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SECOND ANNUAL REPORT

of the

AID - ARS Project

Major Cereals in Africa
1965

SECOND ANNUAL REPORT

of the

AID-ARS Project

Major Cereals in Africa
G. F.Sprague

This report will include (1) current status of the project, (2) a brief summary of accomplishments and, (3) detailed reports by location. The individual reports are extensive but sections 1 and 2 are sufficient to provide an adequate picture of developments.

CURRENT STATUS

This AID-ARS project was initiated in 1963. Two regional locations were planned, one in Nigeria and the second in Uganda and Kenya. In each region our staff would be associated with existing research institutions. The plan of operation would be to extend or supplement existing research programs through provision of additional staff equipment and financial support. The program is to be fully cooperative in all aspects.

The program, as planned, can be divided into three major phases; cooperation with research institutions in Nigeria, Uganda and Kenya to enlarge and provide additional support to programs designed to increase production of the major cereals, (2) to sponsor and stimulate cooperative research among all countries within each region and, (3) to provide in-service training, at the headquarters stations, to individuals sponsored by their respective governments.

The location of the current and proposed staff is indicated below:

Location	Name	Discipline	When posted
Institute for Agr. Res. Zaria, Nigeria	O.J.Webster	Sorghum Geneticist	Sept. 1964
	M. Futrell	Pathologist	"
	O. York	Entomologist	Feb. 1966
	K.R.Stockinger	Soil Scientist	March 1966
Kaduna, Nigeria	A. Kosage	Admin. Ass't.	July 1965
Moor Plantation Ibadan, Nigeria	J. Craig	Maize Path.-Breeder	Oct. 1965
Maize Research Centre Kitale, Kenya	S.A.Eberhart	Maize Geneticist	July 1964

Serere Experiment Station			
Serere, Uganda	A. J. Casady	Millet Geneticist	Aug. 1965 1/
	- - - - - -	Entomologist	April 1966 1/
	G.A.Schumaker	Soil Scientist	April 1966 1/

1/ These dates are tentative depending upon the completion of housing.

The research activities of our staff at each of the locations listed is fully cooperative. It would, therefore be extremely difficult to separate accomplishments into segments assigning proper credit to the cooperating agency and to our staff. The present report, therefore, will not attempt any such separation but rather will endeavor to provide a measure of total progress. A summary of progress is presented in the following section to be followed by detailed reports from those locations where we have had staff assigned prior to August 1965.

SUMMARY

The sorghum and millet program of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria is extensive in scope and modern in outlook. Several thousand nursery and yield test plots are devoted annually to the improvement phases of this program.

Previous work has indicated that yield increases can be obtained by pedigree selection within locally adapted sorghum varieties. Improved strains exhibiting yield increases of 20 percent have been obtained. Such improved types are now being included in provincial trials to establish their areas of adaptation with the objective of increase and distribution of superior types.

The yield potential of local types is low and major increases in yield will depend upon the introduction of new varieties and hybrids. Preliminary studies have established the yield potential of U. S. hybrids. While these are high yielding they are unsuited to local culture as they mature during the rainy season. Extensive studies are underway to develop adapted cytoplasmic sterile female parents and restorer lines. This new material looks very promising and adapted high yielding hybrids should be available within the next few years. The World Sorghum Collection (5000 items) is being grown and evaluated for resistance to the important diseases.

Maize has not been a common crop in the Northern Region of Nigeria. Preliminary experiments suggest it may compete favorably with sorghum in some areas of the region and breeding and cultural studies have been initiated.

In the drier areas of the Northern Region, the Pennisetum millets are an important food crop. Cultural studies have shown a direct relation between stand level and yield, with yields of 619 pounds per acre at stands of 3,500 plants per acre to 1,357 pounds per acre at 57,600 plants per acre. Selection experiments have been effective in isolating types which are superior to local varieties. Some of these selections are being increased for possible distribution.

The World Millet Collection (approximately 2,000 items) is being grown at Kano, Nigeria. Promising material from this collection, as well as local selections, are being crossed to cytoplasmic sterile strains with the hope of finding suitable parents for the production of hybrids.

Studies have been initiated at Serere, Uganda on the Eleusine and Pennisetum millets. The Serere collection of finger millets (Eleusine) have been evaluated, and the more promising varieties have been increased for regional testing. The World collection (724 varieties) was grown in 1965 for observation. One of the disease resistant types has been crossed with adapted types in an attempt to combine disease resistance and high yield.

In previous studies introduced types of Pennisetum have been compared with local types. Six open-pollinated varieties of the Zuarungu type have been identified as superior in yield to the commonly grown local varieties. These are quite variable and additional selection will be undertaken. These superior strains are also being crossed to cytoplasmic sterility sources to determine whether hybrids are feasible.

Studies on grain sorghum have included three somewhat separate phases; the development of bird resistant types, the development of fully fertile tetraploid types and the development of suitable hybrids. Experimental crosses involving the U. S. sterile type, Combine Kafir 60, have shown promise. This sterile source, however, is too susceptible to the central shoot fly to provide a sound basis for the development of hybrid sorghum. Cytoplasmic sterility is being transferred into adapted types. When these become available the commercial production of hybrid sorghum for this area is a definite possibility. The Kenya Seed Company is making plans to undertake the production of hybrid sorghum seed as quickly as suitable parents have been isolated and identified.

Phenominal progress has been achieved by the Maize program in Kenya. Work is currently being conducted at two locations; Kitale and Katumani. Limited production of conventional double-crosses was initiated in 1963 in the Kitale program. This seed was offered under a package arrangement. Each purchaser of hybrid seed was required to buy the recommended amount of fertilizer, and insecticide and to follow certain specified cultural practices. In spite of a yearly doubling of seed production the seed supply has never equalled the demand. This system has ensured the maximum effect on agricultural production. Yield increases achieved by the grower represent the combined superiority of each of the individual improvements in practice. In effect hybrid maize is considered as a new crop and no problems have been encountered through attempts to utilize second-generation seed.

The hybrid program at Kitale, Kenya was originally based on the production and use of conventional double-crosses. These have produced yield increases of 25-30 percent, a figure comparable to the superiority of the first double-crosses utilized in the United States. More recently it has been established that a varietal hybrid between the local variety (Kenya Flat White) and a Central American type (Ecuador 573) gives increases in yield of 50-100 percent. This varietal cross currently accounts for the bulk of the hybrid seed being sold in Kenya. Genetic studies have indicated that simple selection schemes can be expected to increase yields of the parental varieties by about 5-10 percent per generation and these increases should be reflected in increased yield of subsequent hybrids. Current experimental data confirm this expectation.

The extensive genetic studies and experimental findings have clear implications to all other developing countries planning to initiate or in the early stages of developing a maize breeding program.

The second maize breeding program is centered at Katumani. This is a low rainfall area, and early drougth escaping types are required. In spite of this climatic limitation, improved types have produced yield increases of approximately 50 percent.

There is need for a third breeding center at Embu to serve the Central Province, one of the most densely populated areas of Kenya. This is an area requiring maize of medium maturity which cannot be adequately served from either the Kitale or Katumani locations. Funds for the initiation of this program may be available from local PL 480 funds.

Two scientific articles have been published. One deals with the ergot disease in sorghum and the second with a new yellow endosperm millet. The yellow color in this new type is a carotenoid pigment and presumably has some pro-vitamin A potency. As millet is the important food crop of the area this new type could have important nutritional value.

Two regional conferences were held in October 1965. The conference held at Zaria, Nigeria, was called by Dr. A. O. Adelola, Secretary General, Scientific Technical and Research Commission of OAA. Invitations were sent to thirty-six countries to send delegates. When it became apparent that no representation could be expected from the East African countries a second conference was planned for Kitale, Kenya.

Eleven countries were represented at the Zaria conference. The Nigerian Sorghum, Millet and Maize breeding program was reviewed in detail and reports of current work were presented by delegates from each of the other countries represented. Plans were developed for the exchange of breeding stocks and for the expansion of a cooperative testing program.

The conference held at Kitale, Kenya was equally effective. Nine countries were represented with a total of 26 persons in attendance. The main emphasis of this conference was directed toward breeding procedures adapted to developing countries with particular emphasis on the use of exotic germplasm. There was much interest in this program and plans were developed for supplying seed of exotic maize stocks to Malawi and Zambia.

Although this project is still not fully staffed certain segments have been in operation for nearly two years. Our staff has enjoyed excellent cooperation and effective support from the cooperating agencies. In turn our men are contributing significantly to the projects with which they are associated.

Two aspects of this project, as initially visualized, are not yet fully operative. These are: (1) the utilization of our professional staff in an advisory capacity by countries other than those where they are based, and (2) an adequate development of the in-service training facilities. It is felt, however, that some progress is being made in these areas.

SORGHUM IMPROVEMENT IN NORTHERN NIGERIA

by

Andrews, D.J., Curtis, D.L. and Webster, O.J.

INTRODUCTION (D.L.C.)

The present program, which began in 1956, may be divided into several phases. A preliminary assessment of the local varieties grown at present, their uses and relative importance, was concluded in 1958 when a comprehensive sample survey was carried out with the co-operation of the extension services. Between 1957 and 1961 replicated yield trials were conducted throughout Northern Nigeria to assess the performance of local varieties in different ecological zones. At the same time, pedigree selection within the most promising local varieties was started at four locations, and improved strains which have been developed are being distributed to the farmer. Each year since the program began, exotic varieties and more recently hybrids have been tested. This work continues but when it became apparent that exotic material was not likely to prove useful in high rainfall areas, a hybridisation program based on crosses between local and introduced varieties was started. The hybridisation program has produced a range of material from which stable lines for immediate release and female lines for use as parents in hybrid combinations are being selected.

As an adjunct to the main breeding program some genetical and cytogenetical studies have been started.

PRELIMINARY ASSESSMENT (D.L.C.)

SURVEY

821 sample panicles were collected in the survey. The original panicles were photographed, branches were preserved and seed has been maintained by growing all the accessions in nurseries at Samaru. Each sample was accompanied by a questionnaire and information is available on the uses, importance and distribution of the local sorghums which were collected.

Sorghum is grown for grain in Nigeria although crop residues may be fed to cattle or used in various other ways. Most people prefer a white, flinty grain although there are important areas in the Sudan savanna (Keay, 1958) where grain with a yellow endosperm is accepted.

The samples were classified into seven races. Of these seven races four are economically important and they are described briefly.

Guinea race

Varieties are typically tall and late-maturing with loose, often pendulous panicles. The flattened grains are exposed at maturity between long, widely-gaping glumes.

The Guinea race should be regarded as an additional world group, ranking with kafir, milo, etc. It closely resembles the shallus.

In West Africa the Guinea race is distributed in the wet Guinea savannas and in Nigeria this race predominates as far north as latitude 11° 30' N.

Kaura race

The Kaura race is characterized by having large, round grains protruding from tightly adpressed glumes. The endosperm is usually yellow, containing carotenes.

Kaura varieties are large grained kafirs, classified by Snowden (Snowden, 1936) as S. caudatum var Kerstingianum.

The Kaura race is most important in the densely populated central Sudan savanna although varieties occur throughout Northern Nigeria.

Farafara race

Varieties in the Farafara race resemble large-grained kafirs without the dorsal hump and yellow endosperm characteristic of the Kaura grain.

Varieties of this race are grown as alternatives to Kaura in the Sudan zone.

Chad race

Chad varieties possess a grain which exceeds the glumes in length at maturity but is bent towards the lower glume. The Chad race most closely resembles hegari.

This race is predominant in north-eastern Nigeria but some varieties are grown as an early crop in other parts of the country.

REPLICATED YIELD TRIALS

Results from replicated yield trials in which local varieties were grown in areas where they are not normally cultivated, showed quite clearly that local varieties are closely adapted to the length of season. Therefore several areas have been delineated: a different variety or type is needed for each area. These areas in Northern Nigeria are as follows:

Eastern Sudan Savanna

The same variety can be grown successfully in a large area around Maiduguri in the eastern Sudan Savanna. Similar conditions may exist in parts of the northern Sudan Savanna. It is thought that these areas offer the best prospects for the successful introduction of early maturing exotic varieties although locally adapted sorghums take from 80 to 90 days from sowing to anthesis.

Central Sudan Savanna

This areas embraces parts of the densely populated provinces of Katsina and Kano. It is the most important sorghum growing area in Nigeria and the strain recommended for use takes approximately 115 days from sowing to anthesis.

Northern Guinea and Sub-Sudan Savanna

Several areas at a latitude of approximately 11°0'N appear to offer similar growing conditions. Suitable local varieties take 125 to 130 days to anthesis from a sowing date in late May or early June.

Southern Guinea Savanna

Sorghum cultivation extends southwards into ecological zones with a long rainy season. Local varieties may take as long as 150 days from sowing to anthesis, and varieties from further north are unsuitable. The exact boundaries of this area have not been determined.

Derived Savanna

Sorghum is cultivated in areas where a long wet season is usually broken by a short dry period in August. As far as sorghum is concerned this represents a distinct area where yields from all varieties are low (400 lb/acre). Sorghum is not the major foodcrop in this area.

PEDIGREE SELECTION WITHIN LOCAL VARIETIES (D.J.A.)

MATERIALS AND LOCATION

Selection has been practised on five varieties representing the four most important Nigerian races of sorghum.

Variety	Race	Selection Centre	Zone
Gwoza Local	Chad	Maiduguri	E. Sudan Savanna
Yar Gunki	Kaura	Kano	Central S. Savanna
Caffra ex Biye	Farafara	Samaru	Northern Guinea and)
Farafara	Guinea	Samaru	Sub-Sudan Savanna)
Mokwa varieties	Guinea	Mokwa	Southern G. Savanna

'Gwoza Local' is a variety typical of the Chad race and the seed has a white pericarp and a coloured testa.

'Yar Gunki' has a high-quality, hard, yellow grain containing carotene.

'Caffra ex Biye' possesses a hard, white grain of a higher quality than is normal in the Farafara race.

'Farafara' variety of the Guinea race under selection at Samaru has a white or pearly white grain of high quality.

'Mokwa varieties' are all of the Guinea race but later maturing than the Samaru 'Farafara' variety. Pericarp colour may be white, yellow or red.

METHODS

At each centre, material derived originally from single plant selections made in farmers crops, is represented as cohorts for successive years. These cohorts are grown in yield trials and reselections of the best lines are made from selfed replications. A control strain is included in all trials. In the initial year, selections are grown in a randomised block design but in subsequent years a compact family block design (Panse and Sukhatme, 1954) with five replications and a plot size of $\frac{1^{th}}{400}$ acre is used. Pedigree selection is continued until the variance between progenies within a family approaches the variance between dummy progenies in the control strain. This normally takes three or four years. In the final year strains are formed from the highest yielding progenies and these are then tested in trials at provincial centres chosen to represent the ecological zones. Randomised block or Latin square designs (with a standard plot size of $\frac{1^{th}}{40}$ acre) are used for provincial trials in which the latest strains are compared with the best local variety and a standard control.

In addition to yield performance, grain acceptability comparisons are made between strains and local varieties by using the seed from trials for replicated palatability tests at each location.

Eastern Sudan Savanna, Maiduguri

Chad race

A basic control G59 has given an average increase in yield of 248% of the local variety (685 lb/acre) at one provincial site (3 years) Although further selections have outyielded the basic control by as much as 26% at Maiduguri, they have not maintained their superiority in provincial trials.

Central Sudan Savanna, Kano

Kaura race

Provincial sites	No. of trials	Mean Yield Local Variety lb/acre	% Improvement Strain YG5760-3
Gusau	4	1368	35
Kafinsoli	4	1381	21
Birnin Kudu	4	2065	21
Azare	4	1275	7
Potiskum	4	682	15

Northern Guinea Savanna, Samaru

Guinea race

Provincial sites	No. of trials	Mean Yield Local Variety lb/acre	% Improvement	Best strain
Zuru	3	1419	14	SFF60
Gimi	3	996	18	SFF60
Bauchi	2	1230	12	FFBL3
Darazo	3	959	3	SFF60
Hong	2	1185	6	FFBL3
Mubi	2	833	28	FFBL3

Farafara race

Strains of Caffra ex Biye were included in provincial trials for the first time in 1965. Previous work at Samaru has shown that these strains outyield existing strains of the Guinea race by approximately 20% .

Southern Guinea Savanna, Mokwa

Strains selected from samples collected before 1962 did not give subtantial yield increases. All the Guinea varieties found in this zone lodge badly and effective, single-plant selection is difficult. Pedigree selection was abandoned but bulks of selections made previously have given yields over 20% more than the control, unselected Mokwa Local, in 1963 and 1964. If results are confirmed this year, provincial trials will be sited at locations where previous trials with unselected Mokwa Local had shown that improved strains might be suitable.

DISCUSSION AND CONCLUSIONS

It has been shown that useful increases in yield can be obtained by pedigree selection within the local varieties cultivated in Nigeria. Several improved strains have been isolated and they are being distributed by the Ministry of Agriculture to farmers in the Sudan, Sub-Sudan and Northern Guinea savannas. However, the general yield potential of local sorghums is low and major increases in yield will depend almost certainly on the introduction of new varieties and hybrids. Therefore the continuation of pedigree selection within varieties which have already undergone the first cycle of selection is questionable; elite lines have been isolated which are recommended for general cultivation and they are also available for use as parent material.

At Samaru and Kano the stage has been reached where it has become increasingly difficult to isolate lines which outyield the initial selections. As expected, it was relatively easy to select lines which outyielded the original varieties because populations grown by the farmers are mixed: apart from the rejection of unpalatable types at harvest, no conscious selection for yield is practised. It was thought that further yield advances might be obtained by increasing the range of variation available for selection and therefore samples were collected from populations grown throughout each zone. In practice the most promising lines were selected from a few, intensively sampled populations and not from a wide range of populations represented by only a few samples. As several populations from the Guinea and Kaura races have been sampled intensively at Samaru and Kano, further work will be restricted to completing the initial selection cycle on material already collected. By the time this phase has been completed, new varieties of hybrid origin should be available for testing.

SAMARU FIELD PROGRAM

		Field
AN 11 (60) R65.	Farafara Progenies in Families II	
	8 families of 10 progenies introduced 1960	V4
AN 12 (63) R65.	Caffra ex Biye Progenies in Families III	
	9 families of 9 progenies. Introduced 1960	V3c
AN 9 (65).	Farafara Progenies in Families IV	
	4 families of 10 progenies. Introduced 1964	T9a
AN 5 (62) R65.	Replicated progeny Rows	
	31 samples collected in 1964	T9a

AN 8 (61) R65. Farafara Strains Trial

8 strains developed from 1956 to 1962 cohorts V4

AN 1 (64) R65. Sorghum Final Assessment Trial

4 varieties, Farafara, Short Kaura, Caffra ex Biye and WX60 (Farafara x Hagari selection) T9c

AN 1 (63) R65. Sorghum Strains Maintenance.

17 strains being maintained either by selfing or in isolation Varous

EXOTIC VARIETIES AND HYBRIDS (O.J.W.)

Short-season varieties and hybrids have been grown at Samaru for a few years and their potential has been established. For example, in 1963 a collection of hybrids from the United States and India were grown in observation plots planted June 6th and August 15th. A yield of nearly 5000 lb/acre was recorded for one hybrid. The average grain yield (dry weight basis) of 6 hybrids was 2,900 lb/acre and the stover yield was 3,100 lb., a grain/storer ratio of about 1:1. The comparable yield of the local variety, SFF60, was 2,300 pounds of grain and 18,000 pounds of stover, a ratio of 1:8. The yield was considered very good for SFF60. The hybrids bloomed in 57 days after sowing and the local variety in 125 days. The yield of several of the hybrids was reduced by a half when they were sown in August and the grain quality was poor. These late sowings were well fertilized and sprayed with an insecticide to control shoot fly (Atherigona spp.). Shoot fly normally causes a marked reduction in stands when the crop is not sown with the first rains in late May or early June.

The early-maturing hybrids and varieties could provide a source of grain for livestock feed if ensiled. The potential of early-maturing hybrids and varieties is being investigated in the extreme northern areas of Nigeria where the season is limited to 3 to 4 months.

Appendices I and II contain the detailed results from observation plots at Samaru and in other parts of West Africa.

HYBRIDIZATION (D.L.C. & D.J.A.)

OBJECTIVES

The necessity to breed a new range of material has been outlined elsewhere (Curtis, 1965). The average yields obtained from Nigerian sorghums are low. The national average yield is between 600 and 700 lb grain/acre and the highest yields at Samaru rarely exceed 3000 lb/acre. Spectacular yield increases have not been achived by the use of seed dressings, earlier sowing, closer spacing, fertilizers or by spraying against pests and diseases. Neither have treatments designed to improve soil conditions, like cross-tying ridges and mulching, increased the yield of local varieties to a level approaching that of unadapted, introduced sorghum (4,500 to 5,000 lb/acre).

The main objective in the hybridisation program has been to produce grain sorghums which mature at the end of the rains with a grain quality similar to Nigerian varieties but which will respond to close spacing and fertilizer applications. At the same time cytoplasmic male sterility of the CK60 and 9E types has been introduced with a view to obtaining A and B lines for use in hybrid combinations.

Grain quality

In Nigeria, good quality refers to grain which is acceptable for making 'tuwo', a type of porridge. Information on locally acceptable varieties was obtained from the sample survey and palatability tests carried out in conjunction with all replicated yield trials.

Colour

A white pericarp is generally preferred, especially where traditional methods of removing the bran have been replaced by plate mills. However, a red pericarp is equally acceptable in high rainfall areas in the south: partly because sorghum is used for beer and partly because the endosperm beneath a red pericarp is less likely to be discoloured by insect and fungal attack. In areas where Kaura varieties are grown a yellow pericarp is acceptable.

Thickness of mesocarp

A thin mesocarp is generally preferred but this is normally recognised in association with a thick corneous layer and no conscious selection for this character is practised at Samaru.

Thickness of corneous layer

There is a strong preference for flinty types and this character is an important objective in the program.

Testa

Although some of the varieties cultivated in Nigeria possess a coloured testa this character is not generally acceptable.

Plant colour

Most Nigerian sorghums have purple plant colour and when late rains occur the endosperm is stained with water-soluble pigments from spots on the pericarp. The pigments associated with tan plant colour do not stain the endosperm and this character has been introduced into several lines.

Grain size

There is a strong preference for large grains and varieties with a 1000 grain weight of less than 35g. are unlikely to prove acceptable.

Threshability

It is essential that the grain threshes clean: it may not be so important if threshing and cleaning are done mechanically or if the grain is fed to livestock. Under Nigerian conditions, varieties which do not thresh easily yield a poor quality, coloured flour because the glumes cannot be separated from the grain by hand winnowing.

Protein content

Studies have only just started on the protein content and amino-acid composition of varieties grown at Samaru.

Yield

Local varieties of sorghum have a low grain yield potential. The grain/straw ratio in the dry matter produced per acre is very low. Grain yields do not increase with high plant populations because the number of fertile tillers/plant and head size decrease at populations over 14,000 plants/acre. It is assumed that increased yields of grain in Nigerial will result from the use of short varieties with a high grain/straw ratio, grown with the addition of fertilizers at high plant populations. Furthermore, as government policy is directed towards increased mechanisation, short sorghums will be essential.

Height

Most of the crosses have been made to 3-dwarf introductions. The short segregates are not as short as the 3-dwarf parent because they are late maturing and carry 24 to 26 leaves compared with 16 to 18 leaves borne by most U.S. hybrids at Samaru.

The effect of mutual leaf shading on yield in plants which carry 24 to 26 leaves on a short stem has not yet been studied. Of more immediate concern is the poor exsertion of the panicle from the flag leaf found in many of the short segregates. Although it is known that the inheritance of peduncle length is controlled indepndently of internode length, the isolation of dwarf plants with good exsertion is proving difficult.

Maturity

It has been shown that Nigerian varieties do not yield well if they flower earlier or later than the locally adapted variety. Locally adapted varieties flower at the end of the rains. Varieties which flower early also yield poor quality grain. This problem cannot be solved by late planting because all the varieties tested so far, including local and exotic types, give decreased yields when sown late. Decreased yields are obtained even when late sowings are protected against pest and diseases and nitrogenous fertilizers are added.

Therefore, at Samaru, the objective has been to produce varieties which take approximately 125 days to anthesis from sowings made in early June.

Panicle shape and density

Panicle shape and density are likely to affect both yield and quality of grain. Local varieties cultivated south of latitude 11° 30'N have loose, open panicles. These types of panicle dry quickly in high rainfall areas and they do not harbour insect pests but the grain yield is low.

At Samaru, Short Kaura which has a semi-compact panicle, yields a good quality grain although the most common local varieties have loose open heads. Provided that the new selections flower at the end of the rains, it is thought that panicle density, can be increased to at least that of Short Kaura.

Cytoplasmic male sterility

Most West African sorghums are potential R lines with respect to the milo type of cytoplasmic male sterility. Therefore, in order to have potential B lines among the hybrids the exotic parents chosen in crosses have been B lines.

Apart from a few varieties which semi-restore fertility most Nigerian sorghums are potential B lines with respect to 9E type male sterility (Webster, 1964). Feterita is a restorer to this type of sterility and it is from crosses with Spur Feterita that potential R lines will be selected.

METHODS

		(reference to next page)
Local x local Exotic x local etc.	Pedigree selection →	I
	Various degrees of backcrossing. →	II
	Test crosses to CKA and development of A lines. →	III
A lines x local or exotic (Milo type)	Development of A lines by backcrossing →	IV
	Development of A & B lines by alternate backcrossing and selfing with eventual cytoplasm switch. →	V
	Development of lines for use as stable lines or potential restorers. →	VI
Local or exotic A lines (9E Martin)	Development of A lines by backcrossing →	VII

GENERAL PEDIGREES

Reference to methods	Parents	Row No. 1965
	Local x Local	
I and II	Gwoza Local	1 - 76
	Samaru Farafara	385 - 390
	Short Kaura	Yield trial
	Makaho da Wayo	AN 18 (65)
	Exotic x Local and reciprocal	
	Exotic Parents:	
	Wad Akr 8	
	Zirazira	1 - 76
	Agen	
	Doborr	
	Varous USA types mainly:	
	Combine Kafir	201 - 398
	Shallu - Kafir	6246 - 6601
III	CKA	5017 - 5100
	Farafara	
IV	CKA	
	Purdue	4965-5002
	Liposa	
V & VI	CKA	
	Redlan A	77 - 184
	Martin A	5101 - 6107
	Shambul	
	Farafara	
	Short Kaura	

VII 9E Martin
WX (Kaura)
Farafara
Short Kaura
Shambul
DS 6

GENETIC STUDIES

GAMMA IRRADIATED SHORT KAURA (D.J.A)

In 1959, Short Kaura seed was gamma irradiated at several rates using Co^{60} with the object of including mutations for dwarfness and early maturity. Other mutants were not looked for at that time. Apart from the material described below, only slight changes were observed and the few remaining lines are in row 417 - 428.

In 1963 segregation for height and male sterility occurred in lines derived from seed receiving 20,000 r. Data collected so far indicate that the male sterility is genetic and controlled by one recessive pair of alleles and that the three height groups which occur are the result of a pair of alleles in the dominant, heterozygous and recessive conditions. Maturation has not been affected.

Unlike normal Short Kaura, the derivatives of this particular 20,000 r line all act as non-restorers in respect of the milo type cytoplasmic male sterility. Non-restoration is not linked with the genetic male sterility. The derivatives are much more susceptible to sooty stripe (Ramulospora sorghi) than Short Kaura. In respect of 9E type male sterility the lines are all non-restorers, in common with the Short Kaura parent stock.

Several sorghum varieties and lines have been crossed on to these irradiated lines both for genetic study and to provide a range of material for selection. The F_1s and F_2s of the crosses are in rows 527 - 718. The parents used include Short Kaura, Caffra ex Biye WX60, Shallu/Kafir, kafir, hegari, milo, durra, W7078, Coes Ms3 ms3, and various selections from other hybridisations.

HEIGHT AND MATURITY STUDIES (D.L.C.)

In 1963 genetic stocks received from Dr. Quinby (Pioneer Hi-bred Corn Co. USA) were crossed to four local Nigerian sorghums.

The objective was to study the inheritance of height and length of season in populations segregating for both characters. Populations derived from crosses involving two local sorghums have been sown in 1965. These are:

Texas Blackhull Kafir	x Shambul	F_3 Field V5
Combine Hegari	x Shambul	
Durra	x Shambul	
100 day milo	x Shambul	
Texas Blackhull Kafir	x SFF60	F_2 and V4 backcrosses
Combine Hegari	x SFF60	
Durra	x SFF60	
100 day milo	x SFF60	

The other local parents used were Short Kaura and Yar Gunki.

GENETIC STOCKS ex LINCOLN, NEBRASKA (O.J.E.)

Dr. Webster brought with him in 1964 a collection of sorghum genetic stocks. The inheritance and linkage studies of 18 mature plant characters already reported (Webster, 1965) are being continued. Eight reciprocal chromosomal translocations are expected to be isolated from the progeny of plants grown from seed of Combine Kafir-60 irradiated with 5,000, 10,000, and 15, 000 r units of Co^{60}.

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Appendix I

Appendix II

SORGHUM OBSERVATION PLOTS
1963.

Introduction.

In 1963 for the first time a standard set of U.S.A. sorghum varieties and hybrids were grown at eleven locations throughout West Africa. The plots at Niamey, (Niger Republic) failed and the results from Roni (Nigeria) have not yet been received.

Methods.

(a) Design.

Unreplicated observation plots. In Nigeria, two rows 36 feet long and 3 feet apart ($\frac{1}{242}$ acre nett). In Haute - Volta two rows 10 metres long and 80 cm apart ($\frac{1}{253}$ acre nett ?) In Senegal each variety occupied two rows (Yields calculated on $\frac{1}{242}$ acre nett).

(b) Planting date.

There was only sufficient seed to allow one planting date in Senegal, Niger and Haute - Volta. The plots were sown late in order to synchronize flowering with the end of the rains.

In Nigeria two planting dated were used. These were intended to represent normal, early planting and late sown to mature at the end of the rains.

(c) Spacing.

Suggested plant populations/acre were:-

U.S.A. varieties approximately 50,000.

Local varieties (local spacing) approximately 14,500.

In Nigeria it has been shown that plant populations exceeding this figure for local varieties do not lead to increased yields.

(d) Manures and Fertilizers.

Variable. Within Nigeria 3 tons F.Y.M./acre, 112 lb/acre single superphosphate and 112 lb/acre sulphate of ammonia were recommended.

(c) Cultivations.

According to local practice.

Comments.

(a) Samaru.

First planting gave high yields. Second planting sprayed with Sevin against shoot fly and stem borer. Heads did not fill out and this is reflected in drastic yield reductions.

Both plantings reasonably well established. It is possible higher yields may have obtained with increased plant populations.

(b) Kano and Gumel.

Yields from first planting were disappointingly low. Second planting a failure - too late.

Plant populations in both plantings very low.

(c) Maiduguri.

Several U.S.A. varieties and hybrids showed promise compared with the local. Again, plant populations too low.

(d) Sokoto and Sandamu.

Poor yields obtained from introductions in comparison with locals. Low plant populations. NK 330 worth trying again.

(e) Bambey.

All introductions heavily outyielded by the best local.

(f) Saria.

This planting probably corresponds to the second planting at Kano. Too late. Plant populations low.

General.

Difficult to draw sound conclusions at these low level of plant populations. At several stations a range of local varieties was grown. For comparison only the highest yielding plot of the local variety has been included in the tables as a check.

Number of days from Planting to 50% heading.

	VARIETY	Samaru (1) 6/6/63	Samaru (2) 15/8/63	Kano (1) 12/6/63	Kano (2) 24/7/63	Gumel (1) 27/6/63	Gumel (2) 30/7/63
1	RS 301 F	58	57	61	84	x	x
2	SD 451	48	46	55	73	44	62
3	RS 501	51	50	55	71	47	60
4	NB 505	50	49	55	76	44	65
5	Whito Sorghum	51	48	x	x	44	62
6	Whito Martin	55	53	60	76	49	61
7	Whito 7078	58	55	60	92	53	65
8	RS 610	59	53	56	76	49	73
9	RS 60[illegible]	58	53	55	82	47	60
10	RS 617	58	53	55	89	x	x
11	KS 603	57	53	57	84	47	66
12	(N 80)	56	51	61	78	46	61
13	RS 681	56	50	57	78	47	58
14	GA 609	57	50	x	x	49	56
15	AKS 614	55	50	x	x	49	55
16	OK 612	58	51	55	80	x	x
17	OK 632	60	51	59	91	51	59
18	CK 60[illegible]	60	53	62	85	x	x
19	TE 77	58	55	62	90	53	58
20	TE 88	58	55	59	97	54	57
21	DoKalb F - 63	58	55	60	91	52	55
22	DeKalb x 1590	58	53	56	82	52	55
23	NK 125	48	49	55	82	x	x
24	NK 145	48	49	48	92	x	x
25	NK 210	53	53	53	86	x	x
26	NK 2[illegible]3	59	54	65	97	53	58

Days to 50% anthesis

Number of days from Planting to 50% heading.

	Maiduguri	Sokoto		Sandamu		Bambey	Saria	Farako-Ba
		(1)	(2)	(1)	(2)			
	9/7/63	26/6/63	15/7/63	4/7/63	15/7/63	3/7/63	22/7/63	16/7/63
1 RS 301 F	x	x	x	x	x	x	x	x
2 SD 451	545	58	36	40	55	5[illegible]	48	57
3 RS 501	1271	59	47	40	53	50	48	58
4 NB 505	847	53	41	40	53	50	66	59
5 Wh.Norghum	666	55	56	40	53	50	63	62
6 Wh.Martin	1[illegible]29	6[illegible]	52	56	53	63	65	63
7 White 7078	847	66	56	56	57	63	69	74
8 RS 610	666	66	52	53	55	50	56	58
9 RS 608	1755	62	52	53	55	52	68	61
10 RS 617	x	x	x	x	x	x	x	x
11 KS 603	666	55	52	53	55	52	65	67
12 (N 80)	1997	55	54	53	55	52	68	59
13 RS 681	2057	50	43	53	55	63	65	63
14 GA 609	1210	50	18?	53	55	52	68	63
15 AKS 614	968	47	47	53	55	52	65	62
16 OK 612	x	x	x	x	x	x	x	x
17 OK 632	666	47	49	53	55	52	68	71
18 OK 60 A	x	x	x	x	x	x	x	x
19 TE 77	726	62	54	56	55	63	68	79
20 TE 88	1573	65	53	56	55	59	69	72
21 DeKalb F-63	1089	59	53	56	55	75	69	76
22 DeKalb x1590	1634	50	47	53	55	59	68	72
23 NK 125	x	x	x	x	x	x	x	x
24 NK 145	x	x	x	x	x	x	x	x
25 NK 210	x	x	x	x	x	x	x	x
26 NK 283	1150	65	59	56	57	75	68	75

Not given.

SECOND PLANTING FAILED.

VARIETY	Samaru (1) 6/6/63	Samaru (2) 15/8/63	Kano (1) 12/6/63	Kano (2) 24/7/63	Gumol (1) 27/6/63	Gumol (2) 30/7/63	Maiduguri 9/7/63
27 NK 300	64	54	67	97	59	55	3025
28 NK 310	59	56	64	92	58	61	847
29 NK 330	64	54	66	97	59	62	2178
30 SK 60 (Samaru)	130	x	x	x	x	x	x
31 (1) K 48 (Kano)	x	x	95	x	x	x	x
32 (2) K 72 (Kano)	x	x	x	96	x	x	x
33 (1) K31 (Gumol)	x	x	x	x	94	x	x
34 (2) Failed (Gumol)	x	x	x	x	x	F	x
35 Shambul (Maiduguri)	x	x	x	x	x	x	1029
36 (1) Jaddawa (Sokoto)	x	x	x	x	x	x	x
37 (2) Yerabani (Sokoto)	x	x	x	x	x	x	x
38 (1) Yar Machina (Sandamu)	x	x	x	x	x	x	x
39 (2) Kabel (Sandamu)	x	x	x	x	x	x	x
40 50 - 59 (Bambey)	x	x	x	x	x	x	x
41 Zaria 29 B (Zaria)	x	x	x	x	x	x	x
42 Zaria No. 32 (Waruko-Ba)	x	x	x	x	x	x	x

(Printed vertically in the Samaru column: Days to 50% anthesis. Printed vertically in the Maiduguri column: SECOND PLANTING FAILED.)

Symbols: x not grown
F failed
(1) first planting
NG not given
NH not harvested
* corrected to 12% moisture
(2) second planting

	Sokoto (1) 26/6/63	Sokoto (2) 15/7/63	Sandamu (1) 4/7/63	Sandamu (2) 15/7/63	Bambey 3/7/63	Saria 22/7/63	Farako-Ba 16/7/63
27 NK 300	75	64	65	57	79	69	71
28 NK 310	60	54	56	57	75	69	71
29 NK 330	75	59	67	59	79	70	71
30 SK 60 (Samaru)	x	x	x	x	x	x	x
31 (1) K 48 (Kano)	x	x	x	x	x	x	x
32 (2) K 72 (Kano)	x	x	x	x	x	x	x
33. (1) K31 (Gumel)	x	x	x	x	x	x	x
34 (2) Failed (Gumel)	x	x	x	x	x	x	x
35 Shambul(Maiduguri)	x	x	x	x	x	x	x
36 (1) Jaddawa (Sokoto)	o 85	x	x	x	x	x	x
37 (2) Yarabani (Sokoto)	x	o 60	x	x	x	x	x
38 (1) Yar Machina (Sandamu)	x	x	NG	x	x	x	x
39 (2) Kabel (Sandamu)	x	x	x	NG	x	x	x
40 50-59 (Bambey)	x	x	x	x	65	x	x
41 Saria 29 B (Saria)	x	x	x	x	x	64	x
42 Saria No. 32 (Farako-Ba)	x	x	x	x	x	x	71

Symbols: x not grown
F failed
(1) first planting
NG not given
NH not harvested
* corrected to 12% moisture
(2) second planting

Yield of threshed grain in lb/acre.

	VARIETY	Samaru* (1) 6/6/63	Samaru* (2) 15/8/63	Kano (1) 12/6/63	Kano (2) 24/7/63	Gurol (1) 27/6/63	Gurol (2) 30/7/63	Maiduguri [illegible]/7/63
1	RS 301 F	3768	2291	707	101	x	x	x
2	SD 451	1705	F	606	170	121	-	545
3	RS 501	2668	1654	626	283	161	161	1271
4	NB 505	2365	1731	869	182	232	141	847
5	White Sorghum	2008	F	x	x	30	40	666
6	White Martin	2283	1958	586	170	182	182	1029
7	White 7078	2255	1037	465	61	113	121	847
8	RS 610	28[illegible]	2354	133[illegible]	222	464	464	666
9	RS 608	3328	1225	484	1[illegible]1	343	60	1755
10	RS 617	4750	2998	1778	121	x	x	x
11	KS 603	2358	1267	444	81	383	100	666
12	(N 80)	2613	1514	505	202	504	80	19[illegible]7
13	RS 681	3548	921	416	101	332	161	20[illegible]
14	GA 609	3795	2893	x	x	393	182	121[illegible]
15	AKS 614	4345	2646	x	x	444	182	9[illegible]3
16	OK 612	2915	1250	485	121	x	x	[illegible]
17	OK 632	2304	1306	1010	101	212	240	6[illegible]5
18	CK 60 A	2530	1814	404	101	x	x	x
19	TE 77	3410	2042	1050	81	192	182.	726
20	TE 88	3823	2665	1475	61	242	343	1573
21	DeKalb F - 63	3245	1564	1091	61	323	40	1039
22	DeKalb x 1590	4923	3545	1535	222	222	343	1634
23	NK 125	2063	1162	565	81	x	x	x
24	NK 145	NH	2428	1576	61	x	x	x
25	NK 210	2750	1528	1293	1[illegible]1	x	x	x
26	NK 293	36[illegible]	[illegible]15	1677	[illegible]0	242	200	1150

SECOND PLANTING FAILED.

Yield of threshed grain in lb/acre.

	Sokoto (1) 26/6/63	Sokoto (2) 15/7/63	Sardamu (1) 4/7/63	Sardamu (2) 15/7/63	Bar[illegible]ey 3/7/63	[illegible]ria 22/7/63	Farako-Ba 16/7/63
1 RS 301 F	x	x	x	x	x		x
2 SD 451	196	431	145	121	742	578	1104
3 RS 501	189	426	629	121	129	795	1334
4 NB 505	173	242	629	242	975	306	892
5 White Norghum	109	46	24	73	848	150	153
6 White Martin	75	484	145	363	445	539	384
7 White 7078	84	339	145	315	191	384	75
8 RS 610	278	680	871	484	2120	1062	1640
9 RS 608	160	557	871	315	1113	398	631
10 RS 617	x	x	x	x	x	x	x
11 KS 603	145	315	629	121	392	231	161
12 (N 80)	484	569	1113	121	1410	209	728
13 RS 681	436	953	871	242	859	473	303
14 GA 609	346	893	871	363	912	289	142
15 AKS 614	823	411	629	484	1283	489	295
16 OK 612	x	x	x	x	x	x	x
17 OK 632	[illegible]	288	145	315	1336	364	75
18 CK 60 A	x	x	x	x	x	x	x
19 TE 77	319	648	629	363	541	411	35
20 TE 88	397	552	629	484	1006	353	131
21 DeKalb F - 63	278	515	145	242	498	161	72
22 DeKalb x 1590	1036	951	629	121	1463	370	81
23 NK 125	x	x	x	x	x	x	x
24 NK 145	x	x	x	x	x	x	x
25 NK 210	x	x	x	x	x	x	x
26 NK 283	557	433	145	363	286	114	75

	VARIETY	Samaru* (1) 6/6/63	Samaru* (2) 15/8/63	Kano (1) 12/6/63	Kano (2) 24/7/63	Gumel (1) 27/6/63	Gumel (2) 30/7/63	Maiduguri 9/7/63
27	NK 300	4950	1938	1232	81	595	724	3025
28	NK 310	2998	1861	1273	101	272	121	847
29	NK 330	4043	2883	1414	121	706	363	2178
30	SK 60 (Samaru)	2730	x	x	x	x	x	x
31	(1) K 48 (Kano)	x	x	2545	x	x	x	x
32	(2) YG 571 (Kano)	x	x	x	242	x	x	x
33	(1) K31 (Gumel)	x	x	x	x	1448	x	x
34	(2) Failed(Gumel)	x	x	x	x	x	F	x
35	Shambul(Maiduguri)	x	x	x	x	x	x	1029
36	(1) Jaddawa (Sokoto)	x	x	x	x	x	x	x
37	(2) Yarabani (Sokoto)	x	x	x	x	x	x	x
38	(1) Yar Machina (Sandamu)	x	x	x	x	x	x	x
39	(2) Kabel(Sandamu)	x	x	x	x	x	x	x
40	50 - 59 (Bamboy)	x	x	x	x	x	x	x
41	Saria 29 B (Saria)	x	x	x	x	x	x	x
42	Saria No. 32 (Farako-Ba)	x	x	x	x	x	x	x

SECOND PLANTING FAILED.

Symbols: x not grown
NH not harvested
* corrected to 12% moisture
(2) second planting
NH not harvested
F failed
(1) first planting
NG not given

Variety	Sokoto (1) 26/6/63	Sokoto (2) 15/7/63	Sandamu (1) 4/7/63	Sandamu (2) 15/7/63	Bambey 3/7/63	Saria 22/7/63	Farako-Ba 16/7/63
27 NK 300	922	704	387	847	753	61	189
28 NK 310	540	849	387	605	1007	250	108
29 NK 330	849	1752	1355	1694	774	60	150
30 SK 60 (Samaru)	x	x	x	x	x	x	x
31 (1) K 48(Kano)	x	x	x	x	x	x	x
32 (2) YG 571(Lanb)	x	x	x	x	x	x	x
33 (1)K31 (Gumel)	x	x	x	x	x	x	x
34 (2)Failed(Gumel)	x	x	x	x	x	x	x
35 Shambul(Maiduguri)	x	x	x	x	x	x	x
36 (1) Jaddawa (Sokoto)	1333	x	x	x	x	x	x
37 (2) Yarabani (Sokoto)	x	1142	x	x	x	x	x
38 (1) Yar Machina (Sandamu)	x	x	1936	x	x	x	x
39 (2)Kabel(Sandamu)	x	x	x	1040	x	x	x
40 50-59 (Bambey)	x	x	x	x	3271	x	x
41 Saria 29 B (Saria)	x	x	x	x	x	278	x
42 Saria No. 32 (Farako-Ba)	x	x	x	x	x	x	628

Symbols: x not grown
F failed
(1) first planting
NG not given
NH not harvested
* corrected to 12% moisture
(2) second planting

Experiment No. AN 13 63. Observations on a range of U.S.A. and Indian Sorghum : F1 Hybrids and Varieties.

Object:- To compare the performance of exotic sorghums planted early and late with two locally recommended strains planted early.

Site:- Field T_{10} Institute for Agricultural Research, Samaru.

Layout:- Unreplicated observation plots.

Two rows 36" apart x 36' long - gross.
Two rows 36" apart x 30' long - nett = $\frac{1}{242}$ acre.

Discard:- Apart from discard at the end of each row the whole block of exotic varieties was surrounded by a 18' discard planted to Combine Kafir 60. The local varieties were grown separately in the same field and sample rows were taken from within the main blocks.

Spacing:- Exotic varieties - 2 plants/stand. Stands 6" apart = 50,080 plants/acre
Local varieties - 1 plant/stand. Stands 1' apart = 14,520 plants/acre
(Previous results have shown that closer spacing using local varieties will give lower yields at Samaru).

Seed Dressing:- Exotic varieties - treated but product not known. Probably an organo - mercurial dressing.
Local varieties - Aldrex T at 0.3% weight for weight.

Manuring and Fertilizers:-

2 tons F.Y.M.
2 cwt. single superphosphate } per acre before planting.
56 lb. sulphate of ammonia/acre after thinning.
56 lb. sulphate of ammonia/acre as dressing late on.

Treatments:- Second planting of exotics sprayed with Sevin (Vetox 80) as a protection against shoot fly and stem borers. Both plantings of exotics sprayed with D.D.T. to protect against sorghum midge.

Planting Dates:- 1st planting - June 6th, 1963.
2nd planting - August 15th, 1963.
Only one date of planting, June 6th, was used for the local varieties. This is the normal date for planting at Samaru and it has been shown that reductions in yield are experienced with later plantings.

August 15th was chosen as the second date of planting to ensure that the exotic varieties bloomed at the same time as the local varieties planted earlier.

Results:-

Interpretation of results and discussion:-

A. General.

The general growing conditions were good and at no time did either planting suffer a setback before anthesis. Reasonably uniform stands were obtained after thinning and subsequent field operations were limited to earthing up. Weeds were not a major problem.

Although the plots were not replicated, sample checks from the local varieties and the CK60 discard confirmed visual impressions that the field was remarkably uniform.

The differences in yield between sample plots of CK60 did not exceed the equivalent of 50 lb. threshed grain per acre. The yield comparisons between these observation plots may be regarded as fairly reliable.

Total rainfall was as follows:-

Rainfall, 1963 Field T12 in inches.

January	- Nil	July	- 5.86
February	- Nil	August	- 11.75
March	- Nil	Sept.	- 6.28
April	- 0.90	Octo.	- 6.67
May	- 2.39	Nov.	- Nil
June	- 6.18	Dec.	- Nil to date

B. Time to anthesis.

Local Samaru shorghums take between 120 - 130 days to reach anthesis when planted at the normal time (i.e. end of May, beginning of June). Later plantings reach anthesis much quicker and tend to flower at approximately the same time as earlier plantings. Significant reductions in the yield of grain are experienced with late plantings.

In these observations the early-planted, exotic sorghums flowered between 48 and 74 days after sowing. (i.e. in the middle of the rains). The second planting flowered at the same time as the local sorghum. (i.e. towards the end of the rains).

1st Planting.

The earliest sorghums were SD 451 (South Dakota) and two hybrids from Northrup King seed company; NK 125 and NK 145. These sorghums gave poor yields or grain.

Apart from local varieties, hybrids supplied by the Rockefeller Foundation, New Delhi, including CKA x Karad, CK A x Shenoli and CK A x Nandyal were the last to head. These hybrids gave low yields.

2nd planting.

With few exceptions, varieties and hybrids in the second planting reached anthesis quicker by anthing up to ten days. Generally speaking, the potentially later maturing sorghums were hastened relatively more than those which had taken less than 60 days to reach anthesis in the first planting.

The very early hybrids took roughly the same time to reach anthesis. Two Indian hybrids, CK 60 x 55-4937 and CK 60 x M35-1 were exceptions in that they appeared to take longer to reach anthesis in the second planting.

The general effect of late planting on the time to anthesis was to bring most sorghums within the range of 48 - 57 days with the exception of the later maturing Indian hybrids.

C. Plant Height.

Most Nigerian sorghums are tall, mainly because they possess a high node number. When planted very late, some of them, like SK 60 are as short as combine varieties because the number of leaves produced is less.

In these observations both local varieties, as might be expected, were taller than exotic varieties.

Among the exotic varieties planted early all but two of the Indian hybrids were over 6 feet tall. Apart from hybrids presumably developed for forage, including RS 301 F, NK 145, NK 300 and NK 330, the U.S.A. sorghums were short. The varieties White Norghum and White 7078 and the hybrid N. 80 at 3' 4" were the shortest.

Varieties were shorter in the second planting with the exception of the Indian hybrids which in some cases were 1' - 2' taller. Accurate leaf number counts were not made and it is therefore impossible to state whether this general dwarfing in most varieties was due to fewer nodes, shorter internodes or a combination of both. The increase in height among the Indian hybrids was not always reflected in higher dry matter per acre.

D. Diseases.

The usual spectrum of leaf diseases experienced each year at Samaru was present on these plots. Ramulispora spp. and Downy Mildew (Sclerospora sorghi) were the first to appear and were followed by Gleocercospora sorghi, Cercospora spp. and other less prominent ones. No attempt was made to score each disease separately but an overall assessment based on a score of 1 - 9 was used by Dr. O. J. Webster on the first planting and by Mr. D. L. Curtis on the second planting. The differences between first and second plantings may well be attributed to different observers.

Gleocercospora sorghi was much more prominent in the second planting and this may account for the fact that although the late planting appeared to be much cleaner than the first, this is not always reflected in the relative scores. Rust, Puccinia purpurea was observed on the second planting but not on the first.

As a group, the Indian hybrids compared favourably with the local checks. Those with Zerazera as the male parent were remarkably free from leaf diseases; an observation confirmed in other Samaru projects where Zerazera is being used as a parent. CK60 A and B were also relatively clean and two hybrids from the S.E. part of the USA, GA 609 and AKS 614, as expected, remained fairly free from spots. Others which received a low rating in both plantings included RS 301 F, RS 617, x 1590 DeKalb, and TE 88.

Apart from leaf spots, the only other disease which caused concern was Ergot, Sphacelia sorghi. This disease is not usually seen at Samaru but this year it was very severe. Sorghums in the same field were badly attacked and sclerotia were frequently formed, particularly in SK60. The appearance of the sphacelia stage coincided with the flowering of the local sorghums and therefore the disease was not recorded on the first planting of the exotic material. In the second planting, although some heads in each row were attacked by the sphacelia stage, few ergots were formed. Nevertheless, the possible effect of this disease on the yields obtained in the second planting should be borne in mind in interpreting the results.

E. Pests.

The worst insect pests of the crop in the field at Samaru are sorghum midge, stem borers and shoot flies.

Although both plantings were sprayed against midge, complete control was not achieved in the second planting. This was probably due to poor spray coverage. The hybrids which were particularly affected were the Indian hybrids CK60 x Karad, CK60 x Shenoli, CK60 x Nandyal and CK60 x M35-1. The fact that these plots were adjacent suggests the severe attack was due to poor spray coverage rather than inherent differences in susceptibility between hybrids. In these hybrids, the midge damage was sufficient by itself to explain yield differences between the two plantings. Therefore the yield of CK60 x Nandyal in the second planting is surprisingly high.

It is difficult to establish a late planted crop of sorghum at Samaru because stands are reduced and excessive tillering is induced by shoot fly. The second planting was sprayed frequently with Vetox 80 and this appeared to control both shoot fly and stem borers.

No borer counts were taken in the first planting but damage was not severe. In the CK60 discard there appeared to be some link between heads with poorly filled grain and those in which the rachis was bored. This was not apparent in the observation plots.

Bird damage is not usually severe at Samaru except in early maturing material. Bird scarers were employed and although some damage occured in the Indian hybrids this was comparatively light.

F. Yield.

(I) Dry matter.

The yield of dry matter ranged from 29,44 in CK 60 x Nyandal to 2,231 pounds per acre in MF 125.

In general, with the exception of some Indian hybrids there was a reduction in the yield of dry matter with the later planting. Dry matter production in the local varieties was among the highest recorded.

(II) Grain.

The highest yielding local variety at Samaru so far has been SK 60. In these plots it yielded 2,730 pounds per acre. This compares reasonably with past yields which have usually ranged between 2,500 and 3,000 pounds per acre.

The second local variety, SAF 60 belonging to the Guinea race, yielded 242 pounds per acre. This yield is higher than that usually obtained from this variety.

First planting.

Of the 41 varieties and hybrids in these observation plots, 25 gave yields of more than 2,500 pounds per acre. The highest yielding hybrids all came from the U.S.A. and five of these produced more than 4,000 pounds of grain per acre. Hybrids produced by commercial companies occupied three of the top five places.

Although the very early hybrids all gave low yields and the top five were among the latest of the U.S.A. hybrids to mature, a relationship between duration of growth and yield cannot be applied generally. The late-maturing, Indian hybrids gave yields which were disappointingly low as their vegetative growth had been promising.

Among the U.S.A. hybrids, with few exceptions, the yield of dry matter and grain appear to be related as one might expect within similar types. In fact, notable exceptions were forage types or hybrids like GA 609 which have very different parentages.

The two earliest and shortest Indian hybrids gave yields of grain slightly higher than SK 60. All the other Indian hybrids in the first planting gave lower yields. The yield for OK 632 has been adjusted for a poor plant count and NK 145 a forage type was not recorded.

Second planting.

Yields were generally reduced by late planting. Few varieties or hybrids gave yields as good as those obtained from the local varieties planted at the normal time. All the U.S.A. sorghums gave lower yields, often less than half those obtained from the first planting. Only x 1590 DeKalb exceeded 3,000 pounds per acre and this was low compared with the 4,923 pounds obtained from the early sowing.

This generalisation does not apply to the Indian hybrids. Of the three hybrids based on Zerazera, one gave roughly the same yield and the other two gave increased yields in the second planting. The ranking order among these three hybrids was completely reversed and this is difficult to explain. All three hybrids appeared to be very similar; the plant count for 3572 was slightly lower in the first planting but not in the second planting. Two other Indian hybrids gave increased yields in the second planting.

General.

Although it is difficult to explain the increased yields obtained in the second planting with some Indian hybrids, the reduction experienced in the U.S.A. hybrids and varieties may be taken a step further by referring to observations taken at harvest.

Plant populations were the same in both plantings and although the second planting headed a few days earlier and was not quite as tall, the main difference lay in the extent to which the heads filled out. It was very noticeable that in the second planting the grain was small and almost completely enclosed by the glumes. All the Indian and local sorghums were normal but among the U.S.A. varieties only CK 60 A, x 1590 DeKalb and NK 330 filled out.

In addition, two apparently distinct types of lodging occurred. Normal lodging in which the whole stem bent over was experienced in several plots, especially AKS 614 where all plants were affected. This was not considered as important in relation to grain yield as the second type of lodging.

A type of lodging occurred in which the stems bent and eventually snapped clean just above a node about 2" - 3" above the soil. There were marked varietal differences between the plots and SD 451 and White Norghum were so badly affected they were not harvested.

It is possible there may have been a relationship between this second type of lodging and the inability of most varieties in the second planting to set normal sized grain. If it is assumed that all those varieties and hybrids which failed to produce normal grain were affected by the same thing, the differences in the percentage of stems broken may have been merely a reflection of differences in mechanical strength.

The following observations are relevant:-

(1) The cause was not entomological. Stems were examined carefully and the damage was not due to stem borers.

(2) The symptoms began as a drying out of the pith from the base upwards. This took place about three weeks after anthesis. When the bending and breaking occurred the pith had completely dried out in the lower 4" - 6" of the stem leaving the vascular strands separated.

Pathological examinations failed to reveal the cause. No fungal mycelium or bacterial cells were found in teased material and no species was consistantly present in cultures from pieces of the stems.

(3) As it seemed unlikely the cause was either entomological or pathological, soil pits were dug in the White Norghum plots which were badly affected and in Zerazera (3533) on an adjacent, unaffected plot where grain formation had been normal. Although, in fact, the root development in the x Zerazera plots was better than in White Norghum, there were also differences in the soil profile and it would be wrong to relate the failure to set good seed in White Norghum to this observation without a more careful examination.

Therefore, all that can be said at this stage is that the second planting of U.S.A. hybrids failed to fill the grain; lodging and stem breaking were common but it is unlikely this was caused by pests or diseases.

Ratoon crop.

The first planting ratooned quite well but flowered much later than the second planting and has not yet been harvested.

G. Quality.

Assuming the local sorghum to possess the quality demanded by the Nigerian consumer, the only ones in these observation which approached the same standard were the Indian hybrids CK 60 x 7530, CK 60 x 7532 and CK 60 x Zerazera.

Grain harvested from the first planting weathered badly unless it had a brown perciarp and testa in which case it was not palatable anyway. Unfortunately the grain filling in the second planting was not normal otherwise it is possible that white seeded types like White Norghum would have been acceptable.

H. Conclusion.

The many problems associated with growing relatively early maturing sorghums in high rainfall areas like Samaru, whether planted early or late, may not be insurmountable, but they would appear to justify the attempt being made to produce improved, dwarf, long-season types.

Variety	Days to 50% anthesis		Height ft. & in.		Exsertion in.		Leaf diseases scale 1 → 9 severe	
	1	2	1	2	1	2	1	2
RS 301 F	58	57	7' 4"	6' 4"	3	2	2	3
SD 451	48	46	4' 2"	x	12	12	9	4
RS 501	51	50	4' 8"	5' 0"	8	8	4	4
ND 505	50	49	4' 4"	3' 0"	10	12	5	4
White Sorghum	51	48	3' 4"	x	4	6	8	4
White Martin	55	[illegible]	4' 8"	3' 4"	4	6	3	4
White 7078	58	55	3' 4"	2' 4"	1	3	5	6
RS 608	59	53	4' 4"	3' 4"	8	8	4	5
RS 610	58	53	4' 4"	3' 6"	5	7	4	6
RS 617	58	53	4' 10"	5' 0"	8	8	2	3
KS 603	57	53	4' 8"	4' 11"	6	8	4	4
N. 80	56	51	3' 4"	3' 4"	6	7	4	6
RS 681	56	50	4' 0"	4' 6"	8	11	4	5
GA 609	57	50	5' 4"	4' 8"	6	8	2	3
OK 612	55	50	4' 4"	4' 6"	12	14	5	6
OK 632	58	51	5' 0"	4' 4"	12	12	4	5
AKS 614	60	51	4' 8"	4' 2"	8	7	2	4
CK 60 A	60	53	4' 8"	3' 6"	4	4	2	2
TE 77	58	55	4' 6"	4' 2"	5	8	3	4
TE 88	58	55	4' 6"	5' 0"	6	8	3	3
DeKalb F-63	58	55	4' 8"	4' 2"	5	6	3	5
x 1590 DeKalb	58	53	5' 2"	3' 10"	10	9	2	3
NK 125	48	49	4' 0"	3' 4"	12	12	7	4
NK 145	40	49	6' 10"	4' 10"	10	4	4	5

Variety	Dry Matter lb/acre 1	Dry Matter lb/acre 2	Yield lb. grain acre at 12% moisture 1	Yield lb. grain acre at 12% moisture 2	%moisture at harvest 1	%moisture at harvest 2	Date harvest 1	Date harvest 2
RS 301 F	11,706	10,637	3,768	2,291	23.7	24.5	19-9	19-11-63
SD 451	3,151	x	1,705	x	22.2	x	5-9	19-11-63
RS 501	4,813	5,246	2,668	1,654	31.0	37.4	5-9	19-11-63
NB 505	4,264	3,773	2,365	1,731	29.0	14.5	5-9	19-11-63
White Norghum	3,758	x	2,008	x	28.0	x	5-9	19-11-63
White Martin	4,854	5,600	2,263	1,958	34.4	19.0	5-9	19-11-63
White 7078	4,932	3,779	2,255	1,037	39.6	23.4	5-9	19-11-63
RS 608	5,614	4,761	3,328	1,223	32.8	17.4	5-9	19-11-63
RS 610	6,926	6,701	2,860	2,354	3[illegible].0	28.8	5-9	19-11-63
RS 617	8,666	9,244	4,730	2,998	36.6	27.0	5-9	20-11-63
KS 603	4,973	3,618	2,558	1,267	35.4	11.5	5-9	20-11-63
N. 80	4,375	3,581	2,613	1,514	36.0	23.2	5-9	20-11-63
RS 681	5,411	4,224	3,548	921	31.0	12.9	10-9	20-11-63
GA 609	13,811	7,211	3,795	2,893	30.0	22.6	19-9	20-11-63
OK 612	6,502	5,053	2,915	1,250	21.7	25.0	10-9	20-11-63
OK 632	4,358	5,163	2,304	1,306	24.2	14.2	19-9	20-11-63
AKS 614	7,814	8,229	4,345	2,646	21.6	29.0	19-9	20-11-63
CK 60 A	6,316	5,316	2,530	1,814	24.7	31.8	19-9	19-11-63
TE 77	10,116	4,808	3,410	2,042	27.3	23.5	19-9	20-11-63
TE 88	8,806	6,655	3,823	2,665	22.9	26.0	19-9	20-11-63
DeKalb F-63	6,857	4,651	3,245	1,564	33.6	22.2	10-9	20-11-63
x 1590 DeKalb	6,428	5,632	4,923	3,545	29.0	11.6	10-9	20-11-63
NK 125	2,231	3,455	2,063	1,162	21.9	[illegible].5	10-9	20-11-63
NK 145	x	4,261	x	2,428	x	15.6	x	20-11-63

Variety	Days to 50% anthesis		Height ft. & in.		Exsertion in.		Leaf diseases scale 1 → 9 severe	
	1	2	1	2	1	2	1	2
NK 210	53	53	4' 2"	3' 4"	6	10	3	7
NK 283	59	54	4' 10"	4' 2"	10	12	3	7
NK 300	64	54	7' 4"	4' 4"	5	8	2	5
NK 310	59	56	4' 8"	3' 6"	8	10	2	4
NK 330	64	54	7' 2"	5' 6"	4	5	3	4
CK 60 (check)	60	54	4' 10"	4' 0"	4	3	-	3
x 55-4937 (532	53	56	4' 4"	4' 0"	5	6	3	4
x 7530 (2947)	58	57	4' 8"	4' 2"	6	8	2	3
x 7532 (3667)	65	57	6' 4"	7' 6"	6	6	2	2
x Zerazera (3533)	64	57	7' 4"	8' 0"	6	6	1	2
x Zerazera (3555)	64	57	7' 0"	7' 8"	6	4	1	4
x Zerazera (3572)	66	51	6' 4"	7' 2"	6	5	2	3
x Karad (1121)	74	65	8' 0"	7' 6"	4	2	2	4
x Karad (1122)	74	65	6' 4"	7' 0"	6	2	2	5
x Shenoli (1120)	74	64	6' 0"	8' 2"	4	3	2	4
x Nandyal (3814	70	65	6' 10"	7' 8"	6	6	2	3
x M35-1 (1054)	60	66	6' 10"	7' 8"	6	3	3	5
SFF 60 (local check)	125		18' 4"		5		3	
SK 60 (local check)	130		10' 2"		2		3	

1 = first date of planting
2 = second date of planting

	Dry matter lb/acre		Yield lb. grain acre at 12% moisture		% moistures at harvest		Date harvest.	
	1	2	1	2	1	2	1	2
NK 210	6,222	5,368	2,750	1,528	28.0	8.0	19-9	20-11-63
NK 283	7,872	5,710	3,630	1,315	26.6	16.0	10-9	20-11-63
NK 300	15,677	10,274	4,950	1,938	30.0	19.4	19-9	20-11-63
NK 310	8,281	5,685	2,998	1,861	21.9	25.0	19-9	20-11-63
NK 330	19,198	8,960	4,043	2,883	36.4	26.2	10-9	20-11-63
CK 60 (check)	8,027	7,396	3,122	2,244	29.[illegible]	34.0	20-9	21-11-63
x 55-4937 (532	7,461	7,694	3,328	2,259	24.0	13.8	19-9	21-11-63
x 7530 (2947)	7,775	9,583	2,998	2,353	30.2	26.0	19-9	21-11-63
x 7532 (3687)	9,404	13,612	2,668	3,914	23.9	29.6	20-9	21-11-63
x Zerazera(3533)	9,673	9,802	2,173	2,074	27.8	24.0	20-9	21-11-63
x Zerazera(3555)	13,900	9,125	1,786	2,612	19.2	33.6	20-9	21-11-63
x Zerazera(3572)	18,433	10,859	1,238	3,522	18.5	30.2	20-9	21-11-63
x Karad (1121)	21,330	14,843	1,925	1,544	33.5	35.0	20-9	21-11-63
x Karad (1122)	21,814	16,454	2,255	1,776	36.5	30.2	20-9	21-11-63
x Shenoli (1120)	12,816	12,288	2,393	2,265	36.8	35.0	20-9	21-11-63
x Nandyal (3814)	29,444	15,707	1,485	1,876	31.6	34.0	20-9	21-11-63
x M35-1 (1054)	8,826	11,537	2,228	1,134	18.5	34.0	20-9	21-11-63
SFF 60 (Local check)	20,760		2,421		22.6		11-11	
SK 60 (Local check)	19,277		2,730		32.0		11-11	

1 = first date of planting
2 = second date of planting

Remarks and observations on the second planting.

Variety	% true lodging	% stem break	Head filled 1--4 normal	REMARKS
RS 301	0	0	2	
SD 451	?	75	1	Nor harvested
RS 501	-	5	2	
NB 505	-	25	1	
White Norghum	-	85	1	Nor harvested. The worst plot of all
White Martin	-	10	2	
White 7078	0	0	2	Standing very well
RS 608	5	5	2	
RS 610	5	5	3	
RS 617	5	0	2	
KS 603	5	0	1	
N 80	0	0	2	Standing very well
RS 681	5	5	1	Only tillers filled grain
GA 609	75	5	2	
OK 612	5	5	1	Very poorly filled heads
OK 632	10	10	1	
AKS 614	100	0	2	
CK 60 A	0	0	4	Female sterility very marked ½ head?
TE 77	0	0	3	
TE 88	0	0	3	
DeKalb F-63	5	0	2	
x 1590 DeKalb	5	0	4	
NK 125	0	25	1	
NK 145	5	0	2	
NK 210	5	0	2	
NK 285	0	80	1	
NK 300	0	75	2	
NK 310	5	0	2	
NK 330	5	0	4	
CK 60 (check)	5	0	3	
x 55-4937 (532)	0	0	4	Grain small
x 7530 (2947)	0	0	4	
x 7532 (3687	5	0	4	
x Zerazera (3533)	0	0	4	
x Zerazera (3555)	0	5	4	
x Zerazera (3572)	80	0	4	
x Karad (1121)	0	0	See remarks	Very bad midge attack 50%
x Karad (1122)	75	0	- do -	------ do ------
x Shenoli (1120)	10	0	"	"
x Nandyal (3814)	5	0	"	"
x M35-1 (1054)	?	75	"	"
SFF 60 (check)	25	0	4	
SK 60 (check)	0	0	4	

Maize Project, Samaru, Nigeria

O. J. Webster

The maize work at the Institute for Agricultural Research, Samaru, in the past has been limited mostly to yield trials with few entries. These trials have demonstrated the potential of the crop in the area. For example, yields of 5000 pounds per acre were harvested in 1963 and in 1964 yields of 2000-3000 pounds were recorded from a crop considered to be relatively poor.

With the increased support available from the S.T.R.C. "Major Cereals Project", the maize work has been expanded to determine if varieties can be found or bred, and crop production practices which would make it possible for this crop to be grown on a commercial basis throughout the ecological zone of West Africa served by the Institute. In 1964, in addition to the Federal Maize Trial, a small collection of varieties from Ibadan were grown in a nursery for observation. Four populations of varietal hybrids were grown in isolated fields for initiating a mass selection project.

These included:

Variety	Pedigree	Identity
V - 10	A - 2 x A - 72	H 504 x ETO
V - 56	A - 48 x ES - 1	Ogbomosho 6492 x ES - 1
V - 58	A - 2 x ES - 1	H 504 x ES - 1
V - 59	A - 1 x ES - 1	H 503 x ES - 1

The numbers A - 1 and A - 2 are advanced generation hybrids H 503 and H 504, respectively. The plots of V - 56, V - 58 and V - 59 were divided into quarters and approximately 100 ears were selected from each. The best ears from each were shelled and equal numbers of seed were bulked to make up a composite for growing in a yield trial in 1965 and for planting a 2nd cycle selection plot. Drs. Lindsey and Wiggin from Ibadan assisted in making the selections in the plot planted to V - 10. This field was subdivided into plots, 5 rows x 12 yards in length. Plots with perfect stands contained 95 plants. Ears were selected from 20 competitive plants in each of the 42 plots. Each selected ear was shelled and the grain weighed. Equal numbers of seed from the 4 plants with the most grain were bulked. As a check, equal numbers of kernels from the 4 ears from each plot with the lowest weight,were also bulked. These two bulked lots are indicated in the 1965 trials as High Composite and Low Composite.

An irrigated (dry season) nursery was planted in December 1964 as a trial to determine how the crop would develop and what success can be expected from controlled breeding in this season of the year. The seedlings grew slowly during January but eventually developed into normal plants. Soil fertility was a limiting factor for plant development in parts of the nursery. Good seed sets were obtained by hand pollination provided they were made soon after sun-rise. The hot-dry wind dryed the tassels soon after anthesis. A green manure crop of macuna and cowpeas will be ploughed into the soil in preparation for the 1965-66 dry season nursery. In addition heavy application of farm-yard manure, superphosphate and sulfate of ammonia will be applied.

The rains were late in 1964 and the ridging for the project was not done until the last of May. Most of the nursery was planted in a dry seed bed, the first week in June. Rains followed at frequent intervals and germination was good. Prior to ridging, the fields were given an application of approximately 200 pounds of superphosphate and 3 tons of farm-yard manure per acre. This is the standard practice followed over the experiment station for the cereal work. Most nurseries were planted at a double rate and thinned to one plant per foot of row. Sulfate of ammonia was applied at the time of thinning at a rate of 30 pounds of nitrogen per acre by placing a measured amount in a shallow hole 2 to 3 inches from each plant. A second application at the same rate was applied 4 weeks later and a third at the time of tasseling.

Plant growth this year is excellent. Root lodging will be a factor in yield differences between varieties this year as well as last. Cultural practices may be devised to reduce this type of lodging but there is greater hope in the selection of lodge resistant types. Many of the entries this year have stalk 12 to 14 feet in height with ear placement at 6 to 7 feet. When such stalks carry heavy ears they are vulnerable to the storms which frequent the area. In 1964, the variety V - 8 (H 504 x Tsolo) was outstanding for its resistance to lodging. In 1965, it appears that the resistance to lodging is inherited from Tsolo parent. The most promising group of varieties for standability is a Columbia collection, seed supplied by Dr. Lindsey, Rockefeller Foundation, University of Ibadan. The ear placement on these varieties is, in my opinion, about what is needed for Samaru for dry-grain production. The continued attempt to improve the yield of Mexico-5, V - 10, and other such varieties may be unwise and greater emphasis should be placed on using the Columbia material in the breeding program. The variety with the highest potential for yield is of no value, particularly for dry-grain production, if the stalks are vulnerable to wind storms.

The breeding work with maize in its initial phase, at Samaru, will continue to emphasize the evaluation of introductions and saving only those which have characteristics thought to be of value in the breeding programs.

One possible hazard to growing of maize in this area is the potential damage from stem borers. The local sorghum plant can tolerate a number of borers but maize plants infested with these pests are liable to stalk breakage. More information is needed to determine if borers, particularly the first cycle, can be controlled with D.D.T. as they are in East Africa and elsewhere.

The plant spacing trial was planned to determine if there are yield differences between plots with plants spaced at one foot and those with 2 plants in hills spaced at 2 feet or 3 plants in hills spaced at 3 feet. To date, all the maize has been planted by placing each seed in the soil with fingers or a stick. If a hand corn planter is to be used hill planting could be done more easily.

Numerous fertilizer trials with sorghum have been conducted in the Samaru area but very little is known about the response of maize to different fertilizers in this area. Most of the sorghum and millet planted on farms receive no commercial fertilizer. If these crops develop heads, some grain is usually produced. On the other hand, maize planted in the same fields may produce a spindly-yellow plant which may produce a tassel but no grain. The simple trial planted as a part of the project this year demonstrated that in soils with relatively good initial fertility, the plots receiving no nitrogen will yield poorly while those with 30 pounds applied at the time of thinning are better but show the signs of a shortage of nitrogen. The plots with 60 pounds of nitrogen have remained vigorous and green throughout the season and it will be of interest to see if the 90 pounds application will give an economic return over the plots receiving 60.

YIELD TRIALS

EXPERIMENT I FEDERAL (65-1-11)

No. Replications - 6 Plot size - 5 rows x 12 yds Date planted - June 2-3.

Entries	Entries
ES 1	Diacol V - 135
NS 4	Eafro 231
NS 5	V - 1 Ex W/Region
H 503	Bomo Local (Samaru)
H 507	Mexico - 5 (Samaru)
Eafro 255	

EXPERIMENT II (Mass Selection)

No. Replications - 8 Plot size - 3 rows x 12 yds Date planted - June 3.

Entries	
Mexico - 5	Unselected
Mexico - 5	Mass selected
V - 10	Unselected
V - 10	Mass selected (High yield components)
V - 10	Mass selected (Low yield components)
V - 10	Detasseled
V - 56	Unselected
V - 56	Mass selected
Synthetic	Samaru
V - 59	Unselected
V - 59	Mass selected
V - 59	Detasseled
V - 58	Mass s elected.

(Entries from Western Nigeria, Dr. Wiggin)

EXPERIMENT III

No. Replications - 3 Plot size - 2 rows x 12 yds Date planted - June 2.

Entries	Pedigree	
V - 8	A - 2 x A 49	H 504 x Tsolo 6813
V - 10	A - 2 x A 72	H 504 x ETO
V - 66	A - 76 x A 195	Br. 155 x H 507
V 6 67	A - 76 x A 196	Br. 155 x H 501
V - 68	A - 76 x A 156	Br. 155 x Diacol V 254
V - 69	A - 76 x A 271	Br. 155 x Metro
V - 70	A - 76 x A 159	Br. 155 x V - 100
V - 71	A - 76 x A 154	Br. 155 x Diacol V-100
V - 72	ES - 1 x A 154	ES - 1 x Diacol V-101
V - 73	ES - 1 x A 196	ES - 1 x H 501
V - 75	ES - 1 x A 271	ES - 1 x Metro
V - 76	ES - 1 x A 159	ES - 1 x Diacol V-156
V - 77	ES - 1 x A 156	ES - 1 x Diacol V-254
A - 2		H 504 (Advanced generation)
A - 49		Tsolo 6813
A - 72		Eto (Eafro 238)
Mexico - 5	Unselected	Samaru
V - 10	Unselected	Samaru

EXPERIMENT IV

No. Replications - 4 Plot size - 3 rows x 12 yds Date planted - June 2 - 3

Progeny	Entries	Progeny	Entries
11152	Mokwa Local Bulk	11142	Eafir 269
11143	Bida Local Yellow	11140	Eafir 271
10656-1	Bida Local White	11141	Eafir 272
10656-1	Bida Local White	11141	Lagos White
11146	K - 2	11153	ES - 1
11149	K - 3	11144	ES - 2
11147	K - 6	11329	ES - 4
11151	K - 44	11123	ES - 5
11148	K - 50	11112	H - 503
11139	Eafro 250	11113	H - 507
11257	Eafro 231	11250	Diacol V - 133
11145	Eafro 237	11593	Sicaragua
11150	Eafro 254		

EXPERIMENT V Date of Harvest

Varieties - Mexico - 5 and V - 10

No. Replications - 3 Plot size - 5 rows x 12 yds Date planted - June - 3

Area harvested - 40 competitive plants per plot

Harvest Dates

A	50% pollen shed	Aug. 13
B		Aug. 27
C		Sep. 9
D		Sep. 23

Weights are taken on stalk, leaves and ears.

EXPERIMENT VI University of Ibadan (Lindsey)

No. Replications - 0 Plot size - 1 row x 12 yds Date planted - July 10

Entry

US 4 - A III x Caribe
FDC - Flint - Dent Composite
C 42 - H 154
C 43 - H 104
C 48 - H 205
C 49 - H 253

C 53 - V 206
C 54 - V 254

C 41 - H 102
C 50 - H 252 C
M 36 - (Mexican Poble Cross) F2
(N-9 x N-69) x (N-28 x N-31)
(N-9 x N-69) x (N-15 x N-28)
(N-15 x N-6) x (N-31 x N-38)
(N-15 x N-6) x (N-30 x N-38)
(N-28 x N-31) x (C 121 E x C 131 A)
Mexico - 5 (Samaru)

EXPERIMENT VII (Late planting)

No. Replications - 4 Plot size - 4 rows x 12 yds Date Planted - July 9

Entries

Mexico - 5	(Selected)
V - 10	(Selected)
V - 56	(Selected)
V - 59	(Selected)
ES - 1	(Ibadan)
Eafro 235	"

EXPERIMENT VIII Spacing Trial

No. Replications - 6 Plot size - 4 rows x 12 yds Date planted - June 3

Variety V - 10

Spacing

A 1 plant per foot and row
B 2 plants in hills spaced 2 feet in the row
C 3 plants in hills spaced 3 feet in the row

EXPERIMENT IX Fertilizer trial with nitrogen

No. Replications - 6 Plot size - 4 rows x 12 yds Date planted - June 3

Variety V - 10

Treatments

A - Control
B - 30 lbs N at thinning June 29
C - " " " " " plus 30 lbs July 24
D - " " " " " plus 30 lbs July 24 and plus 30 lbs Aug. 24.

OBSERVATION PLOTS

Seed supplied by Dr. Lindsey. Planted and sibbed during dry season 1964/65. Imported from Colombia

Code	Pedigree
C-1	(USA 342 x Diacol V 206) - 5#
C-2	(Eto x USA 342) - 5#
C-3	Cub. 325 x USA 342) - 5#
C-4	(Yotoco x Cub. 325 Bl.) - 4#
C-5	(Yotoco x Diacol V 351) - 3#
C-6	(Yotoco x Eto) - 3#
C-7	(Yotoco x USA 342) - 3#
C-8	((USA 342 x Diacol V 206) - 4# x Diacol V 254) #
C-9	((Eto x USA 342) - 4# x Diacol V 254)#
C-10	((Cub. 325 x USA 342) - 4# x Diacol V 254)#
C-11	(Yotoco x Cub. 325 Bl.) - 3# x Diacol V 254)#
C-12	((Yotoco x Diacol V 351) - 2# x Diacol V 254)#
C-13	Compuesto Flint-Dent Caribe (Granada Grup 2) - 2#
C-14	Compuesto Tuxpantigua Amarillo - 2#
C-15	Compuesto Tuxpeno Flint Caribe (Tuxpeno x Francisco Flint de Peru) - 2#
C-16	Compuesto Caribe Amarillo (Cuba-Puerto Rico) - 2#
C-17	Compuesto Tuxpeno Amarillo Caribe (Tuxpeno Sanvibag) - 2#
C-18	Composite III Amarillo Centro America (Cuba 40-Hawaii 5 - San Luis Potosi 104) - 2#
C-19	Compuesto Caribe Amarillo (Cuba Antibersan) - 2#
C-20	Compuesto Flint-Dent Caribe (Puerto Rico Grupo 2) - 2#
C-21	(Mez. 17 Lineas Amarillas) - 4#
C-22	(Mez. 17 Lineas Amllas. x Mez. 4 vards. Ams) - 3#
C-23	(Mez. 4 Vars. Amarillas) - 4#
C-24	(Mez. 5 Lineas Blancas) - 4#
C-25	(Mez. 9 Lineas Blancas x Mez. 5 variedades Blancas) - 3#
C-26	(Mez. 5 variedades Blancas) - 4#
C-27	(Per. 330 x Eto) - 6#
C-28	(Ven. 305 x D.V. 351) - 6#
C-29	(D.V. 1 x D.V. 351 - #) - 5#
C-30	(D.V. 101 x D.V. 351) - 4#
C-31	(Ven. 1 - 6# x EtO) - 4#
C-32	Eto
C-33	D.V. 351
C-34	Ven. 1 - 5#
C-35	Per. 330 - 8#
C-36	Ven. 305 - 3#
C-37	Nar. 330a - 7#a
C-38	Nar. 330b - 12#b
C-39	Colombia 2
C-40	Mz. Cruces Int. Amarillo

BREEDING

1. Varieties for 2nd cycle mass selection

   V - 10 and V - 56

   Variety for 1st mass selection

   Mexico - 5

2. Ear to row plantings for observation and inbreeding

Variety	No. Rows
V - 10	355
Mexico - 5	139
V - 56	89
V - 58	73
V - 59	113

3. S, Lines for inbreeding and planting in a top cross plot with Mexico - 5 as a pollen source.

Variety	No. lines
V - 10	282
Mexico - 5	119
V - 58	58
V - 59	93

Research programme on *Pennisetum* millets at Kano, Northern Nigeria.

by

A. O. Abifarin

In the Northern Region of Nigeria, millet is second only to guineacorn (*Sorghum spp*) as a food crop and in the drier northern areas it supercedes guineacorn in importance. Three main types of millet are recognised; 'gero' *Pennisetum typhoideum*, 'dauro' and 'Maiwa' both of which are regarded at present as *Pennisetum maiwa*. New nomenclature for the genus is being proposed.

'Gero' millet is the most widely grown of these types over a large area in the far North. It is early sown and early maturing, taking about 90 days from sowing to harvest. Considerable morphological variability exists between 'varieties'. Head length varies from a few inches to over six feet, grain colour, hairiness of the head (a possibly useful character for resistance to bird damage) plant height and tillering capacity are all highly variable. One of the least variable characters is season length, there being a difference of only about ten days between the earliest and the latest of the 'varieties' tested in this country.

'Maiwa' millet is generally less important than 'gero' although it is found throughout the *Pennisetum* growing areas of Northern Nigeria. It is however more important in the south west of Bornu Province, in northern Katsina Province and in the south west part of Niger Province. 'Maiwa' is freely tillering, hairy and usually red-based during active growth.

'Dauro' differs only from 'maiwa' in being a transplanted crop and is glabrous. It is grown only on the Jos Plateau and in southern Zaria.

Cultural practises employed by the local farmers for the three types are different. With 'gero' no preliminary cultivation is done, the crop is usually intercropped with guineacorn or cowpea at six feet intervals in furrows three feet apart. Sowing is done as early as possible after the first appreciable rain. 'Maiwa' is sown later, frequently when it is too late for 'gero' or on land that is too poor to support guineacorn. In some areas it is sown as a sole crop but intercropping is more usual. Sowing normally takes place in July. 'Dauro' is a transplanted crop. It is generally sown broadcast in manured nursery beds near coumpounds in June or July. Plants are transplanted when 18 - 24 inches high: one plant per stand at six inches spacing. When 'dauro' is sown direct it resembles 'maiwa'. 'Maiwa' and 'dauro' can be crossed with 'gero' but this does not normally take place in the field because of the different time of flowering. 'Gero' is not light sensitive and will flower at any time in the year whereas 'maiwa' is light sensitive and being a short-day plant it flowers only late in the year (October and November) when day lengths are short.

Most of the work done has been with the 'gero' type of millet. In 1958 a survey was carried out and collections were made thróughout Northern Nigeria. Commencing in 1960 a series of yield trials were conducted. In these trials varieties representative of the 'gero' crop within each area were tested. Yield variation of trials in this series was only limited, with generally fairly low yield levels. In 1962 the highest yield was only 855 lb. of grain per acre. However, some varieties appeared promising and five of them were subsequently tested in a second series of interzonal trials.

In the second series, the standard set of five varieties were compared at locations in the main ecological zones. The variety ex Bornu, representing a population from Gashua, has done consistently well at all sites and the average yield from five locations in the important Sudan savanna zone over the three years to 1964 was 1,311 lb of grain per acre.

Over the years these inter and intra- zonal trials helped to determine the adaptability of these varieties to a wide range of ecological conditions. Last year nine outstations yield trials included these best five populations of 'gero' millet selected and maintained in isolation in Kano, and an appropriate local control. The results were generally less consistent than in previous years.

At Daura and Birnin Kebbi the ex Bornu variety was top as it had been in 1963. At Yandev all the varieties supplied from Kano outyielded the local by a large (at least 84 per cent) margin but they did not differ between each other. Taking these three results together with those of previous years, the ex Bornu variety has done consitently well and it has been put into multiplication at each of the sites this year. At Maiduguri, yields of entries were not different from each other. The local variety was top and the phenotypically identical ex Bornu, second. At many other stations last year there were no consistent yield trends.

Further collections of 'gero' and 'maiwa' varieties were made from Gashua in Bornu Province because the original collection from there had proved successful. In 1964 from this collections, P64/4 and P64/17 looked promising throughout the season and had final yields of 2,118 and 2,017 lb. per acre respectively, compared with the ex Bornu control mean of 1,269 lb. per acre. These two selections replaced ex Sokoto and ex Kano in the 1965 series of outstation trials.

This year 309 Nigerian populations of 'gero' millet were grown in observation plots. These include B35, and N6, which outyielded the ex Bornu control in 1964. The Nigerian collection was scored for vigour, disease incidence and other characters. The collection contains a wealth of unstudied potential genetic markers such as anther colour, fascicle hairs and leaf colour.

The exotic collections included 64 lines from Bambey, Senegal and were grown with a systematic control. None of the lines outyielded the mean of the neighbouring controls, although lines CG 28, CG 45, CG 4 and CG 33 closely approached the control in yield.

A collection of six typical 'gero' millet varieties from Niger Republic was received in late June, 1964. Unfortunately although all varieties formed heads, none set seed. In 1965 seed setting is satisfactory.

The 46 survivors of the USA collection last year are sown in unreplicated observation plots this year. Their characteristics and yield are being further studied.

A world collection of Pennisetum received from Dr. Rachie in India has been sown for preliminary assessment this year.

As a result of cooperation with USA and help from Dr. Burton, work on cytoplasmic male sterile lines was started last year. Unfortunately due to the late arrival of seed and the subsequent drought after planting, no seeds were formed. Our ultimate long term objective is to develop a high yielding hybrid based on a Nigerian cytoplasmic male sterile parent.

In 1962, 26 lines from the ex Bornu populations were selected and put in a polycross nursery in 1963. The seed harvested from these 26 mother lines in the 1963 polycross Nursery was put into replicated yield trial in 1964. Yields of the lines were different, ranging from 2,069 lb. to 1,383 lb. per acre. This year the eight highest yielding lines from last year's polycross Nursery entered the second polycross cycle.

Population studies in 1964 showed that yield increased linearly from 619 lb. per acre at low populations (3,600 plants per acre) to 1,357 lb. per acre at high populations (57,600 plants per acre). At the highest population 0.72 fertile tillers per plant were produced.

In a date of planting test last year the highest yield (1,114 lb. per acre) of 'gero' was harvested from the first planting (May 28th). Later plantings gave poor yields and seeding after the end of June failed. The highest two yields of 'maiwa', 643 lb. and 920 lb per acre, were obtained from plots planted the first two weeks of July; subsequent plantings failed. In growth habit the 'dauro' resembled 'maiwa' although its yields were much lower (highest, 171 lb. per acre).

This year there is a trial for testing the variability in terms of yield, heading time, morphological characters and disease resistance of 5 varieties of local 'maiwa' and one bulk of a 'dauro' variety.

As an appendix to this paper, a list of the material held in the various collections in Kano is given.

Acknowledgements.

The present programme on millets was initiated by D. A. Guymer and this paper is based largely on reports of his work. I also wish to acknowledge the help received from W. S. Stonebridge (Officer in charge, Kano).

Sorghum and Millet Breeding Studies
Serere Experiment Station
Serere, P.O. Soroti, Uganda.

A.J. CASADY.

INTRODUCTION

The sorghum and millet breeding phase of the project has been delayed because of lack of housing for personnel. Through the courtesy of the East African Agriculture and Forestry Research Organisation, housing has been made available until U.S.A.I.D./A.R.S. housing is completed. A.J. Casady, plant breeder, arrived for duty at the Serere Research Station July 28, 1965.

Although the sorghum and millet breeding work of the project will be centered at the Serere Research Station, it is not intended that the services of project be confined to the country of Uganda. It is intended that the results and services of the project be extended to all East African countries that wish to participate.

FINGER MILLET

Finger millet (Eleusine coracana) is an important cereal in many parts of East Africa. For example, about 1,250,000 acres are grown annually in Uganda, and it is the staple food for more than 50 percent of the people of that country. Although not as extensively grown in other East African countries, considerable acreages are grown in Kenya, Tanzania, and Zambia.

Finger millet has several advantages. The grain stores well and has few storage insects. The grain can also be easily ground by the equipment possessed by the peasant farmers. It responds well to good cultural and fertilizer practices, and yields of at least 2,000 pounds per acre can be expected under good rainfall with good cultural and fertilizer practices.

Finger millet has certain disadvantages. Because of its inherently small seed, it is difficult to get good stands. Also the small seedlings do not compete well with weeds. The heads ripen unevenly, and the grain has a tendency to shatter before properly ripe. The grain is also low in protein content as compared to other common cereals. It is believed, however, that stand and weed problems can be overcome through agronomic experimentation, and that uneven ripening, shattering, and low protein can be corrected by plant breeding.

The most serious disease of fingermillet in East Africa is blast (Piricularia oryzea). In susceptible varieties, this disease probably destroys 10 percent or more of the heads. Resistant varieties are available; therefore, breeding for resistance to blast is feasible.

Breeding of Finger millet:

A. Previous work at Serere Exmperiment Station.

Many local and introduced varieties of finger millet have been observed and tested by a number of plant breeders at the Serere Station. From this work only 52 varieties have been retained on the basis of yield, disease resistance, and other desirable characteristics.

B. Work Carried out in 1965.

1. The 52 varieties in the Serere collection were planted in single 25 - foot rows in February and grown during the first rains season for observation and seed increase. Based on observation and past yield trials, 12 varieties were planted August 11 in large plots for further seed increase. The seed increase was for the purpose of initiating wide scale testing in 1966 to determine the range of adaptation of the varieties. Intrest in such tests has been expressed by several of the East African countries, including Uganda, Kenya, Tanzania, Sudan, Zambia, and Somali Republic.

2. The World Collection of Finger millet, which has been collected in India, was obtained through the Plant Introduction Station, Beltsville, Maryland. This collection consists of 724 varieties and represents germplasm from all the important, finger millet producing countries of the world. Such a collection should prove valuable in furnishing such characteristics as high yield, straw strength, disease and insect resistance, and grain quality.

Unfortunately, the seed of the World Collection arrived late in the first rains season, and, as a consequence, it could not be planted until April. In general, the varieties did not do well, probably due in part to late planting. Several varieties failed to emerge, and a number failed to head. However, seed was obtained from 605 varieties. These will be grown in the first rains season of 1966 for observation and evaluation.

3. One of the varieties in the Serere collection has shown immunity to blast (Piricularia oryzae). This variety, 359, has large glumes, a low threshing percent, and low yield. Crosses were made between 359 and five of the highest yielding varieties in the Serere collection. From these crosses, a pedigree breeding system will be followed in the anticipation of combining the immunity of 359 with high yield

BULRUSH MILLET

Bulrush millet (*Pennisetum typhoides*) is an important cereal crop in several East African countries. It is grown extensively on the more sandy soils in northern Uganda, and it is the second most important cereal crop in Sudan. The crop is also grown in Kenya and Tanzania. Interest in the crop has also been expressed by the Somali Republic.

Bulrush millet has certain features which make it an attractive crop. It is more drought resistant than sorghum and does better on sandy soil. The grain is higher in protein than either sorghum or maize. Therefore, it has a definite advantage for those developing countries which have a protein deficient diet. Because of its relative large seed, strong seedling vigor, and ease of harvesting, it should fit well into modern economic agriculture. The price paid to East African farmers is usually about 30 - 35 East African cents, and Serere farm yields average 1,500 pounds per acre, making the crop a very attractive proposition. It responds well to good cultural and fertiliser practices, giving up-ward to 2,000 - 2,500 pounds per acre.

Bulrush millet is not seriously pleagued by insects and diseases in East Africa. Its most serious disease is Sphacelia disease (conidial stage of *Claviceps*). No good resistance to this disease is known; however, the disease is not serious under low rainfall conditions where the crop is usually grown.

Breeding Bulrush Millet:

A. The discovery of cytoplasmic male sterility in 1958 by G.W. Burton, Crops Research Division, Agricultural Research Service, U.S.D.A. made the development of bulrush millet hybrids possible. With the use of hybrids, it is expected that grain yields can be increased very substantially. The breeding program of the project will be directed toward the production of hybrids and the explotation of hybrid vigor.

B. Previous Work at the Serere Experiment Station.

A number of local and introduced varieties have been grown and observed at the Serere Station. The most important of these is the Zuarungu type introduced from West Africa. It has a larger grain and higher yield than the local types and it is preferred by the trade.

By use of mass selection, six open pollinated varieties have been developed from the Zuarungu type. Yield tests have shown these varieties, to be higher yielding than the local types. The varieties are somewhat variable, however, in regard to head type, height, and presence of awns. Therefore, additional selection is needed.

At the present time, it is not known if any of the six varieties possess the fertility restorer gene that is essential for production of bulrush millet hybrids. However, eleven inbred lines have been developed from the varieties, and testing for fertility restoration genes will be carried out with these inbred lines.

C. Work Carried out in 1965.

1. The six Serere varieties were grown for seed increase and selfing to establish inbred lines for use in the development of hybrids. The seed increase was for the purpose of obtaining sufficient seed for wide scale testing. Although the varieties are not entirely uniform in all respects, uniformity is not too essential under the present system of agriculture in East Africa.

2. Approximately 500 individual plants were selfed in each of the six varieties. Many of the plants set little or no seed under the selfing bags, and a number of the bags were blown off by high winds before blooming was completed. Despite such losses, selfed seed was obtained from approximately 200 plants of each variety. This number should fairly well sample the varieties, and serve as a basis for developing inbred lines to be used as parents of hybrids.

3. The eleven inbred lines developed at the Serere Station were crossed to Tift 23 and Tift 18 cytoplasmic male sterile lines. The resulting hybrids will be evaluated in 1966 for fertility restoration and general performance.

4. No extensive hybridization program was initiated in 1965. However, the eleven Serere inbred lines were crossed to Tift 239, a dwarf variety developed by G.W. Burton. Lodging is a problem, and reduction of height may help to alleviate the problem.

D. World Collection of Bulrush Millet.

The World Collection has been assembled in India and contains approximately 2,100 lines. The collection has been obtained through the courtesy of Dr. Kenneth O. Rachie, Rockefeller Foundation, New Delhi, India. This collection will be evaluated under the conditions of East Africa, and the more promising material will be incorporated in the breeding program.

The India bulrush millet breeders have a well advanced hybrid breeding program, and they have a number of promising hybrids under test. Dr. Rachie has supplied seed of ten of the more promising India hybrids. These hybrids will be grown in a replicated yield trial in 1966.

Comparative grains yields of the bulrush millet variety, Serere Farm Bulk, and the bulrush millet hybrid, Tift 23 x Serere 10L/3. Serere Research Station, 1965.

Paired Plot No.	Lbs. per Acre. Farm bulk	Lbs. per Acre. Tift 23 x Serere 10L/3
1	1415.7	3310.6
2	965.6	3448.5
3	1248.7	2453.9
4	1589.9	2453.9
5	1190.6	3223.4
6	1815.0	4174.5
7	2395.8	3630.0
8	1698.8	3630.0
9	1764.2	3267.0
10	1982.0	3310.6
Mean	1606.6	3290.2

SORGHUM

Sorghum (Sorghum vulgare) is one of the most important cereals in East Africa, and it is the most important cereal crop in some countries, for example Sudan. Although maize is preferred by many of the people of East Africa, sorghum is the staple food of a large number of people. Sorghum will give higher yields than maize under low rainfall and poor soil conditions. Therefore, sorghum culture should be encouraged for such areas.

Sorghum is easy to handle as a crop, and would fit easily into mechanized agriculture. It has a large seed, competes well with weeds, and the shorter types can be readily harvested with a combine. However, most of the crop is presently harvested by hand in East Africa, so combine height is not an essential feature. Sorghum responds well to good cultural and fertilizer practices. With good management, 2000 pounds per acre can be expected from the open pollinated varieties and up to 3000 pounds from hybrids.

Sorghum has some serious pests. Birds present a problem in some areas and some seasons. Breeding for bird resistance has alleviated the problem to some extent, and no doubt further progress can be made. Central shoot fly is probably the most serious insect pest. Stem borers and aphids also cause serious yield reductions under some conditions. Striga (witchweed) is the most serious weed of sorghum.

Several diseases attack the sorghum crop in East Africa. Two smuts, covered kernel smut and head smut, are prevalent on some varieties. Sphacelia disease can be a serious disease under high rainfall conditions.

Breeding Sorghum:

A. There has been a very active and well conducted sorghum breeding program at the Serere Experiment Station since 1958. This program has been developed by Hugh Doggett of the East African Agriculture and Forestry Research Organization. It is not the intention of the USAID/ARS Project to initiate a sorghum breeding program of its own, but rather to supplement the existing program.

B. The tradional approach to sorghum improvement at the Serere Station has been to develop pure line varieties by selection and hybridization, and more recently by the development of hybrids. Considerable progress has been made in yielding ability, bird resistance, Striga resistance, and some progress has been made in Central Shoot Fly resistance. The development of hybrids have increased yield by at least 25 per cent.

C. Work Carried out in 1965.

1. Variety and Hybrid Improvement.

(a) Parents of existing hybrids are being improved by backcrossing for such undesirable characters as excessive height, small grain, purple straw color, and susceptibility to leaf blight. F_1 rows of 119 first and second backcrosses were grown in the first rains season, and

236 F_2 rows were grown in the second rains. Also, a 10-row bulk of each cross was grown. Fifty-nine second and third backcrosses were made from the F_1 rows grown in the first rains, and these backcrosses were grown in the second rains. A large number of selections was made from this material. F_3 and F_4 rows from the first crosses and first backcrosses were grown in progeny row trials; 184 of such entries were planted in two replications in the first rains. Selections from the best of these were grown in a two replication screening trial in the second rains.

Since sorghum is used for human consumption in East Africa, grain quality is an important aspect of sorghum breeding. The objective of this phase of the breeding program is to develop a medium maturity sorghum with high grain quality. One hundred and twenty-five replicated progreny rows were devoted to this work in the first rains, and 161 replicated progeny rows were grown in the second rains.

A program of recurrent selection, using populations incorporating cytoplasmic male-sterility, is an important phase of the breeding program. During the first rains, four bulk populations were grown, and selections were made from them. Two bulks and a trial of 125 strains were grown in the second rains.

(b) Development of new male sterile lines is essential in any hybrid sorghum program. Seventy-two progeny rows in the first rains and 206 in the second rains were devoted to developing new male sterile lines to be used as parents in future hybrids.

(c) Sixty-one new sorghum hybrids were made in the first rains season. They were tested in a replicated yield trial during the second rains. Nine of these new hybrids proved to be as good as or better than the control hybrid (H x 57), and the best hybrids yielded nearly three times as much as the standard variety Serena.

(d) Fifteen hybrids received from the Rockefeller Foundation, New Delhi, India were tested in a replicated yield trial during the second rains. Three of these Indian hybrids yielded as much as the standard Serere hybrids, H x 57 and H x 58. The best of the hybrids yielded 78 per cent more than the variety Serena.

(e) The sorghum breeding program at the Serere Station is designed to serve all the countries of East Africa. Therefore, if the program is to be successful, it is essential that the varieties and hybrids developed and tested at the Serere Station be tested at many locations in East Africa. In 1965, the most promising varieties and hybrids from the Serere program were tested at 37 locations throughout Uganda, Kenya, and Tanzania. The results of these trials should be most informative regarding the adaptation of the varieties and hybrids. Sufficient seed of seven new hybrids was produced in 1965 for regional trials in 1966.

2. Breeding for Central Shoot Fly Resistance.

Central Shoot Fly is a serious insect pest of sorghum in East Africa. Since no economical insecticidal control is known, breeding for resistance is a logical means of control. Some of the Serere varieties have shown some resistance, and one approach has been to intercross the best of these varieities in the anticipation of concentrating the genes for resistance. Namatare, a Buganda beer sorghum, has very good resistance. Namatare has been crossed with the best Serere varieties with the hope of transferring its resistance to good grain types.

In the first rains, 75 progeny rows derived from the first backcross of the two types of crosses were grown in three replications. In the second rains, 114 selections from the first backcross material were grown in three replications.

Second backcrosses to Namatare were made in the Namatare material during the first rains. These backcrosses were grown in 275 rows for observation and selection during the second rains.

3. Development of Tetraploid Sorghum.

The development of tetraploid grain sorghum is an important phase of the Serere sorghum breeding program. One of the major difficulties in developing a tetraploid grain crop is obtaining good seed set. This difficulty has largely been overcome by crossing and backcrossing colchicine-induced tetraploid cultivated varieties to *S. almum*, a tetraploid sorghum with good seed set.

The following outline gives a summary of the scope of the tetraploid work in 1965:

(a) *S. almum*. 87 rows grown in first rains.

(b) 1st backcross. Tetraploid grain sorghum x *S. almum*.
20 rows in first rains.

(c) 2nd backcross. Tetraploid grain sorghum x *S. almum*.
68 rows in first rains.

(d) 3rd backcross. Tetraploid grain sorghum x *S. almum*.
1302 rows in first rains, and
727 rows in second rains.

(e) Tetraploid cytoplasmic male-steriles.
18 rows in first rains, and
56 rows in second rains.

(f) Intercrosses of 3rd backcross tetraploid derivatives.
66 rows in first rains, and
135 rows in second rains.

(g) Autotetraploid grain sorghums for maintenance and crossing.
90 rows in first rains, and
145 rows in second rains.

(h) Seventeen tetraploid breeding bulks were composed, grown, and selection made within in 1965.

4. Maintenance of Pure Lines.

Fifty-two male-sterile lines were grown together with their corresponding B-lines for maintenance and multiplication. These male-sterile lines represent lines from the Serere Station, United States, and other countries. They will be used as female parents in developing new hybrids from pollinator lines developed at the Serere Station.

A varietal collection of 468 pure lines was grown for maintenance. This collection is fairly representative of the sorghum varieties in existance, and it serves as a gene pool for many characteristics. Such a collection is invaluable as source material for breeding problems and genetic studies.

MAIZE GENETICS

Kitale, Kenya

Steve A. Eberhart

Maize breeding in Kenya is conducted by the Maize Research Section as a single coordinated program. Funds for this research come from the following sources; the Kenya Ministry of Agriculture; the Kenya Maize Marketing Board; the Department of Technical Cooperation, Great Britain; the Rockefeller Foundation; and the United States Agency for International Development and the Agricultural Research Service of the U. S. Department of Agriculture in cooperation with E.A.A.F.R.O.

The primary contribution of the USAID-ARS/EAAFRO maize genetics research is adapting breeding methods to conditions present in developing countries and in evaluating the relative efficiencies of these methods so that future breeding programs can make maximum progress for the minimum expenditure of funds. As these results become available, this information as well as other information obtained from statistical genetic theory and similar experimental data elsewhere is used to advise maize, sorghum and millet breeders how to increase the effectiveness of their breeding programs.

Because the maize research in Kenya is conducted as one coordinated program, the contribution of any one supporting agency cannot be clearly defined. Hence, this report will cover some of the most important aspects of progress made by the Maize Research Section as a whole.

The ecological conditions in Kenya require maize breeding programs for three distinct areas. One long rainy season occurs west of the Rift Valley and most of the maize is grown between 4500 and 7500 feet. Maize breeding for this area is done at Kitale and Kakemega. The senior staff at Kitale consists of the Senior Maize Research Officer, M. N. Harrison; Maize Geneticist, S. A. Eberhart; Maize Breeder, F. Ogada; Maize Agronomist, A. Y. Allan; Assistant Maize Breeders, R. Sandhu and B. Gichui; and Assistant Agronomist, J. Mugambi. One assistant Maize Breeder, B. Wamalwa is at Kakemega. Breeding trials are also conducted at Njoro and Endebess. East of the Rift Valley there are two rainy seasons and two crops a year requiring medium maturity varieties at similar altitudes. The breeding work for the better rainfall parts of this region was initiated in the first rainy season this year at Embu by C. Kagira, Maize Breeder. The drier areas of this region require a much earlier maturing maize to escape the drought. The breeding of these early maturing varieties is done at Katumani near Machakos, where Mr. E. Omolo is the assistant maize breeder.

The results of variety trials of the late maturing hybrids at 34 locations indicates the increased yields already obtained by the development of improved varieties and adapted hybrids (figure 1). Kitale II is an improved synthetic variety developed from a local variety; H631 and H621 are three-way and double cross hybrids developed from the local varieties; and H611 is a variety

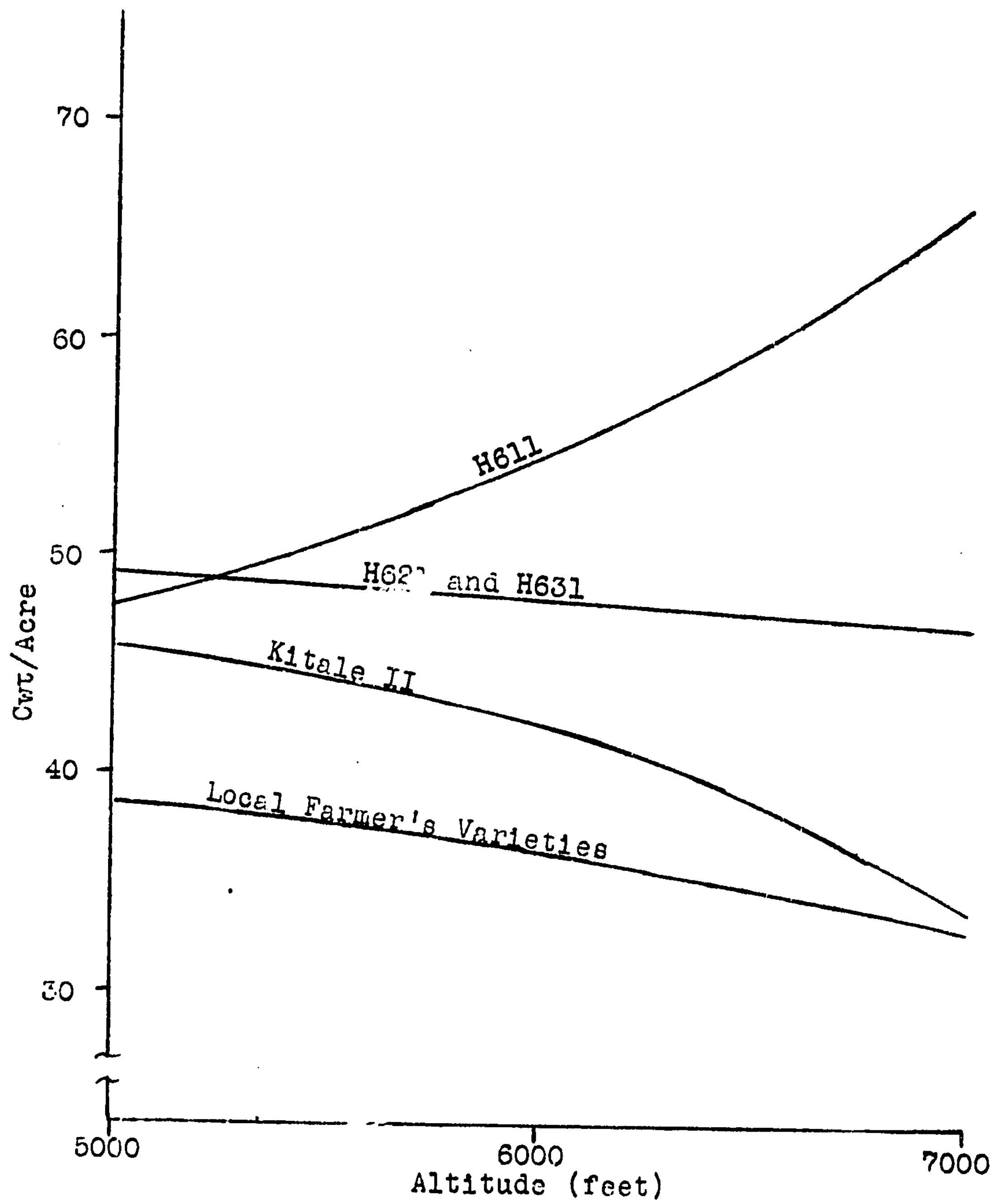

Figure 1. Performance of Kenya Varieties and hybrids in 1964 at 34 locations.

cross between Kitale II and Ecuador 573 (a variety introduced from Central America). The superiority of this latter hybrid over local farmers varieties is even greater at the higher altitudes (50% at 6,000 and 100% at 7,000 feet).

By means of recurrent selection even further yield increases can be obtained in Kitale II and Ec. 573 which should also result in increased yields of the variety cross hybrid. Estimates of genetic variances were obtained in the maize genetics research project from the plant-row recurrent selection program in 1964, (table 1). The estimates of increases in yield per year (G) are also given. A new composite variety, Kitale Composite A (formerly Kitale IV) has been formed by random mating H611. The corresponding estimates are also given for this composite.

The observed increase in yield obtained after one cycle of plant-row selection in this population is 3.6 cwt. per acre or 10% which agrees well with predicted progress. These data were obtained from two replications at three locations in 1965. Selection will be continued in this variety and similar increases in yield are expected each year until the genetic variance begins to decrease. If this progress can be maintained for ten years, yields will be doubled which is a greater advance than achieved through hybrids in the U. S. over the past 30 years. This progress per year from recurrent selection is also much greater than obtained from any similar program

Table 1. Estimates of genetic parameters for three maize varieties in 1964.*

Genetic Parameters	Kitale II	Ec. 573	Kitale Comp. A
σ_g^2	10 ± 4	57 ± 10	29 ± 7
σ_{ge}^2	14 ± 7	19 ± 7	20 ± 9
σ_e^2	109 ± 9	95 ± 8	133 ± 16
G			
cwt/A.	1.7	6.1	3.4
Per cent	4	13	8

*σ_g^2, σ_{ge}^2, and σ_e^2 are the genetic variance, genotype-environmental interaction and experimental error variance components. G is an estimate of the expected gain per year from recurrent selection.

in the U. S. but has been equalled in Mexico, Columbia and other areas with varieties also having considerable genetic variation. Kitale Composite A will be released for commercial production in 1966 for farmers unable to buy H611. The improved variety from each cycle of recurrent selection will be increased and released so that the variety available to farmers will be improved each year.

More Central American varieties have been obtained and composited as Kitale Composite C. A composite of local varieties, Kitale Composite B, has also been formed. Because of the greater genetic variation in these composites and the heterosis between them, recurrent selection is expected to produce even better varieties and variety cross hybrids from these composites than from Kitale II and Ec573. The selection of the method of recurrent selection to be used in these composites will greatly effect future improvement of the variety cross hybrids. Hence, the results of the comparisons of the various recurrent selection methods is of great importance to the applied breeding program in Kenya and all other developing countries.

Yield trials involving the following recurrent selection methods were conducted in 1965:

Method	Variety	No. of plots
Mass selection	Kitale Composite A	300
Plant-row	Kitale II	396
Plant-row	Ec. 573	396
Recurrent selection for general combining ability	Kitale Composite A	1000
Plant-row	Kitale Composite A	2388
Reciprocal Recurrent Selection	Kitale II	800
Reciprocal Recurrent Selection	Ec. 573	800

Crosses were made in the nurseries so that the additional methods will be in yield trials in 1966 in Kitale Composite A: S_1 progeny testing; and recurrent selection for general combining ability using a low yielding and a high yielding tester.

A further illustration of the effectiveness of recurrent selection methods is provided by the spectacular progress achieved by applying them at Katumani. The Local White variety was selected for earliness but not for yield with the increases in yield under low rainfall and short seasons shown in figure 2 for Katumani Syn. I and Syn. III but decreased yields with higher rainfall. An early variety, Taboran, was introduced from Tanzania (originally Tavoran of the Mexican race Salvador.

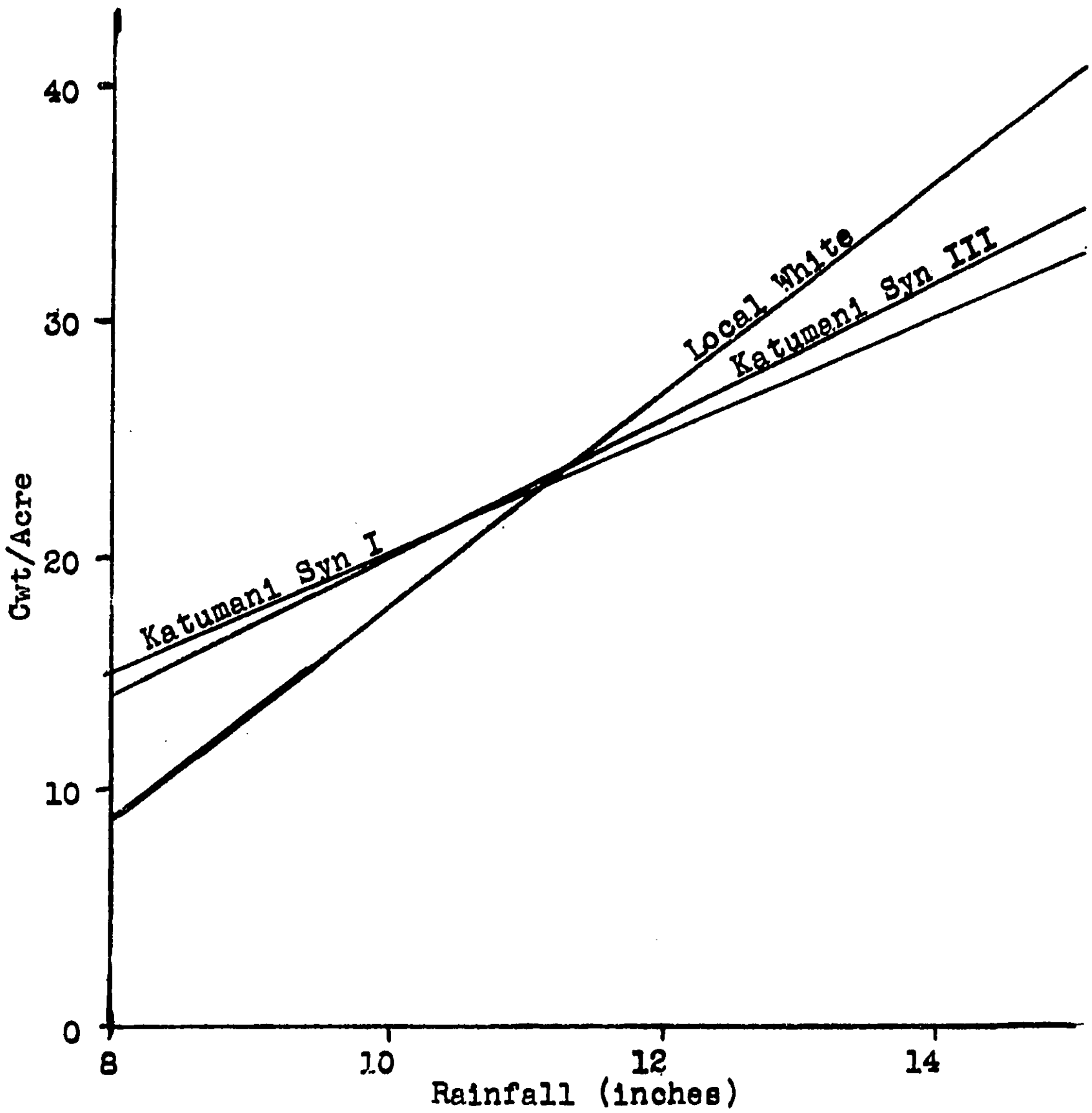

Figure 2. Yields of a Local White variety and two synthetics developed from it. (eight environments 1963-65)

Selections from this variety, from a local yellow variety and from several Wisconsin hybrids were composited to form Katumani Syn. II with the resulting yield increases shown in figure 3. Katumani Syn IV has been subsequently developed by recurrent selection for yield from Syn. II. Recent results give the comparisons shown in table 3, in which Katumani Syn. IV has outyielded Katumani II by 35%. Although the recurrent selection method used in producing Katumani Syn. IV required five seasons, proposed modifications should produce similar progress in the future in three seasons. Hence, the potential yield of synthetic varieties very probably can be doubled in ten seasons or five years at Katumani also.

The cross of Katumani Syn. II and Syn. III also gave yield increases over the parental varieties (table 4). The composite formed from random mating the variety cross, Katumani Syn. III x Katumani Syn. IV, will be released to farmers as Katumani Composite A and is expected to give even higher yields than Katumani IV.

Because of the extremely short duration of the rains usually occurring in the Katumani area, the food supply is usually limited and famine relief is often necessary. Importations of 150,000 tons of American maize have been required to alleviate the food shortage in Kenya this year at a cost of approximately $11,000,000. when delivered in Kenya. The major shortage, as usual, is from the region

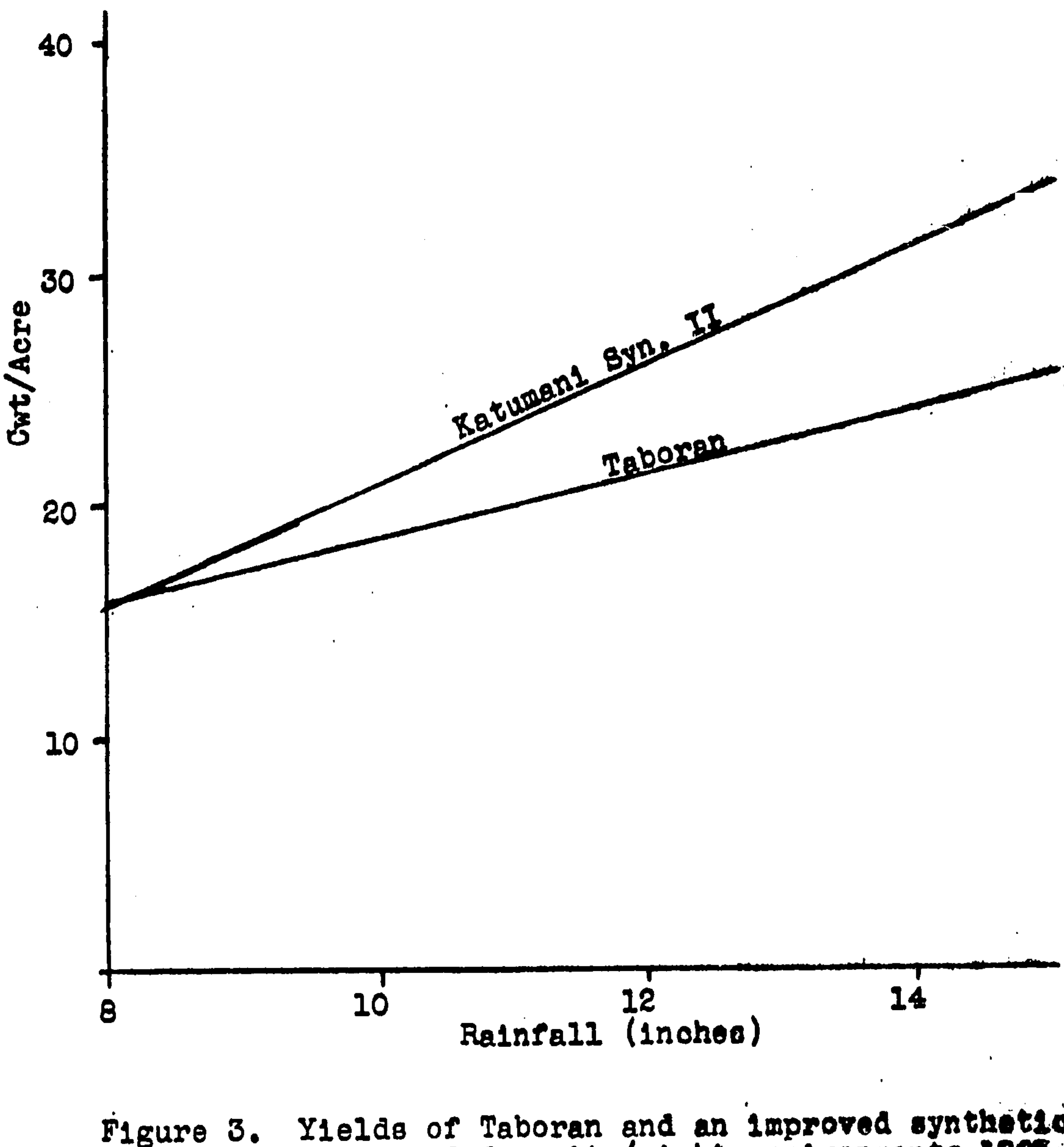

Figure 3. Yields of Taboran and an improved synthetic developed from it (eight environments 1963-65)

Table 8. Yields (cwt/acre) of improved early maturing synthetic varieties.

Variety	Short Rain 1964-65		Long Rain 1965	Mean
	Katumani	Kampi Ya Mawe	Katumani	
Katumani Syn. I	24.0	27.2	11.2	20.8
Katumani Syn. III	29.0	27.4	9.8	22.0
Katumani Syn. II	26.4	22.2	16.6	21.8
Katumani Syn. IV	34.8	34.8	18.2	29.4
Rainfall (ins.)	11.5	20.8	5.5	

Table 4. Yields (cwt/acre) of the variety cross, parental varieties and the composite formed from the variety cross of two early maturing synthetics.

Variety	Kampi Ya Mawe			Katumani				Mean
	1963/64	1964	1964/65	1963/64	1964	1964/65	1965	
Katumani Syn. II	24.0	18.8	25.0	43.4	37.2	30.6	16.6	28.0
Katumani Syn. III	23.2	14.6	21.8	43.4	39.0	23.8	9.8	25.0
Syn. III x Syn. II	30.0	24.2	28.6	58.8	44.6	33.0	19.4	34.0
Katumani Composite A*	27.4	20.6	27.0	46.4	39.8	30.2	18.6	30.0
Rainfall (ins.)	20.4	10.6	20.8	30.1	14.6	11.5	5.3	

*Katumani Composite A is (Katumani IV x Katumani III) random mated.

served by the Katumani breeding program. If the improved varieties developed at Katumani were grown by the local farmers using recommended agronomic practices, food shortages would be extremely rare if not completely eliminated as demonstrated by the results obtained in yield trials in the long rains in 1966 (tables 3 and 4). The land was fallow during the previous season but there was only 11.5 inches of rain. The trial was dry-planted so that all available moisture was utilized. When only 5.3 inches of rain fell during the 1965 growing season, all other crops in the area were a complete failure except some of the extension service demonstration plots planted in a similar manner. This combination of maize breeding, maize agronomy, and extension work have provided a long term solution whereas annual famine relief is only a temporary measure.

The Embu maize breeding program for medium maturing varieties is being established using the methods that have been so successful at Kitale and Katumani. Collections of local varieties have been made and introductions have been obtained from Central and South America, United States, and other African countries. Because medium maturity varieties are required in many East African areas, a cooperative trial has been designed. Maize breeders and agronomists from Tanzania, Uganda, and Kenya have agreed to conduct this trial at 15 locations in the 1966/68 season. The trial will provide information on genotype-variety interactions. This information will be used to decide whether several separate breeding programs are required or whether one coordinated program can produce the necessary medium maturing varieties and hybrids for all of East Africa. The best varieties in this trial will be selected for more extensive testing in order to form two high yielding composites suitable for future breeding work. The variety cross of these composites will be released as the commercial hybrid and recurrent selection will be initiated to give continued improvement.

Not only has the Maize Research Section been extremely effective in developing improved varieties and hybrids, but in cooperation with the extension service, they also have been successful in getting the hybrid varieties into commercial production on both large scale and small farms. Firstly, the Kenya Seed Company in cooperation with the Maize Research Section has produced the seed of this superior product at a reasonable cost and packaged it in a suitable manner--200 lb. bags for large scale farmers and 20 lb. bags for small farmers at $18.50 and $2.10, respectively. Secondly, the extension service has established a program of demonstration plots with the goal of having an acre of hybrid maize properly grown within walking distance of every small farmer. These are package deals in which the farmer must agree to buy hybrid seed, fertilizer and insecticide and to carry out appropriate agronomic practices. In return the agricultural officers of the extension service give advice and supervision. Land preparation and planting operations are used as method demonstrations and the harvest is used as a result demonstration. Instead of the 35 - 50 per cent increases in yield expected due to superior hybrid varieties, yield increases of 200 to 300 per cent are obtained from the combination of improved seed and agronomic practices. Whereas, little success was obtained previously in getting improved agronomic practices adopted, hybrid seed has been used as a "lever".

The following figures give the approximate expansion of hybrid maize in Kenya based on past and expected production of hybrid seed.

Year	Cwt. of Hybrid seed produced	Approximate Acreages Grown	
		Large Scale Farms	Small Scale Farms
1963	80	390	10
1964	6,000	27,000	3,000
1965	14,000	52,000	18,000
1966	(24,000)	(55,000)	(65,000)
1967	(90,000)	(100,000)	(350,000)

Figures in parentheses are expected figures.

Seed sufficient to plant 300,000 acres was ordered for 1966. Even though seed production was nearly doubled in 1965, the demand by small scale farmers increased so greatly that the supply was completely inadequate. This demonstrates (contrary to the common supposition that peasant farmers will not buy hybrid seed) that given good quality seed of high yielding hybrids at a reasonable price, small scale farmers will buy and continue to buy it and not plant second generation seed.

In order to familiarize other Eastern African maize, sorghum, and millet breeders with the recent developments in maize breeding and to help coordinate the breeding programs, a Maize-Sorghum-Millet Workshop Conference was held at Kitale, October 13-16. Delegates from Sudan, Somalia, Tanzania, Uganda, Kenya, Zambia, Malawi, and Rwanda participated in the conference. Interest in recurrent selection was stimulated and a more extensive exchange of breeding material has resulted from this conference. The Maize Geneticist also attended a similar conference in western Africa at Zaria, Nigeria, October 1 - 8.