table 4.57). Except local cultivars, all other cowpea cultivars tested did not appear to compete differently from sorghum at all locations.

Cowpea seed yields were: nil at Broukou/Kara, Togo; very low at Atekou/Kante, Togo (0.0 to 0.3 t/ha); Bordo/Kankan, Guinea Conakry intermediate at Oronkua/Diebougou, Burkina Faso (0.2 to 1.0 t/ha); and high (0.1 to 1.6 t/ha) at Maroua, Cameroon (Table 4.57). High virus and fungal disease infections and pod sucking bug pressures and high rainfall were responsible for the low cowpea seed yields at Broukou and Atekou (Togo). Similarly, water logging at Bordo/Kankan, Guinea Conakry reduced cowpea seed yields (Table 4.57).

Intercropping cowpea with sorghum reduced cowpea seed yields significantly at all locations (Table 4.57). Similarly, lack of insecticide application significantly reduced seed yields in both pure and the intercropped cowpea at all locations. At Tilli/Bolgatanga (Ghana) and Atekou/Kante (Togo) which are located close together in a similar ecological zone, no cowpea seed yields were obtained when Oronkua/Diebougou (Burkina Faso) and Maroua (Cameroon) where yields of up to 0.3 t/ha in intercropping and 0.4 to 0.9 t/ha pure-stand were obtained without insecticide protection.

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

TVx 3236 yielded similarly or higher than KN-1 without insecticide application in pure-stand and intercropped plots

Table 4.57: Sorghum and cowpea seed yields as affected by insecticide sprayings and intercropping at Oronkua/Diebougou, Burkina Faso ; Tilli/Bolgatanga, Ghana ; Bordo/Kankan, Guinea-Conakry ; Maroua, Cameroon; and Broukou/Kara and Atekou/Kante, Togo in 1987.

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

§ Two insecticide sprays at flower bud formation and pod formation.

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

£ LER = Land equivalent ratio was computed using the yield of the pure crop local cowpea variety under each spray regime.

although, the yield differences were not significant. Local cultivars yielded either equally to or significantly less than TVx 3236 (TAble 4.57).

With insecticide application, intercrop yields of the three cultivars were similar at all locations (Table 4.57). In pure-stand plots, TVx 3236 produced significantly higher yields than the local cultivars at Maroua (Cameroon) and Atekou/Kante (Togo) and was outyielded by the local variety at Bordo/Kankan (Guinea). Pure-stand yields of both cultivars did not differ significantly at other locations.

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

These results demonstrate that cowpea performance without insecticide protection appeared to depend on the location; intercropping did not enhance seed yields on plots that were not chemically protected against insect pests. Similarly the cultivars TVx 3236 and the local cowpea did not show significant yield advantage over KN-1 in those plots. Therefore, wide spread testing should be conducted over several years in each country to identify locations which require less insecticide protection than others.

COWPEA ENTOMOLOGY

Joseph B. Suh

INTRODUCTION

Trials were conducted in the three principal ecologies of Burkina Faso: the Sahel, Sudan and Northern Guinea Savannahs Rainfall was reduced (6%, 9% and 28%, respectively at Farako-Bâ, Pobe/Djibo and Kamboinse) and poorly distributed during the season.

INSECT PEST SURVEYS AND YIELD LOSS ASSESSMENT

Population trends of the cowpea aphid, A. craccivora, were studied with the aid of yellow pan water traps. As in previous years, flights were earliest and most abundant in Farako-Bâ, followed by Kamboinse and were least intense in Pobe (Fig. 5.1) and followed a south and north progression.

Yield losses of cowpea caused by Aphids, Flower Thrips and Maruca Pod Borer were assessed. Two sampling plots, each 625 m^2, were established per insect pest at Farako-Bâ, Kamboinse and Pobe to assess damage and associated yield reduction caused by these pests. KN-1 (Vita-7) was planted 0.20 m apart along 1.0 m rows and insecticides applied to manipulate the various insect pest populations (for details, see 1986 report). Aphids were sampled weekly by inspection and counts on 20 plants (4 samples each from 5 contiguous plants per row), while Flower Thrips and Maruca Pod Borer were assessed every fourth day from Flower buds and open Flowers. Insect population densities and grain yields in sprayed and non-sprayed plots were compared and grain yield losses calculated.

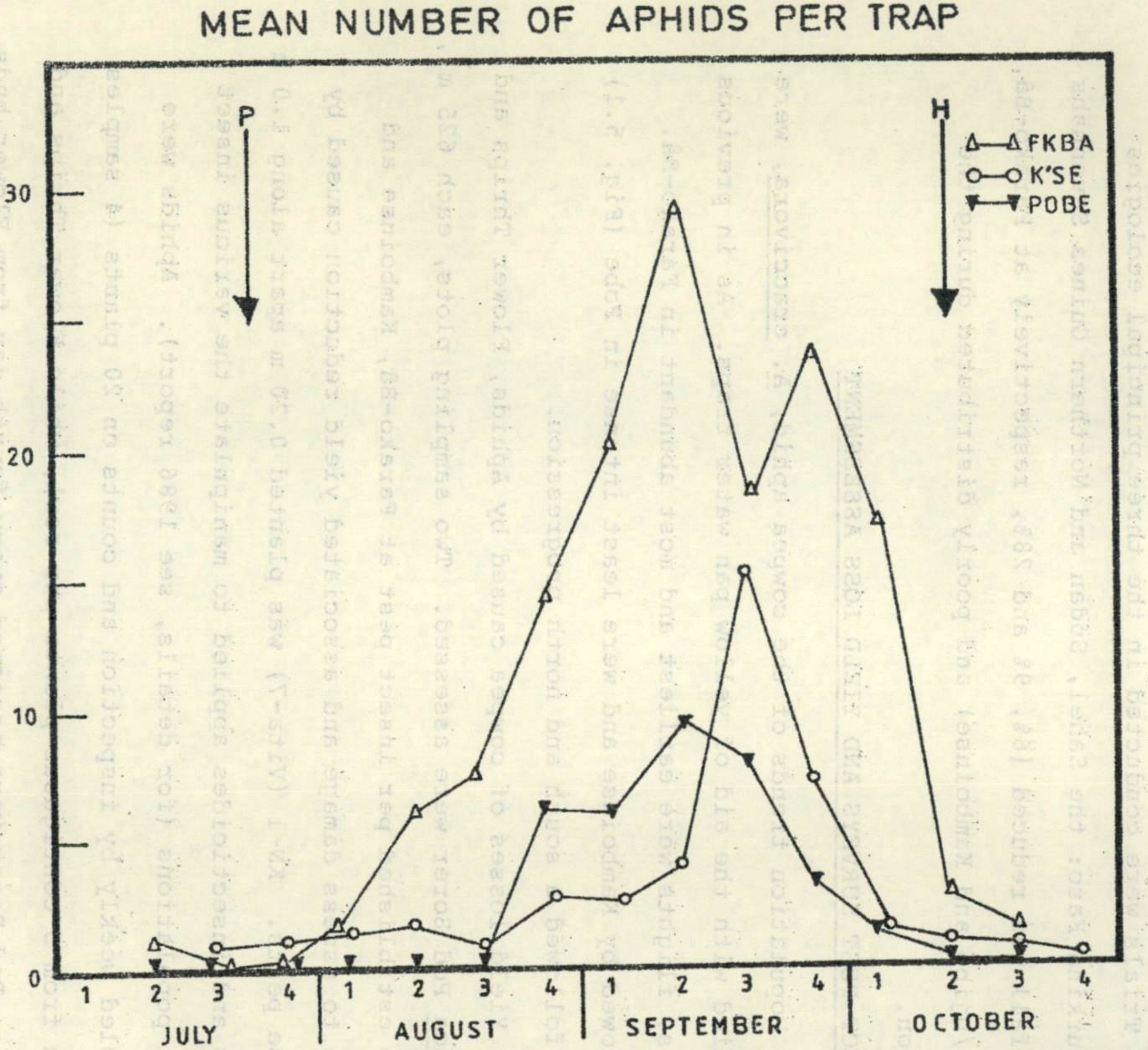

Fig. 5.1. POPULATION FLUCTUATIONS OF THE COWPEA APHID (*A. CRACCIVORA*) IN YELLOW PAN TRAPS AT POBE, KAMBOINSE AND FARAKO-BA, BURKINA FASO, 1987.

Aphid populations were low at all test locations, thus making association of observed yield reduction to aphid feeding damage difficult (Table 5.1). Flower Thrips infestation was lower on cowpea floral buds (racemes) than open flowers. Insecticide sprays significantly suppressed Flower Thrips incidence (Table 5.2). High yield reductions, 58% and 86%, were associated with Flower Thrips damage at Kamboinse and Farako-Bâ respectively. Maruca Pod Borer larval densities were low and similar in the sprayed and non-sprayed crops (Table 5.3). Substantial yield differences occurred at Kamboinse and Farako-Bâ, but these could not be ascribed solely to Maruca larval damage.

HOST PLANT RESISTANCE

Eight of the 15 cowpea accessions tested in 1986 were further evaluated along with 4 check varieties, TVx 3236 - aphid susceptible, Flower Thrips resistant; KN-1, aphid susceptible; IT82E-60, aphid susceptible and TVu-36, aphid resistant, in field trials at Pobe, Kamboinse and Farako-Bâ. Accessions were assigned at random to plots (4 rows 0.75 m wide, 5 m long) in unsprayed (un-protected i.e. aphid infested) and sprayed (protected: Pirimor ED$^{(R)}$ 75g a.i/ha weekly to eliminate aphids) blocks, at 2 planting dates 2 weeks apart. The experimental design was a split plot with aphid suppression and planting dates as main and sub plots respectively, and 3 replicates. The spreader row technique was used to assure uniform aphid infestation. Single rows of the aphid susceptible variety, KN-1 were planted on either side of test plots 2 weeks before the trial was planted. Four weeks later, susceptible plants were uprooted and gently shaken to transfer aphids onto the

Table 5.1. Aphid incidence and damage on cowpea at three locations in Burkina Faso, 1987.

Sampling Dates		No. of Aphids/Meter Protected	No. of Aphids/Meter Un-protected
POBE			
July	20	0.0	0.0
	27	0.0	0.0
	31	0.0	0.0
August	7	0.0	0.0
	14	0.0	0.0
Means ± S.E.		0.0	0.0 + 0.0
Grain Yield (Kg/ha)		345	273
KAMBOINSE			
August	20	5.3	0.6
	27	24.6	33.2
Sept.	3	0.0	0.0
	10	16.3	0.0
	17	0.0	0.8
Means ± S.E		9.2	6.9 ± 14.70
Grain Yield (Kg/ha)		305	242
FARAKO-BA			
August	2	0.0	0.0
	8	0.0	0.0
	18	0.0	0.0
	25	0.2	0.0
Sept.	1	0.0	0.4
Means ± S.E		0.04	0.10 ± 0.15
Grain Yield (Kg/ha)		1770	1034

Table 5.2. Flower Thrips incidence and damage on cowpea racemes and flowers at 3 locations in Burkina Faso, 1987.

Sampling Dates		Thrips/10 Racemes		Thrips/10 open flowers	
		Protected	Un-protected	Protected	Unprotected
			POBE		
August	19	0.6	0.0	-	-
	22	0.8	0.0	1.6	0.2
	30	0.0	0.0	2.2	6.2
September	3	0.8	1.8	1.4	11.0
	7	-	-	1.7	14.8
	15	0.0	0.0	1.0	9.8
Means ± S.E		0.4 ± 0.18	0.9 ± 78	1.6 ± 0.44	8.40 ± 5.52
Grain Yield (Kg/ha)		166			156
Yield Loss (%)			6.0		
			KAMBOINSE		
September	2	0.6	0.0	-	-
	8	0.2	2.2	2.2	10.6
	12	0.2	2.6	10.0	50.8
	15	2.5	3.0	4.8	21.2
Mean ± S.E		0.9 ± 1.10	2.0 ± 1.24	5.7 ± 3.97	27.5 ± 20.83
Grain yield (Kg/ha)		581.0	244		244
Yield Loss (%)			58.0		
			FARAKO-BA		
August	15	0.1	0.1	-	-
	20	0.0	0.3	0.4	77.2
	24	0.1	1.8	0.9	53.2
	28	0.5	2.6	0.4	99.7
September	1	0.6	10.7	3.8	114.1
	5	0.2	14.1	5.1	11.0
	9	-	-	0.0	29.4
Mean ± S.E		0.3 ± 0.24	4.9 ± 5.96	1.8 ± 2.14	64.1 ± 40.20
Grain yield (Kg/ha)		1358.0			184.0
Grain Loss (%)			86		

Table 5.3. Incidence and damage by *Maruca* Pod Borer on cowpea flowers at three locations in Burkina Faso, 1987.

Sampling Dates		*Maruca* Larvae/ 10 open flowers	
		Protected	Un-protected
POBE			
August	30	0.2	0.3
September	3	0.2	0.3
	7	0.7	0.5
	11	0.5	1.0
	15	0.6	1.0
Means ± S.E.		0.40 ± 0.26	0.60 ± 0.36
Grain Yield (Kg/ha)		761	760
Yield Loss (%)		Nil	
KAMBOINSE			
September	9	0.0	1.1
	12	0.0	0.2
	17	0.0	0.8
Means + S.E.		0.0	0.70 ± 0.51
Grain Yield (Kg/ha)		567	456
Yield Loss (%)		19.6	
FARAKO-BA			
August	8	0.1	0.3
September	5	0.4	0.0
	11	1.0	0.0
	15	0.0	0.0
Means ± S.E.		0.40 ± 0.45	0.10 ± 0.15
Grain Yield (Kg/ha)		2125	1044
Yield Loss (%)		50.9	

2 week old test crop. Two sprays of Deltamethrin (12.5g a.i/ha) were applied to all plots 30 to 35 days and 40 to 55 days after planting (DAP) to suppress Flower Thrips, Maruca Pod Borer and Pod sucking bugs.

The trials at Pobe and Farako-Bâ had very low aphid incidence and are excluded from this report. Results from Kamboinse appear in Table 5.4. Infestation was low but significantly higher in the late planted (second planting date) compared to the early (first planting date) crop. Aphid population densities at both planting dates were similar in protected and unsprayed crops. However, significant differences in aphid incidence were observed between varieties in the later planted crop: KVx 165-14-2, KVx 146-27-4, KVx 165-14-1, KVx 146-27-6, KVx 145-99-1, KVx 146-44-1 (4) and TVu 36 (resistant check) supported lower aphid populations than the susceptible checks (TVx 3236, IT82E-60 and KN-1).

Grain yields were moderate (0.5 to 0.9 t/ha) and similar between planting dates as well as among varieties. High yielders included TVu 36, KVx 146-44-1 (4), KVx 146-27-4, KVx 145-27-4 and IT82E-60 (Table 5.4). Despite a low initial infestation, aphid suppression on the early crop (first planting date) resulted in significant increases in grain production.

CULTURAL CONTROL: EFFECT OF ROW INTERCROPPING ON INSECT PEST INCIDENCE AND COWPEA YIELDS.

Row intercropping trials were repeated at Pobe (millet/ cowpea), Kamboinse (sorghum/cowpea) and Farako-Bâ (maize/cowpea) to assess the effect of alternating 2 to 4 cowpea rows with a cereal intercrop on insect pest infestation and cowpea grain yields. Cowpea received three insecticide treatments as follows:

Table 5.4. Aphid incidence and grain yield (kg/ha) of 12 cowpea accessions on two planting dates, with and without aphid suppression at Kamboinse, Burkina Faso, 1987.

Accessions	Infestation % 1/ and Rank 2/						Yield (kg/ha)					
	July 18 (D1)			August 1 (D2)			July 18 (D1)			August 1 (D2)		
	Protected	Un-protected	Means	Protected	Un-protected	Means	Protected	Un-protected	Means	Protected	Un-protected	Means
TVu	0.0(1.0)	0.0(1.0)	0.0(1.0)	11.5(1.3)	8.9(1.2)	10.2 (1.3)	817	264	540	521	1942	1232
TVx 146-44-1(4)	2.1(1.0)	0.0(1.0)	1.1(1.0)	5.2(1.4)	10.8(1.2)	8.0(1.3)	951	111	531	741	524	632
KVx 146-27-4	2.3(1.0)	4.5(1.0)	3.4(1.0)	8.3(1.0)	3.5(1.0)	5.9(1.0)	988	847	918	760	647	704
IT82E-60	0.0(1.0)	0.0(1.0)	0.0(1.0)	13.4(1.4)	19.3(1.5)	16.4(1.5)	953	479	716	729	643	686
KVx 145-27-4	2.4(1.0)	1.2(1.0)	1.8(1.0)	1.0(1.0)	6.1(1.0)	8.1(1.0)	994	429	712	625	539	582
KVx 146-27-6	0.0(1.0)	9.6(1.3)	4.8(1.2)	0.0(1.0)	8.9(1.0)	4.4(1.0)	993	565	779	626	446	536
KVx 146-99-1	0.0(1.0)	0.0(1.0)	0.0(1.0)	4.1(1.0)	9.6(1.0)	6.8(1.0)	818	483	651	523	445	484
KVx 146-49-3	0.0(1.0)	0.0(1.0)	0.0(1.0)	16.1(1.0)	5.8(1.0)	10.9(1.0)	884	182	533	664	451	557
KN-1	2.3(1.0)	0.0(1.0)	1.2(1.0)	9.3(1.2)	23.8(2.0)	16.6(1.0)	775	606	691	419	358	388
KVx 165-14-1	1.6(1.0)	0.0(1.0)	0.8(1.0)	11.1(1.2)	8.1(1.0)	9.6(1.1)	862	157	510	616	507	562
TVx 3236	0.0(1.0)	5.7(1.0)	2.9(1.0)	21.3(2.0)	28.8(2.0)	25.0(2.0)	807	190	499	503	509	506
KVx 165-14-2	2.3(1.0)	2.3(1.0)	2.3(1.0)	3.3(1.0)	2.5(1.0)	2.9(1.0)	751	160	456	460	600	530
Means	1.1(1.0)	1.5(1.0)		9.5(1.2)	11.3(1.2)	10.4(1.2)	873	373	628	599	634	617
COMPARISONS	LSD (5%)			C.V. (%)			LSD (5%)			C.V (%)		
Planting dates	25.0			81.4			NS			63.2		
Sprays	NS			81.4			803			63.2		
Varieties	4.23			81.4			NS			63.2		

1/ Arcsin transformations of Means of 3 ratings infested plants on 2 middle rows per plot (on August 6, 10 and 15 for early crop (D1) and August 17,22 and 29 for later crop (D2).

2/ Ranking determined on visual scores 1 to 5 where 1 = low; 3 = moderate; 5 = high.

3/ Weekly sprays of Pirimpor ED(R) (75g a.i./ha weekly from 7-10 DAP for aphid suppression and 2 applications of Deltermethrin (12.5g a.i./ha) 30 to 35 and 45 to 55 DAP to eliminate Flower Thrips, Maruca Pod Borer and Pod sucking bugs.

4/ Two sprays of Deltermethrin (12.5g a.i./ha) 30 to 35 and 45 to 55 DAP for Flower Thrips, Maruca and Pod sucking bug suppression.

No protection, no sprays): minimum protection - two sprays of deltamethrin and dimethoate (12.5 + 400g a.i/ha) 30 to 35 and 45 to 55 DAP; and full protection - four sprays of the same pesticide mixture 20, 30, 45 and 60 DAP. Records of populations of Aphid, Flower Thrips, Maruca Pod Borer and Pod sucking bugs were taken to determine the levels of pest infestations. Flower production and grain yields were also recorded. Results are given in Tables 5.5 and 5.6.

Incidence of Aphids was higher at Pobe than Kamboinse and Farako-Bâ, insecticide sprays significantly reduced pest infestations only at Pobe and Kamboinse than Pobe and Farako-Bâ. Insecticide application suppressed raceme and flower infestations (Table 5.5). Two sprays appeared to be as effective as 4 sprays in reducing Aphid and Flower Thrips incidence. Infestations of Maruca Pod Borer and Pod sucking bugs were low and not significantly reduced by insecticide application. Flower production was enhanced by insecticide application regardless of the number of sprays (Table 5.5).

Cowpea seed yields in protected crops were low at Pobe (0.2 to 0.3 t/ha) but were considerably higher at Kamboinse and Farako-Bâ (0.4 to 0.7 t/ha, Table 5.5). Although insecticide protection significantly improved grain production at Pobe, yield increases by 2 and 4 sprays were similar at all test locations. Maize and Millet yields were generally low presumably due to drought conditions. Inter-cropping significantly depressed component crop yields at various test sites (Table 5.6). Nevertheless, total productivity of cereal-crop combinations (or yield advantage measured by LERs higher than 1.0) was satisfactory (Table 5.6). Wider cowpea strips seemed to produce higher yield advantage. While insecticide application is easier and more efficient on wider cowpea strips, it is doubtful if farmers

Table 5.5 Insect Pest Incidence, Flower and grain production of cowpea under three levels of insecticide protection in row inter-cropping trials at 3 locations in Burkina Faso, 1987.

Insecticide protection	Aphid infestation % *	Flower Thrips Racemes	Flower Thrips Flowers	Maruca lavae/10 flowers	Pod sucking bugs per 2 meters	Flower production/ meter row	Cowpea yield (kg/ha)
				POBE (Millet (L. Pobe) + Cowpea (TVx 3236; SUVITA-2)			
No spray	60.85	0.21	4.54	0.13	0.06	3.81	122
Two sprays**	58.79	0.01	1.95	0.01	0.10	8.14	233
Four sprays***	46.02	0.09	3.34	0.02	0.08	10.75	281
LSD (5%)	7.17	0.18	NS	NS	NS	3.15	254
C.V. (%)	3.70	50.0	-	-	-	11.8	52.82
				KAMBOINSE Sorghum (Framida, white seeded) + Cowpea (TVx 3236; KN-1)			
No spray	36.42	10.05	187.8	0.41	1.07	6.83	245
Two sprays**	14.16	7.40	108.6	0.39	0.46	11.87	434
Four sprays***	13.66	13.89	89.8	0.42	0.48	10.43	512
LSD (5%)	8.82	6.87	100.35	NS	NS	NS	NS
C.V. (%)	15.90	18.70	22.20	-	-	-	-
				FARAKO-BA Maize (Jaune de Fo) + Cowpea (TVx 3236; KN-1)			
No spray	28.07	3.63	19.61	1.22	0.15	8.73	470
Two sprays**	25.12	0.31	4.62	0.69	0.03	12.55	668
Four sprays***	27.06	0.51	3.52	0.73	0.06	11.51	690
LSD (5%)	NS	2.53	14.31	NS	NS	NS	NS
C.V. (%)	-	48.5	44.0	-	-	-	-

*Arcsin transformations of means of 3 ratings of infested plants on 2 middle rows per plot.

**Deltamethrin + Dimethoate (12.5 + 400g a.i/ha) 30 to 35 and 45 to 55 DAP.

***Same mixture in ** above, 20, 30, 45 and 60 DAP.

Table 5.6 Performance of different cereal cowpea association in a row intercropping trial at three locations in Burkina Faso, 1987.

Crop combination	Yield (kg/ha) Cereal	Yield (kg/ha) Cowpea	Cereal LER	Cowpea LER	Inter crop LER
			POBE		
Millet monocrop (S1)	402	-	1.0	-	-
Cowpea monocrop (S2)	-	398	-	1.0	-
2 millet + 2 cowpea (S3)	396	137	0.99	0.34	1.33
2 millet + 3 cowpea (S4)	247	190	0.61	0.48	1.09
3 millet + 4 cowpea (S5)	528	122	1.31	0.31	1.62
LSD (5%)	222	67			
C.V. (%)	32.9	21.2			
			KAMBOINSE		
Sorghum monocrop (S1)	1162	-	1.0	-	-
Cowpea monocrop (S2)	-	593	-	1.0	-
2 Sorghum + 2 cowpea (S3)	1291	201	1.11	0.34	1.45
2 Sorghum + 3 cowpea (S4)	829	330	0.71	0.56	1.27
3 Sorghum + 4 cowpea (S5)	1235	464	1.06	0.78	1.84
LSD (5%)	668	417.8			
C.V. (%)	34.5	70.1			
			FARAKO-BA		
Maize monocrop (S1)	1473	-	1.0	-	-
Cowpea monocrop (S2)	-	943	-	1.0	-
2 maize + 2 cowpea (S3)	1564	445	1.06	0.47	1.53
2 maize + 3 cowpea (S4)	703	632	0.48	0.67	1.15
3 maize + 4 cowpea (S5)	1443	415	0.98	0.44	1.42
LSD (5%)	107.5	159.42			
C.V. (%)	48.35	17.4			

would be willing to trade off the land required for wider cowpea strips at the expense of their cereal base crop.

CHEMICAL CONTROL: INSECTICIDE EVALUATION FOR INSECT PEST SUPPRESSION.

Seven insecticides were evaluated singly and in mixtures as foliar sprays on cowpea insect pests. KN-1 (Vita-7) was used and treatments were allocated randomly to plots (4 rows 0.75 m, 5 m long), in a randomised block design with 4 replicates. Two (30 to 35 and 45 to 55 DAP) and three (20, 35 and 50 DAP) insecticide applications were made, using knapsack sprayers. Aphid infestation was assessed weekly from 7 to 10 DAP on 20 plants (4 samples each of 5 contiguous plants per row). Flower thrips and Maruca pod borer incidence were evaluated from receme and flower samples taken every fourth day between 30 and 45 DAP. Flower production was estimated from two flower counts on 1 m of cowpea row per plot between 40 and 50 DAP. Pod sucking bug infestation was determined by visual counts along a 5 m row per plot at four day intervals, 7 to 10 days after onset of flowering. Results are presented in Table 5.7.

Aphid incidence was moderate. Significant population reduction resulted from three sprays of Karate + Dimethoate ED(R), Karate ED(R), Deltamethrin + Endosulfan EC and Deltamethrin + Dimethoate EC. Thrips infestation of racemes was low compared to flowers. The best protection on flowers was obtained from two and three applications of Karate + Dimethoate ED(R), Cymbush Super ED(R), Deltamethrin + Dimethoate EC and Karate ED(R). Maruca Pod Borer and Pod sucking bug infestations were low and not significantly reduced by insecticide protection. Flower production was markedly improved by chemical application regardless of the number of sprays.

Table 5.7 Aphid and Flower Thrips incidence, Flower production and grain yield (kg/ha) of KN-1 (VITA-7) sprayed two and three times at Kamboinse, Burkina Faso, 1987.

Insecticide	Dosage applied (g a.i/ hectare)	Aphid infest.(%) 1/ 4 WAP			Flower Thrips/10 flowers			Flowers per meter			Yield (kg/ha)		
		No 2/ spray	2 3/ spray	3 4/ sprays	No spray	2 sprays	3 sprays	No spray	2 sprays	3 sprays	No spray	2 sprays	3 sprays
Karate + Dimethoate ED (R)	20 + 40	-	34.3	8.6	-	13.8	6.4	-	19.3	19.2	-	879	985
Karate ED (R) (Cyhalothrin)	20	-	24.3	9.2	-	17.3	19.6	-	19.1	12.6	-	906	860
Cymbush Super ED (R) (Cypermethrin + Dimethoate	12.5 + 20	-	10.5	23.8	-	10.8	12.0	-	16.5	16.5	-	604	1005
Deltamethrin + Dimethoate EC	12.5 + 400	-	18.5	18.9	-	20.8	13.7	-	20.2	15.7	-	686	754
Deltamethrin + Endosulfan EC	12.5 + 400	-	35.5	8.8	-	60.6	23.7	-	10.9	19.5	-	443	882
Deltamethrin EC	12.5	-	26.9	27.0	-	40.2	32.0	-	17.4	11.4	-	601	699
Deltamethrin + Malathion EC	12.5 + 400	-	17.8	15.6	-	53.6	66.4	-	15.7	15.8	-	456	704
Control (No spray)		36.0	-	-	126.8	-	-	7.4	-	-	254	-	-
		(36.0)	(27.4)	(13.7)	(126.8)	(31.0)	(24.8)	(7.4)	(17.0)	(15.8)	(254)	(659)	(835)
LSD (5%)			20.1			31.9			9.8			337	
C.V (%)			65.33			64.59			43.37			33.03	

1/ Arcsin transformations of 2 rows per plot.

2/ No protection.

3/ Two sprays at 30 to 35 and 45 to 55 DAP.

4/ Three sprays at 20, 35 and 50 DAP.

Grain yields were satisfactory. Although in most cases, yields were similar between two and three sprays, insecticides protection increased seed production significantly. Nevertheless, the highest grain production (0.9 to 1.0 t/ha) resulted from three applications of Cymbush Super ED(R), Karate + Dimethoate ED(ER), Deltamethrin + Endosulfan EC as well as two sprays of Karate ED(R) and Karate + Dimethoate ED(R).

MINIMUM INSECTICIDE PROTECTION TRIAL

During the cowpea and maize workshop in March 1987, National scientists expressed interest in conducting the SAFGRAD Regional Entomology Trial on Minimum Insecticide protection of cowpea insect pests. A trial was therefore established to assess the performance of 10 cowpea varieties (8 improved entries of varying maturity periods with multiple resistance to insects, diseases, *Striga* and drought, and 2 local late photosensitive cultivars) under minimum insecticide protection, i.e. two sprays of deltamethrin + dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 to 55 DAP respectively). Twelve sets were sent, upon request, to 8 national programs in Central and West Africa, and collaborators were requested to take observations on insect pest incidence, flower production and grain yields.

Trials in Burkina Faso were conducted at Pobe, Kamboinse and Farako-Bâ using a split plot design with insecticide protection as main plots and cowpea varieties as sub-plots, and 4 replications. In other locations a randomised complete block design with 4 replications was used.

At Pobe, the trial was planted on July 10, 1987. Crop establishment was good but later growth and development were hampered by sand blast, heat and drought stress. Results are shown in Tables 5.8 and 5.9. Insect pest incidence was low. Significant differences emerged between varieties in respect of flower Thrips incidence on racemes and flowers: TVx 3236 supported lower Thrips populations than local varieties - Gorom Local (SUVITA-2), Pobe Local (Table 5.8). Maruca Pod Borer and Pod Sucking Bug infestations were mild and similar among varieties. Gorom Local (SUVITA-2) produced the best yield (0.4 t/ha) followed by KVx 165-14-1, KVx 30-G172-1-6K, TVx 3236, IT82E-32 and IT84S-2246-4 (0.2 to 0.3 t/ha). Insecticide application significantly reduced Thrips population densities on cowpea racemes and flowers and markedly increased flower production (Table 5.9). However, grain yield was only marginally improved by insecticide protection.

The trial at Kamboinse was sown on July 13, 1987: Germination and development were satisfactory. Insect pest density levels were generally low with significant varietal differences in Flower Thrips, Maruca Pod Borer and Pod Sucking Bug incidence (Table 5.10). Flower production was moderate and markedly higher in improved varieties (KVx 165-14-1, IT84S-2246-4, TVx 3236) than local cultivars. Seed yields of 0.7 to 0.9 t/ha were produced by IT84S-2246-4, IT84S-2231-15, TVx 3236 but these were comparable to 0.5 to 0.6 t/ha by IT82E-32, IT84S-2231 and KN-1. Premature cessation of rains caused severe reduction in grain yields of local varieties - Kaokin and Kamboinse Local. Only Thrips infestation of cowpea flowers was significantly depressed by insecticide sprays (Table 5.11), which tended to improve

Table 5.8. Flower Thrips, Maruca Pod Borer and Pod Sucking Bug Incidence, Flower Production and Grain Yields (Kg/ha) of 10 Improved and Local Cowpea Varieties with and without Minimum Insecticide Protection [1/] at Pobe, Burkina Faso, 1987.

Varieties	Flower Thrips per 10		Maruca larvae	Pod Sucking	Flowers per	Yield
	Racemes	Flowers	per 10 flowers	bugs per meter	meter	(Kg/ha)
1. TVx 3236	1.4	1.5	1.0	1.0	3.1	200
2. IT82E-32	1.7	1.7	1.0	1.0	2.8	195
3. KVx 165-14-1	1.5	1.2	1.0	1.1	3.6	213
4. IT84S-2246-4	1.9	1.4	1.0	1.0	3.6	191
5. IT84S-2231-15	1.6	1.8	1.1	1.1	3.3	92
6. KVx 30-G172-1-6K	1.9	1.5	1.0	1.1	2.0	205
7. IT81D-994	1.3	1.2	1.0	1.1	2.1	148
8. KN-1	2.1	1.2	1.0	1.0	2.7	126
9. Local Gorom Local (SUVITA-2)	2.3	1.7	1.0	1.1	3.0	345
10. Local (Pobe Local)	3.2	2.7	1.1	1.0	2.7	148
Mean	1.9	1.6	1.0	1.0	2.9	186
LSD (5%)	0.62	0.35	NS	NS	NS	NS
C.V. (%)	33.17	22.16	-	-	-	-

1/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 to 55 DAP).

Table 5.9 Effect of Minimum insecticide Protection */ on insect Pests (Flower Thrips, *Maruca* Pod Borer, Pod Sucking Bug), Flower Production and Grain Yields (Kg/ha) of Improved and Local Cowpea Varieties at Kamboinse, Burkina Faso, 1987.

Insecticide protection	Flower Thrips per 10		*Maruca* larvae per 10 flowers	Pod Sucking bugs per meter	Flowers per meter	Yield (Kg/ha)
	Racemes	Flowers				
Protected*	1.6	3.5	1.5	1.7	8.7	582
Un-protected (no spray)	1.8	5.8	1.6	4.0	7.9	400
Mean	1.7	4.6	1.5	2.8	8.3	491
L.S.D. (5%)	NS	1.30	NS	NS	NS	123
C.V. (%)	-	41.66	-	-	-	74.37

*Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 and 55 DAP).

Table 5.10. Flower Thrips, Maruca Pod Borer and Pod Sucking Bug Incidence, Flower Production and Grain Yields (Kg/ha) of 10 Improved and Local Cowpea Varieties with and without Minimum Insecticide Protection 1/ at Kamboinse, Burkina Faso, 1987.

Vaarieties	Flower Thrips per 10		Maruca larvae	Pod Sucking	Flowers per	Yield
	Racemes	Flowers	per 10 flowers	Bugs per meter	meter	(Kg/ha)
1. TVx 3236	1.0	3.1	1.7	4.7	10.2	814
2. IT82E-32	1.5	4.0	1.6	3.6	7.5	608
3. KVx 165-14-1	1.3	4.4	2.0	3.4	8.3	923
4. IT84S-2246-4	1.1	3.0	1.6	2.5	20.0	760
5. IT84S-2231-15	1.5	3.6	1.7	9.9	18.3	538
6. KVx 30-G172-1-6K	1.1	4.6	1.7	2.0	1.3	353
7. KVx IT81D-994	2.9	4.3	1.0	0.1	3.1	206
8. KN-1	1.3	4.0	1.9	1.9	8.2	479
9. Local (Kaokin Local)	1.9	6.7	1.1	0.2	4.2	102
10. Local (Kamboinse Local)	3.7	8.4	1.1	0.1	2.0	128
Mean	1.7	4.6	1.5	2.8	8.3	491
L.S.D. (5%)	0.62	1.90	0.36	5.09	3.63	NS
C.V. (%)	36.66	41.66	24.37	183.72	44.23	-

1/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 to 55 DAP).

Table 5.11 Effect of Minimum Insecticide protection */ on Insect Pests (Flower Thrips, Maruca Pod Borer, Pod Sucking Bugs) Flower Production and Grain Yields (Kg/ha) of Improved and Local Cowpea Varieties at Pobe, Burkina Faso, 1987.

Insecticide protection	Flower Thrips per 10		Maruca larvae per 10 flowers	Pod Sucking bugs per meter	Flowers per meter	Yield (Kg/ha)
	Racemes	Flowers				
Protected*	1.6	1.2	1.0	1.0	3.0	209
Un-protected (no spray)	2.2	2.0	1.1	1.0	2.8	164
Mean	1.9	1.6	1.0	1.0	2.9	186
L.S.D. (5%)	0.29	0.23	NS	NS	0.53	NS
C.V. (5%)	33.17	22.16	-	-	18.47	-

* Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 to 55 DAP).

flowering. Nevertheless, insecticide protection significantly increased grain production (0.6 and 0.4 t/ha on sprayed and unsprayed crop, respectively).

The Farako-Bâ trial was planted on July 9, 1987. Initial crop establishment was good, but water-logging severely impeded later crop development. Insect pest incidence was mild and similar within varieties except for Flower Thrips and Pod Sucking Bug infestations on flowers and pods respectively (Table 5.12). Flower production was low but significantly higher in IT84S-2231-15, IT84S-2246-4, KVx 165-14-1 and IT82E-32 compared to IT81D-994, KVx 30-G172-1-6K or Local Kaya. Grain yields were poor (average 0.2 t/ha) and no marked differences were recorded between varieties although IT84S-2231-15, IT84S-2246-4, KVx 165-14-1 yielded up to 0.3 to 0.4 t/ha. Minimum protection significantly suppressed Flower Thrips and Maruca larval densities on racemes and flowers (Table 5.13). Consequently, flowering was markedly improved resulting in substantial grain yield increases of 0.3 and 0.5 t/ha on protected and unprotected crops respectively.

In Cameroon, the trial was conducted at the IRA Station in Maroua. Pest insect infestation was low (TAble 5.14) and marked varietal differences were obtained for Flower Thrips and Maruca larval incidence. Flower production was high and varied significantly among varieties. Grain yields were satisfactory: IT82E-32, KN-1, TVx 3236, IT84S-2246-4 and KVx 165-14-1 produced 0.8 to 1.0 t/ha compared to 0.5 to 0.7 t/ha by KVx 30-G172-1-6K, IT84S-2231-15, Vya Local and IT81D-994. Maroua Local, however, failed to produce any grain yields.

Table 5.12 Flower Thrips, Maruca Pod Borer and Pod Sucking Bug Incidence, Flower Production and Grain Yields (Kg/ha) of 10 Improved and Local Cowpea Varieties with and without Minimum insecticide Protection _/ at Farako-Ba, Burkina Faso, 1987.

Vaarieties	Flower Thrips per 10		Maruca larvae	Pod Sucking	Flowers per	Yield
	Racemes	Flowers	per 10 flowers	bugs per meter	meter	(Kg/ha)
1. TVx 3236	1.4	6.3	1.8	1.5	2.4	128
2. IT82E-32	1.6	6.3	1.9	1.3	3.3	162
3. KVx 165-14-1	1.6	7.6	1.8	1.3	3.4	292
4. IT84S-2246-4	1.9	4.7	2.1	1.4	3.6	320
5. IT84S-2231-15	1.9	4.8	1.7	1.4	4.3	436
6. KVx 30-G172-1-6K	1.7	4.7	2.0	1.3	1.7	76
7. IT81D-994	1.7	2.1	1.4	1.2	1.1	88
8. KN-1	1.7	6.5	1.6	1.3	2.2	152
9. Local (Kaya Local)	1.8	2.8	1.2	1.2	2.0	72
10. Local (Logofrousso Local)	2.1	7.1	1.4	1.2	2.3	104
Mean	1.8	5.3	1.7	1.3	2.6	183
LSD (5%)	NS	2.08	NS	0.17	0.59	NS
C.V. (%)	-	39.70	-	13.29	23.03	-

_/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./Ha) at floral bud formation and podding 30 to 35 and 45 to 55 DAP).

Table 5.13 Effect of Minimum Insecticide Protection */ on insect Pests (Flower Thrips, Maruca Pod Borer, Pod Sucking Bugs), Flower Production and Grain Yields (Kg/ha) of Improved and Local Cowpea Varieties at Farako-Bâ, Burkina Faso, 1987.

Insecticide protection	Flower Thrips per 10		*Maruca* larvae per 10 flowers	Pod Sucking bugs per meter	Flowers per meter	Yield (Kg/ha)
	Racemes	Flowers				
Protected */	1.5	4.1	1.4	1.3	3.0	317
Un-protected (no spray)	2.1	6.4	1.9	1.3	2.3	49
Mean	1.8	5.3	1.7	1.3	2.6	183
L.S.D. (5%)	0.42	0.33	0.19	NS	0.31	121
C.V. %)	37.94	39.70	37.88	-	23.03	149.98

*/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30-35 and 45 to 55 DAP).

Table 5.14. Flower Thrips, Maruca Pod Borer and Pod Sucking Bug incidence, Flower Production and Grain Yields of 10 improved cowpea varieties with Minimum Insecticide Protection */ at Maroua, Cameroon, 1987.

Varieties	Flower Thrips per 10 2/		Maruca larvae per 10 flowers	Pod Sucking bugs per meter	Flowers per meter	Yield (Kg/ha)
	Racemes	Flowers				
TVx 3236	1.03	0.78	0.23	0.38	226.63	928
IT82E-32	1.65	2.58	0.58	0.00	98.88	941
KVx 165-14-1	0.85	1.00	0.75	0.20	203.38	780
IT84S-2246-4	0.38	0.63	0.38	0.13	239.88	850
IT84S-2231-15	0.78	2.63	1.13	0.25	34.75	556
KVx 30-G172-1-6K	0.73	0.58	0.53	0.13	110.13	718
IT81D-994	0.33	0.40	0.33	0.15	32.50	475
KN-1	1.15	1.13	1.13	0.20	102.63	939
Local (VYA)	1.48	0.75	0.00	0.08	14.38	630
Local (Maroua 75)	0.58	0.25	0.13	0.00	6.75	0
Mean	0.89	1.07	0.52	0.15	106.99	682
L.S.D. (5%)	0.79	1.24	0.41	NS	86.96	244
C.V. (%)	61.54	79.85	54.39	-	56.02	24.64

*/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha)

The Gambia trial was planted at the Yundum Station on July 29, 1987 using 6 varieties (2 local, 4 improved). Thrips infestation of flowers was moderate, while incidence of Maruca Pod Borer and Pod Sucking Bugs was mild (Table 5.15). Grain yields were moderate and differed significantly between varieties: KVx 165-14-1, TVx 3236 and IT84S-2246-4 yielded 0.7 to 0.8 t/ha while IT84S-2231-15 and the local varieties produced less than 0.4 t/ha.

The trial in Ghana was established at the Nyankpala Agricultural Research Station (CRI) on June 30, 1987. Insect pest densities were very low yet marked varietal differences were recorded (Table 5.16). Flower production was good and varied significantly among varieties. Grain production was satisfactory; IT82E-32, KN-1, Sumbriezie Local, KVx 165-14-1, IT84S-2246-4, TVx 3236 and IT82E-16 produced between 0.8 and 1.0 t/ha.

In Guinea Conakry, the trial was planted on July 27, 1987 at Kankan. Pest insect population levels were low with significant varietal differences (Table 5.17). Flower production was moderate and similar among entries. Despite three sprays of Parathion, grain yields were poor. The highest production (0.4 to 0.5 t/ha) was by IT84S-2246-4, KVx 165-14-1, KN-1 and a local variety.

The Niger trial was established at Maradi on June 27, 1987. Flower Thrips populations on cowpea racemes were low with marginal varietal differences (Table 5.18). Grain yields were moderate and differed significantly between cultivars. The highest production (0.5 to 0.7 t/ha) was by locally adapted

Table 5.15. Flower Thrips, *Maruca* Pod borer and Pod Sucking Bug incidence, and Grain Yields of 6 improved and local varieties with minimum insecticide protection */ at Yundum, The Gambia, 1987.

Varieties	Flower Thrips per 10 Racemes	Flower Thrips per 10 Flowers	*Maruca* larvae per	Pod Sucking Bugs per m.	Yield (Kg/ha)
TVx 3236	1.47	10.80	0.35	0.20	767
KVx 165-14-1	0.07	29.77	2.62	0.27	805
IT84S-2246-4	0.25	12.32	0.35	0.07	755
IT84S 2232-15	0.07	9.72	0.22	0.07	288
Local (Soso Koima)	1.60	8.52	0.65	0.27	395
Local (TN88-63)	0.0	6.17	0.40	0.32	142
Mean	0.57	12.88	0.76	0.20	525
L.S.D. (5%)	0.58	7.91	1.23	0.46	133
C.V. (%)	67.29	40.77	106.58	150.50	17.0

*/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 to 55 DAP).

Table 5.16. Flower Thrips, Maruca Pod Borer and Pod Sucking Bug incidence, flower production and Grain Yields (Kg/ha) of 10 improved and local cowpea varieties with minimum insecticide protection 1/ at Nyankpala, Ghana, 1987

Varieties	Flower Thrips per 10 2/		Maruca larvae per 10 Flowers 3/	Pod Sucking bugs per meter (Sumbrizie)	Flowers per meter	Yield (Kg/ha)
	Racemes	Flowers				
TVx 3236	0.85	0.82	0.70	1.55	49.63	792
IT82E-32	0.85	1.39	0.77	1.50	45.00	940
KVx 165-14-1	0.82	1.25	0.70	1.63	38.25	859
IT845-2246-4	0.82	1.23	0.74	1.36	40.87	859
IT84S-2231-15	0.85	1.59	0.70	1.72	33.12	357
KVx 30-G172-1-6K	0.84	1.45	0.74	1.66	29.75	378
IT81D-994	0.83	1.09	0.88	1.47	32.37	626
KN-1	0.82	1.55	0.74	1.46	37.75	905
Local (IT82E-16)	0.83	1.31	0.77	1.40	42.37	767
Local (Sumbrizie)	0.86	1.07	0.72	1.48	45.12	902
Mean	0.84	1.27	0.74	1.52	39.42	739
L.S.D. (5%)	0.06	0.47	0.16	0.30	5.30	273
C.V. (%)	5.44	25.41	15.29	13.69	39.42	25.39

1/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30 to 35 and 45 to 55 DAP).

2/ Square Root Transformation.

Table 5.17 Flower Thrips, Maruca Pod Borer and Pod Sucking Bug uncidence, Flower production and Grains Yields (Kg/ha) of 10 improved and local cowpea varieties with minimum insecticide protection 1/ at Kankan, Guinea Conakry, 1987.

Varieties	Flowers Thrips per 10 2/		Maruca larvae per 10 flowers	Pod Sucking bugs per meter 2/	Flowers per meter 2/	Yield (Kg/ha)
	Racemes	Flowers				
TVx 3236	1.34	1.31	0.90	1.14	10.40	215
IT82E-32	1.38	1.60	1.14	1.12	8.25	254
KVx 165-14-1	0.85	1.79	0.80	1.69	10.85	395
IT84S-2246-4	0.82	1.37	1.10	1.52	8.05	514
IT84S-2231-15	0.78	1.26	1.03	1.19	9.20	210
KVx 30-G172-1-6K	1.12	1.58	1.04	1.26	8.50	128
IT81D-994	0.82	1.77	0.94	1.10	9.97	173
KN-1	0.94	1.42	0.98	1.26	8.77	366
Local (unspecified)	0.95	1.17	0.81	0.70	9.70	464
Local (Soso Kankan)	1.14	1.91	0.90	1.31	10.07	241
Mean	1.01	1.52	0.96	1.23	9.37	296
L.S.D. (5%)	0.65	0.95	0.33	0.96	3.14	140
C.V. (%)	44.28	43.29	23.70	53.87	23.11	32.58

1/ Three sprays of Parathion

2/ Square Root Transformation.

Table 5.18. Flower Thrips incidence and Grain Yields (Kg/ha) of 10 Improved and Local Cowpea Varieties with Minimum Insecticide Protection -/ at aradi, iger, 1987.

Varieties	Flower Thrips per 10 Racemes	Yield (Kg/ha)
1. KVx 3236	1.90	364
2. IT82E-32	0.82	229
3. KVx 165-14-1	0.77	345
4. IT84S-2246-4	2.02	358
5. I::84S-2231-15	1.27	182
6. KVx 30-G172-1-6K	1.0	486
7. IT81D-994	0.92	1
8. KN-1	1.15	294
9. Local (TN -78)	1.55	694
10. Local (TN88-63)	0.77	498
Mean	1.02	345.0
L.S.D. (5%)	1.09	171.02
C.V. (%)	74.06	34.12

_/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) a floral bud formation and podding (30 to 35 and 45 to 55 DAP).

varieties, e.g. TN-5-78, TN88-86 and KVx 30-G172-1-6K, compared with 0.3 to 0.4 t/ha by TVx 3236, IT84S-2246-4 and KVx 165-14-1.

In Nigeria, the trial was sown on July 21, 1987 at Kano. Pest infestations were mild and comparable among entries (Table 5.19). Flower production was moderate with significant varietal differences. Grain yields were low with marked differences between cultivars. Grain yields ranged from 0.4 to 0.5 t/ha in KVx 165-14-1, IT82E-36, IT84S-2246-4, KVx 30-G172-1-6K and IT84S-2231-15, TVx 3236, KN-1, while the local cultivars yielded 0.3 to 0.4 t/ha with minimal protection.

Across trial locations, seed production was low (0.2 to 0.3 t/ha) at Kankan (Guinea), Pobe and Farako-Bâ (Burkina Faso); moderate (0.4 to 0.5 t/ha) at Maradi (Niger) and Kano (Nigeria); and promising (0.6 to 0.7 t/ha in Kamboinse (Burkina Faso), Maroua (Cameroon) and Nyankpala (Ghana) (Table 5.20). Under minimum insecticide protection, IT84S-2246-4 (Aphid, Bruchid, Flower Thrips resistant) yielded over 0.5T grain per hectare across various locations, while KN-1, IT82E-32, KVx 30-G172-1-6K and local varieties produced between 0.3 and 0.5 t/ha. An average grain yield of 0.3 t/ha obtained across test sites from IT81D-994 (Bruchid resistant, late maturing) was attributed in part, to low plant densities caused by poor germination.

These results show that judicious use of insecticides to give minimum protection against insect pests, effectively complimented moderate levels of host plant resistance, particularly in adapted cowpea varieties in assuring grain yields of the order of 0.5 t/ha.

Table 5.19. Flower Thrips, Maruca Pod Borer and Pod Sucking Bug Incidence, Flower Production and Grain yields (Kg/ha) of 10 improved and Local Cowpea Varieties with Minimum Insecticide Protection */ at Kano, Nigeria.

Varieties	Flower Thrips 10 Racemes	Flower Thrips 10 Flowers	Maruca larvae 10 Flowers	Pod Sucking Bugs per m	Flowers per m.	Yield (Kg/ha)
TVx 3236	0.32	1.75	0.0	0.0	8.15	361
IT82E-32	0.32	4.75	0.25	0.0	12.20	468
KVx 165-14-1	0.20	3.50	0.37	0.0	13.22	512
IT84S-2246-4	0.32	2.12	0.0	0.25	15.20	456
IT84S-2231-15	0.82	4.12	1.20	1.50	11.15	425
KVx 30-G172-1-6K	0.12	1.0	1.0	0.25	1.02	445
IT81D-994	0.35	2.0	1.37	0.0	5.12	1
KN-1	0.15	1.87	0.37	0.0	3.95	374
Local (Dan-Ilan)	0.20	2.0	0.25	0.0	9.40	370
Local (SVC 1-48	0.65	2.62	0.12	0.0	5.52	325
Mean	0.34	2.37	0.29	0.15	8.49	373
L.S.D. (5%)	NS	2.45	NS		4.67	102
C.V. (%)	-	71.09	-		37.88	18.78

*/ Two sprays of Deltamethrin + Dimethoate (12.5 + 400g a.i./ha) at floral bud formation and podding (30-35 and 45-55 DAP).

Table 5.20. Grain yields (kg/ha) of 10 improved and local cowpea varieties under minimum insecticide protection[1/] in 9 Semi-Arid locations of West and Central Africa, 1987.

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

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

2/ Three sprays of Parathion.

SOIL WATER MANAGEMENT

N.R. Hulugalle

All the experiments reported here were conducted at Kamboinse Research Station on Upland Alfisols.

Effect of Tied Ridges on Soil Properties and Crop Yields in the Sudan Savannah of Burkina Faso.

The effect of tied ridges on soil properties and crop growth and yield were studied in a series of trials intiated in 1985 and continued in 1986 and 1987 at Kamboinse Research Station (Ann. Repts. 1985 and 1986). The objectives of these trials were:

i) to quantify the tied ridge system in terms of soil physical, chemical and hydrological properties;

ii) to define the responses of the major crops of the West African Semi-Arid Tropics (WASAT) to tied ridges in terms of water use, root growth and crop yields. The crops studied in 1987 were maize (*Zea mays* (L.) cv., SAFITA-2, millet (*Pennisetum americanum* (L.) Leek cv. Kapelga) and bambara groundnut (*Voandzeia subterranea* var. *subterranea* cv. Kamboinse Local, (Syn. *Vigna subterranea*)).

Soil water content was measured at weekly intervals gravimetrically in 0.15 m depth increments to a depth of 0.75 m. Soil bulk density in the surface 0.05 m was measured on cores 50 mm high and 50 mm in diameter. Water infiltration was measured with double-ring infiltrometers during the dry season. Composite soil samples obtained from the surface 0.05 m were analyzed for particle size distribution (hydrometer method), soil organic matter (OM) and carbon (C) (Walkley and Black Method), soil nitrogen (Kjedahl analysis) and total CEC and exchangeable Ca, Mg, Na and K (1N Ammonium acetate pH 7). Top and root growth and relative leaf water contents of crops were measured at regular intervals.

The results obtained in 1987 can be summarized as follows:

i) Tied ridges significantly increased profile water content by an average of 30 mm per week in 1987 (Table 6.1). (See also IITA/SAFGRAD Ann. Reps. 1985 and 1986).

ii) The chemical properties of soils in the surface 0.05 m of ridges were not significantly affected by tied ridging. Mean clay, silt and sand contents were 8.7%, 11.1% and 80.2%, respectively; mean OM, C, N and C/N ratios were 1.17%, 0.68%, 0.057% and 12.1%, respectively; and exchangeable Ca, Mg, K, Na and total CEC were 19.3, 5.6, 2.1, 0.7 and 28.3 m mol (+) kg^{-1}, respectively. With furrows, however, soil chemical properties were significantly affected by tied ridging (Table 6.2); tied ridging significantly increased clay, silt, OM, C, C/N, Ca, Mg, K and total CEC and decreased sand content. Soil nitrogen was not significantly affected by tied ridging.

Table 6.1 Effect of tied ridges on profile water content to a depth of 0.75 m during the growing season of 1987

Soil management system[1]	Profile water content (mm)												
	7/7	14/7	21/7	28/7	7/8	11/8	18/8	25/8	1/9	9/9	15/9	25/9	3/10
Tied ridges	95.4	110.1	101.3	100.3	146.4	128.8	147.7	149.6	121.0	72.2	46.2	115.4	107.6
Flat	71.4	93.8	87.7	91.9	98.1	84.3	100.7	99.8	65.4	47.4	35.0	78.2	105.9
± SE	2.76	8.78	8.41	8.44	3.52	7.13	3.22	6.57	7.12	5.33	4.14	5.10	17.89
P <	0.01	NS	NS	NS	0.01	0.05	0.01	0.05	0.05	0.05	NS	0.05	NS

1. Preplanting land preparation was disc-harrowing to a depth of 0.20m with incorporation of crop residues remaining from the previous crop.

Table 6.2 Effect of tied ridges on particle size distribution and soil chemical properties in 0-0.05 m depth of furrows, November 1986.

Ridging system	Particle size distribution			OM	N	C	C/N	CBC (m mol (+) kg^{-1})				
	Clay(%)	Silt(%)	Sand(%)	(%)	(%)	(%)		Ca	Mg	K	Na	Total
Tied ridges	9.6	12.1	78.3	1.52	0.063	0.89	14.1	20.4	5.2	2.6	0.7	42.2
Open ridges	7.2	10.7	82.1	0.89	0.059	0.48	8.1	8.4	2.0	1.5	0.4	19.8
± SE	0.32	0.71	0.88	0.087	6.12×10^{-3}	0.049	1.41	0.64	0.18	0.06	0.09	1.80
P <	0.01	0.05	0.05	0.01	NS	0.01	0.05	0.01	0.05	0.01	NS	0.01

iii) Soil bulk density was significantly greater ($P<0.05$) in furrows than in ridges of tied ridged plots (See also IITA/SAFGRAD Ann. Reps. 1985 and 1986).

iv) Water infiltration in furrows of tied ridged plots were significantly lower than those of either open ridged or flat planted plots (Table 6.3). This is primarily due to the concentration of fine particles (i.e. clay + silt) in furrows of tied ridged plots. (See also IITA/SAFGRAD Ann. Rep. 1985 and 1986).

v) Soil temperature at a depth of 30 mm was reduced during the growing season by tieing ridges (Fig 6.1), primarily because of higher soil water content. Prior to planting, in early June, when rainfall was light and infrequent, soil temperatures on ridges in all treatments were significantly higher ($P<0.01$) than that in flat planted plots due to the greater surface roughness in ridged plots.

vi) Root growth of millet was significantly increased ($P<0.01$) by tied ridging when pre-planting land preparation was limited to scarification, but not significantly affected by tied ridging.

vii) Relative leaf water contents (RLWC) of maize and bambara groundnut were significantly increased by tied ridging (Table 6.4). Irrespective of preplanting land preparation, RLWC of millet was not significantly affected by tied ridging (see also IITA/SAFGRAD Ann. Rep. 1986).

Table 6.3. Effect of soil management system on cumulative infiltration and infiltration rate at 2 hours after commencement of infiltration in 1987.

Soil management system	Cumulative infiltration (mm)	Infiltration rate (mm h-1)
Tied ridges	43.4	1.2
Open ridges	63.7	10.5
Flat	154.5	30.8
± SE	2.45	1.44
P <	0.01	0.01

Fig. 6.1. Effect of soil management system on diurnal variation of soil temperature within and between plant rows at a depth of 30mm during the rainy season of 1987.

▲ - tied ridges; △ - open ridges; 0 - flat

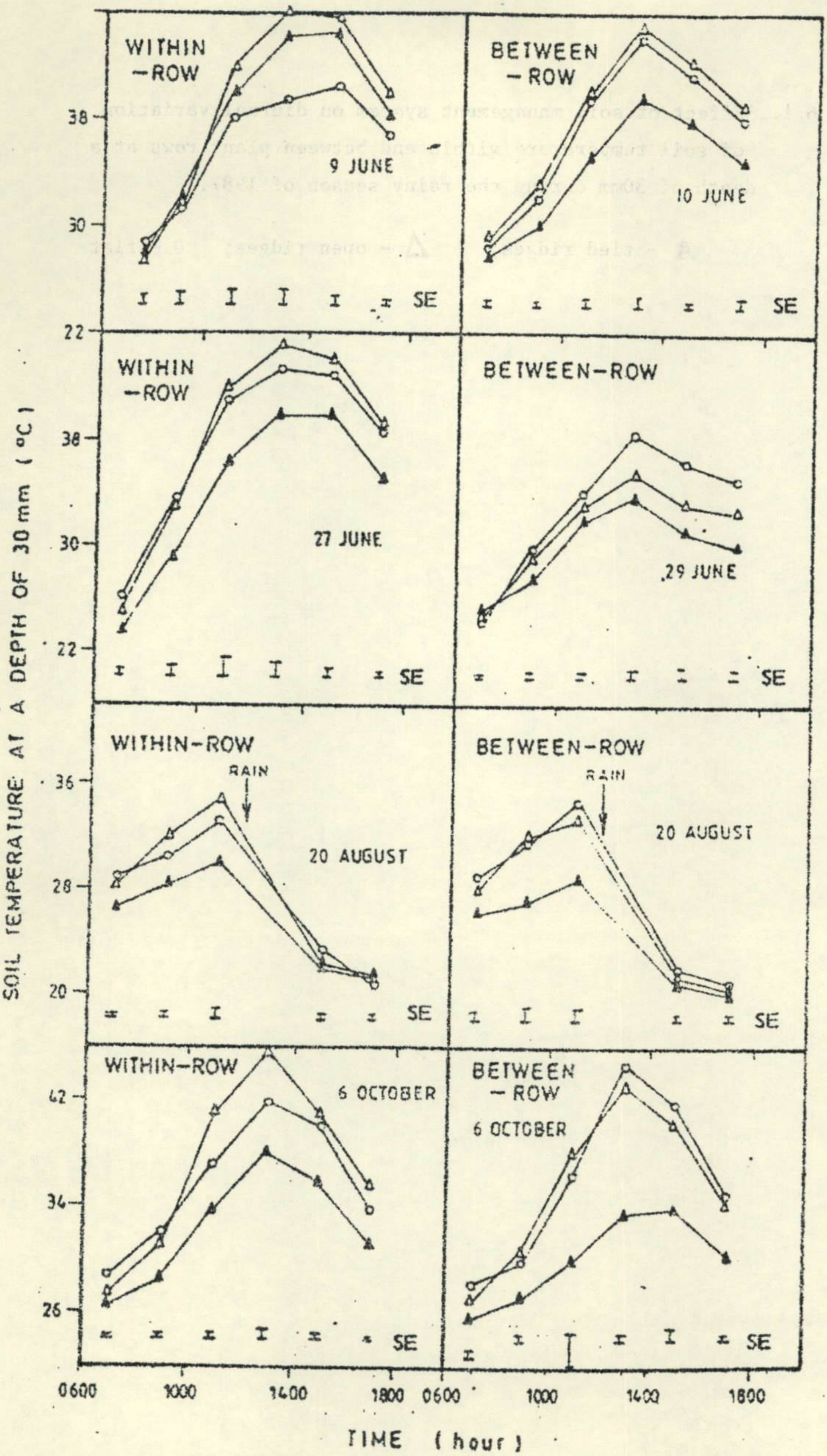
WITHIN -ROW
BETWEEN -ROW
9 JUNE
10 JUNE
27 JUNE
29 JUNE
20 AUGUST
RAIN
6 OCTOBER
SE
SOIL TEMPERATURE AT A DEPTH OF 30 mm (°C)
TIME (hour)
0600
1000
1400
1800
22
30
38
20
28
36
26
34
42

FIG. 6.1

viii) Grain and DM yield of maize and millet (scarified), and DM yield of bambara groundnut were significantly increased by tied ridging, whereas grain and DM yields of millet (ploughed) and grain yields of bambara groundnut were not significantly affected (Table 6.5). Ploughing results in limited increase in water infiltration, therefore drought resistant crops, such as millet do not respond when tied ridging is combined with ploughing.

Conclusion

The results obtained during the past 3 growing seasons indicate that tied ridging results in significant improvements in soil physical, chemical and hydrological properties. Crop responses are, however, variable. Drought-sensitive crops such as maize, respond with high yield increases in both wet and dry years. Crops sensitive to waterlogging such as cowpea and cotton respond with yield increases in dry years, and yield decreases or insignificant responses in wet years. Drought resistant crops such as millet respond with yield increases only in the absence of other soil ameliorative measures such as ploughing or mulching.

Table 6.4. Effect of tied ridges on crop relative leaf water content (%) at 1300h in 1987. (DAP = days after planting).

Crop	Pre-planting land preparation	Crop age (DAP)	Tied ridges	Open ridges	Flat	± SE	P<
Maize	Scarified*	26	98.2	90.6	-	1.74	0.01
		39	95.4	87.6	-	1.17	0.01
		51	94.6	82.0	-	1.63	0.01
		59	90.7	81.0	-	1.03	0.01
Millet	Scarified	42	87.7	92.0	93.5	2.26	NS
		60	92.2	94.8	92.7	1.53	NS
		74	83.9	82.1	84.0	1.02	NS
Millet	Ploughed **	46	90.3	-	91.4	1.20	NS
		67	88.5	-	83.5	2.40	NS
		87	86.8	-	85.8	1.73	NS
Bambara Groundnut	Ploughed	46	97.6	-	98.4	1.59	NS
		67	86.2	-	78.5	1.50	0.01
		87	87.8	-	83.2	1.60	0.05

* Cultivation to a depth of 0.05m with daba hand-hoes, and repairing of ridges and ties constructed the previous year.

** Disc-harrowing to a depth of 0.20m. Crop residue of the previous crop left in situ was incorporated during land preparation.

Table 6.5. Effect of tied ridges on crop yield (Mg ha^{-1}) in 1987.

Crop	Pre-planting land preparation	Yield parameter	Tied Ridge	Open ridges	Flat	± SE	P<
Maize	Scarified	Grain	2.5	0.4	-	0.10	0.01
		Dry matter	3.8	2.2	-	0.26	0.01
Millet	Scarified	Grain	0.6	0.2	0.2	0.05	0.01
		Dry matter	10.0	3.2	3.2	0.68	0.01
Millet	Ploughed	Grain	0.7	-	0.5	0.09	NS
		Dry matter	9.6	-	6.0	1.31	NS
Bambara groundnut	Ploughed	Grain	0.3	-	0.3	0.05	NS
		Dry matter	2.7	-	1.2	0.22	0.05

Effect of Cover Crop on Soil Physical and Chemical Properties of an Alfisol in the Sudan Savannah of Burkina Faso.

A trial was established in 1986 to evaluate the effects of several graminaceous and leguminous cover crops on soil properties of a moderately eroded Alfisol (see IITA/SAFGRAD Ann. Rep. 1986). This study attempted to quantify the effects of cover crops on soil physical and chemical properties in a minimum tillage system which involved rotation with cereal crops. The cover crops sown during 1986 were Echinochloa colona, Digitaria ciliaris, Lablab purpureus cv. Highworth, Cajanus cajan, Macroptilium artropureum cv. Siratro, M. lathyroides, Vigna radiata var. radiata, Psophocarpus palustris and Alysicarpus vaginalis. For comparison, maize (Zea mays cv. SAFITA-2), cowpea (Vigna unguiculata cv. TVx 3236) and a bare fallow were also included in the trial. Following local farmer practices, maize and cowpea residues were removed from all plots. Residue from all other treatments was retained as in situ mulch.

Maize cv. SAFITA-2 was sown in all plots in 1987 at spacings of 0.25 x 0.75 m at a population of 5.33×10^4 plants/ha. Prior to planting, a 0.20 m strip was cultivated to a depth of 0.05 m within plant rows with 'daba' handhoes. Fertilizer 13:20:15 NPK was applied at the rate of 200 kg/ha. Urea was applied as a side-dressing at 30 days after planting (DAP). All plots were weeded at 10 and 40 DAP; an additional weeding was required at 55 DAP on plots sown to E. colona and D. ciliaris in 1986. Care was taken to minimize disturbance of the residue mulch during weeding. Observations were made of plant emergence at 4 and 5 DAP in 1987. Relative leaf water content of maize at

1300h was measured at 37, 45, 60 and 72 DAP in 1987. Composite soil samples were obtained from the 0-0.5 m depth in March 1987 and analyzed for particle size distribution (hydrometer method), soil organic matter (OM) and carbon (C) (Walkley and Black method), soil nitrogen (Kjedahl analysis), Bray-1-P, soil pH (1:2.5 H_2O, and exchangeable Ca, Mg, K and Na and total CEC (1N Ammonium acetate, pH 7). Water infiltration over 2 hours was measured with a double-ring infiltration in January and October 1987. Total porosity was determined from the formula.

$$\text{Total porosity} = 1 - \frac{(\text{Bulk density})}{(\text{Particle density})}$$

Diurnal variation in soil temperature at a depth of 30 mm was measured during the 1987 growing season with mercury-in-glass bent-stem soil thermometers. Dial-type vacuum-gauge tensiometers were installed at depths of 0.30 and 0.60 m in all plots and soil water potential measured during the growing season. In situ water retention (drying) curves were derived for the same depths. Apparent pore size distribution was inferred from total porosity and soil water retention characteristics utilizing the surface tension relationship, h = 0.298/d where h and d are soil matric potential (-cm water) and pore diameter (cm), respectively.

Sand and silt contents, soil N, Bray-1-P, exchangeable Ca, Mg and Na, and total CEC in the surface 0.05 m were not significantly affected by cover crop (Table 6.6). Clay content, and soil OM, C, C/N, pH and exchangeable K were significantly affected by cover crop. Clay content and soil OM were both

Table 6.6. Effect of preceding cover crop on particle size distribution and soil chemical properties in the 0-0.05m depth, March 1987.

Preceding cover crop	Particle size distribution (%) Sand	Silt	Clay	OM (%)	C (%)	N (%)	C/N	pH	Bray-1-P	Exchangeable cations (m mol (+) kg^{-1}) Ca	Mg	K	Na	Total CEC (m mol (+) kg^{-1})
Zea mays	32.9	49.5	17.6	0.39	0.23	0.042	5.5	5.4	255	15.5	5.2	1.9	1.1	35.0
Vigna unguiculata	37.0	48.9	14.1	0.60	0.35	0.039	9.4	5.6	241	12.2	3.1	1.7	1.1	26.7
Bare fallow	31.5	49.0	19.5	0.36	0.21	0.041	5.2	5.6	252	18.8	9.0	2.2	1.9	38.9
Cajanus cajan	35.5	44.0	20.1	0.56	0.32	0.042	7.9	5.6	308	11.7	4.2	2.3	1.3	32.3
Digitaria ciliaris	40.1	44.3	15.6	0.79	0.49	0.046	10.6	6.0	264	12.1	5.6	2.7	1.8	29.8
Echinochloa colona	39.7	46.2	14.1	0.46	0.27	0.046	5.6	5.9	252	14.4	4.4	3.5	1.8	32.3
Alysicarpus vaginalis	35.4	46.8	17.8	0.39	0.23	0.045	5.0	5.7	239	16.6	5.0	2.5	1.4	32.4
Macroptilium artropurpureum	39.2	45.2	15.6	0.96	0.57	0.053	10.7	6.1	278	17.8	5.7	3.1	1.6	36.6
M. lathyroides	37.0	49.3	13.7	0.79	0.49	0.048	10.2	6.0	266	13.4	3.8	2.2	1.1	25.2
Lablab purpureus	40.3	46.3	13.4	0.82	0.47	0.046	10.2	5.9	229	12.8	3.5	2.5	1.4	26.6
Psophocarpus palustri	35.8	47.2	13.4	0.63	0.37	0.052	7.1	5.7	273	15.6	4.2	2.3	1.3	33.3
Vigna radiata	35.3	49.3	15.4	0.66	0.38	0.047	8.0	6.0	272	16.7	4.1	2.3	1.5	36.3
± SE	3.01	2.84	1.34	0.089	0.056	0.030	0.99	0.09	11.9	3.46	1.95	0.24	0.43	4.20
P <	NS	NS	0.05	0.01	0.01	NS	0.01	0.01	NS	NS	NS	0.05	NS	NS

related primarily to ground cover (GC, %) at 47 DAP in 1986, thus:

$$\text{Clay} = 20.50 - 0.10\ \text{GC}, \quad r = -0.66^{***} \quad n = 48$$

$$\text{OM} = 0.44 + 5.28 \times 10^{-3}\ \text{GC}, \quad r = 0.54^{***} \quad n = 48$$

These results suggest that where cover crops which formed ground cover rapidly (e.g. M. artropurpureum) were sown, less clay was lost by surface runoff. Where formation of ground cover was slow (e.g. bare fallow, C. cajan, A. vaginalis, Zea mays) there was rapid loss of topsoil leading to exposure of the clay-rich subsoil. Both pH and exchangeable K (m mol (+) kg^{-1}) were related to soil Om, as follows:

$$\text{pH} = 5.44 + 0.57\ \text{OM}, \quad r = 0.49^{***}, \quad n = 48$$

$$\text{Exch. K} = 1.9 + 0.84\ \text{OM}, \quad r = 0.34^{*}, \quad n = 48$$

Total porosity at 0-0.05 m depth in June, in the 0-0.10 m depth in August, and in the 0.28-0.3 m and 0.58-0.63 m depths in October were not significantly affected by cover crop. Mean porosities were 0.457, 0.430, 0.377 and 0.351 $m^3\ m^{-3}$ in the 0-0.05 m, 0-0.10 m, 0.28-0.33 m and 0.58-0.63 m depths, respectively. Infiltration rates were significantly increased ($P<0.01$) by cover crop in January 1987 (Table 6.7). High infiltration rates were recorded in plots which had been planted to E. colona, M. artropurpureum, M. lathyroides, L. purpureus and P. palustris. Infiltration rate was lowest in bare fallow, and in plots planted to C. cajan and Z. mays. Infiltration rate (dI/dt, mm h^{-1}) in January 1987 was related primarily to the ratio of clay and soil OM, thus:

$$dI/dt = 174.92e^{-2.30} \times 10^{-2}\ (\text{Clay/OM}), \quad r = -0.51^{***}, \quad n = 48$$

Table 6.7. Effect of preceding cover crop on infiltration rate at 2 h after commencement of infiltration and decrease in infiltration rate over time.

Preceding cover crop	Infiltration rate (mm h^{-1}) January 1987	October 1987	Decrease in infiltration rate (mm h^{-1})
Zea mays	76.0	46.7	29.3
Vigna unguiculata	80.0	72.8	7.2
Bare fallow	15.2	15.0	0.2
Cajanus cajan	63.9	54.5	9.4
Digitaria ciliaris	99.9	55.1	44.8
Echinochloa colona	168.0	57.6	110.4
Alysicarpus vaginalis	91.9	74.5	17.4
Macroptilium artropurpureum	156.0	35.6	120.4
M. lathyroides	123.9	154.5	-30.6
Lablab purpureus	167.7	117.7	50.0
Psophocarpus palustris	112.0	57.2	54.8
Vigna radiata	91.8	55.8	36.0
± SE	15.41	15.09	19.82
P <	0.01	0.01	0.01

By October 1987, however, infiltration rates in all treatments except M. lathyroides had decreased significantly ($P<0.01$), but remained relatively high in plots planted to L. purpureus. The woody nature of M. lathyroides and L.purpureus crop residue may result in a lower breakdown rate of mulch, and consequently maintenance of a high infiltration rate for longer periods than is possible with other cover crops. Lowest values of diurnal soil temperature were dound in plots planted to M. artropurpureum. P. palustris and L. purpureus in 1986, whereas highest values were found in plots planted to C. cajan, bare fallow and Z mays in 1986 ($P<0.01$) (Fig. 6.2). Apparent pore size distribution at depths of 0.30 m and 0.60 m was significantly affected by cover crop (Table 6.8). Proportion of macropores (pore radius, $r>14.3$ µm) was greatest ($P<0.01$) and micropores ($r<2$ µm) lowest ($P<0.01$) where M. atropurpureum, M. lathyroides, L. purpureus, P. palustris and E. colona were sown in 1986. Proportion of mesopores ($r = 2\text{-}14.3$ µm) was not significantly affected by cover crop, while the proportion of macropores at 0.30 m and 0.60 m were related to cover crop root density in the 0.20-0.50 m and 0.50-0.75 m depths during 1986 as follows:

$$0.30 \text{ m: } \Sigma m = 31.54 + 2.11 \ln Rw \quad r = 0.53^{***}, n = 48;$$

$$0.60 \text{ m: } \Sigma m = 32.45 + 0.72 \ln Rw \quad r = 0.64^{***}, n = 48;$$

where m is proportion of macropores (%) and Rw is root weight per unit area (kg ha^{-1}). Seasonal soil matric potential was greatest at depths of 0.30 m and 0.60 m where M. artropurpureum, M. lathyroides, L. purpureus, P. palustris and E. colona, were planted and lowest where C. cajan bare fallow and Z. mays were

Fig. 6.2: Effect of preceding cover crop on diurnal variation of soil temperature at a depth of 30 mm at 45 and 70 days after planting during the growing season of 1987. Zea mays ——Δ——; Digitaria ciliaris ---▲---; Echinochloa colona ---▲---; Lablab purpureus —■—; Macroptilium artropurpureum ---□---; M. lathyroides ---■---; Psophocarpus palustris ——□——; Cananus cajan ---O---; Alysicarpus vaginalis ---O---; Vigna unguiculata ---▲---; V. radiata ---●---; Bare fallow ——●——.

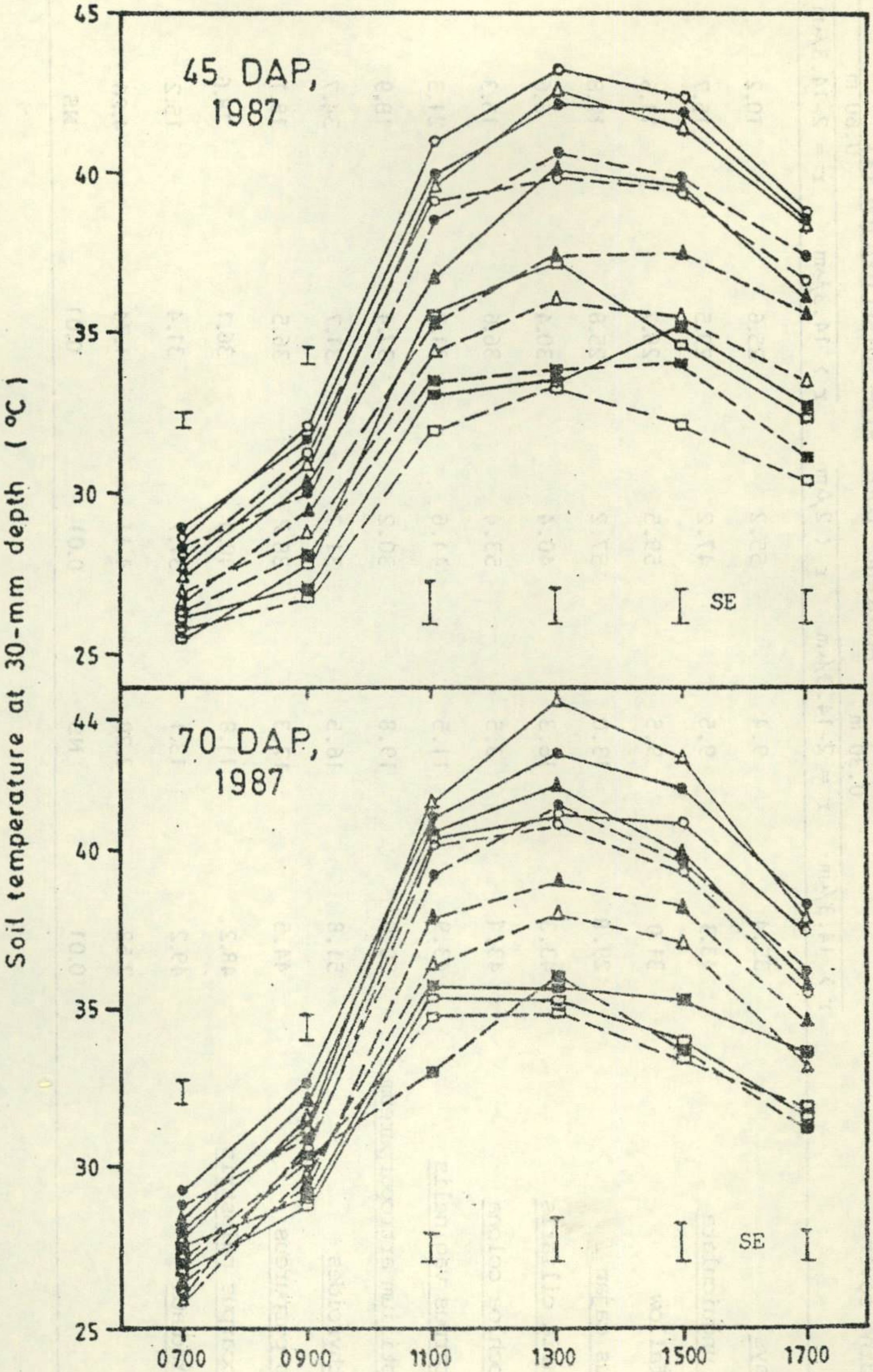
45 DAP,
1987
70 DAP,
1987
Soil temperature at 30-mm depth (°C)
45
40
35
30
25
44
SE
0700
0900
1100
1300
1500
1700
Time (hour)

Figure 6.2.

Table 6.8. Effect of preceding cover crop on apparent pore size distribution at depths of 0.30m and 0.60m (r = pore radius).

Preceding cover	Apparent pore size distribution (%)					
	0.30 m			0.60 m		
	r > 14.3 μm	r = 2-14.3 μm	r < 2 μm	r > 14.3 μm	r = 2-14.3 μm	r < 2 μm
Zea mays	35.4	9.4	55.2	25.6	10.2	64.2
Vigna unguiculata	43.3	9.5	47.2	29.5	15.7	54.8
Bare fallow	31.0	9.5	59.5	28.7	11.6	59.7
Cajanus cajan	29.8	13.0	57.2	25.8	12.8	61.4
Digitaria ciliaris	43.3	16.3	40.4	30.4	6.6	63.0
Echinochloa colona	43.1	3.5	53.4	36.6	15.3	45.1
Alysicarpus vaginalis	43.9	11.5	44.6	31.2	21.3	47.5
Macroptilium artropurpureum	50.0	19.8	30.2	37.4	18.9	43.7
M. lathyroides	51.8	16.5	31.7	31.7	34.7	38.4
Lablab purpureus	44.5	17.3	38.2	36.5	18.1	45.5
Psophocarpus palustris	48.2	11.8	40.0	36.1	18.6	45.3
Vigna radiata	49.2	13.1	37.7	31.4	15.2	53.4
± SE	2.52	3.29	4.11	1.74	4.26	3.07
P <	0.01	NS	0.01	0.01	NS	0.01

sown in 1986 ($P<0.01$) Mean seasonal soil matric potential (Ψm, -kPa) was related to proportion of pores with $r \leq \mu m$ (ξ, %) and mean of infiltration rates measured in January and October 1987 (dI/dt, mm h^{-1}) thus:

0.30m: $\Psi m = 225.56e^{-2.12 \times 10^{-2}\xi - 7.79 \times 10^{-3}(dI/dt)}$ $R = 0.70^{***}, n = 48$

0.60m: $\Psi m = 103.54e^{-4.92 \times 10^{-3}\xi - 3.94 \times 10^{-3}(dI/dt)}$ $R = 0.56^{***}, n = 48$

Emergence of maize in 1987 was most rapid and relative leaf water content greatest in plots sown in E. colona, M. artropurpureum, M. lathyroides, L. purpureus and P. palustris in 1986 ($P<0.01$) (Table 6.9). Conversely, emergence was slowest and relative water content lowest in treatments sown to Zea mays, C. cajan and bare fallow in 1986. Dry matter and grain yields were highest ($P<0.01$) in plots sown to M. artropurpureum and M. lathyroides in 1986. Moderately high maize yields were recorded where E. colona, P. palustris and L. purpureus were planted before maize. Grain (Y, Mg ha^{-1}) and dry matter (DM, Mg ha^{-1}) yields of maize were related primarily to mean soil matric potential at depths of 0.30 m ($\bar{\Psi}0.30$ -kPa) and 0.60 m ($\bar{\Psi}0.60$, -kPa) during tasseling (39-46 DAP) and late vegetative growth (21-38 DAP), respectively, as follows:

$Y = 1.98e^{-0.23 \bar{\Psi} 0.30 + 8.01 \times 10^{-2} \bar{\Psi} 0.60}$, $R = 0.84^{***}$, $n = 48$;

$DM = 16.05 - 1.52 \ln \bar{\Psi}_{0.30} - 1.97 \ln \bar{\Psi}_{0.60}$ $R = 0.92^{***}$, $n = 48$.

Significant yield increases of maize can therefore, be obtained in the Alfisols of the West African Sudan Savannah by rotation with cover crops such as M. artropurpureum and M. lathyroides when combined with minimum tillage practices. Such increases in yield are due to improvements in surface and subsoil physical properties, although increases in soil pH, OM, properties tend to be greater where ground cover formation and subsoil root growth of the cover crop were rapid.

Table 6.9 Effect of preceding cover crop on maize emergence, relative leaf water content at 1300 h, and crop yield during 1987.

Preceding cover crop	Emergence (%)		Relative leaf water content (%)				Yield (Mg ha^{-1})	
	4 DAP	5 DAP	37 DAP	45 DAP	60 DAP	72 DAP	Dry matter	Grain
Zea mays	23.5	54.9	87.0	79.0	77.8	65.0	1.1	0.2
Vigna unguiculata	30.4	77.4	88.7	84.3	80.7	70.0	1.6	0.2
Bare fallow	10.8	32.8	86.2	74.8	79.9	65.0	0.2	6.7×10^{-6}
Cajanus cajan	15.2	53.4	82.4	71.4	75.6	69.0	0.6	1.0×10^{-3}
Digitaria ciliaris	46.6	77.5	93.5	87.5	93.1	80.4	2.4	0.7
Echinochloa colona	75.7	91.6	93.2	95.4	94.1	89.4	3.3	1.1
Alysicarpus vaginalis	36.6	78.9	91.0	81.1	84.8	72.4	1.7	0.4
Macroptilium artropurpureum	76.0	91.7	93.9	94.7	96.2	89.6	4.3	2.2
M. lathyroides	74.6	86.3	93.6	91.5	93.3	90.4	5.0	2.4
Lablab purpureus	66.7	89.7	92.9	91.5	90.6	87.8	3.2	0.8
Psophocarpus palustris	63.2	85.8	90.3	91.1	97.0	90.2	3.9	1.5
Vigna radiata	40.7	75.0	92.4	82.5	83.8	70.9	2.0	0.5
± SE	6.17	7.67	1.33	2.52	2.11	1.75	0.32	0.16
P <	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

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