SEMI-ARID FOOD GRAIN

RESEARCH AND DEVELOPMENT

STRC/OAU JOINT PROJECT 31

S A F G R A D

AND

IDRC-UPPER VOLTA NATIONAL
COWPEA IMPROVEMENT PROGRAM

REPORT 1979

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

I.I.T.A

B.P. 1783, OUAGADOUGOU (UPPER VOLTA)

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Ouagadougou, April, 1980.

V.L. Asnani
Project Leader

PERSONNEL

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* Co-operators who returned the results before compiling this report.

INTRODUCTION :

The Scientific and Technical Research Commission of the Organisation of African Unity (OAU/STRC) and the U.S. Agency for International Development (USAID) agreed in 1977 to establish a regionally oriented research and development program designated to develop and promote improved cereal and legume crop varieties and cultural practices compatible with African small farmer in Semi-Arid farming systems. This project is known as Semi-Arid Food Grains Research and Development (SAFGRAD) project and is also referred to as OAU/STRC Joint Project 31 (JP-31). The Research and Development work under SAFGRAD project is divided in three components namely (1). Sorghum, millet and groundnuts (2) maize and cowpea and (3) Farming systems. USAID and OAU/STRC have invited the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) for the first component and the University of Purdue U.S., for the third component mentioned above. The International Institute of Tropical Agriculture (IITA) has been invited to undertake regional research and training activities for maize and cowpeas in this project. The Government of Upper Volta agreed to host this effort at the national agricultural research station, Kamboinsé which is used as the headquater for IITA/SAFGRAD component.

I.I.T.A. has placed four of its research scientists viz the maize breeder, maize agronomist, soil fertility specialist (cowpea agronomist) and an entomologist to carry out IITA/SAFGRAD component of SAFGRAD project. In addition to these four positions, IITA has also placed one scientist (cowpea breeder) at Kamboinsé under a seperate bilateral contract with Government of Upper Volta and IDRC Canada for developing the national cowpea improvement program. The cowpea breeder in this project provides the cowpea breeding support to SAFGRAD project in addition to his full time involvement in the national cowpea program. IITA, thus, carries out the program through two teams viz (1) the maize team (breeder, agronomist and entomologist) and (2) the cowpea team (breeder, agronomist and entomologist) with the back-stop support being provided by the IITA core scientists in the cereal improvement program (CIP) and the grain legume improvement program (GLIP) based at IITA, Ibadan (Nigeria).

This year (1979), was the first operational year for all the IITA/SAFGRAD Scientists based in Upper Volta although an initial start was made in the year 1978. For IDRC-national cowpea program, this year was the third year. This report presents the progress of work done in the year 1979.

After completing an intensive French language course in France, most of IITA/SAFGRAD staff arrived in Upper Volta in April-May 1979. Immediate task was to develop the research plans for this year and to create moderate research facilities and infrastructure, so as to ensure that the first season is not lost.Required land and land preparation for various trials at different locations were arranged with the cooperation of IRAT, ORD, ICRISAT and CERCI. Support staff were hired and office buildings at Kamboinsé were arranged and furnished. Seven hactares of land at Kamboinsé was cleared and properly developed for conducting the research trials at Kamboinsé. Efforts were also made to develop contacts with different research workers and organisations, in order to understand the work which has already been done or is in progress so as to avoid unnecessary duplications. This being the first year of our operation, we recognise that various activities performed and reported in this report may not be absolutely perfect.

This report has been edited for conciseness and clarity and details that some readers require may have been eliminated in the process. Additional information may be obtained by addressing a request to the appropriate scientist concerned.

PHYSICAL ENVIRONMENT : SOILS AND WEATHER

IITA/SAFGRAD maize and cowpea research trials were conducted at six locations in Upper Volta representing different agro-climatic regions. These locations were (1) Farako-Bâ (Bobo-Dioulasso), (2) Kamboinsé, (3) Saria, (4) Kaya, (5) Ouahigouya and (6) Saouga. Geographic location (latitude), rainfall and temperature data during the crop season 1979 at all the six locations is given in Table 1.

Farako-Bâ is about 10 km from Bobo-Dioulasso which is about 360 km South-West from Ouagadougou. Kamboinsé is about 15 km North and Saria is about 80 km West of Ouagadougou.
Kaya and Saouga are about 105 km and 300 km North from Ouagadougou. Ouahigouya is located about 180 km North-West from Ouagadougou.

Farako-Bâ lies in the mean annual rainfall zone of about 1100 mm while the annual mean rainfall at Kamboinsé and Saria is between 750 - 800 mm. The average rainfall at Kaya, Saouga and Ouahigouya is about 700, 600 and 500 mm per year respectively.

Soils at Farako-Bâ are classified as ferrallitiques where as soils at Kamboinsé and Saria are "ferrugineux tropicaux". Kaya and Ouahigouya have soils which are grouped as "sols peu évolués d'érosion sur materiau gravillonnaire" and the soils of Saouga are classified as "sols halomorphes à structure dégradée".

Rainfall during 1979 was quite regular and adequate at Kamboinsé and Farako-Bâ. A severe drought for more than two weeks was experianced at Saria at about 35-40 days after planting. Similarly a dry spell of two weeks was also experianced at Saouga. This affected adversly the crop growth at these locations. A sandstorm which came about 10 days after planting at Saouga also affected the crop growth.

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

DECLARATION :

Mention of particular pesticide, herbicide and other chemicals in this report does not imply endorsement of or discrimination against any product by the IITA programmes.

Rainfall and temperature data for locations where maize and cowpea trials were conducted in 1979.

Données de pluviométrie et temperatures des localités où les essais de maïs et de niébé ont été conduits en 1979.

Month - Mois	Location - Localité															
	Farako-Bâ (11°06'N)			Saria (12°16'N)			Kamboinsé (12°28'N)			Kaya (13°28'N)	Ouahigouya (13°35'N)			Saouga (14°23'N)		
	Précipitation Rainfall (mm)	Temperature (C°)		Précipitation Rainfall (mm)	Temperature (C°)		Précipitation Rainfall (mm)	Temperature (C°)		Précipition Rainfall (mm)	Précipition Rainfall (mm)	Temperature (C°)		Précipition Rainfall (mm)	Temperature (C°)	
		Max.	Min.		Max.	Min.		Max.	Min.			Max.	Min.		Max.	Min.
July Juillet																
1 - 10	33.2	30.2	21.9	28.8	31.0	23.2	31.7	32.4	23.0	7.4	16.0	33.4	24.5	2.0	36.9	26.1
11 - 20	41.4	32.7	21.3	24.3	31.3	22.2	45.6	32.7	22.6	5.1	23.0	34.6	25.7	90.7	36.9	27.1
21 - 30	147.2	29.4	20.8	85.7	30.6	21.5	64.8	32.0	22.1	52.7	41.0	37.5	25.7	0.0	34.6	23.5
Total	221.8			138.8			147.5			55.2	80.0			92.7		
August Août																
1 - 10	82.4	29.9	21.6	18.3	31.4	21.8	63.1	31.9	23.0	1.6	17.0	35.5	24.0	24.9	36.4	24.6
11 - 20	5.1	31.0	22.5	8.5	32.1	22.7	24.4	31.8	21.8	23.2	47.5	33.7	23.1	15.4	35.9	24.4
21 - 30	193.0	28.9	21.1	111.7	30.2	21.6	114.9	30.6	23.3	72.9	34.0	35.2	24.2	72.6	36.5	25.2
Total	280.5			138.5			202.4			97.7	98.5			112.9		
September Septembre																
1 - 10	109.1	28.1	20.3	111.3	29.7	21.4	115.8	31.5	21.3	43.5	10.0	31.3	22.0	19.7	32.6	21.9
11 - 20	22.1	30.9	21.2	47.5	31.9	21.5	46.9	32.4	22.0	35.4	17.5	34.9	23.1	0.0	37.4	25.0
21 - 30	25.0	31.9	21.1	59.0	32.9	21.7	32.7	33.0	22.8	2.2	74.0	35.1	22.9	0.0	37.6	25.2
Total	156.2			217.8			194.5			81.1	101.5			19.7		
Oct.																
1 - 10	19.9	32.4	22.2	5.5	34.3	22.4	5.7	35.1	23.4	10.0	1.5	36.6	23.9	9.8	39.8	25.4
11 - 20	4.9	33.1	21.3	28.0	34.7	22.7	5.9	35.1	23.2	31.6	46.0	-	-	16.1	-	-
21 - 30	4.5	33.6	20.6	6.0	34.9	22.2	1.9	35.8	22.6	7.2	0.0	-	-	0.0	-	-
Total	29.3			39.5			13.5			48.8	47.5			25.9		
TOTAL	637.8			534.6			557.9			312.8	327.5			251.2		

: Temperature date are from Dori which is 40 km south of Saouga (Les données de température sont de [illegible] 40 km au Sud de Saouga).

MAIZE

MAIZE IMPROVEMENT

A) BREEDING

The objectives of maize breeding efforts for 1979 were :

(1) To evaluate the maize germplasm available in various national and international institutions under the Semi-Arid environment.

(2) To organise a regional testing program to evaluate and identify the promising maize varieties which could be used in various nationalprogram directly or as a source of breeding material.

(3) To promote exchange of results and research ideas among the national scientists in the SAFGRAD member countries.

(4) Development of high yielding early and medium maturing varieties and populations tolarant to environmental stresses commonly encountered in the Semi-Arid Tropics.

(5) Assist in strengthening the national maize improvement programs in SAFGRAD member countries by man power development (through various types of training programs) and by providing the technical advice on the research problems through personal visits.

The work done towards accomplishing the five objectives can be grouped under two major activities :

(1) Regional effort

(2) On-site experiments at research stations in Upper Volta.

1) REGIONAL EFFORT

In order to define and develop a regional program the first SAFGRAD maize workshop was organised from February 20 to 23, 1979 at Ouagadougou. Maize researchers (mostly breeders) from 16 national programs attended and participated in the workshop. In addition to other important recommendations one of the decision adopted in the workshop was to develop and organise the Semi-Arid Adaptation Testing(SARMAT) to be coordinated from the SAFGRAD headquater at Kamboinse. Under the SARMAT program it was decided to have two Regional Uniform Variety Trials (RUVT-1 and RUVT-2) and four Regional Family Testing Trials (RFTT-1, RFTT-2, RFTT-3 and RFTT-4). This activity was carried out during the season 1979 and the results are summarised below.

Regional Uniform Variety Trial-1 (RUVT-1) :

This trial consisted of early maturing varieties (80-90 days maturity) which have been found to be promising in different national programs who nominated the variety/varieties to be included in this regional trial. Twelve varieties were tested in

.../...

a RBD trial with four replications. The plot size was 4 rows 5 meter long. This trial was sent to Rep. of Benin, Cameroon, Mauritania, Ghana, Mali, Ivory Coast, Senegal, Sudan, Guinea and Upper Volta.

Data on germination, days to flower, plant height, ear height, stalk and root lodging, number of plants harvested, total number of ears, number of diseased ears, plant diseases and yield were recorded.

Results from Rep. of Benin, Mali, Ivory Coast, Senegal, Gambia and Upper Volta were received and statistically analysed. In the remaining countries either the seed could not reach in time (due to phytosanitary clearance or air freight delays) or the trial could not be planted due to other reasons.

Statistical analysis indicated significant differences among the varieties for grain yield at all the locations. Number of plants harvested showed significant difference in Senegal and Kamboinse. Days to flower showed significant difference in Senegal. Grain yield (kg/ha) and days to flower for the varieties tested in this trial are given in Table 1 and Table 2 respectivoly. There were considerable differences in the performance of varieties at different locations. At Kamboinse (Upper Volta) BDS III gave the the highest yield of 5945 kg/ha followed by Jaune de Fo, IRAT 100, ZM 10 and Massayomba with no significant difference among these varieties. At Saria (Upper Volta) the highest yielding variety was IRAT 100 (3400kg/ha) withBDS III, Massayomba, IARZ E3, TZE4, TZE3 being statistically at par. Highest yielding variety at Sefa (Senegal) was local check (3570 kg/ha) followed byZM10 and IRAT 100. At Bouake (I. Coast) the yield levels were generally very low due to heavy lodging and % CV was also very high. IRAT 100 and local check were top yielders with no significant difference between two varieties. The yields at Masantola (Mali) were also low. BDS III, IRAT 100, ZM 10 and Jaune de Fo were promising. At Kogoni, in Mali, the highest yielding variety was BDS III (4930 kg/ha) closely followed by IRAT 100. At Ina in Rep. of Benin the yield levels were very low and the C.V. was high. Considering the average performance of these varieties across all the location, it was seen that IRAT 100 was the highest yielding entry (3023 kg/ha) followed by BDS III (2970 kg).

Regional Uniform Variety Trial-2 (RUVT-2)

Twelve medium maturing varieties nominated by various national and international institutions on the basis of earlier performance in their national programs were tested in this trial. Randomised block design with four replications was adopted to conduct the trial. The plot size was four rows five meter long. The trial was sent to Rep. of Benin, Ivory Coast, Senegal, Mauritania, Mali, Ghana, Gambia, Sierra Leone and Upper Volta. Data were recorded on the same characters as indicated earlier in RUVT-1.

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Tableau 1. Rendement en grains (kg/ha) des variétés testées dans RUVT-1 en 1979.

Table 1. Grain yield kg/ha of varieties tested in RUVT-1, 1979.

Variety Variété	Origin Origine	Kamboinsé Upper Volta	Saria Upper Volta	Sefa Senegal	Bouaké I. Coast	Masantola Mali	Kogoni Mali	Ina Benin	Average Moyenne
Massayomba	U. Volta	4165	2947	2005	1190	1020	3712	963	2286
Jaune de Fo	U. Volta	4313	2210	2567	1020	1473	3712	1003	2328
IRAT 100	U. Volta	4301	3400	2624	2550	1587	4602	2097	3023
ZM 10	Senegal	4250	2590	2919	980	1473	3259	759	2319
BDS III	Senegal	5945	3077	2400	1320	1813	4930	1303	2970
Comp. D	I. Coast	3910	2023	1320	227	1247	2182	1077	1712
Comp. M	I. Coast	3227	2590	1042	482	1303	3627	680	1950
IARZ E1	Nigeria	2391	1609	1604	215	680	3372	363	1462
IARZ E3	Nigeria	3446	2834	2465	612	1110	3230	1031	2104
TZE3	IITA	3927	2703	2340	612	1417	3287	1099	2198
TZE4	IITA	3950	2731	2114	1037	1133	3015	1247	2175
Check Témoin		3780	2397	3570	2023	1360	1927	1587	2378
C.D. 5 %		1756	798	980	702	357	1014	652	
C.V.		13,8 %	6 %	15 %	49 %	20,0 %	20,6 %	40,7 %	

Tableau 2 Délais de floraison des variétés testées dans l'essai RUVT-1 en 1979

Table 2 Days to flower of varieties tested in RUVT-1, 1979.

Variety Variété	Origin Origine	Kamboinse Upper Volta	Sefa Senegal	Bouake I. Coast	Kogoni Mali	Ina Benin	Average Moyenne
Massayomba	U. Volta	52	61	61	54	56	57
Jaune de Fo	U. Volta	51	57	55	50	56	54
IRAT 100	U. Volta	53	60	60	52	59	57
ZM-10	Senegal	51	56	57	51	56	54
BDS III	Senegal	50	56	56	47	54	53
Comp. D	I. Coast	47	52	53	45	47	49
Comp. M	I. Coast	51	57	58	49	53	54
IARZ E_1	Nigeria	50	57	60	47	54	54
IARZ E_3	Nigeria	51	55	58	49	54	53
TZE3	IITA	48	52	55	45	47	49
TZE4	IITA	49	53	53	45	48	50
Check		51	56	62	45	52	

Till February 1980, the results have been received from Ivory Coast, Senegal, Mali, Gambia and Upper Volta. At other places either the trial could not be planted or the data has not been returned. Data received from various countries has been statistically analysed and the results are summarised below.

Significant differences among varieties were found for grain yield at all the locations. Grains yield (kg/ha) and days to flower for all the varieties are presented in Table 3 and Table 4, respectively. Varieties performed differently at different locations. At Bobo-Dioulasso (Upper Volta) IRAT 102 gave the highest yield (3117 kg/ha) which was not significantly different from the yield of N.H.2. Two varieties namely TZB and IRAT 80 fall in the second group in terms of their performance. In Senegal, control check variety was the top yielder followed by N.H.2 and Jaune de Fo which were at par to the check variety. TZB was the highest yielding variety (2765 kg/ha) in Ivory Coast closely followed by TZPB. Serious lodging was experienced at this location (Bouaké) and it was interesting to note that TZB and TZPB were the only varieties which showed some level of standability in the field. Sotuba (Mali) was the only location where reasonable yields have been obtained in this trial. In addition, C.V. is also low and, therefore, the results are more reliable. IRAT 102 gave the highest yield (6744 kg/ha). Other varieties which were at par to IRAT 102 are TZB, TZSR (W), TZPB and comp. Y. On the basis of average performance across all the locations, IRAT 102 gave the highest yield (3398 kg/ha) closely folloowed by TZB (3192 kg/ha) and N.H.2 (3169 kg/ha).

Table 4 which records days to flower indicated that on an average Tiemantie was the earliest among the group (59 days) while TZSR (W) took the maximum days (65 days). IRAT 102 and TZB took 62 and 64 days to flower respectively.

Regional Family Testing Trials :

Four base populations namely TZE3, TZE4 (both early maturing),TZB and TZPB (both medium maturing) were identified to be the promising materials to initiate the population improvement program through the SAFGRAD net work. Full-sib families in all the four populations were developed at Saria (Upper Volta) during 1978 season. In the 1979 SAFGRAD workshop it was decided to test these full-sibs in some countries having a stronger national programs. Thus four full-sib family testing trials (RFTT) were organised with an objective of selecting the families which are most adapted to this region and then to utilise the selected families in reconstituting the four populations. Through such recrurrent selection program it should be possible to shift these populations for better adaptation to semi-arid conditions. Because of the limited quantity of the seed of full-sib families, it was decided to conduct each RFTT trial in three countries.

RFTT-1 and RFTT-2 consisting of 140 full-sibs of TZE4 and TZE3 respectively

Table 3 Grain yield (kg/ha) of varieties tested in RUVT-2, 1979.

Tableau 3 Rendement en grain (kg/ha) des variétés testées dans l'essai RUVT-2 en 1979.

Variety Variété	Origin Origine	Bobo Upper Volta	Senegal	Bouake I. Coast	Sotuba	Mean Moyenne
Massayomba	Upper Volta	1433	1870	1008	5214	2381
Jaune de Fo	Upper Volta	1360	2193	867	5225	2411
IRAT 102	Upper Volta	3117	1530	2199	6744	3398
IRAT 80	Upper Volta	2142	1275	1122	4080	2155
Tiemantie	Mali	1360	1218	566	4658	1951
Comp. Y	I. Coast	1717	1910	839	5950	2604
N.H.2	Benin	2720	2590	1813	5554	3169
C.J. 1	Benin	1320	1558	980	4194	2013
TZSR (W)	IITA	1587	1683	1643	6460	2843
TZPB	IITA	1320	1530	2539	6177	2892 ✓
TZB	IITA	2114	1315	2765	6574	3192 ✓
Control - Témoin		1915	2816	2153	3542	2607
C.D. 5 %		750	816	538	1173	
C.V. %		28.5	31.6	24.8	15.1	

Tableau 4 Délais de floraison des variétés testées dans l'essai RUVT-2 en 1979.

Table 4 Days to flower for varieties tested in RUVT-2, 1979.

Variété Variety	Origine Origin	Bobo Upper Volta	Senegal	Bouake I. Coast	Moyenne Mean
Massayomba	U. Volta	66	61	61	63
Jaune de Fo	U. Volta	62	59	59	60
IRAT 102	U. Volta	63	63	61	62
IRAT 80	U. Volta	66	62	62	63
Tiemantie	Mali	51	64	62	59
Comp. Y	I. Coast	66	59	61	62
N.H. 2	Benin	62	58	59	60
C.J.1	Benin	68	62	62	64
TZSR (W)	IITA	68	62	64	65
TZPB	IITA	61	63	63	64
TZB	IITA	64	64	63	64
Control Témoin		67	58	62	62

were sent to Senegal, Upper Volta and Nigeria. Like wise, 140 full-sibfamilies of TZPB and TZSR (+ TZDS) were sent in separate trials namely RFTT-3 and RFTT-4 respectively to Rep. of Benin, Ivory Coast and Upper Volta. Four check varieties were included in each trial thus making a total of 144 entries. 12 x 12 simple lattice design with two replications was utilised for all the RFTT trials. The plot size was one row plot five meter long. Data on all the characters listed under RUVT-1 trial were recorded in these trials.

At the time of writing this report data from I. Coast, Senegal and Upper Volta were received. Based on the results of at least two countries 45-50 full-sib families were selected from each of the RFTT trials and the selected families were planted in the irrigated nursery (in December 1979) at Kamboinse to generate new set of full-sibs in all the four populations to be tested in RFTT trials in 1980.

Grain yield (kg/ha)of the selected families in RFTT-1, RFTT-2,RFTT-3 and RFTT-4 are given in the Tables 5, 6, 7 and 8 respectively.

In RFTT-1, the grain yield of full-sib families tested at Bobo (Upper Volta) ranged from 667 to 4806 kg/ha. While these families yielded from748 to 4138 kg/ha at Senegal. Mean grain yield of all the families averaged over both the locations was 1976 kg/ha. Mean grain yield of selected families averaged over both locations was 2559 kg/ha (29 % higher). Like wise the mean grain yield of TZE3 population (overall mean of all families tested inRFTT-2)was 2588 kg/ha while the mean grain yield of selected families was 3081 kg/ha (19 % higher). Grain yield varied from 213 to 2248 kg/ha in Senegal and from 1640 - 5566 at Kamboinse in Upper Volta. In RFTT-3 (TZPB) the grain yield of families varied from 4686 to 12567 at Fereke, I; Coast and from 1258 to 4743 kg/ha at Saria, Upper Volta. The average yield of selected families was 6151 kg/ha which was 19 % more than the population mean (5160 kg/ha). Full-sib families tested in RFTT-4 yielded from 3408 to 10330 kg/ha at Fereke, I. Coast and from 2300 to 6326 kg/ha at Kamboinse, Upper Volta. Mean grain yield of all the families tested in this trial was 5239 kg/ha and the average yield of the selected families was 6052 which is about 15 % higher than the population. With this recurrent selection scheme implemented through SAFGRAD regional testing network, it is hoped that the base populations can be substantially improved for the grain yield <u>per se</u> and for the greater adaptability in the semi-arid zone. After completing few cycles of selection in these populations, as and when other promising populations are identified these could either be added to the on going recurrent selections scheme or could be used to replace some of the populations which are now being used in this program.

<u>Visits to National Programs</u> :

One of the important activity of IITA/SAFGRAD teams was to visit the national programs to understand the production problems and to discuss the ways and means to

Tableau 5 Rendement en graine des familles sélectionnées traitées en RFTT-1.

Table 5. Grain yield (kg/ha) of selected families tested in RFTT- 1. 1979.

Entrée N° Entry N°	Bobo Upper Volta	Senegal
5	2403	4138
8	2136	2617
10	3071	2269
11	2536	2136
16	2803	1549
19	2670	1682
23	2803	3604
27	2536	3952
31	2937	1602
32	1335	2670
37	3337	3471
44	4806	3471
47	935	2403
48	1602	2670
52	1869	2937
53	2830	2803
54	3070	3070
61	1468	2536
62	2670	1282
68	4539	2403
69	2136	2136
72	1735	2803
73	2803	2617
74	2670	2536
76	2002	3738

Entrée N° Entry N°	Bobo Upper Volta	Senegal
85	2136	2483
86	2803	1735
87	1869	2750
90	2670	1148
92	3738	1335
94	2536	2617
97	3204	1549
99	1335	3017
101	3471	4005
102	3204	2536
103	2536	2403
106	2670	2536
107	2803	2937
108	1735	2670
109	1735	2536
110	2803	1549
113	1735	3471
118	3204	1735
119	2670	2937
127	2136	2884
128	2136	2937
136	2803	3204
140	1468	2536

Variation = 667 - 4806 748-4138
Range

Mean all families averaged over both locations : 1976

Moyenne de toutes les familles établies dans les deux localités : 1976

Mean selected families averaged over both locations : 2559

Moyenne des familles sélectionnées établies dans les deux localités = 2559

Tableau 6 Rendement en grains (kg/ha) des familles sélectionnées testées en RFTT-2 en 1979

Table 6 Grain yield (kg/ha) of selected families tested in RFTT-2, 1979.

Entrée N° Entry N°	Senegal	Kamboinsé Upper Volta
2	1384	5159
3	1917	5082
9	1917	4598
12	2513	5033
23	1491	5082
28	2449	3243
30	1917	4840
34	1917	4066
39	1917	3775
51	1874	3049
57	1129	4840
58	1981	3920
59	2513	4356
69	809	5082
70	2407	3533
72	1235	4985
76	958	5034
81	1874	3533
84	1172	4840
86	2236	3049
91	1704	3388
94	1342	4598
97	958	5227
98	1278	5130
99	1917	4356
103	2087	4501
104	1597	4937
108	1597	5034
109	1981	4646
114	852	5082
116	1278	5276
118	1597	5034
119	1384	5324
121	1448	4792
123	916	4598
125	1278	4985
126	1278	4791
128	1235	5130
129	2236	3969
131	852	4888
134	1491	4259
136	1065	4549
137	1384	4985

Variation = 213 - 2248 1640-5566
Range = " " " "

Mean all families averaged over both locations = 2588

Moyenne de toutes les familles établies dans les deux localités = 2588

Mean selected families averaged over both locations = 3081

Moyenne des familles sélectionnées dans les deux localités = 3081

Tableau 7. Rendement en grains (kg/ha) des familles testées en RFTT-3, 1979.
Table 7. Grain yield (kg/ha) of selected families tested in RFTT-3, 1979.

Entrée N° Entry N°	Fereke I. Coast	Saria H. V.
5	10117	3243
6	9159	3581
10	10117	2420
15	10011	3388
17	10969	1984
20	10224	3098
25	10650	3340
27	9372	3194
33	12567	3098
44	7029	3146
48	6496	3388
56	10224	2323
59	7668	2904
63	7668	3001
65	10437	2807
67	10543	2614
68	9798	2904
69	8946	4743
72	7881	3194
75	8733	3001
78	7029	3243
79	9585	2904
84	8094	3049
86	7455	3436
89	10011	2759

Entrée N° Entry N°	Fereke I. Coast	Saria H. V.
92	10011	2904
93	7668	4452
96	8733	3098
97	9372	3775
102	8733	3001
113	7987	4162
114	10011	2372
118	10011	2517
121	8307	3340
123	9159	3678
125	9798	3291
131	6816	3582
133	10011	2759
136	8946	2904
137	10650	2468

Variation = 4686-12567 1258-4743
Range = " " " "

Mean all families averaged over both locations = 5160

Moyenne des familles établies dans les deux locations = 5160

Mean selected families averaged other both locations = 6151

Moyenne des familles sélectionnées établies dans les deux localités = 6151

Tableau 8. Rendement en grains des familles sélectionnées testées en RFTT-4, 1979.
Table 8. Grain yield (kg/ha) of selected families tested in RFTT-4, 1979.

Entrée N° Entry N°	Rendement Yield	
	Fereke I. Coast	Kamboinse Upper Volta
3	5751	4686
6	7455	4047
9	3621	4345
12	4686	4303
13	5964	5261
14	5325	5261
17	7881	5261
18	6070	5538
22	8307	3962
25	8520	5261
30	7029	5495
34	9585	4771
41	7455	4047
46	5964	5218
55	4899	5410
59	6390	4536
61	9585	6219
62	5112	5218
65	8733	4494
66	8733	6326
68	9159	5261
69	9585	4686
78	6177	4111
81	5964	4835
83	7668	4537

Entrée N° Entry N°	Rendement Yield	
	Fereke I. Coast	Kamboinse Upper Volta
85	8094	4835
86	8307	4494
87	7668	4686
88	7135	6027
90	7668	4047
91	8733	4388
92	5751	5112
95	7455	5943
99	4984	4920
103	7029	4771
107	5964	5155
113	6603	5495
115	7774	5112
116	6603	5602
119	8946	4835
123	6390	5069
128	10330	3365
130	7881	4835
133	6390	5112
135	8520	3813
136	7668	4579

Variation = 3408-10330-2300-6326
Range = " " " "

Mean all families averaged over both locations = 5239
Moyenne des familles établies dans les deux localités = 5239

Mean selected families averaged over both locations = 6052
Moyenne des familles sélectionnées établies dans les deux localités = 6052

integrate SAFGRAD efforts into various national programs. Sincere efforts were made by SAFGRAD team to visit as many national programs as possible. This provided an additional oportunity to monitor the SAFGRAD regional trials and the other international trials sponsered by different organisations. During 1979 IITA/SAFGRAD team members visited thirteen countries. These visits proved to be very useful in various ways.

The other activity initiated this year was to organise a joint visit by national research workers to different national maize programs with an objective to develop better contacts among the nationalscientists to exchange ideas and results. One national maize research worker from each of the six SAFGRAD member countries was invited to visit six national programs namely Senegal, Mali, Upper Volta, I. Coast, Ghana and Rep. of Benin.

Two members (maize breeder and maize agronomist) of SAFGRAD/IITA team joined this group visit which was organized during the crop season in September 1979. This group visit provided a unique opportunity to evaluate various materials included in SAFGRAD regional trials which were being conducted in different national programs. This program proved to be extremely informative for everybody and it was recommended that such visits should be extended to cover more country programs in the next year.

2) ON-SITE EXPERIMENTS AT RESEARCH STATIONS IN UPPER VOLTA

In Upper Volta,the SAFGRAD research trials were conducted at three locations namely (1) Kamboinse (2) Saria and (3) Bobo-Dioulasso. Geographic location of these sites and the weather data for all the locations are given in the beginning of this report.

In all, ten varietal trials were conducted. There were : (1) RUVT-1 ; (2) RUVT-2 (3) RFTT-1 ; (4) RFTT-2 ; (5) RFTT-3 ; (6) RFTT-4 ; (7) country trial-1 ; (8) PET-1 ; (9) PET-3 and (10) TZPB (EPS) full-sib family trial. The results from two RUVT trials and four RFTT trials have already been presented in this report under regional activity. Results of other trials are summarised below :

Country Trial-1 :

In 1978 more than hundred varieties, composites and populations were evaluated at Saria in observation plots. Based on these results 49 cultivars were selected and evaluated in 7 x 7 lattice design with two replications at Kamboinse, Saria and Bobo in 1979. Plot size was four row plot five meter long.

Table 9 records the data on grain yield per hectare. Significant differences in grain yield were observed among the varieties at all the three locations. At Kamboinse, promising varieties were : Phil DMR Comp. 1, Composite 4, TZPB (Prolific), ATPF x Phil DMR E_2

.../...

Comp. Hungaria, Golden crystal Tuxp. x E to, TZB, NCARb, H 763, BDS III, Ant. Gpo. 1 x R.D ; S.A. white and BIU yellow all yielding more than 5000 kg/ha. At Saria the entries which had the yield of 3000 kg and above were : BDS III, NCARb, ATPF x Phil DMR E_2, Comp. Hungaria, Phil DMR Comp. 2, Tuxp x Eto, Cuban yellow, IRAT 100. At Bobo-Dioulasso the promising entries yielding more than 3500 kg/ha were : BIU yellow, $IPAE_2$ x U.V.F.S., Phil. DMR Comp. 1, IRAT 100, TZSR (W), BDS III and Shaba Safix Eto. On the basis of average yield over three locations, H 763 was the highest yielding entry (4590 kg/ha) followed by BDSIII (4306 kg/ha), Phil DMR Comp. I (4280 kg) and BIU yellow (4170 kg/ha). TZPB on an average yielded3693 kg/ha. IRAT-100, IRAT-80 and Massayomba yielded 3494, 3021 and 3329 kg/ha respectively. Among the early maturing varieties tested in this trial TZE4 yielded 3370 kg/ha. The other promising early maturing varieties were IPA E_2xU.V.F.S. (3744 kg/ha), ATPF x Phil DMR E_2 (3751 kg/ha) and ATPF F.S.7 x F.S.20 (3387 kg/ha).

Preliminary Evaluation Trials (PET-1 and PET-3)

Preliminary Evaluation Trial-1 (PET-1 and PET-3) were received from CIMMYT, Mexico and both the trials were conducted at Kamboinse in 1979. PET-1 consisted of tropical early maturing populations and PET-3 consisted of temperate or temperate x tropical populations generated by CIMMYT program. There were 10 entries in PET-1 and 18 in PET-3. Both trials were laid out as RBD with four replications. Plot size was four row plot five meter long.

Grain yield and days to flower for varieties tested in PET-1 and PET-3 are recorded in Table 10 and 11 respectively. Significant differences among varieties were observed in PET-1 while varieties in PET-3 did not show statistical difference for grain yield. None of the varieties tested in PET-1 trial was significantly superior to the highest yielding check variety (IRAT-102). However, Ant. Rep. Dominican (Pop. 35), Tropical early yellow dent (Pool 17) and Tropical early white dent (Pool 16) were quite promising. In PET-3 although the differences among varieties were statistically not significant Ant. Rep. Dominicana x corn belt, Temperate early yellow dent (Pool 30), Temperate intermediate yellow dent (Pool 34) and Temperate early white flint (Pool 27) were found to be promising from the point of grain yield and maturity.

TZPB (EPS) Full-sib Family Trial :

Full-sib families developed in TZPB (EPS) population at Ibadan (Nigeria) in 1978 were tested in RBD trial at Saria with an objective to select the most promising families for reconstituting the population adapted to Semi-Arid environment. On the basis of grain yield and other agronomic characters 50 families have been selectedand will be utilised for recombination in 1980 season.

In addition to the variety trials discussed above to identify the promising genotypes, some breeding effort was also done to generate new breeding materials as a

.../...

Tableau 9 Rendement en grains (kg/ha) des variétés testées dans l'essai Haute-Volta en 1979.

Table 9 Grain yield kg/ha of varieties tested in country trial 1 1979.

Variété Variety	Kamboinse	Saria	Bobo	Moyenne Mean
H 634	4715	2789	3344	3616
ATC 4388	3349	1430	3117	2632
H 763	5253	2570	3315	4590 ✓
Los Posta	4804	2036	2125	2988
Ant. Gp. x R.D.	5190	2158	2493	3280
Phil DMR Comp. 1	5680	2910	4250	4280
Mez. Amar. P.B.	4830	1261	2748	2946
Pioneer 304 A	4817	2668	3400	3628
Pozahica 7428	4868	2401	1615	2961
South African white	5049	1988	2862	3299
Blancocrist-1	4301	2570	3117	3329
Ant. Gp. 02 x TVxPB	4933	1940	1842	2905
Cuban yellow local	3967	3080	2323	3123
Mi x 1 x colG.p.1 x Eto	4845	2546	1757	3049
Phil DMR comp. 2	4572	3201	2919	3564
IW 91	1662	1237	1927	1608
Composite 4	5616	2207	3202	3675
TZSR (W)	3888	1649	3825	3121 ✓
Zaïre TUxpxEto	3345	3099	2833	3759
IDRN	4855	1649	2805	3103
TZPB (Bulk)	4624	2958	2522	3368 ✓
Comp. Hungaria	5463	3274	2522	3753
TZB (Bulk)	5333	2958	2210	3500 ✓
NCA RB	5282	3589	2635	3835
GRH	4521	1867	2182	2857
Ant. Gp. 2 sel Bl.	3865	2158	1077	2367
Shaba Safi x Eto	3104	1940	3542	2862
TZPB (POL.)	5602	2983	2493	3693
BIU yellow	5021	2304	5185	4170
Mexico 18	3916	2570	2663	3050
Ant. Gp.2xR.D.	4301	2134	2493	2976
Golden Crystal	5422	2837	2663	3641
TZY (Bulk)	4845	2352	3344	3514
TZE3	4212	1285	2720	2739
TZE4	4919	2498	2692	3370

Tableau 9 (suite)
Table 9 (Contd)

Variété Variety	Kamboinse	Saria	Bobo	Moyenne Mean
IRAT-100	3451	3007	4024	3494
IRAT-102	4505	2668	3202	3458
IRAT-80	4613	1746	2805	3021
Massayomba	4417	2255	3345	3329
(1 PAE 6 x U.V.) E1	4868	2231	3174	3424
PBI F.S. 11 x 10	3825	2813	2238	2959
PBI x U.V.S.2	3774	2983	2578	3112
BTPF x U.V. E1	4018	2837	2663	3173
$IPAE_2$ x U.V.F.S.	4636	2061	4534	3744
PBI x U.V.F.S. II	4959	2207	2975	3380
ATPF x Phil DMR E2	5588	3371	2295	3751
ATPF F.S. 7 x F.S. 20	4907	2789	2465	3387
BDS III	5216	3904	3797	4306
C.J. I	4505	1988	2890	3128

Tableau 10 Rendement en grains (kg/ha) et délais de floraison des variétés testées en PET-1 (CIMMYT à Kamboinsé) 1979.

Table 10 Grain yield (kg/ha) and days to flower of varieties tested in PET-1 (CIMMYT) at Kamboinse. 1979

Variétés Varieties	Rendement Grain yield	Jours de floraison Days to flower
Tropical Amarillo cristalino 2	4930	49
Tropical early white flint (Pool 15)	4930	48
Tropical early white dent (Pool 16)	5089	49
Tropical early yellow flint (Pool 17)	4874	48
Tropical early yellow dent (Pool 18)	5270	48
Ant. Rep. Dominicana (Pool 35)	5327	49
Ant. Rep. Domi. Pairu. Indonesia	4704	48
TZE4	3627	48
IRAT 102	4534	49
TZPB	3797	50
C.D. 5%	896	
C.V.	13.3 %	

d = 1 Day ??

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Tableau 11 Rendement en grains et délais de floraison des variétés testées en PET-3 (CIMMYT) à Kamboinsé en 197

Table 11 Grain yield (kg/ha) and days to flower of varieties tested in PET-3 (CIMMYT) at Kamboinse. 1979.

Variétés Varieties	Rendement en grains Grain yield	Jours de floraison Days to flower
Temperate early white flint (Pool 27)	4476	44
Temperate early white dent (Pool 28)	4052	45
Temperate early yellow flint (Pool 29)	4324	44
Temperate early yellow dent (Pool 30)	5015	43
Temperate Intermediate white flint (Pool 31)	3740	50
Temperate Intermediate white dent (Poll 32)	3667	51
Temperate Intermediate yellow flint (Pool 33)	3406	48
Temperate Intermediate yellow dent (Pool 34)	4573	49
Blanco Sub-tropical (Pop. 34)	4709	51
Amarillo Bajio (Pop. 45)	4233	48
Hungarian comp. (Pop. 48)	4194	48
Amarillo Bajio x Templados	4284	49
Ant. Rep. Dominicana x corn belt	4273	51
Indonesian comp x corn belt	5055	47
Selec. Planta Pequena Mazorca grande	4364	50
TZE4	3315	48
IRAT 102	4477	52
TZPB	3400	53
C.D. 5 %	N.S.	
C.V.	23.1	

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back-up activity for the SAFGRAD regional program. Breeding program carried out during the year is summarised below :

Seed increase of full-sib families included in RFTT trials :

Conventionally, it is the remanant seed of families selected through full-sib family trials (RFTT) that is used either to develop the experimental varieties or to reconstitute the base populations. However, this year, all the families included in four RFTT trials were also planted in breeding nurseries either at Kamboinse or at Saria for seed increase by hand pollinations. This was done to exercise a mild selection pressure on the families in semi-arid environment before the families selected from trials are utilised for recombination. In addition, this provided enough seed of the families to be utilised for various purposes.

Recombination of selected full-sib families :

All the families included in regional trials were planted (from 1979 seed increase plots) in irrigated nursery at Kamboinse in December 1979. By the time these families started flowering, data from most of the RFTT trials was in and the selected families (described in RFTT results) were utilised to generate new set of full-sibs in all the four populations during the second season at Kamboinse. These families will be now sent out in RFTT trials for 1980.

Recurrent selection program :

As a back-up program recurrent selection was carried out in TZPB (Prolific) and four early maturing populations at Saria and in U.S. x Tropical population at Kamboinse. Full -sib families developed in all these populations at IITA (Nigeria) in 1978 were planted in the SAFGRAD program this year. Selected plants in the selected families were utilized for developing new families by hand pollinations. These families will be evaluated during 1980 in the SAFGRAD resident program to carry out another cycle of selection before including these in the regional activity.

Evaluation of new introductions :

Several new materials received from various countries in Africa, Asia and South America were planted at Kamboinse for evaluation and seed multiplication. Promising introductions will be utilised in various breeding programs.

SAFGRAD MAIZE AGRONOMY PROGRAM

SUMMARY OF ANNUAL REPORT

1979

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1. INTRODUCTION

The Maize Agronomist arrived at Ouagadougou on February 19, 1979 in order to participate in the First SAFGRAD Maize Workshop (February 20 - 23, 1979) and spent then 2 months in France (March - April) in French language training courses. Upon return to Ouagadougou in early May, immediate steps were taken to try to make as much use as possible of the growing season. Based on a preliminary (and far from comprehensive review of some of the pertinent literature, much of it coming from IRAT, and on information arriving from personal contacts with some of the scientists already working in the area, several research projects and experiments were selected as being of potential interest. It was felt that given the Maize Agronomist's lack of experience with the particular conditions of the Semi-Arid Tropics and the relative lack of information on the main agronomic problems relevant to the culture of maize in the Semi-Arid Tropics, a multiple-front approach should be used so that the relative importance of the many cultural practices potentially affecting maize as a crop could be evaluated.

2. OBJECTIVES

The objectives of the Maize Agronomy Program of the SAFGRAD Project are :

1) To determine what are the main factors affecting maize production and to assess the yield potential of maize as a crop for the different agroclimatic zones of the Semi-Arid Tropics (SAT).

2) To establish suitable management pratices for the production of maize in the area under low-medium-high management/input conditions, the suitability of a practice being evaluated in terms of both its ecological and socio-economic implications.

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

4) To collect and distribute information on the soil, climatic and biotic factors of the different regions in order to arrive at a characterisation of the different agroclimatic zones, which would increase the efficiency of the Breeding Program and facilitate the extrapolation of research results from one place to another.

3. STRATEGY

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

1) Research trials conducted directly by the SAFGRAD Maize Agronomist in Upper Volta.

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

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

4) The exchange of results and other relevant information among the maize researchers working in the area, through mutual visits, conferences, reports, etc.

4. FIELD TRIALS

Maize agronomy trials were conducted in Upper Volta at 3 locations in 1979 : Kamboinsé, Saria and Farako-Bâ.

A total of 11 trials were planted between June 28 and July 16, 1979, as follows.

4.1 Density trials : The objective of these trials were :

a) to test adequacy under semi-arid conditions of the log-linear model (first proposed by Duncan) relating the log (yield/plant) and plant density.

b) to evaluate the density response of several contrasting materials under different fertility conditions.

4.1.1 Treatments : A factorial combination of 5 plant densities x 3 fertilizer levels x 3 varieties. Planted at Saria and Farako-Bâ.

4.1.2 Fertilizer levels

a) Saria

	14-23-14	+	Urea	=	Total
F1	100 kg/ha		20 kg/ha		34-23-14
F2	300		60		102-69-42
F3	500		100		170-115-70

b) Farako-Bâ

	14-23-14	+	Urea	=	Total
F1	100 kg/ha		30 kg N/ha		44-23-14
F3	500		150		240-115-70

Note : the F2 level was deleted at this location because of limited available land. However, one variety (IRAT 100) was planted at the F2 level (300 kg 14-23-14 plus 90 kg N/ha) with 2 replications.

4.1.3 Densities and plant spacing

Density (Plants/ha)	Plant Distance cm	Actual Density Plants/ha
D1 20,000	66	20,200
D2 40,000	33	40,400
D3 60,000	22	60,600
D4 80,000	16,5	80,800
D5 100,000	13	102,600

Row distance : 75 cm.

4.1.4 Varieties

Saria	Bobo-Dioulasso
V1 JFS (Jaune Flint de Saria)	Massayomba
V2 TZE 3	TZPB
V3 IRAT 80	IRAT 100

4.2 Soil preparation trial : The objective of this trial was to compare different methods of soil preparation in their effect on maize and cowpea yields (in collaboration with the cowpea agronomist).

4.2.1 Treatments

		Depth of soil preparation (cm)
T1	Zero tillage (paraquat)	0
T2	Tractor disk plowing and harrowing at the end of the rainy season	20 - 30
T3	As T2 but at the start of the rainy season	20 - 30
T4	Farmer's hand cultivation (with daba)	2 - 3
T5	Oxen plowing and harrowing	8 - 12
T6	Chisel plowing (75 cm appart) plus paraquat.	25

Location : the trial was planted in Saria and the necessary arrangements were made to start it in Kamboinsé in 1980. In Saria it was not possible to have the plots for T2 preparared at the end of the rainy season : in 1978 because the project started in 1979, and in 1979 because of the lack of tractor and equipment.

4.2.2 Fertilization

Urea : 150 kg N/ha

Single superphosphate : 54 kg P_2O_5/ha

KCL : 50 kg K_2O/ha

4.2.3 Variety and density : TZE 3 at 67,000 plants/ha (75 cm between rows, 40 cm between hills, 2 plants/hill)

4.3 Seedbed trial : The objective of this trial was to study the effect of several seedbeds on maize yields.

4.3.1 Treatments : A factorial combination of 4 seedbeds x 2 varieties

4.3.2 Seedbeds

S1 : Flat (no ridges)

S2 : Ridges

S3 : Tied ridges

S4 : Flat + earthing ("buttage") at 3 WAP, tying the ridges.

4.3.3 Varieties and density : V1 = JFS, V2 : TZE4, planted at 67,000 plants/ha (75 cm between rows, 40 cm between hills, 2 plants/hill).

4.3.4 Location : Kamboinsé, Block 7 (weathered tropical ferruginous soils).

4.3.5 Fertilisation :

300 kg 14-23-14/ha + 100 kg N/ha (as urea)

4.4 Spatial arrangement trials : The objective of these trials was to manipulate the relative water losses by evaporation and transpiration and to study the effect on maize yields.

4.4.1 Treatments : 5 spatial arrangements x 2 plant populations (40,000 and 67,000 plants/ha). Planted at Saria and Kamboinsé. The spatial arrangements were (T1 to T10 = 10 treatments).

.../...

Spatial Arrangements	Row distance cm	Plant distance (cm) ;.........plants/ha........ 40,000	66,700
S1	37.5	66.7 T1	40.0 T6
S2	75	33.3 T2	20.0 T7
S3	112.5	22.2 T3	13.4 T8
S4	37.5	33.3 T4	20.0 T9
	Cut every other row 4 weeks after planting (as much)		
S5	37.5	33.3 T5	20.0 T10
	Cut every other row 6 weeks after planting (as much)		

4.4.2 Fertilizer 300 kg 14-23-14/ha + 100 kg N/ha (as urea)

4.4.3 Plant densities : D1 = 40,000 plants/ha
D2 = 67,000 plants/ha

4.4.4 Varieties and spacings : JFS (Saria) and TZE3 (Kamboinsé). Row distance = 75 cm ; 1 plant/hill).

4.5 <u>Mulching trials</u> : The objective of these long terme trials is to study the effect of crop residues on maize yields and soil properties.

4.5.1 Treatments : 3 crop residue managements x 2 fertilizer levels. The trial was planted in Saria and Kamboinsé. The residue managements are :

R1 Crop residues removed
R2 Crop residues left on the ground
R3 Crop residue amount doubled.

Fertilizer levels :

F1 : 100 kg 14-23-14/ha + 26 kg N (as urea)
F2 : 300 kg 14-23-14/ha + 78 kg N (as urea)

The main objective in the first season was to produce the crop residues, but at the same time the trials permited to compare TZE3 VS two local materials (local Kamboinsé and JFS) at two fertility levels.
Varieties : Kamboinsé : TZE3 and local variety (Kamboinsé)
Saria : TZE3 and JFS.

4.5.2 Density : 67,000 pl/ha (75 x 20 cm2, 1 plant/hill at Saria ; and 75 x 40 cm2, 2 plants/hill at Kamboinsé.

4.5.3 Soil preparation : At Kamboinsé all the land was tractor plowed and disked after land clearing. In Saria the trial was planted in a plot that was prepared with "daba" (hoe), following the traditional farmer's method.

4.6 <u>Rotation trial</u> : In collaboration with the cowpea agronomist a (long term) trial was started to study the effect (on maize and cowpea yields) of growing continuous maize as opposed to several maize-cowpea rotations.

4.6.1 Treatments : A factorial combination of 6 rotations x 2 fertilizer levels.

4.6.2 Rotations :

R1 M M M M Continous maize
R2 M C M C } Maize - cowpea
R3 C M C M }

.../...

R4	M M C M	Maize - maize - cowpea
R5	M C M M	
R6	C M M C	

4.6.3 Fertilizer levels :

Maize
- F1 : 100 kg of 14-23-14 + 26 kg N/ha (as urea)
- F2 : 300 kg of 14-23-14 + 78 kg N/ha (as urea)

Cowpea
- F1 : 0- 0-0
- F2 : 0-30-0 (source : single superphosphate)

4.6.4 Variety and density : TZE4, at 67,000 plants/ha (75 x 20 cm2, 1 plant/hill).

4.6.5 Location : Saria, Block 4. Leached tropical ferruginous soil ("sols à pseudo-gley de profondeur"), with a laterite crust deeper than 100 cm.

4.7 Phosphatic rock trial : The objectives of this trial were to compare the local phosphatic rock and single superphosphate as sources of P for maize and to study the effect of different methods of incorporation.

4.7.1 Treatments : A factorial combination of 2 phosphorus sources x 3 methods of incorporation. There were 4 phosphorus rates of each source.

4.7.2 P Sources :

S1 : single superphosphate

S2 : Phosphatic rock.

4.7.3 Methods of incorporation :

M1	: Banded		
M2	: Broadcast, incorporated		2-3 cm (daba)
M3	: "	"	10-12 cm (disk harrow)

4.7.4 Rates :

	S1	S2
R1	20 kg P_2O_5/ha	0 kg P_2O_5/ha
R2	50	100
R3	100	200
R4	150	300

4.7.5 Location : Saria, Block 17 (Leached tropical ferruginous soil without concretions, not well differenciated and 50-100 cm deep).

4.8 Planting depth trial : The objectives of this trial were :
a) to determine the effect of planting depth on maize germination and seedling establishment ;
b) to explore the interaction between planting depth and genotype, and between planting depth and seedbed.

.../...

4.8.1 Treatments : A factorial combination of
2 seedbeds x 2 planting depths x 3 varieties

4.8.2 Seedbeds : S1 : flat
S2 : ridging

4.8.3 Planting depths : P1 : 3-5 cm
P2 : 8-10 cm

4.8.4 Varieties : V1 : Local Kamboinsé
V2 : JFS
V3 : TZE4

4.8.5 Location : Kamboinsé (Block 9)

4.8.6 Plant density : 67,000 plants/ha (75 x 20 cm2, 1 plant/hill)

4.8.7 Fertilization : 400 kg 14-23-14/ha + 100 kg N/ha (as urea)

4.9 Observations and measurements

4.9.1 Crop related : The following variables were measured on a plot basis :

a) Plant height from ground level to the tip of the tassel.
b) Ear height. Taken only for the density trial at Farako-Bâ. Because of a misunderstanding, this measurement was not taken for the other trials.
c) Number of days to 50 % silking.
d) Number of harvested plants
e) " " ears (not including the ears without any grain).
f) Number of ears without any grain.
g) Number of ears attacked by termites.
h) Number of ears with incomplete pollination (not including those ears where only the very tip had no grains).
i) Number of "forked" ears, i.e. of ears showing a malformation where the main ear branches into several ears.
j) Number of plants with root lodging and number of plants with stem lodging. This evaluation was usually made several weeks before harvest.
k) Ear weight (grain + cob) after sun-drying.
l) Moisture content of the grain.
m) Grain weight (after shelling the ears)
n) Number of grains in 100 grams, in order to calculate the weight of 1000 grains (which is expressed on a zero percent moisture basis in this report).
o) Rating for waterlogging (only for the density trial and the

.../...

spatial arrangement trial at Saria), based on the following scale :

5 : 0 - 10 % of leaves brown (dry)
4 : 11-25 % " " "
3 : 26 -50 % " " "
2 : 51 -75% " " "

q) Number of seeds not germinated (Planting depth trial only).

r) Number of hills without any germination (Planting depth trial only).

4.9.2 Soil analyses : The results of the chemical and mechanical analyses of the samples taken in the experimental plots are not yet available.

5. RESULTS AND DISCUSSION

All the grain yields presented in this report are on a zero percent moisture basis.

5.1 Plant Density trials

5.1.1 Farako-Bâ : The plot to plot variability in this trial was fairly large and it is reflected in the high C.V. for grain yield (26.5%) Nevertheless, the Main Effects and the Interactions were often significant or highly significant. The grain yield results are plotted in Figures 1- 3.

5.1.2 Saria : This trial was located on a soil with poor internal drainage. As a result, waterlogging conditions in many of the plots severely affected germination and sand and/or plant growth. After rating the plots for waterlogging conditions (scale 1 - 5, 5 = worst) and counts of plant stand, 51 plts were eliminated because of either high ratings for waterlogging or actual stands which were up to around 20 % below the intended plant densities. The results presented are thus the means after eliminating such 51 plots.

The treatment means for grain yield are shown in Table 1, whereas the individual observations for JFS at the low fertility rate are plotted in Figure 4.

5.1.3 Duncan's linear model : Duncan's model is expressed as the following linear relationship :

$$\log Z = \log K + bD + e$$

where,

.../...

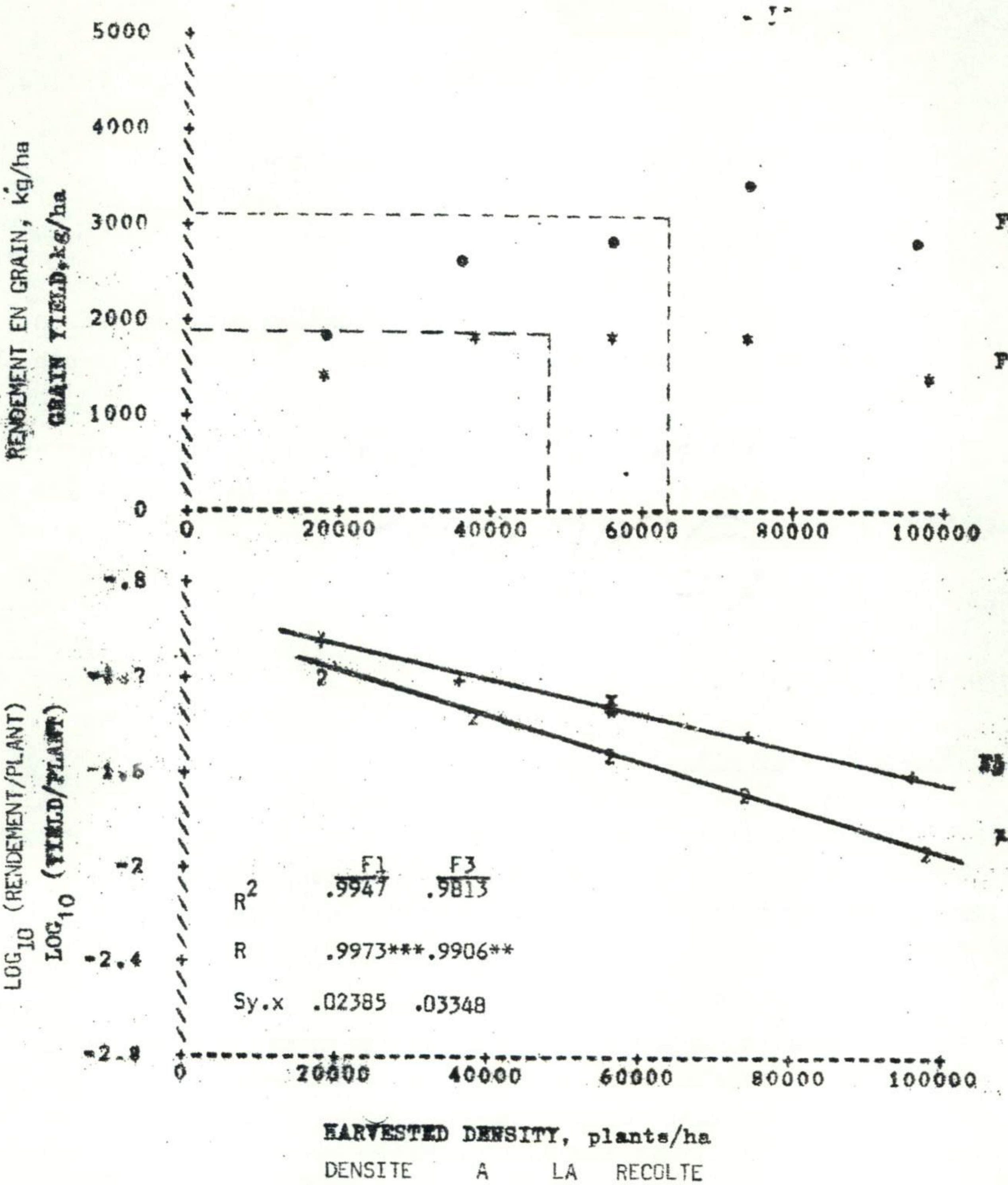

Fig. 1. The effect of plant population on: a) the grain yield; b) the $\log_{10}$(yield/plant) of Massayomba, grown at two fertilizer levels. Plant density trial, FARAKO- BA.1979

Above : The dotted lines show the estimated optimum density and maximum yield.

Below : * : observed values

x : estimated values

+,2 : the observed and the estimated values coincide.

Fig. 1. L'effet de la densité de plants sur:a) le rendement en grain;b) le $\log_{10}$ du rendement en grain/plant. Variété Massayomba à deux niveaux d'engrais. Essai de densité de plants. FARAKO-BA. 1979.

Haut : Les lignes en pointillés représentent l'estimation de la densité optimale et du rendement maximum.

Bas : * : valeurs observées ; x : valeurs estimées

+,2 : les deux valeurs coincident.

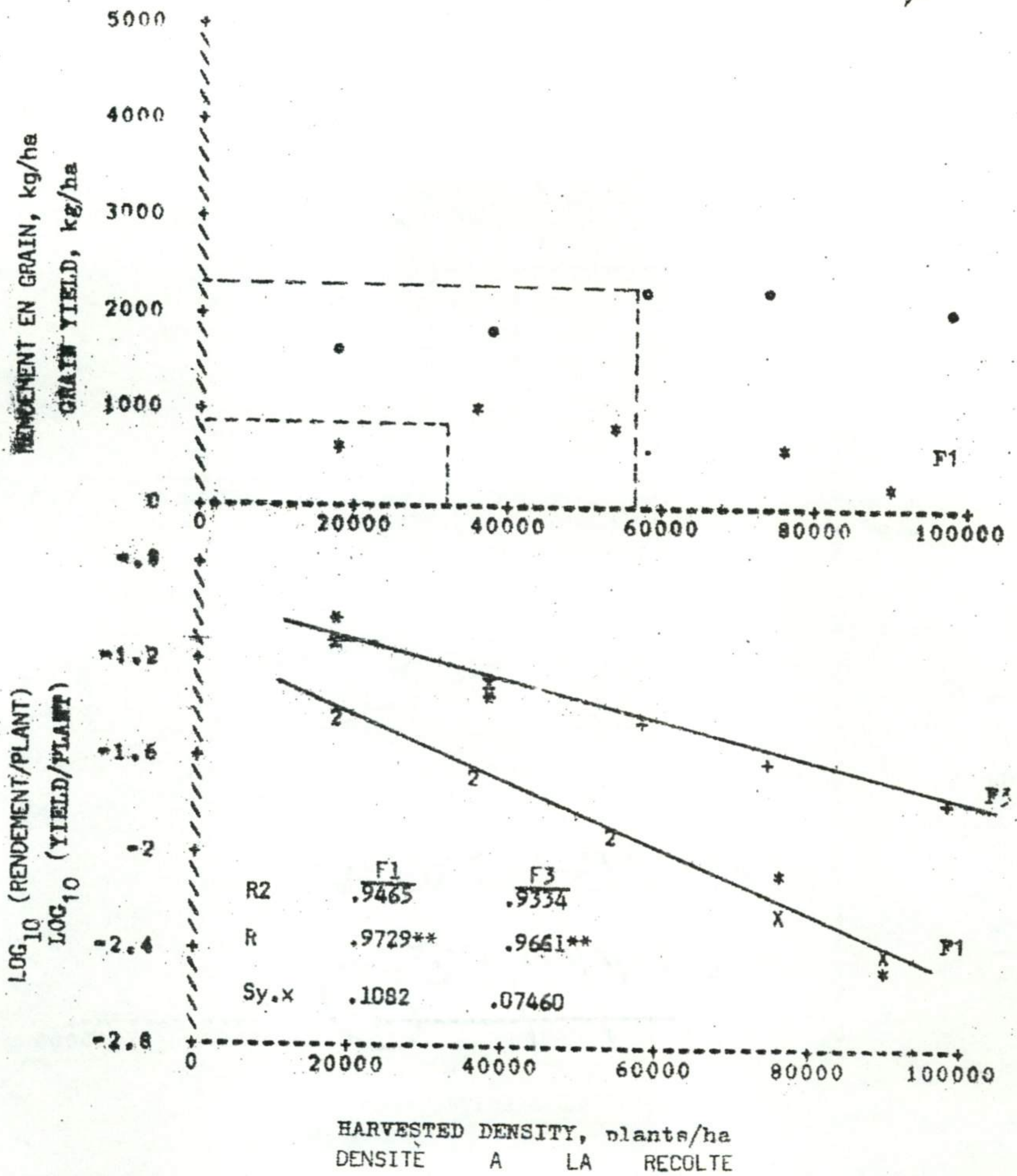

Fig. 2. The effect of plant population on : a) the grain yield ; b) the $\log_{10}$ (yield/plant) of TZPB, grown at two fertilizer levels. Plant density trial, FARAKO-BA. 1979

Above : The dotted lines show the estimated optimum density and maximum yield.
Below : * : observed values
x : estimated values
+,2 : the observed and the estimated values coincide.

Fig. 2. L'effet de la densité de plants sur: a)le rendement en grain; b) le $\log_{10}$ du rendement en grain/plant. Variété TZPB à deux niveaux d'engrais. Essai de densité de plants. FARAKO-BA. 1979

Haut : Les lignes en pointillés représentent l'estimation de la densité optimale et du rendement maximum.
Bas : * : valeurs observées ; x : valeurs estimées
+,2 : les deux valeurs coincident

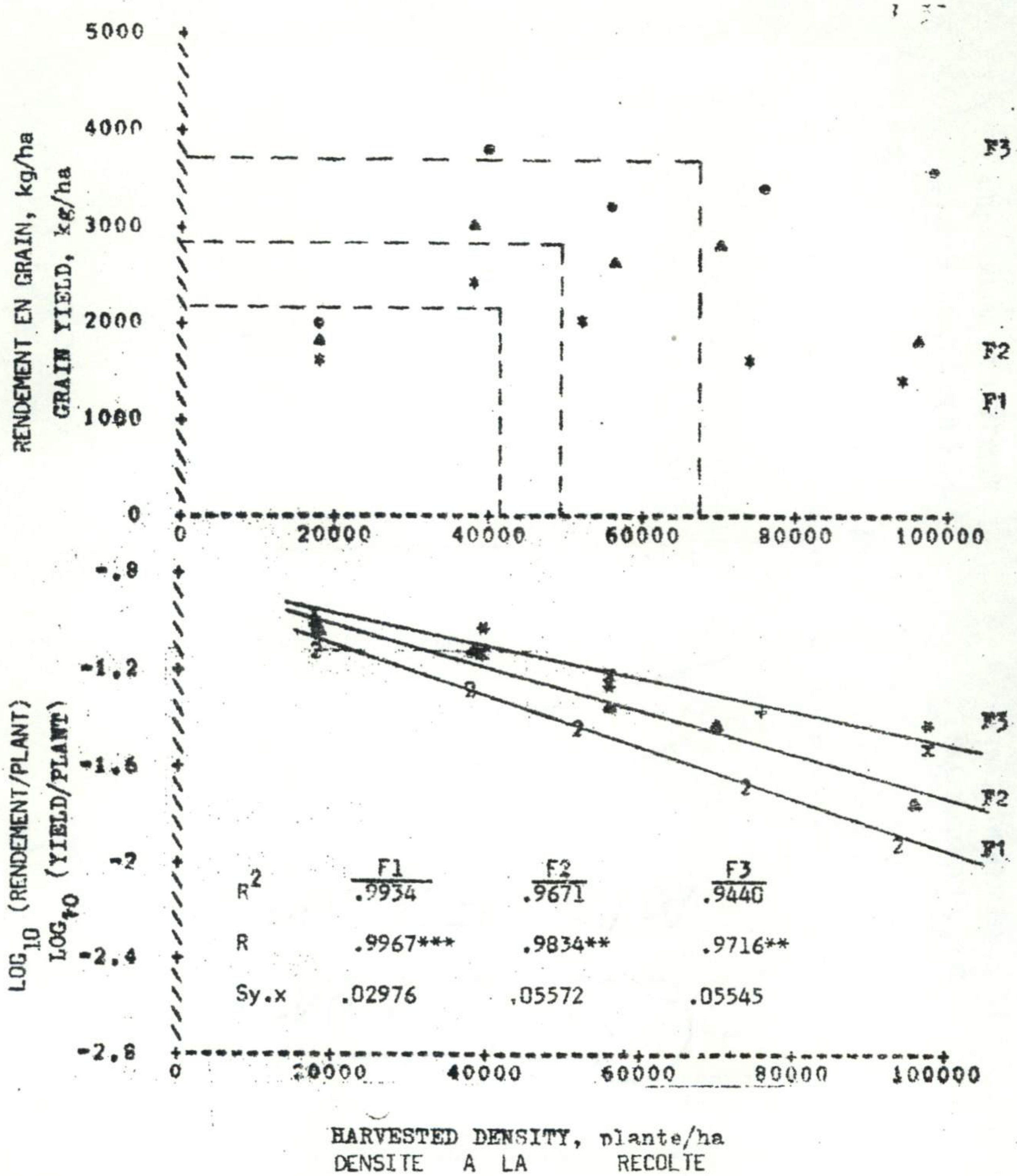

Fig. 3. The effect of plant population on : a) the grain yield ; b) the $\log_{10}$ (yield/plant) of IRAT 100, grown at three fertilizer levels. Plant density trial, FARAKO-BA. 1979

Above : The dotted lines show the estimated optimum density and maximum yield.

Below : * : observed values
x : estimated values
+,2 : the observed and the estimated values coincide (At F2 only the observed values are shown).

Fig. 3. L'effet de la densité de plants sur: a)le rendement en grain; b)le $\log_{10}$ du rendement en grain/plant. Variété IRAT 100 à trois niveaux d'engrais. Essai de densité de plants. FARAKO-BA. 1979

Haut : Les lignes en pointillés représentent l'estimation de la densité optimale et du rendement maximum.

Bas : * : valeurs observées ; x : valeurs estimées
+,2 : les deux valeurs coïncident. (Note : pour F2 seules les valeurs observées sont représentées).

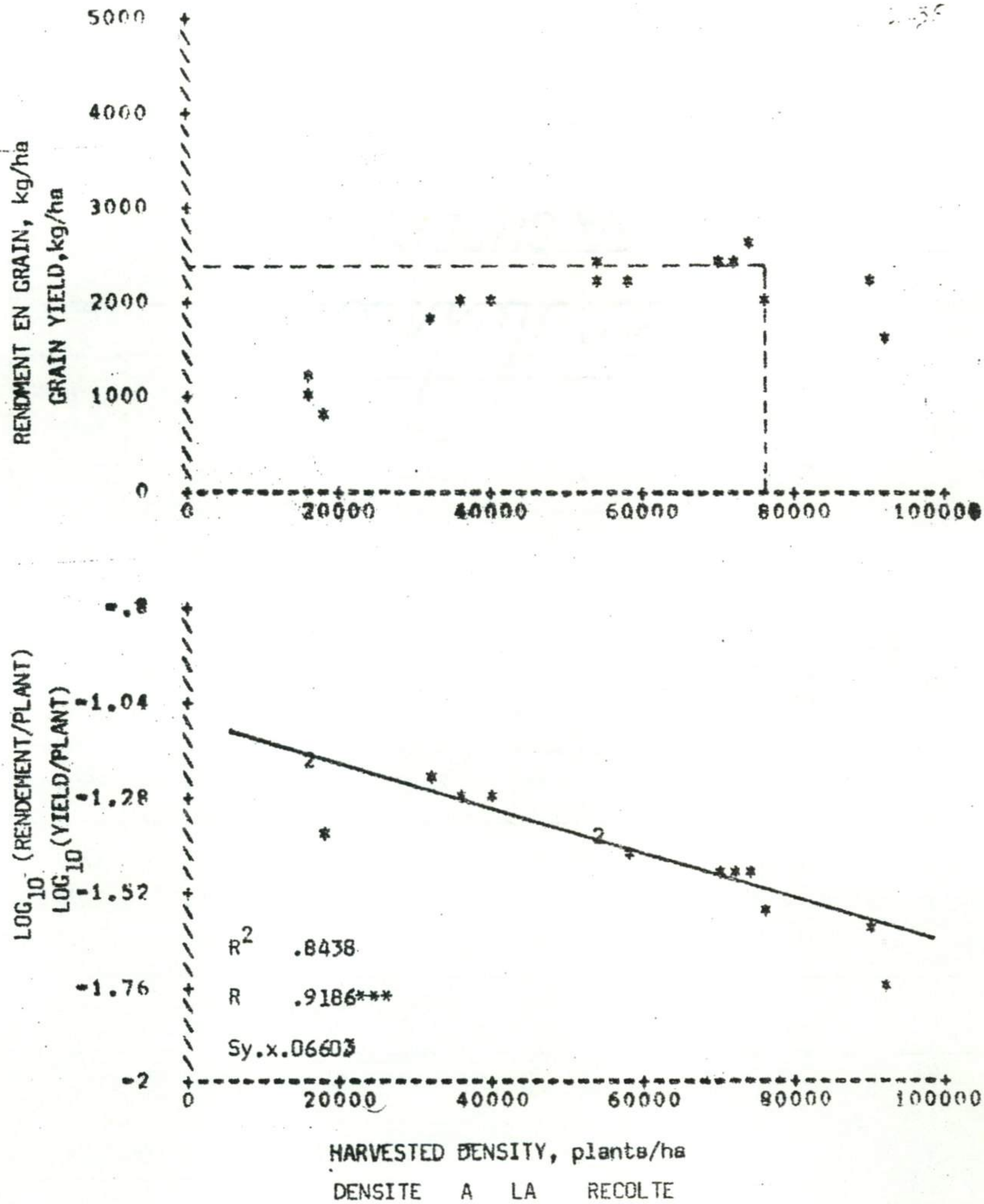

Fig. 4. The effect of plant population on: a) the grain yield; b) the $\log_{10}$(yield/plant) of Jaune Flint de Saria, grown at a low fertilizer level. Plant density trial.SARIA.1979

Above : The dotted lines show the estimated optimum density and maximum yield.

Below : * : observed values

2 : two observed values coincide.

Fig. 4. L'effet de la densité de plants sur: a)le rendement en grain; b)le $\log_{10}$ du rendement en grain/plant. Variété Jaune Flint de Saria à un bas niveau d'engrais. Essai de densité de plants. SARIA. 1979

Haut : Les lignes en pointillés représentent l'estimation de la densité optimale et du rendement maximum

Bas : * : valeurs observées

2 : deux valeurs se coincident

Table 1
Plant density trial. SARIA(Upper Volta). 1979
Grain yield (kg/ha, at zero percent moisture)

Fertilizer level kg NPK/ha	Variety	Density					Means
		1	2	3	4	5	
34-23-14	JFS	1080	2090	2380	2500	2040	2020
	TZE3	1460	1730	2150	2690	2190	2050
	IRAT 80	1660	2210	2340	1850	1950	2000
102-69-42	JFS	1420	2260	2320	3230	2820	2410
	TZE3	1310	2000	2230	2660	2610	2160
	IRAT 80	1650	2470	3100	2770	2450	2490
170-115-70	JFS	1490	2320	2620	3020	2750	2440
	TZE3	1610	1780	2420	2860	2780	2290
	IRAT 80	1810	2800	2550	3700	3150	2800
Variety means	JFS	1330	2220	2440	2920	2540	2290
	TZE3	1460	1840	2270	2740	2530	2170
	IRAT 80	1710	2490	2660	2770	2520	2430
Overall mean							2300

C.V.* %	Main plot	35.1
	Sub-plot	31.7
	Sub-subplot	19.7

L.S.D.'s (5 %)*

Fertilizer levels	337
Varieties	261
varieties at same fertilizer level	453
Fertilizer levels at same variety	621
Densities	198
Densities at same fertilizer level	343
Fertilizer levels at same density	453
Densities at same variety	343
Varieties at same density	403

* C.V.'s and L.S.D.'s are based on 180 plots. Actual values should be below those given.

Z = grain yield/plant

log K = intercept

b = slope = regression coefficient

D = plant density (plants/ha)

e = error term

Therefore, the grain yield/ha (Y) can be expressed by the exponential equation $Y = ZD = DK10^{bD}$
from this, the optimum density is given by $D \text{ optimum} = \frac{-1}{\ln 10\ b}$

and the maximum yield, i.e. the yield at the optimum density, is given by $Y \text{ maximum} = -0.1598/b$

5.1.4 Adequacy of Duncan's model under semi-arid conditions.

In spite of the very large observed soil variability in both Farako-Bâ and Saria, Duncan's model held very well. The model was fitted to the means (of 4 replications) in Farako-Bâ and the individual observations (after deleting the 51 plots) in Saria. Tables 2 and 3 show the regression statistics, the optimum density and the maximum yields for each variety and fertility level in Farako-Bâ and Saria, respectively. In all cases the regression equations were statistically significant at the 5 % of lower level of probability. Some of the regression equations have been plotted in Figures 1 - 4.

The trial in Farako-Bâ was subjected to a dry spell of 8 - 10 days in the middle of August, 6-7 WAP, i.e. 2-3 weeks before 50 % silking. The trial in Saria was also hit by a dry spell of more than one week in August, 5 WAP i.e. 2-3 weeks before 50 % silking and by another dry spell of about 10 days in September, about 2-3 weeks after 50 % silking.

The validity and usefulness of Duncan's model has been shown by many authors working on maize in the temperate zone and also in some cases with tropical maizes. To the authors's knowledge, the model had not been tested in the Semi-Arid Tropics. In spite of the high soil variability the model gave a very good fit and it is felt that this model should be used extensively in all maize agronomy trials where plant density is the factor of interest, particularly in fertilizer experiments, variety trials where widely contrasting materials are compared, and time of planting trials.

The model being linear, only two points i.e. two plant densities are required to find the optimum density and the maximum yield under the particular set of experimental conditions. The lowest density should be such that interplant competition is present (a density of 15 - 20,000 plants/ha is suggested as minimum), and the highest density should be such that being as high as possible (in order to get a precise estimate of the slope coefficient) the ocurrence of barrenness and/or lodging problems do not become limiting.

It should be added that not even a pocket calculator is essential for finding the slope and the intercept. A simple graphical solution will suffice and for the remaining calculations only a table of logarithms is needed.

Table 2

Plant density trial. FARAKO-BA (Upper Volta). 1979

Regression of $\log_{10}$ (yield/plant) on plant density ; optimum density, and estimated maximum yield.

Regressions based on means of 4 replications

Fertilizer level kg NPK/ha	Variety	Regression of $\log_{10}$ (yield/plant) on density					Optimum density plants/ha	Grain yield at Dopt. kg/ha
		Intercept x (-1)	Slope b_5 x (-10^5)	R^2	R	Confidence limits for b(5%) x (-10^5)		
44 - 23 - 14	Massayomba	.96637	.91279	.9947	.9973***	.79046 ; 1.03400	47,600	1,890
	TZPB	1.12934	1.35581	.9465	.9729**	.76389 ; 1.94772	32,000	880
	IRAT 100	.84927	1.04716	.9934	.9967***	.89011 ; 1.20421	41,500	2,160
132-69-42	IRAT 100	.81356	.87677	.9671	.9834**	-- --	49,500	2,800
220-115-70	Massayomba	.88157	.68264	.9813	.9906**	.50937 ; .85592	63,600	3,070
	TZPB	.96003	.76547	.9334	.9661**	.38968 ; 1.14126	56,700	2,290
	IRAT 100	.82723	.64387	.9440	.9716**	.35579 ; .93196	67,400	3,690

*,**,*** : significant at 5%, 1%, and 0.1% probability levels, respectively

Table 3

Plant density trial. SARIA (Upper Volta). 1979

Regression of $\log_{10}$ (yield/plant) on plant density ; optimum density and estimated maximum yield.

Regressions based on individual observations.

Fertilizer level kg NPK/ha	Variety	Regression of $\log_{10}$ (yield/plant) on density					Optimum density plants/ha	Grain yield at Dopt. kg/ha
		Intercept x (-1)	Slope b_5 x (-10^5)	R^2	R	Confidence limits for b(5%)x(-10^5)		
34 - 23 - 14	JFS	1.07279	[illegible]	.8438	.9186***	.42426 ; .71898	76,000	2,360
	TZE3	.98187	.74096	.8796	.9379***	.55902 ; .92290	58,600	2,250
	IRAT 80	.87770	.93206	.9444	.9718***	.79662 ;1.05748	46,600	2,270
102-69-42	JFS	1.02960	.52116	.8203	.9057***	.39186 ; [illegible]	83,300	2,860
	TZE3	1.05006	.55375	.9096	.9537***	.41142 ; .69608	78,400	2,570
	IRAT 80	.89581	.72239	.8770	.9365***	.57353 ; .87125	60,100	2,810
170-115-70	JFS	.99786	.56632	.8631	.9290***	.44220 ; .69043	76,700	2,840
	TZE3	1.02337	.56222	.6753	.8218**	.28754 ; .83689	77,200	2,690
	IRAT 80	.87970	.66226	.8338	.9131***	.45395 ; .87056	65,600	3,180

*,**,*** : significant at 5%, 1%, and 0.1% probability levels, respectively

5.1.5 Optimum densities and maximum yields at Farako-Bâ and Saria :
As expected, the optimum density increased with the fertilizer level, although in Saria there was basically no response in grain yield and no change in the optimum densities between the medium and high fertilizer levels.

For the medium maturity varieties (around 60 days to 50 % silking, including IRAT 80 at Saria) the optimum densities were between 40,000 to 50,000 plants/ha (32,000 for TZPB) at the low fertilizer level*; As for the early maturity varieties (around 50 days to 50 % silking), the optimum densities were close to 80,000 plants/ha at the 3 fertilizer levels, except for TZE3 at the low fertilizer level which gave 59,000 plants per hectare as the optimum density. Note however that in Saria yield responses to fertilizer were small (yield increased from 2.3 up to 3.2 ton/ha). In Farako-Bâ, yields increased from 0.9 - 2.2 to 2.3 - 3.7 ton/ha.

The estimated optimum densities really apply only to the particular conditions of the experiments and there is a need to determine how the optimum density is affected by the date of planting or by the occurrence of dry spells that hit the crop at more critical stages e.g. at flowering. Optimum densities will also change of course with soil factors such as inherent fertility, soil texture and depth,and previous management practices.

The trials at both Farako-Bâ and Saria were planted fairly late (June 28 and July 7, respectively) and earlier plantings might have given higher yields with correspondingly higher optimum densities. Maize planted on June 30 (1976 and 1977) yielded only about 50 % of maize planted on May 30 in the SW area of Upper Volta (Poisson, 1977).

Note that the maximum yields obtained at Farako-Bâ at the highest fertilizer level were not too high. Massayomba, with a yield potential of 5 ton/ha yielded only 3070 kg/ha. TZPB yielded only 2290 kg/ha, whereas in another trial, planted 10 days earlier in the same block, it yielded 5 ton/ha (F. Brockman, personal communication, 1980). There was also an increase in the number of days to 50 % silking for the variety TZPB (67 days when "normal" values are around 60 days). It is not clear why the grain yields of TZPB were so low and flowering so retarded in the density trial at Farako-Bâ.

5.2 Soil preparation trial

There were statistically significant differences between soil preparation methods in the grain yields, plant height, days to 50 % silking and number of grains per square meter.

This trial was located in Saria on a shallow soil (less than 50 cm to the laterite crust). As a result the crop was badly affected by a 2-week dry spell in the middle of August, 4 weeks after planting. Table 4 shows the treatment means for the grain yield and other variables. The poor crop growth and the water stress are indicated by the low mean plant height (1.49 cm) and the number of days to 50 percent silking (55), when "normal" values for the variety TZE3 would be above 2 m and around 50 days,respec-

and between [illegible]

M-38

Table 4
Soil preparation trial. SARIA (Upper Volta). 1979
Treatment means for selected variables.

Soil preparation method	Grain yield kg/ha *	Grain yield %	Plant height cm *	Days to 50 % silking **	grains per m2 *	Weight of 1000 grains g
1. Zero tillage (paraquat)	1530	109.3	140	56.2	910	167
2. Tractor tillage	1970	140.7	156	53.8	1290	153
3. Tractor tillage (as 2.)	2010	143.6	152	54.0	1190	167
4. Farmer's conventional	1400	100	142	57.2	910	157
5. Bullock plowing	2080	148.6	164	54.2	1230	169
6. Chisel plowing	1860	132.9	140	55.0	1040	178
Mean	1810	-	149	55.1	1090	165
C.V	17.4	-	8.2	2.1	16.1	8.4
L.S.D. (5 %)	473	-	18	1.75	264	21

*, ** : significant at P = 0.05 and P = 0.01, respectively

tively. The number of grains per square meter was also sharply reduced. Zero tillage and the conventional farmer's method (hand hoeing with "daba") gave significantly lower yields (about 1500 kg) than either factor disk plowing or bullock plowing (about 2000 kg/ha) (Note : In the first season there was no difference in the actual time of disk plowing ; the plots for both treatments 2 and 3 were plowed at the start of the rainy season). The expectation was that tractor plowing would give higher yields than bullock plowing, the plowing depths being 20-30 and 8-12 cm, respectively. These results show that a least for some shallow soils and under conditions of irregular rainfall, where dry spells can occur anytime during the growing cycle, bullock plowing can be as good as tractor plowing. Put in different words, the risk factor is such that tractor plowing will not always give yields higher than those obtained with bullock plowing.

5.3 Seedbed trial

There was a significant difference between seedbeds only in the weight of 1000 grains and the rating for crop aspect. Comparing the varieties, Jaune Flint de Saria was significantly earlier than TZE4 (49 VS 53 days to 50 % silking), had more ears per plant (0.98 VS 0.95), had a larger number of grain per square meter (1820 VS 1670), and had a higher shelling percentage (82 VS 78 %). In spite of being earlier, JFS yielded as much as TZE4 (3220 VS 3080 kg grain/ha).

The mean grain yields are shown in Table 5. There was no statistically significant (P=0.05) difference between seedbeds nor between varieties. However, the F test for seedbeds was significant between P=0.05 and P=0.01. Although the difference in grain yields between a flat seedbed and plain ridges was small, the comparison between a flat seedbed and both seedbeds with tied ridges consitently shows higher yields for the tied-ridges seedbeds, of the order of 700 to 1000 kg/ha (L.S.D. = 782 at P=5 %).

Both varieties kept a green foliage longer under both tied-ridges seedbeds than in the flat or plain ridges seedbeds, indicating that more soil moisture was available to the plants in the former two seedbeds. This was reflected in higher grain weights, i.e. the weight of 1000 grains was significantly (P=5%) higher in the tied ridges (194 g VS 160-170 g in the other 2 seedbeds).

It should be added that what seemed to be N deficiency symptoms (affecting only the basal half of the plant) developped under both tied ridges sooner and to a greater degree than in the other two seedbeds, an apparently obvious consequence of having more water percolating through the soil profile. This indicates that although a tied-ridges system could lead to greater maize yields it could also result in heavier N leaching and volatilization losses. The N deficiency symptoms in the ridges tied at planting time developped well in advance in relation to those in the seedbeds ridged (and tied) 4 WAP, as expected. Thus, there would appear to be no advantage to an early tying of the ridges, especially if maize is to be grown at low-medium N levels.

This trial was planted on July 14 at Kamboinsé. During the last days of August and early September the rains were fairly uniformly distributed. As a result,

.../...

Table 5
Seedbed trial. KAMBOINSE (Upper Volta). 1979
Grain yield (kg/ha, at zero percent moisture)

Seedbed x variety (ns)	Variety (ns)		Mean
Seedbed (ns)	1 JFS	2 TZE4	
1. Flat	2750	2560	2650
2. Ridges	2980	2940	2960
3. Tied ridges	3350	3370	3360
4. Ridging 4 WAP (tied)	3800	3440	3620
Mean	3220	3080	3150

C.V. Main plot	17.6 %
C.V. Sub-plot	10.6 %

*, ** : significant at 5 and 1 %

n s : non significant

L.S.D.'s (5 %)

Seedbed	782
Variety	313
Seedbed x variety (same seedbed)	627
(different seedbed)	899

the maize was subjected to waterlogging or near saturation conditions in both seed-beds with tied ridges for a 2-week period (192 mm of rain in 14 days) before flowering. It seems most likely that this would have a negative effect on crop growth and grain yields and so the observed grains under the tied-ridges are over and above the compensation for the negative effects of waterlogging. It seems worthwhile to look further at the system, giving attention to the optimum time for tying the ridges.

5.4 Spatial arrangement trials

5.4.1 Kamboinsé : For the grain yield, the C.V. was moderatly high (14,1 %) and there was a highly significant effect of spatial arrangements and a highly significant interaction of densities and arrangements.

Differences in the number of harvested plants within each density level cannot account for the observed grain yield differences between spatial arrangements (Table 6). The highest grain yields were obtained at the high density except for arrangements 3 (112.5 cm row distance) and 5 (37.5 cm row distance, every other row cut 45 DAP).

5.4.1.1 Effect of increasing the row distance : At the low density (40,000 plants/ha) the grain yields were not significantly affected by using a 37.5, 75.0, or 112.5 cm row distance and correspondingly smaller within-row distances (66,7, 33.3 and 22.2 cm, respectively). At the high density (66,700 plants/ha), grain yields were the same (around 3200 kg/ha) for row distances of 37.5 and 75.0 cm (within-row distances of 40 and 20 cm, respectiveley), but significantly decreased (2510 kg/ha) when the row distance was increased to 112.5 cm (13.4 cm between plants), indicating that plant to plant competition became limiting, causing a large decrease in the number of grains per square meter and a smaller decrease in the weight of 1000 grains. This accounts for part of the arrangement x density interaction.

5.4.1.2 Effect of cuttint every other row as mulch : Planting at a row distance of 37.5 cm to achieve densities of 80,000 and 133,400 plants/ha (33.3 and 20.0 cm between plants, respectively) and then cutting every other row as mulch (thus halfing the final plant density) had different effects depending on the time the rows were cut and the density.

When every other row was cut 31 DAP, at the low density the grain yield was comparable to the yield obtained in plots with the same spacing (75 cm x 33.3 cm) since planting time (2890 VS 2910 kg/ha, respectively). At the high density, however, the yield tended to be higher in the mulched plots (3680 VS 3150, L.S.D. = 574 kg/ha). The interpretation of these results is difficult because of the many factors involved. It could be that at the low density soil moisture was not a limiting factor of crop growth ; therefore, the reduction in evaporation losses, induced by the mulch coming from the cut rows, was not of enough importance to result in higher grain yields and/or to compensate for any possible detrimental effects of growing twice the final density up to 31 DAP, whereas this particular effect of the mulch was of more importance at the high density where competition for water among plants was more pronounced. As similar argument can be ...

Table 6
Spatial arrangement trial. KAMBOINSE (Upper Volta). 1979
Grain yield (kg/ha, at Zero percent moisture)

Arrangement x density (**)	Density, plants/ha (ns)		Mean
Arrangement (**) row distance	40,000	66,700	
1. 37.5 cm	2590	3220	2910
2. 75.0 cm	2910	3150	3030
3. 112.5 cm	2800	2510	2660
4. 37.5 cm Every other row cut 31 DAP	2890	3680	3280
5. 37.5 cm " " row cut 45 DAP	2380	1830	2110
Mean	2710	2880	2800
		C.V. %	14.1

*,** : significant at P=0.05 and P=0.01, respectively
n s : non significant

L.S.D.'s (5 %)

Arrangement	406
Density	257
Arrangement x density	574

developped not for soil water and reduced evaporation losses by mulching, but for the nutrients stored in the mulch (reducing leaching losses) and then slowly made available to the remaining plants.

When every other row was cut 45 DAP, grain yields decreased in relation to those of plots with the same spacing (75 cm x 33.3 cm) since planting time and such decrease was far less marked at the low density (2380 VS 2910 kg/ha) than at the high density (1830 VS 3150 kg/ha), which accounts for the remaining part of arrangement x density interaction. There is no doubt that, at 45 DAP, interplant competition in plots with 80,000 and 133,400 plants/ha had reached a level such that yields could be depressed especially at the high density. The number of grains per square meter and the ears/plant were sharply reduced, the number of days to 50 % silking increased by more than 2 days, and stem and root lodging were also increased. Although the amount of mulch in the plots where every other row was cut 45 DAP was much greater (and also decomposed more slowly) than in the plots where the cutting was 31 DAP, the yield reductions due to too high interplant competition make it inadvisable to delay the cutting of the rows for so long.

5.4.2 Saria : The trial in Saria was badly affected by waterlogging and poor drainage during periods of high or frequent rainfall and also by drought (at least two dry spells of one week or longer). As a result, crop growth was poor and uneven and there were at least 9 plots which should be considered as missing because of severe waterlogging. It was judged that no reliable interpretation of the results (the comparison of the spatial arrangements in particular) could be made. In spite of the poor drainage and water stresses, the overall mean grain yield was surprisingly high (2480 kg/ha)

5.5 Mulching trials

As already explained, the crop residues were to be producted in the first year, but at the same time the trials were used to compare TZE3 against a local variety at Kamboinsé and against Jaune Flint de Saria at Saria, under two fertilizer levels in both cases.

In both locations there was a highly significant difference in grain yields between both fertilizer levels. TZE3 had yields similar to those of the local Kamboinsé (2640 VS 2400 kg/ha, respectively) and JFS (1900 VS 1750 kg/ha, respectively), the difference being not significant in the first case (C.V. = 19.3 %) but highly significant - if small- in the second one (C.V. = 11.2 %). JFS was earlier than TZE3 (49 VS 52 days to 50 % silking) and the latter in turn was earlier than the local Kamboinsé (51 VS 53 days to 50 % silking). The variety x fertility interaction was not significant at Kamboinsé but it was highly significant at Saria. Table 7 shows the grain yields at both locations. Although TZE3 and JFS had similar yields at the low fertilizer rate (1420 and 1460 kg/ha), TZE3 yielded 16 % more than JFS at the high fertilizer level (2380 VS 2040 kg/ha). This is somewhat surprising since both varieties gave similar yields in the density trial at Saria under comparable fertilizer levels (Table 3) but on a deeper soil.

Table 7
Mulching trial. KAMBOINSE and SARIA (Upper Volta). 1979
Grain yield (kg/ha, at zero percent moisture)

Fertilizer level kg NPK/ha	KAMBOINSE			SARIA		
	Variety(ns)		Mean	Variety (**)		Mean
	TZE3	Local		JFS	TZE3	
1. 40 - 23 - 14	2340	2120	2230	1460	1420	1440
2. 120 - 69 - 42	2940	2680	2810	2040	2380	2210
Mean	2640	2400	2520	1750	1900	1820
No fertilizer	1740	1390	1560	-	-	-
Fertilizer level	**		C.V.=19.3%	**		C.V.=11.2%
Fertility x variety	ns			**		

*,** : significant at P = 0.05 and P = 0.01, respectively
ns : non significant

	L.S.D.'s (5 %) KAMBOINSE	SARIA
Fertilizer levels	200	130
Varieties	259	109
Varieties at Fert. level	367	154
Fert. levels at same variety	325	168

Table 7 also gives an idea about the yield levels obtained at Kamboinsé with no fertilizer application the first year of cropping after land clearing, following more than 20 years of fallow period. TZE3 yielded 1740 kg/ha.

Mean grain yields in these trials were higher in Kamboinsé than in Saria (2520 VS 1020 kg/ha) and at least three factors are involved. At Kamboinsé the trial was located in a deeper soil and on land recently cleared, the rainfall distribution was better, and the soil was tractor plowed (in Saria it was prepared following the farmer's conventional hand-hoeing).

5.6 Rotation trial

Being the first year, no crop rotation results are available yet. The overall mean grain yield was 2320 kg/ha and there was only a small, not significant increase in yield with the high fertilizer level. The vegetative growth of the crop suggested that the grain yields would be higher than those actually found. Although the weight of 1000 grains filling stage (soil depth : + 1 meter), the number of grains per square meter was logically low (1050). The shelling percentage (calculated by selling all the ears of 8 plots) was uncharacteristically low (72.6 %). It seems that this was due to poor pollination caused by too much rainfall. Thirty eight percent of the ears were classed among those with poor pollinisation. The crop reached 50 % silking on August 31, but between August 28 and September 4 the rainfall was 158.5 mm in 6 days with rain.

5.7 Phosphatic rock trial

As was the case for the density trial and the spatial arrangement trial at Saria, this trial was badly affected by waterlogging and 2 dry spells. Soil variability was high and plant growth poor (average plant height = 140 cm). In spite of that, the average grain yield was 1900 kg/ha.

There was no significant difference in grain yields between sources or between incorporation methods. There was a significant but small effect of P rates (Table 8). Grain yield was 1950 kg/ha with no P application and no significant yield increases were obtained with the application of up to 100 kg P_2O_5/ha source single superphosphate, or up to 200 kg P_2O_5 source phosphatic rock. The highest rate of single superphosphate (150 kg P_2O_5/ha) significantly reduced grain yield (down to 1500 kg/ha). It seems that the soil phosphorus level in the soil was fairly high before the trial was started.

5.8 Planting depth trial

The mean grain yield was fairly high (3800 kg/ha) and the C.V. low (10.5 %). The high yields may be attributed to better soil moisture conditions and maybe higher organic matter content given that this trial located down the slope.

The statistical analyses showed significant differences in grain yields between planting depths as well as significant interactions between seedbeds and planting depths and between planting depths and varieties. The mean grain yields were 3940 and 3650 kg/ha for the shallow (3-5 cm) and deep (8-10 cm) planting depths, respectively (Table 9). However, this difference was entirely due to a yield decrease in the local

Table 8

Phosphatic rock trial. SARIA (Upper Volta). 1979

Grain yield (kg/ha, at Zero percent moisture)

Incorporation method (ns)	Source (ns)								Mean
	Single superphosphate				Phosphatic rock (U.V.)				
	Rate, kg P_2O_5/ha (**)								
	1. 20	2. 50	3. 100	4. 150	1. 0	2. 100	3. 200	4. 300	
1. Banded	1700	2100	2010	1500	1870	1640	1610	1830	1780
2. Broadcast (2 - 3 cm deep)	2260	2250	2680	1780	2060	2060	2310	1840	2160
3. Broadcast (10-12 cm deep)	1410	1800	1880	1400	1910	1720	2170	1810	1760
Mean	1790	2050	2190	1560	1950	1810	2030	1830	--
Mean	1900				1900				1900
								C.V.	20.1 %

*, ** : significant at P = 0.05 and P = 0.01, respectively

ns : non significant

L.S.D.'s (5 %)	
Methods	353
Methods at same source	817
Rates at same source	310
Sources at same rate	438

dependent on the cultural practices and the farmer himself seems to have difficulty in seeing the advantage of the "improved" varieties.

The total number of lodged plants/plot (3 rows) at 80 DAP was not significantly affected by seedbed although it was always greater in ridges than in a flat seedbed (13 VS 10). Lodging at 80 DAP was not affected by planting depth (12 VS 12 plants), but there were significant differences between varieties, the local one being the most susceptible to lodging with about 25 % lodging (5.1, 10.4 and 19.4 lodged plants for TZE4, JFS and local variety, respectively ; L.S.D. = 4.4). Thus TZE4 showed no yield advantage over the local material (same maturity as TZE4) or over JFS (a few days earlier than TZE4), but it had more resistance to lodging.

6. SUMMARY AND CONCLUSIONS

The water problems of the Semi-Arid Tropics are not restricted to low and erratic rainfall. The problem is aggravated by soil conditions (e.g. crusting) and soil management practices (e.g. crop residue removal) that lead to reduced water infiltration and increased runoff. In addition, in some of the soils waterlogging or moisture excess will also occur during the rainy season, reducing maize growth and yields.

The occurrence of dry spells during the growing season appears to be - in the author's opinion - a factor of more importance than the lenght of the growing season for raising a succesful maize crop. Thus, early varieties will not necessarily outyield late ones and it depends rather on the growth stage at whichthe crop is subjected to moisture stress. In Saria, for instance, in the density trial (Table 3), the IRAT 80 variety (60 days to 50 % silking) yielded as well as Jaune Flint de Saria and TZE3 (both about 50 days to 50 % silking) in spite of the late planting date (July 7) and of the limited useful rainfall after 80 days after planting. In the Regional Uniform Variety Trial in Saria (RUVT-1, Breeding Program) late varieties well outyielded early ones.

The erratic occurence of the dry spells during the growing season poses difficult crop managment problems. Thus, although August is generally the wettest month (in both total precipitation and number of rainy days), that was not the case for Saria in 1979 and even in Farako-Bâ there was a dry spell in the middle of August. The variability in precipitation pattern occurs not only from year to year but also from one location to another and even from one field to another not far away.

It follows then that in order to reduce the risks of growing maize in these environments the drought resistance of maize should be increased and earliness in itself (i.e. drought escape) is not enough. Of course, there is a threshold of maximum maturity depending on the average lenght of the growing season. Moreover, materials which are early in relation to the lenght of the growing season have a place for especial management situations, e.g. lateplantings, replantings, relay cropping systems, etc.

It is clear also that the risks for growing maize will be reduced by manage-

Table 9
Planting depth trial. KAMBOINSE (Upper Volta). 1979
Grain yield (kg/ha, at zero percent moisture)

Planting depth, cm (*)	Seedbed (ns)	Variety (ns)			Mean
		Local	JFS	TZE4	
3 - 5	Flat	4030	3500	3710	3750
	Ridges	4190	4420	3800	4140
	Mean	4110	3960	3750	3940
8 - 10	Flat	3620	3810	3820	3750
	Ridges	2940	3700	4020	3550
	Mean	3280	3750	3920	3650
Seedbed	Flat	3820	3660	3760	3750
	Ridges	3570	4060	3910	3850
Mean		3690	3860	3840	3800

Seedbed x variety	(ns)	C.V. %	Main plot	11.7
Seedbed x depth	(*)		Sub-plot	16.3
Depth x variety	(*)		Sub-sub-plot	10.5
Seedbed x variety x depth	(ns)			

*, ** : significant at 5 and 1 % levels, respectively

n s : non significant

L.S.D.'s (5 %)

Seedbeds	639
Varieties	582
Varieties at same seedbed	823
Seedbeds at same variety	759
Depths	289
Depths at same seedbed	408
Seedbeds at same depth	669
Depths at same variety	500
Varieties at same depth	680

variety at the deep planting depth. At the shallow planting depth the local material yielded as well as JFS and TZE4, but when planted deep the local variety had lower yields than the other 2 varieties (planting depth x varieties interaction). Under a f flat seedbed there was no (mean) difference in yield between planting depths (3750 kg/ha at both depths), but deep planting gave lower yields under ridges (3550 VS 4140 kg/ha), with a marked decrease in the yield of the local variety (2940 VS 4190 kg/ha) but no effect on TZE4 (4020 VS 3900 kg/ha), which was the reason for the seedbeds x d depth interaction.

Confirming the results from the seedbed trial (Selection 5.3), there was no difference in the grain yields between a flat seedbed and plain ridges.

The differences in yield between planting depths cannot be accounted for in terms of stand differences. The number of seeds not germinated at the deep planting depth was greater than at the shallow depth (99 VS 57, out of 390 planted per plot, in 5 rows). The number of hills without any seed germinating was also greater under the deep planting depth (9 VS 2, out of 130 planted per plot, in 5 rows). However, 3 seeds were planted per hill, to be later thinned to 1 plant/hill. Final plant stands at harvest were 76 and 74 plants/plot (3 central rows) for the shallow and deep planting depths, respectively. Although this small difference in harvested plants was statistically significant, it is evident that it could not account for the large difference in yield.

The planting depth effect on grain yield, which was restricted to the local variety only, not affecting JFS nor TZE4 (it seems more logical to assign a yield of about 4000 kg/ha to JFS at the shallow depth under both seedbeds), could be attributed at least in part, to an increase in the plant to plant variability in the number of days to emergence. Thus, the first plants to emerge get an advantage in their growth and development in relation to their neighboring plants wich suffer from increased inerplant competition with a final decrease in total yield per unit area. The local Kamboinsé variety seems to be particularly susceptible to this delays in emergence when planted deep .

The number of days to 50 % silking was significantly increased by deep planting, the effect being confined (statistically) to the local variety (49.8 VS 51.8 days ; L.S.D. = 1.4). Similarly, the number of ears per plant was decreased in the local variety by deep planting (0.94 VS 0.81 ears/plant ; L.S.D. = 0.112).

These results show the importance of planting depth as a factor potentially affecting maize yield, and the observed Variety x Planting depth interaction is also of importance when trying to evaluate the yield potential of different materials. Thus had we compared TZE4 and the local material under only a shallow planting depth, the grain yields would be similar if not greater for the local material (4110 VS 3750 kg/ha), whereas a completely different picture would arise if they were compared at a deep planting depth (3280 VS3920 kg/ha). No wonder why, sometimes when we pretend to have varieties, which are "better" than the local varieties, th [illegible] ment practices such as planting maize on the deeper soils or on soils situated in the lower parts of the toposequence. Other management practices likely to increase water infiltration in the soil and/or to reduce water losses will also reduce the risk factor for growing maize, e.g. depth of soil preparation, cultivations, additions of organic residues and manure, mulching, etc but there is clearly a need to quantify these effects and to determine their cost - benefit ratios.

Table 10 gives a summary of the overall mean grain yields for all the 1979 trials and the treatments with the highest grain yields (at zero percent moisture). The lowest mean grain yields per trial were obtained in Saria (1810 kg/ha) on a shallow soil whereas the highest were obtained at Kamboinsé (3800 kg/ha) on a deep soil. The highest-yielding treatments for the same trials gave 2080 and 4420 kg/ha, respectively.

The results of 1979 showed that the linear model postulated by Duncan to relate the yield per plant to plant density can also be used in the Semi-arid Tropics (SAT). By having only 2 plant densities it is then possible to calculate the optimum density and the grain yield at the optimum density.

For medium-maturity varieties (about 60 days to 50 % silking) the optimum densities were between 30,000 and 70,000 plants/ha. For early-maturity varieties (about 50 days to 50 % silking) the optimum densities varied from 60,000 to 80,000 plants /ha. The optimum densities tended to increase with the fertilizer level.

In spite of large differences in the depth of soil preparation between bullock and tractor plowing, there were no differences in grain yields between both methods in a trial planted on a shallow soil. Both methods gave yields 40 to 50 % superior to those obtained with the farmer's conventional daba (hoe) soil preparation. Zero tillage with paraquat weed control was no better than the farmer's conventional method.

There was no difference in grain yield between planting on a flat seedbed and planting on ridges. Planting on tied ridges and also planting on a flat seedbed with ridging and tying 4 weeks after planting tended to give yields higher than those obtained with plain ridges because of increased water reserves in the soil.

At a low plant density (about 50 % of optimum plant population) there was no effect of row spacings (37.5, 75.0 and 112.5 cm) on grain yields. At a density close to the optimum, however, the widest row spacing (112.5 cm) gave significantly lower yields because of too high inter-plant competition.

Growing a maize crop at very high plant densities up to 31 days after planting and then cutting half of the plants for mulch in situ gave yields same (as above) final plant densities since planting time (control). When the cutting of the excess plants was delayed until 45 DAP, grain yields were decreased in relation to the control.

Based on 1979 results, TZE3 and TZE4 appear to offer no grain yield advantage over Jaune Flint de Saria (a local population improved by IRAT through mass selection) nor over two local Kamboinsé matérials. All these materials are of similar matu-

Table 10
Maize agronomy trials. 1979. Overall means and best treatment grain yields (at Zero percent moisture)

Trial	Location	Overall mean kg/ha	Best treatment *	
			kg/ha	Remarks
1. Plant density	Farako-Bâ	2080	3690	IRAT 100 (110 days), at 67,000 plants/ha)
	Saria	2300	3180	IRAT 80 (110 days), at 66,000 plants/ha
2. Soil preparation methods	Saria	1810	2080	Bullock plowing, shallow soil
3. Seedbeds	Kamboinsé	3150	3800	JFS (90 days) ; ridging 4 WAP (tied)
4. Spatial arrangements	Kamboinsé	2800	3680	Planted at 133,000 plants/ha ; every other row was then cut 31 DAP
	Saria	2480	3260	------------------------------
5. Mulching	Kamboinsé	2520	2940	TZE3 (90 days)
	Saria	1820	2380	TZE3 (90 days) ; shallow soil
6. Rotation	Saria	2320	2490	120-69-42 kg $N-P_2O_5-K_2O$/ha
7. Phosphatic rock	Saria	1900	2680	100 kg P_2O_5/ha;source single superphosphate
8. Planting depths	Kamboinsé	3800	4420	JFS (90 days) ; deep soil

* These are the treatments with the highest grain yields, but treatment differences were not always statistically significant.

rity (around 50 days to 50 % silking). It seems, however, that TZE3 and TZE4 have more resistance to lodging and also more resistance to foliar diseases.

Planting depth was an important factor affecting the yield of a local variety but not that of TZE4 or JFS. At a shallow planting depth (3-5 cm), all 3 varieties had similar yields, both under ridges and under a flat seedbed. At a deep planting depth (8 - 10 cm) the yield of the local variety was sharply reduced. It appears that this variety has more difficulty to emerge through deep planting depths and variability in emergence increases interplant competition in a way such that final grain yield per unit area is decreased.

MAIZE ENTOMOLOGY

Since little information was available on insect complex of maize crop in Upper Volta, it was necessary that in the first year research efforts should be concentrated to find out the insect and non-insect pests associated with this crop.

Studies were carried out to assess avoidable loss by insecticide treatments on important pests that feed at different stages of crop growth.

1. Insects associated with maize at Kamboinse

Various insect species found feeding on maize crop at different stages of crop growth are listed in Table 1. Out of these millipedes, termites and armyworm are more important. At times they can substantially reduce yields.

Borers, Sesamia calamistis and Eldana saccharina were observed on a crop planted on June 6, 1979. Percent infestation ranged from 5.9 to 46.3 in Jaune flint de Saria and 30.4 to 45.1 in Jaune de Fo, the two improved local varieties. Crops planted in late June or July had no borer infestation.

Armyworm, an important leaf feeding insect was also observed. Number of infested plants varied from 5.9 to 12.4 percent in Jaune flint de Saria and 6.0 to 16.5 percent in Jaune de Fo in June 6 planting, and from 3.7 and 5.0 per cent in late June planting.

2. Estimation of loss due to insect pests of maize

The experiment was planted on July 15, 1979, in a "split plot" design. The whole plots were insecticide treatments, untreated (WP1) vs. treated (WP2) ; sub-plots were four varieties of maize; Jaune flint de Saria (JFS), TZE-3, IRAT-102 and TZPB. Plot size was six rows x 5 meter long. Row to row spacing was 75 cm and between hills 50 cm. Plants were thinned to two per hill. Before planting heptachlor at the rate of 0.5 kg a. i./h mixed with the fertilizer and applied in the soil to check infestation by millipedes. Basal dose of fertilizer contained 42N, 70P and 42 kg of K/h. Additional dose of 108 kg of N was applied, splitted two times after 21 and 42 days after planting.

At seedling stage no insect was noticed. At whorl stage few armyworm infested plants were seen. Leaf hoppers were also present in small numbers at that

Table 1. Liste des insectes attaquant le maîs à Kamboinsé
Insect pests found feeding on maize at Kamboinse.

Stade Crop Stage	Nom Commun Common Name	Nom Scientifique Scientific Name
Plantule Seedling	Termites Termites	Unidentified
Montaison Whorl	Armyworm	Mythimma unipunota
	Leaf hopper	Cicadulina sp.
	Sauteriaux Grasshopper	Zonocerus variegatus
	Leaf folder	Marasmia trapezalis
Tige Stem	Ver rose Pink borer	Sesamia calamistis
		Eldana saccaharina
Epis et soie Cob and Silk	Armyworm	Mythimna unipuncta
	Ear worm	Helicoverpa armigera
	Termites Termites	Unidentified
Grains Grains	Armyworm	Mythimna unipuncta
	Termites Termites	Unidentified
	Scarabées Beetles	Carpophilus sp.
	Scarabées Beetles	Pachnota cordata
Panicule Tassel	Scarabées de pollen Pollen beetles	Coryna sp.
		Cylindrothorax westermani
		Epicauta sp.
		Melyris abdominalis
		Mylabris sp.
	Aphides Aphid	Rhopalosiphum maidis
Grain emmagrasiné Stored Grain	Charançon Weevil	Sitophilus zeamais

* Non-insect pest
* Ce n'est pas un insecte

time. To check the multiplication of these pests carbofuran 5 per cent granules were applied in whorls at the rate of 0.75 kg a. i./h 21 DAP. Population of none of these insects increased in treated and untreated plots. After few days one or two plants in border rows observed to be infested by termites. As a precautionary measure heptachlor 5 per cent at the rate of 1 kg a. i./ha was applied in the treated plots. In untreated plots no heptachlor was applied. Slight infestation of termites was observed 30 and 35 DAP. Because of rains, third observation on termite infestation could not be made until 64 DAP. Data (Table 2) indicated significantly higher number of plants infested (14.08 %) by termites in untreated plots as compared to treated plots (0.67 %). Infestation of this insect significantly increased when observed 82 DAP and was 23.88 per cent and 3.16 per cent, in untreated and treated plots, respectively. At this stage, some of the plants were even covered up to cob level by termite galleries (Table 3).

Attack of termites made the plants weak at the feeding site and caused lodging. Data (Table 4) showed that 14.27 per cent plants lodged in untreated plots as compared to 2.94 per cent in treated plots. No significant difference was found among varieties for susceptibility to this insect.

Damage to cobs was also significantly higher in untreated plots than treated plots (Table 5). The intensity of attack in this experiment would have been far greater if basal application of heptachlor was not given.

Infestation of armyworm reappeared at the silk stage. Larvae of this insect cut silk and try to penetrate inside the cob. To prevent the infestation of this insect, endosulfan was applied at the rate of 0.7 kg a. i./h. There was a heavy shower 4 hours after insecticide application. Observations taken 4 days after treatment (55 DAP, Table 6) indicated that significantly higher number of silks were cut in untreated plots. IRAT 102 and TZPB showed significantly less infestation than TZE-3 and Jaune flint de Saria (JFS). The differences were because of late flowering in IRAT-102 and TZPB. Significant differences between varieties were observed 62 DAP both in treated and untreated plots (Table 7). Up to this time JFS had the maximum infestation. It was 38.55 percent in the treated and 45.35 percent in the untreated plots followed by TZE-3. There was no difference between IRAT-102 and TZPB within and between treated and untreated plots. Observations taken 69 DAP indicated the same trend but higher level of infestation (Table 8). No more observations were possible from JFS and TZE-3 because they reached maturity. However, another observation was made 76 DAP (Table 9) from IRAT-102 and TZPB. Based on final observation in all the varieties, JFS got the maximum infestation (51.05 %) which was not significantly different in both the

Table 2. Pourcentage de plantes infestées par les termites 64 JAS
Percent termite infested plants 64 DAP

Variété (SP) Variety (SP)		Non traitées (WPI) Untreated (WPI)	Traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	VI	12,80 (20,65)	0,90 (3,80)	6,85 (12,23)
TZE-3	V2	15,28 (20,40)	0,00 (0,00)	7,64 (10,20)
IRAT-102	V3	15,65 (22,39)	0,30 (I,57)	7,98 (11,98)
TZPB	V4	12,58 (20,33)	1,48 (4,92)	7,03 (12,63)
Moyenne Mean		14,08 (20,54)	0,67 (2,57)	7,38 (11,76)

( ) Date in parentheses transformed to angle

L.S.D. at 5 % for whole plot = 7,59 (8,36)

C.V. " " = 91,47 (63,17)

L.S.D. at 5 % for sub. plot = 8,09 (7,60)

C.V. " " = 104,44 (61,53)

L.S.D. for comparisons of means within groups = 11,44 (10,74)

L.S.D. for comparisons of means of different groups = 12,26 (12,27)

( ) Donnée entre parenthèses transformée en angle

L.S.D. 5 % pour la parcelle entière = 7,59 (8,36)

C.V. " " = 91,47 (63,17)

L.S.D. 5 % pour la sous - parcelle = 8,09 (7,60)

C.V. " " =104,44 (61,53)

L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 11,44 (10,74)

L.S.D. pour les comparaisons des moyennes de différents groupes = 12,26 (12,27)

Table 3. Pourcentage de plantes infestées par les termites 82 JAS.
Percent termite infested plants 82 DAP

Variété Variety (SP)		Non traitées (WP1) Untreated (WP1)	Non traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	V1	22,85 (28,49)	3,30 (9,07)	13,08 (18,78)
TZE-3	V2	29,00 (32,36)	3,65 (10,58)	16,33 (21,47)
IRAT-102	V3	21,33 (27,35)	2,73 (8,06)	12,03 (17,71)
TZPB	V4	22,33 (27,70)	2,98 (9,44)	12,65 (18,57)
Moyenne Mean		23,88 (28,98)	3,16 (9,29)	13,52 (19,13)

( ) Data in parentheses transformed to angle
L.S.D. at 5 % for whole plot = 10,99 (10,73)
C.V. " " = 72,29 (49,84)
L.S.D. at 5 % for sub. plot = 4,86 (4,33)
C.V. " " = 34,19 (21,57)
L.S.D. for comparisons of means within groups = 6,87 (6,13)
L.S.D. for comparisons of means of different groups = 12,27 (11,77)

( ) Donnée entre parenthèses transformée en angle
L.S.D. à 5 % pour la parcelle entière = 10,99 (10,73)
C.V. pour la parcelle entière = 72,29 (49,84)
L.S.D. à 5 % pour la sous - parcelle = 4,86 (4,33)
C.V. " " = 34,19 (21,57)
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 6,87 (6,13)
L.S.D. pour les comparaisons des moyennes de différents groupes = 12,27 (11,77)

Table 4. Pourcentage de plantes atteintes de verse dûe aux termites

Percent plants lodged due to termite

Variété Variety (SP)		Non traitées (WP1) Untreated (WP1)	Traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	V1	17,50 (24,44)	3,30 (9,07)	10,40 (16,75)
TZE-3	V2	17,25 (24,06)	3,30 (10,16)	10,28 (17,11)
IRAT-102	V3	10,70 (18,88)	2,73 (8,06)	6,71 (13,47)
TZPB	V4	11,63 (19,29)	2,43 (8,65)	7,03 (13,97)
Moyenne Mean		14,27 (21,67)	2,94 (8,99)	8,03 (15,33)

( ) Data in parentheses transformed to angle

L.S.D. at 5 % for whole plot = 9,13 (10,39)

C.V. " " = 94,31 (60,29)

L.S.D. at 5 % for sub plot = 4,49 (4,43)

C.V. " " = 49,66 (27,49)

L.S.D. for comparisons of means within group = 6,35 (6,26)

L.S.D. for comparisons of means of different groups = 10,45 (11,52)

( ) Donnée entre parenthèses transformée en angle
L.S.D. à 5 % pour la parcelle entière = 9,13 (10,39)
C.V. " " = 94,31 (60,29)
L.S.D. à 5 % pour la sous - parcelle = 4,49 (4,43)
C.V. " " = 49,66 (27,49)
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 6,35 (6,26)
L.S.D. pour les comparaisons des moyennes de différents groupes = 10,45 (11,52)

Table 5. Pourcentage de dégâts aux épis à la récolte

Percent cobs damaged by termites at harvest

Variété Variety (SP)		Non traitées (WP1) Untreated (WP1)	Traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	V1	5,60 (12,98)	0,90 (3,80)	3,25 (8,39)
TZE -3	V2	6,73 (12,56)	0,35 (1,69)	3,54 (7,13)
IRAT-102	V3	3,83 (10,96)	1,03 (2,92)	2,43 (6,94)
TZPB	V4	4,25 (11,72)	0,00 (0,00)	2,13 (5,86)
Moyenne Mean		5,10 (12,05)	0,57 (2,10)	2,84 (7,08)

( ) Data in parentheses transformed to angle
L.S.D. at 5 % for whole plot = 2,34 (2,09)
C.V. " " = 73,49 (26,21)
L.S.D. at 5 % for sub plot = 2,92 (4,66)
C.V. " " = 97,93 (62,66)
L.S.D. for comparisons of means within groups = 4,12 (6,59)
L.S.D. for comparisons of means of different groups = 4,21 (6,04)

( ) Donnée entre parenthèses transformée en angle
L.S.D. à 5 % pour la parcelle entière = 2,34 (2,09)
C.V. " " = 73,49 (26,21)
L.S.D. à 5 % pour la sous - parcelle = 2,92 (4,66)
C.V. " " = 97,93 (62,66)
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 4,12 (6,59)
L.S.D. pour les comparaisons des moyennes de différents groupes = 4,21 (6,04)

M-59

Table 6. Pourcentage de dégât aux sorés causé par les chenilles 55 JAS
Percent silk damage by armyworm 55 DAP

Variété Variety (SP)		Non traitées (WP1) Untreated (WP1)	Traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	V1	38,88 (38,54)	22,03 (27,88)	30,45 (33,21)
TZE-3	V2	16,85 (24,18)	12,78 (20,37)	14,81 (22,28)
IRAT-102	V3	3,13 (9,57)	1,93 (6,44)	2,53 (8,00)
TZPB	V4	3,25 (8,07)	2,70 (8,07)	2,98 (8,48)
Moyenne Mean		15,53 (20,29)	9,8[illegible] (15,69)	12,69 (17,99)

M-60

( ) Data in parentheses transformed to angle
L.S.D. at 5 % for whole plot = 4,19 (4,32)
C.V. " " = 29,34 (21,39)
L.S.D. at 5 % for sub plot = 4,39 (5,20)
C.V. " " = 32,95 (27,51)
L.S.D. for comparisons of means within groups = 6,21 (7,35)
L.S.D. for comparisons of means of different groups = 6,69 (7,58)

( ) Donnée entre parenthèses transformée en angle
L.S.D. à 5 % pour la parcelle entière = 4,19 (4,32)
C.V. " " =29,34 (21,39)
L.S.D. à 5 % pour la sous - parcelle = 4,39 (5,20)
C.V. " " =32,95 (27,51)
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 6,21 (7,35)
L.S.D. pour les comparaisons de moyennes de différents groupes = 6,69 (7,58)

Table 7. Pourcentage de dégâts dus à <u>Mythimna</u> 62 JAS.
Percent silk damage by armyworm 62 DAP

Variété Variety (SP)		Non traitées (WP1) Untreated (WP1)	Traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	V1	45,35 (42,33)	38,55 (38,24)	41,95 (40,29)
TZE-3	V2	25,18 (30,07)	22,73 (28,35)	23,95 (29,21)
IRAT-102	V3	8,28 (16,55)	5,25 (12,68)	6,76 (14,61)
TZPB	V4	6,08 (13,70)	2,80 (8,35)	4,44 (11,02)
Moyenne Mean		21,22 (25,66)	17,33 (21,91)	19,28 (23,78)

( ) Data in parentheses transformed to angle
L.S.D. at 5 % for whole plot = 3,64 (3,45)
C.V. " " = 16,79 (12,89)
L.S.D. at 5 % for sub plot = 5,68 (4,53)
C.V. " " = 28,08 (18,14)
L.S.D. for comparisons of means within groups = 8,04 (6,41)
L.S.D. for comparisons of means of different groups = 7,77 (6,44)

( ) Donnée entre parenthèses transformée en angle
L.S.D. à 5 % pour la parcelle entière = 3,64 (3,45)
C.V. " " =16,79 (12,89)
L.S.D. à 5 % pour la sous - parcelle = 5,68 (4,53)
C.V. " " =28,08 (18,14)
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 8,04 (6,41)
L.S.D. pour les comparaisons des moyennes de différents groupes = 7,77 (6,44)

Table 8. Percent silk damage by armyworm 69 DAP

Tableau 8. Pourcentage de dégâts aux soies par <u>Mythimna</u> 69 JAS

Variété (SP) Variety (SP)		Non traitées (WP1) Untreated (WP1)	Traitées (WP2) Treated (WP2)	Moyenne (SP) Mean (SP)
JFS	V1	51.05 (45.60)	47.18 (43.38)	49.11 (44.49)
TZE-3	V2	33.80 (35.49)	25.15 (29.91)	29.48 (32.70)
IRAT-102	V3	21.63 (27.59)	11.38 (19.61)	16.50 (23.60)
TZPB	V4	17.40 (24.38)	6.00 (14.06)	11.70 (19.22)
Moyenne Mean		30.97 (33.27)	22.43 (26.74)	26.70 (30.00)

( ) Data in parentheses transformed to angle
L.S.D. at 5 % for whole plot = 4.38 (3.55)
C.V. " " =14.58 (10.51)
L.S.D. at 5 % for sub. plot = 5.31 (3.63)
C.V. " " =18.92 (11.51)
L.S.D. for comparisons of means within groups = 7.50 (5.13)
L.S.D. for comparisons of means of different groups =7.72 (5.58)

( ) Donnée entre parenthèse transformée en angle
L.S.D. 5 % pour la parcelle entière = 4.38 (3.55)
C.V. " " = 14.58 (10.51)
L.S.D. 5 % pour la sous-parcelle = 5.31 (3.63)
C.V. " " = 18.92 (11.51)
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes = 7.50 (5.13)
L.S.D. pour les comparaisons de moyennes de différents groupes = 7.72 (5.58)

Table 9. Percent silk damage by armyworm 76 DAP

Tableau 9. Pourcentage de dégâts aux soies par Mythimna 76 JAS

Variety Variété		Untreated (WP1) Non traitées (WP1)	Treated (WP2) Traitées (WP2)	Mean (SP) Moyenne (SP)
JFS	V1	51.05 (45.60	47.18 (43.38)	49.11 (44.49)
TZE-3	V2	33.80 (35.49)	25.15 (29.91)	29.48 (32.70)
IRAT-102	V3	38.43 (38.22)	22.43 (27.96)	30.43 (33.09)
TZPB	V4	34.30 (35.65)	9.30 (17.59)	21.80 (26.62)
Mean Moyenne		39.39 (38.74)	26.01 (29.71)	32.71 (34.23)

( ) Data in parentheses transformed to angle
Donnée entre parenthèses transformée en angle

L.S.D. at 5 % for whole plot = 7.62 (4.36)
L.S.D. 5 % pour la parcelle entière

C.V. at for whole plot = 20.72 (11.32)
C.V. pour la parcelle entière

L.S.D. at 5 % for sub. plot = 7.65 (4.87)
L.S.D. 5 % pour la sous-parcelle

C.V. for sub-plot = 22.27 (13.36)
C.V. pour la sous-parcelle

L.S.D. for comparisons of means within groups = 10.82 (6.89
L.S.D. pour les comparaisons de moyennes à l'intérieur des groupes

L.S.D. for comparisons of means of different groups = 11.86 (7.27)
L.S.D. pour les comparaisons de moyennes de différents groupes

treated and untreated plots. Other three varieties differed significantly from JFS but did not differ among themselves in the untreated plots. But TZPB had significantly less silk damage in the treated plots.

At harvest number of cobs damaged by armyworm were significantly more in untreated plots in all the varieties as compared to in treated plots (Table 10). No difference was found among varieties.

In addition to above mentioned insects, Carpophilus sp. was also found feeding on grains at milk stage. Adults of this insect enter inside the cob through entry holes made by other pests. The cobs which had short sheath are being preferred as they provide easy accessibility to grains. In the present study insecticide application for the control of armyworm had some effect on this insect also. There was significant difference between treated and untreated plots. Both the medium maturing varieties, JFS and TZE 3, got significantly higher number of infested cobs than IRAT-102 and TZPB. Percentage of infested cobs may be higher in different varieties but the extent of grain damage was very little.

To know whether insect damage had any influence on crop growth, plants were measured at harvest. There was no significant difference in plant height between treated and untreated plots but varieties differed significantly.

Grain yield varied significantly in treated an untreated plots and also among varieties. In untreated plots TZE-3 yielded significantly less than JFS and IRAT-102 but there was no difference in yield between TZE-3 and TZPB (Table 11) In treated plots TZPB gave lowest grain yield and there was no difference among other varieties. IRAT-102 gave the highest yield of 4820 kg/h (Table 12).

It is interesting to note that TZE-3 produced 806 kg more yield per hectare in treated plots than untreated. No other variety had such a big difference. Varieties JFS and IRAT 102 also produced higher yield in treated plots and the differences were 447 and 480 kg/h, respectively. There was very little difference in yield between treated and untreated plots for TZPB.

From yield data it appeared that insects caused significant losses in yield. Infestation of termites would have been more if no basal dose of heptachlor was given. Similarly, Eldana which survives on organic matter in the soil, might also have attacked the crop if insecticide was not applied.

In this experiment no borer infestation was observed from beginning till harvest.

Table 10. Percent cob damage by armyworm at harvest
Tableau 10. Pourcentage de dégâts aux épis par Mythimna à la récolte.

Variety (SP) Varieté (SP)		Untreated (WP1) Non traitée (WP1)	Treated (WP2) Traitée (WP2)	Mean (SP) Moyenne (SP)
JFS	V1	4.33 (10.10)	2.90 (6.28)	3.61 (8.23)
TZE-3	V2	3.50 (10.24)	1.90 (5.61)	2.70 (7.93)
IRAT-102	V3	4.45 (11.94)	3.13 (9.87)	3.79 (10.91)
TZPB	V4	9.23 (17.57)	4.75 (12.09)	7.01 (14.83)
Moyenne Mean		5.38 (12.49)	3.17 (8.46)	4.28 (10.48)

(D) Data in parentheses transformed to angel (Donnée entre parenthèses transformée en angle)

L.S.D. at 5 % for whole plot = 1.55 (3.82)

C.V. " " =32.29 (32.38)

L.S.D. at 5 % for sub. plot = 3.72 (5.46)

C.V. " " =82.67 (49.64)

L.S.D. for comparisons of means within groups = 5.25 (7.72)

L.S.D. for comparison of means of differet groups= 4.78 (7.60)

L.S.D. 5 % pour la parcelle entière = 1.55 (3.82)
C.V. " " = 32.29 (32.38)
L.S.D. our la sous-parcelle = 3.72 (5.46)
C.V. " " = 82.67 (49.64)
L.S.D. pour les comparaisons des moyennes à l'intérieur des groupes = 5.25 (7.72)
L.S.D. pour les comparaisons des moyennes des différents groupes = 4.78 (7.60)

Table 11 Grain yield (kg) per plot
Tableau 11 Rendement en grains (kg) par parcelle

Variety (SP) Variété (SP)	Untreated (WP1) Non traitées)(WP1)	Treated (WP2) Traitées (WP2)	Mean (SP) Moyenne (SP)
JFS	6.15	6.82	6.49
TZE-3	4.99	6.20	5.59
IRAT-102	6.51	7.23	6.87
TZPB	5.67	5.96	5.82
Mean - Moyenne	5.83	6.55	6.19

L.S.D. at 5 % for whole plot = 0.40
C.V. " " 5.75
L.S.D. at 5 % for sub. plot = 0.77
C.V. " " = 11.76
L.S.D. for comparisons of means within groups = 1.08
L.S.D. for comparisons of means in different groups = 1.01

L.S.D. 5% pour la parcelle entière = 0.40
C.V. " " = 5.75
L.S.D. 5 % pour les sous-parcelles = 0.77
C.V. " " = 11.76
L.S.D. pour les comparaisons des moyenne à l'intérieur des groupes = 1.08
L.S.D. pour les comparaisons des moyennes des différents groupes = 1.01

Table 12 . Grain yield (kg) per hectare
Tableau 12 - Rendement en grains (kg) par hectare

Variety Variété	Untreated Non traitées	Treated Traitées	Difference Différence
JFS	4100	4547	+ 447
TZE-3	3327	4133	+ 806
IRAT-102	4340	4820	+ 480
TZPB	3780	3973	+ 193

COWPEA

COWPEA BREEDING

INTRODUCTION

The Upper Volta National Cowpea Improvement Program began in June 1977 with support provided by the government of Upper Volta and the International Development Research Centre of Canada (IDRC). An IITA cowpea breeder was based at Kamboinse Agricultural Research Station, 15 km north of Ouagadougou, the capital of Upper Volta. In 1979, the program was expanded with the addition of a full time cowpea agronomist and a part-time entomologist under the SAFGRAD project which has a regional mandate. During 1979 research activities were limited to Upper Volta except visits to other national programs in the region. Major research efforts were concentrated at Kamboinse for breeding and entomology and at Saria for Agronomy work. In addition experiments were conducted across a range of ecolçgical environments in Upper Volta.

OBJECTIVES :

Research is focussed on the development of lines of cowpea that combine stable yield with resistance to insect pests, diseases and drought stress. Material originated at IITA, comprising, breedind nurseries, preliminary, advanced and international trials, has been the major source for selecting suitable lines for Upper Volta environments. At the same time, results obtained in Upper Volta provided valuable information to IITA program in determining their selection strategy, thus serving a mutual interest.

Research activities have been expanded with the initiation of SAFGRAD project. The project has now assumed the additional responsibility of research for the semi-arid regions of the SAFGRAD member countries. The main activities will include establishing regional variety trials in collaboration with member country national programs, supplying improved cowpea material and meeting some of the needs for logistic support.

The other important objective of the program is the development of trained manpower. Initially there was provision for training to MSc level in plant breeding, agronomy, entomology, plant pathology and in-service training. In the SAFGRAD project, similar opportunities exist for qualified candidates from all member countries for fellowships for both advanced degree as well as in-service short term training.

REPORT OF PROGRESS - COWPEA IMPROVEMENT PROGRAM

For testing purposes Upper Volta has been divided into three major agroclimatic zones : southern zone (with annual rainfall 900 - 1100 mm), central zone (700 - 900 mm) and northern zone (350 - 700 mm). A representative test site has been identified in each zone : Farako-Bâ, southern ; Kamboinse, central ; and Saouga, northern. The northern zone comprises most of the semi-arid regions of the country where the growing season is less predictable due to high variation in rainfall. To get a better measure of the performance of improved material, two additional sites have been selected in this zone : Kaya and Ouahigouya. The rainfall and temperature data for 1979 at these locations and their latitudes (°N) are given on page VI. Rainfall in the growing season (July - October) was highest at Farako-Bâ in the south with total of 688 mm and lowest at Saouga with just over 250 mm. Temperatures during the growing season increased from south to north.

Traditional varieties of cowpea have evolved over centuries in a subsistence farming system based on sorghum and millet. They are day-length sensitive and are usually specifically adapted to flower at the end of the rains in the locality they are grown. Their yields are low and to raise yields significantly new and different plant types will be required.

Types of experiments conducted in 1979 are shown in Table 1 . Trials have helped to identify lines suited to particular environments. The results have shown that in the past three years, except in the extreme dry environments of the north, improved varieties have producted higher yields and are earlier maturing than traditional forms. Their early maturity, permitting harvest at a time when food is scarce, has attracted interest particularly in the drier parts of the country.

Table 1. Types and dates of planting of experiments conducted in Upper Volta, in 1979.

Nature of experiments	Locations	Date of planting
On farm trials	16 locations	Various
Upper Volta yield trial	Kamboinsé	6 July
	Kaya	25 July
	Ouahigouya	
	Buiedougou	19 July
IITA International yield trials	Farako-Bâ	12-13 July
	Kamboinsé	7 July
	Saouga	12-13 July
IITA Advanced yield trials	Farako-Bâ	11-12 July
	Kamboinsé	7 July
	Saouga	12 July
IITA Preliminary yield trials	Kamboinsé	7 July
Upper Volta preliminary yield trial	Kamboinsé	22 July
Seed size increse observation lines	Kamboinsé	22 July
Intercropping sub-populations		22 July
Crosses between selected improved and local cultivars	IITA	July

1. On Farm Trials :
Three main groups of trials were designed, on each for rainfall zones of 500 - 600 , 600 - 700 and 700 - 800 mm. The varieties included in each group were based on their performance in different ecological zones in 1978. For example, TVx 289-4G was included only in the trials for more humid areas, and TVx 1948-01F in the trials for dry areas. Each of the three main groups were further sub-divided into two, one containing VITA-4 and the other VITA-5 as the check variety. A local cultivar and TVx 309-1G were included in all the trials. These trials were conducted by the SAFGRAD Accelerated Crop Production Officer, who is a liaison officer between research and extension in Upper Volta. The detailed results of these trials will be published in a separate report.

In summary, the yield of some varieties at different sites was found to be affected by the amount of rainfall during the growing season, the fact supported by their high and significant correlation coefficients between yield and rainfall (e.g. TVx 309-1G = 0.71 TVx 1193-7D = 0.99*). On average over locations, TVx 289-4G was the highest yielder. This variety also produced high yields in last year's experiments and was particularly good in wetter areas. Because of its consistently good yields, it has been recommended for release and is renamed as Kamboise Niebe-1 (KN-1) in Upper Volta. During 1979 it was included in the demonstration plots and the GOUV has multiplied one hectare of its seed during the rainy season for distribution next year. Based on its superior performance at a wide range of locations in IITA's international trials, it has also been described as VITA-7.

2. Upper Volta Yield Trial :
Lines which performed consistently well during 1977 and 1978 and others showing promise were included in the Upper Volta Yield Trial. The major objective was an assessment of stability of yield and adaptability across ecological zones. The trial comprised seven cultivars, six improved and one local. Amongst the improved cultivars, four were spreading and two erect types. The experiment was grown at 11 locations between latitudes of 12°0' - 13°5'N, but at the time of writing,results have been received from only six locations of which three are at Kamboinse and one each at Kaya (13°06'N), Ouahigouya (13°35'N) and Guidedougou 13°00'N, rainfall 383.5mm during the growing season). The three sites at Kamboinse represented three kinds of soils on a toposequence ; shallow, medium and deep. The shallow soil at the trop of toposequence is less fertile and has poor water holding capacity.

The seed yields are summarised in table 2. The local variety used was not the same at all the sites. Therefore its data was excluded from the analysis. To assess stability of performance the regressions of individual lines are graphically presented in gure 1.

.../...

On ovrage over locations, KN-1 produced the highest yield (1642 kg/ha), but was not the most stable as it exhibited a high regreeion coefficient, producing higher yields in favorable environments than under less favorable conditions. The difference between its highest and the lowest yield across locations was fairly large (916 kg/ha). The more suitable line for lower yielding environments appeared to be TVx 1948-01F. It combined good yield with a good lower regression coefficient and smaller deviations from regression.

At Kamboinse, the highest mean yield of varieties was obtained at the centre of the toposequence (medium soil), whereas the plant growth, measured in plant height and width, was higher in the fertile deep soil at the bottom of the slope (Table 3). Low yields on the deep soil appear to be due to excessive vegetative growth at the cost of grain production as this was more pronounced for the spreading type varieties. The yield in the most erect variety, TVx 309-1G, was little affected. These results were similar to those obtained in the advanced yield trials, where yield differences in plant growth were less pronounced for the spreading varieties (Advanced Trials 1 and 2) than for erect types (Trial 3). Similar results have been obtained in the cowpea management trial at Kamboinse, where excessive plant growth caused by high applications of phosphorous reduced seed yields considerably more in spreading local than erect varieties (TVx 309-1G).

Low yields under shallow soil were due to poor growth resulting from low fertility of the soil.

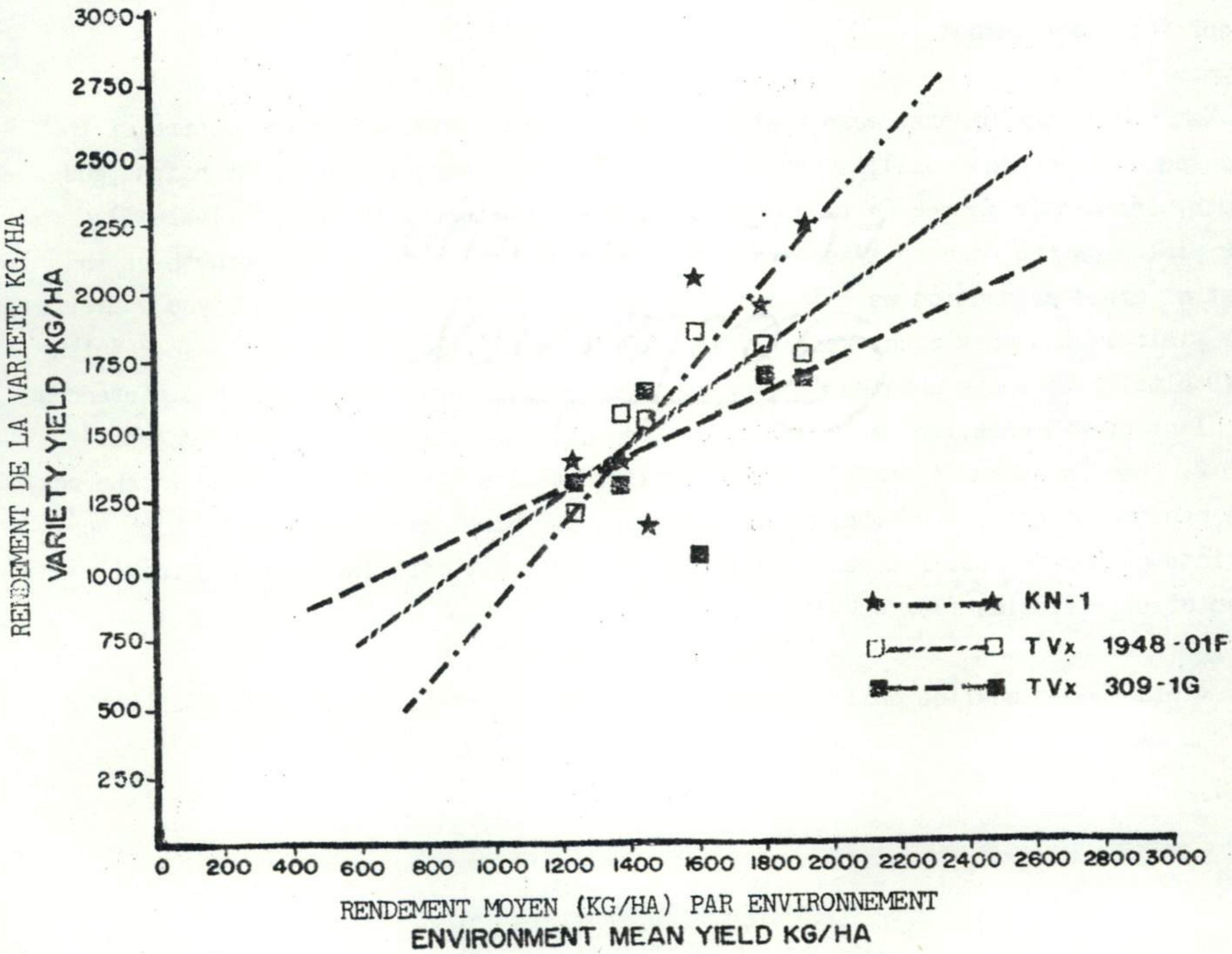

Figure I- Regression of individual variety on environment mean seed yield (kg/ha^{-1})
Regression de la variété individuelle sur rendement moyen en graines (kg/ha) par environnement.

Table 2. Seed yields (kg-ha^{-1}) of cultivars in Upper Volta yield trials, 1979

Tableau 2. Rendement en grains des cultivars des essais de rendement en Haute-Volta, 1979

Line ligne	Kamboinsé-S[1]	Kamboinsé-M[2]	Kamboinsé-D[3]	Kaya	Ouahigouya	Guiedougou	Mean Moyenne
KN-1	1333	1920	1094	1327	2167	2010	1642
TVx 309-1G	1278	1635	1621	1290	1670	1009	1417
TVx 1193-7D	1153	1753	1311	9[illegible]2	16[illegible]3	673	1248
TVx 1948-01F	1033	1752	1517	1526	1735	1835	1566
VITA-4	1497	1755	1528	1124	2203	1615	1632
VITA-5	893	1704	1398	1660	1832	2177	1611
LOCAL	432	1250	249	1009	1405	796	857
Trial Mean Moyenne de l'essai	1088	1681	1245	1284	1804	1445	1424.5
S.E. of Mean ± S.E. des moyennes	115.6	96.5	116.9	163.8	245.7	83.0	55.9
C.V. %	20.17	10.87	17.71	24.21	25.88	15.36	19.0

NOTE : 1 = Shallow soil - Sol peu profond

2 = Medium deep soil - Sol moyen

3 = Deep soil - Sol profond

C-7

Table 3. Canopy heights and widths of lines in the Upper Volta yield trial on three soil types at Kamboinsé, 1979.

Tableau 3. Taille (hauteur et largeur) des lignées des essais de rendement en Haute-Volta sur les trois types de sols à Kamboinsé, 1979

Varieties / Variétés	Locations / Localités					
	Shallow soil / Sol peu profond		Medium soil / Sol moyen		Deep soil / Sol profond	
	Height / hauteur (cm)	width / largeur (cm)	height / hauteur (cm)	width / largeur (cm)	height / hauteur (cm)	width / largeur (cm)
KN-1	31	50	36	71	39	60
TVx 309-1G	38	36	34	53	45	61
TVx 1193-7D	34	31	29	45	35	42
TVx 1948-01F	31	46	29	56	36	59
VITA-4	58	54	43	51	43	60
VITA-5	31	45	28	56	40	64
Local	58	75	26	75	41	75
Trial mean / Moyenne de l'essai	36	48	32	58	40	60
S.E. of mean ± / S.E. des moyennes	5	7	4	8	3	6
C.V. %	26	30	22	27	15	18

3. International Yields Trials :

These trials from part of IITA's Cowpea International Cultivar Trial series. There were two trials : trial 1 consisted of 20 (18 + local) semi-erect and spreading types and trial 2 consisted of 10 (9 + local) erect lines. They were sown at Farako-Ba, Kamboinse and Saouaga. The yield of the more promising lines and of the standard checks are shown in Tables 4 and 5.

Yields in these trials were highest at Kamboinse and lowest at Saouga, it was particularly low in Trial 1 at Saouga where a sand storm at end of July retarded growth. In Trial 1, on overage over three locations, KN-1 gave the highest seed yield (1599 kg/ha). Its performance was particularly good at Kamboinse and Farako-Ba where there was adequate rainfall, but poorer under the relatively dry conditions at Saouga ; thus confirming observations of its performance in other trials.

TVx 1999-02E was the second highest yield with 1477 kg/ha, not significantly different from KN-1. TVx 1999-01F, a sister line of TVx 1999-02E, also produced a reasonably good yield. and was the best yielder at Saouga. These two lines were the top yielders in Advanced Trial 1 in 1978. Because of their consistently good performance during the last two years, particularly in they dry areas, they appear to be the potential new selections. These will be included in the 1980 Upper Volta Yield Trial to be further tested at a wide range of environments.

In International Trial 2, TVx 1836-015J was the best yielder (1514 kg/ha) ranking first at both Farako-Ba and Kamboinse and being not significantly different from the other improved varieties. TVx 1193-7D and TVx 2394-02F also yielded well. TVx 1193-7D also performent well in the last year's trials at different sites in West Africa, and based on its superior performance, has been described by IITA as VITA-6.

The best performing varieties produced significantly better seed yields than the local checks at Farako-Ba and Kamboinse but not at Saouga. At this location only TVx 1999-02E and TVx 1999-01F have equalled the local variety in this years International Trials. Photoinsensitive IITA lines appeared to switch to reproductive growth too soon to accumulate in sufficient vegetative growth to support highyields. Photosensitive lines grow well vegetatively but switch to reproductive growth too late to avoid moisture stress during pod fill. In the local variety the phases are synchronised closely with the rainfall enabling an extended period vegetative growth associated with a switch to reproductive growth in sufficient time to exploit available soil moisture.

.../...

This local variety, along with three other improved lines, differing in plant type from erect to spreading, was grown at Saouga at two different dates with and without phosphorous, in two plant densities to determine the relative importance of plant type in relation to varying levels of soil fertility and available soil moisture (sowing date). Because of highly unfavourable growing season, the results are not conclusive. The trial will be repeated.

In the meantime, crosses have been made between this and other promising cowpea varieties to select plants capable of producing high yields in hot and dry environments. It is recommended that this variety be tested in controlled environment conditions for heat tolerance and drought stress.

Table 4. Yields (kg/ha^{-1}) of cultivars in International Yield Trial-1 in Upper Volta in 1979.

Tableau 4. Rendement en (Kg/ha) des cultivars de l'essai international-1 en Haute-Volta en 1979.

Cultivars	Farako-Bâ	Kamboinsé	Saouga	Mean Moyenne
PROMISING LINES				
Lignées prometteuses				
Tvx 33-1J	1146	1481	608	1078
Tvx 1850- 01E	1073	2109	483	1222
Tvx 1948- 01E	1313	2060	404	1259
Tvx 1952-01E	938	1198	179	772
Tvx 1999- 02E	1583	2156	692	1477
Tvx 1999- 01F	1333	1678	779	1263
Tvx 2907- 02D	1021	2144	400	1188
Tvx 2912-011D	979	1514	321	938
Tvx 2939- 09D	1083	1907	304	1098
Tvx 2949- 01D	1135	2038	375	1183
Tvx 2949- 03D	1312	2073	342	1242
Tvx 3048- 02D	1375	1860	483	1239
Tvx 3218- 02D	1688	2020	375	1361
STANDARDS				
VITA-3	792	2086	150	1009
VITA-4	1168	1703	267	1046
VITA-5	1042	2250	192	1161
Tvx 66-2H (VITA-8)	896	1972	196	1021
VITA-7 (KN-1)	1667	2562	567	1599
IFE BROWN	1813	1687	508	1336
Local	1125	312	700	712
Trial mean Moyenne de l'essai	1224	1841	416	1127
S.E. of mean ± S.E. des moyennes	154.0	179.1	79.8	79.4
C.V. %	25.2	19.5	38.3	27.7

Table 5. Yields (kg/ha^{-1}) of cultivars in International Yield Trial-2 in Upper Volta in 1979.

Tableau 5. Rendement en (kg/ha) des cultivars de l'essai international-2 en Haute-Volta en 1979.

Cultivars	Farako-Bâ	Kamboinsé	Saouga	Mean Moyenne
Tvx 7-4K	1266	1814	800	1293
Tvx 309- 1G	1516	1716	956	1396
Tvx 1193- 7D	1431	1945	950	1442
Tvx 1576- 01E	953	2105	925	1328
Tvx 1836-013J	1188	1636	844	1223
Tvx 1836-015J	1547	2169	825	1514
Tvx 2394- 01F	938	1996	694	1209
Tvx 2394- 02F	1188	2173	775	1379
4R-0267 - 1F	1244	1981	981	1402
Local	1231	639	1338	1036
Trial Mean Moyenne de l'essai	1250	1818	909	1325.7
S.E. of Mean ±	93.9	164.1	124.0	73.5
C.V. %	15.0	18.1	27.4	20.2

Table 6. Analysis of variance from stability analysis (Eberhart and Russell, 1966) of seed yield kg/ha^{-1} in cowpea advanced yield trials in Upper Volta.

Tableau 6. Analyse des variances des rendements des [illegible] avancés en Haute-Volta selon la méthode (Eberhart et Russell, 1966)

Source of variation Source de variance	D.F.	Mean square Moyenne des carrés		
		A-1	A-2	A-3
Varieties Variétés	24	5556.2**	2809.6	4780.2**
Locations (Linear) Localités	1	164932.1**	163898.7**	181904.2**
Variety x Locations (Linear) Variété x Localités	24	1696.5	1103.5	1383.5
Pooled deviations Pool des déviations	25	1088.6	1453.4**	1181.5
Pooled error Pool erreur	144	775.7	711.0	1158.1

** Significant at 10 % level of probability.
Significatif à 10 % du niveau de probabilité.

4. Advanced Yield Trials :

Advanced trials have been designed to evaluate promising lines, selected on their preliminary evaluation, more thoroughly across a range of ecological and climatic environments. Three trials, each including 25 varieties, were sown at Farako-Ba (11°06'N), Kamboinse (12°28'N) and Saouga (14°23'N).

Data were subjected to stability analysis based on the model of Eberhart and Russel (1966). The analysis of variance is given in Table 6. Highly significant differences between varieties were observed in advanced trials 1 and 3, but were not significant in trial 3. Variety x location (linear) interactions were non-significant. The yields of the more promising lines compared with those of the standard checks and their regression coefficients and r^2 values are shown in Tables 7, 8 and 9.

In all the three trials, VITA-1 was poorest because of its sensitivity to photoperiod. VITA-4 and VITA-5 were relatively more suited to favorable environments as indicated by their high regression coefficients and low deviations from regression.

In Trial 1 (Table 7), Ife Brown was the highest yielder at Farako-Ba and Saouga but several lines were similar to it. VITA-7 (KN-1) was best yielder at Kamboinse, but not significantly different from the most promising lines. It had a high regression coefficient (1.91) and low deviations from regression, thus reconfirming its suitability to favorable environments. Amongst the new lines,TVx 3381-02F was best at FARAKO-BA (1633 kg/ha) and TVx 3405-014E best both at Kamboinse and Saouga. On average over the three locations, TVx 3381-02F was highest yielder (1566 kg/ha), and it was the most stable line across environments as shown by its closer to unity regression coefficient (1.093) and low deviations from regression line. Other high yielding lines were TVx 3405-04E (1542 kg/ha), 7R-0189D (1487 kg/ha) and TVx 3385-027D. These varieties produced mean seed yields either similar to or better than the best standard check variety (VITA-4).

In Trial 2 (Table 8), no one single line was the highest yielder at the three locations. TVx 3404-012E was highest yielder at Farako-Ba, TVx 3391-014D at Kamboinse and TVx 3343-03E at Saouga, and none of them was significantly superior to the best performing standard check variety. On overage over the three locations, TVx 3404-012E was highest yielder (1477 kg/ha) followed by TVx 2724-010F (1405 kg/ha) and TVx 3385-029E. But based on stability analysis, TVx 3336-04D seemed to be more stable. Amongst the check varieties, VITA-4 was the highest yielder (1329 kg/ha).

In Trial 3 (Table 9) also, no one single line performed best at all the three locations. TVx 3428-03E was highest yielder at Farako-Ba and was significantly better than the best check variety (Ife Brown). TVx 3337-015E was best at Kamboinse, but not significantly different from the best check variety (VITA-4). However, highest yielder at Saouga, TVx 3382-033E, was significantly better than the best check variety (Ife Brown) at that location. On average over the locations, TVx 3428-03E was the highest yielder (1846 kg/ha) followed by TVx 3382-033E (1786 kg/ha). Ife Brown was the best yielder amongst the check varieties. TVx 3356-04F had high value of regression coefficient (1.797) and lower deviations from regression suggesting its, suitability to more favorable environments.

TVx 3072-01E had low regression coefficient and low deviations, and therefore could be more suitable for unfavorable environments.

The location mean seed yield was lowest at Saouga, It was highest at Kamboinse for Trials 1 and 2, and at Farako-Ba for Trial3 (Table 10). The low seed yields in Trial 1 and 2 at Farako-Ba than at Kamboinse can be attributed to the lower threshing percentage of poor quality pods caused by weather conditions at the time of harvest. The high yields in Trial 3, in spite of low threshing percentage, were the result of extremely high number of pods (Table 10).

In the extreme environment of Saouga, low yields were due to a lower number of pod. A drought spell of 18 days (21 July to 7 August), high temperatures and lack of sufficient moisture at the pod filling stage (rains ended only 10 days after the average flowering date, Table 1) contributed greatly to poor vegetative and reproductive growth and poor yield.

Other factors probably influencing yield at Saouga were fertility and water holding capacity of the soil. Soil analysis revealed a very low level of phosphorous, low organic carbon (0.28 %) and a higher proportion of sand to silt and clay (Table 11). Capability of a soil to retain water is very crucial, especially in areas where rainfall is insufficient and irregular.

Records of height and width did not adequately describe plant growth especially for spreading type varieties in trial 1 and 2, where plant width is restricted by between row distance. For such, some other method of assessing vegetative growth may be more accurate to differentiate the yield differences, particularly between Farako-Ba and Kamboinse.

Table 7. Yields kg/ha and regression of individual variety on environment mean yield of most promising cowpea cultivars in comparison to IITA VITA lines in advanced yield Trial-1 at three locations in Upper Volta during 1979.

Tableau 7. Rendement en kg/ha et regression d'une variété individuelle sur le rendement moyen du milieu des cultivars de niébé les plus promettants en comparaison avec les variétés VITA de l'IITA dans l'Essai-1 de rendement avancé dans 3 localités de la Haute-Volta en 1979.

Line Lignées	Farako-Bâ	Kamboinsé	Saouga	Mean Moyenne	Regression coefficient coefficient de regression	r^2
PROMISING LINES Lignées prometteuses						
TVx 3381-02E	1633	1891	1173	1566	1,093	0.993
TVx 3385-027D	1579	1813	1018	1470	1.231	0.999
TVx 3405-014E	1429	1952	1244	1542	0.964	0.759
TVx 3410-05E	1441	1907	1001	1450	1.321	0.933
7R-0189D	1439	1797	1224	1487	0.808	0.856
STANDARDS						
VITA-1	733	664	443	613	0.399	0.765
VITA-4	1528	1871	900	1433	1.481	0.994
VITA-5	1164	1553	526	1081	1.556	0.989
VITA-7	1313	2035	711	1353	1.913	0.915
Ife Brown	1669	1149	1358	1392	0.031	0.027
Trial mean Moyenne de l'essai	1274	1456	813	1181		
S.E. of mean ± S.E. des moyennes ±	125	194	157	91.6		
C.V. %	17.0	23.0	33.4	24.5		

Table 8. Yields kg/ha and regression of individual variety on environment mean yield of most promising cowpea cultivars in comparison to IITA VITA lines in advanced yield Trial-2 at three locations in Upper Volta during 1979.

Tableau 8. Rendement et coefficient de regression des lignées prometteuses en comparaison avec les lignées VITA de l'IITA dans l'essai avancé de rendement-2 dans les trois localités de Haute-Volta en 1979.

Line Lignées	Farako-Bâ	Kamboinsé	Saouga	Mean Moyenne	Regression Coefficient Coefficient de regression	r^2
PROMISING LINES Lignées prometteuses						
TVx 3391-014D	1043	2081	919	1348	1.644	0.725
TVx 3385-029E	1491	1801	904	1399	1.377	0.997
TVx 3404-012E	1627	1808	996	1477	1.268	0.967
TVx 3379-01F	1559	1537	921	1339	0.997	0.827
TVx 3343-03E	1177	1732	1198	1369	0.737	0.601
TVx 2724-01F	1260	1774	1182	1405	0.841	0.746
TVx 3336-040E	1495	1691	950	1379	1.149	0.981
STANDARDS						
VITA-1	847	793	560	733	0.387	0.703
VITA-4	1587	1602	799	1329	1.290	0.862
VITA-5	1193	1831	698	1241	1.684	0.962
VITA-6	1501	1370	728	1200	1.060	0.720
Ife Brown	1568	1329	911	1269	0.726	0.520
Trial mean Moyenne de l'essai	1255	1511	855	1207		
S.E. of mean ± S.E. des moyennes ±	138	190	126	87.4		
C.V. %	19.1	21.8	25.4	22.1		

Table 9. Yields kg/ha and regression of individual variety on environment mean yield of most promising cowpea cultivars in comparison to IITA VITA lines in advanced yield Trial-3 at three locations in Upper Volta during 1979.

Tableau 9. Rendement et coefficient de regression des lignées prometteuses en comparaison avec les lignées VITA de l'IITA dans l'essai avancé-3 dans les trois localités de Haute-Volta.

Line Lignées	Farako-Bâ	Kamboinsé	Saouga	Mean Moyenne	Regression coefficient Coefficient de regression	r^2
PROMISING LINES Lignées prometteuses						
TVx 3368- 02F	1675	1834	1369	1626	0.495	0.532
TVx 3337-015E	1952	1848	1042	1641	1.364	0.910
TVx 3428-03E	2561	1661	1316	1846	1.724	0.872
TVx 3356- 04F	2049	1370	843	1241	1.707	0.966
TVx 3382-033E	2067	1641	1651	1786	0.552	0.626
TVx 3072- 01E	1633	1470	1257	1453	0.541	0.999
STANDARDS						
VITA-1	1440	927	799	1055	0.878	0.812
VITA-4	1989	1816	720	1508	1.895	0.926
VITA-5	1638	1333	739	1237	1.310	0.995
Ife Brown	2035	1453	1213	1567	1.141	0.883
Trial mean Moyenne de l'essai	1731	1453	1039	1407.7		
S.E. of mean ± S.E. des moyennes ±	203	207	178	113.2		
C.V. %	20.4	24.6	29.7	24.9		

Table 10. Mean location performance of important agronomic characters and yield in three advanced yield trials, 1979.

Tableau 10. Moyenne des performances de rendement des importantes caractéristiques agronomiques des essais avancés de rendement, 1979.

Character Caractéristiques	Advanced Yield Trial Essais avancés de rendement								
	1			2			3		
	Location Localité			Location Localité			Location Localité		
	Farako-Bâ	Kamboinsé	Saouga	Farako-Bâ	Kamboinsé	Saouga	Farako-Bâ	Kamboinsé	Saouga
DFF Nbre de jour de floraison	46	43	47	46	42	46	46	41	47
Height (cm) Hauteur (cm)	41	36	42	40	42	40	41	35	38
Width (cm) Largeur (cm)	58	78	65	62	59	65	52	43	50
Pods/m2 gousse/m2	117	97	53	115	102	54	178	109	73
% damaged seed % dommage des graines	5.2	1.7	3.7	4.8	0.8	2.9	4.8	0.8	2.6
1000 seed weight poids de 1000 graines	116	143	124	113	139	128	112	138	124
Threshing % Battage %	59	68	73	61	70	75	61	72	77
Seed yield (kg/ha) Rendement (kg/ha)	1274	1456	813	1255	1511	855	1731	1453	1039

Table 11. Soil analysis from the sites of advanced yield trials in Upper Volta.

Tableau 11. Analyse de sol des sites des essais avancés de rendement en Haute-Volta.

Site Site	pH	Organic carbon % Carbone organique	Total N (%) Total N (%)	Available P (ppm) P disponible (ppm)	Sand (%) Sable (%)	Silt (%) Limon (%)	Clay (%) Argile (%)
Kamboinsé I and II	5.7	0.84	0.088	8.0	57.6	27.2	15.2
Kamboinsé III	5.7	0.84	0.078	5.3	59.6	27.2	13.2
Saouga I, II and III	5.9	0.28	0.013	2.4	77.6	9.2	13.2

Note : I, II, III are sites respectively for advanced yield trials 1, 2 and 3.
Results for Farako-Bâ were not ready.

I, II, III sont respectivement les sites des essais avancés 1, 2 et 3.
Les résultats de Farako-Bâ n'étaient pas prêts.

5. Preliminary Yield Trials :

Three trials were sown at Kamboinse. Two were IITA preliminary yield trials, each consisting of 144 entries, and one was the Upper Volta preliminary trial including 256 entries. The trials compared selections from F_3 breeding nurseries with standard dhecks and local variety. The yield and agronomic characters of promising selections and of the checks are listed in Tables 12, 13 and 14.

In all the three trials, several lines producting similar yields to the best standard checks were identified. TVx 3882-02E produced highest yield (2597 kg/ha) in trial 1, TVx 1850-01H (2343 kg/ha) in trial 2 and TVx-UV-140 (2260 kg/ha) in Upper Volta trial. Yields in these varieties were 8, 14 and 10 per cent higher over the best standard check in the respective trials.

Improved varieties lacked the most prefered large white seeds, and therefore future research emphasis be placed on the improvement of this character while maintaining the high yield potential.

Table 12. Comparison of promising cowpea lines with standard checks in IITA preliminary yield Trial-1 at Kamboinsé in 1979.

Tableau 12. Comparaison des lignées prometteuses avec les standards témoins de l'essai préliminaire de rendement IITA - 1 à Kamboinsé en 1979.

Line Lignées	Days to 50% flowering Jours de floraison à 50%	Plant type Type de plant	Width (cm) Largeur (cm)	Height (cm) Hauteur (cm)	Seed yield (kg/ha) Rendement en grain kg/ha
PROMISING LINES Lignées prometteuses					
TVx 3882-02E	44	3	145	58	2597
TVx 3891-03E	44	3	155	40	2216
TVx 3871-01E	43	3	155	63	2048
TVx 3763-03E	43	3	120	50	2040
TVx 3901-03E	45	3	155	45	2001
TVx 3914-01E	38	2	78	20	1980
STANDARDS					
VITA-1	48	3	145	58	1070
VITA-4	45	3	119	50	2275
VITA-5	45	4	121	34	1679
VITA-6	43	2	56	34	951
VITA-7 (KN-1)	46	3	150	47	1686
Ife Brown	44	3	150	33	81
TVx 309-1G	43	2	61	36	1199
Trial mean Moyenne de l'essai	43	2.52	103.3	39.8	1332
S.E. of mean ± S.E. des moyenne ±	2.7	0.33	27.0	6.9	302
C.V. %	9.0	18.6	36.9	24.6	32.0

Table 13. Comparison of promising cowpea lines with standard checks in IITA preliminary yield Trial 2 at Kamboinsé in 1979.

Tableau 13. Comparaison des lignées prometteuses avec les standards témoins dans l'essai préliminaire de rendement IITA-2 à Kamboinsé en 1979.

Line Lignées	Days to 50 % flowering Jours de floraison à 50 %	Plant type Type de plant	Width (cm) Largeur (cm)	Height (cm) Hauteur (cm)	Seed yield (kg/ha) Rendement en grain kg/ha
PROMISING LINES Lignées prometteuses					
TVx 1850-01H	47	3	140	65	2343
TVx 3476-01E	44	3	108	43	2193
TVx 3477-01E	42	3	118	40	2189
TVx 3938-03E	43	3	140	35	2138
TVx 2921-05E	42	3	145	43	2117
TVx 3382-01H	45	4	150	63	2092
TVx 3933- 2E	42	3	125	58	2052
STANDARDS					
VITA-1	48	3	116	56	1504
VITA-4	42	3	129	53	2165
VITA-5	45	4	132	30	1527
VITA-6	42	2.5	73	31	1275
VITA-7 (KN-1)	44	3	123	41	1843
Ife Brown	43	3	122	39	1306
TVx 309-1G	41	2	76	40	1208
Trial mean Moyenne de l'essai	42.6	2.63	107.9	42.6	1500
S.E. of mean ± S.E. des moyennes ±	1.16	0.3	18.4	5.8	271
C.V. %	3.9	13.8	24.1	19.2	25.5

Table 14. Comparison of promising cowpea lines with IITA VITA lines a local variety in the Upper Volta preliminary trial conducted at Kamboinsé in 1979.

Tableau 14. Comparaison des lignées prometteuses avec les lignées VITA de l'IITA et une variété locale dans l'essai préliminaire en Haute-Volta implanté à Kamboinsé en 1979.

Line Lignées	Days to 50 % flowering Jours de floraison à 50 %	Plant type Type de plant	Width (cm) Largeur (cm)	Height (cm) Hauteur (cm)	Seed yield (kg/ha) Rendement en grain kg/ha	Seed colour Couleur des graines
PROMISING LINES Lignées prometteuses						
TVx UV-3	38	3	117	42	1836	Brown-medium Brunâtre
TVx UV-140	42	3	115	45	2260	Mixer Mélangé
TVx UV-141	41	3	135	42	2050	Brown + white mixer Brun + Blanc mélangé
TVx UV-153	39	2	87	47	1938	Striped brown small Zébré légèrement brun
TVx UV-157	41	3	152	50	2203	Pink medium Rosâtre
TVx UV-172	40	2	82	45	1887	Brown medium Brunâtre
TVx UV-180	41	3	135	42	2059	Mixed Mélangé
TVx UV-189	38	3	115	35	1956	White-medium Blanchâtre
TVx UV-193	42	3	150	37	1929	Brown-medium Brunâtre
TVx UV-208	40	3	137	55	1947	Scarred-brown-medium rayure brunâtre
TVx UV-211	41	3	125	55	2139	White-medium Blanchâtre
TVx STANDARDS						
VITA-1	47	3	150	44	954	Red Rouge
VITA-3	49	3	140	45	1376	Red-medium Rougeâtre
VITA-4	40	3	117	43	1710	White small Légèrement blanc
VITA-5	43	3	115	30	1401	White-medium Blanchâtre
VITA-6	38	1.5	50	30	1233	Brown-medium Brunâtre
VITA-7 (KN-1)	42	3	120	37	2053	Brown-medium Brunâtre
Local - Locale	57	4	150	30	735	White-large Blanc clair
Trial mean Moyenne de l'essai	40	2	93	37	1235	
S.E. of mean ± S.E. des moyennes	1.6	0.4	21.3	6.1	286	
C.V. %	5.6	23.8	32.4	23.5	29.4	

Table 15. Yield, seed size and correlation between yield and seed size in backcrosses of VITA-4 and VITA-5.

Tableau 15. Rendement et relation entre rendement et grosseur des graines des backcrosses de VITA-4 et VITA-5.

Character Caractéristiques	Backcross VITA-4	Backcross VITA-5	Remarks Remarques
Mean yield (kg/ha) Rendement moyen (kg/ha)	170	325	
Range in yield (kg/ha) Ecart de rendement (kg/ha)	38-283	62-823	
Mean 100 seeds wt (gm) Poids moyen de 100 graines	12.72	13.66	Average seed size of VITA-4 and VITA-5 is 10 and 11 gm/100 seeds En moyenne les poids de 100 graines de VITA-4 et VITA-5 sont respectivement de 10 et 11 gms.
Range in 100 seeds wt (gm) Ecart de rendement de 100 graines	11-14	10-17	
Correlation between yield and seed size Relation entre les rendements et la grosseur des graines	0.37*	0.15	

* Significant at 5 % level of probability.
Significatif à 5 % du niveau de probabilité.

6. Breeding Nursery :

1210 F3 families, of crosses among parents having high yield, resistance to diseases and insect-pests and desirable seed and plant characteristics, from IITA were planted at Kamboinse. The progenies were grown under minimum insecticide control ; the first-spray starting at the time of flowering followed by two more sprays at 10 days interval. A total of 355 single plants were selected for desirable combination of good yield potential, desirable seed quality, maturity, plant type, resistance to major diseases and minimum insect damage, and are being multiplied for preliminary trial in 1980.

7. Intercropping Sub-populations :

Two segregating population bulks, one originating from crosses between photo-sensitive and back-up population (Bulk A) and the other from crosses between thrip resistance and advanced lines (Bulk B) were received from IITA. They were evaluated at Kamboinse for their suitability to intercropping with sorghum ; the most common method of growing cowpeas in this area. Forty-nine and 36 plants respectively were selected from the two bulks on the basis of yield resistance to disease, maturity, seed colour and seed size and are being multiplied in the dry season for further evaluation next year in a replicated trial.

8. Seed Size Increase Observation Lines :

62 lines originating from backcrosses of VITA-4 and VITA-5 with large white seeded varieties were grown at Kamboinse. Data were recorded on seed size and an estimate of yield was obtained. Correlation coefficients between seed yield and seed size were calculating. The results are summarised in Table 15. Both the backcrosses had shown almost similar improvement in their mean seed size over the original parents, but the variation between lines gives opportunity for further improvement. Correlation coefficient was significant for the VITA-4 backcrosses whereas it was non-significant for the VITA-5 backcrosses. It suggested a higher possibility of selecting lines with good yield and higher seed size among the VITA-4 backcrosses. Lines with good yield and above average seed size will be further evaluated in 1980.

9. Crosses between Seclected Improved Lines and Local Cultivars :

Crosses were made at IITA between local varieties from Gorom-Gorom, Ouahigouya, Kaya and Kamboinse and improved varieties to evolve plant types that will combine good yield, tolerance to heat and resistance to drought stress. The F1 generations are being multiplied in the dry season and the F2's will be grown at different sites in dry areas to select desirable plants.

CONCLUSIONS

1. TVx 289-4G, designated as VITA-7 by IITA and KN-1 (Kamboinse Niébé 1) in Upper Volta, was the most outstanding variety, particularly in wetter areas. It has consistently given superior yields over other selections during the three years of its testing in Upper Volta.

2. Sister lines, TVx 1999-02E and TVx 1999-01F, confirmed their ability to produce higher yields over a range of environments. They performed particularly well in the dry, hot environments of the north.

3. Other lines which appeared well in advanced and international yield trials, but which require further testing were : TVx 3381-02F, TVx 3405-014E, TVx 3404-12E, TVx 3343-03E, TVx 3428-03E, TVx 3382-033E, TVx 1836-015J and 2394-02F.

4. As last year, the local variety at Saouga produced the highest yield in comparison to IITA improved selections. Temperature control of flowering and ability to make better use of soil moisture were the reasons suggested for its high yield. Work on drought resistance needs to be strenthened to evolve varieties for dry areas.

5. Low fertility of soil, its poor water holding capacity, high temperatures and insufficient rains at pod formation stage reduced yield (pod m^2) at Saouga. Wetter conditions at the time of harvest at Farako-Ba lowered the threshing percentage and therefore the yields.

6. Plant growth was related to yield but its score based on plant height and width did not provide a good measure for the spreading type varieties.

COWPEA AGRONOMY RESEARCH PROGRAM

INTRODUCTION

The SAFGRAD Cowpea Agronomy Research Program is responsible for identifying critical management factors and developing practical, economic and acceptable pratices for growing cowpea in the semi-arid zones of Africa. Research trials designed to achieve these objectives are conducted by the SAFGRAD Cowpea Agronomy Program in Upper Volta across a range of environments representative of different agroecological zones of semi-arid Africa. Wider scale testing of promising practices developed from these trials will be carried out in collaboration with scientists in the various SAFGRAD member countries in a Regional Trial Program.

The SAFGRAD Cowpea Agronomy Research Program was initiated in May 1979 and, during the growing season, several exploratory trials were conducted. Initially, priority has been placed on the following research areas :

(1) Improvement of cowpea yield under intercropping. In the semi-arid zone of Africa, cowpeas are generally grown in mixtures with cereal crops and cowpea yields are very low. Emphasis is being placed on finding ways of increasing the yield of cowpeas in the mixture while maintaining the yield of the cereal (which is the base crop).

(2) Development of pratices for production of cowpea as a monocrop. Although cowpeas are presently grown under intercropping as a subsistence food crop, there would appear to be possibilities of production under monoculture as a cash crop to meet the growing need in urban centers for an inexpensive protein source. Thus management factors for sole cropping are also being investigated.

(3) Development of cultural methods of insect control. Insect damage has been identified as the major constraint to increased cowpea production in semi-arid Africa. In view of this, the development of cultural practices which would reduce yield losses due to insect damage has been taken as an important research objective.

(4) Development of methods to utilize cowpeas for maintenance or improvement of soil fertility. Cowpeas can be important in cropping systems, not only for the production of food and fodder, but also for its beneficial effects on soil fertility through nitrogen fixation. With the increasing cost of chemical fertilizer, it becomes increasingly important to fully exploit this attribute of the crop.

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COWPEA VARIETAL EVALUATION FOR INTERCROPPING WITH SORGHUM

Twenty-seven cowpea varieties (including seven local cultivars), representing a range of plant types and maturity groups were grown at Saria as an intercrop (simultaneous planting) with sorghum (E 35-1 : mid-season, 2 m. height) and as a monocrop for comparison. Cowpeas and sorghum were intercropped in alternate rows 80 cm. apart. Intercropped sorghum density was 41,667 plants per hectare. Intercropped cowpeas densities were 31,250 plants per hectare for spreading and prostrate plant types and 41, 667 pl/ha. for erect and intermediate types. Monocrop populations were double the intercrop populations. Cowpea insects were controlled by insecticide application at ten day intervals starting at 30 DAP.

The effects of cropping systems and varieties and the interaction between varieties and cropping systems were all highly significant (0,5 % level of probability) (Table 1) This indicates that the lines under test in this experiment differ in response to cropping system and suggests that a separate selection process is required for varieties to be used in intercropping. Intercrop cowpea yields ranged from 311 to 844 kg/ha. The highest yielding variety under intercropping was VITA-4. There were significant differences in sorghum yields depending on the intercropped cowpea variety indicating that there were differences in competitive ability between cowpea varieties. Intercropped sorghum grain yields ranged from 1585 to 2791 kg/ha. Monocrop sorghum yield was 3417 kg/ha.

There was no significant correlation between intercropped cowpea grain yield and plant type (Fig.1) or maturity (days to 50 % first flower) (Fig.2) indicating that there is no particular plant type or maturity group that has a peculiar adaptation to intercropping. There was also no correlation between sorghum yields and cowpea yields (Fig.3) suggesting that ability to produce good yields under intercropping is not strongly linked to competitiveness with sorghum.

MAIZE / COWPEA RELAY CROPPING

In the Guinea savanna, cowpea is generally grown in mixtures with sorghum or millet. Cowpea yields are low and there seems little scope for improving yield as long as the cowpea must compete throughout its growth cycle with the tall, late maturing cereals. However in this area, maize has been shown to offer a better prospect for substantially increasing cereal grain production than sorghum or millet. A further consideration in considering potential /

Table 1 Grain yield of cowpea cultivars grown as intercrop with sorghum and as monocrop, grain yield of sorghum grown in association with cowpea and plant characteristics of intercropped cowpea cultivars.

Variety	Cowpea grain yield intercrop (kg/ha)	Cowpea grain yield monocrop (kg/ha)	intercrop as % of monocrop	Sorghum intercrop grain yield (kg/ha)	Plant type	DFF	DFRP
VITA-4	844	2395	35.2	2170	3.0	45	65
Kaya Local	698	1538	45.4	1532	4.0	77	100
TVx 7-4K	683	1787	39.2	2046	1.5	42	62
TVx 1948-01E	659	1514	43.5	2152	2.3	44	64
Ouahigouya Local	658	1749	37.6	2170	4.0	63	85
TVx 66-2H	632	1723	36.7	1940	2.3	46	66
Local 337	630	1787	35.3	1833	4.0	80	104
TVx 289-4G	617	1980	31.2	1514	3.0	46	66
TVx 1836-015J	609	1710	35.6	2064	1.8	40	61
4R-0267-01F	605	1932	31.3	2294	1.3	41	61
VITA-5	604	2259	26.7	1957	3.8	47	66
TVx 33-1J	595	1910	31.2	1620	1.8	44	64
TVx 2912-011D	577	2107	27.4	1869	2.5	47	67
TVx 1576-01E	575	1468	39.2	1674	2.0	45	65
Kamboinse Local	555	1637	33.9	1585	4.0	65	87
TVx 1850-01E	552	1735	31.8	2223	2.0	43	61
TVx 1999-02E	542	2243	24.2	2081	2.3	46	66
TVx 1999-01F	525	1697	30.9	2188	2.5	45	66
TVx 309-1G	518	1828	28.3	2081	1.5	42	64
TVx 2394-01F	518	2399	21.6	1496	1.5	42	66
Gorom Gorom Local	512	1623	31.5	1709	4.0	51	72
TVx 1193-7D	509	1628	31.3	1833	1.5	41	62
TVx 2394-02F	471	1354	34.8	2010	1.3	42	64
TVx 2907-02D	464	1780	26.1	1603	2.0	45	65
TVx 1836-013J	426	1569	27.2	2720	1.5	40	62
Local 304	372	1160	32.1	1620	4.0	51	79
Local 302	311	1396	22.3	2791	4.0	57	84
$LSD_{.05}$	325	325	9.7	919			

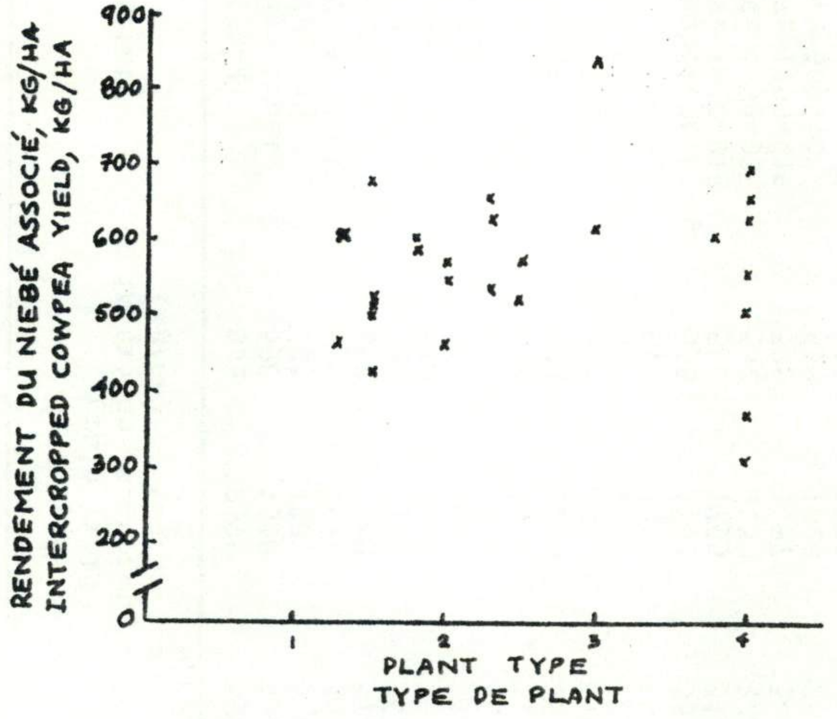

FIG. 1. RELATIONSHIP BETWEEN INTERCROPPED COWPEA YIELD AND PLANT TYPE.

FIG. 1. RAPPORT ENTRE LE RENDEMENT DU NIEBÉ ASSOCIÉ ET LE TYPE DE PLANT.

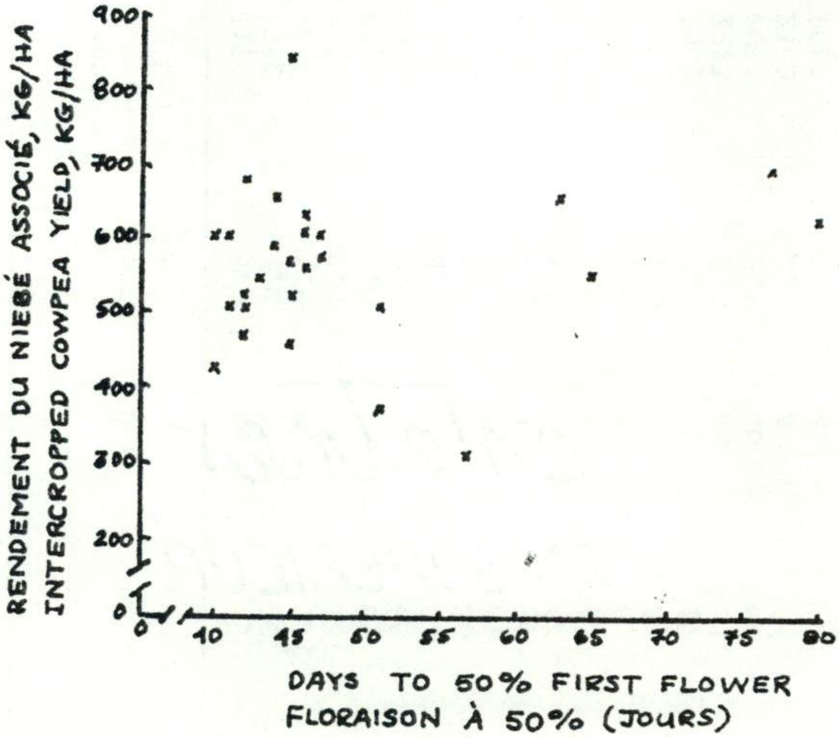

FIG. 2. RELATIONSHIP BETWEEN INTERCROPPED COWPEA YIELD AND FLOWERING DATE.

FIG. 2. RAPPORT ENTRE LE RENDEMENT DU NIEBE ASSOCIÉ ET LA DATE DE FLORAISON.

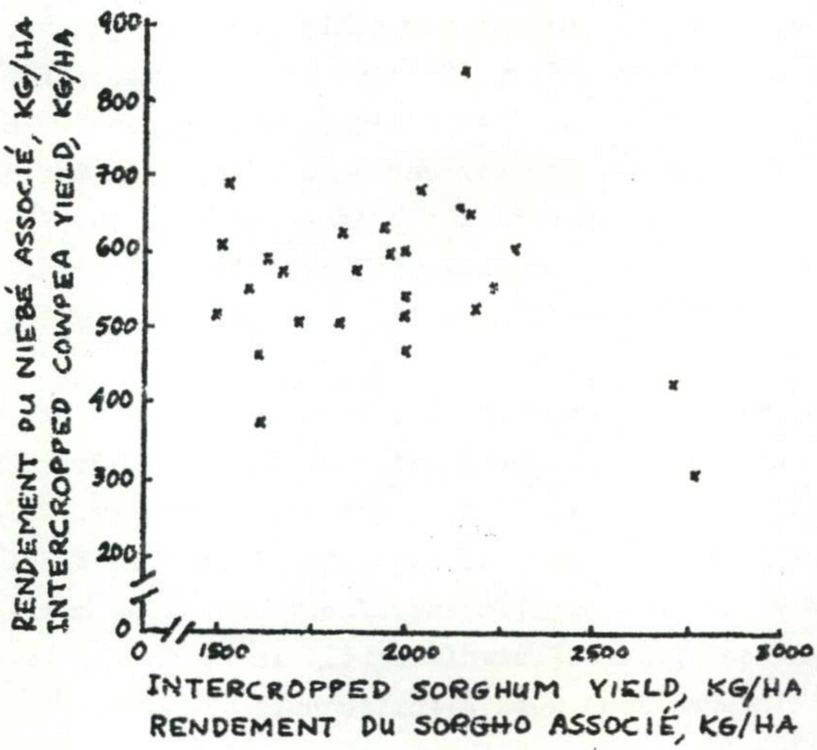

FIG. 3. RELATIONSHIP BETWEEN INTERCROPPED SORGHUM AND COWPEA YIELDS.

FIG. 3. RAPPORT ENTRE LES RENDEMENTS DU SORGHO ET DU NIEBÉ DANS CULTURE ASSOCIÉ

cropping systems is that maize can be harvested during the rains while sorghum cannot because of its susceptibility to head moulds. In the Guinea savanna, there is a growing season long enough to grow a crop of maize and a relay crop of cowpea with only a short overlap between the two crops. A trial was conducted at Farako-Ba to investigate management factors involved in such a cropping system. The factors considered were maize variety, maize plant population, cowpea variety, and cowpea sowing date.

Two maize varieties were used : TZPB (115 days) and TZE4 (90 days). The maize was grown at populations of 26,667 (75 x 50 cm, one plant per hill) or 53,333 plants/ha (75 x 50 cm, two plants per hill). Four cowpea varieties were used : TVx 309-1G (erect, determinate), TVx 1193-7D (intermediate), VITA-4 (spreading), and IAR 1696 (photoperiod sensitive). The cowpeas were planted either 52 or 73 days after maize. The cowpeas were planted in the maize row between maize stands at 75 x 50 cm with two plants per hill (53,333 plants/ha). Cowpea insects were controlled by spraying with azodrin (0,5 kg a.i./ha) at 10 days intervals from appearance of first flower buds.

The means for maize and cowpea yields for the main effects of the various treatments are given in Table 2. The mean maize yield was 4,606 kg/ha. The late variety, TZPB gave a 25 % greater yield than the early variety, TZE4. The higher maize population resulted in 20 % more maize grain yield than the lower population. The only factor having a significant effect on cowpea grain yield was cowpea sowing data. Cowpea yield was significantly lower in the late sowing. None of the treatment interactions were significant.

Cowpea yield levels were low in comparison with what might be expected from sole crop plantings. Two main factors control cowpea yield in this relay cropping system : the duration of the overlap between the two crops and the length of the growing period (length of time between cowpea sowing and the time at which soil moisture reserves are exhausted at the end of the growing season). The greater the duration of overlap of the two crops, the lower the yield of the intercropped cowpeas. And, of course, the shorter the growing period, the smaller the cowpea yield. Figure 4 shows the cropping sequence of this trial in relation to rainfall and evapotranspiration. Assuming that the crop becomes dependent on stored soil moisture when precipitation falls below 50 % potential evapotranspiration and assuming a soil moisture reserve sufficient for 18 days growth, the length of the growing period for the first planting was 75 days. The duration of the overlap with maize for the first cowpea planting was 42 days and 67 days with TZE4 and TZPB, respectively. In the

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Table 2. Main effects of maize variety, cowpea variety, cowpea sowing date, and maize population on maize and cowpea grain yield in Maize/Cowpea Relay Cropping Trial.

Treatment	Maize Yield (kg/ha)	Cowpea Yield (kg/ha)
Maize variety	**	
Early (TZE4)	4106	618
Late	5106	549
Cowpea variety		
Erect (TVx 309-1G)	4589	532
Intermediate (VITA 6)	4602	600
Spreading (VITA 4)	4575	511
Photoperiod sensitive	4660	689
Cowpea sowing date		*
Early (52 days after maize)	4704	673
Late (73 days after maize)	4508	493
Maize plant population	**	
26,667 plants/ha	4204	607
53,333 plants/ha	5008	559

*,** : significant at P = 0.05 and P = 0.01, respectively

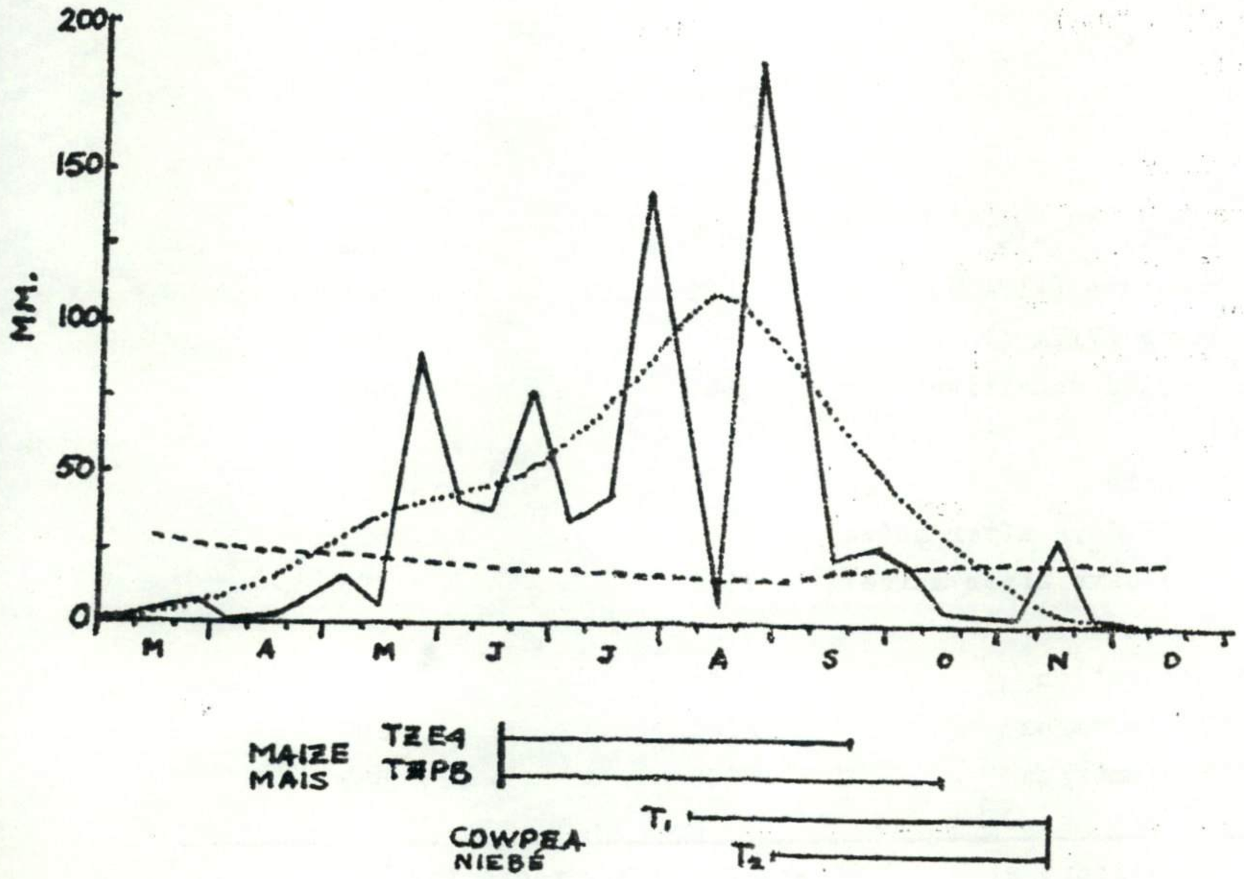

FIG. 4 . CROPPING SEQUENCE IN RELATION TO RAINFALL REGIME - COWPEA/ MAIZE RELAY CROPPING TRIAL, FARAKO-BA

——— RAINFALL, 1979
······· RAINFALL, LONG TERM AVERAGE
----- 50% POTENTIAL EVAPOTRANSPIRATION

FIG. 4. SEQUENCE DES CULTURES PAR RAPPORT AU RÉGIME DE LA PLUVIOMÉTRIE - ESSAI DE CULTURE DE RELAIS NIEBÉ/MAIS, FARAKO-BA

——— PLUVIOMÉTRIE, 1979
······· PLUVIOMÉTRIE, MOYENNE À LONG TERME
----- 50% DE L'EVAPOTRANSPIRATION POTENTIELLE

second planting, the growing period was 54 days and the overlap periods were 21 and 46 days for TZE4 and TZPB, respectively. The low yield of the second planting is unquestionably due to the short growing period. At 54 days, the crop was only in the early green pod stage. The 73 day growing period for the first planting should have been adequate for at least moderate yield levels and this planting did, in fact, yield 37 % more than the second planting. However it would appear that even the shorter overlap period for this planting (42 days with TZE4) was too long for optimal yields.

Although cowpea yield levels were low in comparison to yields normally attainable with a sole crop, it would appear that higher cowpea yields could be obtained with this system. Assuming that sowing can commence when precipitation begins to exceed 50 % evapotranspiration, the meterological data (Fig. 4) indicate that in 1979, maize could have been planted approximately one month earlier than it was. Futhermore, long term data show that, on the average, the growing season is 40 days longer than it was in 1979. This indicates that, under rainfall conditions as exist at Farako-Ba, it should be possible to relay crop cowpeas with only a minimal overlap with maize. This is a cropping system which would appear to be well adapted to the needs of the farmer. By early planting of a short season maize, his need is met for a cereal crop as soon as possible after the rains commence and by relay cropping cowpeas into the maize, full season use is made of the land and a second crop is obtained. It is clear, however, that options as to planting dates and choice of maize varieties (as to maturity group) will differ in different rainfall zones.

EFFECT OF INTERCROPPING ON INSECT DAMAGE TO COWPEA

It is widely held that insect damage to cowpea is less when grown as an intercrop than when grown as a monocrop. However research results have not been conclusive. Thus a trial was established to test the hypothesis that intercropping at low cowpea densities and in intimate crop mixtures provides protection from insect damage and to determine the extend to which such protection might be exploited in intercrop systems.

Cowpea and sorghum were intercropped at Saria in different proportions (100, 50, 33 and 25 percent cowpeas) and in different planting arrangements (cowpeas and sorghum in same row or in separate rows) and the various intercrop treatments were either treated with insecticide or untreated.

Loss of cowpea grain yield on a per unit area basis due to insect damage

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decreased with decreasing proportion of cowpeas in the crop mixture (Fig.5). The differences in yield loss between planting arrangements became more pronounced at lower cowpea proportions with less yield loss in the separate row planting arrangment. It has previously been reported that higher numbers of Megalurothrips sjostedti per cowpea flower were found in intra-row mixtures of cowpeas and maize than in inter-row mixtures (IITA Annual Report, 1977).

As the proportion of cowpeas in the mixture decreased, grain yield per plant in the treated plots remained constant when cowpeas and sorghum were planted in the same row and decreased whem they were planted in separate rows (Fig.6). This indicates that the sorghum is more competitive in the separate row planting arrangement). In contrast the yield per plant in the untreated plots increased with decreasing proportion of cowpea. This difference in response between treated and untreated plots to decreasing proportion of cowpea in the mixture is futhur indication that intercropping provides protection from insect damage.

Although grain yield per plant increased in the untreated plots as the proportion of cowpeas in the mixture decreased, the increase was only enough to offset the effect of decreasing cowpea population and cowpea grain yield per hectare remained relatively constant at about 300 kg/ha (Fig.7). However with insect control, intercropping severely reduced cowpea yields. The yield in a 50 % mixture was only approximately 40 percent of the monocrop yield.

It is of interest to compare the total productivity of cowpea-sorghum mixtures where cowpea insecticide is used with total productivity of mixtures where it is not used, Sorghum yields increased as the proportion of sorghum in the mixture increased, with a similar response shown by all insecticide-planting arrangement treatments except treatment I,A, (insecticide + same row arrangement) (Fig.8). It seems likely that the elevated yields of this treatment are due to the effect of the cowpea insecticide on sorghum. When spraying the cowpeas planted in the same row with sorghum, it was impossible to avoid also spraying the sorghum. Other sorghum treatments received no direct insecticide application.

Total productivity (LER*) was calculated for each intercrop mixture using the yield of the cowpea monocrop receiving the same insecticide treatment. Thus the LER of intercrop mixtures receiving insecticide was calculating using the yield of the treated monocrop and the LER of untreated mixtures was calculated using the yield of the untreated monocrop. Thus it is possible to compare total productivity under two sets of conditions, i.e. the situation in which insecti-

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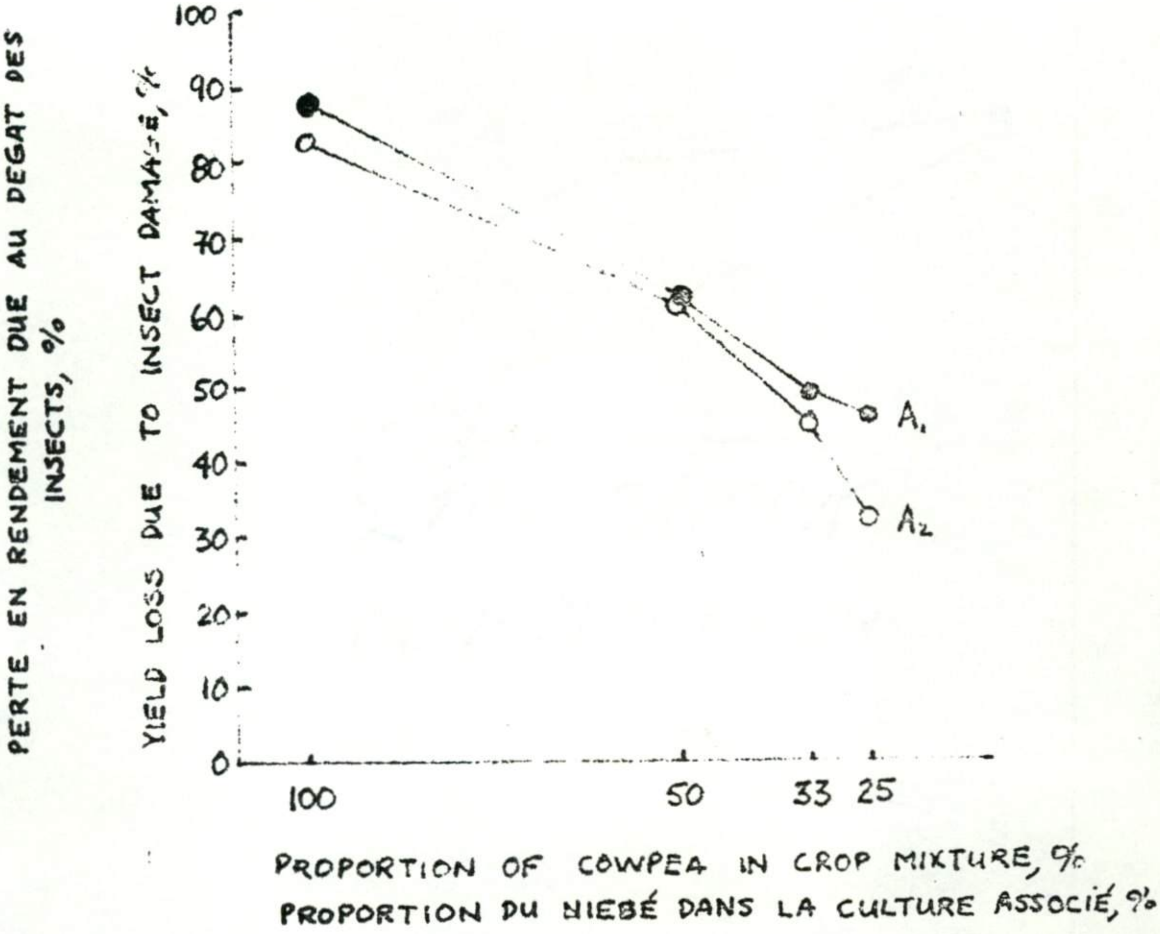


FIG. 5. EFFECT OF COWPEA: SORGHUM RATIO IN CROP MIXTURE ON COWPEA YIELD LOSS DUE TO INSECT DAMAGE.

● SAME ROW PLANTING ARRANGEMENT (A_1)

○ SEPARATE ROW PLANTING ARRANGEMENT (A_2)

FIG. 5. EFFET DU RAPPORT SORGHO: NIEBÉ DANS LA CULTURE ASSOCIÉ SUR LA PERTE DE RENDEMENT EN NIEBÉ DUE AU DEGAT DES INSECTS.

● LE SORGHO ET LE NIEBÉ DANS LA MEME LIGNE (A_1)

○ LE SORGHO ET LE NIEBÉ DANS LES LIGNES SEPARÉES (A_2)

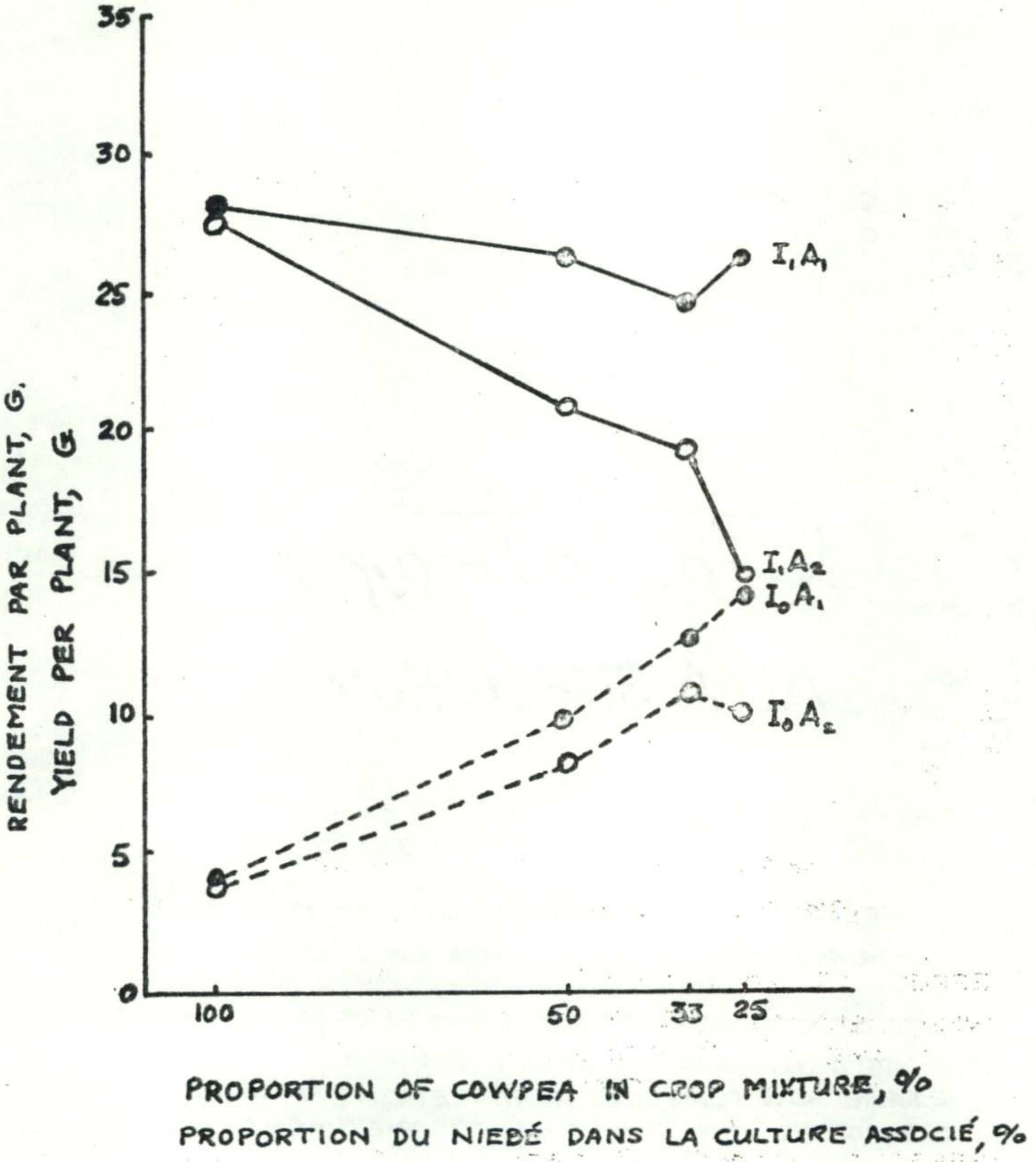


FIG. 6. EFFECT OF COWPEA: SORGHUM RATIO IN CROP MIXTURE ON COWPEA GRAIN YIELD PER PLANT

- ● SAME ROW ARRANGEMENT (A_1)
- o SEPARATE ROW ARRANGEMENT (A_2)
- —— WITH INSECT CONTROL (I_1)
- ---- WITHOUT INSECT CONTROL (I_0)

FIG. 6. EFFET DU RAPPORT NIEBÉ : SORGHO DANS LA CULTURE ASSOCIÉ SUR LE RENDEMENT EN GRAINS DE NIEBÉ PAR PLANTE.

- ● LE SORGHO ET LE NIEBÉ DANS LA MEME LIGNE (A_1)
- o LE SORGHO ET LE NIEBE DANS LES LIGNES SEPARÉES (A_2)
- —— AVEC LUTTE CONTRE L'INSECTS (I_1)
- ---- SANS LUTTE CONTRE L'INSECTS (I_0)

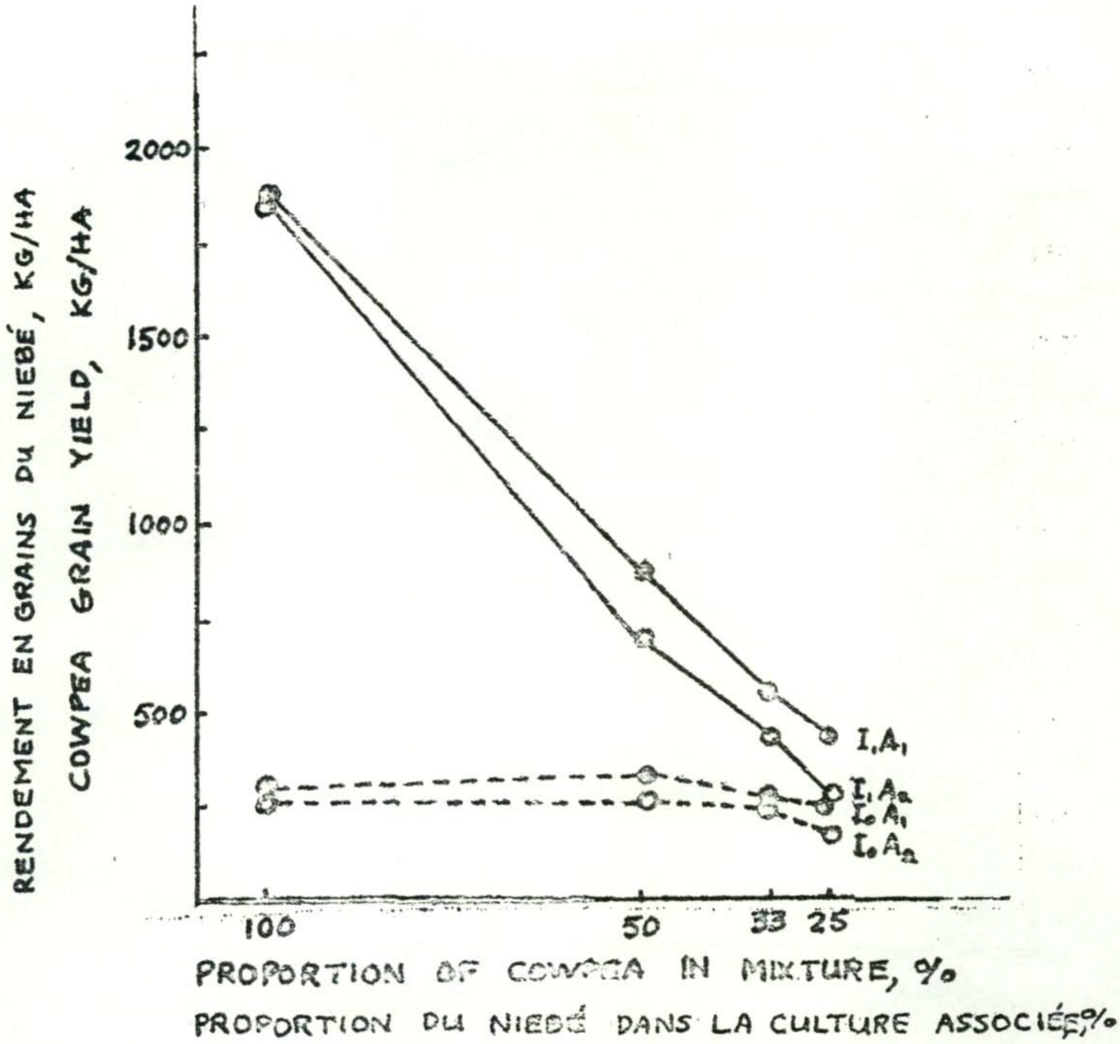


FIG 7. EFFECT OF COWPEA: SORGHUM RATIO IN CROP MIXTURE ON COWPEA GRAIN YIELD

- ● SAME ROW ARRANGEMENT (A_1)
- ○ SEPARATE ROW ARRANGEMENT (A_2)
- —— WITH INSECT CONTROL (I_1)
- - - - WITHOUT INSECT CONTROL (I_0)

FIG. 7. EFFET DU RAPPORT NIEBE: SORGHO DANS LA CULTURE ASSOCIÉE SUR LE RENDEMENT EN GRAINS DE NIEBÉ.

- ● LE SORGHO ET LE NIEBÉ DANS LA MEME LIGNE (A_1)
- ○ LE SORGHO ET LE NIEBÉ DANS LES LIGNES SEPARÉES (A_2)
- —— AVEC LUTTE CONTRE LES INSECTES (I_1)
- - - - SANS LUTTE CONTRE LES INSECTES (I_0)

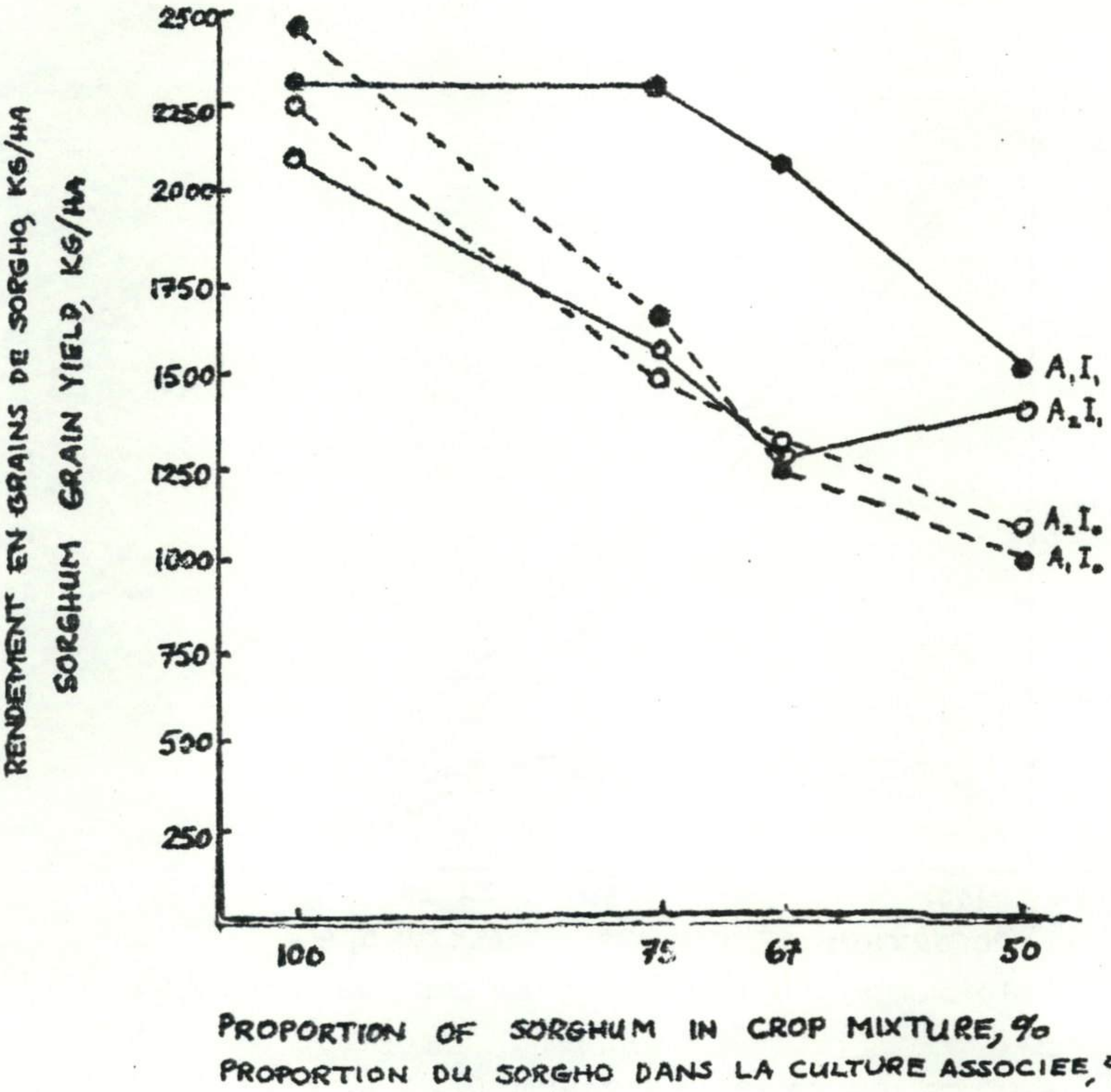


FIG. 8. EFFECT OF COMPONENT POPULATION AND PLANTING ARRANGEMENT ON SORGHUM YIELD

- ● SAME ROW ARRANGEMENT (A_1)
- ○ SEPARATE ROW ARRANGEMENT (A_2)
- —— WITH INSECT CONTROL (I_1)
- - - - WITHOUT INSECT CONTROL (I_0)

FIG. 8. EFFET DU RAPPORT SORGHO: NIEBÉ DANS LA CULTURE ASSOCIÉE SUR LE RENDEMENT EN GRAINS DE SORGHO.

- ● LE SORGHO ET LA NIEBÉ DANS LA MEME LIGNE (A_1)
- ○ LE SORGHO ET LA NIEBÉ DANS LES LIGNES SEPARÉES (A_2)
- —— AVEC LUTTE CONTRE LES INSECTES (I_1)
- - - - SANS LUTTE CONTRE LES INSECTES (I_0)

cide is used and that in which it is not. It is apparent that the yield advantage of intercropping is substantially greater in the situation in which insecticide is not used than where it is used. (Fig. 9). Without insecticide, intercropping resulted in up to a 64 percent increase in total productivity over monocropping, while with insecticide, intercropping resulted in a small increase, or in some mixtures even a decrease in total productivity. Planting arrangement also had an effect on total productivity. Planting sorghum and cowpea in the same row resulted in a higher total productivity than planting in separate rows both with and without insecticide. Total productivity was independent of the proportion of the two crops in the mixture, only the proportion of the two crops in the total yield varied.

These results indicate that, in view of the inputs available to him, the farmer has made a very rational decision in choosing to grow cowpeas as an intercrop. Because of the protection from insect damage that intercropping offers, he can go to low cowpea : sorghum ratios and still get a cowpea yield comparable to monocrop yield while sacrificing little in sorghum yield.

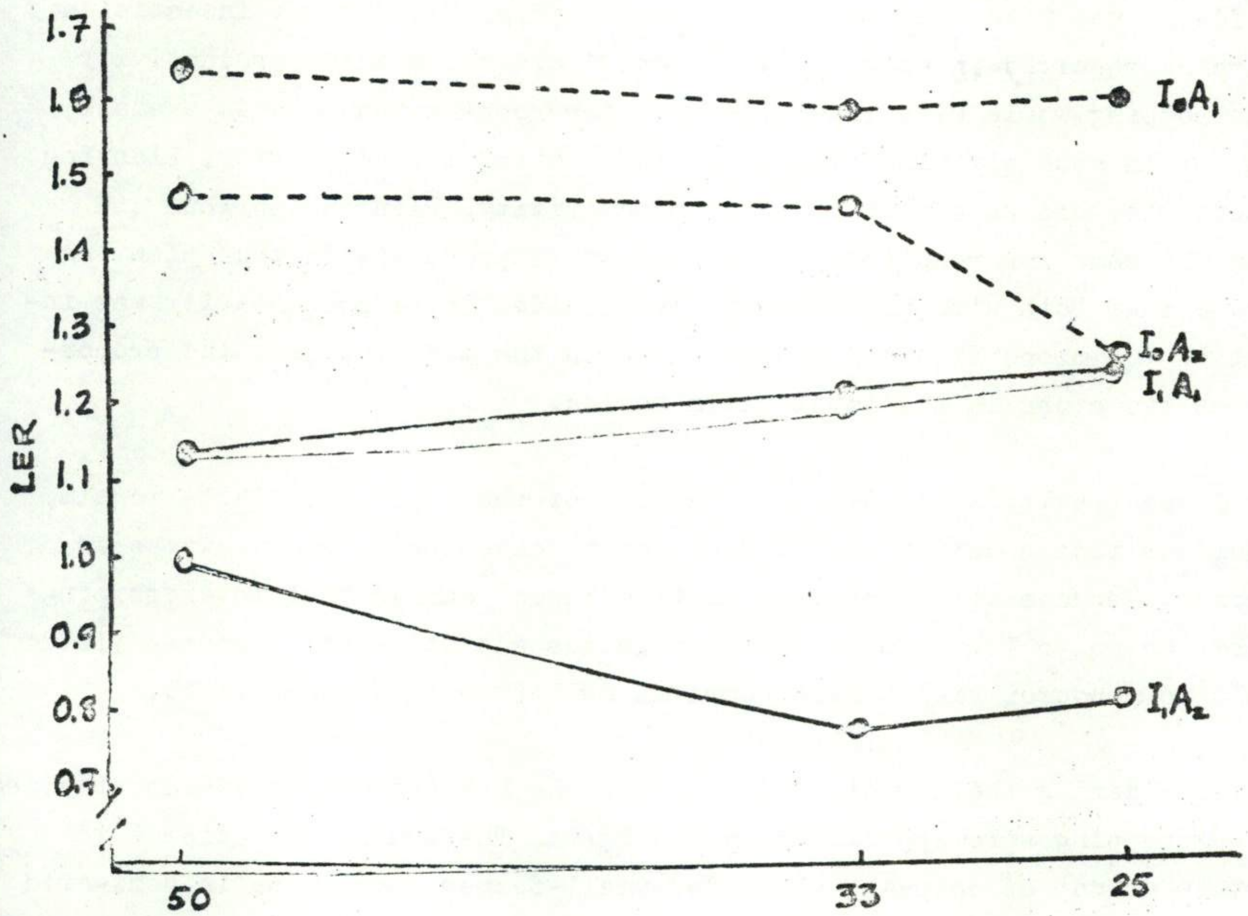
Considering the use of insecticides, the highest cowpea yields obtained under intercropping were approximately 800 kg/ha. The use of insecticide to produce this amount of cowpea grain under small-farmer conditions in semi-arid Africa is an unrealistic proposition. Use of insecticide on cowpeas can only be considered for cropping systems which have a high cowpea yield level such as monocropping and possibly relay cropping systems.

* LER is calculated as the total land area required under monoculture to give the same production of the same crops as that obtained from one hectare of intercrop.

FACTORS LIMITING GROWTH AND YIELD OF COWPEAS IN SUDAN AND SAHEL SAVANNA

Observation and yield data from variety trials in Upper Volta have shown unexplained variation in growth and yield of cowpeas in the drier (< 800 mm rainfall) savanna zones. Varietal testing in these zones has failed to identify varieties which are consistently higher yielding than the local cultivars. Thus a trial was conducted to attempt to determine the factors limiting growth and yield in these environments. Factors considered were plant type, soil fertility and water available for crop growth.

Four plant types were used : erect, determinate (TVx 309-1G), intermediate (TVx 1193-7D), spreading (VITA 4) and the type represented by the local



PROPORTION OF COWPEA IN CROP MIXTURE, %

PROPORTION DU NIEBÉ DANS LA CULTURE ASSOCIÉE, %

FIG. 9. EFFECT OF COMPONENT POPULATION AND PLANTING ARRANGEMENT ON LAND EQUIVALENT RATIO.

- ⊙ SAME ROW ARRANGEMENT (A_1)
- o SEPARATE ROW ARRANGEMENT (A_2)
- —— WITH INSECT CONTROL (I_1)
- ---- WITHOUT INSECT CONTROL (I_0)

FIG. 9. EFFET DU RAPPORT NIEBÉ : SORGHO DANS LA CULTURE ASSOCIÉE SUR LE "LAND EQUIVALENT RATIO" (LER).

- ⊙ LE SORGHO ET LE NIEBÉ DANS LA MEME LIGNE (A_1)
- o LE SORGHO ET LE NIEBÉ DANS LES LIGNES SEPARÉES (A_2)
- —— AVEC LUTTE CONTRE LES INSECTES (I_1)
- ---- SANS LUTTE CONTRE LES INSECTES (I_0)

variety of the area (prosfate and photoperiod sensitive except at Saouga where it is spreading and probably little sensitive to photoperiod). Two levels of soil fertility were obtained by applying no fertilizer or by applying 750 kg/ha of single super phosphate. Water available for plant growth was varied by planting either at the normal time for the locality or approximately three weeks later. It was assumed that moisture would become limiting for the late planting in the later stages of crop development. In addition, an attempt was made to manipulate the degree of drought stress, both at the end of the season and during periodic dry spells in the course of the season, by using two plant populations : 50,000 and 100,000 plants/ha. All treatments were combined in factorial combination and arranged in a confounded arrangement in four blocks of eight plots each.

The trial was planted at five locations : Saouga (358 mm mean annual rainfall), Ouahigouya (565 mm), Kaya (729 mm), and three sites at Kamboinse 763 mm). The three sites at Kamboinse were loacated one below the other on a slope on which it was predicted that, as one moved down the slope, soil moisture conditions during dry periods would become more favorable.

Mean yield varied from 1,353 to 278 kg/ha (Table 3). Yields at Saouga were low due to a sand storm 16 days after the first planting which caused severe abrasion to the young seedlings, to a 18 day drought from 9 to 26 days after the second planting. Mean yield at Kaya was also low. The mean yield of the first planting was only 40 % of the average yield for the same four varieties in the Upper Volta Yield Trial, planted on the same day on a similiar soil only 100 meters distant. These low yields may be due to damage by white grub and to striga infestation. The low yield of the second planting can be attributed to dry soil conditions during podfilling.

Of the various factors examined, sowing date had the most general effect on grain yield at the various locations (Table 3). At all locations except Kaya (where, as previously discussed, first planting yields were very low), yields of the second planting were significantly lower than those of the first. At the Kamboinse sites and at Saouga this would clearly seem to be due to the later planted crop encountering an unrelieved drought earlier in its growth cycle (Figs. 10 and 11). It is noteworthy that, at these two sites there was not a significant interaction between variety and planting date. It might have been expected that a variety such as TVx 309-1G which produces a large proportion of its total yield in one early harvest would have a relatively better yield performance in late plantings than indeterminate varieties such as VITA-4 and

.../...

Table 3. Analysis of variance for cowpea grain yield (Kg/ha) - cowpea management Trial at six locations.

Source	df	Mean squares x 10^{-3}					
		Kamboinsé Lower Slope	Kamboinsé Middle Slope	Kamboinsé Upper Slope	Ouahigouya	Kaya	Saouga
Blocks	3	216	47	22	46	116	3
Fertilizer, F	1	503	274	566*	66	522*	6
Cowpea variety, C	3	352	338*	612**	258	96	16
Sowing Date, S	1	3,667***	3,278***	4,007***	2,873***	19	950***
Plant Population, P	1	228	5	137	36	83	137*
F x V	3	248	716***	533**	10	4	38
V x S	3	170	245	155	484*	12	13
V x P	3	135	51	259	42	11	8
F x S	1	345	57	9	1	47	2
F x P	1	24	439*	24	311	5	71
S x P	1	142	0	602	37	101	225*
F x S x P	1	102	11	40	342	6	70
Error	9	156	65	71	117	62	24
Total	31	315	285	328	234	67	62
Mean yield (kg/ha)		1,353	1,052	1,024	1,185	432	278
CV (%)		29	24	26	29	58	56

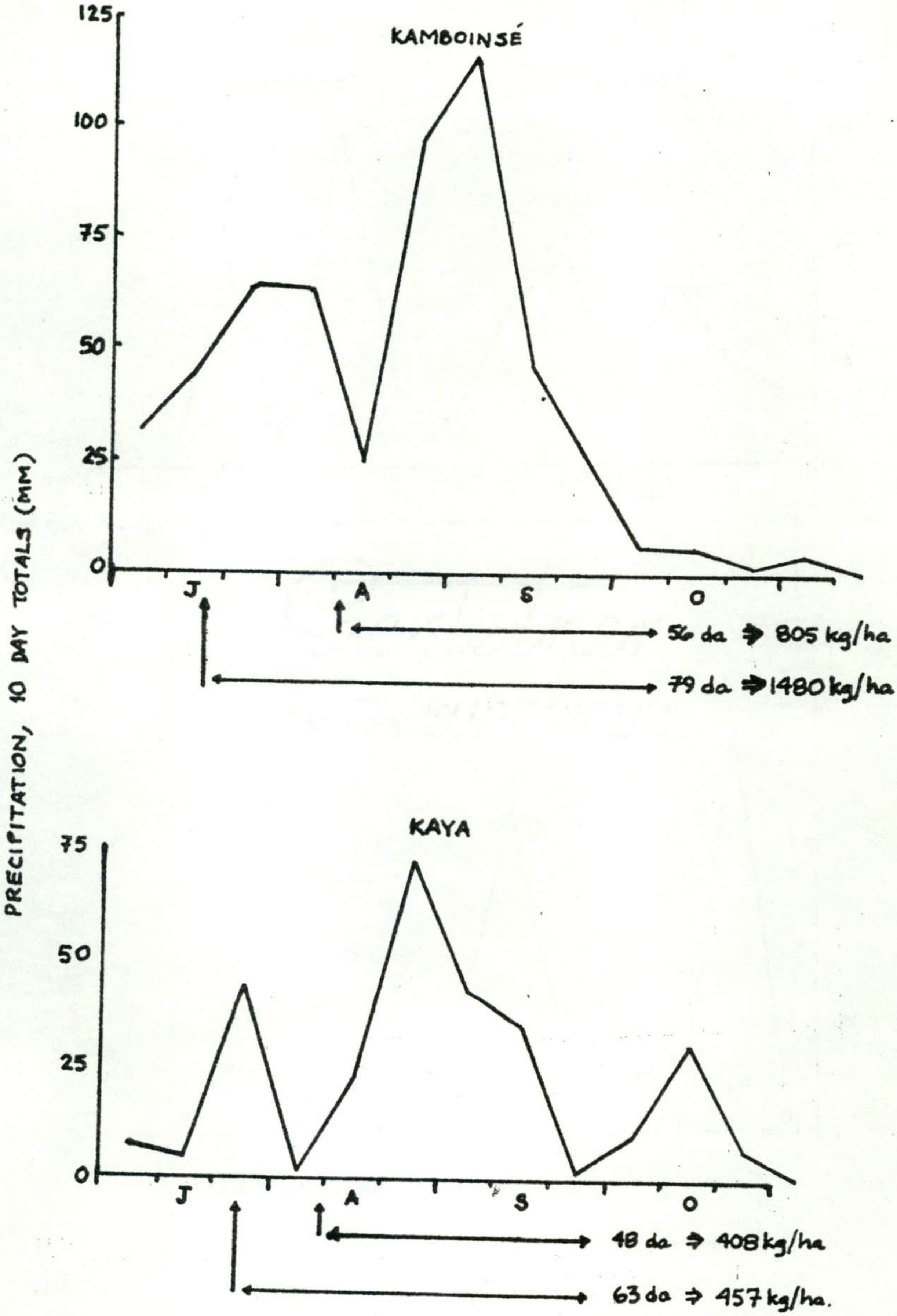


Fig. 10. Rainfall regime, planting dates, time intervals between planting and end of rains and cowpea grain yields for Cowpea Managément Trial at Kamboinsé and Kaya.

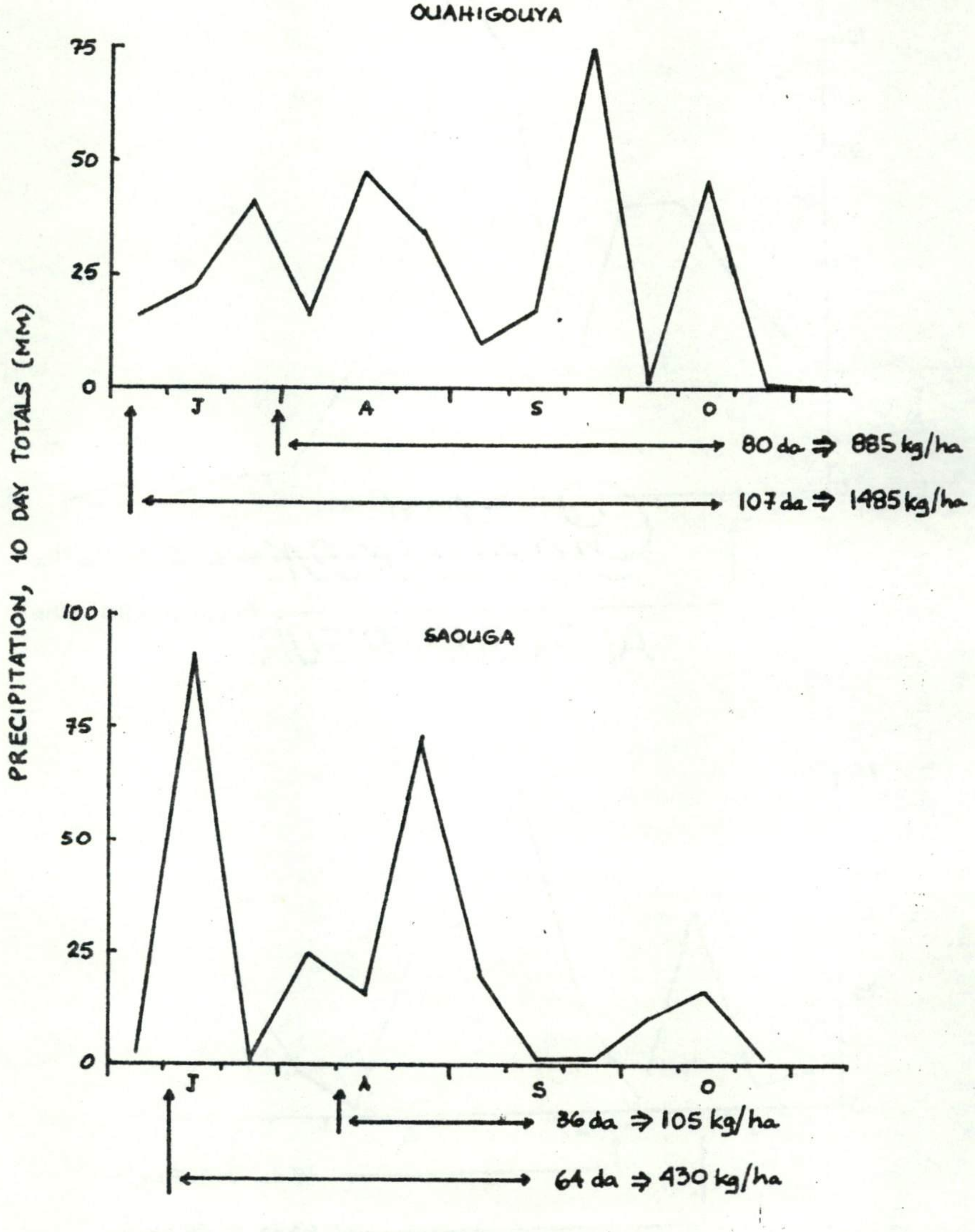


Fig. 11. Rainfall regime, planting dates, time intervals between planting and end of rains and cowpea grain yields for Cowpea Management Trial at Ouahigouya and Saouga.

the local cultivar. However there is no evidence for this. At Ouahigouya (Table 4), the yield of TVx 309-1G, TVx 1193-7D and VITA-4 was reduced by late planting while that of the local variety was not. At this location, a 19 day dry period during which only 10,5 mm of precipitation were received may have had a greater effect on yield than the time interval between sowing and the end of the rains. This dry period occured at 55-75 DAP for the first planting and at 29-49 DAP for the second. At the time of drought stress, in the first planting, first ripe pods had already been produced by TVx 309-1G, TVx 1193-7D and VITA-4 while the local variety was only at early flowering. In the second planting, the stress occurred while TVx 309-1G, 1193-7D and VITA-4 were flowering but the stress was relieved just before the local variety commenced flowering. Thus, the different stages at which drought stress occured for the different varieties at the two planting dates may account for the different responses to planting date.

Application of single super phosphate resulted in significant yield responses at several locations (Table 5). At Kaya, all varieties showed a yield increase. At Kamboinse, all varieties showed a dramatic growth response to application of single super phosphate but the yield response differed with variety. On upper and middle slope sites, TVx 309-1G and TVx 1193-7D gave a 67-84 % yield increase, the yield of VITA-4 was not significantly affected and the yield of the local cultivar was depressed by almost 50 %. The yield depression would appear to be due to stimulation of vegetative growth at the expense of reproductive growth. At the Kamboinse lower slope site, although a marked growth response was observed in all treatments receiving single super phosphate, there were no significant yield responses. It would be of interest to determine the growth and yield responses of these varieties to more moderate rates of fertilizer. It should also be borne in mind that, in addition to P, single super phosphate contains impurities, in particular, S, which could affect growth and yield. At Kamboinse middle slope site, a significant interaction between fertilizer treatment and plant population was observed (Table 3). The response to increased plant population was positive at the low fertility level and negative at the high level (Table 6). This is difficult to explain but the fact that there was no indication of such an interaction in the two experiments immediately adjacent suggests that this may be a spurious result.

The only location at which there was a significant response to population was at Saouga (Table 7). At this site, with early planting, the high plant population yielded 100 % more than the low population while with late planting there was no response to plant population. Two factors may be involved. It may be that, in the late planting, increased drought stress due to high plant

.../...

Table 4. Effect of planting date on grain yield of four cowpea varieties - Cowpea Management Trial at Ouahigouya.

Variety	Planting date	
	Early	Late
	kg/ha	
TVx 309 - 1G	1525 b	569 e
TVx 1193-7D	1470 b	896 de
VITA-4	1917 a	962 cd
Local	1027 cd	1115 c

Means followed by different letters are significantly different at the 5 % level.

Table 5. Effect of 750 kg/ha of single super phosphate (SPP) on grain yield of four cowpea cultivars-Cowpea Management Trial at six locations.

Cultivar	Grain yield (kg/ha)											
	Kamboinsé Upper Slope		Kamboinsé Middle Slope		Kamboinsé Lower Slope		Ouahigouya		Kaya		Saouga	
	-SPP	+SPP	-SPP	+SPP	-SPP	+SPP	-SPP	+SPP	-SPP	+SPP	-SPP	+SPP
TVx 309-1G	845	1409	764	1368	1026	1795	952	1142	389	655	265	236
TVx 1193-7D	964	1691	930	1708	1551	1697	1158	1208	279	510	322	186
VITA-4	865	1074	1090	924	1151	1251	1423	1455	138	451	177	347
LOCAL	890	453	1054	583	1181	1168	1024	1117	414	624	290	397
MEAN	891	1157	960	1145	1227	1478	1139	1231	305	560	264	292
LSD. 05 : FERT.	NS		NS		NS		NS		50		NS	
FERT.xCULT.	213		204		NS		NS		NS		NS	
SOIL ANALYSES												
Bray n°1 P, ppm	1.2		1.6		1.2		10.8		7.2		3.6	
EXTRACTABLE S,	2.41		2.48		2.70		4.6		2.05		1.75	

Table 6. Effect of fertilizer (750 kg/ha of single super phosphate) and plant population on grain yield of cowpeas - Cowpea Management Trial at Kamboinsé, Middle Slope.

Plant Population (pl/ha)	Fertilizer	
	None	750 kg/ha SPP
	kg/ha	
50,000	830 c	1249 a
100,000	1089 b	1040 b

Means followed by different letters are significantly different at the 5 % level.

Table 7. Effect of sowing date and plant population on grain yield of cowpeas - Cowpea Management Trial at Saouga.

Theoretical Plant Population (pl/ha)	Sowing date	
	Early	Late
	kg/ha	
50,000	300 b	123 c
100,000	599 a	86 c

Means followed by different letters are significantly different at the 5 % level.

population prevented any yield response to high population. Also involved may be the fact that severe stand thinning occured in the early planting due to the sandstorm which resulted in stands which were, on the average, 53 % of the thecretical stand. (In the late planting, the stand was 81 % of theoretical). The density of 26,500 plants/ha in the low population-early sowing date treatment is probably well below the optimum.

Conclusions : Unfortunately, results from Saouga and Kaya were affected by sandstorm damage and white grub and striga infestation respectively which may have obscured the affects of other, more interesting factors on growth and yield. However, some tentative conclusions can be drawn from this series of trials :

(1) Soil fertility can be a factor limiting yield of, at least, determinate varieties. Yield increases up to 84 % were obtained with application of single super phosphate at Kamboinse. More work is required to determine : (a) the extent to which this is a yield limiting factor, (b) the response of indeterminate types to lower rates of single super phosphate and (c) the relative importance of P and other nutrients, especially S, which are present in single super phosphate.

(2) The experiment did not reveal differences between plant types in their ability to yield under conditions of limited water supply. The only significant interaction observed between varieties and factors affecting water supply (sowing date) or drought stress intensity (plant population) was the variety X sowing date interaction at Ouahigouya. This interaction seems explainable in terms of the different time at which drought stress occurred relative to the growth stage of the plant rather than differences in drought resistance.

RESPONSE OF COWPEAS TO ROCK PHOSPHATE

Phosphorus levels are frequently low in the soils of the semi-arid zones of West Africa and phosphorus deficiency may be a factor limiting yield of cowpea in these areas. Several countries of semi-arid West Africa have deposits of rock phosphate. A limited amount of field experimentation has been conducted which has demonstrated the possibilities of applying ground rock phosphate directly to the soil to increase crop production.

An experiment was established at Saria to evaluate the effectiveness of Voltaique (Arly) rock phosphate as a source of phosphorus for cowpeas. The rock phosphate was applied at rates of 0, 75, 150, 225, and 300 kg P_2O_5/ha. For com-

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parison, single super phosphate was applied at rates of 0,20, 40, 60, 80 and 100 kg P_2O_5/ha. Application of both materials was made by broadcasting and incorporating by hand hoe before planting or by banding beside the row at planting. A semi-upright cowpea variety, KN-1 (TVx 289-1G) was used.Muriate of potash was applied at the rate of 60 kg K_2O per hectare to ensure that potassium was not limiting. Although soil chemical analysis showed available P (Bray n°1) to be only 3.0 ppm, this was adequate to give a yield of almost two tons per hectare without any phosphate fertilizer. Nonetheless, there was a significant yield response to single super phosphate (Fig.12). Method of application of the single super phosphate had no effect. There was no yield response to the rock phosphate, but it is well known that availability of phosphate may be low in the year of application and it is planned to evaluate, residual effects of rock phosphate in subsequent seasons.

EFFECT OF METHOD OF LAND PREPARATION ON COWPEA YIELD

In collaboration with the maize agronomist, five methods of land preparation were compared for cowpeas and maize at Saria on a shallow soil ($<$ 50 cm to laterite crust). Results for cowpea are reported here. The five methods used were :

(1) tractor plowing and harrowing
(2) oxen plowing and harrowing
(3) chisel plowing + paraquat
(4) hand hoeing
(5) zero tillage (paraquat)

Significant differences in cowpea yields were observed with different methods of land preparation (Table 8). In general the differences seemed to be related to depth of tillage. The exception to this trend is chisel plowing. It should be noted that 55 kg P_2O_5/ha was broadcast before land preparation and depth of incorporation could be a factor. However, it seems more likely that moisture available for crop growth was the key factor as differences between treatments in severety of drought stress symptoms were observed during dry spells and those treatments showing the more severe symptoms were those that ultimately gave the lower yields. Since a suitable preemergence herbicide was not available, weeds in the chisel plowed and zero tillage plots were controlled by pulling the weeds by hand (to simulate herbicide weed control). Thus there was minimal disturbance of the soil surface and it appeared that surface crusting in these treatments resulted in less water infiltration than in other treatments.

It would appear that tillage as it affects available water holding capa-

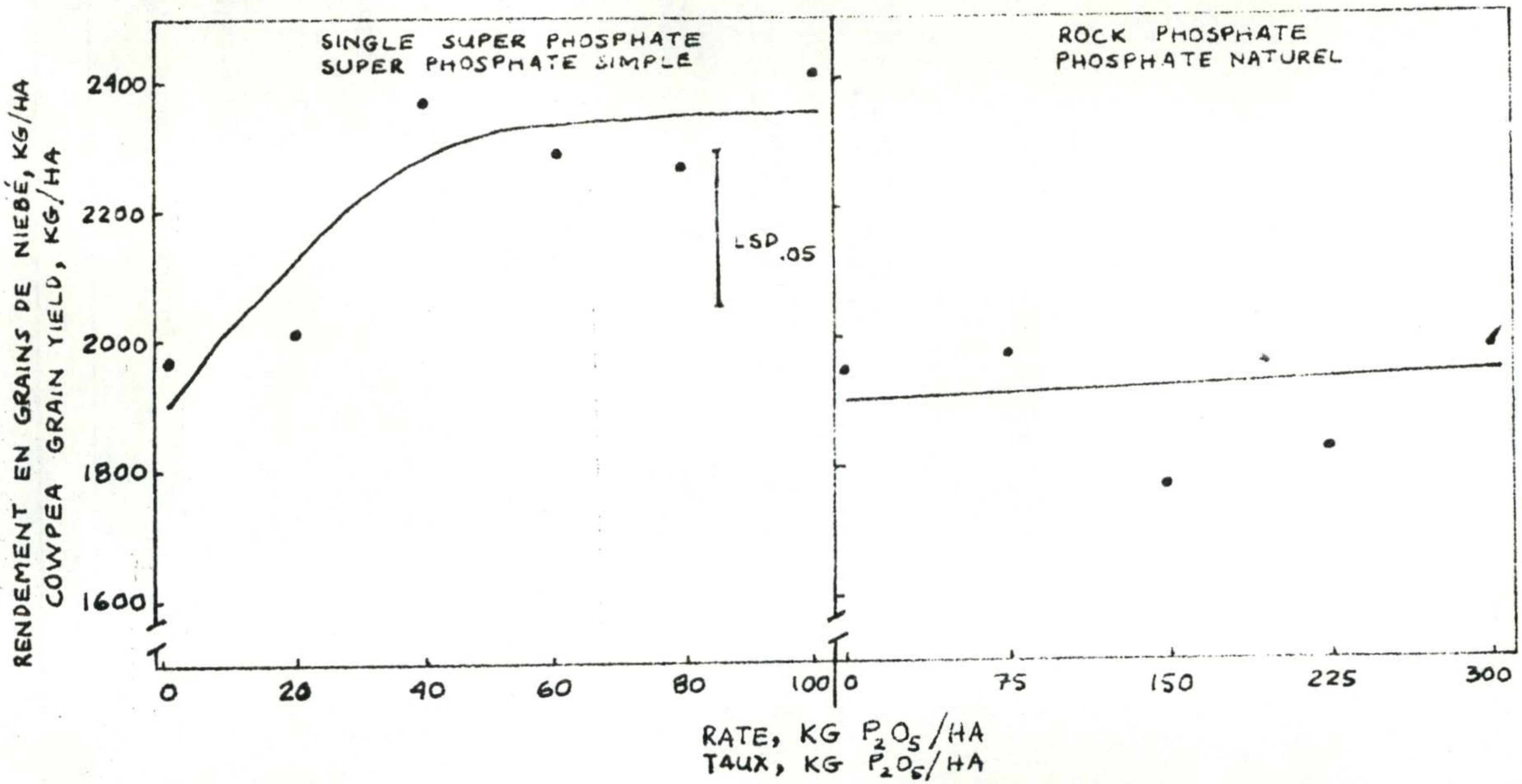

FIG. 12. RESPONSE OF COWPEAS TO SINGLE SUPER PHOSPHATE AND ROCK PHOSPHATE.

FIG. 12. REPONSE DU NIEBÉ AU SUPER PHOSPHATE SIMPLE ET AU PHOSPHATE NATUREL

Table 8. Effect of method of land preparation on grain yield of cowpeas.

Method	Grain yield (kg/ha)
Tractor plowing and harrowing	1758 a
Oxen plowing and harrowing	1589 ab
Chisel plowing + paraquat	1308 bc
Hand hoeing	1247 c
Zero tillage (paraquat)	1123 c

city, water infiltration and root development can be an important factor affecting growth and yield of cowpeas. The results obtained with land preparation by oxen plowing are particularly interesting as this is an improvement over traditional hand hoe preparation which can be economically and technically feasible for the small farmer.

SOIL IMPROVEMENT WITH COWPEAS

A trial was initiated in 1979 to investigate the effect of several factors on the residual effects of cowpea on a subsequent cereal crop. Two cowpea varieties, TVx 309-1G (erect, determinate) and KN-1 (semi-erect) were planted as a monocrop and as a intercrop with sorghum. Three types of harvest were used : (1) the entire above-ground portion of the plant was removed (as commonly occurs for fodder production), (2) only the pods were removed, or (3) nothing was removed. Monocrop sorghum was also grown at the same time. In 1980, maize will be planted over the entire experiment to evaluate the residual effects of these treatments. An estimate of the contribution of nitrogen by cowpea will be obtained by applying nitrogen at different rates to the plots on which sorghum was grown in 1979 and comparing the maize yield from these plots with the yield from those on which cowpea was grown in 1979.

COWPEA ENTOMOLOGY

OBJECTIVES :

Very little information was available on cowpea insect complex in Upper Volta. Research efforts, therefore, were focused to identify the pest problem, the crop stage at which a particular pest species is active and amount of loss in yield it may inflict. This information was essential to determine the pest status and for the development of a sound pest management program.

Efforts were also made to find out whether yield fluctuations in Advanced Yield Trials across locations in Upper Volta were mainly due to insect damage or not.

Experiment was conducted to determine the population levels of various insects on cowpea when intercropped with sorghum.

RESEARCH FINDINGS :

1. Insects associated with cowpea at different stages of crop growth

Insect species found feeding on cowpea at different growth stages are listed in table 1. Four insect species viz. Aphids, Aphis craccivora, flower thrips, Taeniothrips sjostedti, flower and pod borer, Maruca testulalis and various species of pod sucking bugs were seen abundantly. Other insect species were present in small numbers and did not seem to be of economic importance in cowpea production.

2. Estimation of loss due to insect pests of cowpea

The experiment was planted on July 6, 1979 at Kamboinse in a Randomized Complete Block design with three replications and 8 treatments (Table 2). Plot size was 6 rows X 4 meters with a row to row spacing of 75 cm and plant to plant 20 cm. The crop growth was divided into three categories - seedling stage (S_1), flowering stage (S_2) and post flowering stage (S_3). Insecticide was applied according to these three growth stages. First application of monocrotophos (Nuvacron) was made at 500 g a. i./h 21 days after planting (DAP) to control foliage thrips and aphids, and the second 40 DAP at 700 g a. i./h to check the infestation of flower thrips. To control the damage of Maruca in the flowers (S_2) and by Maruca and

Table 1. Various insects recorded on cowpea at Kamboinsé.
Tableau 1. Insectes du Niébé à Kamboinsé.

crop stage stade	Name of insect / Noms des insectes common name nom commun	scientific name nom scientifique	order ordre
Seedling stage Stade de plantule	Foliage thrips	Sericothrips occipitalis	Thysanoptera
	Aphid	Aphis craccivora	Homoptera
	Leaf hoppers	Empoasca dolichi	Homoptera
	Whitefly	Bemisia spp.	Homoptera
	Grasshopper	Zonocerus variegatus	Orthoptera
	Foliage beetle	Ootheca mutabilis	Coleoptera
	Striped foliage beetle	Paraluperodes quaternus	Coleoptera
Growing plants Montaison			
Foliage	Aphid	Aphis craccivora	Homoptera
	Leafhopper	Empoasca dolichi	Homoptera
	Tobacco Caterpillar	Spodoptera littoralis	Lepidoptera
	Grasshopper	Zonocerus variegatus	Orthoptera
Buds and flowers Inflorescence	Aphid	Aphis craccivora	Homoptera
	Flower thrips	Taeniothrips sjostedti	Thysanoptera
	Flower & Pod borer	Maruca testulalis	Lepidoptera
	Pollen beetle	Mylabris spp.	Coleoptera
Pods gousses	Pod sucking bugs	Clavigralla tomentosi-collis	Heteroptera
		Anoplocnemis curvipes	Heteroptera
		Riptortus dentipes	Heteroptera
	Stink bug	Nezara viridula	Heteroptera
	Aphid	Aphis craccivora	Homoptera
	Tobacco Caterlillar	Spodoptera littoralis	Lepidoptera
	Corn earworm	Helicoverpa armigera	Lepidoptera
	Pollen beetle	Mylabris spp.	Coleoptera
Storage * Stockage	Storage weevil	Callosobruchus maculatus	Coleoptera

* An unidentified mite is always found associated with cowpea in storage.
On trouve toujours une mite non identifiée associée au niébé emmagasiné.

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Table 2. Population de thrips des feuilles, d'aphides et de thrips des fleurs à Kamboinsé
Population of foliar thrips, aphid and flower thrips at Kamboinsé.

Traitement / Treatment			Thrips des feuilles / Foliar thrips			Population d'aphides / Aphid population				Thr fl Thr Flo
			3 jours avant traitement / 3 days before treatment (18 DAP)	2 jours après traitement / 2 days after treatment (23 DAP)	7 jours après traitement / 7 days after treatment (28 DAP)	Feuilles / Leaves: 3 jours avant traitement / 3 days before treatment (18 DAP)	Feuilles / Leaves: 2 jours après traitement / 2 days after treatment (23 DAP)	Feuilles / Leaves: 7 jours après traitement / 7 days after treatment (28 DAP)	Fleur / Flower (52 DAP)	(52 D
S1	S2	S3								
Untreated +	Untreated +	Untreated1	20	1	0	112(1.98)	858(2.93)	14(0.88)	15	82(
Untreated +	Untreated +	Insecticide	25	2	0	54(1.74)	587(2.77)	43(1.19)	4	96(
Untreated +	Insecticide +	Untreated	24	0	0.7	74(1.81)	699(2.83)	34(1.36)	1	12(
Untreated +	Insecticide +	Insecticide	12	2	0	59(1.69)	659(2.77)	30(1.38)	0	5(
Insecticide +	Untreated +	Untreated	22	0	0	64(1.69)	0(0.00)	2(0.39)	3	111(
Insecticide +	Untreated +	Insecticide	25	0	0.3	40(1.58)	0(0.00)	4(0.66)	1	125(
Insecticide +	Insecticide +	Untreated	17	0	0	48(1.69)	0(0.00)	1(0.31)	0	27(
Insecticide +	Insecticide +	Insecticide	14	0	0	81(1.89)	0(0.00)	3(0.47)	0	19(
Moyenne / Mean			19.88	0.63		66.50(1.76)	50.38(1.41)	16.38(0.83)	3.0	59.62
L. S. D. à 5 % / L.S. D. at 5 %			13.05	1.44		65.23(0.39)	25.91(0.18)	43.08(0.97)	13.19	40.33(
C. V.			37.34	132.38		56.11(12.97)	48.21(7.16)	50.19(6.99)	154.76	38.57(
Valeur de F. / F - Value			1.51	2.98*		1.09(0.97)	15.34** (66.47**)	1.41(1.87)	1.43	13.54* (1

( ) Les chiffres entre paranthèses indiquent des valeurs logarithmiques.
( ) Data in parentheses indicate log transformed values.

1. Untreated = non traité

pod sucking bugs at pod stage (S_3), endosulfan (Thiodan) was applied at 1000 g a. i./h 48 and 58 DAP.

Results in Table 2 revealed that population of foliage thrips before insecticide application varied from 12 to 25/ 10 plants, but the differences among treatments were not significant. After application of insecticide the population of this insect drastically reduced in the treated plots. At the same time it was found to be greatly reduced in the untreated plots which could be associated to unfavourable environmental conditions.

Aphid population was similar in various treatments before the application of insecticide, but significant differences were observed 2 days after the insecticidal treatment. The plots which did not receive any insecticide, the aphid population ranged from 587 to 858/10 plants as compared to zero in treated plots. Aphid population, when counted 7 days after the insecticide application, was found to be very low both in treated and untreated plots. The reduction of aphids in untreated plots was due to rains that washed them away. Aphid population was highly variable at flowering stage. The population of flower thrips varied significantly among the treatments (Table2). In the plots which received insecticide at flowering stage (S_2) the number of thrips ranged from 5 to 27/10 flowers while in the untreated plots it ranged from 82 to 125. But the number of thrips in the untreated plots (So) were comparatively lower than other plots in which insecticide was not applied at flowering stage (S_2). Crop in untreated check might not have been very attractive to thrips when large number of flowers were available to them in other plots.

Maruca larvae were found in small numbers in flowers (Table 3). The maximum number of larvae were 2.7/10 flowers in untreated plots while the population ranged 0.3 to 1.0 larvae in other plots. Significant differences were observed in percent Maruca infested pods. The infestation was higher in plots not treated at post flowering stage (S_3).

The data on number of pods from various treatments varied greatly. Maximum number of pods were obtained from plots which were protected at all the three stages of crop growth (S_1+S_2+S_3) and number was lowest when no protection was provided. Differences in number of pods were not significant when compared between not treated and treated at the seedling stage (S_1). The significant differences were also not observed between plots when protected throughout the crop growth (S_1+S_2 +S_3) and protected only in the last two stages (S_2+S_3). This suggested that protection at the seedling stage does not help to produce more pods.

.../...

Table 3. Population of Maruca, number of pods and grain yield at Kamboinsé.

Tableau 3. Population de Maruca, nombre de gousses et rendement en grains à Kamboinsé.

Treatment / Traitement			N° of Maruca larvae in flower / Nbre de larves de Maruca dans la fleur	% Maruca infested pods / % gousses infestées par le Maruca	N° of pods / Nbre de gousses	Grain yield / Rendement (kg/plot) kg/parcelle	Grain yield / Rendement kg/h kg/h
S1	S2	S3					
Untreated	+ Untreated	+ Untreated	2.7	19.3 (25.6)x	328	0.513	427.5
Non traité	+ non traité	+ Non traité					
Untreated	+ Untreated	+ Insecticide	0.0	8.5 (16.8)	910	1.260	1050.0
Untreated	+ Insecticide	+ Untreated	0.0	21.6 (27.7)	1765	1.922	1601.7
Untreated	+ Insecticide	+ Insecticide	0.3	10.7 (18.7)	1974	2.127	1772.5
Insecticide	+ Untreated	+ Untreated	0.3	20.1 (26.4)	530	0.573	477.5
Insecticide	+ Untreated	+ Insecticide	0.3	9.5 (17.5)	1040	1.427	1189.2
Insecticide	+ Insecticide	+ Untreated	1.0	10.6 (18.3)	1560	1.720	1433.3
Insecticide	+ Insecticide	+ Insecticide	0.0	12.1 (20.3)	2431	2.317	1930.8
x Values in parentheses transformed to angle Les valeurs entre parenthèses sont transformées en angles.							
Mean Moyenne			0.58	14.05 (21.41)	1317.25	1.482	
L.S.D. at 5 %			1.35	8.34 (6.86)	552.33	0.692	
C.V.			132.26	33.88 (18.31)	23.94	26.675	
F - Value			4.12*	3.76* (3.79)*	16.26**	8.715**	

Grain yield differences were significant among various treatments (Table 3). Yield was lowest in the untreated check plots. There was no significant difference in grain yield from untreated plots and those protected at the seedling stage (S_1). Also non-significant differences were observed between plots treated only at S_1 and S_3 stages. Crop protected at all the three stages gave the highest yield but was not significantly different from the yields of plots that received protection at S_2, S_1+S_2 and S_2+S_3 stages. This clearly showed that S_2 stage is most critical and protection of crop at this stage would contribute more in yield than at S_1 or S_3.

To find out which treatment combination contributed more towards yield, the treatment sums of square was partitioned into seven combinations each at one degree of freedom (Table 4). Maximum contribution to grain yield was obtained by protecting the crop at flowering stage (S_2) followed by at post flowering stage (S_3).

On the basis of number of pods, grain yield and insect populations, it appeared that flower thrips was the most important pest followed by Maruca and pod sucking bugs. Aphids could be harmful and cause yield losses if the dry spells are longer.

3. Observations on insect population in Advanced Yield Trials after insecticide Spraying

Yields at various locations in Upper Volta was highly variable in the last two years. To assess whether fluctuation in grain yield was due to insect damage samples of buds, flowers and pods at different stages of crop growth were taken from VITA-5 and Ife Brown, the two varieties used as an index. Advanced Yield Trials were planted at three locations - Saouga (North), Kamboinse (Centre) and Farakoba (South). Samples were taken from all the three locations. Data were recorded on insect number per ten buds or flowers and on bug feeding punctures for ten pods.

Data revealed that thrips, pod bugs and aphids were present in all the three locations. Presence of Maruca was evident only in Kamboinse and Farakoba, not at Saouga. However, all the three insects were under control and they would not have caused significant reduction in yield.

In addition to above mentioned insects, attack of white grub was noticed at Saouga. White grubs feed on the underground parts. Attacked plants can be recognized from a distance due to dry leaves but when level of injury is high, the whole plant dries up which can be pulled out easily. All such plants show feeding

Table 4. Partitioning of treatment sums of square

Tableau 4. Somme des carrés des traitements

Source of variation Source de variation			D.F.	F - Value valeur de F
S1	S2	S3		
Untreated	+ Untreated	+ Insecticide	1	13.84**
Untreated	+ Insecticide	+ Untreated	1	44.60**
Untreated	+ Insecticide	+ Insecticide	1	1.53
Insecticide+	Untreated	+ Untreated	1	0.11
Insecticide+	Untreated	+ Insecticide	1	0.60
Insecticide+	Insecticide	+ Untreated	1	0.14
Insecticide+	Insecticide	+ Insecticide	1	0.19
Total			7	

cavity or cut in the main root. To find out the extent of damage caused by white grubs observations were taken from trial.1.

Data presented in Table 5, indicated that infestation ranged from 0.47 to 9.37 percent. Although significant differences were observed among the varieties, the intensity of attack was not high enough to categorize any variety as resistant or susceptible. Since cowpea crop has great compensating ability, death of 10 per cent plants should not cause any variation in yield. This insect was also found damaging cowpea at Kaya and Ouahigouya.

4. Screening of lines from Upper Volta Preliminary Yield Trial for resistance to thrips and Maruca

Crosses made at IITA using thrip resistant lines were grown at Kamboinse in 1977 and 1978. The material selected on the basis of yield and agronomic characters was grown as Upper Volta Preliminary Yield Trial. The trial was consisted of 256 lines, and was grown separately for yield and insect screening. Only 249 lines germinated properly and they were evaluated for thrip and Maruca resistance.

To evaluate thrip infestation, observations were taken on number of flowers per meter 45 and 52 DAP. When observations were taken, even a single flower was not found in any of these lines and all the buds were aborted. Based on this observation, all these lines were rated as susceptible. At this stage crop was treated with monocrotophos at 500 g a. i./h twice at an interval of one week. All the lines produced large number of flowers which eventually turned into pods. When most of the lines had fully developed pods notes on Maruca infestation were taken on 1 - 5 scale where, 1 = no or very little damage to fewpods and 5 = maximum damage and many pods show bunching. This arbitrary scale used just to separate out the susceptible ones. Out of 249 lines the following five lines were rated least susceptible :

TVx UV - 3	3.50
TVx - UV - 149	2.25
TVx - UV - 158	2.50
70 - 67	3.25
Local	1.00

To confirm resistance in the above lines they will be subjected to rigorous laboratory tests.

.../...

Table 5. Observations on whitegrub infestation in Advanced Yield Trial-1 at Saouga

Tableau 5. Observations sur l'infestation des vers blancs en Essai de Rendement Avancé-1 à Saouga.

Line/variety Lignées/variétés	% infested plants % plants infestés
VITA-1	6.17
VITA-4	4.53
VITA-5	3.63
Ife brown	3.17
Tvx 289-4G	3.70
Tvx 3040-01E	2.60
Tvx 3339-03D	5.17
Tvx 334-09E	2.00
Tvx 3343-07D	8.30
Tvx 3348-08F	5.50
Tvx 3363-01D	2.80
Tvx 3363-07D	9.37
Tvx 3368-021E	5.10
Tvx 3380-042E	1.57
Tvx 3381-02F	1.70
Tvx 3382-08F	5.40
Tvx 3385-027D	4.73
Tvx 3388-04E	5.73
Tvx 3388-06E	7.30
Tvx 3405-01E	6.53
Tvx 3405-08E	5.07
Tvx 3405-014F	3.20
Tvx 3410-05E	0.47
Tvx 3425-01E	1.80
7R-0189 D	3.30
Mean Moyenne	4.35
L.S.D.	5.58
C.V.	78.00
F. Value Valeur de F	1.25*

5. Entomological observations in cowpea : sorghum intercropping experiment (in collaboration with Dr. Brockman)

Traditionally cowpea is grown as an intercrop with sorghum, millet and maize. It is believed that cowpea grown in lower densities with intense mixture reduces the attack of insects and high grain yields are obtained. To test this hypothesis cowpea (VITA-5) was planted with sorghum (E35-1) in a split plot design where treatments were confounded in a factorial set-up. The main plots were insecticide treatment, treated (T_1) and untreated (To). The sub plots were spatial arrangement ; growing cowpeas and sorghum by varying plant population within the row (A_1) or by varying number of rows of each crop (A_2) at four densities (D).

	Sorghum : cowpea		
D_1	0:1	(Cowpea plant population	66,000/h)
D_2	$\frac{1}{2}$:$\frac{1}{2}$	(" " "	33,000/h)
D_3	$\frac{2}{3}$:$\frac{1}{3}$	(" " "	22,000/h)
D_4	$\frac{3}{4}$:$\frac{1}{4}$	(" " "	16,550/h)

In the treated plots monocrotophos was applied at 20, 30, 40 and 50 DAP and endosulfan at 51, 60 and 70 DAP (for more details please see agronomy section). At the initial stage of crop growth slight infestation of foliage thrips and aphids was noticed in untreated plots. Forty-eight days after planting, population of thrips and aphids was counted. Number of thrips varied from 0 to 2/10 flowers in treated plots as compared to from 14.5 to 35.0 in untreated plots. There was a significant difference between treatments, but plant density and spatial arrangement had no influence on thrip population (Table 6). Aphid population also revealed that insecticide application was responsible for a significant difference, not the density or arrangement.

Number of Maruca larvae were negligible in flowers.

To assess the intensity of attack of insect pests to reproductive parts flowers and pods were counted from 5 plants. The number of flowers were significantly higher in treated plots than untreated. A similar trend was observed when number of pods were taken into account. In untreated plots the production of flowers and pod formation may be delayed due to insects as compared to in treated plots. Therefore, data was also computed by combining the number of flowers and pods. In the combined

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Table 6. Tableau recapitulatif des valeurs de F.
SUMMARY OF F - VALUES

Source de variation Source of variation	Nbre de thrips N° of thrips	Nbre de d'aphides N° of Aphids	Nbre de fleurs N° of flowers	Nbre de gousses N° of pods	Nbre de fleurs+gous. N° of Fl. + pods	Nbre de punaise N° of bugs	Nbre de scarabée N° of beetles	% de gousses infestées par les Marucas Percent Maruca infested pods	Nbre de récoltée N° of po harves
Traitement Treatment (T)	10.77* (55.99)**	3.60 (18.54)*	113.65**	82.56**	271.54**	0.71	0.01	0.87 (0.01)	43.66**
Densité Density (D)	0.18 (0.28)	1.53 (1.29)	0.13	0.85	0.95	5.39**	8.11**	4.82**(3.70)	0.26
Amenagement Arrangement (A)	3.50 (2.17)	0.00 (0.21)	0.06	1.81	2.01	1.10	0.68	0.84 (1.06)	3.29
D.X.A.	1.07 (1.00)	2.06 (0.17)	1.09	0.70	0.77	0.37	0.14	0.17 (0.43)	0.98
T X D	0.30 (3.28)*	1.54 (1.56)	0.94	0.40	0.59	0.60	0.14	0.31 (0.19)	5.22**
T X A	2.78 (0.02)	0.00 (0.35)	0.05	0.54	0.29	0.39	0.01	4.01 (3.75)	0.13
T X A X D	0.90 (0.06)	2.06 (0.22)	1.95	0.81	1.19	0.60	0.10	0.66 (1.29)	3.28

*, **Significatif pour 5 % et 1 %.

*, **significant at 5 and 1 % respectively

( ) figures in parentheses indicate F-value for transformed data analysis the insecticide application had significant effect irrespective of spatial arrangement and density.

The population of pod sucking bugs, pollen beetles and per cent maruca infested pods varied with plant density (Table 6). Population of pod sucking bugs and beetles was higher in the plots with higher plant density (D_1) and their number decreased as the plant density was lowered. However, there was no significant difference in the pod bug and beetle population in other three plant densities. Statistically plant density may be playing an important role for variation in number of pod sucking bugs and beetles but practically no difference existed. No conclusion could, therefore, be drawn on the basis of highly variable and low populations of these insects.

Per cent Maruca infested pods were significantly less at higher density (D_1) followed by at lowest (D_4). But no difference was observed in the number of infested pods between D_2 and D_4. The maximum number of Maruca in pods was found in D_3.

It is interesting to note that difference in Maruca infestation in the treated and untreated plots was not significant.

The number of pods counted on 5 plants, few days before harvest, increased significantly with insecticide treatment at all plant densities. Treatment x density interaction was significant as a result of high pod number at high plant density in the treated plots and at low plant density in the untreated plots. The interaction between treatment x density x arrangement was also significant because in treated plots at plant density D_3 the pods produced were maximum at A_2 while A_1D_3 gave maximum pods. However, in untreated plots at D_3 both arrangements A_1 and A_2 produced similar number of pods. Also at D_2 and D_4 the number of pods produced were higher at A_1 than A_2.

The number of pods followed the same trend as grain yield.

In summary the data showed that untreated cowpeas at low density under intercropping can produce a good yield as compared to under sole crop but to exploit their maximum yield potential insecticide treatment is essential.

6. Preliminary observations on aphid biotypes

Research work conducted on aphid biotypes at IITA indicated that there were two biotypes designated as A and B. Cowpea lines were either resistant to A or B or to both biotypes (Personal communication from Mrs Ansari).

In the present study 13 lines, 3 resistant to biotype A and 1 resistant to biotype B, and 9 resistant to biotype A&B, were planted in field with a susceptible check KN-1 to see the natural preference of aphids. The lines selected are listed in Table 7.

Table 7. Field reaction of resistant lines to aphid in Kamboinse

Line	Resistant to biotype	Reaction 15 DAP
TVu 36	AB	Free
TVu 42	AB	Free
TVu 62	AB	Free
TVu 107	A	5-10 aphid/plant
TVu 170	AB	Free
TVu 200	A	Free
TVu 205	AB	Free
TVu 223	AB	Free
TVu 257	B	Free
TVu 328	AB	Free
TVu 352	AB	Free
TVu 363	AB	Free
TVu 410	A	Free
KN-1	Susceptible	Many aphids

Observations taken 15 DAP showed that all the lines, except TVu 107, were absoluty free from aphids. TVu 107, which is resistant to biotype A, had 5-10 aphids per plant. On some of its plants 1st and 2nd instar nymphs were seen. Variety KN-1 had lot of aphids. Twenty days after planting, 100-150 aphids per plant on 10 plants in each line were released 3 times on alternate days. Performance of these lines under artificial infestation could not be judged as all the aphids were washed away due to heavy rains.

In Ouahigouya and Kaya VITA-4 was found free from aphids in IITA trials. All other varieties in adjacent plots were seriously affected. Mrs Ansari has personally communicated that VITA-4 was resistant to biotype A in her studies at IITA. It indicated that probably it is the same biotype present both at Ouahigouya and Kaya.

Lines found resistant to biotype A,B and to A and B at IITA will be tested in

Table 8. Evaluation de perte du· au C. maculatus
Assessment of loss due to <u>Collosobruch maculatus</u>

	Nov., 79	Dec., 79	Jan., 80
% de grains infestés par C. maculatus % C. maculatus infested grains	7.90	16.08	13.48
poids de grains infestés (g) wt. of infested grains (g)	8.02	15.31	12.33
% de degâts causés par les autres facteurs % damaged grains by other factors	8.48	9.73	9.31
poids de grains attaqués (g) wt. of damaged grains (g)	6.80	7.91	7.94
% de grains sains % healthy grains	83.62	74.19	77.21
poids des grains sains (g) wt. of healthy grains (g)	85.18	76.78	79.73

When the samples were weighed, the difference in weight followed the same trend as that of percent seed infestation by C. maculatus.

Lorsque les échantillons furent pesés la différence dans le poids a suivi la même tendance que le % de grains infestés par C. maculatus.

Kamboinse to ascertain kind of biotype present there.

7. Estimation of loss due to Callosobruchus maculatus

To estimate the amount of loss caused by Callosobruchus maculatus in Upper Volta at different times of the year, a local variety of cowpea was purchased from the market every month. Five samples, each of 100 g, were taken and healthy grains were separated from grains damaged by C. maculatus and other factors, and were counted and weighed. The results of sample taken from November - January are given in Table 8.

The extent of damage caused by C. maculatus was in the November sample, but increased considerably in December and stayed almost similar in the month of January. The low damage in the November sample was due to fresh infestation.

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