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SEVENTH ANNUAL REPORT

of the

AID-ARS Project

Major Cereals in Africa
1970

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SEVENTH ANNUAL REPORT

of the

AID-ARS Project

Major Cereals in Africa
G. F. Sprague

GENERAL RESUMÉ

The objective of this section will be to highlight some of the progress which has been achieved. Those interested in details will have need to study the individual reports.

West Africa

Sorghum:

The regional sorghum trials for the Guinea Savanna included twelve entries grown in six countries. The hybrid 93 x 5764 produced the highest average yield: 3583 kg/ha. Differences in yield response among locations was extreme indicating need for both extensive regional testing and local breeding programs. Recently 2 new varieties of sorghum have come from the breeding program in Senegal, 1 from Niger, 3 from Nigeria, and 2 from Cameroons. Regional testing will be required to establish the areas of adaptation of this new material.

Regional trials for the Sudan Savanna involved 13 varieties grown at 11 locations. Differential response was striking. The highest yielding entry was the U. S. hybrid NK 300 but this variety would not be readily acceptable as a food cereal.

Broad-based composites have been formed which may be utilized by the National programs to obtain high yielding material suited to their specific ecological requirements. Such material will now have a high degree of usefulness with the increasing emphasis on cereal improvement in West Africa. In 1963, only 7 persons were spending a major portion of their time on cereal improvement and 4 of these were in Nigeria. At present some 21 persons are active in cereal breeding. The countries involved are Senegal, Mali, Upper Volta, Niger, Gambia, Ivory Coast, Ghana, Dahomey, Nigeria, Cameroons, and Chad. Eight of these 21 are Africans.

Millet:

Regional trials of millet, involving 11 varieties, were grown at 6 locations. Bird damage was severe at most locations precluding

reliable results. High yields of Ex-Bornu, 4442 kg/ha, Samaru, indicate the yield potential of this crop if some of the disease and production problems can be solved.

Maize:

It has been demonstrated that maize is potentially a very productive crop in the Guinea Savanna zone where the annual rainfall is 35 to 55 inches per year. New production techniques are required but under proper population densities and fertilization yields of 5000 kg/ha are not uncommon. This is a substantially higher yield level than has been achieved with sorghum. In a joint effort involving Zaria, Mokwa, and Ibadan three broad-based composites have been formed. These have had good performance records in the regional trials of 1970; giving yields substantially higher than most of the local varieties. Recurrent selections studies have been initiated and, based on the experience in Kenya, further increases in yield should be readily possible.

The genes $opaque_2$ and $floury_2$ are being incorporated into all of the composites. Genes for resistance to rust, (*Puccinia polysora*) and leaf blight (*Helminthosporium maydis*) have been found and are being introduced into these stocks. These are two of the most important diseases of tropical Africa.

Sorghum and Millet Pathology:

Control of the important disease of these crops must come through the development of resistant varieties. Over 4000 items from the World Sorghum collection have been screened for resistance to downy mildew, *Sclerospora* sp). sooty stripe (*Ramulispora sorghi*), *Anthracnose* (*Colletotrichum graminicola*), rough leaf spot (*Ascochyta sorghina*), oval leaf spot (*R. sorghicola*), zonate leaf spot (*Glococereospora sorghi*), Gray leaf spot (*Cercospora sorghi*), and the several kernel smuts. Screening is also underway to the parasitic witchweed (Striga). Control for this parasite can be achieved with herbicides but these are expensive and unsuited to current levels of technology.
The smuts may be controlled by seed treatments but seed treatment is not commonly used. Progress is being made on the identification of resistant types which will be incorporated into the breeding program.

The most serious diseases of millet are downy mildew, smut and ergot. Mildew alone is estimated to cause an annual yield loss of 10 percent in Nigeria. Some native varieties possess resistance and this resistance is being transferred to higher yielding varieties.

Agronomic practices:

The soils of West Africa are highly weathered, acid and have a very low base exchange capacity. The proper fertilizer regime for such soils will be difficult to establish. Conditions and responses vary greatly among fields and among locations. The establishment of general recommendations may be extremely difficult. Laboratory analyses of soils and plant materials may be required to provide any general guides. Furthermore as potentially high yielding types are developed and production practices improve, potash as well as some of the minor elements become limiting. In general maize is more responsive under improved technology than is sorghum. The reason for this difference has not been firmly established but one factor may be the generally low level of response of all of the local sorghum types. Many exotic types are more responsive emphasizing the need for coordination of breeding and agronomic studies.

Entomology:

Shoot flies, stem borers and midge are the major insects of sorghum in West Africa. Some resistance has been found in sorghum varieties from India and Israel and material from Uganda possesses a promising level of tolerance to the shoot fly. This insect can also be controlled by the insecticides, Furadan and Phorate. Stem borers can be controlled by whorl application of Thiodan (endosulfan). The use of insecticides is not a common practice in West Africa.

East Africa

The sorghum and millet breeding, entomology, and agronomic practices research is located at the Serere Experiment Station, Soroti, Uganda.

Sorghum:

Several new experimental hybrids are showing promise. The first hybrids tested utilized the U.S. line CK60 as the female parent. While satisfactory yields could be obtained seed production was hazardous because of the insect and disease susceptibility of the unadapted CK60. New sterile types have been developed and these are being used in the current experimental hybrids. A new breeding system has been developed which makes use of new developments in recurrent selection. Random mating composites have been developed through use of the genetic sterile type ms_3. Both B and R versions are under development and selection and the first cycles appear promising. The sorghum program has been under the direction of Dr. Hugh Doggett for many years. He returned to England in December 1970. Due to his long experience in Africa and his cooperative spirit he was most helpful to our staff in the broad fields of insect

resistance, agronomic practices and cereal milling and processing. This position must be filled with a competent scientist or the whole operation at Soroti will suffer.

Millets:

Two types of millet are in common use: finger millet (Eleusine coricana), and bulrush millet (Pennisetum typhoides). Finger millet is commonly grown as a first-rains crop. Items from the World collection have been screened for adaptation and resistance to blast. Several promising strains are undergoing final stages of evaluation. Blast resistance is being incorporated into types with superior grain quality and performance characteristics.

The U. S. sterile type, Tift 23 is not well suited to East Africa. Locally developed sterile types have been developed and are being used to produce experimental hybrids of bulrush millet. A large number of items from the World collection have been screened for fertility restoration and B and R composites are being developed. The S_1 type of recurrent selection is underway and should be as effective in this crop as with maize.

Entomology:

The main emphasis has been on host resistance to shoot fly and stem borers. Again using the recurrent selection technique, in cooperation with Dr. Doggett, marked progress has been made in increasing the level of tolerance to the shoot fly in sorghum populations. This technique gives promise of adequate control of this serious insect pest. Somewhat less progress has been made in increasing resistance to the stem borers. This limited progress is probably due to the lack of adequate techniques of developing uniform infestation levels to permit accurate evaluation. Techniques are being developed for the artificial rearing of this insect. If rearing can be handled on an adequate scale, breeding for resistance should become much more productive.

Agronomic Practices:

Fertilizer and plant population trials have been conducted at several sites in Uganda. Results are somewhat erratic but generally no response is obtained from N unless P is also applied. Returns from K are usually limited. At present price levels for fertilizer and grain, fertilization with N and P is an economic practice. Possibly due to a limited Extension effort little commercial use is made of either improved varieties of fertilizer recommendations.

Maize:

Commercial utilization of hybrids in Kenya is based on both conventional hybrids and inter-varietal or inter-composite hybrids. Use has increased from 300 acres in 1963 to 325,000 acres in 1970. Over half of the current acreage planted to hybrids is grown by small-scale land holders. This development, involving breeding, agronomic practices, Extension, the Kenya Seed Company, and the existance of a market for above-subsistence needs provides an excellent picture of what can be accomplished when all the required elements are present.

The genes $opaque_2$ and $floury_2$ are being introduced into all composites. Attention is also being given to $brachytic_2$ in an effort to reduce the height of the long season high altitude types.

Regional maize trials were initiated in 1966. At various times Ethiopia, Uganda, Tanzania, Congo, Burundii, Malawi, and Zambia have participated. Regional adaptation of the Kenya and other material has been established. The maize programs in Eastern Africa have been reorganized and currently generally follow the pattern developed at Kitale. Changes in staff within the cooperating countries has definitely limited progress which might be achieved. None of the people, outside Kenya, who were involved in maize breeding in 1966 are still active. Many of the positions remain unfilled or have been filled with people with no previous experience with maize. The high and medium altitude materials developed in Kenya are well adapted to parts of Ethiopia, Uganda and Tanzania. Essentially no effort has been devoted to the development of improved types for low altitude areas.

Cereal Prosessing:

Research on cereal processing at Nairobi has been directed primarily to sorghum. Various types of milling procedures have been shown to give acceptable products. The relation among kernel characteristics and milling properties should provide valuable guides to the plant breeder in the development of high yielding and satisfactory milling types. Protein and amino acid analyses have been determined on sorghum millet and maize samples. Results indicate some differences among and within crops but this aspect of the work cannot be extensively pursued at the level of staffing and funding.

The Department of Home Economics of the University of Nairobi has cooperated in the development of new recipes utilizing various milled products. These have been demonstrated at some of the Agricultural Fairs and have met with enthusiastic reception. The recipes have been prepared in mimeographed form and distributed.

Field Trials Officer:

The post of Field Trials Officer in Tanzania was filled in July 1970. Dr. Judy will be conducting field trials covering varietal evaluation, time and rate of planting and fertilizer response with maize, sorghum, and millets. The experiments will be located for the most part on existing Tanzanian stations or substations. Because of distances involved and timing of various operations many of the procedural operations will have to be left to local staff. This may not be completely satisfactory due to general understaffing and general lack of appreciation for experimental procedures. The effectiveness of this position would be greatly enhanced if Tanzania possessed a stronger research base.

INTRODUCTION

This report will include: (1) a general resume of activities and progress, (2) current status of the Project; and (3) detailed reports of the activities of the individual scientists.

Current Status

This AID/ARS Project was authorized in 1963 under PASA, AID/RES20. The initiation of research ac tivities was delayed due to: (1) problems in obtaining formal approval of the African Governments and research institutions, (2) unavailability of local housing, and (3) delays in recruiting competent staff. The first staff assignments were made in July and September of 1964.

The program, as initially outlined, had three major objectives: (1) to increase cereal production capabilities in Africa through cooperation with and support to research organizations in Niger, Kenya and Uganda, (2) to stimulate and sponsor cooperative research on all aspects of crop production throughout the area, and (3) to provide in-service training at the headquarters stations, to individuals sponsored by their respective governments.

Regional centers were established in West and East Africa to serve the differing ecological conditions. In West Africa the sponsoring agency is STRC, one of the committees authorized by OAU. Nigeria serves as the host country with centers located at Ahmadu-Bello University, Institute for Agricultural Research, Zaria, and the Federal Department of Agricultural Research, Moor Plantation, Ibadan, Staff at the first location is concerned with sorghum, millet and maize breeding, insect and disease control and soil-water-fertility-plant relations. Work at the Federal Department of Agricultural Research is limited to maize breeding and pathology.

In East Africa the sponsoring agency is EAAFRO. Research work is conducted at four locations: Soroti Experiment Station, Uganda; the National Maize Research Station, Kitale, Kenya; the East African Industrial Research Organization at Nairobi, Kenya; and the Tanzania Ministry of Agriculture, Dar es Salaam, Tanzania. Research at Soroti is concerned with sorghum and millet breeding, soil-water-ferility-plant relations and insect control. The research at Kitale is concerned with maize breeding and production. Work on cereal milling and processing, with primary emphasis on sorghum, was initiated in 1968 at Nairobi, Kenya. A Regional Field Trials Officer position was established at Dar es Salaam in 1970. Emphasis will be given to varietal evaluation, date of planting, and fertilizer and population density responses.

It was the original intent that our research activities would supplement and strengthen ongoing research. Our operational procedure, therefore, has been to develop local cooperation to the maximum degree possible and to establish new research in subject matter areas receiving limited research emphasis. In consequence reporting will include reports by our staff and by other scientists with whom we have cooperative relations.

The location of the current and proposed staff is as follows:

O. J. Webster[1/]	Geneticist and Res. Director STRC26, Zaria, Nigeria September 1963
S. B. King[2/]	Plant Pathologist, Zaria, Nigeria, Aug. 1967
K. R. Stockinger[1/]	Soil Scientist, Zaria, Nigeria, June 1966
G. T.York[1/]	Entomologist, Zaria, Nigeria, February 1966
J. Craig[1/]	Maize Pathologist-Breeder, Ibadan, Nigeria, Sept. 1965
G. A. Schumaker[3/]	Soil Scientist, Soroti, Uganda, May 1966
R. Davis[4/]	Soil Scientist, Soroti, Uganda, June 1970
Leroy Peters[2/]	Millet Geneticist, Team Leader, Soroti, Uganda, June 1969
Dean Barry	Entomologist, Soroti, Uganda, 1969
Larry L. Darrah	Maize Geneticist, Kitale, Kenya, 1970
Allan Shepherd[2/]	Cereal Technologist, Nairobi, Kenya, 1968
Wm. H. Judy	Agronomist, FTO, Dar es Salaam, Tanzania, 1970
L. H. Penny[5/]	Agronomist, Kitale, Kenya, 1964

1/ Now serving third tour of duty
2/ Now serving second tour of duty
3/ Completed second tour of duty June 1970
4/ Transferred from Legume Project, Delhi, India
5/ Completed first tour of duty November 1970

Actual and proposed changes in policy deserve inclusion as background information. The original PASA was funded by AID/TCR (now Bureau of Technical Assistance, Office of Agriculture and Fisheries). In Fy-69 funding of the East Africa segment was assumed by the Agriculture Division of the African Bureau. Beginning July 1, 1967 the same agency also provided the financial support for the West Africa segment. Due to reorganization within AID the two segments of the project were separately supervised and funded beginning in 1970. The West Africa segment is funded by the Central West Africa Office of Regional Affairs (AFR/CWR) and the East Africa segment by the Office of East and South Africa Affairs (AFR/ESA). This subdivision is of importance to the Project primarily in relation to differing policies on support of training of scientists.

The need for training of African scientists was recognized at the inception of the project. Initially, however, it was hoped that such training could be handled under the Mission training program. Due to the tremendous need for training the Mission effort has been Country oriented and training has not been available to provide trained counterparts for our regional staff.

Additional funds were provided under AFR/CWR in Fy-71. Several trainees were selected; some are now registered in U.S. Universities and others are in various stages of clearance. Upon completeion of training these individuals may be associated with the Regional Project or may assume positions of responsibility within their own countries.

The philosophy in AFR/ESA has been somewhat different. Individuals will not be selected for training unless they can return to an established post within EAAFRO. The in-service trainees who have worked at either Kitale or Serere have had no established posts and therefore no civil service status. Accordingly turn-over has been high. The request to establish posts for all of our positions in East Africa was included in the last budget asking. If these are approved by the East Africa Community we shall be able to initiate a more productive training program.

WEST AFRICA

Regional Activities

O. J. Webster

The cereal breeders within Nigeria work as a team. Annual meetings of the persons interested in maize are held in Ibadan where reports of the past year's work are reviewed and plans for the coming season are discussed, the entries to be included in the National Zonal Trial are selected and recommendations for the increase and distribution of seed of new varieties are made. This year it was recommended that seed of Bulk-3 be increased and recommended in 1972. It will be some time before new varieties will be forthcoming from the Composite Program and Bulk-3 will be a good variety for immediate release.

At this year's meeting we were informed that an aggressive Nigerian business man imported 50 tons of seed of a commercial maize hybrid from Trinidad in 1969 and sold it to 300 farmers in the Western State. He purchases the grain from these farmers at a pre-determined price for feed for his poultry industry which requires up to 4,000 tons per year. This man wanted to import 500 tons of seed for 1971 but the Company approved the sales of a more modest amount and sent a representative to investigate the development of a seed industry in the area.

The members of the workers conference agreed that the Nigerian Government should encourage such a private enterprise and that the research personnel should take steps to see that the hybrid or hybrids to be produced and sold are well adapted to the area. The hybrid sold in 1969 has been tested and the yield performance has been favorable. It may, however, be susceptible to rust. The development of a hybrid seed industry within Nigeria, will stimulate the breeders to take immediate steps towards the development of hybrids and put less emphasis on synthetics. Dr. Tatum advised that the elite lines in the S_1 recurrent selection program in the Composite be isolated for possible use in a hybrid program.

Cereal Seminars and Conferences

The staff participated in two seminars sponsored by the Ford Foundation, IRAT (Institute for Tropical Agricultural Research) and IITA (International Institute for Tropical Agriculture). The maize

seminar was held in Ibadan April 27 - May 1. Dr. King led a discussion dealing with diseases of maize and I prepared two papers; "The current status of maize research in Anglophone west Africa", and "The potential of maize in the Northern Guinea Savanna".

The Sorghum-Millet Seminar was held at Bambey, Senegal, August 31 to September 4. Dr. King read a paper dealing with diseases of millet in west Africa and I gave a paper, "Current status of Sorghum Research in OAU-STRC Joint Project 26". In this paper I pointed out the problems which confront the cereal breeders in west Africa and suggested methods to be followed for the improvement of these crops.

The draft committee for the Bambey seminar prepared a summary and the first four items of the introduction are significant:

1. Millet and sorghum constitute the basic food of a large part of the population of Africa and other tropical areas. About 100 million hectares are grown to these two crops in the world, of which approximately 25 millions are in Africa. Nevertheless, so far little - international effort has gone into the improvement of these crops, other than the OAU-STRC Joint Project No. 26.

2. The target of the present seminar was to assemble experts and to discuss research done and being conducted in the field of crop improvement, in order to determine the common areas of action and the problems to be resolved while formulating suggestions for solutions to these problems.

3. The participants concluded that the number of researchers working on these crops bears no relation to the gravity of the practical problems which require a solution.

4. The participatns emphasized the need to establish in Africa a sorghum collection as well as a millet gene bank. The importance of observing phytosanitary regulations was stressed, but it was felt that the rules governing movement of seed within Africa should be reviewed and revised in order to facilitate seed exchanges.

The Major cereals project will sponsor its 4th biennial conference in Dakar, Senegal, July 19-22, 1971. The theme will be, "Environmental factors affecting yields of cereals in Tropical Africa". The format of the conference will call for key papers to be presented by guest speakers on the topics followed by discussion:

1. Photosynthetic potential of the tropics.
2. Other climatic factors limiting yield.
3. Effect of date of planting.
4. Relations of nitrogen and phosphorus and other elements.
5. Soil erosion and tillage.

Regional travel: Following the seminar in Senegal, Drs. York and Barreto and I returned to Nigeria via Mali and Upper Volta. This was the first visit to Mali by any of our staff, although we conduct cooperative trials with M. Bono, Director of IRAT in Mali. Arrangements were made for us to visit the Ministry of Agriculture.

J. F. Poulain, Director for IRAT in Upper Volta arranged for our tour in that country. We met Dr. Sery, Director of Agriculture who expressed an interest in the project and suggested that his country may have four candidates to nominate for our participant training program. These persons have received degrees in agriculture from University in Ghana. C. Robledo is now the cereal breeder for Upper Volta and the program has been strengthened by the addition of a second French expatriate.

From June 22 to July 10, I toured Ivory Coast, Ghana and Dahomey with M. Harrison, maize specialist for IITA and Dr. E. Sprague, Director of the maize program of CIMMYT in Mexico. N'Guetta Bosso, maize breeder in Ivroy Coast has two degrees from American Universities and spent six months at CIMMYT as a trainee before beginning his work. We were very impressed with the scope of his project.

Ghana has a number of well trained agricultural scientists but the research program is hampered by a shortage of operating funds. Composites have been synthesized and have shown a good potential in the west African Maize Trials. We visited two large commercial farms specializing in mechanized maize production. Ghana has land resources which can be developed in a system of modern mechanized agriculture. Numerous problems have arisen in crop management and weed control which must be solved before this type of agriculture can succeed.

I joined the Grain Stabilization team from Kansas State University in Mali on November 6 as an advisor on crop production, and toured with it to Ivory Coast and Upper Volta. The purpose of the team was "to develop step-by-step guidelines with approximate time schedules for needed recipient countries 'and donors' actions, including resource inputs, for initiation, expansion and operations of food grain production, marketing, storage, transport and distribution programs in Mali, Senegal and Upper Volta". A Canadian team

was to make the survey in Niger. My function on the team was to relate the experiences I have gained relating to agricultures production in west Africa and its potential. Such information was of value to the team in planning the types of storage facilities which will be required. The information that I was able to provide was substantiated and supplemented by the agricultural research staff in these countries.

Copies of trip reports are available.

Training

Daniel Adedzwa, graduate of the Botany Department of Ahmadu Bello University served as a graduate-in-training with the maize project from September 1969 until he left for Iowa State University in August 1970. He is supported from a grant from Rockefeller Foundation. Upon his return he will either be posted at Samaru as maize breeder or at Mokwa to fill the vacancy when Franz deWolff left.

Gideon Akleniyi replaced Adedzwa on the Cereal project and will expect to leave for Iowa in August of 1971. Both Adedzwa and Adeniyi will return to Ahmadu Bello University to complete their requirements for M.Sc. degrees and will join the team of cereal breeders.

Siman K. Manze, after a year's training with Dr. King, left in December 1970 for a year of study in the Plant Pathology Department of the University of Minnesota. When he returns, he will continue his research on the smuts of sorghum for his M.Sc. thesis.

J. M. Fajemisin worked several months as an assistant to Dr. Craig at Ibadan before leaving in January of 1971 for the University of Illinois where he will work towards a Ph.D. degree.

Kingsly Adeoya received his B.Sc. degree in soils at the University of Ibadan and has been working since July 1, 1970 as a trainee under Dr. Stockinger. Arrangements have been made for him to go to Iowa State University for a year and return to complete his work for his degree at Ahmadu Bello University.

Negotiations are underway to send J. Eckebil from the North Camerouns to the States for training.

An offer was made to N. Bosso of the Ivory Coast for training toward a Ph.D. degree. After due consideration we agreed that because of the special type of training that he would require to fit him for his future position in the Faculty of Agriculture that he should accept a Ford Foundations; offer for support.

Our project should not be concerned who supports participants but should rather concentrate on number of trained specialists to be established in west Africa when the project is phased out. The few people on the Major Cereals Project will not in the life of the project make any great contribution to the development of a number of new varieties or determining crop production techniques to increase production in the region. The major contribution will be the organizing of the few specialists in the area to work as a team and to leave an increased number of trained people.

In the third year I taught plant breeding to the part III student of the Faculty of Agriculture, Ahmadu Bello University. There were 28 students in the class.

Regional Sorghum and Millet Trials, 1969

O. J. Webster

The regional sorghum trials have demonstrated that sorghums are generally adapted to specific ecological zones. Based upon the results of the trials first started in west Africa in 1966 it was decided to establish two nurseries, one for the Guinea Savanna and a second for the dryer Sudan Savanna Zone. The yield data from these trials suggests that the two zones should be further subdivided.

For example, the varieties which Mr. Andrews has developed for the northern Guinea Savanna are not suited to the season in the southern parts of the Guinea Savanna or the Sudan Savanna Zones. Sorghums planted at Samaru, Nigeria with the first rains in late May or early June, head out about the first of October and mature during the dry season on residual moisture in the soil. The grain produced on such varieties is relatively free of fungus and preferred for human consumption. Earlier maturing varieties may give higher yield but the grain quality is poor and unacceptable as food.

The development of improved sorghum varieties for west Africa requires that they fit the specific requirements of narrow ecological zones no wider than 75 to 100 miles. The few breeders are able to develop new varieties for only the zone in which they are working. This means that the local varieties usually give the best yield performance in the regional trials at a location.

The Guinea Savanna included 12 entries planted at 5 locations (Table 1). The best yields were reported from Soucoundou, Camerouns. Hybrid 93 x 5764 gave the highest yield at all locations, with 3583 kg/ha. The entries from Nigeria averaged less than 250 cm in height while those from Ghana ranged up to 418 cm (Table 2). The Nigerian varieties bloomed in 106 to 115 days while those from Ghana ranged from 89 to 104 (Table 3).

Table 1. Yields reported from the Guinea Savanna Regional Sorghum Trial, 1969 (kg/ha)

Entry	Source	Country Location	Nigeria Samaru	Ghana Nyankpala	Gambia Yundum	Senegal Sefa	Cameroun Soucoundou
AA 226/3M	Ghana		50	102	1133	2631	1829
AA 228/3M	Ghana		36	254	1446	2738	2087
AA 347/5M	Ghana		423	67	883	1750	2408
Bawku Local	Ghana		68	38	903	2000	2555
Mankaragu	Chana		405	971	788	1857	2989
5912 Short Kaura	Nigeria		2678	114	301	1238	2951
2141 GSK-WX	Nigeria		1813	70	302	851	2104
2083 CKB-SK-MDW	Nigeria		1966	140	412	1119	1890
Hybrid 93 x 5764	Nigeria		1966	114	524	1071	3583
2123 SKB-FF	Nigeria		2216	222	506	1571	1751
2347 SK-MDW	Nigeria		1322	127	888	1095	2220
1879 GSK-RC	Nigeria		--	178	706	655	2341

Table 2. Heights reported from the Guinea Savanna Regional Sorghum Trial, 1969 (cm)

Entry	Country Location	Nigeria Samaru	Ghana Nyankpala	Gambia Yundum	Senegal Sefa	4 - State Average
AA 226/3M		365	410	305	430	378
AA 228/3M		410	425	347	490	418
AA 347/5M		310	405	335	385	359
Bawku Location		400	405	320	470	399
Mankaragu		380	480	360	450	418
5912 Short Kaura		200	250	255	270	244
2141 GSK-WX		175	215	180	245	204
2083 CKB-SK-MDW		180	205	180	215	195
Hybrid 93 x 5764		130	180	160	190	165
2123 SKB-FF		125	155	160	160	150
2347 SK-MDW		110	170	165	165	153
1879 GSK-RC		--	160	140	145	148

Table 3. Number of days to bloom reported from the Guinea Savanna Regional Sorghum Trial, 1969

Entry	Country Location	Nigeria Samaru	Ghana Nyankpala	Gambia Yundum	Senegal Sefa	Cameroun Soucoundou	5 - Station Average
AA 226/3M		94	108	89	88	64	89
AA 228/3M		96	108	86	104	65	92
AA 347/5M		118	100	109	105	63	99
Bawku Local		98	112	89	89	65	91
Mankaragu		126	103	109	88	92	104
5912 Short Kaura		127	103	113	114	100	111
2141 GSK-WX		127	106	113	117	110	115
2083 CKB-SK-MDW		126	103	113	117	104	113
Hybrid 93 x 5764		120	100	113	106	97	107
2123 SKB-FF		120	100	107	105	98	106
2347 SK-MDW		124	104	119	116	100	113
1879 GSK-RC		-	100	113	115	98	107

Yield were higher in the Sudan Savanna Trial (Table 4). Hybrid NK 300 gave the best yield in most trials as it has in past years. It yielded 5423 kg/ha at Samaru, Nigeria and 5387 kg/ha at Richard Toll, Senegal. This hybrid does well at most locations not only because it has a good yield potential but also because the seed is brown which is non-weathering and relatively bird resistant. The grain quality is such that it would not be acceptable by most people. However, in a palatability trial at Kano in 1969 the women reported that they would eat it if there was a supply and the price was right. The farmers have been asking for seed but until hybrid seed can be produced locally, hybrid sorghum production will not be encouraged.

We have a hybrid with white grain which would be more readily accepted but we have not been able to produce seed in quantity. Pilot scale production plots will be tried in 1971 by planting in August on land which can be irrigated. More favorable results may be expected from delayed plantings in the season now than when previously tried because of the chemicals now available for insect control. Delayed planting will solve the problem of isolation, seed produced during the early part of the dry season will be of good quality, the problem of infection from ergot will be minimized and insects such as midge and numerous grain feeders will not be a problem.

The Indian hybrid CSH-1 has acceptable grain quality and yields are good in most trials. GSH-1 had an average blooming date of 57 days (Table 5). The latest variety, Dobbs bloomed in 84 days. All entries except Sorgho 29 and SH-11 are relatively short, less than 200 cm. (Table 6). Once the desirable types have been developed then work will proceed to the development of millet hybrids.

Table 4. Yields reported from Sudan Regional Sorghum Trial, 1969, Kilograms per Hectare

Entry	Country	Nigeria		Uganda	Gambia	Niger		Upper Volta		Senegal		Cameroun
	Location	Samaru	Kano	Serere	Yandum	Tarna	Kawara	Saria	Farako-ba	Richard Toll	Bambey	Guetale
Sorgho 29			998	4450	1784	2120	1600	406	2184	2184	600	2125
SH - 11		1584	730	2990	1425	2583	2050	290	1415	2507	1173	3033
CSH - 1		3381	2951	--	2887	2291	2400	749	740	2678	2418	2150
137 - 62		4509	2604	2960	1837	2437	2500	334	1775	3274	2618	3691
NK 300		5423	3366	3785	2358	4435	3300	493	2271	5387	3942	3391
Serena		3473	947	4000	2251	1535	2900	278	2999	2440	1382	3608
Dobbs		1676	712	--	2136	877	1375	28	2012	1626	1035	2983
5D x 57/1/E		3138	1801		2107	3266	2725	328	1746	3169	1333	3367
H x 60/7/2A		2102	1897		2116	2583	825		2121	2492	422	1716
5D x 160/4/1		1279	143		1876	1072	1125	87	1806	1507	489	2350
5D x 36/1/2		1706	296		2285	1121	1300	28		2191	671	2367
IS 9290		4301	1546	2760	1873	2632	1650	246	1656	3333	1742	3192
CE 90		2345	2106		402							

Table 5. Sorghum days to bloom reported from Sudan Savanna Regional Trial, Days

Entry	Country	Nigeria		Uganda	Gambia	Niger		Upper Volta		Senegal		Cameroun	9
	Location	Samaru	Kano	Serere	Yundum	Tarna	Kawara	Saria	Farako-ba	Richard Toll	Bambey	Guetale	Station
Sorgho 29		79	91	64	67	78	88	80	77	78	83	65	78
SH - 11		74	82	64	64	68	88	79	76	69	76	61	73
CSH - 1		62	58		62	45	54	59	62	58	52	57	57
137-62		70	75	54	64	63	80	77	74	70	76	63	71
NK - 300		60	69	50	62	60	70	73	62	67	62	59	63
Serena		79	79	63	62	72	88	--	84	75	76	71	76
Dobbs		89	89		76	78	88	--	85	86	83	81	84
5D x 57/1/E		78	78		64	66	80	--	77	78	72	72	74
H x 60/7/2A		88	91		77	74	88	86	87	81	79	77	82
5D x 160/4/1		88	92		72	76	86	84	86	84	83	78	83
5D x 36/1/2		87	89		76	76	88	79	75	86	76	78	81
IS 9290		74	79	58	64	67	72	--	--	69	66	61	69
CE		67	67		56								

Table 6. Sorghum heights reported from Sudan Savanna Regional Trial, 1969 (cm)

Entry	Country Location	Nigeria Samaru	Kano	Gambia Yundum	Niger Tarna	Kawara	Upper Saria	Volta Farako-ba	Senegal Richard Toll	Bambey	Cameroun Guetale	10 Station Average
Sorgho		350	400	240	355	360	310	370	387	381	350	350
SH - 11		330	410	250	348	247	275	350	365	374	315	326
CSH - 1		155	155	160	93	110	125	88	142	107	135	127
137 - 62		215	200	160	190	160	135	160	215	223	170	173
NK - 300		210	185	180	165	176	140	135	207	178	160	174
Serena		230	190	165	189	110	135	190	203	176	195	178
Dobbs		250	180	180	192	160	145	215	194	215	205	194
5D x 57/1/E		220	175	140	150	165	135	160	185	161	170	166
H x 60/7/2A		200	180	155	151	125	120	165	186	152	180	161
5D x 160/4/1		250	190	170	183	146	160	165	203	195	210	187
5D x 36/1/2		250	200	175	188	118	155	-	204	217	200	190
IS 9290		150	140	140	112	174	115	110	148	128	130	135
CE 90		170	180	140								

Sudan Savanna Regional Trials
O. J. Webster

The regional Sudan Savanna nursery made up of early maturing varieties is grown in seven west Africa countries and was planted at 4 locations in Nigeria. It included 12 entries, CK-60 x SA7706-5-1, NK-300, IS9290, NK9357, CE90, Serena, 5DX 36/1/2, 137-62, SH-11-D-1, Damougari No. 55, Sorgho 29, and Zauna Inua. The other 12 entries listed in Table 20 were included because of local interest. Stem borer infection of the peduncles was nearly 100% of a few varieties which caused a significant reduction in yield. Grain sucking insects are also suspected to reduce seed size but no methods have been found to determine losses.

The hybrids, CK-60 and 4 dwarf CK-60 x SA7706-5-1 are white seeded and yield as well as NK-300 which is the best yielding entry in the west African trial. These hybrids do not have the "bird resistance" or non-weathering characteristics of NK-300. Experimental seed production of the two hybrids will be attempted.

A composite is being synthesized using a genetic male-sterile. It is expected that this composite will be a source of new varieties in the Sudan Savanna region.

Six locations reported yields from the Sudan Savanna Observation nursery (Table 7). Yields from the single plots per location were variable but in general NK 300 and hybrid CK-60 x SA7706-5-1 gave the best yields. The entries in this nursery are relatively early maturing, ranging from 60 to 83 days to bloom (Table 8). IS956 is the tallest of the group (Table 9). For the 6-station average it was the only entry to exceed 200 cm in height. This variety has good resistance to foliar diseases and has good seed quality.

Millet Regional Trials

The first regional millet trial was conducted in 1969. There are two major types grown in west Africa. The early type, known in Nigeria as Gero, is the predominate one in Senegal, Niger and northern Nigeria. The late millet, known as Maiwa, is day-length sensitive and is found in Mali, Upper Volta, Ghana, and in scattered areas in northern Nigeria as a sole crop or often interplanted in the same field with Gero. An early type found in Mali and Ghana resembles the millet from

Table 7. Yields reported from Sudan Savanna sorghum observation, nursery, 1969. kg/ha

Entry	Country Location	Niger Kawara	Nigeria Samaru	Gambia Yundum	Uganda Serere	Cameroun Guetale	Senegal Bambey
IS 517		1692	1220	1856	2100	2267	1340
IS 956		2412	3660	1652	690	2500	2060
IS 1054		2052	1403	2028	1540	1833	1660
IS 2341		2952	2135	1706	2995	2583	2640
IS 3170		1008	--	815	--	1383	460
IS 3663		2700	1647	719	1860	250	1140
IS 3665		2412	3111	805	2015	1167	560
IS 3922		1476	610	655	--	300	780
IS 4131		2448	--	1685	--	1600	440
IS 9289		4140	3477	1620	2855	3933	2120
IS 9320		2844	2745	805	1250	1533	2060
IS 9366		2052	2135	719	545	1517	1480
IS 9370		1980	--	944	--	2350	1220
CK-60 x SA7706-5-1		3996	6771	2017	2925	6500	4000
NK - 300		4068	7198	2897	2700	5560	3880
NK - 265		2412	3782	2274	940	3750	
7199		3168	--	1084	2500	2933	
7652		1908	3233	1599	2155	3850	
7692		2772	3355	2253	2170	3817	
C 9357		3276	--	2113	2955	3983	
C 9358		3384	--	1491	1570	3417	
C 9411		3168	--	2157	2955	4200	
C 10453		2736	5307	1663	2100	2867	
C 10461		3276	--	1878	1720	4433	

Table 8. Days to bloom reported from the Sudan Savanna Sorghum Observation nursery, 1969

Entry	Country Location	Gambia Yundum	Ghana Nyankpala	Cameroun Guetale	Nigeria Samaru	Upper-Volta Saria	Senegal Bambey	5-Station	6-Station
IS 517		64	53	57	65	75	55	62	62
IS 956		78	71	66	73	84	72	74	74
IS 1054		89	69	57	82	84	76	76	76
IS 2341		86	64	57	79	78	70	73	72
IS 3170		64	66	58	69	75	58	66	65
IS 3663		64	58	58	65	75	58	64	63
IS 3665		67	53	62	64	75	55	64	63
IS 3922		76	66	72	73	75	62	72	71
IS 4131		86	73	77	90	90	76	83	82
IS 9289		68	62	57	78	78	70	69	69
IS9320		70	62	63	69	75	62	68	67
IS 9366		76	65	63	72	80	62	71	70
IS 9370		70	62	61	70	75	55	68	67
CK-60 x SA7706-5-1		64	53	57	65	75	58	63	62
NI -300		56	53	59	64	75	62	61	62
NK -25		60	62	55	65	67	--	62	--
C 9357		62	71	61	--	75	--	67	--
C 9358		64	68	61	--	78	--	68	--
7199		64	63	57	--	71	--	64	--
C9411		60	67	57	--	78	--	66	--
C 10453		62	64	57	65	75	--	65	--
C 10461		62	66	57	--	71	--	64	--
7652		53	63	55	59	71	--	60	--
7692		57	70	60	61	75	--	65	--

Table 9. Heights reported from the Sudan Savanna sorghum observation nursery, 1969

Entry	Country Location	Gambia Yundum	Ghana Nyankpala	Cameroun Guetale	Nigeria Samaru	Upper Volta Saria	Senegal Bambey	5 Station Ave.	6 Station Ave.
IS 517		140	124	109	140	119	70	122	117
IS 956		245	250	264	335	306	330	240	288
IS 1054		175	200	172	210	200	180	191	190
IS 2341		150	300	167	220	192	165	206	199
IS 3170		140	144	169	180	170	135	161	156
IS 3663		100	120	103	135	115	75	115	108
IS 3665		110	130	111	140	125	80	123	116
IS 3922		110	145	108	135	128	80	125	118
IS 4131		210	215	180	220	192	155	203	198
IS 9289		135	175	169	190	176	150	169	166
IS 9320		150	170	140	180	174	125	163	157
IS 9366		135	150	121	165	134	105	141	135
IS 9370		160	170	158	190	160	135	168	162
CK-60 x SA7706-5-1		160	200	181	210	188	180	188	187
NK 300		175	180	179	210	190	160	187	182
NK 265		150	150	139	140	127	---	151	---
C 9357		175	185	169	---	178	---	151	---
C 9358		150	165	147	---	151	---	153	---
7199		125	135	119	---	131	---	128	---
C 9411		145	155	139	---	141	---	145	---
C 10453		145	150	139	150	146	---	146	---
C 10461		155	160	146	---	161	---	156	---
7652		150	135	132	150	147	---	143	---
7692		150	145	132	150	144	---	144	---

Uganda, having short, thick spikes in contrast to the long slender ones of the Geros. The highest yield of 4400 kg/ha was made by Ex Bornu at Samaru (Table 10). Yields of over 3000 kg/ha are considered good but we do not know what the real potential of this crop may be with improved varieties grown under good management. As yet we do not have the varieties nor do we know what are good management practices, such as dates of planting, populations, fertilizers to use etc.

The millets included in the trial are divided into early (46 to 62) days and late (80 to 85) days to bloom (Table 11). The late varieties were also the taller (Table 12).

The breeding work is designed to further improve Ex Bornu and to inbreed within this population in an attempt to locate sources of resistance to the disease, downy mildew, smut, and ergot. Considerable progress has been made in isolating lines resistant to the first two diseases.

Crosses have been made to develop millet lines shorter in stature than the locals which can be planted at higher populations. Once the desirable types have been developed then work will proceed to the development of millet hybrids.

An occasional field of finger millet (Eleusine coracana) is found on the Jos Plateau. Seed of 10 varieties was introduced from Uganda and planted in a trial at Samaru. The best varieties gave yield of about 1700 kg/ha. The crop does not seem to be too well adapted to this part of Nigeria when planted in early June. Later plantings in the season may do better.

Table 10. Yields reported from regional millet trial, 1969 (kg/ha).

Entry	Source	Country Location	Niger Tarna	Kolo	Ghana Nyankpala	Cameroun Guetale	Nigeria Samaru	Senegal Bambey
Zongo	Niger		1702	664	90	--	1278	0
P-3 (Kolo)	Niger		1940	1036	54	1290	2025	285
M-2	Ghana		1920	168	18	3062	1371	125
NKB	Mali		1786	837	1002	2407	taken by bird	0
NKK	Mali		1756	662	969	2278	do	0
NBB	Mali		1425	641	1184	2241	do	0
NBK	Mali		1517	715	664	1716	do	0
M-7	Mali		1469	773	158	1802	do	0
Ex Bornu	Nigeria		2729	733	72	2278	4442	768
Souna	Senegal		1924	---	--	2869	do	1741
115-4	Senegal		1779	---	--	3333	do	-

Table 11. Days to bloom reported from regional millet trial, 1969 (days).

Entry	Country Location	Gambia Yundum	Niger Tarna	Kolo	Ghana Nyankpala	Cameriou Guetale	Nigeria Samaru	Upper Volta Saria	Senegal Bambey	8 Station Average
Zongo		65	55	58	81	63	47	68	55	62
P-3 (Kolo)		57	58	64	77	58	47	63	55	60
M-2		50	38	45	48	46	31	62	45	46
NKB		86	91	101	78	46	85	85	80	82
NKK		86	91	101	84	50	85	85	80	83
NBB		80	88	99	83	74	83	85	80	84
NBK		80	91	101	85	77	81	85	80	85
M-7		84	80	97	82	69	65	85	80	80
Ex Bornu=		65	48	64	63	57	42	62	55	57
Souna		57	63	--	--	54	--	62	60	--
115-4		57	58	--	--	55	--	62	--	--

Table 12. Heights reported from regional millet trial, 1969 (cm)

Entry	Country Location	Gambia Yundum	Niger Tarna	Niger Kolo	Ghana Nyankpala	Cameroun Guetale	Nigeria Samaru	Upper Volta Saria	7 Station Average
Zongo		230	250	170	325	310	330	170	255
P-3 (Kolo)		250	250	210	260	300	320	147	248
M-2		210	185	150	185	210	190	163	185
NKB		260	355	215	270	375	420	148	292
NKK		265	350	265	285	350	430	12	295
NBK		270	330	250	290	350	410	190	299
M-7		260	320	245	265	320	420	135	281
Ex Bornu		220	245	180	290	280	240	171	232
Souna		230	225	---	---	260	---	146	---
115-4		235	255	---	---	260	---	151	---

The West African uniform maize trials were started in 1967. The purposes of this regional project were to identify high yielding hybrids, synthetics or varieties, to determine the zones of adaptation of these maize selections in West Africa and to increase the exchanges of seed and information among maize improvement specialists in West Africa.

Participating countries send seed of their trial entries to the trial center at Ibadan. This trial seed is distributed to participants and trials are conducted by maize specialists in each of the cooperating countries. Results of the trials are sent to AID-ARS major cereals project for compilation and distribution to participants.

The trials have been of great value in providing information to West African maize breeders on promising maize selections in this region. The results of the 1969 trials are shown in Table 13.

Nine countries- Dahomey, Senegal, Upper Volta, Gambia, Ghana, Ivory Coast, Mali, Sierra Leone and Nigeria participated in the 1970 uniform maize trials. Only Nigeria and Upper Volta had submitted the 1970 trial results at the time this report was prepared (Table 14).

Table 13. Yields of 1969 West African Uniform Maize Trial Entries at 8 sites.

Entry	Origin	Ivory Coast	Sites and yields* in quintals per hectare							
			Gambia	Upper Volta	Ghana	Senegal	Mokwa Nigeria	Samaru Nigeria	Ibadan Nigeria	Mean
Composite 2	Ghana	24.4 ab	29.4 a	48.6 a	29.2 a	35.2	33.5 ab	66.1 a	22.2 a	36.1
Composite 3	Ghana	23.5 abc	34.1 a	41.8 b	30.9 a	31.7	35.1 a	63.6 a	20.1 ab	35.1
094	Nigeria	25. ab	38. a	44.4 ab	31.8 a	28.1	32.4 abc	62.6 a	18.1 b	35.
Massayomba	Upper Volta	24.9 ab	29.9 a	46.3 a	28.6 a	36.4	28.5 cd	58.1 a	17.8 b	33.8
BDS	Senegal	18. cd	36.6 a	39.6 b	24.7 a	41.1	25.4 d	60.1 a	12.9 c	32.3
NSI	Nigeria	23.9 ab	33.5 a	33.7 a	28.3 a	30.8	30.6 bc	58.8 a	11.5 c	31.4
Jaune Hatif	Upper Volta	17. d	38.3 a	40.1 b	25. a	38.6	20.1 e	48.5 a	10. c	29.7
Darsalam	Upper Volta	20. bcd	32.3 a	39.2 b	21.4 a	32.1	20.5 e	52.7 a	9.3 c	28.4

* Yields in quintals per hectare of dry shelled grain. At each site yields with any alphabetical letter in common are not significantly different at the 5%. Yields with no alphabetical letter in common are significantly different.

Table 14. Yields of 1970 west African uniform maize trial entries at 4 sites.

Entry	Origin	Upper* Volta	Mokwa** Nigeria	Samaru* Nigeria	Ibadan * Nigeria	Mean
094	Nigeria	52.7 a	38.4	60.1 a	41. a	48
NCB	Nigeria	46.6 abc	41.5	62.2 a	32.4 b	45.7
Composite 2	Ghana	49.3 ab	40.5	63.1 a	26.6 bcd	44.9
NCA	Nigeria	41.9 bc	39.5	64.8 a	30.6 bc	44.2
BDS	Senegal	41.4 bc	--	64.6 a	16.9 e	41.
Composite 3	Ghana	45.2 abc	31.	61.4 a	24. d	40.4
CJI	Dahomey	41. bc	36.	55.8 a	24.6 cd	39.3
Jaune Hatif	Upper Volta	36.8 c	28	52.2 a	11.3 e	32.1

* Yields given quintals of dry shelled grain per hectare. Yields with any alphabetical letter in common are not significantly different at the 5% level. Yields with no alphabetical letter in common are significantly different at the 5% level.

** L.S.D. 6Q/ha.

Local Activities

Sorghum Breeding - Nigeria

D. J. Andrews and J. A. Awoniyi

The sorghum breeding program of the Institute for Agricultural Research at Samaru consists of breeding programs at Kano and Samaru designed to produce dwarf varieties and hybrids suitable for grain production in the Sudan and Northern Guinea Savanna zones. Foundation seed of improved local cultivars, a range of which are now available for all the major sorghum growing areas, is produced at Kano, Samaru and Mokwa for state multiplication schemes. Mokwa is situated in the Southern Guinea Savanna Zone where there is a bimodal rainfall pattern and the local varieties span both seasons. No intensive breeding of dwarf varieties is carried out at Mokwa but planting the Samaru dwarf varieties in the late season has given encouraging results in the Southern Guinea zone, and is being further investigated.

The onset of the rainy season was late especially in the northern areas and delayed planting at the Kano station by about 6 weeks. This rendered most yield trials ineffective though it was possible to continue selection work in segregating populations.

Work at Samaru consisted of trials on date of planting, population and intercropping in addition to the breeding program.

Crossing and selection were continued at Samaru to produce dwarf lines and hybrid parents suitable for the sub-Sudan and Northern Guinea Savannas. Three hundred and fifty new introductions were screened in 1970 and 16 were selected as breeding parents, each being hand-crossed both to six of the best existing dwarf lines and to male sterile bulk (below). Some 70 of the introductions were also kept for possible use in drier areas, and a group with good grain weathering characteristics were selected. Population breeding using genetic male sterility (ms7) was continued on the original bulk started in 1966. Selections were made among the F_2s of various crosses made to this bulk. These will form several new bulks parts of which may be recombined. Twenty-three new lines, from crosses made two to four-years ago were yield-tested in 1970. Four proved very satisfactory and will move forward into the 1971 main dwarf lines trial which is replicated through the northern states.

The results of the 1970 dwarf lines trial at three sites around Zaria are shown in Table 15. Line 5912 SK, newly recommended at Bauchi (10° 20' N, 9° 50'E) and Hong (10° 20'N, 13° 0'E) maintained its premier position among the medium tall (2-2.5m) 2-dwarf lines and 2141 (gSK-WX), also newly recommended at Hong, gave a good yield. Among the shorter

Table 15. Sorghum dwarf lines trials, Zaria area 1970. Grain yields in $Kgha^{-1}$

Line and type	Samaru	N.T.C.	Shika	Average kg ha^{-1}	Average lb/ac
3 dw. lines					
1904 (CK-SK)SK	2761	2153	1384	2099	1872
1682 (") "	3850	3045	1379	2758	2460
1143 (CK-FF)	2310	1938	1910	2053	1831
1018 (CK-Kur)	1758	1446	1345	1516	1352
1161 (CK-FF)	2615	2350	2622	2529	2256
1879 (CK-RC)	2790	2368	2011	2390	2132
mean	2680	2217	1775	2224	1984
2 dw. lines					
1878 (CK-SK)SK	3444	2124	2407	2658	2371
2141 (gSK-WX)	4025	2362	3158	3182	2838
1685 (CK-SK)SK	3502	1503	2650	2552	2276
60 WX	2310	2068	2751	2376	2119
5912 SK	4373	2797	3362	3511	3132
1208 (Gsk-WX	2659	2537	2966	2721	2427
mean	3385	2232	2882	2834	2528

Fertilizer: 50 $kgha^{-1}$ P_2O_5; $kgha^{-1}$ split dressing of N.

3-dwarf lines 1161 (CK-FF) performed well and has better grain quality than 1682 (CK-SK) SK) and 1879 (gSK-RC). 1161 is the final selection of the 2123 type, and showed a slight improvement in yield and grain size. 1161 which is white seeded, is now recommended for the Zaria-Daudawa area after showing a mean yield of 1854 bl/ac in 10 variety trials. This is 35% more than the six year average of the best white seeded improved local cultivars.

The 1970 date of planting experiment was a repeat of the 1969 trial of the same design. The object was both to measure the rate of loss of grain yield with delay in planting and to compare the reaction of a typical dwarf variety (line 2123) with a local cultivar (FFBL 3-1-6).

As in 1969 good yields were given by the first several plantings, up to the 6th May. Table 16 shows the yields declined from planting on and after 13 June. As in 1969 the early part of the wet season was rather dry which may have prolonged the optimum planting period. Over the first four plantings line 2123 gave 40 percent more yield than FFBL 3-1-6. The yields on the later plantings were lower than in 1969 owing to an end-of-season drought. Essentially the two varieties reacted the same to date of planting and line 2123 can be planted over the same period as the local sorghums.

The new dwarf varieties of sorghum bred at Samaru permit plant densities to be used which are higher than the optimum for the tall local cultivars (36,00 plants per ha; 14,500 plants per acre.) The 1970 population trial was similar to those carried out in the two previous years where line 2123 was used as being typical of the dwarf type. Populations of sole sorghum were also included in intercropping trials (below).

Table 17 shows that the best yield was obtained from a harvest population of 65,234 plants per ha (72,450 seeded). The grain yields from the wide range of populations used were not greatly different. This is largely explained by the amount of tillering occurring at the low populations and by the elimination of up to 35 percent of the plants before heading in the high populations.

The present results agree well with those from the previous trials and indicate that the dwarf types best at about double the population used for the local varieties. With good fertility a population of about 72,000 plants per ha is best, which is equivalent to plants 0.15m apart on 0.9-m rows (6 x 36 in.) or 0.2m on 0.7-m rows (8 x 28 in.). However, it is important to note with the dwarf type that near optimum yields were given over a wide range of populations and it is not critical to exactly reach the density stated above.

Table 16. Sorghum planting sequence Samaru 1970 comparing tall (FF BL 3-1-6) and dwarf (Line 2123) varieties at eight weekly intervals. Grain yields in kg ha^{-1}.

Planting date	16 May	23 May	30 May	6 June	13 June	20 June	27 June	4 July
FF BL 3-1-6	1,613	1,621	1,668	1,488	1,188	891	299	175
Line 2123	2,169	2,434	1,986	2,369	1,774	1,036	773	430

Fertilizing 50 kg ha^{-1} P_2O_5; 75 kg ha^{-1} split dressing of N.

Table 17. Dwarf sorghum plant population trial, Samaru 1970. Populations in plants per hectare (p.p.h). Grain yields in kg. per hectare.

Planted p.p.h	Established pct.	Surviving at Harvest p.p.h	Surviving at Harvest Pct.	Heads per plant	Grain kg ha^{-1}	Total dry matter kg ha^{-1}
24,142	100.0	23,733	98.6	3.54	4,141	21,041
72,450	99.3	65,234	94.3	1.57	4,583	26,209
118,534	99.5	90,439	78.4	1.12	4,374	25,929
165,928	98.3	101,657	62.5	1.06	4,132	24,965
S.E.					± 192	± 995

Test variety: Line 2123. All treatments on rows 70 cm. apart.

Ferterilizing: 50 kg ha^{-1} P_2O_5; 75 kg ha^{-1} split dressing of N.

An intercropping trial was carried out using dwarf sorghum (2123) and improved local early maturing millet and cowpea. The millet and sorghum were planted together early in the season and the cowpeas in mid season, after the millet harvest.

The 1970 trial was developed through a series of trials over the three previous years. The principal object was to find out if intercropping can be completely mechanised on a row basis and to separate the effects of population and intercrop competition. The crop mixture selected is one commonly used by farmers.

The gross returns in Table 18 show that intercropping gives a big gain over sole cropping either of the cereals and some advantage over relay cropping the millet and cowpeas. However, the necessity of having the ground completely bare between crops makes relay cropping dangerous where erosion is likely. The best return was given where there were single rows of sorghum alternating withdouble rows of millet followed by cowpea.

This was the best combination to exploit the relay cropping while allowing the maximum benefit to sorghum when planted in single rows. This is also the easy to mechanise since the double row allows entry after the millet harvest to cultivate and seed the cowpea crop. In the 1:2 mixture the millet rows gave an increase in yield of 37 percent over the yield of equivalent rows in a sole crop and the sorghum an increase of 81 percent compared to a row in a sole crop. Planting the crops on alternate rows (1:1) gave almost as good a return per ha as the 1:2 ratio. Cowpea grain yields were greatly depressed by intercropping (all cowpeas were sprayed).

Though planted at the same time (farmers often plant millet first) the different growth cycles of the millet and sorghum crops largely separate their demands on the environment and allow each crop to benefit. The extent of this gain depends on how the crops are mixed. Where the mixture consisted of alternate rows (Treatment 3) the millet gave a yield of only 22.2 percent (2,380 kg ha^{-1}) less than the millet sole crop (2,893 kg ha^{-1}) and the sorghum 25.3 percent less than the sole crop yield. The loss in yield is due to two components: drop in population and competition. For Treatment 3 the experiment showed that 9.6 percent of the millet loss in yield was due to population, and 12.6 percent due to the presence of sorghum. It is apparent, especially where the competition from the other crop is low, that the row population of the crops may have to be raised above the normal sole crop density,to take full advantage of the situation.

All operations on this experiment, which occupied about 1 ha, with the exception of cultivating and planting single rows of cowpeas, were carried out mechanically with the same effectivenss as on sole crops.

Table 18. Intercropping with dwarf sorghum early millet and cowpeas, Samaru 1970.

Summary of grain yields and gross returns			
Treatment Number	Grain yield kg - ha^{-1}	Gross value from one hectare (shillings)	
100% sorghum	2,893	1,594	
(1)			1,594
100% millet followed	3,060	1,807	
by 100% cowpeas	998	726	
(2)			2,533
50% Sorghum (1 row)	2,162	1,192	
50% Millet (1 row)	2,380	1,405	
f.b. 50% Cowpeas	229	166	
(3)			2,763
33% Sorghum (1 row)	1,750	965	
67% Millet (2 rows)	2,806	1,657	
f.b. 67% Cowpeas	352	256	
(4)			2,878
50% Sorghum (2 rows)	2,113	1,165	
50% Millet (2 rows)	2,081	1,228	
f.b. 50% Cowpeas	258	188	
(5)			2,581

Prices:

Sorghum	551/-	per	1,000 kg	(560/-	per ton)
Millet	591/-	"	"	(600	" ")
Cowpeas	728/-	"	"	(740	" ")

Fertilizing: 50 kg ha^{-1} P_2O_5 and 75 kg ha^{-1} split dressing of No.

Millet Research - Kano Research Station

B. D. Bhardwaj

Plant Breeding

The primary aims of pearl millet improvement at Kano are to develop strains and hybrids productive of grain, resistant to lodging, downy mildew, ergot and smut and suitable for cultivation in Sudan Savanna zone. Selection and yield-testing of local strains and collections from a number of countries was continued. Work on isolation of inbred lines, production of cytoplasmic male sterile lines and new strains was continued during 1970.

Progress - Yield trials

A yield trial with local populations was continued at Hong at the request of the North East State (Table 19). Although Ex Bornu gave the highest average yield of 2,035.5 kg ha^{-1} over the last two years, this yield was not significantly different from the performance of other strains in the trial. Since no significant differences in grain yield have been observed among the strains for the past two years it is proposed to conclude further testing of local strains of Gero.

Yield testing of local Maiwa populations was continued at four sites in the northern states (Table 20). At the fourth location, Mokwa, the trial had been a failure for the first three years for one reason or another and the results for 1970 are still awaited. Over the past four years at Kano, ExGashua gave highest average yield of 1,507 kg ha^{-1} followed by Ex Ajingi and Ex Riyom each with an average yield of 1,441 and 1,381 kg ha^{-1} respectively. Ex Gashua was also found to be consistently the highest yielder over the past four years. At Kasarawa Ex Riyom gave the highest average yield of 976 kg ha^{-1}. Ex Riyom was also found to be consistently the top yielder at Kasarawa. Over the past four years at Potiskum Ex Tukuru gave the highest yield of 970 kg ha^{-1} followed by Ex Agingi and Ex Riyom with an average yield of 969 and 950 kg ha^{-1}. It is proposed to conclude further testing of local strains of Maiwa since it is now possible to arrive at a definite conclusion about these strains.

A replicated yield trial was carried out with a number of strains received from various countries through the Leader, OAU/STRC Cereals Project 26 (Table 21). Most of the strains in the trial were of medium maturity taking days for 50 percent anthesis. The average height ranged between 1.20-2.27 m. Highest yield of 1,897 kg ha^{-1} was given by 115-4 from Senegal followed by Ex Bornu Syn-1 (Nigeria) and Souna-2 (Senegal) each with a grain yield of 1,762 and 1,702 kg ha^{-1} respectively.

Table 19. Grain yield of Gero strains in yield trial at Hong.

Strains	Grain yield kg/ha		
	1969	1970	Average
Samaru 67	1625	2156	1890.5
Ere Benue	1949	2122	2035.5
B5	1925	2025	1975.0
Ere Bornu	1667	1889	1778.0
Local	1914	1838	1876.0
Ere Bauchi	1651	1810	1730.5
N6	1625	1777	1701.1
	N.S	NS	

It is proposed to repeat the trial in 1971 if fresh seeds can be obtained. A number of new introductions received from different countries were grown in observation plots during 1970. These introductions were made by the OAU/STRC Project 26. The strains were evaluated for various traits (Tables 22 and 23) for late and early millet respectively. Among the late millets, four introductions from Mali gave the highest yields ranging from 2,304 to 2,439 kg ha^{-1}. M2 D2 NKK from Mali were the earliest and took 79 days for blooming. Nyanza-2 from Ghana was the latest in maturity and took 95 days to bloom. All strains were very tall ranging in height from 2.29 to 2.71 m. Since most of these introductions appear to be very promising under Nigerian conditions, efforts will be made to obtain more seed for detailed testing in 1971. The yields of early introductions were very low ranging from 339 to 834 kg ha^{-1}. All the strains were of medium height and maturity. The height ranged between 1.06 to 1.54 m. 6A from Uganda was the earliest and took 49 days to bloom and the composite from Senegal was latest taking 62 days to bloom.

Table 20. Grain yield kg/ha of local strains of Maiwa millet.

Location	Year	Varieties							Remarks
		Ex Tukuru	Ex Gashua	Ex Ajingi	Ex Riyom	Local	Ex Audu	Ex Mokwa	
Kano	1967	1232	1568	1614	1481	1306	1402	-	*
	1968	1039	1074	1067	979	528	816	87	*
	1969	1572	1861	1587	1590	1487	1445	971	*
	1970	1536	1528	1496	1474	1445	1444	1235	N.S.
	Average	1345	1507	1441	1381	1191	1277	764	
Kasarawa	1967			Trial	written	off			
	1968			Trial	written	off			
	1969	326	312	265	392	299	252	150	*
	1970	1322	1369	1247	1559	833	924	291	*
	Average	824	850	756	976	566	588	220	
Potiskum	1967	870	869	1072	928	998	766	-	N.S
	1968	678	727	646	646	511	600	203	*
	1969	904	917	722	736	836	678	759	*
	1970	1426	1247	1437	1491	1098	1328	1487	*
	Average	970	939	969	950	861	868	816	

Table 21. Grain yield days to 50% anthesis and plant height of new strains.

Pedigree	Origin	Grain yield in kg/ha	Days to 50% Anthesis	Plant height in cms
115 - 4	Senegal	1897	60	203
Ex Bornu Syn-1	Nigeria	1762	60	208
Souna-2	Senegal	1702	61	194
P-3 Kolo	Niger	1656	62	208
Kano local	Nigeria	1567	62	227
Ex Bornu Mass.Sel.69	Samaru	1536	60	207
115-4 x 1067	Senegal	1521	61	192
Zongo	Niger	1310	59	221
Ex Bornu Syn-2	Nigeria	1114	60	195
3 A	Uganda	636	51	158
M-2	Ghana	580	50	154
23A x 3A	Uganda	542	49	134
Mangania	Ghana	528	49	147
Ex Bornu Sel.2-1-1-1-2	Nigeria	451	63	120
S.E. = 1.02				

Table 22. Yield and other agronomic data for new introduction late millet (Maiwa type).

Pedigree	Origin	Grain yield in kg/ha	Days to 50% anthesis	Plant height in cms
NKK	Mali	2439	79	270
NBB	Mali	2439	84	257
NBK	Mali	2304	81	263
NKB	Mali	2304	81	271
Sanya	Gambia	2101	91	240
M2D2	Mali	1762	79	259
M-7	Mali	1762	84	264
Nyanza-2	Ghana	271	95	229

Plot size = 2 ridges, 36 ft. long with plants 3 ft. apart.

Table 23. Yield and other agronomic data for new introduction of early millet (Gero type).

Pedigree	Origin	Grain yield in kg/ha	Days to 50% anthesis	Plant height in cms
Composite	Senegal	834	62	129
10 1b	Uganda	813	50	129
6A	"	813	49	132
26/9	"	678	57	154
17	"	678	50	130
26/19	"	542	56	129
10 1a	"	407	50	128
Millet Sel.	Batswana	339	50	106

Plot size = 2 ridges, 36 ft. long with plants 3 ft. apart.

Breeding projects

Isolation of inbred lines

During the year, 1,508 lines of Gero and 409 lines of Maiwa were carried through a fourth cycle of inbreeding and selection. As a result of selection 800 lines of Gero and 888 single plant selections of Maiwa have been retained. It is proposed to discontinue further inbreeding in Gero since most of the lines now appear to be quite uniform. During 1971 part of the seed of each Gero inbred will be used to plant observation plots to evaluate these lines for various characters. The remaining seed will be stored for use in coming years for production of hybrids and to compose now populations. Maiwa single plant selections will be carried through one more cycle of inbreeding and selection since these are still segregating.

Two hundred and ten lines of Gero with bristles were carried through a fourth cycle of inbreeding and selection. Of these 395 single-plant selections with varying density and length of bristles have been retained. Since the inbreds are still segregating, it is proposed to carry these single-plant selections through one more cycle of inbreeding and selection. The bristled lines will be eventually used in producing strains resistant to bird attack.

Further inbreeding was carried out to isolate lines with red venation and white seeded characters. Thirteen single-plant selections with red venetion and 15 with white seeds have been retained. Since these T lines are still segregating it is proposed to carry them through further cycles of inbreeding and selection.

One hundred and forty-four dwarf single-plant selections of Maiwa from 1969 were carried through one more cycle of inbreeding and selection in progeny rows. A number of the progenies were found to be reasonably uniform for height and maturity. Seed of the uniform lines has been bulked and will be used in 1971 to plant observation plots to evaluate the lines for yield and other characters. Selected single plants from the segregating progenies will be carried through one more cycle of inbreeding and selection. The height of the selected lines varied from 0.6 to 1.8 m and head count ranged from 10.30 heads per plant.

New strains of Gero

Out of the 15 F_5 bulks of Tift 23A x Ex Bornu, which were yield-tested in 1969 only eight could be tested in replicated trials at Kano and Samaru. The other strains could not be included because of the lack of seeds. Compared to 1959, performance of all the strains was very poor owing to late planting and early onset of drought during the growing season (Table 24). Maximum yield of 1,182 kg ha^{-1} was given by KG 70 and lowest yield of 165 kg ha^{-1} was given by KG 52. In the test conducted in 1969 KG 70 and KG 52 yielded 2,386 and 2,493 kg ha^{-1} respectively.

Since the millet crop is highly cross-pollinated, seed increase of such a large number of strains poses a special problem. However, every effort will be made to increase the seed of these new strains so that these strains can be yield-tested on a large scale. The preliminary data indicate that some of the strains are very promising.

New strains of Maiwa

Bulked seed of selected F_2 plants from crosses made between Tift 23B and five populations of Maiwa was planted in two isolation plots. In one of the plots, selection was made for downy mildew resistant, medium height, early and day-length neutral (Gero type) plants. All other plants in the plot were removed before anthesis. The Bulked seed will be used for planting an isolation plot in 1971 for further selection. Because of the late planting due to the late rains selection for late and daylength sensitive (Maiwa type) plants could not be done in the second isolation block. The plants were, however, allowed to intercross within the block and the resultant seed will be used in 1971.

Table 24. Yield and other agronomic data from new strains of Gero millet

Pedigree	Plant height in cms	Days to 50% anthesis	Yields kg/ha	
			1969	1970
KG 70	143	61	1182	2386
Local	205	62	1032	922
KG 74	209	65	977	-
KG 3	161	59	813	-
SYN-1	162	60	813	2251
KG 6	149	63	799	2006
KG 10	117	58	656	1260
KG 67	115	63	640	1382
KG 9	138	60	522	867
KG 69	110	60	174	1193
KG 52	125	62	165	2493

After a few years of selection, it is hoped to obtain high-yielding, medium-height strains of both Gero and Maiwa types out of this program.

Cytoplasmic male sterile lines of Gero

Fifteen cytoplasmic male sterile lines with their maintainers have been selected. These lines will be multiplied during the 1970-1 dry season to produce adequate seed for detailed evaluation in 1971. In addition 110 B lines have also been retained from this program for future use.

Cytoplasmic male sterile lines of Maiwa

A total of 36 progenies of male sterile lines of Maiwa were tested during 1970. Out of these 17 progenies were selected and maintained on a single-plant basis. These selections will be further evaluated in 1971 for sterility genotype and other agronomic characters. In all about 400 male sterile progenies will have to be evaluated in 1971.

Modified mass selection

The products of three cycles of mass selection of Ex Bornu population of Gero were compared with the original population for yield and other characters. No significant difference for yield, height and days to bloom were found between the original population and the populations resulting from one, two or three cycles of mass selection (Table 25). The results indicate that the method of mass selection followed was not effective to raise the yield level of the original population.

Table 25. Yield and other agronomic data for original and mass seleced Ex Bornu population of Gero.

Selections Cycle	Yield	Height in cm	Days to 50% anthesis
Original	1350	209	58
MS 67	1426	209	58
MS 68	1382	203	61
MS 69	1376	205	59

MS 67 - one cycle of modified mass selection
MS 68 - Two cycles of modified mass selection
MS 69 - Three cycles of modified mass selection

Inbreeding depression

The resultant population of the inbreeding cycles was compared with the original populations of Maiwa in replicated trial. Statistical analysis of the results is yet to be completed.

Current recommendations - None

Proposals for new recommendations - The following populations of Maiwa are recommended for cultivation:

1. Ex Gashua for the Kano area
2. Ex Riyom for the Kasarawa area
3. Ex Tukur for the Potiskum area

Enough seed of these populations is available from the Agricultural Research Station, Kano.

Regional yield trials at Samaru

Progress - A West African millet trial was started in 1969 so that the breeders in the region could observe the performance of the varieties being grown. The trial grown at Samaru in 1970 included 19 varieties from seven countries. The highest yields (2,442 to 2,676 kg ha^{-1}) were made by three selections from a local population known as Ex Bornu. The breeding work is designed to improve Ex Bornu further and to inbreed within this population in an attempt to locate sources of resistance to the diseases, downy mildew, smut and ergot. Considerable progress has been made in isolating lines resistant to the first two diseases. Crosses have been made to develop millet lines shorter in stature than the local ones so that they can be planted at higher populations. Once the desirable types have been developed, work will procede to the development of millet hybrids. An occasional field of finger millet (Eleusine coracana) is found on the Jos Plateau. Seed of 10 varieties was introduced from Uganda and planted in a trial at Samaru. The best varieties gave yield of about 1,700 kg ha^{-1}. The crop does not seem to be too well adapted to this part of Nigeria when planted in early June: later plantings may do better.

Maize Improvement Work in Northern Nigeria

O. J. Webster

Maize is a minor crop in northern Nigeria and is grown mostly as a "compound" crop, i.e. near the village where soil fertility can be maintained from refuse. The ears are generally eaten green; boiled in the husk or roasted over a charcoal fire free of husk. The farmers plant as early as possible, using early maturing varieties in order to benefit from the higher prices for the first of the crop to be sold. The color of the grain is white or yellow but is usually mixed with purple. Much of the crop harvested for dry grain is a yellow flint. The breeding work at Samaru is designed to improve maize for dry grain production. The local varieties are suitable for eating green and yield is not a prime requirement.

Yields ar Samaru and at other locations in the north exceed 4500 kg/ha when proper management is used. Maize will fail on soils which have been continuously cropped for a few years without fertilizer. Sorghum and millet planted on the same land will produce something even though the yields are low. Maize acreage in the north is increasing where farmers are using fertilizers.

In addition to developing varieties for the area, it is necessary to determine the production practices to be followed for good yields. One recommendation cannot be made for the entire region but each must be tailored to fit local soil conditions. This means conducting numerous fertilizer trials which are not possible at the present due to a shortage of supervisory staff. The best that is possible at the present is to concentrate our research effort in one area at a time.

The breeding work at Samaru is cooperative with other locations in Nigeria and west Africa. When the program was first started in 1964, three composites were formulated using a few varieties from South America and a US corn belt dent. Recurrent selection has been conducted using ear to row, full-sib and mass selection. Most work has been concentrated on Samaru Composite 3. This composite has been productive and well suited to northern Nigeria. In 1970 it was used in numerous trials throughout the North. For the first time in six years blight was epidemic in the north and much to our disappointment Composite 3 is highly susceptible. Fortunately no susceptible varieties have been released and the maize populations are heterogeneous for resistance which will make it possible to develop resistant varieties.

The major breeding effort is now being concentrated on the development of new varieties by a recurrent selection program in four very broad based composites known as Nigerian Composites A, B, C, and D. The composition of the first three was decided by a west African maize workers conference held in Ibadan in 1967. Since it is possible to grow two and three crops of maize a year the composites quickly synthesized so that a recurrent selection program could begin in 1970. Composite A includes all of the components found in Samaru Composites 1, 2, and 3.

The yield trials in 1970 at Samaru included:-

	No. of entries
National zonal	15
West African Regional	12
Local and Exotic Varieties	22
Composites and Intercrosses	27
Variety hybrids and parents	121
Variety topcrosses	81
Full sib trial, 2nd cycle Samaru-Composite 3	121
S_1 Trial Nigerian Composite B	121
S_1 Trial Biu Yellow	121

The National Zonal trial is grown at a number of locations throughout Nigeria and the highest yields are usually reported from Samaru. The entries for this trial are selected at the annual Nigerian maize workers' conference held in January. Unselected Nigerian Composites A, B, and D were added in 1970. Composites A and B ranked second and fourth which suggests that improvement in yield can be expected with selection.

The performance of Mexico-5, Samaru Composite 3 and NS-5 was reduced by blight. The loss from blight was greater than most people could believe. The 6-year average yield of 7 entries in this trial has been about 5400 kg/ha per acre (Table 26). H504 has the best yield for the period but for the 3-year period Bulk-3 has exceeded H503 by 670 kg. The Regional West African trial is grown in 8 west African countries (Table 27). Yields this year ranged from 5177 kg/ha to 6481 kg for Nigerian Composite A. Variety 094 is a blight and rust resistant version of Bulk-3 and merits consideration for increase and recommendation. The potential of B D S, from Senegal should be tested more extensively in Nigeria. Its low 3-year average yield is due to its unexplained poor performance in 1969.

A number of productive variety hybrids have been tested and could be released to farmers if there was a seed industry in the country to produce and market seed. The present improvement program is the simultaneous development of productive varieties with an extension effort to demonstrate the potential of maize in northern Nigeria.

The development of high lysine varieties of maize is in progress at Samaru and Mokwa.

Table 26. Summary of yield (kg ha) of maize varieties included in the National zonal trial. Samaru, 1964-1970.

Entry	1965	1966	1967	1968	1969	1970	Av. 1965/70	Av. 1968/70
H 503	6331	4390	5154	5191	6691	5716	5579	5867
Diacol V-153	5770	4732	5826	5298	5842	5274	5457	5471
H 507	5795	3625	5359	3788	6328	5809	5117	5309
NS - 1	5442	4379	5632	5333	6166	6296	5542	5932
NS - 5	5849	3490	5946	5954	6449	4875	5428	5759
Mexico-5	5942	4808	5255	5217	6328	5312	5477	5619
EAFRO 231	4713	4608	5635	3793	6246	5716	5118	5252
Bulk - 3	--	--	--	6438	7197	5928	--	6521
C-10 x Biu Yellow					6914	7579	--	--
Composite 3					7096	5218	--	--
NC - A						6308	--	--
NC - B						6128		
NS - 1 (Mokwa)						5617		
NC - D						5473		
Tsolo x Biu Yellow						5468		

Table 27. Summary of yields of varieties grown in the West African Regional Tirals at Samaru. Yields (kg/ha)

Variety	Source	1968	1969	1970	Av. 1968/70	Av. 1969/70
Mexico-5	Nigeria	5218	6180	5776	5724	5978
NS - 1	Nigeria	5800	5407	5551	5586	5479
B D S	Senegal	5692	4390	6460	5514	5425
Ghana Composite 2	Ghana			6311		5992
Ghana Composite 3	Ghana			6140		5906
094	Nigeria			6011		5954
Nigerian Composite A	Nigeria			6481		
Nigerian Composite B	Nigeria			6225		
Tsolo x Biu Yellow	Nigeria			5177		
Samaru Composite 3	Nigeria			5433		
Comp. d'Ina	Dahomey			5583		
Jaune Hatifl	Upper Volta			5219		

The following maize experiments were carried out at Mokwa in 1970 - by Fran deWolff.

Variety trials

National zonal
West African regional
Selections within Ns-1
Silage yield
Mexican introductions
Sweet maize

Breeding and selection

Maintenance and selection within Mokwa
Composites A and B
Full-sib family selection, Colombian Composite
Plant characters associated with yield and resistance to lodging

The yields in the National zonal trial ranged from 2386 kg/ha for NS-5 to 4592 kg/ha for the variety hybrids C-10 x Biu Yellow (Table 28). The low yield of NS-5 was due to an attack by blight (Helminthosporium-carbonum). This disease was severe at Mokwa but fortunately there is resistance in some varieties and breeding materials. Bulk 3 similar to 094 ranked in second place.

The results from the West African Regional trial are given in Table 29.

Table 28. National zonal variety trial.

Entry	50% tasseling, days to bloom	Ear height cm	Ears/plant no.	Stem lodging %	Root lodging %	Yield kg/ha-1
C 10 x Biu Yellow	51	99	0.98	3	6	4592
Bulk - 3	56	142	1.04	5	16	4245
EAFRO. 231 (Ibadan)	58	155	0.96	4	20	4133
H 503	58	137	1.13	4	11	4054
Comp. B	52	135	1.03	4	10	3987
Comp. D	55	135	0.99	3	13	3954
EAFRO 231 (Mokwa)	63	178	0.94	7	37	3920
NS-1m (Mokwa)	59	167	1.05	11	19	3864
NS-1 (Ibadan)	54	137	1.01	3	13	3640
Ibadan Comp. A.	53	113	0.98	2	14	3517
H 507	56	136	1.16	4	10	3494
Mokwa Comp. A	53	125	0.99	3	9	3259
Diacal V 153	55	122	0.91	3	9	3170
Colombian Comp.	53	130	0.94	6	13	3024
Mokwa Local	58	165	0.99	24	26	2979
NS - 5	53	128	0.92	8	8	2386

L. S. D., = 541 kg C.V. : 10.5%

Table 29. West African Regional Maize Trial.

Entry	Origin	50% Tasseling Days to Tasseling	Ear height cm	No. of ears/ plant	Stem lodging %	Root lodging %	Yield kg ha
Composite B	Nigeria	52	132	1.05	6	14	4122
NS-1 (Mokwa)	Nigeria	59	174	1.06	13	17	4088
Composite 2	Ghana	56	144	1.01	4	15	4043
Ibadan Comp. A	Nigeria	53	120	1.02	6	8	3942
094	Nigeria	54	129	1.02	4	8	3830
Mokwa Comp. A	Nigeria	53	136	0.96	4	18	3629
Comp. J.d'INA	Dahomey	50	116	0.98	11	7	3595
Composite 3	Ghana	56	134	1.01	6	19	3091
Colom 6 Comp.	Nigeria	55	127	0.94	7	8	3158
Jaune Hatif	Upper Volta	47	101	0.92	24	3	2789

L. S. D., 0.05 = 504
C. V: 9.6%

Maize Variety - Fertilizer Trials

This year (1970) a uniform variety-rate of nitrogen trial was planned for:

Farm Center-Gusau, 100 miles west of Zaria
Cotton seed farm, Daudawa 50 miles west of Zaria
Shika Livestock Farm 12 miles west of Zaria - I.A.R. Samaru
Farm Center Maigana 13 miles east of Zaria
Local Farm mile 34 Zaria-Jos road

The entries included three of our best variety-hybrids and 3 varieties. The plan called for a uniform preplant application of 440 pounds of super phosphate and a split application of 198 and 264 kg of nitro-chalk (22% N) per ha. The purpose of these trials was to determine what yields we could obtain from these treatments.

The best trial was at Samaru (Table 30). This trial as well as the one at Guasu was planted in a 6x6 Latin design. Replications 1-3-5 at Samaru received 97 kg/ha of nitrogen and replications 2-4-6 received 134 kg/ha of nitrogen. The additional 37 kg of N gave an increase of 829 kg of grain per ha, a profitable return. The yield of Composite 3 was reduced by blight as in all other trials.

The trial at Shika (Table 31) was first planted on June 6. A rain fell that afternoon and no more was recorded for a week. During this period the soil became hard and stands were erratic. The trial was replanted on the 16th. Stands were quite variable even from the second planting. The difficulty of stand establishment in this trial is an illustration of a problem which is characteristic of the soils of west Africa. The extra increment of nitrogen gave no increase in yield.

The trial at Gusau shows the potential of maize for this area (Table 32). Prior to 1970 maize had never been grown on the Farm Center and only in small patches by the farmers in the area. A pre-plant soil analysis revealed a deficit of potash so in addition to the phosphate and nitrogen 56 kg/ha of potassium chloride was applied. There was a soil fertility or moisture gradient across the field which may account for the failure to benefit from the higher rate of nitrogen. The failure to get a response may also have been due to the minimum amount of phosphate applied. It is proposed that an NPK trial be conducted in 1971.

Table 30. Yields and other agronomic data from fertilizer trial, Samaru, 1970. Plot size 2 rows spaced 2.3 feet apart x 33 feet in length, planted June 6.

Entry	Reps 1-3-5 with 97 kg/ha nitrogen			Reps 2-4-6 with 134 kg/ha nitrogen			Average yield
	Stand at harvest	Blight score[1/]	Yield	Stand at harvest	Blight score[1/]	Yield	
	pl/ha	(0-11)	kg/ha	pl/ha	(0-11)	kg/ha	kg/ha
Tsolo x By	17237	1	5682	16598	1	5970	5826
C-12 x By	14683	1	5107	15322	1	5490	5299
NS - 1	17237	1	5873	21706	1	7502	6688
C-10 x By	15961	1	5618	21706	1	6736	6177
M-5	17237	2	5587	16918	4	6225	5906
Comp - 3	16598	4	3544	15322	4	4469	4006
Average			5235			6064	

Fertilizer - 179 kg/ha 21:14:10 preplant, 59 kg of N (Nitrochalk) June 30. 37 kg/ha N applied to Reps. 2,4,6 July 23.

1/ Blight score 0 resistant - 11 susceptible CV = 18% LSD .05 = 1366 kg

Table 31. Yield and other agronomic data from fertilizer trial, Shika, Nigeria 1970. Plot size 2 rows spaced 3 feet apart x 20 feet in length - planted June 16.

Entry	Reps 1,4 with 100 kg/ha nitrogen				Reps 2, 4 with 134 kg/ha nitrogen				Yield
	Stand harvest pl/ha	Blight score 1/ (0-11)	Av. days to tassel dys	Yield kg/ha	Stand harvest pl/ha	Blight score 1/ 0-11	Av. days to tassel dys	Yield kg/ha	Average yield
Tsolo x by	18295	1	58	5732	15449	1	59	3699	4716
C-12 x By	15449	2	62	3577	17482	3	62	3212	3395
NS-1	17889	2	61	4228	17482	3	61	2806	3517
C-10 x By	15858	1	62	4269	16669	1	59	4757	4514
M-5	18702	4	64	2521	16669	4	64	2602	2561
Comp - 3	17076	5	59	2114	17482	5	60	4757	3548
Average				3741				3639	

Fertilizer - 224 kg/ha super phosphate and 39 kg N preplant, rep 1 and 4 62 kg/ha N and reps. 2 and 3 95 kg/ha N July 25.

1/ Blight score 0 resistant - 11 susceptible C.V. = 36% LSD. 05 = NS

Table 32. Yields and other agronomic data from fertilizer trial, Gusau, Nigeria 1970. Plot size 2 rows spaced 3 feet apart x 30 feet in length. Planted June 12 and harvested October 1.

Entry	100 kg/ha nitrogen			134 kg/ha nitrogen			Av. yield
	Stand at harvest	Blight score 1/	Yield	Stand at harvest	Blight score1/	Yield	
	pl/ha	(0-11)	kg/ha	pl/ha	(0-11)	kg/ha	kg/ha
Tsolo x Biu	16340	1	5477	15518	1	5758	5618
C-12 x Biu Yellow	13327	2	5631	23597	1	4728	5180
NS - 1	14970	1	5179	15518	1	5224	5201
C-10 x Biu Yellow	15518	1	6011	14057	1	5477	5744
Mexico-5	15062	2	4682	15518	1	4221	4452
S. Comp. III	13784	4	4013	15335	5	3868	5023
Average			5165			4880	

Fertilizer, 224 lb superphosphate, 56 lb potash, 34 lb nitrogen (nitrochalk) applied preplant; 34 kg nitrogen applied 6/7. Reps 1,3,5 34 kg nitrogen and Reps 2,4,5, 68 kg nitrogen 24/7.

1/Blight score) resistant - 11 susceptible
C.V. = 11%, LSD .05 = 806 kg

Nitrogen was applied at one rate in the Daudawa trial. Yields were relatively low, ranging from 2856 to 3587 kg/ha. Potash may be a limiting factor in crop production at the location and an NPK trial should be conducted in 1971.

The trial at Maigana was planted on June 13. The delay in receiving planting rains delayed field operations. The planting was made on high, peaked ridges and should have been delayed until the ridges could have been worked down. Stand establishment was good but severe root lodging occurred in early August and the trial was abandoned. We would have expected less lodging if the trial had been planted more on the flat.

Seed bed for the trial at mile 34 (Zaria-Jos road), was ridged by hand by the farmer-cooperator after we had scattered phosphate at a rate of 212 kg/ha and nitro-chalk at a rate of 30 kg of N per ha. The trial was planted May 26 on low, flat ridges with good moisture for germination. The area where this test was located suffered from a drought the last half of June and plant growth, arrested at this time did not fully recover. The test area sloped towards the road and the amount of soil moisture during the time of stress decreased up the slope. A second application of 44 kg of N was applied in June 16 and 50 kg/ha was applied to Reps 2 and 3 on July 14. The trial was harvested by the agriculture instructor, with the help of the farmer and the ears from each replication was bulked. The yield in kg per replication was: 1 -186, 2 - 180, 3 - 160, 4 - 144. The difference in soil moisture early in the season probably had more to do with variations in yield than the extra nitrogen applied to reps 2 and 3. The trial yielded 5610 kg/ha, a good reason for the farmer's request for another trial in 1971.

Maize Improvement Project - Ibadan

J. Craig

The maize program at Ibadan is concerned with conduct of regional maize trials, development of maize composites for breeding programs in West Africa, research on maize diseases and the training of research personnel in maize improvement.

Uniform Maize Trials:

Maize Composites: Syntheses of the maize composites NCA, NCB and NCC have been completed. These 3 composites have a wide range of variability and offer good selection possibilities for desirable agronomic characteristics. The maize cultivars used to form these composites were selected with the objective of providing wide genetic divergence among the composites. This divergence should result in appreciable heterosis in crosses between selections from NCA, NCB and NCC.

Both normal grain type and high lysine versions of NCA and NCB have been developed. NCC is a local floury grain type produced primarily to furnish selection populations for areas where this grain type is desired i.e., Southern Nigeria.

These composites were developed to provide breeding populations with good selection possibilities for maize breeders in West Africa. In an attempt to demonstrate the possibilities of these composites to maize improvement workers NCA and NCB were placed in the 1970 West African uniform maize trials and in the Nigerian zonal trials. The results reported to date show that these composites even in their unselected state compare favourably with many maize varieties and synthetics now recommended for use. This promising performance should lead to rapid utilization of these composites for maize improvement in West Africa.

Yield Selection: The composite NCB is being subjected to recurrent selection for yield using S_1 testing. In a cooperative project with Mr. M. N. Harrison, Maize Breeder for the International Institute of Tropical Agriculture, 363 S_1 lines of NCB were evaluated in yield trials in the early season of 1970. The best 45 lines on a basis of yield, standability and disease resistance were recombined in the late season of 1970 to provide the population for the next cycle of selection.

Selection for disease resistance:

The third back-cross of the opaque-2, blight and rust resistant maize selection (Rbo-2) to NCB was completed in March 1970. Progeny of this backcross was selfed in the early season of 1970 and opaque-2 seed of the S_1 lines were bulked and planted in the late season of 1970. These plots were inoculated with Helminthosporium maydis; all blight susceptible plants were destroyed and surviving plants were crossed to produce an opaque-2, H. maydis resistant version of NCB. Seed from this plot was planted in January of 1971. These plants will be inoculated with Puccinia polysora. Rust susceptible plant will be rogued out and the remainder will be crossed to produce an opaque-2, rust resistant and blight resistant version of NCB in March of 1971.

The same program has been followed to produce a normal grain (not opaque-2) disease resistant version of NCB which will also be completed in March 1971.

Selection for erect leaves:

One method of approach to the improvement of light utilization in maize is the development of maize selections having a more upright position of the leaves particularly the upper leaves on the plant. Two upright leaf maize lines with normal ligules have been selected from NCB. These two lines (UA and UB), a liguless - 2 type upright leaf maize selection and a maize variety, 033, with normal leaf arrangement were grown in the early season of 1970 and observed for leaf angles (Table 33).

Studies of the UA and UB type leaf arrangement are continuing. A cooperative study with the plant physiology selection involves measurement of light intensity at different depths within the maize canopies of the upright leaf and normal leaf selections, other studies involve effect of population density on yield per plant of the different leaf types and determination of the mode of inheritance of the upright leaf factors in the UA and UB lines. In addition UA and UB versions of NCB are being produced; the second backcross of the upright leaf lines to NCB was completed in the 1970 late season. The third and final backcross to NCB will be completed in March 1971. The blight and rust resistant version of NCB was used as the recurrent parent in the final backcross. Progeny of the third backcross will be selfed. Selections will be made in the S_1 population for the upright leaf character, rust resistance and blight resistance to produce a disease resistant upright leaf version of composite NCB.

Table 33. Observation on leaf angle in 4 maize selections.

Angle* from stem at leaf base to highest part of leaf		
Maize selection	Leaf 1**	Leaf 2**
Liguless-2	22^0	31^0
UA	24^0	42^0
UB	31^0	45^0
033	48^0	61^0

* Observations represent means of 89 Liguless-2 plants, 66 UA plants, 93 UB plants and 79 033 plants.

** Leaf 1 is the leaf representing the 25th percentile (from top downwards) of total number of leaves on the plant. Leaf 2 is the leaf representing the 50th percentile of total number of leaves on the plant.

Disease resistance studies:

Studies of relationships among the genetic factors conditioning reaction of P. polysora in 3 resistant maize inbreds were conducted throughout 1970 and completed in January 1971. The reactions and segregation ratios exhibited show reaction is controlled in these lines by a single factor, or very closely linked genetic factors, that dominance for resistance is intermediate and that rust reaction in these 3 lines is either controlled by the same factor or allelic factors.

The maize pedigrees needed to determine if the gene loci involved in the chlorotic lesion reaction to H. maydis have different indivudal effects were produced in December of 1970. This study is expected to be completed in 1971.

In 1970 the maize line Rb which combines chlorotic lesion resistance to H. maydis and hypersensitive resistance to P. polysora and the maize cultivar Hays Golden which is extremely susceptible to these pathogens were planted 6 sites in Nigeria. These sites ranged in latitude from $6^{0}30'$ N to 11^{0}N. At all sites Hays Golden was severely damaged by blight and rust and Rb was resistant.

In addition seeds of these lines were sent to the 9 countries participating in the 1970 uniform maize trials for observations on susceptibility to blight and rust. At present only Ghana and Dahomey have reported. In both countries Hays Golden was very susceptible to blight and rust and Rb was highly resistant.

Training:

Mr. J. M. Fajemisin, research officer of the Federal Department of Agricultural Research of Nigeria, was assigned to AID-ARS major cereals project for training in maize disease work in 1968. Mr. Fajemisin received an USAID scholarship for graduate training in plant pathology at the University of Illinois and departed Nigeria in January of 1971.

Travel:

In response to a request from the U.S. Peace Corps I visited Dahomey in January of 1971 to assist with the planning of maize production and storage program proposed for Southern Dahomey. A detailed report of this tour is given in Appendix I.

APPENDIX I

Report of Tour of Dahomey - J. Craig

I visited Dahomey from January 24 - January 30, 1971 in response to a request from the United States Peace Corps/Dahomey to assist with planning a program for maize production and storage in Southern Dahomey. During the course of this tour I conferred with Agricultural Specialist and Peace Corps personnel and visited areas in which the maize project would be carried out (Appendix II).

The objective of the proposed maize program is to increase the income of farmers growing maize by improving yield per hectare through better agronomic practices and by utilization of drying and storage facilities to allow the farmer to sell his maize at a time when market prices are favourable.

Maize Yield Improvement - Any significant increase in maize yields per hectare will require changes in the peasant farmers methods of maize culture. Some of these changes entail more work and cash cost; the greater this increase in labour or cash cost the less likely the acceptance by the farmers.

The agronomic practices detailed below represent the minimum necessary to increase maize yields significantly over those resulting from the farmers present methods. It is expected that the group of practices recommended should give increases of about 750 kg of grain per hectare. These recommendations are not designed to give maximum yields but rather to keep costs of implementation and the change from farmers practices as small as possible and still achieve increases in yield large enought to make the new practices worthwhile to the farmer. After the economic practicality of the minimum improved practices has been demonstrated higher levels of improvement can be initiated if justified by conditions.

Seed - Maize synthetics or hybrids which have shown high yields in IRAT trials in Southern Dahomey. CN7 x ATC appears very promising.

Time of Planting - As soon as possible after the rainy season is established. Farmers are usually good judges of this.

Land preparation - Any method that will destroy weeds and provide a good seed bed. A good seed bed allows seed to be placed in intimate contact with moist soil and well covered. In addition it allows for each penetration upward by the seedling stem and easy penetration outward and downward by the roots when the maize germinates. Such conditions can be achieved by working soil deeply with a hoe at the site of each stand. Ridging is not necessary.

Plant Spacing - Rows should be spaced 80 cm apart and the stands in the row should be 60 cm apart with 2 plants per stand. This spacing will give a plant population of 41.667 plants per hectare.

To achieve this population or a satisfactory approximation without the necessity of thinning or replanting the seeding rate must be determined by the germination percentage of the seed and the amount of loss expected from causes such as insects, rodents and birds. If the losses expected after germination are assumed to be 10% the rate of seeding for given germination percentages are shown below:

Germination %	Seed Per Stand	Plants/ha
95	2	35417
90	2	33334
85	2	31250
80	3	43750

Always use seed with highest germination percentage available.

Using this system replanting should not be necessary, however, if done only stands with no plants should be reseeded and this should be done as soon as possible after seedling emergence of the original planting.

Weeding - Weeding should be done as frequently as necessary to prevent serious weed competition with maize for water, nutrients and sunlight. Weeding is most important during the first 4 weeks after emergence of the maize. Usually 2 to 3 weedings are required. Keep hoeing as shallow as possible to reduce damage to maize roots. Do not weed after maize begins flowering.

Fertilizer application - Apply 200 kg per hectare of 15-15-15 fertilizer 10 to 14 days after maize seedlings emerge. Fertilizer should be applied by making a small hole about 3 inches deep and 6 inches away from the stand, dropping the required amount of fertilizer in the hole (10 gms per stand required for 200 kg per hectare) and closing the hole by stepping on it.

15-15-15 selling in Dahomey for 15CFA per kg appears to be the cheapest fertilizer available, however, if cheaper sources of the recommended amounts of nutrients (30 kg/ha N, 30 kg/ha P_2O_5 and 30 kg/ha K_2O) can be found these should be substituted for 15-15-15.

Harvest - If adequate drying facilities are available maize can be harvested as soon as it reaches a grain moisture content of 30% or less. Usually maize that flowers 50 to 60 days after planting can be harvested 90 to 110 days after planting.

A grain moisture content of more than 35% indicates that the seed may still be increasing in dry matter content and yields may be reduced if harvested at this stage. Harvesting at 30% moisture content will increase the length of the drying period and the cost of drying but it will decrease pre-harvest insect damage and losses due to lodging. The relative importance of these various factors should be considered when deciding upon the best time to harvest.

Drying - The grain dryers ("bush crop dryer") constructed by villagers and Peace Corps personnel which I saw in operation during this tour are quite adequate for reducing grain moisture content to the 12-13% range required for storage in shelled grain silos.

Storage - The possible profit to the farmer from increased maize yields is dependent on his ability to store his grain safely until market prices are favourable. The bins commonly constructed by the farmers using bamboo or similar material are designed for storage of unhusked ear maize. These bins provide no protection against insect damage to the grain and are unsuitable for the length to storage period required for good market prices.

Two types of shelled grain stores, metal silos and concrete stave silos are being evaluated for use in Dahomey. Studies are being conducted to compare these types for cost, durability and efficiency in maintaining grain quality.

Several concrete stave silos have been constructed by farmers and Peace Corps personnel. Maize stored in these silos was treated with phostoxin after filling to kill insects. The phostoxin fumigation is repeated if necessary to control reinfestation by insects. In some of these silos maize had been stored for 5 months, September-January, without appreciable loss. The storage period envisaged in the maize program, September-March, appears feasible.

APPENDIX II

Itinerary of Dahomey Tour

January 24 - Ibadan to Cotonou. Meeting with Mr. Rakov, Peace Corps Director, Mr. Corcoran, Associate Director Peace Corps and Mr. Clarke, Peace Corps Volunteer.

January 25 - Visit I.R.A.T. research station at Niaouli. Meeting with Mr. Glele, Director of the station. Visited Ayou Youth Farm Club. Visited Allada, visited Swiss Farms and met Mr. Fountannaz an Agronomist on the staff. Returned to Cotonou.

January 26 - Meet with Mr. Wertz, Director IRAT/Dahomey, in Cotonou. Meeting with Peace Corp officials in Cotonou. Drove to Savi met Mr. McHugh, Peace Corps volunteer and visited his grain storage sites at Agacame. Travelled to Dogho and talked with Mr. Hartzell and Mr. Greene, Peace Corp Volunteers.

January 27 - Visited Mr. Green's maize demonstration plot. Toured local farmers fields with Mr. Hartzell and observed sites of future maize demonstration plots. Visited Mr. Hartzell's grain storage site at Dadahoua and met with Agricultural Extension Officer. Returned to Cotonou.

January 28 - Visited Swiss Farm at Sekou. Meeting with Mr. Berney, Director of Swiss Farm, and Mr. Fontannaz. Toured farm and studied maize fields and hybrid seed production plots. Returned to Cotonou. Visited grain storage centre of Dahomean Marketing Board (OCAD). Travelled to Ouaudo (near PortoNovo) visited Horticultural and Nutritional Center. Met with Mr. Zwaan and visited grain storage experiments. Returned to Cotonou.

January 29 - Visited Mr. Wertz in Cotonou. Travelled to Department of Queme; visited Sonader, on oil palm plantation company, at Ikpinle. Had talks with Mr. Biaou, food crops research assistant, and Mr. Osseni, extension agent. Visited Mr. Gould, Peace Corps Volunteer at Ita-Djebou, visited grain storage site and an agricultural training centre for young people near Ita-Djebou. Returned to Cotonou.

January 30 - Meeting with Peace Corps Officials in Cotonou.
Cotonou to Lagos.

January 31 - Lagos to Ibadan.

I would like to express my appreciation to the people listed above and several others unnamed for their assistance, information and hospitality during my tour of Dahomey.

Agronomic Studies

K. R. Stockinger and M. Jones

Date of Planting Experiment

A large reduction in yield of maize has been noted when the planting is delayed after the start of the rains. Most crops are also affected similarly and consequently all plantings and cultivations should be made at the same time. This results in poor distribution of labor demand. If this effect could be overcome, planting could be staggered and larger areas planted. Also since much of the maize is eaten green, it would be available over a longer period without sacrificing yield. This effect has been generally observed throughout tropical Africa. However, the reason for the effect has not been found.

To study the causes of the date of planting effect, an experiment was started this year with four dates of planting and five fertilizer variables. Because of the interest in the causes of the effect, the plants were studied in considerable detail at various stages of growth. Dry matter production and uptake of various nutrients were measured at 4 weeks, 6 weeks, 50% silking, 2 weeks after 50% silking, and final harvest. Also the potential yield was determined at silking by counting the number of cobs and number of potential seeds per cob. The actual yield was measured by counting number of cobs and number of seeds per cob, as well as the weight yield of grain.

The 1970 growing season was characterized by a low total rainfall (37.55 inches compared to 44 inches normal rainfall), a severe drouth during the last two weeks in June, and a very abrupt end to the rains on the 25th of September. The planting dates were May 16, June 5, July 2, and July 15. The third planting was delayed because of lack of rain and dry soil. Also the first planting was severely stressed for about a week before a good rain on June 29. It wilted and did not regain turgidity during the night. The second planting did not show wilt but was stunted compared to the other planting at the same stage. The rainfall was more or less normal in July, August, and September, but the abrupt end to the rains caused the last planting to mature quickly and lose many of its leaves before harvest.

The fertilizer treatments were control (no fertilizer), NP, NK, PK, and NPK with the nitrogen, N, applied at the rate of 112 kg/ha as nitro-chalk; phosphorus, P, applied at the rate of 40 kg/ha as superphosphate; and potassium, K, applied at the rate of 50 kg/ha as potassium chloride. The maize was machine planted in 90 cm rows and thinned to 48,000 plants per hectare. A split plot design with three replications was used with the date of planting as the main plot and the fertilizer treatments as the sub-plots. Because of the unusual and severe drouth during a critical stage in its development, the growth and yield of the first planting were severely distorted and results from this planting will not be reported or discussed.

Yields of grain and total dry matter production at the final harvest are given in the following table:

	June 5		July 2		July 15		
	Grain kg/ha	D.M.P.	Grain kg/ha	D.M.P.	Grain kg/ha	D.M.P. final	D.M.P. 2 wks. silking
NPK	4380	9250	2790	9840	1670	8050	9560
NP	4640	9810	2570	9400	1940	8020	9160
NK	4300	10110	2270	7640	1800	6560	7030
PK	1340	6070	1440	5960	1300	5560	6720
Control	920	4310	900	4930	1320	5510	5360

The dry matter production of the last planting was low due to loss of leaves during maturation. Its dry matter actually declined from that at the time of the previous sampling, shown in the last column. The treatments which received nitrogen had the same production of dry matter regardless of planting date while the grain yield declined sharply (significant at the 1% level). This indicates that the decline is not due to a lack of photosynthesis but converting the dry matter into grain. Also, when nitrogen was lacking, the date of planting had little or no effect on yield or dry matter production.

Potential yield was measured at silking by counting the number of cobs and the number of potential seeds per cob. The number of potential cobs was the same on all plantings except the July 2nd planting, which had a 10% reduction due to a similar reduction in stand. Stand reduction was due to fewer seeds being planted inadvertently. The number of potential seeds per cob was the same on the three planting dates.

Both the number of filled cobs and the number of seeds per cob were significantly less in the third and fourth plantings. Almost one-third of the plants were barren in the last planting. This accounted for much of the reduction in yield due to delay in planting. Lack of nitrogen also increased the number of barren plants and decreased the number of seeds per cob. The effect on the number of seeds per cob was much greater

and there were 37% fewer seeds per cob than on the nitrogen fertilized plots.

Seed size decreased by 10% on the last planting, probably because the rains ceased shortly after silking.

Lack of moisture was not a limiting factor on the last three plantings except as noted above. However, from July 15 to September 30 about 27 inches of rain fell. This caused some root lodging in the later planting. Internal drainage is quite good in this soil but poor aeration conditions may have existed for a short time. Rain may have washed pollen off the tassel and out of air on the July 2 planting, but not on the July 15 planting. It is doubtful if rain interferred with pollination on any of the plantings.

The maximum temperature decreased about 6°C from early June to mid-July and soil temperatures showed a similar decline during this period. The air and soil temperature were quite constant from mid-July to the end of September. Consequently, the temperatures during the first four weeks of growth are higher for the early plantings. From six weeks to maturity the temperature conditions were the same for all the plantings.

Analysis of nitrogen, phosphorus, potassium, calcium, magnesium, boron and zinc is being made on the dry matter production samples. Nitrogen has been completed and boron and zinc are available from some of the results. Total nitrogen uptake was the same for all planting dates at the same stage of development when nitrogen fertilizer was used. When nitrogen was not added the third planting took up 9 kg/ha, and the fourth 13 kg/ha more nitrogen than the second planting. Since the later plantings mineralized nitrogen over a longer period of time, the additional nitrogen taken up was probably from this source. Also the nitrogen liberated early in the season was not leached beyond the reach of the roots of the late plantings.

The boron content of the index leaves is uniformly low and averages about 2.2 ppm. This is very low but showed no difference between planting dates. The large percentage of barren plants and poor seed set on other plants corresponds to the boron deficiency symptoms described by Berger et al (Soil Sci. Soc. Am. Proc. 21:629-632 (1957). The chemical analysis showed no effect of date of planting on the index leaves, but this may be because the index leaves do not show the boron stress as well as other plant parts and other analyses are being made to check this further.

Zinc analysis of the stover at final harvest showed a large decline (significant at the 5% level) in zinc content with date of planting. Zinc declined from 17 ppm in the June 2 planting to 12 ppm in the last planting in the NP and NPK treatments. Phosphorus fertilization reduced the zinc content but the effect of date of planting was similar in the control and the NK treatments. Since zinc is necessary for auxin formation, this may account for poor set.

The results show that delay in planting resulted in reduced yield of grain but not in dry matter production. The reduction in yield is apparently due to poor pollination, since the same number of normal ears were present on all plantings at silking but many ears failed to set any seeds and others set fewer seeds on the two later plantings. The effect occurred only at the higher yield potential with adequate nitrogen. Total radiation, soil and air temperatures, and rainfall are very similar for the three plantings in the period immediately before and after silking. The boron content of the index leaves was very low for all plantings and may be deficient. The zinc content of the stover decreased with delay in planting and may be deficient in the late plantings. Both elements need to be investigated further.

Maize leaf blight attacked the maize in late August. It was more severe on the last two plantings and may have caused some of the reduction in yield. However, since it did not reduce dry matter production and since the date of planting affect has been observed in other years when the blight was not a factor, it is doubtful if blight was the only cause of lower yields on the late plantings.

Two other minor date of planting experiments gave poor results and no conclusions could be drawn from them. Early planting with irrigation at different moisture levels was variable and there were no differences between treatments. The plantings at 10-day intervals were sited on sloping plots which resulted in extra moisture on the lower part of the plot. Early plantings benefited from this and late plantings' germination and stand were inhibited by the extra moisture.

It is planned to repeat this experiment in 1971 with closer observation of pollination and other factors which may cause barren plants. Also, another smaller experiment is planned in which extra zinc and boron will be supplied to the plants at two or three planting dates.

Fertilizer Field Trials

K. R. Stockinger and R. G. Heathcote

The trials with nitrogen, potassium, lime, and trace elements were repeated at five farm centers (demonstration sites operated by the extension staff) and the three research farm of Institute for Agricultural Research. On only one site, Gwaza near the border with Chad, were the results satisfactory and apparently reliable. Variable soils and personnel not trained in field experimentation results in a high mortality rate in the experiments. It is concluded that a 2^4 factorial is too complex for field experimentation.

The trial at Gwaza gave a large nitrogen response with sorghum but no effect from potassium, lime or trace elements. At the IAR stations there were good responses to nitrogen at Mokwa with maize, and at Kano with sorghum. There was no response to nitrogen with sorghum at Samaru. Also at these stations there was a potassium response. At Mokwa, 43 kg/ha of potassium gave an increase in yield of 1700 kg/ha and is probably still limiting yield. The yield increases are greater than with nitrogen. Lime and trace elements have had no effect on yield at any location. In general, nitrogen is limiting yields at all locations. However, long seasoned sorghum at Samaru is able to accumulate enough nitrogen so that it does not respond to extra nitrogen. Similar results have been observed at other locations. Shorter seasoned sorghum grown at Gwaza and Kano responded to added nitrogen, probably because less nitrogen is mineralized during the growing season. Potassium becomes limiting with more intense continuous cultivation and will probably be needed on many soils shortly after nitrogen and phosphate fertilizers are used intensively. This will be especially true for maize because of its higher yield potential and relatively short season. Lime does not appear to be needed on these soils unless an acidifying nitrogen fertilizer is used. Responses to trace elements have been very erratic, but evidence indicates that molybdenum on groundnuts, boron on cotton and zinc on maize may be limiting yields. Further work on more locations is urgently needed but a simpler experiment must be designed which can be handled by extension service personnel.

The effect of acidifying fertilizers and lime on soils and crops is being investigated in an experiment with treatments to produce soil p^H varying from 3.3 to 7.5. The first year the pH was around 5 to 6 with a decline in yield at either end. The effect of the treatments is limited to the upper 15 cm of the profile with little or no effect below this. The experiment will be continued this year using maize as a test crop.

Chemical analysis of soils and plant material is being used to correlate responses with soil conditions and also to try to find means to extend recommendations to areas where field trials are not available. Soil tests appear to be promising for potassium, soil acidity, and boron. Plant analysis is promising for zinc, potassium, and phosphorus but more work needs to be done.

Because of its much higher yield potential and consequent responsiveness to fertilizer, maize has become the preferred test crop for much of field work in Soil Science at Samaru. Since this is due to the much greater yield potential of maize, trials should be arranged to demonstrate the superior ability of maize to respond to high fertility compared to other crops such as sorghum or millet. Preliminary trials along these lines are being planned for Kano, Mokwa, and Samaru to devise simple trials which could be used at other areas in Nigeria and West Africa to explore the area of adaptation of maize at high fertility levels.

Use of heavy applications of fertilizer on soils with a low base exchange capacity could easily lead to nutritional imbalances, and loss of other nutrients by leaching. An experiment was started this year to study the effect of several years heavy application of fertilizers on soils and crops. This will enable us to monitor the consequences of a major change in farming pattern on the soil, the crop and estimate its effect on ground water and stream water before it is adopted.

Cereal Pathology - Samaru

S. B. King

During 1970, attention was given to pathology problems which occur on each of the three major cereal crops. Sorghum received approximately 75 percent of the research effort, millet 15 percent, and maize 10 per cent. In most years, sorghum and maize receive slightly less time and millet more. However, during 1970 much of the millet pathology work was abandoned because of the unusually low incidence of downy mildew. Maize pathology received more attention because of the unusually high incidence of maize blight in northern Nigeria.

The following report describes the major disease problems of sorghum, millet, and maize in the savanna zones of West Africa. It presents information on major areas of pathology research and the results of 1970 in particular.

SORGHUM

1. World sorghum collection:

The world sorghum collection is grown on the Institute for Agricultural Research (I.A.R.O farm primarily to identify, under West African conditions, plant characteristics of potential use in sorghum breeding programs. Parts of the collection has been grown in 5 of the last 6 years. Seed of a new collection from India was requested in 1968 because: (1) the purity of the old collection was in doubt, and (2) the collection had grown considerably in size since it was obtained in 1964. Seed did not arrive in time for planting in 1969. Hence, the new collection was grown for the first time in 1970 when 4,000 entries were planted in single, 8 meter rows. Hopefully, additional seed from India will arrive in time to plant a different set of 5,000 entries in 1971.

During 1970, entries were observed for reaction to six naturally occurring leaf diseases and witchweed. Results are discussed later in this report. Over 1,200 entries which flowered after September 23 were also screened for possible midge resistance. Seed of the 111 entries which showed little or no midge damage will be given to the entomologist for further testing. Early maturing entries which produced good quality seed were also noted and will be further tested. For each entry, records were also kept on plant height, number of days to 50 percent anthesis, panicle type and density, and seed color, shape, and size.

Increasing a small quantity of seed of each entry was a major task. Four heads of each entry were selfed. However, we were unable to harvest satisfactory seed from about 15 percent of the entries. Most of the loss was attributed to stem borer damage, but seed molds and preharvest seed germination were also factors. Some late maturing entries which ran short of water also produced poor seed. Seed of the 15 percent will be increased from remnant seed by growing plants under more controlled conditions.

Due to the wide range of maturities expressed in the collection, bagging had to be started the second week of July and continued three times weekly through the first week of November. To minimize poor seed quality caused by seed molds and preharvest germination, pollinating bags were opened two weeks after bagging and heads were harvested no later than six weeks after bagging. To ease the task of locating within the field entries which were ready for these operations, a short strip of colored surveyors' flagging ribbon was stapled to one of the four pollinating bags at bagging. Within any given week, all rows bagged were identified by the same color or ribbon. This color was not repeated in following weeks until the seventh week, by which time rows previously marked with this color had been harvested. Color coding

some of the seed multiplication operations not only reduced the amount of time involved but also enabled illiterate laborers to help.

2. Leaf diseases:

As a rule, leaf diseases are not serious on sorghum in West Africa. This is due in part to the fact that some natural resistance occurs in most locally adapted sorghums. However, the common practice of wide spacing between plants is believed also to contribute to the low incidence of leaf diseases. Low plant populations coupled with intercropping considerably reduce the suitability of environmental conditions necessary for pathogen dissemination and infection. Pathogens of most sorghum leaf diseases can be found in at least trace amounts in Nigeria.

Because of the potential threat of sorghum leaf diseases, it is imperative that new varieties and hybrids for West Africa have adequate resistance. During the 1970 growing season 4,000 entries of the world sorghum collection were scored for reaction to anthracnose (*Colletotrichum graminicola*), rough leaf spot (*Ascochyta sorghina*), sooty stripe (*Ramulispora sorghi*), oval leaf spot (*R. sorghicola*), zonate leaf spot (*Gloeocercospora sorghi*), and grey leaf spot (*Cercospora sorghi*). Entries were rated susceptible or resistant depending on whether or not the disease was easily apparent. In addition, a severity rating was given to entries which showed very high susceptibility, since this information might be of value when selecting material from the collection for plant characteristics other than disease resistance. Disease reaction of entries tested in 1970 is summarized below:

Disease (pathogen)	Percent of 4,000 entries showing: Definite susceptible reaction	Resistant or escape reaction
Anthracnose (*Colletotrichum graminicola*)	13.4	86.6
Rough leaf spot (*Ascochyta sorghina*)	35.9	64.1
Sooty stripe (*Ramulispora sorghi*)	68.4	31.6
Oval leaf spot (*R. sorghicola*)	18.7	81.3
Zonate leaf spot (*Gloeocercospora sorghi*)	22.0	78.0
Grey leaf spot (*Cercospora sorghi*)	92.0	8.0

These data suggest that conditions during the 1970 growing season were well suited for obtaining information on resistance to grey leaf spot and possibly sooty stripe. Some lack of infection was believed due to disease escape rather than host resistance.

A number of problems are encountered in obtaining reliable disease reaction data on the world sorghum collection. Most of these fit into the three areas listed below:

1. Wide range of maturity dates (75 to 205 days during the 1970 growing season) and its relation to fluctuations in inoculum level and environmental conditions suitable for infection during the growing season.

2. Yearly variations in conditions suitable for disease epiphytotics.

3. Arrangement of seed within the world collection which, if planted in order of I.S. numbers, may result in pockets of resistance that could impede dissemination of pathogens throughout the field.

Measures are being taken to minimize the influence of these three factors on results. With respect to item 1, all entries are scored at least twice during the season and late maturing types are scored a third time.

Entries which give a susceptible reaction during any one of the scoring periods are rated susceptible. Ideally, high levels of inoculum and suitable environmental conditions for disease should exist throughout the growing season. However, such is not the case, and thus several disease readings during the season only reduce, at best, the problem of proper disease exposure. With respect to item 2, each entry ideally should be scored during several seasons. This procedure will be followed to the extent time and adequate staffing permit. With respect to item 3, the order of I.S. numbers in the field is being mixed systematically in order to limit the amount of genetically similar lines to not more than 25 consecutive rows.

3. Witchweed:

Witchweed, identified as *Striga hermonthica*, is found in practically all sorghum-growing areas of West Africa. Overall yield loss is difficult to ascertain, although it is believed to rank high when compared with most disease problems. The complexity and magnitude of the witchweed problem in West Africa far out weigh the amount of attention which it has received. In Nigeria, fields are sometimes abandoned by farmers because of high *S. hermonthica* infestation, and yield losses in excess of 50 percent have been observed in several fields. *S. hermonthica* also attacks maize, late millet, and native grasses, but to a lesser degree. There is some evidence to support the hypothesis that different strains of *S. herminthica* are involved in the parasitism of the three major cereals crops.

Very little is known about resistance in sorghum to S. hermonthica. Several locally adapated sorghum such as Farafara and Short Kaura show tolerance, but under very heavy infestation such varieties may not produce grain. Local varieties also trigger and support growth of large numbers of S. hermonthica plants. Unless these plants are destroyed before flowering, an abundance of S. hermonthica seed is produced which can parasitize several future crops of sorghum. Since witchweed does much of its damage before emergence above the soil surface, there is a limit to the advantage gained by weeding. Host resistance would seem to be an ideal method to control S. hermonthica in West Africa since it is widespread and chemical control would require considerable expense and development in the agricultural sector. An effort is underway to identify sources of resistance for use in a sorghum breeding program.

During 1970, part of the world sorghum collection was scored for reaction to S. hermonthica. All entries were checked at least twice and some late maturing types as many as three times. Susceptibility was based on the appearance of chlorotic or necrotic spotting, or both, on sorghum leaves. Using this critarion for susceptibility, 56 percent of the 4,000 entries tested were classified as susceiptible. A large number of entries which showed no symptoms are believed to be escapes since the land used was not heavily infested with S. hermonthica. Symptomless entries will be tested in 1971 in a field set aside specifically for work pertaining to S. hermonthica. At planting, the witchweed infestation already in the soil will be increased by adding S. hermonthica seed to the planting furrow with a modified hand planter. A concerted effort was made in the fall of 1970 to collect an abundance of S. hermonthica seed for this purpose. In later stages of screening additional rating criteria will be necessary. Leaf spotting is presently used because it adapts easily to screening a large number of entries. There is some evidence that not all susceptible sorghums develop leaf spotting.

In 1969, a total of 40 exotic sorghums were tested to determine reaction to S. hermonthica. In 1970, this was expanded to over 90 entries including several Nigerian sorghums. Sorghum leaf spotting was used as the criterion for susceptibility, and entries were scored on a 0 to 7 severity rating scale at three stages of plant development. Results were similar to those of 1969. Feteritas again showed good resistance; milos, hegaris, and sorgos were generally moderately susceptible; and most kafirs were highly susceptible. Nigerian sorghums, as a rule, showed little or no leaf damage, and a selection of several U.S. hybrids ranged from slightly to highly susceptible. Two Nigerian maize selections tested showed moderate susceptibility.

4. Downy mildew:

Downy mildew (Sclerospora sorghi) is potentially a very destructive disease of sorghum, particularly in tropical areas of the world. This disease has not become serious in West Africa, although environmental conditions in much of the sorghum-producing area would seem to be favorable. As farmers begin to practice more intensive cropping and plant populations increase, it is likely that the incidence of this disease will increase unless resistant varieties are used.

In recent years, the most serious attack of downy mildew observed in a farmer's field was at mile 9 on the Zaria-Kano road in October, 1969. An estimated 10 percent of the plants did not produce heads because of severe systemic infection. In 1970 an attack of similar magnitude was observed 12 miles east of Zaria at the Maigana Farm Center. The farm manager mentioned observing losses of 5 to 10 percent in farmers' fields a few miles south of Maigana. Epiphytotics of downy mildew occassionally occur on the I.A.R. farm, although there have been none in the past five years.

Because of the potential threat of downy mildew and the absence of a satisfactory artificial inoculation technique, it was decided to start a downy mildew "sick plot" in 1970. This plot will be used to identify resistant material when the inoculum level of the soil has been raised to a high level. The plot covers approximately 0.1 hectares and is located on relatively heavy, poorly drained soil. In 1969, a downy mildew susceptible local selections, FFBL 3-1-6, growing on the site showed approximately 2 percent systemic infection.

In 1970, soil in part of the plot was amended immediately before planting with one- and two-year-old oospore-bearing leaf trash. To measure the effect of this treatment on the incidence of downy mildew, a locally adopted downy mildew susceptible line, 2123, was planted on untreated as well as treated soil. The number of plants showing systemic cymptoms were recorded at 3 weeks, 5 weeks, and at flowering. Data are presented in the following table:

Time of observation	Treated soil			Untreated soil		
	Total No. plants	No. plants infected	% infection	Total no. plants	No.plants infected	% infection
3 weeks	2045	152	7.4	2128	33	1.6
5 weeks	1462	184	12.6	1500	37	2.4
Flowering	1361	198	14.5	1479	49	3.3

These results show that adding oospores to the soil increased systemic infection 4 to 5 fold. The 14.5 percent infection observed in treated soil at flowering is significant considering that 1970 was a poor year for downy mildew on the I.A.R. farm. No systemic downy mildew infection was observed in the World Sorghum collection in 1970; although the collection grew in the same fields where downy mildew was observed in each of the previous 5 years, including 1965 when the collection was scored against a downy mildew epiphytotic. More oospores will be added to the sick plot prior to the 1971 growing season.

The International Downy Mildew Sorghum Nursery was grown in the downy mildew sick plot in 1970. This nursery consisted of 15 sorghum and 2 maize entries from India, Uganda, Israel, and Texas. All entries were planted in oospore amended soil. As a rule, entries resistant in their country of origin showed little or no infection in Nigeria, and those susceptible showed a moderate amount of infection. A few plants in each maize entry showed apparent systemic downy mildew symptoms. Downy mildew has not been reported on maize in West Africa, although it is serious in some tropical countries, notably in Southeast Asia. The international nursery will again be planted in 1971 and infected maize will be more thoroughly investigated.

5. Smuts:

a. Covered smut - Covered smut (*Sphacelotheca sorghi*) occurs virtually everywhere sorghum grows in West Africa. Yield losses exceeding 50 percent have been observed in fields in several countries, although losses for West Africa are estimated to be 5 to 10 percent. Thiram seed treatment has been shown to give almost 100 percent control of covered smut in tests in several West African countries. However, the vast majority of farmers do not yet use seed dressings.

A wide range of symptoms are associated with covered smut in West Africa. In Nigeria alone, variability is found in the grain/sori ratio of infected heads as well as in the color, shape, and size of sori. Some symptom variation was initially thought to be associated with the existence of different physiologic races; hence, a study was initiated to investigate the extent of pathogenic variation in Nigeria.

During the 1969 growing season, 25 isolates of covered smut were tested against six differential sorghum varieties. In 1970, 40 isolates, including several repeats from earlier tests, were tested against an expanded set of 10 differential varieties.

Results from both years showed few significant differences in reactions produced by various isolates. Most isolates gave a definite or similar reaction to that reported for physiologic race 4. Most isolates were collected in the fall of 1968 and stored in a refrigerator until used. Isolates came from both Candatum and Guineese types of sorghum and represented a wide range of soral characters and geographical locations throughout northern Nigeria.

Because of its economic importance and the fact that few West African farmers use seed dressings, it was suggested at the sorghum-millet seminar, Bambey, Senegal, that breeders consider incorporating resistance to covered smut in new sorghum varieties. As a result, arrangements are being made to extend the covered smut physiologic race study to Senegal, Gambia, Mali, Upper Volta, Ghana, Niger and Cameroun. Seed of 10 differential varieties will be sent and one isolate of covered smut will be tested in each country in 1971. Cameroun will receive additional seed for testing an isolate obtained from dry season "Muskwari" sorghum.

b. Loose smut - Loose smut (S. cruenta) is commonly found on sorghum in Nigeria and Niger, although resulting loss in yield probably does not exceed 2 percent. Little else is known concerning distribution in West Africa except that it is almost nonexistent in Upper Volta and Senegal. Thiram seed treatment generally controls this disease satisfactorily. During the past two years a study has been undertaken to investigate physiologic races of S. cruenta in Nigeria. A total of 13 isolates have been tested on one or more occasions against 5 to 8 differential sorghum varieties. Most isolates gave a reaction type similar to that reported for race 2. A few isolates did not behave like any of the three races of S. cruenta reported in the literature.

Loose smut in Nigeria and Niger is typically found on tillers of plants having healthy primary shoots. In 1968, a field of local sorghum at the Farm Training Center, Kasarawa, about 12 miles south of Sokoto, showed about 5 percent loose smut infection. All infection was limited to tillers and planting seed had been treated with Alderx T, a thiram-aldrin formulation. Similarly, on the I.A.R. farm, and particularly on irrigated sorghum grown in the winter nursery, smutted tillers commonly occur on plants which grow from treated seed. This type of infection could become important if ratoon crops of sorghum were grown to take advantage of the long growing season in Nigeria. No differences have been detected in the pathogenic behavior of isolates obtained from tillers and primary shoots. A pot experiment using sterlized soil amended with S. cruenta teliospores did not lend support to the hypothesis that tiller infection arises from latent infection by soil-borne teliospores. More research is needed to clarify this matter.

c. Head smut - Head smut (Sphacelotheca reiliana) is not a serious problem in Nigeria although it occurs in most sorghum producing areas. It also is commonly observed in Niger, but appears to be rare in Upper Volta and Senegal. In Nigeria, overall loss is estimated at less than 2 percent. However, some serious attacks have been reported in the southern part of Northwest state. In the Samaru area infection is often associated with those parts of fields having trees. In these locations, 20 percent head smut infection has been noted on several occasions. This "tree effect" is not clearly understood.

Very little is known about varietal response to head smut in Nigeria. Since head smut incidence is generally not serious, it has not been possible to identify resistance by use of natural infection. Head smut cannot be controlled by seed treatment; hence, resistance is the only practical method for control. An attempt is being made to establish a head smut sick plot at Samaru which should make it possible to screen for resistance with relatively little effort. In addition, the hypodermic injection technique for artificial inoculation now appears to be sufficiently reliable for use as a technique to determine host response to this disease.

Teliospores collected from locally grown sorghum at the end of the 1969 growing season were added to soil of part of the head smut sick plot immediately before planting in 1970. Spores were hoed into the upper 5 cm of soil within rows at a rate of approximately 8 g per meter row. Seed of a susceptible Pink Kafir selection was then planted in the rows at a depth of 2.5 cm. Observations were made on the incidence of smut in both the first and ratoon crops. Plants showing smut symptoms prior to cutting back were up-rooted. These data are presented below:

Soil treatment	Total no. plants	No. of plants infected: First crop	No. of plants infected: Ratoon crop	Total no. plants infected	% Infection
Teliospores	3564	91	147	238	6.6
No teliospores	367	0	0	0	0.0

These results show that adding teliospores to the soil increased infection from 0.0 to 6.6 percent. The ratoon crop showed more than a doubled incidence of infection. If a sufficient quantity of spores can be added to the soil, the plot should, in 2 to 3 years, be ready for screening sorghum.

Twenty-one sorghum varieties, including 5 Nigerian sorghums and 16 exotic sorghums from the U. S. were tested for reaction to head smut. Plants were artificially inoculated at 3 weeks of age using the hypodermic injection technique. The Nigerian sorghums, which included SK 5912, YG-95760-3-10, Line 2123, ZI 69, and FFBL 3-1-6, gave infection ranging from 71.0 to 90.3 percent. Most exotic types, including White Yolo, CI.182 Feterita, Texas Blackhull Kafir, Pierce Kafirita, Combine 7078, Spur Feterita, Leoti, Combine Kafir 60, Martin, and Westland, showed no infection. Kansas Orange, Dwarf Hegari, Tx 09, Finney Milo, and NK 300, each showed less than 6 percent infection. Pink Kafir showed 47.2 percent infection. Two maize selections were also inoculated in the same manner. Head smut did not develop in the maize; however, several plants showed distortions including multiple earning, tassel-silk, tassel-ears, absence of tassels, and shortened, twisted internodes.

Data obtained to date on varietal response to head smut suggest that a heretofore undescribed physiologic race of head smut occurs in Nigeria. A confirmation of this, however, will require further testing. Over 60 exotic sorghums, many of which have a known head smut race reaction in the U. S., are presently being tested under irrigation. Plans call for an extension of this type of work during the 1971 growing season with a wider range of Nigerian sorghums.

d. Long smut - Long smut (Tolyposporium ehrenbergii) is generally of minor importance in West Africa. This disease occurs most commonly in drier sorghum-growing areas found in the Sudan Savanna Zone. In some years losses may reach as high as 10 percent in specific areas, however losses of this magnitude are not common. Infection is generally believed to occur through flowers, although more research is needed to verify this.

The immediate objective of the long smut program is to develop an artificial inoculation technique with which to determine host reaction. At present, very little information is available regarding resistance to this disease. During the past year, several inoculation techniques were tried at the I.A.R. farm without success. These included dusting seed with teliospores prior to planting and inoculating flowers with sporidia and teliospores at various stages of development. Both morning and evening inoculations were made on cloudy and sunny days, and inoculated heads were either bagged or left open. The reason for negative results is not known. It is hoped that Mr. S. K. Manzo will be able to pursue this problem in more detail for his M.Sc. thesis research when he returns from his studies in the United States.

The sorghum breeder at Kano, Mr. J. O. Awoniyi, and his predecessor, Dr. A. O. Abifarin, have attempted to study the effect which seed inoculation and bagging have on the incidence of long smut infection. Many of their results have been inconclusive which can in part be attributed to the natural occurrence of long smut in the Kano area. However, their results do seem to indicate that bagged heads produce more long smut than unbagged ones, particularly if heads are bagged a few days before flowers open.

6. Root rot:

Root rot can be found on sorghum in Nigeria almost annually, although damage caused is usually slight. However, in 1970 severe attacks were observed in several locations, and yield losses in some fields were estimated as high as 50 percent. Very little research has been conducted on this problem apart from observations made in farmers' fields and on the I.A.R. farm.

The root rot which occurs in Nigeria can be observed first as a reddening of roots in young seedling plants. Cortical tissue often rots completely before any discoloration occurs in the vascular cylinder. With severe infection the vascular cylinder also rots. Plants attacked in the seedling stage often remain stunted for a few weeks and their leaves take on a slightly yellow color.

Factors which affect the incidence of root rot are not clearly understood. However, it seems that plants growing in fertile soils with adequate moisture usually recover from seedling infection and produce a normal crop. Under adverse conditions, plants may remain stunted and eventually die before producing grain. It is suspected that the drought which prevailed in much of the sorghum growing area of Nigeria for several weeks after planting was the primary factor in the high incidence of root rot this year. Sorghum is generally interplanted with other crops, such as millet, which compete with sorghum for moisture and nutrients.

Much the same type of root rot was observed on sorghum growing in Senegal. Workers in Senegal report that the disease is especially noticeable in fields planted to sorghum in the previous year. A small experiment was conducted at an IRAT sub-station in Senegal to observe effects which various seed dressings, fertilizers, and lime have on the incidence of root rot. When I observed the experiment in early September it was obvious that plant growth on plots having high fertility and lime was superior to that on plots lacking these amendments. Root rot was observed in all plots; however, a lower percentage of roots were affected in plants growing in plots with high fertility and lime. Seed dressings had no apparent effect on the incidence of root rot.

Attempts have been made to isolate the casual organism(s) associated with root rot in Nigeria. Fungi most commonly isolated from affected roots include Fusarium oxysporium, F. moniliforme, F. roseum, and Cephalosporium sp. To date, attempts to re-infect sorghum with these organisms have failed.

MILLET

Downy mildew (Sclerospora graminicola), smut (Tolyposporium penicillariae) and ergot (Claviceps microcephala) are the three most important diseases of pearl millet in West Africa. Of these, downy mildew causes by far the most damage. Estimates on yield loss attributed to this disease for West Africa are not available; however, the figure would likely approach the 8 to 10 percent annual average estimated for Nigeria.

The primary objective of the downy mildew program is to identify resistance. Some inbred lines within the world millet collection have shown a high type of resistance in several years of screening. Most of these lines originated in Nigeria or Niger. A request has been made to obtain seed of material which shows very little susceptibility to downy mildew in Upper Volta and Senegal. Hopefully this material will be available for testing in Nigeria during the 1971 growing season.

In the past, natural infection has been utilized to identify resistance to downy mildew. Natural epiphytotics of the disease occur almost annually at the I.A.R. farms in Samaru and Kano. However, the incidence of downy mildew during the 1970 season was considerably less than usual. As a result, lines having a high type of resistance could not be identified. This low downy mildew incidence is illustrated by the fact that 5-week-old Tift 23 plants showed only 10 percent infection. In most years Tift 23 shows 100 percent infection as early as two weeks after planting. Low infection is believed due primarily to the dry conditions which prevailed until about the sixth week after planting. Unusually dry conditions before planting may also have lowered the germination rate of soil-borne oospores during the early stages of plant growth. Downy mildew incidence increased considerably after mid-July when rainfall was high.

At present, except for isolated outbreaks, smut and ergot are of little economic importance in West Africa. Most local materials in Nigeria do not become heavily infected by these diseases. However, exotic types which are introduced into the breeding program for high yield and other desirable agronomic characters are generally extremely

susceptible to both of these diseases. Total rainfall appears to have little influence on the incidence of smut, but ergot infection is reduced considerably in areas of low rainfall such as those found in Niger, north of the Nigerian border.

Materials which showed promising smut resistance in previous years were again scored for smut reaction in 1970. Several selections within certain lines continued to show a high type of resistance. Natural infection coupled with bagging again gave a high smut challenge against which materials could be satisfactorily tested.

Resistance to ergot again could not be identified during 1970. This was due primarily to the erratic incidence of ergot infection during the season and the absence of an artificial inoculation technique to provide adequate challenge throughout the booting and flowering period. Some ergot infection appears to be associated with sterility in much the same way this relationship has been demonstrated in sorghum. Because of its apparent association with sterility, ergot may prove to be more of a problem than smut in the development of new varieties and hybrids.

The maize blight picture in Nigeria became considerably more complex during the 1970 growing season. Observations made during the past season suggest that a new form of Helminthosporium, possibly a new strain of H. maydis, was present. In areas as far north as Samaru, both northern leaf blight (H. turcicum) and southern leaf blight (H. maydis) are generally found, but infection is usually limited to isolated lesions and yields are not affected. During the 1970 growing season a blight epiphytotic, believed to be caused by H. maydis, was observed on experimental plots at Samaru and Kano. Diseased leaf samples received from other locations (Maigana, Ganawuri, and Shendam) suggest that severe attacks occurred at other locations in the north as well. An epiphytotic of H. maydis has definitely not occurred at Samaru or Kano with the past 6 years, and there are no records of one having ever occurred at these locations. Slight blight infection caused by H. turcicum was also observed at Samaru, but leaf samples from maize growing at Pankshin and Ryom suggest that northern leaf blight may have been more serious in areas of higher elevation.

H. maydis commonly occurs in the Mokwa area. However, this year plants within Samaru Composite 2, the Columbia Composite, and the variety NS-5 were severely attacked by a type of blight which produced lesions similar to those caused by H. carbonum. In the past, these maize selections have shown good resistance to blight caused by H. maydis. The appearance of blackened ears on some plants also seemed to support the hypothesis that the new blight was caused by H. carbonum. The fungus isolated from blackened ears did in fact resemble H. carbonum; however

the fungus isolated from leaf lesions could not be distinguished from H. maydis. From host response data obtained, Mr. F. DeWolff, maize breeder, Mokwa, concluded that resistance to the new blight was carried in the cytoplasm of the female parent. Hence, it should be possible to eliminate susceptibility within the composites in one selection cycle.

The blight symptoms observed at Samaru were almost identical to those observed on diseased leaf specimens from Mokwa. In addition, the fungus isolated could not be distinguished from H. maydis. No blackened ears were observed at Samaru. Samaru Composite 3, Mexico-5, and NS-5 were all highly susceptible to blight at Samaru.

On the basis of observations made during the 1970 growing season, it seems likely that a new strain of H. maydis now occurs in Nigeria and that this strain is the one of importance in the northern part of the country. However, more observations are necessary before definite conclusions can be drawn. Fortunately, none of the susceptible maize has been released in the north, and it appears that sufficient sources of resistance to this disease are available in breeding material.

As usual, maize rust (Puccinia polysora) was not observed at Samaru until late in the season. Hence, yield losses caused by this disease were insignificant. Most material now used in the breeding program at Samaru has good resistance to this disease.

Maize viruses are generally thought to be of minor importance in West Africa. Streak, which is commonly found throughout Nigeria is generally limited to isolated plants during the rainy season, although it can be more serious on irrigated maize during the dry season. A recent report from Ghana would seem to indicate that virus diseases are perhaps more of a threat in West Africa than was earlier thought. Mr. Wenstran, manager of a commercial maize production farm located about 60 miles northwest of Kumasi, reports that virus diseases are a serious problem on maize grown during the short, winter rainy season. Identity of the diseases has not been confirmed; however, it was suggested that as many as four diseases, including streak, stunt, maize dward mosaic, and sugarcane mosaic, are involved. In addition to streak symptoms, redenning and purpling of leaves is common as well as dwarfing caused by shortened internodes.

TRAINING

Mr. S. K. Manzo gained experience in cereal pathology for three months during the summer of 1969 and from June to December, 1970. In June 1970, he completed requirements for the B.Sc. degree in agriculture from Ahmadu Bello University, graduating with highest honors in his class. He departed for the U. S. as an AID participant in December, 1970, where he will pursue four quarters of course work in plant pathology and related subjects at the University of Minnesota. Also included in his training program are three months to be spent with Dr. L. K. Edmunds, USDA-ARS sorghum pathologist, Manhattan, Kansas, where he will have opportunity to become acquainted with sorghum pathology research and production practices within the U.S. In March, 1972, he is scheduled to return to Nigeria where he will pursue thesis research on long smut of sorghum for the M.Sc. degree in plant pathology from Ahmadu Bello University

During the summer of 1970 another promising A.B.U. agriculture student, Mr. S. Misari, also worke[illegible] cereal pathology. The principal training which he received involv[illegible] aintenance and disease scoring within the world sorghum collection and recording data on various sorghum smut experiments.

ENTOMOLOGY

G. T. York

Work was continued on the three major pests, the shoot flies, stem borer and the sorghum midge. Although some work was done on the plant bugs and a small noctuid (Eublemma gayneri) infesting heads of sorghum, additional studies are needed to evaluate the damage these insects cause.

Greater emphasis was placed on plant resistance to the shoot flies with material from India and Israel, and plant tolerance to these insects with material from Uganda.

A late and heavy infestation of the stem borer Busseola fusca strongly indicated that migratory moths were responsible for the infestation rather than the local carry-over of diapausing larvae.

Shoot flies - The work on shoot flies continues as a cooperative project between Mr. John C. Deeming and myself. Mr. Deeming has recently submitted for publication a manuscript of the genus Atherigona. He has

described 24 new species of this genus, and has also added information on host plants, distribution, abundance, and other matters of interest. In addition he has submitted a short paper describing the larval and pupal characteristics of one of the Chloropidae.

(a) Resistance of sorghums to the shoot flies: An International testing program of sorghum varieties found to be resistant to the shoot flies has been in progress for a few years under the sponsorship of Dr. W. R. Young, Entomologist with the Rockefeller Foundation stationed in India. During 1970 a large portion of this collection including varieties from India and Isreal was received, planted and observed in Nigeria. Most of the routine field work was done by Mr. A. Adesiyun a student of Ahmadu Bello University.

The planting date was July 15 which was considered late enough to insure a good infestation of shoot flies. Fertilization, observations and records followed fairly close to the recommendations given by Dr. Young.

The varieties from India showed somewhat greater resistance to attack than those from Israel. However all varieties showed considerable less injury than the susceptible variety which was included in the test. The early infestation at Samaru was largely Atherigona lineata ugandae but this was later followed by the more common and generally distributed species A varia soccata.

Although the planting date was considered late enough for a heavy infestation the numbers present were not as high as anticipated. It is therefore felt advisable to continue the experiment one more season before making an assessment of the relative resistance of the different species. Improvement in techniques will be incorporated inthe 1971 experiment.

All pertinent data of the 1970 experiment have been forwarded to Dr. Young for inclusion in his world-wide summary of the problem.

(b) Tolerance of sorghums to the shoot flies: The work on tolerance of sorghum to the shoot flies has been carried on at Serere for several years. (Fifth Annual Report of the AID-ARS Project, Major Cereals in Africa, 1968 pp 76-77). Seeds of 18 selections, which followed considerable breeding and screening work, were received from Dr. B. D. Barry for planting at Samaru in 1970. This experiment had four replicates and was planted on July 17, on land adjacent to the material from India.

Although there was some concern regarding the ability of these selections to produce an acceptable crop, the final outcome of some selections was quite satisfactory. Uniform size and height of tillers and head size was surprisingly good in some of the selections. Others were quite variable and would need further breeding or discarding. One selection, 158-P-1-1-SB79 was selected for more extensive testing next season. Several other selections appeared equally good regarding the tolerance factor but did not have good head exsertion. The variety Serena also performed well under Samaru conditions and will be given further testing.

It should be mentioned that these are not varieties that could be used under local conditions due to their short maturity period, but might be quite acceptable for mid or late season planting to mature at the end of the rainy season.

(c) Insecticides for shoot fly control: Previous work has shown phorate (Thimet) and disufoton (Solvirex) to be effective in controlling shoot flies when used at proper dosages. In 1970 samples of furadan (Carbofuran) were received from Niagara Chemical Division, FMC Corporation of Middleport, N. Y. 14105. Both furadan 75 WP and furadan 3 granules were included in the shipment. These were given preliminary tests during the heavy shoot fly season of 1970.

Furadan had been tested earlier for shoot fly control in India and found to be very effective. It was therefore considered advisable to test it under conditions at Samaru to see if it was equally effective here. Another point of interest was that the wettable powder had been used as a seed treatment, and was the first insecticide that had been successfully used in this manner.

Suggestions for applying the wettable powder were to spray it onto the seeds with a suitable sticker. Since the seed available had already been treated with a fungicide and an insecticide which were in the powder form a further application of insecticide in the liquid form seemed out of the question. As a result the wettable powder was simply mixed as a powder with the already treated seed.

The first test using furadan was planted August 20, 1970. The seed treatment consisted of 20 grams of the 75% WP to 500 grams of seed. The 3 percent granules were applied at 10 lbs. per acre. Ten percent phorate granules were also applied at 10 lbs. per acre.

A second test was made the following day August 21, changing the rate of furadan WP to 10 grams per 500 grams of seed, and the granules to 20 lbs. per acre.

Planting in both tests was done by two different methods even though the two methods were primarily considered for the granules. In one case a small furrow was opened, the granules applied and the seed placed with the granules and then the furrow covered. In the other method the furrow was opened, granules applied and then covered, and planting was done with a small hand planter. The two methods were used to determine if close contact of the seeds with the granules might have any adverse effect.

Due to travel to attend meetings in Senegal and observe experimental work in other West African countries, the tests were not examined for shoot fly injury until September 17 and 18. One additional check was made September 28. Results of these examinations are shown in the following tabulations.

Number of shoot fly infested plants of NK300 sorghum planted August 20, 1970:

Type of planting	Date examined	Treatments: phorate granules(1)	furadan granules(2)	furadan on seed(3)	Check
furrow	Sept. 17	2	8	3	114
planter	"	8	6	3	76
furrow	Sept. 28	8	5	2	11
planter	"	1	5	1	17
Total		19	24	9	218

(1) 10% granules at 10 lbs per acre
(2) 3% granules at 10 lbs per acre
(3) 20 grams of 75% wettable powder on 500 grams of seed.

Number of shoot fly infested plants of NK300 sorghum planted August 21, 1970:

Type of planting	Date examined	Treatments: phorate granules(1)	furadan granules(2)	furadan on seed(3)	Check
Furrow	Sept. 18	2	6	19	82
planter	"	3	3	9	31
furrow	Sept. 28	1	6	4	7
planter	"	2	0	9	12
Total		8	15	41	132

(1) 10% granules at 10 lbs per acre
(2) 3% granules at 20 lbs per acre
(3) 10 grams of 75% wettable powder on 500 grams of seed.

It may be noted in the first planting of August 20 that the phorate and furadan granules gave similar results, while the furadan on seeds gave somewhat better results. All three treatments showed good control in comparison with the untreated check.

In the second test of August 21 where different rates of furadan were used, the most noticeable change was the increased number of infested plants where the seed was treated with only 10 grams of furadan to 500 grams of seed. This apparently was not sufficient for good control.

A third small trial was planted August 24 for a further evaluation of the seed treated with the two rates of furadan. Infested plants for the first examinations made on September 15 were, 3 for the 20 grams and 15 for the 10 grams as compared to 192 for the untreated seed. A second examination made on September 25 gave 73 infested on the 20 grams and 141 on the 10 grams with the untreated at 178. This again showed the 10 grams of furadan per 500 grams of seed a bit light for adequate protection.

During the growing season Mr. D. J. Andrews the sorghum plant breeder, reported serious shoot fly damage to late planted sorghum that was to be used for breeding purposes with the long season varieties. Late planting was necessary for syncronization of flowering of the two groups of sorghums.

Although all previous work with systemic insecticides for shoot fly control had been done at planting time, we felt that a side dressing of phorate would be worth trying. Accordingly small trenches one to two inches deep were dug along side the rows some two inches from the plants. Ten pounds per acre of the 10 percent phorate granules were spread into this furrow and then covered. After a week or 10 days shoot fly damage was reduced to a very low level and plants made a very satisfactory recovery. No check material was left for comparing results since all plants were needed for the breeding program. However, a small patch of sorghum of similar planting date, located near by, was not treated. Very few heads were produced on this sorghum. Both Mr. Andrews and I are convinced that a side dressing of phorate to young plants will give satisfactory control of shoot flies. Applications on more mature plants for ratoon cropping will need further testing.

Stem borers

Busseola fusca is the stem borer of major importance during the rainy season in this area. Mature larvae enter the diapause stage at the end of the rainy season and pass the dry season in this quiescent stage. Several species of Sesamia are present during the rainy season but have not been abundant in the Samaru area. However, they do not have a resting stage during the dry season and infest sorghum, maize and millet in the irrigation plots during the dry period. Farther south Sesamia spp. are the most destructive borers.

Previous work has shown that endosulfan (Thiodan) granules give good control of Busseola. Application of the insecticide can be delayed until feeding scars of the young larvae are noted in the whorl. Thus in times of low infestations no control needs to be applied. One application in most instances is sufficient for adequate control.

During 1970 several of the experimental plots were treated with endosulfan granules, using hand applicators constructed by the Agricultural Engineering Section of the Institute for Agricultural Research. Entire plots had to be treated to maintain uniformity of the trial but all persons involved expressed satisfaction with the control.

Several tests were made during the season using endouslfan as well as other insecticides. The first of these tests had two objectives (1) to calibrate the hand applicator in an attempt to apply uniform rates of the different granules and (2) determine effectiveness of the different insecticides.

Previous work had shown that a uniform setting of the applicator gave a wide range of delivery of the granules due to the differences in texture and composition of the granules. After calibrating the machine it was found that openings from minimum to maximum were not enough to give a uniform delivery of the different granules. To attempt to compensate for this the speed of the operator was varied according to calibrated rates.

Insecticides were applied August 25, 1970 to four replicates of NK300 sorghum. Materials were weighed before and after treatment of the four replicates, rather than individual plots, to get rate of applications. No borer infestation had been noted prior to the application of insecticides.

A few days after the insecticides were applied, a general and rather heavy infestation of borers was noted. However no attempt was made to determine mortality of borers due to the delay of infestation after insecticide application. On August 26, a count was made of sterile heads caused by infestation of the peduncles. Results of this as well as the actual application rates are shown by the following figures.

Granular insecticides applied to NK300 sorghum to determine rate of application of insecticides and borer injury to peduncles:

Code No. of Insecticides	Material	Pounds per acre	No. of sterile heads due to peduncle infest.
1	Gardona	14	98
2	Solvirex 5%	11	125
3	Solvirex 10%	19	63
4	Solvigam	12	86
5	Ekalox	18	52
6	Thiodan (old)	12	21
7	PP-511	14	35
8	Check	--	87
9	DDT 7½%	9	70
10	Thiodan (new)	9	34

Only general deductions can be drawn from this work. (1) Rates of application of granular insecticides with the hand applicator are not uniform in spite of precautions to correct differences. The only sure way to determine amount per acre is to weight insecticides before and after treatment. (2) Thiodan and PP-511 (pirimphos methyl) granules were the most effective insecticides for controlling stem borers. (3) Early applications of granules before borer damage is noted, is probably not as effective as later applications when leaf damage can be seen. (4) Treatment five (Ekalox) cause noticeable burning of foliage, especially in the funnel but in due time it could not be noticed.

A portion of a field of sorghum variety Farafara was treated with five of the granular formulations, Gardona, PP-511, DDT, Thiodan (old) and Thiodan (new). An appreciable difference in growth between treated and untreated plots was noted as the season progressed. Counts were made of the number of dead hearts, that is the main stems that were

killed by borers. The figures are given as percentages, along with amount of insecticides applied, and yield as determined by sampling. It may be noted that yields are not proportional to dead heart percentages but this is no doubt due to the irregular plant stand.

Material	Pounds per acre	Percent dead hearts	Yield in lbs/a
Gardona	10	8.3	1570
PP-511	7	5.7	1450
DDT	9	9.3	1178
Thiodan (old)	10	8.2	1298
Thiodan (new)	6	4.9	1474
Check	--	25.2	1179

The sorghum used in checking insecticides for shoot fly control was later attacked by stem borers. An application of endosulfan granules at approximately 10 lbs per acre (material not weight) was applied to one half of all of the plots. Yield increases in tests one and two were 34 and 31 percent respectively.

Sorghum midge

For several years observations have been made on the sorghum variety IS 3592 with respect to its probable resistance to the sorghum midge. This variety was first noted by Dr. Webster while checking a portion of the world collection that was grown at Samaru. Several subsequent plantings appeared quite promising but midge populations were not known. In 1969 plantings were made at two week intervals so that at least some place in the sequence the sorghum heads would be subjected to a high midge population. Early plantings matured before a high midge population built up and later plantings were virtually wiped out by shoot flies, hence the status remained indefinite.

In 1970 the insecticide phorate was used at planting time to control shoot flies. One of these plantings was subjected to a high midge population while others failed to mature due to lack of rainfall toward the end of the season. Some midge injury was noted and development of the insects through the complete life cycle was possible on the variety IS3592. Thus although it is not immune to attack it still appears to have some resistance. Work will be continued with this variety as well as a number of other varieties selected by Dr. King from his plantings of the world collection.

Miscellaneous Insects:

Several species of plant bugs are known to infest the heads of sorghum. The extent of infestation varies greatly among different varieties. The varieties with compact heads have the highest populations due undoubredly to the protection afforded by this compactness. Counts from individual heads of the hybrid NK300 had over 300 insects per head. Proper assessment of damage from such populations have not been made.

Small larvae feeding on developing seeds of sorghum have been determined as Eublemma gayneri Roths, (Noctuidae). These larvae feed on individual seeds often eating only a portion of a seed before proceeding on to another one. As in the case of the plant bugs the compact heads are most severely attacked. In heads that fail to properly exsert from the sheath, the portion still within the sheath is a particularly favorable site for these worms. As many as 20 larvae have been counted in individual heads.

The false codling moth Cryptophebia lencotreta was again abundant in the silks of corn but infestations occur after pollination so very little injury results. This insect as well as the plant bugs are serious pests of cotton.

SUMMARY

Sorghum varieties selected in India and Israel for resistance to the shoot flies appeared quite promising. Also sorghum selections from Uganda selected for tolerance to shoot flies appeared equally promising. Furadan (Carbofuran) used in a granular formulation as a soil treatment, and in the powder form as a seed treatment gave very good control of shoot flies.

Phorate (Thimet) granules, used for the first time as a side dressing for young sorghum, gave good control of shoot flies.

Endosulfan (Thiodan) granules continued to give good control of the stem borer Busseola fusca. Pirimphos methyl (PP-511) also continued to give good control and has a much lower mammalian toxicity.

The sorghum variety IS 3592 when subjected to high sorghum midge populations suffered some injury but still appears to have some resistance. Plant bugs, and a small noctuid Eublemma gayneri, cause injury to sorghum heads and need further study.

EAST AFRICA

Maize Research

L. H. Penny and L. L. Darrah assisted by
C. M. Ndegwa and E. Mwenda

Dr. L. H. Penny completed his two year tour of duty as ARS-USAID-EAAFRO Maize Geneticist at Kitale in November 1970. He was replaced by Dr. L. L. Darrah, who arrived in late October for orientation and briefing prior to Dr. Penny's departure. Mr. E. Mwenda replaced Mr. C. M. Ndegwa as Assistant Agricultural Officer/Assistant Maize Geneticist in July 1970. Other personnel underwent no changes, remaining at two field technical assistants, one driver, two keypunch operators (serving all of the Maize Research Section), and eight laborers. All personnel with the exception of the Maize Geneticist were Kenya Ministry of Agriculture employees for whom reimbursement was made through EAAFRO by the East African Office of Regional Activities (EAORA) of USAID.

In July EAAFRO assumed financial responsibility for maintenance and operation of the EAORA provided vehicle and for travel of the Maize Geneticist witin East Africa of Community business. Major inputs to the project during 1970 were the replacement of the old Chevrolet truck with a new Jeep pickup and installation of a forced air dryer in one of the drying cribs.

EAAFRO has submitted requests to the East African Community for the establishment of permanent and pensionable positions at Kitale. The positions proposed are for one research officer, two scientific assistants, two laboratory assistants, one clerical officer, and twelve subordinate staff. Final approval must be granted by the East African Legislative Assembly, possibly as early as 1 July 71.

As in the past, the Maize Breeding Methods Study yield trials were grown in four primary locations: Kitale, Endebess, Kakamega, and Njoro. In experiment 24 of 1970 five additional locations were used to better evaluate the materials. The locations and their altitudes are shown on page 92.

Annual rainfall by months is shown in Table 34. Compared to a five year running average, 1970 was wet, particularly in January and March.

Location code	Altitude (m)	Location
01	1890	Kitale (Grasslands, N.A.R.S.)
02	1860	Endebess (W. E. Strong Farm)
03	1524	Kakamega (Agric. Res. Station)
04	2195	Njoro (Plant Breeding Station)
05	1890	Kitale (Top Station, N.A.R.S.)
06	1860	Endebess (Kenya Seed Company)
07	2134	Mt. Elgon (Chorlim ADC Farm)
08	1220	Busia (Expt. Sub-Station)
09	1890	Kitale (Grasslands, N.A.R.S.,late)

Table 34. Annual rainfall at N.A.R.S., Kitale

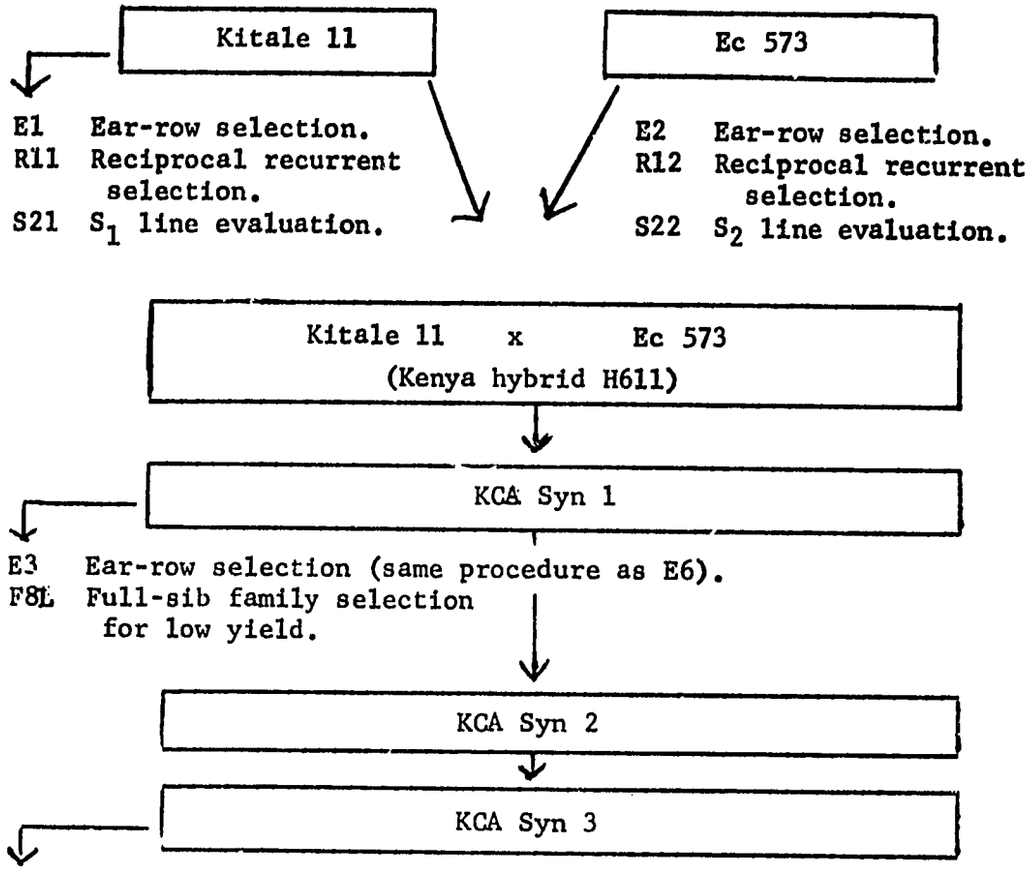
Month	1965	1966	1967	1968	1969	5 year Mean	1970
Jan.	25.2	9.2	2.8	1.1	61.6	20.0	105.7
Feb.	25.1	45.9	20.8	146.6	57.7	59.2	8.7
Mar.	66.8	106.2	103.8	68.6	107.2	90.5	226.4
Apr.	125.9	269.8	223.9	200.6	54.1	174.8	198.7
May	105.7	79.6	259.8	94.5	214.6	150.3	135.7
Jun.	52.9	82.6	144.0	127.2	49.0	91.1	62.6
Jul.	102.6	182.3	190.0	176.3	101.5	150.5	177.3
Aug.	174.9	197.4	113.7	121.0	176.2	156.6	214.1
Sep.	38.8	187.8	58.3	60.4	115.6	92.2	86.1
Oct.	211.9	62.5	230.2	87.6	119.2	142.3	82.7
Nov.	84.4	98.6	83.8	57.1	58.1	76.4	32.4
Dec.	26.8	13.7	6.9	17.8	6.2	14.3	13.6
Total	1041.0	1335.6	1438.0	1158.8	1121.0	1218.2	1344.0

Maize Breeding Method Study (MBMS)

Seventeen different selection experiments were initiated in 1964 to determine the most efficient breeding method for lesser developed countries which had had no previous maize research programs. Studies were undertaken in Kitale II (K11), Ecuador 573 (Ec573); and Kitale Composite A (KCA) which was derived from random mating the cross K11 x Ec573. Breeding methods under evaluation are ear-row selection, mass selection, and recurrent selection. Within the general class of recurrent selection are S_1 line selection, half-sib selection, full-sib selection, and reciprocal recurrent selection. Studies within types of breeding methods differ by material, plant population, selection intensity, number of cycles of random mating, selection among males, number of entries, and tester. Figure 1 outlines the current breeding program.

Two new studies have been started since March 1970. KCA(M17) was grown for the first time in the 1970 yield trials. M17 consists of a mass selection program with 10% selection intensity at a low plant population (23,438 plants per ha). M1700 was taken from a bulk of M1005. When compared to M10 it will provide information on the effect of plant populations in mass selection programs. S22, which is S_1 line selection in Ec573, was initiated in August 1970 with the first yield trials of S_1 lines in 1971. In 1971 S21 will be started in K11 to compliment S22. These will provide a comparison to the ear-row selection method (E1, E2) and to reciprocal recurrent selection (R11, R12).

Results from the 1970 yield trials are presented in Tables 35 through 45. As in 1969, Kakamega had relatively low yields and high coefficients of variation (C.V.). The error mean squares do not seem to be unusually high, hence, the high C.V.'s likely result from low mean yields alone. Table46 shows the estimates of variance components heritabilities (H), selection differential (D), and the expected gain from each cycle of selection. Heritability was calculated as $\frac{s_g^2}{s_{ph}^2}$ where $s_{ph}^2 = \frac{s_e^2}{rl} + \frac{s_{ge}^2}{l} + s_g^2$. In these equations s_g^2 is the genotype variance due to entry differences; s_e^2 is the error variance; s_{ge}^2 is the genotype x environment interaction; and l and r are the number of locations and replications within locations, respectively. Expected gain was computed as ½HD for the ear-row and S_1 line selection experiments and HD for the remainder (F8L, H14, HL15). The pooled error s_e^2, was calculated by averaging errors from each location.



Ear-row selection

E4 23,438 plants/ha., no selection among males, 49 entries.
E5 46,876 plants/ha., no selection among males, 49 entries.
E6 46,876 plants/ha., 50% selection among males, 49 entries.
E7 46,876 plants/ha., 50% selection among males, 100 entries.

Mass selection

M9 2% selection intensity, 46876 plants/ha.
M10 10% selection intensity, 46876 plants/ha.
M17 10% selection intensity, 23,438 plants/ha.

Recurrent selection

S13 S_1 line evaluation.
H14 Testcross evaluation, parent population tester.
HL15 Testcross evaluation, low yield population (F8L) tester.
H116 Testcross evaluation, inbred line tester.
F18 Full-sib family selection.

Figure 1. Outline of Maize Breeding Method Study.

Expected genetic mean squares are shown below:

Source of Variation	Genetic EMS
Entries	$s_e^2 + rs_{ge}^2 + rls_g^2$
Loc. x Entries	$s_e^2 + rs_{ge}^2$
Pooled error	s_e^2

K11(E1) at Kitale had only one replication harvested due to spray damage in the second replication. When s_{ge}^2 was computed it was negative by a large margin and was assumed to be zero. Similarly in KCA(E4) the pooled error mean square was larger than the location x entry mean square and s_{ge}^2 was assumed to be zero.

Among the ear-row experiments KCA(E4) was predicted to have the largest gain (5%). Other ear-row predicted gains ranged down to 3.3%. KCA(F8L) was predicted to decrease in yield by 11% and KCA(S13) to increase by a like amount.

Selection differentials (D) were at new highs in KCA(E4), KCA(E7), KCA(F8L), and KCA(H15). Heritabilities (H) were unremarkable when compared to previous years. No trends could be discerned in s_g^2 or s_{ge}^2.

Experiment KCA(F8L) did not have "plants with ears" data taken at Kakamega. The analysis was computed two ways for comparison. In one method the Kakamega location was simply omitted and in the second the analysis was done using Method 3 for Kitale Endebess, and Njoro and Method 0 for Kakamega. Method 3 utilizes a correction for barren plants (low yielding plants are desired rather than selection for barrenness) where Method 0 does not. Then the combined means were compared for selection it was found that nine of the top ten by each method were in common. In order to keep the estimates of genetic parameters clean and in view of the low influence of Kakamega, data presented in Tables 47 and 48 do not include that location.

Table 35. Analysis of yield data for Kitale 11(E1) in 1970.

Year or Location	Stand %	Yield (q/ha) Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale[1]	97	37.3	-	-	-	-	-
Endebess	98	54.6	18	100	93.82	225.10	-
Kakamega	99	35.1	33	103	138.87	220.43	-
Njoro	94	62.7	24	102	232.10	363.24	-
1964	99	48.1	-	-	137.38	276.42	171.30
1965	92	44.1	-	-	63.31	299.22	77.46
1966	94	60.1	-	-	96.65	287.01	162.81
1967	92	44.1	-	-	137.54	195.04	207.32
1968	91	54.3	-	-	123.56	285.35	178.70
1969	95	67.0	-	-	140.76	219.05	218.23
1970	97	47.4	-	-	154.93	174.99	98.23

[1] One replication

Table 36. Analysis of yield data for Ec 573(E2) in 1970.

Year or Location	Stand	Yield (q/ha) Mean	C.V.	Eff.	Error Ms	Tmt	T x Loc.
Kitale	98	47.8	15	104	51.22	152.79	-
Endebess	99	60.3	16	100	98.71	165.84	-
Kakamega	100	32.6	39	102	162.72	198.26	-
Njoro	96	78.4	17	103	177.19	163.36	-
1964	97	50.6	-	-	118.95	736.08	166.46
1965	94	38.9	-	-	63.68	233.85	125.40
1966	96	53.6	-	-	90.66	298.47	112.52
1967	96	33.5	-	-	61.10	260.64	110.52
1968	97	46.8	-	-	99.98	192.39	108.68
1969	95	63.0	-	-	107.79	251.15	121.91
1970	98	54.8	-	-	122.46	272.29	135.99

Table 37. Analysis of yield data for KCA(E3) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	98	58.9	14	102	70.09	163.34	-
Endebess	98	52.6	17	150	76.95	223.28	-
Kakamega	99	27.3	46	106	160.10	209.14	-
Njoro	92	81.6	12	113	98.39	242.54	-
1964	97	49.0	-	-	167.71	512.14	217.44
1965	94	45.7	-	-	87.74	185.37	134.49
1966	96	53.4	-	-	79.49	235.71	110.98
1967	78	43.3	-	-	99.01	424.12	162.28
1968	95	51.6	-	-	113.73	296.89	185.12
1969	97	66.7	-	-	129.35	294.30	187.05
1970	97	55.1	-	-	101.38	314.97	174.44

Table 38. Analysis of yield data for KCA(E4) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	98	63.4	10	100	38.80	91.99	-
Endebess	99	54.6	10	103	29.54	87.29	-
Kakamega	99	32.4	41	100	175.46	147.85	-
Njoro	94	59.1	13	101	63.28	77.53	-
1965	96	32.3	-	-	21.18	102.11	37.67
1966	94	37.4	-	-	29.55	99.15	39.33
1967	92	33.8	-	-	34.55	108.12	46.88
1968	97	46.0	-	-	42.56	129.66	80.01
1969	98	48.9	-	-	34.53	73.66	53.12
1970	98	52.4	-	-	76.77	178.66	75.33

Table 39. Analysis of yield data for KCA(E5) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	98	58.7	13	103	54.44	103.89	-
Endebess	99	58.4	18	100	109.40	172.26	-
Kakamega	99	33.5	28	122	90.21	167.06	-
Njoro	94	79.6	13	112	111.52	222.86	-
1965	94	38.7	-	-	75.37	193.59	108.67
1966	95	45.4	-	-	90.17	233.85	105.40
1967	94	50.3	-	-	66.03	223.44	146.26
1968	98	49.1	-	-	100.28	289.36	186.85
1969	97	59.4	-	-	119.80	270.56	126.70
1970	98	57.5	-	-	91.39	246.87	139.74

Table 40. Analysis of yield data for KCA(E6) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	99	78.7	11	100	77.20	159.93	-
Endebess	99	51.8	19	100	99.88	123.06	-
Kakamega	99	35.9	32	100	134.91	216.46	-
Njoro	93	81.5	14	100	125.69	174.97	-
1965	94	38.3	-	-	57.62	201.86	99.65
1966	97	52.1	-	-	126.72	221.31	149.08
1967	93	50.7	-	-	135.23	262.42	159.74
1968	98	50.7	-	-	69.44	147.29	150.35
1969	98	53.8	-	-	134.71	351.22	173.15
1970	97	62.0	-	-	109.42	297.33	125.70

Table 41. Analysis of yield data for KCA(E7) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	99	74.7	14	105	106.26	159.79	-
Endebess	99	61.1	19	101	128.85	250.37	-
Kakamega	99	34.2	36	104	150.20	222.89	-
Njoro	96	80.1	15	105	140.11	192.91	-
1965	97	41.7	-	-	69.21	354.88	121.24
1966	95	57.2	-	-	95.52	268.60	124.03
1967	91	43.4	-	-	94.04	242.08	165.60
1968	96	61.8	-	-	109.61	470.64	180.84
1969	98	59.5	-	-	134.34	315.99	198.87
1970	98	62.5	-	-	131.35	283.62	180.78

Table 42. Analysis of yield data for KCA(F8L) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	-	41.3	31	100	160.55	241.63	-
Endebess	-	50.9	15	110	58.97	153.80	-
Kakamega[1]	-	-	-	-	-	-	-
Njoro		69.8	13	100	77.64	188.92	-
1968	93	52.8	-	-	73.92	356.77	121.57
1970	-	54.0	-	-	99.05	275.64	154.35

[1] Data on plants with ears not taken.

Table 43. Analysis of yield data for KCA(S13) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	97	41.2	19	109	63.91	217.93	-
Endebess	98	36.2	24	105	74.56	189.83	-
Kakamega	98	19.3	46	101	79.80	127.22	-
Njoro	93	50.7	18	100	81.99	238.85	-
1966	88	33.7	-	-	55.55	492.18	108.62
1968	85	35.8	-	-	59.67	714.74	120.29
1970	97	36.8	-	-	75.07	408.97	121.62

Table 44. Analysis of yield data for KCA(H14) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	99	69.8	15	100	105.19	164.21	-
Endebess	100	59.5	13	109	64.09	133.66	-
Kakamega	99	41.3	43	100	312.33	255.39	-
Njoro	97	82.7	13	100	111.64	180.71	-
1966	98	57.7	-	-	119.74	225.23	128.35
1968	97	64.2	-	-	86.86	244.84	129.19
1970	97	63.4	-	-	148.31	256.83	159.05

Table 45. Analysis of yield data for KCA(HL15) in 1970.

Year or Location	Stand %	Yield (q/ha)					
		Mean	C.V.	Latt. Eff.	Error MS	Tmt MS	T x Loc. MS
Kitale	99	49.1	30	108	213.16	322.70	-
Endebess	99	61.2	15	101	80.25	168.21	-
Kakamega	99	40.1	31	110	150.85	198.03	-
Njoro	94	79.3	14	100	120.39	147.26	-
1966	98	57.1	-	-	116.04	254.76	150.09
1968	97	55.3	-	-	134.00	329 49	151.43
1970	98	57.4	7	-	141.16	278.87	185.78

The selected lines from each of the experiments in the MBIS are given below.

E1 35-04-02-02-06-05-05
35-04-02-02-06-05-02
35-04-12-06-06-10-04
35-04-12-06-06-10-11
35-04-02-09 09-06-05

E2 12-02-02-05-04-04-08
12-02-02-05-04-04-05
12-02-02-05-04-02-09
12-02-02-05-04-02-03
12-02-02-05-04-04-02

E3 18-02-06-10-05-08-09
18-02-06-10-06-09-03
18-02-06-10-05-10-09
18-02-06-10-06-03-02
18-02-06-10-05-08-09

E4 12-04-10-09-08-08
12-04-10-09-08-02
33-02-11-06-11-02
33-02-11-06-06-05
33 02-11-06 06-10

E5	32-05-06-12-08-03	
	32-05-06-12-05-04	
	32-05-06-12-04-02	
	32-05-06-12-04-10	
	32-05-06-12-04-02	
E6	27-08-02-02-03-08	
	40-09-05-06-11-12	
	40-09-05-06-02-02	
	27-08-02-02-10-02	
	27-08-02-02-10-06	
E7	59-11-10-06-09-04	59-11-09-11-08-03
	66-02-04-08-09-11	66-08-02-04-11-02
	66-02-04-08-09-08	59-11-09-11-08-06
	66-02-04-08-05-10	59-11-09-05-11-08
	59-11-09-05-11-11	66-02-04-08-09-06
F8L	(10 x 41) - 2	(40 x 41) - 2
	(10 x 56) - 3	(40 x 58) - 2
	(10 x 70) - 1	(40 x 39) - 1
	(25 x 41) - 3	(58 x 70) - 1
	(32 x 40) - 2	(58 x 70) - 2
S13	(12 x 26) - 1	(26 x 28) - 3
	(12 x 53) - 5	(26 x 42) - 5
	(12 x 93) - 5	(26 x 57) - 2
	(20 x 28) - 2	(28 x 42) - 6
	(20 x 53) - 1	(28 x 53) - 2
H14	(3 x 91) - 2	(47 x 65) - 5
	(29 x 47) - 2	(47 x 89) - 4
	(29 x 72) - 3	(47 x 91) - 2
	(29 x 85) - 3	(72 x 89) - 1
	(29 x 89) - 5	(72 x 91) - 4
HL15	(14 x 26) - 4	(29 x 82) - 5
	(26 x 61) - 6	(47 x 61) - 4
	(29 x 42) - 1	(47 x 74) - 2
	(29 x 82) - 1	(68 x 74) - 1
	(29 x 82) - 4	(68 x 74) - 3

Table 46. Estimates of variance components, heritabilities (H) selection differentials (D), and expected gain from each cycle of selection.

Exp't	Year	Mean yield	s^2_e	s^2_{ge}	s^2_g	H	D	Expected gain q/ha	Expected gain %
E1	1964	48.1	137.38	16.96	13.14	.38	10 3	1.96	4.1
	1965	44.1	63.31	7.08	27.72	.74	9.5	3.52	8.0
	1966	60.1	96.65	33.08	15.52	.43	10.6	2.28	3.8
	1967	44.1	137.54	34.89	0.00	.00	7 6	0 00	0.0
	1968	54.3	123.56	27.57	13 33	37	10.9	2.02	3 7
	1969	67.0	140.76	38.74	0.13	.00	8 6	0.00	0.0
	1970	47.4	154.93	0.00	10 97	.33	9.5	1 57	3.3
E2	1964	50.6	118.95	23.75	71.20	.77	17 7	6 81	13.5
	1965	38.9	63.68	30.86	13 52	.46	9.8	2.25	5 8
	1966	53.6	90.66	10.93	23.24	.62	10.8	3.35	6.2
	1967	33.5	61.10	24.71	18.76	58	10.0	2.90	8 7
	1968	46.8	99.98	4.35	10.46	.43	9.6	2.06	4.4
	1969	63.0	107.79	7.06	21.54	.51	10.4	2 65	4.2
	1970	54.8	122.46	6.77	17.04	.50	10.3	2.58	4.7
E3	1964	49.0	167.71	24.86	36.84	.58	13.3	3.86	7.9
	1965	45.7	87.74	23.38	6.36	.27	7.1	0.96	2.1
	1966	53.4	79.49	15.74	15.59	53	10.0	2.65	5.0
	1967	43.3	99.01	31 64	32.73	.62	12 3	3 81	8.8
	1968	51.6	113.73	35 70	13.47	.37	8.9	1.65	3.2
	1969	66 7	129.35	28 85	17.88	.36	10.1	1 82	2 7
	1970	55 1	101.38	36 53	17.57	.45	8.6	1.92	3.5
E4	1965	32.3	21.18	8.31	8.06	.63	5.6	1.76	5.5
	1966	37.4	29 55	4.89	7.48	.60	4.4	1.32	3.5
	1967	33.8	34.55	6.16	7.66	57	6.6	1.88	5.6
	1968	46.0	42.56	18.73	6.21	.38	7.6	1.44	3.1
	1969	48.9	34.53	9.30	3.42	.28	6.5	0.91	1.9
	1970	52 4	76 77	0.00	12.92	57	9.2	2.64	5 0
E5	1965	38.7	75.37	16.65	10.62	.44	7.0	1.54	4.0
	1966	45.4	90.17	7.62	16 06	.55	8.5	2.34	5.2
	1967	50 3	66.03	40.12	9.65	.35	9 0	1.58	3 1
	1968	49.1	100.28	43.29	12.81	.35	10.8	1.89	3.8
	1969	59.4	119.80	3.45	23.98	53	12 2	3.23	5.4
	1970	57.5	91.39	24.17	13.39	.42	9.8	2.08	3.6
E6	1965	38.3	57.62	21.02	12.78	51	7 7	1.96	5.1
	1966	52.1	126.72	11.18	9.03	33	8 9	1.47	2.8
	1967	50.7	135.23	12.26	12.84	.39	10.1	1.97	3.9
	1968	50.7	69.44	40.46	0.00	.00	7.7	0.00	0.0
	1969	53.8	134.71	19.22	29.68	51	13.3	3.39	7.2
	1970	62.0	109.42	8.14	21.45	.58	9.3	2 68	4.3

Table 46. Continued.

Exp't	Year	Mean yield	s^2_e	s^2_{ge}	s^2_g	H	D	Expected gain q/ha	Expected gain %
E7	1965	41.7	69.21	26.02	29 20	66	11.0	3.63	8 7
	1966	57.2	95.52	14.26	18 07	.54	10.0	2.70	4.7
	1967	43.4	94.04	35.78	9.56	.32	9.2	1.47	3 4
	1968	61.8	109.61	35.62	36.23	.62	10.7	3 32	5.4
	1969	59.5	134.34	32.27	19.52	.37	10.3	1.91	3.2
	1970	62.5	131.35	24.71	12.85	.36	11.2	2.03	3.3
E8L	1964	61.0	51.53	9.09	5.86	.25	-9.1	-1.14	1.9
	1965	43.7	19.01	4.60	6.17	.47	-5.2	-1.23	-2.8
	1966	44.5	36.83	4.26	21.10	65	-7.9	-2 57	-5.8
F8L	1968	52.8	73.92	23.83	19 40	.66	-8.1	-5.35	-10.1
	1970	54 0	99.05	27.65	20.21	.44	13.5	-5.94	-11.0
R11	1965	52 4	93.05	29 82	7.37	.28	8.6	2.41	4.6
	1967	62.0	133.29	19.08	6.06	.22	8.4	1.85	3.0
	1969	70 1	162.94	19.73	10.26	.23	8.4	1.93	2.8
.12	1965	52.4	102.38	31.04	15.96	.44	10.6	4.66	8.9
	1967	59.0	147.25	28.34	30.11	.54	11 3	6.10	10.3
	1969	71.5	151.85	13.10	3 38	.10	8.9	0.89	1.2
S13	1966	33.7	55.55	26.54	47 95	.78	14.5	- -	-
	1968	35.8	59.67	30 31	74.31	.83	15 9	- -	--
	1970	36.8	75.07	27.65	35.92	.70	11.5	4.05	11 0
H14	1966	57.7	119 74	4.30	12.11	.43	10.6	4.56	7.9
	1968	64.2	86.86	21.17	14 40	.47	8.9	4.18	6.5
	1970	63.4	148.31	5.37	12 22	.38	10.2	3.88	6.1
HL15	1966	57.1	116 04	17.02	13.08	.41	9.0	3.94	6 9
	1968	55.3	134.00	8.72	22.26	.54	9 0	5.18	9.4
	1970	57 4	141.16	22.31	11.64	.33	10.1	3.37	5.9
HI16	1967	54 5	116.42	14.91	34.30	.58	12 7	7.37	13.5
	1969	51.0	106.63	21.02	26.78	.52	11.6	6.03	11 7
F18	1967	43.6	124.55	28.97	15.56	.41	11.7	4.80	11.0
	1969	60.2	133.22	30.70	42.25	.57	14.1	8 04	13.4

Breeding Method Study and KCE Combining Ability Evaluations

Experiment 024 was designed to contrast progress from selection among several breeding methods and to evaluate the performance of KCE in combination populations from the Breeding Method Study. Yields from individual locations are presented in Table 47, agronomic attributes are in Table 48. Stands were satisfactory and no covariance with stand was run (difficulties were encountered with regression coefficients greater than one or negative). By any standards lodging was excessive as two thirds of the plants were lodged. Only small differences were found in days to tassel but it is noteworthy that H613C was one of the earlier entries. The earliest was SR52 x Ec573(R12)02. Ear heights were tremendous, all entry means were above 200 cm and 16 of 36 were above 250 cm. The lowest by 17 cm, was H632. Next was SR52 x Ec573 (E2)04 which was also one of the earliest. An SR52 topcross trial is being grown in 1971 to more fully evaluate the value of SR52 in combination with some of the current populations.

H611(R)CO, C1, C2 were grown for comparison of hybrid improvement with combined yields of 54.8, 64.5, and 69.0 q/ha. The increment from CO to C1 is statistically significant at the .05 probability level and the improvement from C1 to C2, while not statistically significant, still represents a 7% increase in yield. The commercial version of H611, H611C, yields 69.2 q/ha which was essentially the same as our H611(R)C2(69.0).

The comparison in H613 is similar but not as extensive. H613B yielded 54.9 q/ha and the improved version, H613C, yielded 68.2 q/ha. The increase is significant and is an average increment of 12% per cycle.

Hybrid analogs using Ec573(E2)C4 instead of Ec573(R12)C2 were grown. In all comparisons the ear-row population yielded substantially less (range: 10.4 to 3.3 q/ha, mean difference of six comparisons: 7.3 q/ha) than the reciprocal recurrent selection population.

SR52 x Ec573(R12)C2 yielded highest in the test and also was among the earliest and shorter entries. Some production difficulties were indicated by the Kenya Seed Company; however a full discussion of this matter is forthcoming.

KCE did well when crossed to KCA(HL15)C2 and KCA(H14)C2, yielding 59.4 and 57.6 q/ha respectively. The poorest results were from KCE x Ec573CO and KCE x KCA(E4-7)CO. Little difference was found between K11, Ec573, or KCA populations as a whole.

It was noted that there was a wide range of locations as evidenced by the large spread of location means. Unusually high C.V.'s for Busia and Kakamega were due more to a lower mean than any increased error variance.

Plant populations were 46,876 plants per hectare in 22 plant. plots with 80 cm between rows and 26.7 cm between plants.

Table 47. Yields (q/ha) of selected crosses from the Breeding Method Study and combining ability evaluation of KCE, grown as Experiment 24 of 1970.

Pedigree	Kitale N.A.R.S.	Endebess Strong Farm	Kakamega	Njoro
KIICO x Ec573CO	62.0	67.6	41.5	82.1
KIICO x Ec573CO	30.2	49.9	28.3	83.6
KII(R11)C1 x Ec573(R12)C1	72.2	67.8	35.2	91.7
KII(R11)C2 x Ec573(R12)C2	84.3	74.4	55.7	103.8
KII(R11)C2 x Ec573(E2)C4	62.6	57.3	55.4	86.8
KII(E1)C4 x Ec573(R12)C2	56.2	66.4	48.0	100.5
KII(E1)C4 x Ec573(E2)C4	71.3	81.4	137.1	85.0
KIII x Ec573(R12)C2	69.7	79.1	51.9	91.2
KIII x Ec573(E2)C4	75.1	60.4	29.2	87.6
SR52 x Ec573(R12)C2	101.7	73.9	53.0	94.0
SR52 x Ec573(E2)C4	77.1	58.9	45.4	87.9
(F x G) x Ec573CO	69.3	55.6	43.1	77.2
(F x G) x Ec573(R12)C2	79.5	62.9	46.5	93.8
(F x G) x Ec573(E2)C4	54.3	60.9	42.3	95.2
KCE x KIICO	50.7	50.3	43.9	69.0
KCE x KIICO	51.2	38.8	38.7	72.4
KCE x KII(R11)C2	70.1	48.9	26.6	74.0
KCE x KII(E1)C4	63.4	39.5	31.1	78.9
KCE x Ec573CO	48.9	47.8	23.9	69.9
KCE x Ec573CO	46.5	48.5	16.4	67.3
KCE x Ec573(R12)C2	65.1	48.5	31.1	85.7
KCE x Ec573(E2)C4	61.4	53.9	27.0	78.4
KCE x KCA(E4-7)CO	45.2	44.8	27.4	86.0
KCE x KCA(E4-7)CO	55.4	49.4	36.6	73.4
KCE x KCA(E3)C4	58.1	42.3	35.1	76.0
KCE x KCA(E4)C4	50.8	39.3	28.3	74.5
KCE x KCA(E5)C4	61.4	48.8	27.7	73.3
KCE x KCA(E6)C4	56.6	54.3	30.9	74.4
KCE x KCA(E7)C4	52.8	49.9	36.4	70.7
KCE x KCA(M9)C4	53.8	44.1	25.1	80.4
KCE x KCA(M10)C4	63.7	47.7	29.6	82.3
KCE x KCA(S13)C2	56.5	54.7	29.0	69.0
KCE x KCA(H14)C2	56.3	44.4	44.6	101.7
KCE x KCA(HL15)C2	67.0	59.3	40.2	97.7
KCE x KIII	76.2	61.9	37.9	84.8
H632 Commercial	35.9	44.7	49.3	72.4
Mean	61.4	54.9	36.9	82.7
LSD .05	24.9	18.0	20.7	17.6
CV %	24.8	20.0	34.3	13.0

Kitale Top Station	Endebess Kenya Seed Co.	Mt. Elgon Chorlim Farm	Busia	Kitale N.A.R.S. (Late)	Mean
56.4	60.4	82.0	13.5	61.4	58.5
55.5	68.6	76.9	16.2	50.5	51.1
67.4	76.8	94.4	22.8	51.9	64.5
67.5	63.5	89.6	9.4	72.3	69.0
68.9	66.1	77.5	11.2	56.8	60.3
54.1	70.4	86.6	16.3	75.5	63.8
67.6	68.9	75.4	13.3	44.6	60.5
71.2	78.0	96.3	13.1	71.9	69.2
55.0	66.9	97.7	16.6	63.2	61.3
64.0	83.1	81.1	17.8	70.2	71.0
60.9	55.2	75.2	17.6	67.3	60.6
57.5	64.0	53.5	19.6	54.2	54.9
69.6	75.9	89.5	13.6	78.2	68.2
60.7	65.9	57.4	13.1	74.2	58.2
51.0	57.2	54.0	13.1	53.5	49.2
55.5	57.7	55.7	14.2	53.7	48.7
54.6	55.4	73.2	23.9	48.1	52.8
51.0	56.7	54.0	20.9	49.0	49.4
47.6	49.0	74.5	8.2	44.2	46.0
47.3	60.3	66.7	14.4	51.2	46.5
51.2	57.2	83.6	18.0	66.5	56.3
50.8	56.3	91.4	20.3	35.5	52.8
42.4	53.9	44.5	18.6	36.4	44.3
50.2	48.6	72.9	14.1	36.0	48.5
50.0	61.2	65.2	16.8	55.3	51.1
41.6	53.5	75.6	19.3	50.5	48.1
50.1	55.7	63.2	16.3	50.7	49.7
49.4	55.4	65.4	13.2	61.1	51.2
43.7	55.4	71.8	22.9	51.9	50.5
40.9	50.0	69.0	12.6	44.2	46.7
52.5	56.6	71.0	21.0	43.0	51.9
51.1	48.9	67.3	15.6	57.5	50.0
51.0	63.2	83.5	9.9	63.7	57.6
57.2	59.0	77.8	27.3	49.2	59.4
54.8	57.8	61.8	15.7	61.7	56.6
30.4	49.0	67.6	26.3	38.4	46.0
54.2	60.6	73.4	16.6	55.4	55.1
14.0	18.8	25.3	11.8	22.8	7.5
15.8	19.0	21.1	43.7	25.2	----

Table 48. Combined means for yield and other agronomic attributes of selected crosses from the Breeding Method Study and combining ability evaluation of KCE, grown as Experiment 24 of 1970. (Number of locations are shown in parentheses.)

Pedigree	Yield q/ha (9)	Stand % (9)	Lodging % (8)	Bare tips % (9)
KIICO x Ec573CO	58.5	98.5	64.2	19.5
KIICO x Ec573CO	51.1	97.6	69.4	22.7
KII(R11)C1 x Ec573(R12)C1	64.5	97.5	61.8	9.7
KII(R11)C2 x Ec573(R12)C2	69.0	98.0	56.4	12.4
KII(R11)C2 x Ec573(E2)C4	60.3	98.1	61.9	21.2
KII(E1)C4 x Ec573(R12)C2	63.8	99.0	64.6	19.1
KII(E1)C4 x Ec573(E2)C4	60.5	98.1	67.3	20.9
KIII x Ec573(R12)C2	69.2	99.3	56.9	21.2
KIII x Ec573(E2)C4	61.3	98.7	67.3	22.3
SR52 x Ec573(R12)C2	71.0	97.6	68.1	13.6
SR52 x Ec573(E2)C4	60.6	98.3	73.9	19.1
(F x G) x Ec573CO	54.9	98.0	77.5	26.2
(F x G) x Ec573(R12)C2	68.2	98.0	71.8	25.2
(F x G) x Ec573(E2)C4	58.2	98.5	72.7	32.6
KCE x KIICO	49.2	97.8	73.0	19.7
KCE x KIICO	48.7	98.7	69.7	18.6
KCE x KII(R11)C2	52.8	99.2	73.9	15.2
KCE x KII(E1)C4	49.4	98.0	71.0	19.3
KCE x Ec573CO	46.0	98.7	67.7	31.7
KCE x Ec573CO	46.5	97.5	67.8	34.5
KCE x Ec573(R12)C2	56.3	98.1	60.4	15.4
KCE x Ec573(E2)C4	52.8	97.8	74.5	24.9
KCE x KCA(E4-7)CO	44.3	98.8	71.1	22.3
KCE x KCA(E4-7)CO	48.5	98.1	77.1	18.8
KCE x KCA(E3)C4	51.1	97.5	64.6	21.8
KCE x KCA(E4)C4	48.1	97.8	62.7	21.3
KCE x KCA(E5)C4	49.7	99.3	62.3	21.8
KCE x KCA(E6)C4	51.2	98.0	63.0	24.0
KCE x KCA(E7)C4	50.5	98.1	67.2	26.1
KCE x KCA(M9)C4	46.7	98.1	65.7	23.0
KCE x KCA(M10)C4	51.9	97.3	65.8	18.1
KCE x KCA(S13)C2	50.0	96.6	67.2	22.4
KCE x KCA(H14)C2	57.6	99.5	60.7	20.5
KCE x KCA(HL15)C2	59.4	99.2	63.5	23.1
KCE x KIII	56.6	97.8	74.3	21.5
H632 Commercial	46.0	99 0	81.7	18.0
Mean	55.12	98.23	67.57	21.32
LSD .05	7.50	1.60	-----	7.87

Usable ears % (9)	Diseased ears % (9)	Days to tassel (7)	Ear height cm (5)
72.0	5.1	106.5	252.5
68.8	5.2	106.8	254.3
81.5	3.8	104.1	235.3
81.2	5.3	104.6	246.4
76.1	5.6	106.1	247.0
79.8	6.3	105.6	250.2
77.6	6.1	106.7	255.1
77.7	5.4	105.6	245.3
74.3	5.1	106.7	257.4
83.3	4.7	100.3	228.8
77.2	4.6	100.5	220.5
72.9	8.3	104.9	241.2
85.4	6.1	102.6	237.6
73.7	10.1	104.0	245.5
68.3	8.7	106.2	245.0
68.3	7.9	106.6	244.8
72.3	7.1	106.1	237.1
68.5	9.5	107.7	251.1
58.6	5.1	109.5	263.9
62.3	5.0	109.3	267.1
74.0	5.2	107.5	260.3
71.3	7.1	108.4	258.7
61.5	8.9	107.9	252.0
65.4	6.3	107.2	256.1
70.2	5.3	107.5	252.0
68.4	8.2	107.6	252.9
64.9	7.8	107.5	256.9
68.3	5.3	107.9	247.7
68.9	7.6	105.9	242.3
65.1	8.6	109.0	255.6
67.0	7.7	107.2	247.0
71.3	6.2	106.3	238.9
72.5	5.9	105.9	239.2
76.4	8.1	105.7	238.7
74.5	7.6	106.7	239.4
70.5	16.3	103.0	203.2
71.94	6.87	106.15	246.31
7.49	4.11	------	------

Eastern African Maize Variety Trials

Data were compiled and a report issued in May of 1970 on the 1968-69 E.A.M.V.T. Seven countries successfully grew the Trial in 1968-69. Twenty five entries were grown and data were taken for yield, stand, lodging, bare tips, ears per 100 plants, diseased ears, days to tassel, ear height, blight score, and rust score. Table 49 gives the yields in quintals per hectare on a country basis. Kenya and Tanzania are subdivided into two levels of altitude each.

In Kenya and Ethiopia, H611(R)C1 yielded better than other hybrids. Of the composite entries UCA faired best in the same areas. SR52 was tops in Malawi, Uganda, Zambia, and higher elevations of Tanzania. UCB-W did well in many countries particularly the Cameroons where it was second only to H632. Generally the hybrids outyielded the composite varieties. No general conclusion may be drawn relating the composite varieties to the composite crosses.

No E.A.M.V.T. was held for the 1969-70 season as there was not enough new material to warrant such an extensive test. This scheme of alternate year trials may prove reasonable as most of the recurrent selection schemes being utilized require two years per cycle. The principle exception is full-sib selection in the southern Hemisphere where one cycle of testing and recombination is obtained per year. After a one year interval, renewed interest was shown for the 1970-71 E.A.M.V.T. Table 50 indicates participation by country over the duration of the Trials. Participation in 1970-71 has more than doubled over the previous three Trials with respect to site. The ten countries growing the Trial represents an increase of three over the past two E.A.M.V.T.'s.

The 15 entries in the current E.A.M.V.T. include five of the commercial hybrids from Kenya, Ukiriguru and Ilonga composites and their crosses Kawanda Composite A from Uganda and single entries of S.U. 28 from Malawi and SR52 from Zambia.

Results of all previous E.A.M.V.T.'s are available as separate mimeographed reports from the Maize Research Section, P. O. Box 450, Kitale, Kenya.

Table 49. Yields (q/ha) obtained in the 1968-69 Eastern African Variety Trial. (Number of locations for each country are in parentheses. To convert q/ha to bu/a. multiply by 1.6.)

Variety	Cameroun (1)	Ethiopia (7)	Kenya Below 1830m (3)	Kenya Above 1830m (4)	Malawi (3)	Tanzania Below 1000m (5)	Tanzania Above 1000m (6)	Uganda (5)	Zambia (4)
H632	32.2	66.2	47.4	84.7	45.2	34.5	33.2	42.6	58.5
H613B	58.4	64.3	37.9	93.9	40.4	30.3	31.7	36.8	47.6
H511	60.3	55.1	35.5	45.2	39.0	32.7	33.6	34.4	46.3
SR52	79.7	62.2	38.1	69.0	52.8	32.3	38.8	46.8	61.0
H611(R)C1	74.2	70.1	54.2	104.9	40.5	34.0	38.0	36.2	49.8
UCB-W x UCA	83.3	62.1	38.9	73.0	42.7	39.6	33.7	43.6	51.7
KCB x KCC	76.1	60.2	43.3	83.1	41.6	28.5	30.5	29.1	47.5
SR52 x C3J96	58.5	55.4	37.7	61.8	41.0	28.0	29.2	34.6	47.8
SR52 x 63J347	80.7	63.0	47.5	68.6	46.0	38.9	35.0	41.7	56.9
ZCA x UCA	70.7	60.4	45.2	62.1	48.7	31.8	27.2	41.1	52.5
ZCA x KCC	66.6	68.7	36.9	71.0	46.4	31.0	33.8	30.1	50.6
ZCA x IC	71.1	53.1	42.2	48.7	43.7	43.6	29.1	45.0	48.0
KCB x UCA	66.9	64.0	39.6	78.1	46.1	33.1	33.0	37.2	53.3
KCB x IC	70.5	65.0	42.7	69.1	45.3	43.4	31.9	40.4	52.3
KCB x KCE	75.3	60.7	45.5	88.2	38.6	27.3	30.1	32.7	51.9
Kawanda Comp. A	63.3	60.4	40.7	72.6	42.4	35.1	28.4	35.4	50.8
Zambia Comp. A(ZCA)	61.0	44.4	38.3	50.0	42.3	30.2	27.3	31.6	42.8
Ukiriguru Comp. B-Wh. (UCB-W)	79.8	58.2	38.6	62.7	44.7	37.4	33.4	43.3	51.9
Kitale Comp. B(KCB)	70.7	62.0	37.9	68.2	38.5	31.3	27.0	35.3	47.0
Kitale Comp. C(KCC)	74.1	62.8	44.0	77.2	30.3	23.3	30.8	30.2	42.9
Kitale Comp. E(KCE)	67.6	55.7	38.4	75.9	37.2	26.6	25.7	27.4	46.0
Ilonga Comp (IC)	71.4	42.0	40.3	40.7	34.7	43.5	25.0	45.6	36.6
Ukiriguru Comp. A(UCA)	74.3	65.0	48.9	75.2	38.3	33.6	30.8	38.1	50.9
Local Synthetic Var.	39.1	51.4	41.[illegible]	69.7	41.7	39.8	25.9	30.6	42.2
Local Farmer's Maize	51.4	53.7	32.0	69.8	33.0	36.4	24.1	33.1	48.6
Mean	69.1	59.4	41.3	70.5	41.6	33.9	30.7	36.9	49.4

Table 50. Participation in the Eastern African Maize Variety Trials.

Country	Number of Sites			
	1966/67	1967/68	1968/69	1970/71
Burundi	-	-	-	4
Cameroun	-	-	1	[illegible]
Democratic Republic of the Congo	-	-	-	15
Ethiopia	3	7	7	22
Kenya	10	8	7	8
Madagascar	-	-	-	1
Malawi	-	2	3	3
Nigeria	-	1	-	3
Tanzania	-	14	11	22
Uganda	8	7	5	7
Zambia	-	2	4	2
Total	21 ~ 3	41	38	87/10

Kenya Maize Breeding Research Program

The Kenya Maize Breeding Research Program is directed by Mr. F. Ogada, the Senior Maize Research Officer. The Kitale Maize Research Section is lead by Mr. Ogada and assisted by Mr. A. Y. Allan, Maize Agronomist, Mr. E. Omolo in charge of the Qualitative Gene Program and Mr. C. M. Ndegwa directing the Kenya National Program. Work at Kitale is aimed at long season hybrids for the western highlands. While Kitale has a single long rainfall period, other parts of Kenya have a bimodal rainfall distribution and require a shorter season hybrid than is used in the highland areas. The Embu Agricultural Research Station does breeding work for areas where the rainfall is relatively longer and dependable over the season. Some parts of Kenya have a very undependable bimodal rainy season and crops grown in these areas need to be flowering in about 60 days. The Katumani Research Station is responsible for maize breeding in these areas.

The Kenya National Program continues as described in the 1969 Annual Report with the following change suggested by Dr. S. A. Eberhart. The number of lines in the yield trials remains as 363, grown as three 11 x 11 lattice squares. Instead of selecting 30 lines only 28 will be

chosen. These would be 10, 9, and 9 from the three lattices with the tenth selection being the highest of the tenth ranking entries of each lattice. Recombination would be accomplished as a complete diallel of 9 + 9 + 9 selected lines where in one instance the 9 would be entries ranked 2 through 10. The number one entry from the lattice with ten selections will be recombined with the top four selections in a lattice to give the remaining 12 entries to have 363 total. This procedure will be used in KCB and KCE and is preferred to doing complete diallel recombinations within each lattice square.

S_1 testing will be used on Embu 1 and Umbu 2. In March 1970, selfing was done in Embu 1 and Embu 2. Yield trials were grown in October 1970, but the primary objective was to eliminate off-color kernels. The usual S_1 testing with selection for yield will begin following recombination in March 1971. Composite formation was considered complete after four cycles of mixing.

Katumani Synthetic VII underwent S_1 selection for seed color in 1970. Following recombination of clean ears in October 1970, the population was designated Katumani Synthetic V11CO and S_1 yield testing is to begin in March 1971.

October 1970 was the start of an S_1 evaluation cycle to clear up the color in Katumani Synthetic VIII. Katumani Composite B was planted in October to undergo 10% mass selection for an indefinite time.

Commercial Seed Production, Sales, and Distribution

Full success of any breeding program is dependent on commercial utilization of the outputs. The Kenya Seed Company has filled the latter role with much success in past years. 1970 was an even better year than any previous. Hybrid seed maize sales were up 38% from 1969. Supplementing the maize sales are smaller operations in sunflower seed and forage seed. Production is through grower contracts with certification by Kenya Government inspectors. Retail sales are through the Kenya Farmers' Association and MacKenzie Dalgety (Kenya), Ltd.

In 1970, 4,200 acres of seven maize hybrids were grown for seed, up 85% from 1969. Sixty nine growers were contracted within 1970 versus 58 in 1969. African farmer participants increased from 20 to 28. Table 51 gives the complete seed sales summary for 1970. The data of this Table and Table 52 are courtesy of Mr. E. J. R. Hazelden of the Kenya Seed Company. Large scale farmers accounted for 32% of hybrid seed acreage in 1970. Hybrid 613B was the best seller, accounting for over 50% of sales. (Acreage was estimated by assuming 10 Kg of seed per acre.)

The acres of hybrid maize grown in Kenya from 1963 to 1970 are given in Table 52. Trends reveal that the primary source of increased acreage grown is small scale farms. Acreage on small scale farms has increased steadily each year while the large scale farms grew more acreage in 1967 than 1970. In part this reflects the program of Africanization in which many large farms have been broken up and parceled out into several smaller farms. Potential for hybrid seed sales remains high as less than 10% of the estimated 2.5 million acres of small scale farm acreage was planted with hybrids in 1970. Virtually all seed grown on large scale farms has been hybrid for some time.

Cooperation between the Kenya Seed Company and the Tanganyika Wattle Company has continued in 1970. Seed production in the Njombe area of Tanzania, which was attempted on a relatively small scale in 1969, was substantially increased in 1970. With the arrival of the USAID contract Seed Multiplication Team seed production in Tanzania may receive a considerable boost. Success of the operation rest in close coordination and cooperation with existing seed industries.

Production of H611 and H613 has proceeded along lines indicated in the 1969 Annual Report. All seed produced of hybrid 611 in 1970 utilized Ec573(R12)C2 as the male parent and was designated H611C. Mixed production of H613 occurred in 1970 utilizing Ec573CO in some cases and Ec573(R12)C2 in others. All of this seed is being sold as H613B. It is anticipated that only Ec573(R12)C2 will be used in 1971 and the hybrid designation will be changed to H613C.

Table 51. Acres of hybrid maize grown in 1970 from seed produced in Kenya.

Hybrid	Large scale farms	Small scale farms	Total
H511	4,938	13,570	18,508
H611B	9,703	12,804	22,507
H612	10,527	25,436	35,963
H613B	80,537	104,527	185,064
H622	6,236	34,340	40,576
H632	660	48,771	49,431
H512	808	0	808
Total	113,409	239,448	352,857

Table 52. Acres of hybrid maize grown in Kenya 1963 to 1970 (estimated from seed sales).

Year	Large scale farms	Small scale farms	Total
1963	390	10	400
1964	28,700	1,750	29,850
1965	54,700	20,040	74,740
1966	63,900	37,730	101,630
1967	137,140	115,250	252,390
1968	91,195	126,800	216,995
1969	97,605	158,850	256,455
1970	113,409	239,448	352,857

Sorghum and Millets

Growing Conditions at Serere. 1970 was the first year for a long time in which the rainfall lay within the confines of the upper and lower 1:1 confidence limits throughout both rainy seasons, with the exception of the second rains' peak. It is a characteristic of the second rains that the peak may occur at any time from August until November, and the smooth evenness of the curve for the rainfall figures averaged over many years is very misleading. This second rains, the peak occurred in the 23rd - 25th ten-day period, in August, and the rainfall surpassed the upper confidence limit by some 50 mm.

Sorghum Breeding

H. Doggett, R. E. Okello, P. A. Ajau, and B. Okwi

Seed Releases. The purpose of our Unit is to produce better sorghums: and these must reach the farmer if this purpose is to be realised. The commencement of the Uganda Seed Scheme, and the news that similar arrangements are under consideration in Tanzania, was most welcome. "Serena" and the hybrid "Hijak" (H x 57) are both being multiplied by the Uganda Seed Scheme. The variety 5DX 36/1 and its hybrid with CK 60, H x 471, were both put out in a series of large demonstration plots through Tanzania. These have better quality white grain than earlier releases, and their performance, in the areas where bird attack was not crippling, was very encouraging. Dwarf forms of both are therefore being multiplied for further testing and release, under the suggested names of "Lulu" for the variety and "Himidi" for the hybrid.

The hybrid H x 467 often outyields "Hijak", and is appreciably shorter in height and less liable to lodging. This will be released as "Hibred", if further trials confirm its superiority. Its pollinator variety 5DX 61/6/2, will be released as "Simila" if it proves able to yield as well over a wide area as does "Serena". Seed multiplication would be simplified if the pollinator of the hybrid could be released as a variety in its own right. The 1970 regional trial results will guide the decision on these releases, but currently they are all promising types.

Regional Trials. The results and analysis of the 1969 trials are presented in 2 groups in Table 53, the grouping depending upon whether the hybrid CSH-1 or the hybrid H x 467 was included.

Table 53. Yields of grain in kg/ha., and heights of some entries from the 1969 trial series.

VARIETY	Series A 11 Sites		Series B 9 Sites		MEAN YIELD, 20 TRIALS	YIELD AT EMBU, KENYA	YIELD AT SERERE, 2nd RAINS
	Grain	Height[a]	Grain	Height[a]			
Serena	1,515	134	2,170	116	1,810	2,120	3,320
Dobbs	1,275	135	1,840	118	1,530	2,570	3,150
5DX 36/1/2	1,405	145	1,540	127	1,465	-	2,730
5DX 50/4/1	1,350	123	1,610	98	1,465	2,450	1,720
3DX 57/1/E	1,520	121	2,150	114	1,805	2,520	2,610
5DX 142/H	1,395	138	2,030	117	1,680	2,930	3,180
3DX 57/1/H Brown	1,500	129	2,110	110	1,775	2,410	3,030
5DX 61/6/2	1,345	128	1,750	104	1,525	2,830	2,200
5DX 144/1	1,440	123	1,790	96	1,595	-	2,840
5DX 160/4/1	1,400	140	1,770	120	1,565	2,270	3,000
5DX 156/3	1,370	133	1,970	105	1,640	2,670	3,000
HYBRIDS							
CSH - 1	-	-	1,750	108	-	-	2,840
H x 466	1,675	166	2,170	146	1,900	3,930	4,150
H x 467	1,480	130	2,220	116	1,815	3,670	3,600
H x 469	1,470	162	-	-	-	3,090	4,280
H x 471	1,340	161	1,880	156	1,585	3,440	4,460
H x 472	1,600	157	2,390	140	1,955	3,130	4,640
H x 473	1,535	156	2,180	140	1,825	6,680	5,130
H x 474	1,700	153	2,310	143	1,975	3,340	5,010
H x 475	1,700	156	2,400	147	2,015	3,240	4,750
H x 476	1,810	160	2,510	140	2,125	3,560	4,970
L.S.D. (0.05)			432	29	-	214	690

(a) Height measurement scores are relative only.

The 1970 trial series used 5 row plots, of which 2 were discards, so competition effects should have been substantially reduced. Results received are shown in Table 54; as usual, the majority of the trials were planted in the latter part of the year, and complete results are not available at the time of writing this report.

In both Tables 53 and 54, birds result in some very uneven comparisons. This is particularly true for 5DX x 36/1/2 and its hybrid H x 471, and their mean yields over 20 sites in Table 54 are satisfactory for quality grains which undoubtedly suffered bird damage at some sites. The yields of H x 471 at Embu and Serere second rains were good relative to Serena. Neither of these sites was included in the combined analyses as some of the entries differed. In the 1970 trials (Table 54) bird damage was severe on H x 471 and 5DX 36/1/2, and this will have been true at other sites also.

The pattern emerging for the coarse grain types is not at all clear: more testing is essential, and these trials tend to have high coefficients of variability. In the 1969 trials,(Table 53) 5DX 61/6/2 did not show up favourably relative to Serena, but in Table 54 the evidence is more favourable. The same is true for the comparisonof H x 467 with Hijak, and undoubtedly part of this difference is due to the use of larger plots with adequate discards. Some of the hybrids have done well: H x 473 produced a surprising yield at Embu, but it also did quite well at Serere as usual, the best hybrids are the tallest and the most liable to dodging.

Varietal Improvement. The evaluation of derivatives from the series of crosses made between 1963 and 1966 was continued, and further observations will be needed for a few more seasons, especially in the 6DX series. However, they will soon be replaced by fresh sources of breeding material. Promising lines were screened in variety trials during the first rains, and results are summarised in Table

The usual tendency for the better yielders to be both later and taller Serena is clear from the Table. The advantage of greater height may be largely a competition effect in the small plots used. The 1963 cross 3DX 57 has stayed in the trials for some years, but has not yet given a satisfactory variety. 5DX 61/6/2 and 5DX 61/6 are evidently later maturing than Serena, and although both gave better yields, increases were not statistically significant. The 1966 crosses 6DX 2 and 6DX 10 are obviously worth further study, but it remains to be seen whether they will give varieties coupling good yield with the required levels of height and maturity length.

Table 54. Grain yields in kg/ha in the 1970 regional trials

SITE	HYBRIDS			VARIETIES											
	HIJAK	H x 467	H x 471	5DX 142/4	5DX 156/3	5DX 61/6/2	3DX 57/1H/W	DOBBS	5DX 61/2/1	5DX 144/1	3DX 57/1H/B	SERENA	5DX 160/4/1	5DX 36/1/2	L.S.D.
UGANDA															
Serere	4,800	5,110	2,620	3,870	4,360	4,215	1,975	4,055	4,480	3,410	4,440	3,655	4,050	1,375	552
Kumi	1,250	1,430	1,250	1,400	1,410	1,370	1,390	1,370	1,580	1,470	1,440	1,220	1,070	1,080	471
Moroto	3,290	3,020	2,530	3,350	2,510	2,570	2,750	2,210	2,590	2,270	3,270	3,000	2,050	2,420	903
Iriri	2,140	2,020	1,390	1,450	1,450	1,450	1,320	1,450	1,390	1,390	1,450	1,010	1,640	1,070	878
TANZANIA															
Mlingano A	1,870	2,610	1,920	1,760	1,910	2,750	2,440	1,970	2,040	2,600	3,010	2,950	2,140	1,980	617
Mlingano B	1,780	1,480	1,620	1,180	1,280	1,480	980	1,400	1,220	1,190	1,710	1,780	1,850	1,690	651
KENYA															
Kambi ya Mawe	2,750	2,220	2,880	2,610	2,440	2,510	2,940	2,330	2,420	2,260	2,800	2,280	2,560	2,300	722

Table 55. Some grain yields in kg/ha from the screening trials of sorghum crosses made between 1963-1966. (3DX to 6DX numbers)1970.

TRIAL TYPE	5 x 5 Balanced Lattice			TRIAL TYPE	6 x 6 Triple Lattice			TRIAL TYPE	7 x 7 Triple Lattice		
ENTRY	YIELD	HEIGHT	DAYS TO FLOWER	ENTRY	YIELD	HEIGHT	DAYS TO FLOWER	ENTRY	YIELD	HEIGHT	DAYS TO FLOWER
3DX 57/1/2/2	5,235	200	68	3DX 57/2/8	5,660	189	67	6DX 10/1/4	3,245	168	73
5DX 142/5/12	5,200	179	65	5DX 111/2/2	5,405	163	66	6DX 10/1/3	3,240	230	68
5DX 144/2/1/5	4,955	283	70	3DX 57/1H/4	5,325	164	62	5DX 36/2/2/1	3,205	195	72
5DX 157/19/4/2	4,850	183	70	5DX 160	5,185	218	66	6DX 10/1/1	3,110	217	66
5DX 50/4/2/7	4,815	161	62	5DX 142/2/2/4	5,075	172	58	6DX 10/1/5	3,060	223	71
5DX 142/4	4,785	164	65	5DX 135/13	5,030	182	61	6DX 2/2/2/5/1	3,000	277	76
3DX 57/1H/8	4,765	158	64	5DX 61/6	4,985	128	67	6DX 10/1/2/3/8/1	2,920	175	71
5DX 108/2/1/1	4,660	193	67	5DX 157/19/3	4,965	187	67	6DX 2/2/4	2,920	183	72
5DX 61/6/2	4,655	172	68	H x 60/7/2E	4,925	163	63	5DX 135/13/1/3/1/1	2,815	168	62
5DX 157/19/3	4,605	189	72	3DX 57/1/K	4,875	165	61	5DX 36/2/2	2,815	280	74
Serena	4,135	167	60		4,580	178	58		2,285	167	60
Dobbs	-	-	-		4,850	202	66		1,970	187	69
L.S.D. (P = 0.05	680	13	3		702	10	3		572	26	5
C. of V.	13.7%	5.8%	3.3%		9.2%	3.6%	2.6%		13.9%	8.7%	4.6%

The populations being developed for recurrent selection are now a fresh source of selections for varietal improvement. Details of their development are given later in the report. The dwarf population yielded 936 selections which were grown as progeny rows in the second rains, and re-selected. A further 1287 selections were taken from the PRS and RS populations, and these were also grown out in progeny rows for re-selection. When the population work is running properly it will be the main source of breeding material for the development of new varieties and hybrids.

Quality Grains. Some quality lines are included in the programme for varietal improvement outlined above. In addition, there is a breeding programme of the traditional type in operation. Intercrosses of our best selections from the 1963-1966 programme were made first, involving (5DX 36) x (5DX 111), which gave 8DX 1, and (5DX 36) x (5DX 176) which gave 8DX 2. These were then intercrosses, backcrossed to 5DX 36, and crossed to 3DX 57, in a series of crosses numbered 9DX 1 - 9DX 9. Derivatives from these were then crossed on to the early, good grain derivatives of Doggett's former Tanzania programme, there being 119 of these crosses, 9DX 10 - 9DX 118.

One hundred and sixteen F_4 progenies rows of selections from 8DX 1 and 8DX 2 were grown in the second rains, together with 319 F_3 progeny rows of the 9DX 1 - 9DX 9 crosses. The series 9DX 10 - 9DX 118 were grown as F_1 during the first rains, and 884 rows of their F_2 generations were grown in the second rains. The best series of these crosses seemed quite evidently to be those between 5DX 36 and the good grain Ukiriguru lines. These represent intercrosses between the best derivatives of 2 completely separate breeding programmes, based on entirely different material.

Hybrids. Excessive height is still our main problem, and the shortening of selected pollinators and male-steriles by backcrossing was continued, as outlined in the 1969 annual report. The cross 5DX 87 has produced a good looking sterile, which has been called "Kafinam." This is a derivative of CK 60 and Namatera, the Buganda beer sorghum which has shown such good level of pest tolerance and resistance in our tests. Trial hybrid will be made on this next season, for comparison with similar ones on CK 60. The programme for shortening 4 of our tested male-steriles, the 2DMS lines, progressed well, and 15 small bulks were multiplied for yield testing next year. Other selections were taken from the 256 progeny rows of these crosses grown out in the second rains. Further observations were made on steriles received from India, especially those with tan straw and white grains.

Hybrids were made in the first rains between individual plant selections of the pollinators, and CK 60, to try to find shorter hybrids from existing material with good combining ability. Four hundred and ninety four of these were grown for evaluation in the second rains. Some showed promise, but none appeared to be as successful as the short selections obtained in 5DX 36 last year.

A better quality grain hybrid is still desired: "Himidi" is made on CK 60, and therefore has a purple straw. There is reason to hope that a hybrid with tan straw and equally good yield can be made by pollinating one of the tan straw hybrids from India with 5DX 36D. This will be explored next season.

Grain Studies. Grain from 61 varieties representing a range of grain types were sent to Mr. Shepherd of U.S.A.I.D./A.R.S. at the cereals laboratory of E.A.I.R.O. in Nairobi. Protein levels ranged from 10.1 percent to 14.2 percent, and lysine values on the 14 so far analysed ranged from 1.6 - 2.8. All were grown under comparable conditions. Sixteen of the varieties subjected to milling tests showed a range of percentage break flour yields from 4.7 to 15.6, while the range for reduction flour yield was from 33.8 to 45.4 percent. These 16 samples showed a range of percentage of the total grain protein retained in the flour varying from 25.9 to 43.3 percent.

Clearly the scope for selection and improvement is very great, and grain qualities are still a rather neglected field in sorghum research. All these grain types are going into our "good grain" composite, and the second backcross from the ms_3 stocks has been done for most of them. Mr. Shepherd's help will be enlisted in selecting for the grain characters: there is much to be learned about how to do this, but most of the difficulties are not insurmountable, andthis work is among the most important being done for the development of sorghum as a really good food grain.

Bird Resistant Stocks. The original programme for bird resistance aimed to combine goose-neck (pendant head), large glume, and long awn with good grain. The yielding ability of the final derivatives was pathetically low, so it was decided to establish a breeding population. The first backcross of (Serere bird resistant lines)^2 x Serere ms_3 was done during the second rains, using 69 of the bird resistant lines. The Serere ms_3 stock was based on some of our best yielding material.

Sorghum x Sudangrass. The sterilizing of E 1291 as a high altitude cytoplasmic sterile for use as the female parent in sorghum x sudangrass crosses for the higher areas of Kenya was completed; and the seed will

now be sent to Kitale. It was possible to select a shorter form of the original E 1291 stock. Crosses were also made to "Serena" to introduce the "juicy" character (green midrib) to E 1291. The F_1 was grown in the first rains, and the F_2 was grown and selected in the second rains.

The Composite Populations. The progress with these was very satisfactory. Eight populations (PRS 1 - 4, RS 1 - 4) had been composited from a total of 158 sorghum varieties, and subjected to 3 main types of recurrent selection- (1) female choice, (2) alternating female choice and selfed plant (3) S_1 testing. A large 9 x 9 balanced lattice evaluation trial was carried out in the first rains, with a satisfactory level of precision. The results were very instructive. All populations responded to selection in the expected fashion, and the populations under S_1 testing significantly out-yielded the Serena and Dobbs controls after only 3 generations of selection (one complete cycle). This could not be ascribed to the S_1 testing method, as the selection intensity used under S_1 testing was very much greater than for the other systems. None the less, the success of the system in such a short time gives good grounds for believing that the method is essentially sound, although there is still much to learn about the most effective ways of building populations and applying selection pressures to them. One interesting feature was the inbreeding depression which was shown in yields from the progenies of selfed plants taken out of the populations. This was matched by a corresponding yield increase when selfed lines or varieties were recombined by crossing. This indicates that sorghum composites will repay further study and may well be a practical proposition as seed releases to farmers at some future date.

Analysis of the individual plants in the populations showed both the importance of height, and of the linkage of characters with ms_3 which gave the plants carrying this gene a reduced competitive ability. Much more remains to be learned. Full results will be published in "Heredity".

These particular populations were combined into two main new populations once the trial results had been analysed, these being designated RSR for the restorer group and RS/A for the non-restorer group. These were then divided into sub-populations, which will be grown and selected on different systems at relatively low plant population levels.

The remaining populations listed in last year's annual report were continued, and selection in them will be commenced as soon as the staff situation permits.

Tetraploid Sorghum. Another variety trial was grown in the second rains to check on the progress being made in the development of tetraploid grain sorghums. The design was a quintuple lattice with 121 entries, using 2 row plots. Entries were crossed to diploid CK 60A to identify diploids present. Some of the results are shown in Table 56.

It is evident from the table that some tetraploid material is yielding well up to the standard of the Serena and Dobbs diploid controls, and taking no longer to do so, the Dobbs control being the latest maturity entry in the table. Most of the good entries come from "Tet. Pop.", a population made up from all 16 tetraploid bulks maintained on Serere, mixed in with a tetraploid ms_3 bulk. Compositing is not yet completed, but it is likely that the selections performing well in the trials were hybrids, and their yield will decline on inbreeding. However, 3 of our Serere tetraploid bulks, Tet 1, Tet Composite, and Tet 3 were placed among the good yielders. Tet. Pop. bulk itself was unfortunately omitted from the trial. The process of introducing ms_3 into the 16 tetraploid bulks is progressing more slowly than hoped, mainly through shortage of professional staff. Table 56 shows that prospects are good of developing tetraploid grain sorghums, once populations have been made to which selection can be applied.

Acknowledgements. Once again it is a pleasure to record the help and cooperation received from the Department of Agriculture of the 3 East African States. This has been especially evident on the part of Agricultural Department staff at Serere.

Doggett would like to thank all members of E.A.A.F.R.O. staff at Serere for their excellent team work during the past 12 years, for their continued interest, and steady improvement. He leaves all his friends who constitute this Unit at Serere with great regret.

Table 56. Grain yields from tetraploids, in kg/ha, quintuple 11 x 11 lattice, first rains.

ENTRY	YIELD	HEIGHT	DAYS TO FLOWER
Tet. Pop. P 19	5,980	234	60
Tet. Pop. P 52	5,795	249	68
Tet. Pop. P 57	5,665	237	57
Tet. 1 Bulk	5,560	264	59
Dobbs (diploid)	5,250	182	71
Tet. Pop. P 13	5,110	265	57
Tet. Pop. P 42	5,065	267	57
Tet. Pop. P 11	5,035	256	58
Tet. Pop. P 49	5,025	277	61
Tet. Pop. P 23	4,980	244	59
Tet. Pop. P 74	4,795	236	61
Tet. Composite	4,775	250	58
Tet. Pop. P 9	4,745	245	58
Tet. Pop. P 77	4,695	243	60
Tet. Pop. P 81	4,590	244	59
Tet. 3 Bulk	4,390	245	57
Tet. Pop. P 56	4,360	234	57
Serena (diploid)	4,265	155	58
L.S.D. (.05)	790	27	4
C. of V., %	19.2	9.7	4.4

Finger Millet Breeding

L. V. Peters, S. Odelle and E. Atadan*

Seed Release. The finger millet variety, Engenyi was released in 1969 to the Seed Multiplication Scheme in Uganda for increase and distribution to the farmers. This variety possesses good malting characteristics and food grain quality. It is adapted to the growing conditions of Uganda and is also lodge resistant.

The two varieties, Serere 1 and Gulu E have performed very well in trials in Uganda over the past three years. A small quantity of seel of each is being released to the Seed Scheme for increase and possible release.

Regional Trials. The evaluation of finger millet on a regional basis is now being carried out in Kenya, Tanzania and Uganda. Results have been received for most of the 1970 trials in Tanzania and Uganda and grain yields for 24 sites are shown in Table 57.

Good growing conditions prevailed at most locations, producing an average yield for all entries of 2,580 kilograms per hectare. Significant differences in yield were found at seventeen sites. The following six varieties--Serere 1, Gulu E, Serere 104, Engenyi, Serere 358 and Serere 116, were among the top eight entries in both 1969 and 1970. Fourteen of the twenty five varieties tested in 1969 and 1970, plus eleven new selections will be evaluated in the trials in 1971.

Strain Evaluation. As new selections are made at Serere, which show good yield potential, these are included in the larger strain evaluation trials.

Promising selections from the collections were screened in trials during the first rains of 1969 and 1970, and grain yields of some are shown in Table 58.

Highly significant differences was found during both years for grain yield, number of heads, days to anthesis, blast disease resistance, plant height at harvest, lodge resistance and head type. Stand count at the seedling stage as well as at harvest was very uniform for all entries. The eleven new entries for the regional trials of 1971 have been selected from these screening trials.

Improvement Programme. The development of the broad gene pool of the collection, which was initiated during the first rain seasons of 1968, has been continued. The outline for this programme as illustrated in figure 2 shows the progress which has been made.

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Table 57. GRAIN YIELDS IN Kg./Ha. FROM THE REGIONAL FINGER MILIET VARIETY TRIALS, FIRST RAINS 1970

Varieties	UGANDA											
	Teso District							Busoga District			Iango District	
	Kabera-maido	Kuju	Arapai	Kumi	Bukedea	Serere	Katakwi	Vukula	Bugaya	Nakabango	Aduku	Ngetta
Serere 1	3820	3290	3400	4570	2920	3480	3200	2610	2100	2120	3860	2850
Gulu E	3660	3250	3220	4480	3290	3650	3620	2490	1650	2200	4000	3140
Serere 104	3750	3230	3150	4660	2900	3920	3590	1960	1320	1670	3830	3140
Engenyi	3690	2840	3890	4310	2760	3700	2690	2360	1600	1790	3650	2770
Serere 148	3600	3290	2920	4660	2310	3870	3740	2850	1550	2000	3830	3300
Serere 358	3490	3010	3170	5830	2720	3540	3280	2570	1790	1830	3790	3060
Serere 66	3730	3310	3850	4310	2640	3710	2770	2040	1520	2400	3720	3220
Serere 116	3420	3300	3710	4750	2510	3470	3510	1920	1380	1870	3580	3100
Serere 149	3580	3230	3830	3860	3340	3680	3200	2160	1620	1920	3500	2770
Engom	3430	2920	3250	3680	3060	3440	3000	2080	1530	2080	3670	2730
Eding	3680	3080	2770	3860	2980	3480	2490	2200	1200	1870	3810	2770
5 Ex 12 P_1	3150	2990	3480	4040	2640	3790	3540	2160	770	1430	4000	3500
Elaba	3650	3180	3150	4040	2660	3880	2600	2160	1100	1670	3630	2970
Serere 12	3620	3100	3680	3410	2210	4050	2650	1430	1730	1790	3670	3590
Serere 117	3700	3160	2790	4660	3160	3570	2660	1920	1190	1550	3790	3260
Serere 312	3050	3280	3370	5110	2990	3520	2710	1510	1550	1470	3440	2810
Serere 119	3440	3510	2870	3860	1890	3990	2770	2280	1490	1870	2940	2770
Okiring	3330	2670	3570	4040	2250	3840	2890	1870	1490	1550	3940	3340
Serere 91	3550	2760	3500	4130	2320	3100	3510	1960	1030	2040	3690	2930
Serere 82	3780	2960	2730	4390	2570	3430	2710	2120	1300	1430	3900	3220
Serere 101	3680	2860	2730	3860	2390	3640	2260	1960	1150	1960	3860	2770
5 Ex 12 P_5	3000	2730	3130	3680	2330	3680	2920	1630	1040	1470	3740	2890
Serere 21	3370	2630	2950	3860	2170	3850	2540	1790	790	1340	4050	3460
Serere 152	3510	2880	2740	3680	2180	3440	2650	2200	1470	1710	3030	2440
5 Ex 13 P_6	3250	2560	2820	4130	1780	3690	2430	1870	920	1260	3640	3180
Site mean	3520	3040	3230	4230	2600	3660	2960	2080	1370	1770	3700	3040
L.S.D.(.05)	n.s.	520	n.s.	950	560	490	870	640	510	340	500	570
C.V.(per cent)	12.39	14.72	23.79	19.52	18.54	11.60	25.61	26.44	32.02	16.49	11.72	16.17

Table 57.(Cont'd.) GRAIN YIELDS IN Kg./Ha. FROM THE REGIONAL FINGER MILLET VARIETY TRIALS, FIRST RAINS 1970.

Varieties	UGANDA										TANZANIA		Entry Mean
	Acholi District	West Nile Dist.		Madi District.	Karamoja Dist.		Bukedi District			Buganda District	Kituntu	Zanbwa	
	Labore	Abbi	Nebbi	Pakelle	Iriri	Namalu	Kibale	Iki-Iki	Tororo	Namulonge			
Serere 1	3000	3200	770	1730	4030	6260	3240	1710	730	2760	1350	1970	2870
Gulu E	2890	3250	500	1640	2650	5640	3220	1510	730	2630	1260	2190	2790
Serere 104	2800	3810	930	1950	3220	6150	2880	1220	680	2300	1170	1900	2760
Enganyi	2910	3440	860	1670	3380	5680	2820	1680	680	2510	1520	2920	2750
Serere 148	2840	3190	390	1570	3830	5960	2740	1280	740	1880	1900	2300	2730
Serere 358	2720	3250	650	1560	2490	6090	2990	1220	630	2190	1170	2030	2710
Serere 66	3180	2800	440	1870	2610	5790	2710	1410	920	1860	1080	2100	2670
Serere 116	2880	3410	440	1780	3500	5160	2570	1190	730	2310	1080	2250	2660
Serere 149	2630	3110	750	1600	2610	5850	2810	1310	730	2400	990	2090	2650
Engom	2570	2640	840	1620	2890	5280	3180	1490	740	2630	1080	2270	2590
Eding	2830	2660	710	1540	3380	5490	3110	1390	640	2470	1440	1770	2570
5 Ex 12 P_1	2860	3240	660	1610	2610	5540	2550	1140	510	1830	990	2430	2560
Elaba	2350	3110	680	1480	3060	6220	2610	1250	690	1630	1260	2410	2560
Serere 12	2890	2720	750	1560	2690	5780	2560	1280	760	2470	990	1860	2550
Serere 117	2630	2970	680	1510	3220	5230	2500	1280	680	2050	990	1980	2550
Serere 312	2870	2830	680	1540	2690	5510	2390	1240	610	1990	1170	2220	2520
Serere 119	2320	2910	730	1560	3500	5520	2570	1430	740	2460	1080	2090	2520
Okiring	3140	3290	420	1290	2280	5960	2040	1160	600	1800	1170	2260	2510
Serere 91	2830	3400	530	1580	2810	5880	1950	1190	650	1690	720	2180	2500
Serere 82	2990	2750	760	1580	2690	5440	2340	1210	700	1790	1350	1460	2480
Serere 101	3000	3130	770	1390	3020	5820	2540	1290	720	1990	1260	1600	2480
5 Ex 12 P_5	3020	2990	630	1500	2860	5540	2250	1090	530	1670	1080	2580	2410
Serere 21	2850	3450	280	1380	2890	5350	1840	1020	630	1660	1350	1740	2380
Serere 152	2530	2680	580	1340	3300	5370	2490	1220	600	2060	990	1780	2370
5 Ex 13 P_6	2980	3070	410	1010	2730	5620	2170	930	530	1410	900	2200	2310
Site mean	2820	3090	630	1550	3000	5680	2600	1290	670	2100	1130	2100	2580
L.S.D.(.05)	380	n.s.	340	250	870	n.s.	490	260	n.s.	380	n.s.	n.s.	210
C.V.(per cent)	11.54	22.95	46.05	14.21	25.16	13.77	16.40	17.58	29.73	15.76	35.85	33.44	

Table 58. SOME GRAIN YIELDS IN Kg/Ha FROM THE SCREENING TRIALS OF FINGER MILLET AT SEREPE, FIRST RAINS 1969 and 1970

Entries	1969 10x10 Triple Lattice	1970 11x11 Triple Lattice	Entries	1969 10x10 Triple Lattice	1970 11x11 Triple Lattice
P238	3200	4580	WC491	2240	3240
P251	2330	4490	WC637	3410	3220
WC93	3390	4440	WC550	3180	3210
P247	3150	4320	WC421	2210	3200
P339	2930	4200	WC141	2870	3190
P336	2780	4180	WC537	2340	3190
WC97	2860	4070	WC31	3140	3180
WC25	3240	4020	WC83	2980	3130
P241	2300	3990	WC499	3120	3110
P226	2450	3990	WC438	2310	3110
WC489	3160	3940	WC543	3060	3080
P265	3080	3920	WC98	2610	3080
WC606	2190	3910	WC649	2180	3060
WC91	3040	3850	WC253	3030	3060
Engavi	2650	3820	WC99	2730	3050
WC92	3480	3800	WC643	2200	3030
WC293	2670	3740	WC471	2510	3030
WC495	2640	3730	P255	2660	3020
P246	2200	3680	WC96	2990	3010
P277	2350	3670	P211	2220	3010
WC105	2730	3620	WC551	3450	3010
P210	2630	3580	WC88	2420	3000
P320	2110	3550	WC101	2690	2960
WC157	2390	3540	WC120	2680	2960
WC703	3050	3520	WC536	2240	2930
WC86	3010	3520	WC372	2270	2890
WC94	3210	3500	WC114	3120	2880
WC251	3290	3480	WC90	2280	2880
WC130	2910	3460	WC76	2600	2870
P282	2170	3450	WC252	2980	2800
WC509	2690	3440	WC490	2420	2780
WC700	2250	3440	WC89	2230	2650
P302	2420	3430	WC261	2800	2640
WC545	2790	3430	WC78	2190	2630
WC85	3350	3350	WC644	2560	2630
WC290	2570	3340	WC718	3100	2620
WC694	2580	3300	WC276	2330	2610
P284	2560	3270	WC608	2450	2610
P289	2270	3260	WC607	2760	2540
WC113	2860	3250	WC74	2190	2420
			L.S.D.(.05)	790	680
			C.V.(per cent)	20.03	12.34

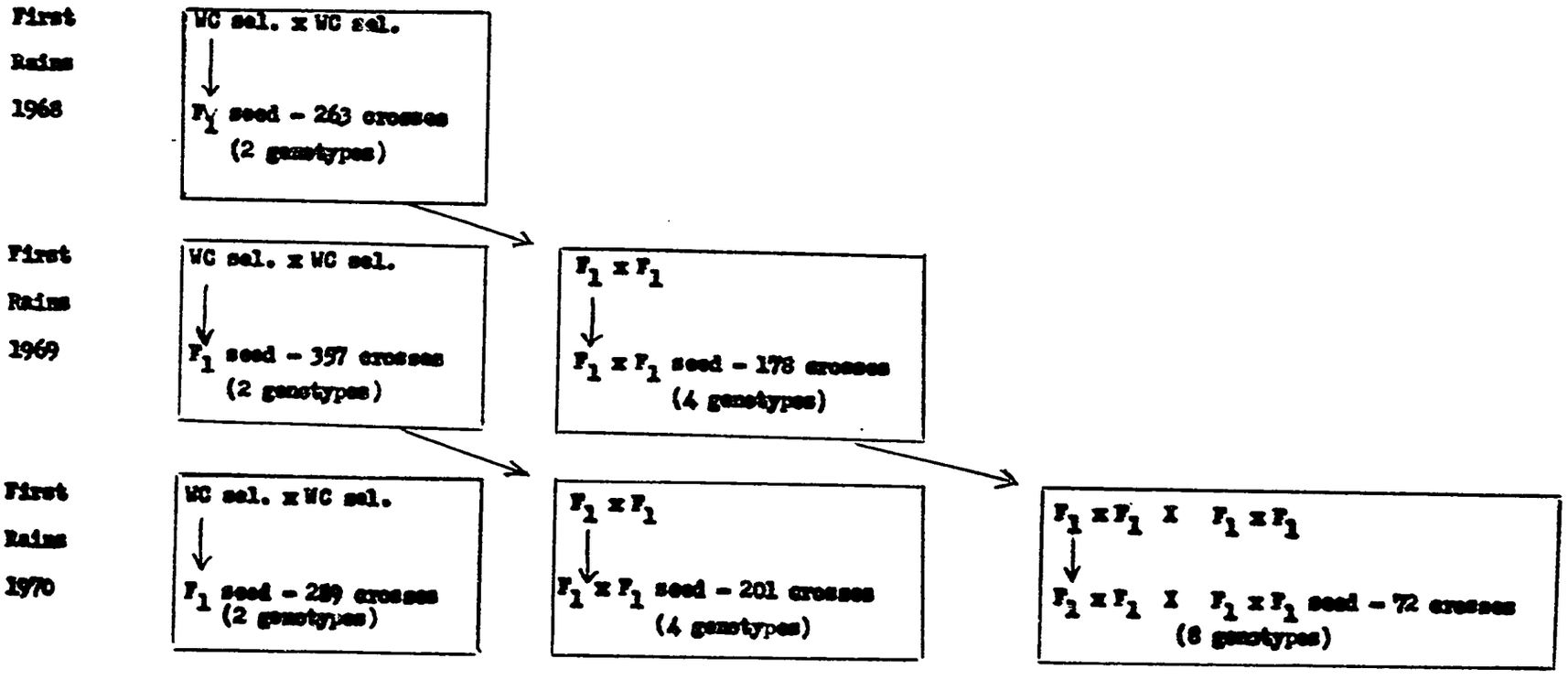

Figure 2. Crossing programme for Finger Millet.

Crossing of selected parent lines was continued as well as crossing of F_1's by F_1's; and of Double Crosses by Double Crosses.

The backcrossing programme for resistance to lodging and blast, Piricularia oryzae was continued with over three hundred crosses being made. Good straw strength and standability will be very important when the high yielding strains are grown with the use of additional fertilizer.

As the use of hot water emasculation techniques has not been completely effective in carrying out our crosses, an attempt was made to introduce male-sterility into some of our lines. Thirty selections which had received five dosage rates of fast neutron were planted at Serere on April 23, 1970. However, probably due to this delayed planting, about one month later than the normal planting date, all of the plants were lost due to an insect-transmitted virus. Seed has again been sent for treatment and plans are to pursue the male-sterility work further.

The evaluation of finger millet strains in the regional trials and the screening trials at Serere have been primarily on agronomic characters which contribute towards grain yield. Preliminary analysis of finger millet samples in 1970 by Mr. Shepherd of U.S.A.I.D./A.R.S. at the cereals laboratory of E.A.I.R.O. in Nairobi, have given a range of protein levels from 6.3 to 9.8 percent and a lysine index of 0.20 to 0.24 for some of our selected strains. More intensive grain quality studies will be carried out in 1971.

Bulrush Millet Breeding

L. V. Peters, S. Odelle and E. Atadan

Regional Trials. The grain yield results and analysis of the regional trials of bulrush millet for the second rains of 1969 in Uganda and first rains of 1970 in Tanzania and Botswana are shown in Table 59.

Significant differences in yield is noted at 18 of the 23 sites, with the hybrids outyielding their pollinator nearly 70 percent of the time. The yields at some sites undoubtedly suffered bird damage which greatly influenced the results. However, the average yield for all entries was very good considering the rainfall during August and September of 1969 which was below the lower 1:1 confidence limits.

Screening Trial. The grain yields for 49 entries grown at Serere during the second rains of 1969 are shown in Table 60.

Table 59. GRAIN YIELDS IN Kg./Ha. FROM THE REGIONAL BUIRUSH MILIET TRIALS? SECOND RAINS 1969 IN UGANDA AND FIRST RAINS 1970 IN TANZANIA AND BOTSWANA.

Entries	UGANDA											
	Teso District						Busoga District	Lango District		Acholi District		
	Kabera-maido	Kuju	Arapai	Katakwi	Kumi	Serere	Bugaya	Aduku	Ngetta	Labora	Kitgum	Patongo
Varieties												
Serere 2A	2430	680	2150	2160	2030	3860	800	2280	2080	3260	1250	500
Serere 3A	2300	710	2440	2360	2400	4180	610	2300	2310	3180	1060	640
Serere 6A	2500	730	2280	2420	2220	3960	650	2410	2320	3000	1640	450
Serere 17	2410	750	2090	2590	2120	3980	590	2080	2350	3150	1110	230
Serere 26/9	2170	590	1440	1170	2110	3120	910	2370	1890	2820	1170	590
Serere 26/19	1990	600	1540	1600	2520	4030	670	1970	1980	2580	810	70
Serere Farm Bulk	2180	490	1580	2200	1920	4100	970	2310	1900	2690	870	230
Serere 30	2190	750	1760	2240	1560	3610	920	2240	2040	2750	1090	240
Hybrids												
Tift 23A x Serere 2A	2540	810	2290	1890	1850	3390	950	2090	2690	3710	1010	250
Tift 23A x Serere 3A	2820	790	2000	2030	2330	3630	800	2400	2100	3380	840	400
Tift 23A x Serere 6A	2630	590	2310	1890	2010	4210	740	2480	2830	3630	1000	400
Tift 23A x Serere 17	2400	700	2000	2870	2360	4240	680	2510	2300	3340	1260	480
Tift 23A x Serere 26/9	2680	700	1970	1970	2550	3840	820	1890	2330	3370	1060	270
Tift 23A x Serere 26/19	2550	620	1840	2480	2660	3460	740	2180	2350	3540	1080	380
Tift 23A x Serere Farm Bulk	2270	600	1870	1520	2110	3880	990	2270	2150	3060	1030	240
Tift 23A x Serere 30	2760	660	1990	2060	2030	3520	760	2230	1910	3100	880	170
Variety mean	2270	660	1910	2090	2120	3850	770	2240	2110	2930	1120	370
Hybrid mean	2580	680	2030	2090	2240	3770	810	2260	2330	3390	1020	330
Site mean	2430	670	1970	2090	2180	3810	790	2250	2220	3160	1070	350
L.S.D. (.05)	330	180	400	750	n.s.	580	250	n.s.	570	530	400	260
C.V.(per cent)	10.86	20.90	15.90	28.31	28.26	12.09	25.14	22.43	20.26	13.20	29.50	59.17

Table 59. (Cont'd) GRAIN YIELDS IN Kg./Ha. FROM THE REGIONAL BULRUSH MILLET TRIALS? SECOND RAINS 1969 IN UGANDA, AND FIRST RAINS 1970 in TANZANIA AND BOTSWANA.

Entries	UGANDA							TANZANIA			BOTSWANA	ENTRY MEAN
	Madi District	West Nile Dis.		Karamoja District								
	Pakelle	Abbi	Nebbi	Iriri	Kotido	Moroto	Namalu	Lubaga	Ukiriguru	Sambwa	Gaborone	
Varieties												
Serere 2A	790	2030	2160	1100	990	1410	3480	3260	3530	2940	890	2000
Serere 3A	670	2010	2140	920	700	1380	3570	2950	3340	3310	950	2020
Serere 6A	650	1830	2070	790	860	1680	3210	3240	3090	3090	900	2000
Serere 17	670	2200	2470	1170	590	1370	3660	2930	3530	2710	950	1990
Serere 26/9	710	1340	2270	680	440	1570	3110	2420	2860	2380	410	1680
Serere 26/19	630	1520	2010	1060	910	1220	2840	2340	2730	1510	990	1660
Serere Farm Bulk	830	1650	2160	600	650	1450	2750	2840	2450	3290	860	1780
Serere 30	940	2070	2230	820	840	1460	3390	2640	3080	2720	650	1830
Hybrids												
Tift 23A x Serere 2A	810	2070	2360	1560	710	1940	3390	3320	3480	3160	590	2060
Tift 23A x Serere 3A	750	2050	1960	1470	550	1960	4120	3150	3420	3300	1060	2050
Tift 23A x Serere 6A	820	2340	2110	1280	700	1690	3480	3170	4040	3210	940	2110
Tift 23A x Serere 17	840	2030	2200	920	400	1740	3570	3740	3590	3290	1050	2110
Tift 23A x Serere 26/9	690	1920	2470	1010	820	1940	3660	3240	3230	2620	1120	2000
Tift 23A x Serere 26/19	820	2640	2800	820	700	2130	3390	3000	3630	1920	1310	2040
Tift 23A x Serere Farm Bulk	930	2200	2660	1280	780	1870	3390	2950	3110	3350	780	1970
Tift 23A x Serere 30	740	2070	2010	1010	710	2170	3660	2910	3650	3100	780	1960
Variety mean	740	1830	2200	890	750	1440	3250	2830	3080	2740	825	1870
Hybrid mean	800	2170	2320	1170	670	1930	3580	3190	3520	2990	1005	2040
Site mean	770	2000	2260	1030	710	1685	3420	3010	3300	2870	910	1955
L.S.D. (.05)	n.s.	550	490	560	n.s.	n.s.	540	540	750	610	280	160
C.V. (per cent)	21.08	21.93	17.23	42.48	47.61	28.99	12.38	14.18	18.07	16.70	24.16	

Table 60. Grain yields in Kg.Ha. from the 7x7 triple lattice screening trial of bulrush millet at Serere, second rains 1969.

Source	As a Pollinator strain	As Tift 23A hybrid	As Serere 10LA hybrid	As Tift 23DA hybrid
Serere 2A	3580	3090	3530	-
Serere 3A	3700	2720	3230	-
Serere 6A	3420	2780	3430	-
Serere 17	2890	2930	3160	-
Serere 26/9	2840	3070	3660	-
Serere 26/19	2290	2660	2990	-
Serere Farm Bulk	3160	2710	3690	-
Serere 30	3600	3010	3640	
Serere Composite 1	3730	--	--	-
Serere Composite 2	3400	--	--	-
Serere Composite 3	3530	--	--	-
Serere Composite 10	2960	3110	--	2800
Serere Composite 11	2590	2290	--	2550
Bajar Hybrid No. 1	--	2490		
Souna 11 - Senegal	2580			
115-4 Tropcross-Senegal	3450			
Nigerian Ex. Bornu	2940			
Nigerian Ex. Ajingi	2040			
Nigerian Ex. Tukuru	2330			
Nigerian Ex. Gashua	2380			
Nigerian Ex.Riyom	2440			
Nigerian Ex. Audu	2690			
Zongo Ex. Niger	2290			
P3 (Kolo) Ex. Niger	3160			
M-7 Ex. Mali	2960			
NBK Ex. Mali	2220			
NBB Ex. Mali	2570			
NKK Ex. Mali	2180			
NKB Ex. Mali	2440			
Mean	2940			
L.S.D. (.05)	740			
C.V.(Percent)	15.40			

The entries in this trial consist of the strains, hybrids and more advanced composites developed at Serere, plus introduction from Senegal, Nigeria, Niger, Mali and Bajar Hybrid No. 1 from India. Most of the West Africa strains are as much as two weeks or more later in maturity than the East African types and yields were greatly reduced due to lack of moisture during the early part of this growing season. The average performance of the eight Serere 10LA hybrids, the eight Tift 23A Hybrids, and their eight pollinator strains, show the Serere 10LA Hybrids yielded nineteen percent more grain than the Tift 23A Hybrids and seven percent more than the pollinators. After the first cycle of selection, S_1 testing and recombination, Serere composite 1 was the top entry in the test.

Based upon the performance of the entries in the regional trials and this screening trial, twenty entries were selected for the regional trials for the second rains of 1970. The results from these plantings are not available at this time.

World Collection. The primary objective of our work with the accessions of the collection is to separate the selections into either the restorer or the non-restorer groups. This has now been determined for all of the accessions of which we have viable seed. Nearly one thousand hybrid rows were grown during the first rain season of 1970. From a total of nearly three thousand crosses of the collection accessions, we have found that seventy-four percent are restorers, six percent are non-restorers and twenty percent carry both restorer and non-restorer genes. These restorer and non-restorer populations were started during the first rains of 1969 with remnant self seed of those plant selections which showed good heterosis with the sterile seed parent. We now have a total of 366 selections in the restorer population and 110 in the non-restorer population. Both of these populations must be intercrossed within their respective groups for at least two or three more times before selection pressure will begin.

New Introductions. A total of 1,345 rows of new introductions from India were planted during the first rain season of 1970 and self seed was obtained from 1,045. These were planted during the second rain season and a total of 1,661 crosses were made onto Tift 23A and Serere 10LA. These crosses will be grown during the first rains season of 1971 for the purpose of classifying the pollinator parent as either a restorer or non-restorer type.

Development of Adapted Male-steriles. These plantings were severely damaged by hail on September 25, 1970 when in the boot stage of development. However, 517 paired matings were selected within the A and B lines of eight strains. Final selection and increase of some of these will be made in 1971.

Cereal Agronomy

G. Schumaker, B. A. Opolot, S. Ogolle and R. J. Davis

Much of the agronomic work conducted in 1970 was a continuation of the work commenced previously. Date of planting trials at some locations were expanded to include new varieties and hybrids. Studies to determine nutrient requirements and optimum levels of application for sorghum and millet continued, as did investigations on minor element deficiencies and water requirements of sorghum. Herbicide studies were expanded to include tractor application of herbicides. In early June R. J. Davis replaced Gilbert Schumaker as Cereal Agronomist. The programme started by G. Schumaker was carried on intact during the second rains season. Data on some of the work of the first four years has been sumonized for publication by G. Schumaker.

Date of planting trials: Finger millet was planted at intervals of two weeks in the first rains at Serere. A new variety S-119 was checked in addition to Engeny the standard variety. The results tend to confirm previous data. As in the past earlier plantings yielded higher.

Table 61. Yield of Finger millet, first rains, 1970

	Date planted			
	10th February	24th February	10th March	23rd March
Engeny	30.97	33.00	30.63	25.50
S-119	28.93	34.30	37.23	34.00

Two sorghum varieties were planted at Serere over six different dates. Yields are shown in Table 62. Although yields were better for the hybrid than Serena the trend for planting date is the same.

Table 62. Yield of sorghum at Serere, first rains, 1970

	Yield in q/ha	
Date planted	Serena	H x 467
26th February	42.7	55.0
12th March	44.5	56.6
26th March	40.5	61.1
9th April	22.4	25.1
23rd April	0.0	0.0
7th May	0.0	0.0
Mean	25.01	32.96
L.S.D.	3.77	5.04

At Kumi and Kitgum four planting dates were utilized as shown in Table 63. The crop at Kitgum suffered from heavy flooding and a hail storm. The fourth date suffered rodent damage at germination followed by drought.

Table 63. Yield of sorghum at Kumi and Kitgum.

	Yield q/ha			
Date of planting	Kumi		Kitgum	
	Serena	H x 57	Serena	H x 57
12th March	40.1	51.0	5.1	14.4
26th March	35.0	42.2	7.8	12.3
9th April	30.3	31.4	4.7	10.0
23rd April	11.4	15.1	0.0	0.0
Mean	29.20	34.94	4.41	9.18
L.S.D.	3.97	8.89	2.36	3.68

A similar trial was initiated on 20th July in the 2nd rains season, at Serere. This included 5 varieties, Serena, the hybrids H x 57 and H x 467, and two varieties developed at Makerere University. Resistance blocks to monitor soil moisture were installed in the area planted to Serena. Blocks were placed 90 cm deep and were read twice weekly to determine when moisture stress occurred. Analysis of the data is incomplete and will be reported next year.

Fertility experiments: An experiment was conducted with sorghum at four locations, two in Kumi county and two in Ngora county with various levels of N, P_2O_5 and farmyard manure as seen in the Table 64. It would appear that with present varieties farm yard manure can, where available in sufficient quantities, produce top yields.

Table 64. Yields of sorghum variety Serena with various fertility treatments.

Treatment (kg/ha)			Yield (q/ha)			
			Ngora 1	Ngora 2	Kumi 1	Kumi 2
N	P_2O_5	FYM				
0	50	0	30.9	13.8	16.3	14.2
50	50	0	39.0	31.8	28.2	30.4
100	50	0	44.0	36.6	35.3	42.1
0	50	0	23.4	15.3	15.1	12.8
0	50	100	36.6	23.6	23.8	26.1
0	50	200	46.3	33.2	39.9	30.7
0	0	0	20.4	14.0	14.9	18.5
0	0	100	38.9	28.6	23.6	32.3
0	0	200	43.0	31.6	33.9	31.6
L.S.D.			8.96	11.23	6.48	8.91

An experiment with zinc applications superimposed on various combinations of nitrogen and phosphorous was conducted at two locations in Kumi county and two locations in Ngora county in the first rains season. The results were inconclusive.

Weed control experiments: Two herbicide trials were conducted in both seasons. One trial to check the toxicity of atrazine on sorghum and various combinations of atrazine and hand weeding. In the second rains the effects were very pronounced. A low application of atrazine cut weeding requirements by 70 percent. In the second experiment two levels of atrazine were checked both pre-and post-emergence application with two experimental herbicides supplied by CIBA. Results are shown in Table 65.

Table 65. Various herbicide and hand weeding treatments on weed control and yield of Serena sorghum, 1970.

Treatment	Percentage 1st rains Yield g/ha	1st rains % of weeds remain.	2nd rains Yield g/ha	2nd rains % of weeds remain.
1.5 at	46.7	47	12.4	30
2.75 At	39.8	27	14.2	30
4.0 At	41.5	27	14.0	13
Hand weeding	4.53	0	32.2	0
1.5 At + HW	46.7	0	33.3	0
2.75 At + HW	42.6	0	34.4	0
4.00 At + HW	36.3	0	30.9	0
No weeding	23.3	100	6.3	100
L.S.D.	11.93		6.90	
2.75 6313 Pre	37.6	57	25.3	43
4.00 6313 Pre	28.9	53	30.0	30
2.75 2242 Pre	39.0	43	42.1	42
4.0 2242 Pre	36.1	27	42.0	13
2.75 2242 Post	40.0	20	41.1	22
4.00 2242 Post	45.8	27	31.8	18
2.75 At Pre	43.3	23	25.7	60
4.00 At Pre	28.9	23	25.9	40
2.75 At Post	32.1	23	17.6	70
4.00 At Post	34.6	23	19.6	67
Hand weeding	39.1	20	48.5	0
No weeding	29.0	0	8.5	100
L.S.D.	11.29	100	8.50	

Rates are in kg/ha. Active Ingredient. Pre-pre emergence application. Post-post emergence application. 6313 and 2242 are experiment herbicides supplied by CIBA *East Africa. HW-hand weeding.

Height Reduction. This material was also damaged by hail, however, 397 selections were made which were crossed to the genetic dwarf lines, selection and increase of some of these lines will begin in 1971.

Recurrent Selection. The third cycle of selection and selfing and S_1 yield testing of 726 selections from Serere Composite 1 was accomplished during the first and second rains reasons of 1970. The S_1 yield testing was carried out in six 11 x 11 lattice trials during the second rains season. Recombination of the top 102 entries is being carried out in a bird proof wire cage with irrigation during the 1970-71 dry season.

Selfing and selections, with S_1 testing was also carried out in a population from West Africa. From 363 S_1 selections tested in three 11 x 11 lattices, 49 were selected for recombination during the 1970-71 dry season.

Although mass selection is being continued in most of the populations, selection and selfing, with S_1 testing will be started in some in 1971.

Protein Studies. Protein and lysine determinations were also made by the U.S.A.I.D./A.R.S. cereal laboratory on 24 bulrush millet selections from Serere Composite 1. The protein level of these samples ranged from 10.8 to 14.5 percent and the lysine index for these same samples was from 0.25 to 0.31.

Cereal Entomology

Dean Barry, Assisted by C. D. Muhwana, P. A. Opolot and J. W. Etengu

This year (1970) again the main emphasis of the Cereal Entomology Section at Serere, Uganda has been to develop lines of sorghum which are resistant to the sorghum shoot fly, *Antherigona Varia Soccata* Rondani and/or the lowland stem borer, *Chilo partellus* Swinehoe. Progress has been made in obtaining some lines of sorghum with some degree of resistance to these insects. Also included in this report are some results of attempts to control these insects with insecticides.

The following tables and discussions under the various areas of work are included to serve as a record of the work conducted during 1970.

General

All experiments were of a randomised block design with 6 replications unless otherwise indicated. The plot areas received 200 pounds of calcium nitrate and 200 pounds of single superphosphate per acre. Experiments concerning selection were planted within borders of earlier planted CK-60 in order to induce heavy populations of shoot fly.

Host Plant Resistance

Shoot fly: For the last two seasons five groups of material have been advanced for recovery resistance. This material is a continuation of work reported in the 1969 annual report. The results of a recurrent selection - screening program of three groups of these are presented in tables 66, 67, and 68.

Table 66 shows that after 4 generations of selection and screening 46 lines which were selected from the third generation compared favorably with Serena (the presently recommended variety) for recovery resistance. The results of a separate yield trial and other plant characteristics with the same materials are presented in table 69 (5 replications for yield cows destroyed the 6th). Some of these lines will be discarded next season if they have low yields and selection index scores or if they are very closely related to a line which has performed better. The selected lines will be placed in variety trials in Uganda and Tanzania during 1971 (seed samples of all materials will be stored at Beltsville, Maryland, U.S.A) It is hoped that after 3-4 seasons of evaluation at the various variety trial centers that several of these lines will be released for farmer use.

In Tables 67 and 68 evaluations of materials which have gone through 3 generations of selection and screening are presented. The selected materials from these will go through one more selection-screening test and yield trial at Serere before being sent to the variety trial centers. All selected lines will have bulk seed produced at Serere for the plantings at the various centers.

Two composite populations which have male-sterile germ plasm have gone through three generations of selection (1st selection from fertile heads, 2nd selection from sterile heads, and 3rd generation from fertile heads). Very little selection can be applied while selecting from the sterile heads since a small percentage (10-20) of the plants are sterile. Each season a population of about 4,000 plants of each population has been planted. Observable difference in the progress of these lines are quite evident and it is anticipated that lines can be selected and developed from these populations after 2-4 more generations of selection.

An international trial with materials from Uganda, India, and Israel was conducted at Serere during both seasons. During the first season 56 lines of sorghum was evaluated and 21 selections from these were reevaluated during the second season (Tables 70 and 71) None of the materials tested gave any definite indications of having primary resistance, but 3 or 4 selections from the India and Israel materials will be tested again. Several lines have indicated a recovery resistance, but most of these came from the Uganda material. Those selected will be placed in the current entomology breeding program at Serere, Uganda.

During the next year about 50 different lines will be provided to India, Israel, and Nigeria for the International Trials Program.

Stem borer: Selection for stem borer resistance (leaf feeding) have produced 5 lines of sorghum (Table 72) which are also resistant (recovery) to the shoot fly. However, it is with a word of caution that we say these lines are resistant to the stem borer. They were originally selected from 108 selected lines of sorghum during the second season of 1969 when several lines were selected. The number of selected lines were reduced each season until the second season of 1970 we only have 5. The reason for using caution in calling them resistant, is the lack of insect pressure. Even though all trials during the various seasons were artificially infested with borer egg masses, the supply was not adequate for the heavy selection pressure desired.

Chemical Control

Shoot fly: During the two seasons 3 experiments were conducted with soil systemic insecticides. In the first of these tests (Table 73) phorate and Sapecron applied in the row just previous to planting and carbofuran as a seed dressing, all provided excellent shoot fly control, but the degree of control was not always proportionally reflected in the yield. The yields from these treatments were significantly better than the control.

In a second test varing the rate of carbofuran and plant population (CK-60)(Table 74), all 3 rates of carbofuran (0.14, 0.28, 0.42 pound per acre) reduced the damage caused by the shoot fly and the increase in yield was directly related to the degree of control. The highest rate of carbofuran (0.42 lb. per acre) was the most effective. Of the 3 plant populations tested, 4, 12 and 20 cm between plants and 60 cm between rows, the 12 cm spacing gave the highest yield.

The results of the other experiment with 2 varieties (CK-60 and Serena), carbofuran treatment and no treatment for shoot fly control and 2 insecticide treatments (thuricide and carbaryl) and a control for stem borer control (no economic population of borers developed) are presented in Table 75. Although carbofuran again reduced the shoot fly infestation, no differences were noted in the yields. No yield difference was noted between the varieties, Serena and CK-60 in this test.

Additional trials of foliar applications of various chemicals (Table 76) on the varieties, CK-60 and Serena, were conducted but differences in yield were not observed in any trial. The reason for no difference in the Serena trials (planted late during the first season) was no doubt due to its recovery ability (resistance), but the only explanation for CK-60 (planted in the second season) was that it was planted too early and escaped an infestation. A future recommendation is to induce heavy infestations of shoot fly on all insecticide trials.

Stem borer: Insecticidal trials were conducted during both seasons, Serena in the first season and Serena and CK-60 in the second season (Table 77). However, since no populations of stem borer developed no yield differences were found due to treatments. Stalks from treated and untreated areas were dissected after harvest to detect insect populations.

Biological Studies

Shoot fly: The duration of the various life stages of the sorghum shoot fly, *Antherigon varia soccata* Rondani were worked out as shown in Table 78 . The life cycle of this insect at Serere, Uganda is longer than that reported from the other East African countries. It is significant for our research that the duration of the life cycle at Serere has been determined. Previously, in order to obtain an adequate population of insects for selecting and screening materials for resistance, we planted border rows of CK-60 (susceptible variety) about 14-16 days before planting our plots, but this work indicates that the border rows should be planted about 21-24 days before the plots are planted.

The details of the life cycle of this insect are being prepared for publication.

Stem borer: Attempts to rear this insect in the laboratory has continued with partial success. Several diets and slight modifications of these have been used, but only two of these have had the freshly hatched larvae to feed upon them and survive to the adult stage in significant numbers. The diet giving the highest survival was initially provided by R. Burton, Southern Grain Insects Laboratory, Tifton, Georgia. The other is a modification of the European corn borer diet. The diets mentioned above are as follows:

Diet A: - A wheat-soy blend (W.S.B.) based diet provided by Robert Burton from the Southern Grain Insects Laboratory, Tifton, Georgia.

W. S. B.	93.5g
Yeast	5.0g
Ascorbic Acid	0.5g
Mithyl p- hydroxy benzoate	1.0g
Formaldehyde (10% soln.)	1 ml
Agar	6.4g
Water	400 ml

1. Blend agar with 200 ml of cold tap water for 2 minutes and then bring to a boil.
2. Blend all remaining ingredients with the remaining water.
3. Add agar and water mixture to the other blended ingredients after cooling to about 60°C.
4. It may be necessary to add a few additional ml of hot water (60°C) which has been boiled to give a better handling consistency.

Diet B: - European corn borer diet number 28 with the oil omitted.

Water	400 ml
Agar	9.0g
Sugar	13.0g
Casein	13.0g
Salt Mixture No. 2	1.6g
Yeast	7.0
Leaf whorl powder (maize)	18.0
Vitamin supplement	3.0
Ascorbic acid	4.0
Mold inhibitor*	4.0ml

* Inhibitor

Ethyl Alcohol (95%) 170 ml
Sorbic acid 20 g
methyl p-hydroxy benzoate 15 g

1. Blend agar and 300 ml of cold water tap for 2 minutes.
2. Transfer water and agar to heating unit (double boiler in this case) and disolve sugar and stir in casein respectively as the solution is heated to about 50-55°C.
3. Add leaf whorl and salt as heating continues and cook for 10-15 minutes to near the boiling point.
4. Blend all other ingredients and remaining water and add the cooked material to the blending process after it has cooled to nearly 60°C. (It may be necessary to add a few ml of hot water (about 60°C) which has been boiled to give a good consistancy for pouring into squeeze bottles and vials)
5. Sanitary conditions should prevail at all times.

Plant Breeding

Primary resistance: Other than the plant breeding considered under host plant resistance earlier, work is continuing in hopes of developing lines of sorghum with primary resistance to shoot fly. Sources of this resistance were identified last year in 10 lines from India, but making various crosses with local varieties and obtaining viable seed presents problems. Attempts will continue to work with the primary resistance germ plasm.

Simulated Armyworm Damage on Sorghum

In cooperation with the Armyworm Division of E.A.A.F.R.O. sorghum was artificially damaged at various life stages, as the armyworm may do by feeding on the leaves, to assess how much damage a plant may stand without reducing yield. The result of this trial is presented in Table 79. It was noted that 75% of the leaf surface could be removed at 4-5, 9-11, and 12-14 leaf stage without reducing yield. All of the leaves were cut completely off at 4-5 leaf stage, without reducing yield.

Maize Variety Trial

In cooperation with the maize breeders at Kawanda Research Station a variety trial was conducted of 10 varieties replicated 6 times. The results are presented in Table 80 . No insect problems, other than maize streak virus which is transmitted by leaf hoppers, were present in the trial. No insecticides were applied.

Introductory Entomology Course

During the period of April 7 to July 30, 1970, two series of 28 entomology lectures (1-1½ hour sessions) were presented for junior staff members at Serere Research Station. Of the 15 participants remaining throughout the course, 12 successfully completed it (a grade of 50% was passing). The course was met with a great deal of enthusiasm, and requests were obtained for more advanced lectures. However, it was felt that only 3 of the participants were qualified for more advance study and 1 of these was transfered. No further entomology lectures are anticipated at present, but several staff members have requested that I present a series of lectures and demonstrations on automobile maintenance and mechanics.

Table 66. Evaluations of sorghum selections during the third and fourth genetation of a recurrent selection-screening program at Serere, Uganda, 1970. (average from 6 reps.)[a]

Entry	First Season				Second Season				
	Stand count[c]	Infested Pct.	Recovered Pct.	Selection index	Stand count[c]	Infested Pct.	Recovered Pct.	Selection index	Yield (kg)
1-P-4-1-1-(1)	11.8	57.7	83.1	40.8	13.6	72.0	94.1	66.1	1.38
2-P-2-1-1-(1)	13.2	62.0	84.8	46.8	15.1	81.4	84.1	65.5	1.45
2-P-1-2-1-(1)	13.0	60.2	80.8	41.0	14.6	71.9	90.4	62.3	1.42
3-P-5-1-1-(1)	11.7	61.4	87.1	48.5	15.1	76.8	88.1	64.9	1.51
4-P-1-1-1	12.0	48.6	80.6	29.2					
7-P-1-2-1	12.8	62.4	71.5	33.9					
7-P-1-1-1-(1)	13.0	65.4	82.1	47.5	12.6	76.1	75.4	51.5	0.76
12-P-1-2-1-(1)	11.7	67.1	74.3	41.4	14.5	82.7	77.9	60.6	0.85
14-P-4-2-1-(1)	12.3	63.5	90.6	54.1	14.3	74.1	86.0	60.1	1.23
14-P-6-2-1	8.3	60.0	66.0	26.0					
14-P-6-1-1-(1)	7.7	58.7	82.5	41.2	7.6	86.8	81.6	68.4	0.48
14-P-3-2-1-(1)	10.0	58.3	85.0	43.3	14.6	73.9	77.4	51.3	1.06
15-P-1-1-1-(1)	12.3	64.9	90.6	55.5	14.3	76.9	81.8	58.7	1.23
15-P-3-2-1	12.2	54.8	80.8	35.6					
19-P-1-1-1	12.8	54.6	79.3	33.9					
24-P-4-2-1	12.8	48.1	81.8	29.9					
24-P-4-1-1	6.2	51.4	70.2	21.5					
25-P-3-1-1-(1)	11.8	57.7	84.5	42.2	14.5	76.5	84.1	60.6	1.17
26-P-2-1-1-(1)	13.2	72.1	78.4	50.5	13.5	70.3	85.2	55.5	0.78
28-P-1-1-1-(1)	14.2	67.0	75.3	42.3	14.3	73.4	87.4	60.8	1.04
28-P-4-1-1-(1)	12.5	64.0	78.6	42.6	13.8	68.8	72.5	41.3	0.85
29-P-3-1-1	11.3	48.5	67.7	16.2					
29-P-4-2-1	13.5	55.6	82.7	38.2					
29-P-1-1-1-(1)	9.8	67.8	78.0	45.8	14.8	79.7	77.7	57.4	0.89
31-P-1-2-1-(1)	13.0	65.4	82.1	47.5	15.3	59.4	77.1	36.5	1.12
31-P-4-1-1-(1)	14.2	64.7	80.0	44.7	15.1	58.2	78.1	36.3	1.06
33-P-3-2-1-(1)	13.7	65.8	89.0	54.8	14.1	70.9	85.1	56.0	1.23
34-P-1-2-1	12.3	60.8	73.0	33.8					
35-P-5-2-1-(1)	13.2	59.4	81.0	40.4	15.3	68.6	77.1	45.7	1.23
35-P-2-1-1-(1)	12.0	59.8	83.3	43.1	15.5	67.7	80.6	48.3	1.02
37-P-3-2-1-(1)	10.5	66.7	82.6	49.3	12.6	69.8	81.7	51.5	1.04
37-P-2-1-1	13.3	56.3	72.5	28.8					
37-P-1-1-1-(1)	13.5	63.0	80.2	43.2	13.0	73.0	75.4	48.4	1.04
38-P-3-2-1	13.2	54.4	75.9	30.3					

Table 66 (Cont'd.)

39-P-4-2-1(1)	12.8	68.8	81.8	50.6	13.5	68.8	77.8	46.6	1.08
45-P-2-2-1(1)	9.2	81.8	89.1	70.9	14.8	72.9	86.5	59.4	1.33
45-P-2-1-1-(1)	13.7	73.2	91.4	64.6	14.0	75.7	87.1	62.8	1.00
48-P-1-1-1-(1)	9.0	68.6	74.1	42.7	14.1	75.1	70.9	46.0	1.05
50-P-2-1-1-(1)	13.2	62.0	84.8	46.8	14.0	66.4	80.7	47.1	1.31
71-P-1-2-1-(1)	11.7	62.8	78.6	41.4	12.6	67.4	79.4	46.8	0.94
71-P-2-1-1	9.7	63.8	75.8	39.6					
71-P-2-2-1-(1)	11.2	62.7	79.0	41.7	14.6	72.6	76.7	49.3	0.63
78-P-2-2-1-(1)	15.2	61.5	89.0	50.5	12.8	80.4	80.5	60.9	0.82
82-P-2-2-1	10.2	54.1	77.0	31.1					
102-P-4-1-1-(1)	11.5	62.4	78.3	40.7	15.1	59.6	62.9	22.5	0.90
102-P-3-1-1	10.8	50.8	66.2	17.0					
107-P-6-1-1-(1)	11.5	72.4	75.4	47.8	13.8	78.2	85.5	63.7	1.19
135-P-5-1-1-(1)	9.8	66.1	79.6	45.7	14.0	65.0	76.4	41.4	1.35
135-P-5-2-1-(1)	11.7	70.0	72.8	42.8	14.0	60.7	73.6	34.3	1.25
135-P-3-2-1	9.8	52.6	78.0	30.6					
137-P-2-2-1	10.0	50.0	72.0	22.0					
143-P-2-2-1-(1)	13.7	67.1	80.5	47.6	14.0	75.0	80.0	55.0	1.32
156-P-5-1-1	10.5	62.3	76.2	38.5					
156-P-5-2-1-(1)	12.3	70.3	82.5	52.8	14.8	78.3	76.4	54.7	1.24
157-P-3-1-1-(1)	12.7	53.9	93.4	47.3	15.3	64.0	80.4	44.4	1.51
165-P-5-2-1	10.2	60.7	75.4	36.1					
165-P-6-2-1-(1)	10.7	62.5	100.0	62.5	9.8	69.3	93.9	63.2	0.83
165-P-6-1-1	12.2	53.4	78.1	31.5					
165-P-4-1-1	10.3	58.1	80.6	38.7					
170-P-1-2-1	12.0	68.1	69.4	37.5					
208-P-4-2-1	11.8	47.9	76.1	24.0					
208-P-5-2-1	14.2	58.8	78.8	37.6					
209-P-2-2-1	14.3	52.3	81.4	33.8					
210-P-5-1-1	14.8	55.1	75.3	30.4					
210-P-5-2-1-(1)	12.8	61.0	83.2	44.2	14.8	76.3	84.5	60.8	1.48
210-P-4-2-1	11.8	56.4	83.1	39.5					
210-P-4-1-1-(1)	13.7	64.6	92.7	57.3	14.8	71.6	86.5	58.1	1.44
211-P-3-1-1-(1)	13.3	66.2	80.0	46.2	14.3	65.0	83.9	48.9	1.21
211-P-2-2-1	12.5	56.0	80.0	36.0					
211-P-1-2-1-(1)	12.0	69.4	77.8	47.2	13.8	79.7	92.8	72.5	1.66
211-P-3-2-1	13.0	53.8	71.8	25.6					
217-P-1-2-1-(1)	12.5	68.0	81.4	49.4	14.8	76.3	82.4	58.7	0.96
218-P-3-2-1-(1)	12.5	68.0	84.0	52.0	14.3	79.0	83.9	62.9	0.91
219-P-1-2-1	13.2	58.2	64.5	22.8					
219-P-2-2-1	13.0	61.5	73.1	34.6					
219-P-2-1-1	12.0	63.9	63.9	27.8					
224-P-4-2-1	9.0	51.9	81.4	33.3					
228-P-1-2-1-(1)	13.0	65.4	75.6	41.0	12.6	77.7	83.3	61.0	0.54
231-P-1-2-1	12.3	63.5	75.7	39.2					

Table 66 (Cont'd.)

234-P-5-1-1	13.0	64.1	75.6	39.7					
234-P-5-2-1-(1)	12.3	71.6	73.0	44.6	13.3	82.7	78.9	61.6	0.78
236-P-1-1-1	13.0	59.0	65.4	24.4					
236-P-1-2-1	12.3	68.9	48.7	17.6					
Serena					12.8	60.9	84.4	45.3	1.14
CK 60					13.8	79.7	49.3	29.0	0.49

(a) Planted the first season trial on April and the second on August 28.

(b) Entries with last digit in parentheses have been selected over four generations.

(c) It is possible to have stand counts of 16 because of poor thinning, but the trial was designed for 14 plants per plot.

Table 67. Evaluation of lines (2nd and 3rd generations of selection) of sorghum derived from various crosses for recovery resistance to the sorghum shoot fly at Serere, Uganda. 1970. Avg. 6 reps.

Entry	First Season				Second Season				
	Stand Count[b]	% Infested	% Recovery	Selection Index	Stand Count[b]	% Infested	% Recovery	Selection Index	Yield kg
45-P-2CK2xNam-1	8.0	56.2	68.8	25.0	14.5	77.9	84.8	62.7	0.82
Serena	9.2	56.4	72.7	29.1	12.8[c]	60.9[c]	84.4[c]	45.3[c]	1.14[c]
82-P-2-CK2xNam-1	7.5	55.5	48.9	4.4					
89-P-5-SerenaxCK2xNam-1	8.2	51.0	55.1	6.1					
Namatara	8.0	50.0	60.4	10.4					
8-P-1-CK2xNam-1	10.0	61.6	78.3	39.9	14.8	78.3	89.9	68.2	1.39
157-P-2-SB79-1	9.5	43.9	75.5	19.4	11.5	78.2	76.5	54.7	0.68
183-P-1-Serena-1	10.2	59.0	78.7	37.7	12.8	78.1	74.2	52.3	0.97
164-P-3-Serena-1	9.0	57.4	61.1	18.5					
27-P-1-CK2xNam-1	9.2	52.7	63.6	16.2					
185-P-2-Serena	7.3	61.4	50.1	11.5					
41-P-2-CK2xNam-1	8.0	62.5	58.4	20.9	15.0	73.3	75.3	48.6	1.05
216-P-1-Serena-1	9.7	56.9	63.8	20.7	13.8	83.3	76.1	59.4	0.84
44-P-1-CK2xNam-1	10.5	50.8	49.2	0.0					
136-P-1-CK2xNam-1	8.8	47.2	60.4	7.6					
36-P-1-CK2xNam-1	8.5	56.8	49.0	5.8					
70-P-1-CK2xNam-1	4.8	34.6	58.6	- 6.8					
165-P-2-Serena-1	10.0	46.7	76.7	23.4	7.0	82.8	88.6	71.4	0.46
78-P-2-CK2xNam-1	12.0	45.8	68.1	13.9					
208-P-4-SB79-1	9.8	56.0	64.4	20.4	10.5	67.6	60.0	27.6	0.66
158-P-1-SB79-1	12.0	59.8	44.4	4.2					
31-P-1-CK2xNam-1	11.7	52.9	38.6	- 8.5					
34-P-1-CK2xNam-1	10.7	60.9	57.8	18.7					
62-P-1-CK2xNam-1	8.8	58.6	62.3	20.9	15.0	82.0	78.7	60.7	0.95
35-P-5-CK2xNam-1	10.7	53.1	53.1	6.2					
161-P-3-SB79-1	8.3	54.0	52.0	6.0					
15-P-1-CK2xNam-1	10.5	46.0	63.5	9.5					
219-P-5-Serena-1	10.0	60.0	58.8	18.3					
156-P-5-Serena-1	8.3	54.0	66.0	20.0	15.1	89.4	79.5	68.9	1.31
19-P-1-CK2xNam-1	8.5	50.9	54.9	5.9					

(a) The first season trial was planted on April 4 and the second season trial on August 28.
(b) Possible number of plants per plot was 14 for the first season and 16 for the second season.
(c) Data taken from an adjacent experiment

Table 68. Evaluations of lines (2nd and 3rd generation of selection) of sorghum from various field selections for recovery resistance to the sorghum shoot fly at Serere, Uganda. 1970. (Avg. 6 reps.)[a]

Entry	First Season				Second Season				
	Stand count[b]	% Infested	% Recovery	Selection Index	Stand count[b]	% Infested	% Recovery	Selection Index	Yield (kg)
V-5-1-(1)	12.3	58.2	63.5	21.7	13.8	72.4	87.0	59.4	1.37
V-6-1	10.3	56.4	56.4	12.8					
V-17-1	10.8	46.2	70.8	17.0					
V-19-1-(1)	11.7	52.9	74.3	27.2	14.1	80.1	83.7	63.8	1.32
V-20-1-(1)	8.5	60.8	72.6	33.4	12.3	79.6	69.1	48.7	0.95
V-27-1	8.8	66.0	47.2	13.2					
V-30-1	8.5	58.8	58.8	17.6					
V-33-1	9.5	49.2	56.1	5.3					
V-37-1-(1)	8.0	64.6	75.0	39.6	13.0	67.6	67.7	34.3	1.01
V-39-1-(1)	9.0	70.3	66.7	37.0	12.5	74.4	72.0	46.4	1.03
V-44-1	10.3	61.3	50.0	11.3					
V-45-1-(1)	9.8	67.8	61.0	28.8	13.5	81.4	75.6	57.0	0.91
V-46-1	9.3	55.4	57.1	12.5					
V-59-1	7.8	53.2	61.7	14.9					
V-61-1-(1)	8.0	56.2	68.8	25.0	15.3	66.0	75.2	41.2	1.28
V-64-1-(1)	8.2	67.3	55.1	22.4	12.6	77.7	75.4	53.1	0.67
V-67-1	9.0	57.4	55.6	13.0					
V-70-1-(1)	11.2	50.8	73.1	23.9	11.5	83.4	87.0	70.4	0.91
V-71-1-(1)	10.8	49.2	83.1	32.3	14.1	69.5	69.5	39.0	1.03
V-73-1-(1)	10.5	58.8	68.3	27.1	14.1	74.4	83.0	57.4	1.18
V-74-1-(1)	10.0	73.3	71.7	45.0	12.8	72.6	89.8	62.4	1.18
V-92-1-(1)	11.2	61.2	65.6	26.8	13.3	71.4	77.4	48.8	1.00
V-99-1-(1)	11.2	55.4	82.1	37.5	11.0	69.0	84.5	53.5	0.94
V-106-1-(1)	9.2	63.6	67.3	30.9	10.6	80.1	68.9	49.0	0.55

(a) Planted the first season trials on April 6 and the second season on August 28.
(b) Possible number of plants per plot was 14 for the first season and 16 for the second season.

Table 69. Variety trial data for 46 selected lines for shoot fly resistance (recovery) with Serena and CK-60 as checks at Serere, Uganda. 1970[a]

Entry	Days to 50% Flowering	Stand count[b]	% Infested	Height (cm)	Yield (kg)[c]
1-P-4-1-1	63.2	68.3	34.4	144	3.45
2-P-2-1-1	62.7	70.3	38.0	145	3.24
2-P-1-2-1	61.8	76.7	38.1	144	3.33
3-P-5-1-1	61.0	84.3	37.6	147	3.68
7-P-1-1-1	72.5	37.8	43.7	155	2.67
12-P-1-2-1	68.2	71.2	41.2	159	2.90
14-P-4-2-1	69.7	79.3	37.6	156	3.86
14-P-6-1-1	69.8	23.2	57.3	164	2.64
14-P-3-2-1	71.5	79.2	34.5	166	4.02
15-P-1-1-1	65.3	79.3	38.2	196	3.54
25-P-3-1-1	72.6	76.2	38.5	174	4.19
26-P-2-1-1	67.3	70.0	40.3	177	2.98
28-P-1-1-1	69.3	63.0	35.4	172	3.47
28-P-4-1-1	66.3	73.7	38.3	162	2.86
29-P-1-1-1	62.0	82.2	36.9	192	3.71
31-P-1-2-1	65.7	79.0	33.5	155	3.82
31-P-4-1-1	68.2	75.2	29.7	187	3.25
Serena	64.3	77.0	36.8	149	3.17
33-P-3-2-1	67.8	82.5	40.2	151	3.74
35-P-5-2-1	66.5	81.0	32.3	154	3.29
35-P-2-1-1	68.2	81.2	31.8	150	3.58
37-P-3-2-1	67.7	84.0	30.1	166	3.44
37-P-1-1-1	68.2	86.7	28.0	153	3.66
39-P-4-2-1	66.3	89.7	28.2	155	3.16
45-P-2-2-1	68.3	75.8	30.6	158	3.71
45-P-2-1-1	61.3	80.5	31.4	195	2.91
48-P-1-1-1	71.8	78.7	36.5	135	3.27
50-P-2-1-1	73.8	21.2	53.3	174	2.04
71-P-1-2-1	69.2	80.8	32.2	191	3.79
71-P-2-2-1	70.7	71.5	33.8	155	2.88
78-P-2-2-1	66.2	78.3	32.6	179	3.69
102-P-4-1-1	61.3	85.2	30.9	139	2.93
107-P-6-1-1	67.5	78.3	39.6	141	3.86
135-P-5-1-1	61.2	57.5	40.0	186	3.30
135-P-5-2-1	72.0	46.2	42.6	155	3.27
CK-60	65.7	84.5	44.1	115	1.56
143-P-2-2-1	68.8	80.8	41.8	201	3.88
156-P-5-2-1	69.5	78.2	42.8	136	2.77
157-P-3-1-1	62.5	82.2	34.9	144	3.05
165-P-6-2-1	67.7	75.2	28.9	151	2.90
210-P-5-2-1	67.8	80.5	30.2	154	3.66
210-P-4-1-1	61.7	65.8	41.5	126	3.40

Table 69 (Cont'd.)

Entry	Days to 50 % Flowering	Stand count[b]	% Infested	Height (cm)	Yield (kg)[c]
211-P-3-1-1	67.7	73.5	30.3	155	3.68
211-P-1-2-1	68.3	77.2	38.6	152	3.59
217-P-1-2-1	68.0	80.5	36.0	216	3.27
218-P-3-2-1	65.2	78.0	37.4	184	3.53
228-P-1-2-1	65.2	59.3	45.9	143	2.03
234-P-5-2-1	66.2	68.7	43.2	135	2.72

(a) Planted August 20

(b) 30 meter plots were planted at 1 plant per 10 cm with 60 cm row width

(c) Yield samples were taken from 10 metres of each row plot

Table 70. Tabulation of various data collected from the International trials at Serere, Uganda. 1970 (Avg. 6 reps.)[a]

	Average No. eggs plot	Avg. days to 50% flowering	Average Shoots	Healthy Tillers	Average Shoots	Healthy Tillers
Serena	12.8	71.0	2.0	11.2	5.0	7.8
Namatara	6.0	98.2	2.3	18.5	4.5	7.2
183-1-1 Serena	9.2	81.7	1.8	16.5	6.3	8.0
164-3-1 Serena	8.8	77.8	2.7	19.7	6.7	10.8
216-1-1 Serena	10.5	75.0	1.5	14.2	7.8	9.5
136-2-1 CK2xNam	5.7	93.5	2.2	9.5	5.2	6.2
62-1-1 CK2xNam	8.0	75.3	2.3	18.0	6.2	8.2
19-1-1 CK2xNam	4.2	89.0	2.2	10.0	5.5	4.7
161-3-1 SB79	8.2	78.3	2.8	16.8	6.7	10.5
158-1-1 SB79	5.7	79.3	1.5	22.0	7.8	12.8
15-1-1 CK2xNam	7.2	87.5	2.8	12.3	6.7	6.5
44-1-1 CK2xNam	10.8	78.7	2.0	21.3	6.3	9.0
82-2-1 CK2xNam	6.8	85.7	2.5	11.8	5.5	8.3
36-1-1 CK2xNam	9.0	84.0	2.0	10.8	5.5	6.3
78-2-1 CK2xNam	8.3	77.8	2.2	13.3	7.0	8.7
8-1-1 CK2xNam	8.3	82.2	2.8	19.2	6.7	8.8
185-2-1 Serena	11.5	77.7	1.2	15.7	6.7	7.0
165-2-1 Serena	13.3	70.3	2.2	17.2	6.7	6.3
31-1-1 CK2xNam	5.8	84.8	3.6	11.6	5.2	7.8
34-1-1 CK2xNam	8.2	85.6	2.2	11.0	7.0	8.2
35-5-1 CK2xNam	9.5	82.8	1.3	21.8	8.3	10.2
27-1-1 CK2xNam	9.0	77.5	1.0	17.0	7.5	10.0
41-2-1 CK2xNam	7.7	79.3	2.0	20.7	7.2	10.3
70-1-1 CK2xNam	3.8	86.7	2.3	7.0	3.3	3.8
CK-60	9.7	79.5	1.8	24.2	6.8	8.8
156-5-1 Serena	7.7	87.5	1.2	14.2	7.8	8.0
89-5-1 Serena	7.8	78.3	2.2	16.2	7.3	8.7
208-4-1 SB79	5.0	85.8	2.0	16.2	7.3	7.7
219-2-1 SB79	11.3	91.7	2.0	8.5	6.3	5.7
157-2-1 SB79	8.5	79.8	2.8	13.2	5.5	6.8
IS 5801	10.5	90.7	3.8	20.0	6.2	6.0
IS 4663	6.7	84.0	3.3	8.0	4.2	3.2
IS 5483	5.7	78.7	3.3	12.8	4.8	5.0
IS 2269	7.3	77.7	4.7	14.2	4.7	2.7
IS 1034	11.0	85.2	3.5	10.2	5.0	3.8
IS 4544	6.0	89.7	1.0	7.8	5.5	3.0
IS 5633	8.0	82.0	2.8	13.7	6.2	3.5
IS 5613	6.3	87.5	3.5	9.2	5.0	2.7

Table 70 (Cont'd.)

	Average No. eggs plot	Avg. days to 50% flowering	Average Shoots	Healthy Tillers	Average Shoots	Healthy Tillers
IS 3962	8.3	90.7	4.0	14.0	5.8	6.3
IS 5383	9.3	80.7	3.8	13.0	4.8	4.3
IS 5470	11.0	83.7	2.2	16.8	7.3	8.2
IS 2146	7.5	77.3	3.7	19.8	5.5	7.5
IS 5642	7.7	94.3	2.8	12.5	5.0	4.5
Swarna	4.0	90.2	1.8	19.3	6.2	10.2
1542-11-1-1	6.3	72.0	2.3	12.5	5.3	5.3
1543-11-1-2	5.7	81.2	2.2	16.8	6.8	5.7
1543-11-1-3	7.2	81.3	2.5	14.3	5.8	7.2
1560-1-1-1	8.0	85.3	1.8	13.3	7.2	7.5
1560-1-1-2	5.0	77.2	1.8	13.3	5.3	5.7
1525-1-1-1	7.7	83.0	2.8	14.2	5.3	5.0
1629-1-1-1	4.3	81.5	3.2	11.3	4.8	5.7
1625-1-1-3	5.2	85.0	2.2	11.3	5.3	5.5
1581-1-1-3	6.5	84.5	4.2	11.5	4.2	6.7
1121-4	4.8	81.2	1.7	11.0	5.2	6.3
1136-2	7.8	75.0	2.8	14.7	5.5	5.8
1456-1-1-1	6.0	81.3	3.0	10.2	5.0	4.2

(a) Planted May 8.

Table 71. Evaluations of international sorghum materials for sorghum shoot fly resistance at Serere, Uganda. 1971 (Avg. 6 reps.)[a]

Entry	First Season				Second Season			
	Stand Count[b]	% Infested	% Recovery	Selection Index	Stand count[b]	% Infested	% Recovery	Selection Index
Serena (check)	8.8	77.3	52.9	30.2				
Namatara	10.2	55.8	45.9	1.7				
183-1-1-Serena	10.8	64.6	57.0	21.6				
164-3-1-Serena	10.8	76.9	63.1	40.0	11.0	95.4	80.0	75.4
216-1-1-Serena	10.5	79.3	60.3	39.6	14.6	96.5	80.5	77.3
136-2-1-CK2xNam	9.5	59.7	49.2	8.9				
62-1-1-CK2xNam	10.2	78.7	65.6	44.3	13.4	92.4	75.2	67.6
19-1-1-CK2xNam	8.7	73.0	47.5	20.5				
161-3-1 SB79	10.7	81.3	64.0	45.3	14.6	94.6	75.3	69.9
158-1-1-SB79	10.5	77.8	49.2	27.0				
15-1-1-CK2xNam	10.5	73.1	55.5	28.6				
44-1-1-CK2xNam	10.5	68.3	61.9	30.2				
82-2-1-CK2xNam	9.2	72.7	67.3	40.0	14.5	93.7	77.2	70.9
36-1-1-CK2xNam	9.3	67.8	48.2	16.0				
78-2-1-CK2xNam	10.5	71.4	47.6	19.0				
8-1-1-CK2xNam	10.7	75.0	62.5	37.5	14.3	84.6	88.8	73.4
185-2-1-Serena	10.0	76.7	56.7	33.4				
165-2-1-Serena	10.8	73.9	64.6	38.4	14.8	79.7	82.4	62.1
31-1-1-CK2xNam	10.6	60.4	32.1	- 7.5				
34-1-1-CK2xNam	10.8	72.2	59.3	31.5				
35-5-1-CK2xNam	10.0	85.0	71.7	56.7	14.3	89.5	78.3	67.8
27-1-1-CK2xNam	10.2	78.7	73.8	52.5	13.3	77.4	95.5	72.9
41-2-1-CK2xNam	10.2	77.0	60.8	37.8	13.8	90.5	81.9	72.4
70-1-1-CK2xNam	6.83	61.1	51.2	12.3				
CK-60 (check)	9.8	79.7	44.1	23.8				
156-5-1-Serena	9.8	83.1	49.1	32.3				
89-5-1-SerenaxCK2	10.7	81.3	57.8	39.1	13.6	83.1	83.1	66.2

Table 71 (Cont'd.)

208-4-1-SB79	10.8	76.9	63.1	40.0	9.6	91.6	76.0	49.4
219-2-1-SB79	10.2	67.2	54.1	21.3				
157-2-1-SB79	11.0	62.1	59.1	21.2				
IS 5801	10.3	72.6	82.3	54.9	9.8	67.3	79.6	46.9
IS 4663	9.3	53.6	51.8	5.4				
IS 5483	9.5	63.2	75.5	38.7	3.2	31.3	68.8	0.1
IS 2269	10.3	67.8	74.3	42.1	9.8	46.9	61.2	8.1
IS 1034	10.0	58.3	50.0	8.3				
IS 4544	8.5	60.8	60.8	21.6				
IS 5633	10.2	68.8	72.1	40.9	13.8	57.9	79.7	37.6
IS 5613	9.7	51.7	77.6	29.3				
IS 3962	10.3	69.4	77.4	46.8	0.0	--	--	--
IS 5383	9.8	64.4	59.3	23.7				
IS 5470	10.5	77.8	88.9	66.7	7.1	63.3	66.2	29.5
IS 2146	10.8	61.6	70.8	32.4				
IS 5642	9.3	64.3	41.1	5.4				
Swarna (check)	10.0	73.3	43.3	16.6				
1542-11-1-1	9.8	59.3	67.8	27.1				
1543-11-1-2	10.2	67.2	62.2	29.4				
1543-11-1-3	9.2	76.3	72.7	49.0	2.6	57.6	88.5	46.1
1560-1-1-1	9.5	73.7	59.7	33.4				
1560-1-1-2	9.3	66.1	69.7	35.8	10.5	79.0	69.5	48.5
1525-1-1-1	9.7	65.5	53.5	19.0				
1629-1-1-1	10.0	58.3	55.0	13.3				
1652-1-1-3	8.8	68.0	52.9	20.9				
1581-1-1-3	9.7	70.6	63.8	34.4				
1121-4	8.0	72.9	79.1	52.0	2.3	86.9	87.0	73.9
1136-2	9.7	60.3	53.5	13.8				
1456-1-1-1	8.8	60.4	58.6	19.0				

(a) First season trials were planted May 8 and second season trials September 1.
(b) Number of plants possible per plot was 11 during the first season and 15 during the second season.

Table 72. Evaluations for stem borer resistance after 2 and 3 generations of selection from selected lines at Serere, Uganda. 1970. (Averages from 6 reps.)

Entry	First season		Second season			
	Stem borer rating	Shoot fly resistance	Stem borer resistance	Shoot fly resistance	Yield (kg)	Height (cm)
V-2-1-(1)	3.7	Good	Good	Good	2.49	145
V-4-1-(1)	3.5	Good	Good	Good	2.24	152
V-6-1	4.0	Good	-	-	-	-
V-11-1	3.2	Fair	-	-	-	-
V-17-1	4.2	Good	-	-	-	-
V-30-1-(1)	3.5	Good	Good	Good	2.32	144
CK-60	3.7	Poor	Fair	Poor	0.96	111
V-41-1	4.2	Fair	-	-	-	-
V-58-1-(1)	3.7	Good	Good	Fair	1.40	144
V-63-1-(1)	3.8	Good	Good	Good	2.05	152
V-69-1	4.5	Fair	-	-	-	-
V-100-1-(1)	3.8	Good	Good	Good	1.92	142

(1) Planted April 6 for the first season and August 1 for second season.

Table 73. Comparison of various measurements on sorghum (CK-60) treated with certain insecticides at Serere, Uganda in 1970[a].

Treatment	Stand Count	Per cent Dead Hearts	Number of heads	Yield (Kg)
C-13963	69.2 b	28.8 a	122.2 ab	5.12 d
Sapecron	89.5 a	6.8 b	128.7 ab	4.96 abc
Phorate	83.8 ab	8.7 b	145.8 a	5.86 a
Carbofuran	81.8 ab	6.7 b	116.5 b	4.20 cd
C-13963+Thiodan	74.5 ab	36.6 a	122.3 ab	4.48 bcd
Sapecron+Thiodan	87.0 a	7.8 b	137.2 ab	5.49 ab
Thimet+Thiodan	85.0 ab	8.8 b	135.3 ab	5.54 ab
Furadan+Thiodan	80.2 ab	8.2 b	115.5 b	4.96 abc
Control	70.5 b	29.2 a	114.3 b	3.49 d

(a) All means followed by the same letter arenot significantly different by Duncan's multiple range test at the 5% level of confidence.

Table 74. Control of shoot fly on sorghum with various rates of carbofuran and at different plant populations at Serere, Uganda. 1970. (second season)(Ck-60).

Treatment	Average Stand counts	Average Dead Hearts	% of Plants Infested	Average yield (kg)	Average height (cm)
Control PP_1	776.2	66.0	8.5	6.13	125.0
$Carbofuran_1$ PP_1	826.2	64.2	7.8	6.85	128.6
$Carbofuran_2$ PP_1	825.8	56.7	6.9	6.94	129.9
$Carbofuran_3$ PP_1	797.0	38.0	4.8	7.22	132.3
Control PP_2	223.8	47.3	21.1	6.34	116.9
$Carbofuran_1$ PP_2	263.7	41.3	15.7	7.49	122.5
$Carbofuran_2$ PP_2	248.8	25.0	10.0	7.42	125.4
$Carbofuran_3$ PP_2	277.2	19.2	6.9	7.78	119.9
Control PP_3	171.2	39.3	23.0	6.38	107.2
$Carbofuran_1$ PP_3	151.8	26.2	17.3	5.82	113.7
$Carbofuran_2$ PP_3	153.2	18.2	11.9	6.51	110.4
$Carbofuran_3$ PP_3	160.3	7.3	4.6	7.08	112.4

PP = plant population

$Carbofuran_1$ = 0.14 lb. A.I. per acre

$Carbofuran_2$ = 0.28 lb. A.I. per acre

$Carbofuran_3$ = 0.42 lb. A.I. per acre

Table 75. The effects of variety and insecticides on shoot fly infestation, yield, and plant height.

Treatment	Average Stand Count	Average Dead Hearts	% of plants Infested	Yield (kg)	Average Height (cm)
CK-60 Carbofuran	307.3	26.3	8.5	7.86	127.4
CK-60 Carbofuran+Carboryl	331.7	30.5	9.2	8.36	133.1
CK-60 Thuricide	276.0	71.7	26.0	6.90	123.6
CK-60	293.7	60.7	20.7	8.24	128.2
CK-60 Carboryl	281.8	54.5	19.3	7.79	126.9
CK-60 Carbofuran+Thuricide	305.3	25.3	8.3	7.92	129.8
Serena Carbofuran	222.7	32.2	14.5	8.27	151.1
Serena Carbofuran+Carboryl	237.8	23.2	9.8	7.58	154.9
Serena Thuricide	249.3	52.5	21.1	7.89	150.0
Serena	264.8	46.7	17.6	7.68	150.3
Sererna Carboryl	279.0	54.7	19.6	7.05	149.2
Serena Carbofuran+Thuricide	262.2	38.0	14.5	7.51	149.5

Carbofuran was applied at 0.25 lb. A.I. per acre

Carboryl was applied at 1 lb. A.I. per acre

Thuricide 90 ts was applied at 1890 ml per acre

Table 76. Effects on yield sorghum with foliar application of various chemicals for shoot fly control at Serere, Uganda. 1970 (averages of 6 replications).

Treatment	First Season Serena Yield (kg)	Second Season CK-60 Yield (kg)
Control	57.4	7.3
$Thiodan_1$	57.1	7.4
$Thiodan_2$	57.3	7.8
$Thiodan_3$	58.0	-
$Sapecron_1$	57.3	7.3
$Sapecron_2$	58.3	8.3
$C - 10015_1$	56.4	-
$C - 10015_2$	59.3	-
$Dieldrin_1$	56.9	-
$Dieldrin_2$	55.0	-
$Sumithion_1$	54.6	-
$Sumithion_2$	53.5	-
$P - 511_1$		7.3
$P - 511_2$		7.1

Table 77. Effects on yield of sorghum when attempting to control stem borer with various chemicals at Serere, Uganda. 1970. (Average from 6 replications).

Treatment	First Season Yield (kg)		Second Season Yield (kg)	
	Serena		Serena	CK-60
	Trial No.1	Trial No.2	Trial No.1	Trial No. 2
Control	62.3	57.7	6.1	5.3
Thuricide$_1$	57.7	55.5	-	-
Thuricide$_2$	54.0	54.8	-	-
D.D.T.$_1$	58.6	56.6	5.5	5.9
D.D.T.$_2$	60.4	57.0	-	-
Sapecron$_1$	55.7	56.5	-	-
Sapecron$_2$	56.3	53.6	-	-
Dieldrin	55.6	57.0	4.7	6.0
Sumithion$_1$	57.4	57.3	-	-
Sumithion$_2$	54.9	53.4	-	-
Sevin$_1$	57.2	55.7	7.6	4.5
Sevin$_2$	59.7	58.6	-	-
P - 511			6.6	5.7
Malathion			5.2	5.1

Table 78. Comparison of number of days required for completion of the various life stages of the sorghum shoot fly at Serere, Uganda, to those previously reported at Morogoro, Tanzania and Muguga, Kenya.

Stage	Serere			Morogoro		Muguga
	Range	Average	No. of Observations	Average	No. of Observations	Average (about)
Egg	2 - 5	3.5	430	2	21	3
Larval	11.5 - 14.5*	13.0	120	8	8	10
Pupal	2.5 - 17.5	10.4	81	6.8	5	7
Adult	1 - 12	--	30	-	-	-

* The average number of days required for 50% pupation since some larvae may have an extended quiescent period before pupating.

Table 79. Effects of various degrees of simulated armyworm damage to Serena grain sorghum at Serere, Uganda, 1970. (Ave. of 4 reps.)

Treatment	Ave. No. of heads harvested	Average Yield (kg)
$Control_1$	71.5	3.30
$Control_2$	66.5	3.31
All leaves removed, 4-5 leaf stage	63.7	3.24
All leaves removed, 9-11 leaf stage	64.5	2.68
All leaves removed, 12-14 leaf stage	57.8	2.48
Plant cut off at ground, 4-5 stage	59.5	2.29
Plant cut off at ground, 9-11 stage	26.0	0.61
Plant cut off at ground, 12-14 stage	20.3	0.26
75% removal of leave area, 4-5 stage	70.0	3.19
75% removal of leave area, 9-11 Stage	69.3	3.21
75% removal of leave area, 12-14 stage	76.0	3.31

Table 80. Results of maize variety trial at Serer, Uganda, 1970. (Averages of 6 reps.) ab

Variety	Stand count	Days to Tassel	Ear Height cm	Incidence of streak	No. of lodged plants	Yield (kg)
Kawanda Composite A	51.3	64	183	1.3	11.7	8.20
Ukiriguru Composite A	50.8	67	182	2.3	7.2	8.10
Ilonga Composite R	43.8	62	152	1.3	2.3	8.27
Ukiriguru Composite BW-G	51.3	64	161	2.3	10.7	9.53
Katumani Composite B	50.8	47	108	1.0	0.0	6.56
Zambian Local Composite A	49.7	64	161	2.5	4.2	7.71
Hybrid 632	51.2	64	166	5.7	0.7	10.36
Hybrid SR 52	51.8	62	145	1.2	1.0	10.33
White Star	48.8	55	132	1.2	0.7	7.41
Western Queen	48.3	53	110	2.8	1.2	6.56

(a) The plot was 1/290.4 of an acre or 1/717.3 of a hectare.

(b) Planted March 17.

Cereal Processing

Allan D. Shepherd

A statistic from the 1969 Kenya census emphasizes the importance of our work. In recently released census figures the annual population growth rate was fixed at 3.3%. At this rate we can look forward to a 25% increase in population in about seven years. Similar figures would probably apply to all of East Africa. With the increased demand for food the pressure on local agriculture will require larger areas with lower average annual rainfalls to be brought into use. Therefore in the production of cereals the more drought resistant sorghums and millets will have to dominate over maize in the increase.

This projected pattern will be contrary to that of the past few decades during which time the use of maize for food in East Africa has increased relative to sorghum and millets. This is most clearly evident in Kenya during the last decade with the introduction of improved maizes. If we are to reverse this trend, it might be well to know why there was the ready shift to maize. We believe users simply found that maize had more desirable food quality attributes. It was more nearly white, either in whole kernel or in meal form, and had a blander flavor than the usual dark seeded sorghums and millets which predominate in this area.

We must learn from the above and produce sorghums and millets with more desirable food quality attributes if we are to be able to gain ready acceptance by the user so that the projected change may be affected easily. One finds sorghums with very excellent food quality attributes being grown in East Africa particularly in Tanzania despite negative attributes of extreme plant height, long growing season, and low yields. These provide grains of excellent food quality with their white color and bland flavor. They are flinty - this imparts good debranning character without substantially nutritional loss.

It may be argued that the consumption of brown-seeded types exceeds that of white-seeded ones without any dispute from this quarter. However, in large measure this use is in the production of local beer where the bitterness appears to be an asset rather than a detriment. Despite arguments that such a product provides good nutrition we choose not to consider such products as something worthy of our attention because of their substantial untoward side-effects (This is not to be construed to eliminate fermentation as a means for producing non alcoholic food stuffs).

There are means by which we can prepare from brown seeded type more attractive products which better recommend their use as foods. However,

this can only be done with a considerable loss in amount and nutritional value from the whole grain. Even so the best of these products retain some pink to purple color which intensifies when wetted making them less desirable for food purposes. Therefore, it would seem that the desirable grain would be from stock with tan plant color, we are told, while these may not be completely white they are light colored and when wetted change to cream or light tan (similar to maize meal) rather than the more vivid pinkish or purplish.

This year we directed our studies mainly on the 61 grain sorghums received from Serere, Uganda. These have been tested and studied to differentiate the sorghums, particularly for those factors which relate to food quality and processing characteristics. Physical characteristics and proximate analyses on the sorghums together with protein analyses on the roller milled products from some of these samples are reported. Yields of some of the samples when run through the CeCoCo rice polisher are recorded. Amino acid assays were also determined. In addition we analyzed some millet sorghum and maize samples for lysine indices using the Udy Dye method.

Physical Characteristics of the 1970 Samples

Early in January 1970, we received quantities of some 61 different sorghums from Dr. Hugh Doggett of Serere, Uganda. The physical characteristics which we studied show definite relationships between endosperm type and mean kernel weight and average kernel hardness. Kernel hardness was measured on a hardness tester. Pressure was applied on a single dried grain placed on a platform and screwing down on a plunger. The increasing pressure was indicated on a dial. When the grain broke, the pressure decreased abruptly leaving a maximum reading needle to indicate the breaking force (i.e. the hardness). Ten grains were tested for each sorghum. There was considerable variation within the grains of a single sample, but mean values do relate to our characterization of the endosperm type arrived at by cutting and visual inspection. Ninety percent of all samples characterized as corneous had average hardness about 5 kg/cm^2. 84 percent of those classed as floury broke below 5 kg/cm^2. The intermediate gave way between 3.2 and 7.4 kg/cm^2. The entire range of the mean hardness was found to lie between 2.0 and 12.0 kg/cm^2. It appears the majority of corneous varieties require as expected, more breaking force (above 5 kg/cm^2) than the floury samples (less than 5 kg/cm^2).

The average kernel weights were determined on 300 kernels of each sorghum. The range was from 13.6 to 40.3 mg/kernel. Here also there is a definite relationship between endosperm nature and kernel weight. The heavier kernels are floury while the lighter ones are corneous. The Proximate Analyses on the 61 Sorghum Varieties, Table 81 shows crude protein moisture, ash crude fat and fiber of these samples. Protein estimation was by the Kjeldahl method (N x 6.25). The range for protein was from 10.0% to a high value of 14.5% in sample 56-70.

Table 81. Proximate analyses of sorghum samples.

Our Sample Number	Other Description	% Protein (NX 6.25)	% Moisture	% Fat	% Fiber	% Ash
1-70	3 Dx 59	11.7	12.2	2.9	1.6	1.5
2-70	Is 3404	11.5	11.7	3.9	1.8	1.7
3-70	E 1257	11.4	12.0	3.4	1.8	1.3
4-70	E 6932	11.3	12.3	2.8	2.1	1.6
5-70	Is 9369	13.1	12.1	3.5	3.0	1.8
6-70	E 6955	11.5	12.5	3.0	2.1	1.5
7-70	Is 2771	12.4	10.5	2.9	1.3	1.6
8-70	E 6051	11.5	12.0	3.0	2.0	2.0
9-70	E 1236	10.9	12.0	3.2	1.2	1.0
10-70	Is 9462	11.0	12.0	3.5	2.8	1.8
11-70	Is 9898	11.4	12.0	3.0	1.9	1.7
12-70	Is 2341	11.5	12.4	2.7	1.6	1.6
13-70	E 6900	11.2	11.8	2.9	1.9	1.4
14-70	E 2334	11.2	11.5	2.7	2.3	1.7
15-70	E 6374	13.2	11.8	3.1	2.2	1.7
16-70	Is 9671	10.4	12.1	2.8	2.0	1.2
17-70	E 1259	11.4	11.3	3.1	1.3	1.3
18-70	Is 2260	11.8	12.2	3.1	2.4	1.7
19-70	E 253	11.8	14.1	3.2	1.6	1.3
20-70	Is 3565	11.5	12.3	2.8	2.0	1.5
21-70	Is 928	11.8	11.8	2.8	1.6	1.4
22-70	Is 2328	13.5	11.5	2.9	1.4	1.7
23-70	Is 956	11.9	11.7	3.6	1.8	1.8
24-70	E 280	11.4	10.4	3.6	1.8	1.0

Table 81 (Cont'd.)

Our Sample Number	Other Description	% Protein (NX 6.25)	% Moisture	% Fat	% Fiber	% Ash
25-70	E 6974	12.2	11.7	3.7	2.3	1.5
26-70	E 6454	11.3	11.3	3.6	2.3	0.8
27-70	E 6435	12.7	11.5	3.8	2.1	1.6
28-70	E 6992	11.2	11.5	2.6	1.7	1.5
29-70	E 3155	11.8	11.4	4.0	1.9	1.4
30-70	E 1248	12.1	12.1	3.6	1.4	1.2
31-70	E 1240	10.1	11.2	3.1	0.9	1.1
32-70	E 6030	11.1	11.9	3.5	2.2	1.7
33-70	E 6305	12.5	11.4	2.6	1.9	1.8
34-70	E 6432	11.7	11.5	1.9	0.7	1.7
35-70	E 6382	12.8	11.5	3.0	1.5	1.6
36-70	E 6022	10.6	12.2	3.4	1.7	1.8
37-70	Is 9533	13.4	12.0	2.9	2.0	1.6
38-70	E 1241	10.0	11.9	2.6	2.3	1.1
39-70	E 6949	11.6	11.1	3.0	2.2	1.7
40-70	E 2891	12.6	11.5	2.9	2.0	2.0
41-70	E 6433	12.5	11.7	3.3	1.7	1.8
42-70	E 1228	12.2	11.3	3.9	1.5	1.4
43-70	E 1226	11.5	11.9	3.3	1.4	1.0
44-70	E 145	12.6	12.0	3.1	2.6	2.0
45-70	E 6977	11.0	11.2	2.8	2.0	1.7
46-70	E 1219	10.1	11.7	2.5	1.4	1.0
47-70	E 6321	14.2	11.9	2.8	2.0	1.5
48-70	E 1266	10.3	11.9	2.9	1.5	1.2

Table 81 (Cont'd.)

Our Sample Number	Other Description	% Protein (NX 6125)	% Moisture	% Fat	% Fiber	% Ash
49-70	E 1242	11.0	10.6	2.8	1.3	1.0
50-70	E 6025	13.4	11.4	2.5	2.5	1.9
51-70	E 142	13.1	11.2	3.5	2.1	1.9
52-70	E 6225	11.9	11.8	3.7	2.0	1.4
53-70	E 1221	11.0	11.7	3.7	1.5	1.1
54-70	E 1270	10.8	11.3	3.3	1.3	1.0
55-70	E 6953	11.9	11.5	3.2	2.2	1.4
56-70	E 6075	14.5	11.3	3.2	2.9	2.1
57-70	E 6338	11.5	11.7	3.0	1.8	1.7
58-70	E 6396	13.5	11.5	2.6	1.8	1.8
59-70	E 6954	11.7	11.0	3.0	1.5	1.9
60-70	Is 9886	12.3	12.0	2.7	1.9	1.4
61-70	5 Dx 36/1/2	10.9	11.7	2.6	2.6	1.4

Nine of the samples had protein more than 13.0%. Moisture was rather constant at about 12.0% for most samples. Fats by ether extraction ranged from 1.9% to 4.0% and the ash levels from 1.0% to 2.1%. Fibers show a range of more than 300% over the lowest value of 0.7%.

Amino Acid Content of Some Sorghum Samples: Of the 61 samples we received, 14 have been analyzed for their amino acid content. Table 82 shows the levels of individual amino acids obtained from each sample after acid hydrolysis. The levels of the first limiting amino acid, lysine, are low in most samples. Sample 8-70 had the highest value among the samples run, 2.8 g/16g of nitrogen. Of the non-essential amino acids, glutamic acid was present in the largest quantities 22.8 - 30.4 g/100g of protein and also as expected all the samples contained proline, alanine and leucine in high concentrations.

Physical characteristics of some sorghum grain varieties

Our Number	Other Description	Color or seed coat	Endosperm type	Hardness test(a) Mean Force kg/Cm^2	Range kg/Cm^2	Average weight/ Grain(b) (mg)
1-70	3Dx59	White, dark-brown patches	Intermed.	5.2	2.7-8.8	22.1
2-70	IS3404	Tan, purple spots	"	4.0	2.8-6.1	19.1
3-70	E1257	Yellowish-white	Corneous	12.0	6.3-16.1	15.7
4-70	E6952	White, reddish-brown spots	"	8.6	5.3-13.2	32.7
5-70	IS9369	Reddish-brown	Floury	3.0	1.6-4.1	31.7
6-70	E6955	White, red spots	Corneous	8.6	4.7-11.3	32.1
7-70	IS2771	White, brown patches	"	4.7	3.1-7.3	13.6
8-70	E6051	White,purple spots	Floury	4.1	2.2-6.9	25.5
9-70	E1236	Cream Coloured	Corneous	7.2	5.1-8.7	19.3
10-70	IS9462	White, purple spots	Floury	3.7	1.9-5.7	19.5
11-70	IS9898	Reddish-brown	"	4.3	3.1-6.6	37.5
12-70	IS2341	White, brown patches	"	4.4	2.1-7.3	27.3
13-70	E 6900	Yellowish-brown, purple spots	Corneous	5.1	2.9-8.0	22.5
14-70	E2334	White, brown spots	Floury	4.4	2.6-6.8	30.9
15-70	E6374	White, reddish-brown patches	"	5.1	3.4-8.9	32.1
16-70	IS9671	Grey red patches	Corneous	7.8	4.4-9.9	23.7
17-70	E1259	Yellowish-white	"	6.6	3.8-9.9	15.4
18-70	IS2260	Grey, red patches	Floury	4.6	3.0-7.9	20.5
19-70	E 253	White, red patches	Intermed.	4.1	2.3-5.6	22.6
20-70	IS3565	Mixed white and brown	"	6.7	4.2-9.9	20.3
21-70	IS 928	Greyish purple	"	5.1	3.0-7.0	22.5
22-70	IS2328	Yellowish-white	Corneous	8.5	5.7-11.7	29.5
23-70	IS956	Cream coloured	"	8.6	4.1-14.9	25.9
24-70	E 280	White, Brown spots	"	8.6	3.2-15.9	23.8
25-70	E 6974	Yellowish-white	Intermed.	3.2	1.8-4.5	25.9
26-70	E 6454	Tan	Corneous	8.8	6.0-13.0	25.9
27-70	E 6435	Yellow, brown patches	"	5.0	3.7-9.1	32.3

Physical characteristics of some sorghum grain varieties. (Continued)

Our number	Other Description	Color or seed coat	Endosperm type	Hardness test(a) Mean Force kg/Cm^2	Hardness test(a) Range kg/Cm^2	Average weight grain(b) (mg)
28-70	E 6992	White, brown patches	Floury	4.6	2.8-6.0	23.7
29-70	E 3155	Yellowish-white	Corneous	4.8	3.1-6.3	23.5
30-70	E 1248	Yellowish-white	"	5.5	3.2-7.7	22.0
31-70	E 1240	Tan	"	8.8	3.1-16.1	19.1
32-70	E 6030	White, brown spots	Corneous	6.7	4.3-11.5	24.4
33-70	E 6305	White, brown spots	Intermed.	7.4	4.4-15.3	30.3
34-70	E 6432	Tan, purple spots	Floury	4.2	2.2-8.9	35.2
35-70	E 6382	White, brown patches	"	4.6	2.1-12.3	36.7
36-70	E 6022	White, dark brown patches	"	5.6	3.1-9.2	23.8
37-70	IS 9533	White, purple spots	Intermed.	4.2	2.4-5.7	25.0
38-70	E 1241	Yellowish-white	Corneous	8.1	3.5-15.9	18.5
39-70	E 6949	Yellow	"	6.3	4.1-8.7	28.7
40-70	E 2891	White, red spots	Floury	4.9	3.2-6.9	31.7
41-70	E 6433	White, red patches	"	3.7	1.4-5.5	40.3
42-70	E 1228	Tan	Corneous	5.2	2.5-8.5	20.8
43-70	E 1226	Yellowish-white	"	8.4	4.7-14.7	19.1
44-70	E 145	Yellowish-white, purple spots	Intermed.	3.8	1.5-6.4	30.1
45-70	E 6977	Yellow, brown patches	"	6.8	6.0-8.4	35.9
46-70	E 1219	Yellowish-white	Corneous	9.3	4.0-15.9	19.5
47-70	E 6321	Greyish white, brown patches	Floury	2.8	1.0-5.3	29.0
48-70	E 1266	Yellowish-white	Corneous	8.0	3.8-15.9	18.2
49-70	E 1242	Tan, purple spots	"	10.3	4.0-15.8	19.4
50-70	E 6025	White, brown patches	Intermed.	4.0	1.4-7.3	19.8
51-70	E 142	White, brown patches	"	3.7	2.0-6.3	33.0
52-70	E 6225	White, brown patches	Floury	7.4	5.2-11.2	29.2

Physical characteristics of some sorghum grain varieties. (Continued).

Our number	Other Description	Color or seed coat	Endosperm type	Hardness test(a) Mean Force kg/Cm^2	Range kg/Cm^2	Average weight grain(b) (mg)
53-70	E 1221	Cream Coloured	Corneous	6.8	5.4-8.4	19.5
54-70	E 1270	White, red patches	"	7.4	5.0-11.2	20.4
55-70	E 6959	White, red patches	"	7.7	3.0-15.3	30.9
56-70	E 6075	Brown, red patches	Floury	2.0	1.0-2.9	21.2
57-70	E 6338	White, purple spots	Corneous	10.2	6.3-13.9	29.9
58-70	E 6396	Yellowish-white	Floury	4.2	1.7-11.8	28.5
59-70	E 6954	White, purple spots	Intermed.	8.3	4.8-14.3	27.2
60-70	IS9886	White, brown patches	Floury	4.1	2.2-6.6	34.1
61-70	5Dx36/1/2	Tan	Corneous	6.1	3.9-8.5	23.3

(a) Obrained by individually breaking 10 to 20 kernels dried 48 hrs. under vacuum at 70°C in Hardness Tester - Ogawa Soiki Co. Ltd., Tokyo

(b) Obtained by weighing 100 kernels in triplicate

Table 82. Amino acid composition of the protein in sorghum

Sample Number	% Protein in Sorghum(a)	Lysine (b)	Phenyla-lanine	Threonine	Leucine	Isoleucine	Valine	Histidine	Ammonia	Arginine	Aspartic Acid	Serine	Glutamic Acid	Proline	Glycine	Alanine	Tryosine
2-70	11.1	2.4	5.8	3.4	14.4	4.6	5.6	2.0	2.7	3.9	8.4	4.8	28.5	8.3	2.9	10.3	4.3
4-70	10.9	2.5	6.6	3.2	12.4	4.6	6.0	2.4	3.3	4.1	8.6	4.3	24.3	9.5	3.5	10.6	2.5
5-70	12.6	2.0	4.6	2.7	12.5	3.7	4.7	1.7	2.3	3.3	6.3	3.8	22.6	7.0	2.7	8.6	3.2
6-70	10.9	2.2	5.6	3.5	19.6	4.7	6.0	2.3	3.2	4.1	8.1	4.3	24.4	10.6	3.3	10.6	4.3
7-70	12.3	2.1	5.7	3.1	15.4	4.3	5.6	2.1	3.1	3.4	7.3	4.4	23.3	9.7	3.0	10.3	4.1
8-70	11.2	2.8	5.9	3.5	14.8	4.4	5.9	2.2	3.3	4.0	10.1	4.4	22.8	10.2	3.4	10.3	4.0
10-70	11.5	1.6	5.0	3.0	17.2	4.3	5.2	1.6	2.5	3.3	6.5	4.6	25.2	8.3	2.9	9.5	3.7
11-70	11.3	2.1	5.9	2.6	14.4	4.5	4.2	2.3	2.8	4.7	7.4	4.6	25.1	8.9	3.1	9.0	4.1
12-70	11.6	1.9	5.5	3.1	10.8	4.7	4.9	1.6	2.5	3.2	7.5	4.4	26.4	7.8	2.8	9.9	3.7
14-70	11.1	2.3	5.3	3.1	14.6	4.1	5.6	2.2	3.0	3.5	8.6	4.6	25.6	9.8	2.9	9.9	4.2
16-70	10.4	2.2	6.9	2.9	12.6	3.7	4.0	2.0	2.8	3.5	7.5	4.1	22.9	8.6	2.7	8.8	3.3
23-70	11.6	2.0	5.7	3.0	14.6	3.9	4.0	2.1	2.8	4.3	7.7	4.3	23.1	9.3	2.8	8.6	4.3
24-70	11.0	1.7	6.6	3.7	17.7	4.8	6.2	1.9	2.8	3.1	8.7	5.4	29.8	10.3	3.0	10.7	4.5
25-70	12.3	2.1	6.2	3.8	14.3	5.0	6.6	1.8	2.5	4.0	8.9	5.3	30.4	9.2	3.9	11.8	4.1

(a) Protein (NX 6.25), 12% moisture basis

(b) Amino acid, g/16 of nitrogen

Milling Yields from Buehler Mill

In order to determine the milling characteristics two pound portions of some of the 1970 samples, tempered at 17% moisture, were milled in the Buehler laboratory mill at the Unga Ltd. laboratories. The results of of these millings are shown in Table 83.

The percent yields of fractions were influenced by the nature of the endosperm. The percentage of break flour serves as indicator to the flouriness or corneousness of the sorghum. It was found that the hardness of the grain, i.e. mean force Table is inversely correlated with the amount of break flour, Table (statistically significant at 1% level). However, to complicate matters the mean force is inversly correlated with grain size (Table 80) (statistically significant at 5% level).

Sample 15-70 gave the highest total flour of 56.2% followed by 8-70 which gave 55.6% and 12-70 with 54.8%. But 8-70 gave the highest break flour of 18.7%, followed by 5-70 (15.6%), 14-70 (15.5%) and 15-70 (15.2%) in that order. These figures are, however, less than those for sagana which gave 24.6% break flour and 62.1% total flour. Sagana variety is the most floury variety we have dealt with.

Amongst the corneous varieties we noted sample 7-70 surprisingly gave the highest percentage of reduction flour (45.4). This is not in conformity with the general observation.

The color of the flours from the majority of the varieties was pink although a few were off white toward the yellow. So, the flours showed a gradual transition from pink, through light pink, pinkish white, white to yellowish white. There was only one sample that gave substantially white flour and that was sample 21-70. This sample has a purple testa and might be expected to give a flour with darker color. But, like Sagana, it defied our speculation and gave a flour with a color approaching that of Sagana flour, which is the whitest to date. Sagana itself has a dark testa.

Protein Balance on Milled Products: Protein and moisture values of fractions from some of these samples we had submitted to Unga Ltd. for milling have been determined. Proteins of the fractions were balanced and compared with those of the original samples (comparison of the third last and last columns of Table 84). The overall balance is quite good, to within 0.6% protein. As expected the protein content of the flours (break and reduction) is much lower than that of the original grain. Substantial differences will be noted in Table 85 between the samples as regards protein retention in the flours. Protein retention was based on the ratio of percent total protein in flour/ percent yield total flour; a value of 1.00 would of course show a protein content of flours equal to that of the whole grain. The best retention was evident in the flours of samples 20-70 and 28-70 with the ratios of .82 and .83 respectively. The lowest ratio of 0.55 was shown by sample 27-70. These samples show that high retention of protein in the flour is associated with high flour yield and vice versa. However, there are enough exceptions (6-70, low yield, high ratio, and 60-70 high yield, low ratio) to raise doubts that extraction rate is the only factor influencing.

Yields on Cecoco Rice Polisher: There was sufficient grain available for 30 of the 61 samples to test their performance in the rice polisher. Two kilogram portions were polished with the setting of the discharge weight fully-in (i.e. mildest mechanical action). The results are reported in Table 86. The whole kernel product from sample 26-70 had the most attractive appearance of all samples. The grains were highly polished and white in color. However, its total edible yield was only 74.8% as might be expected from a grain of intermediate corneousness. Floury samples as represented by 11-70, 14-70 and 45-70 were completely debranned but had a considerable quantity of brokens. Total edible products ranged from 60% in the floury sample 11-70 to 95.5% in the corneous sample 22-70. As expected samples with corneous endosperms tend to have high percentages of total edible.

Protein and Amino Acid Analyses of Whole Grain and Polished Whole Kernel Samples

Four white sorghums with corneous endosperm obtained from different sources were polished in the Cecoco polisher using two Kg portions and with the setting of the discharge weight fully-in (i.e. mildest mechanical action). In table 87 the protein contents and amino acid contents of the protein of the polished whole kernel portions are compared with those for the whole grain. The reduction in protein content was 10% for Konza, the least flinty of the four sorghums but only about 5% or less for the other three. Karachi showed an almost insignificant change of about 2.7%. The essential amino acids showed considerable reductions upon polishing in the Lionja and Karachi samples.

Sample	Percent Reduction In:					
	Lysine	Phenyl-alanine	Threonine	Leucine	Iso Leucine	Valine
62-70, Karachi	21.7	8.0	6.1	26.7	4.5	3.8
122-69, Lionja	16.7	12.5	17.6	7.8	13.6	10.9
91-69, Msumbiji	12.5	--	--	--	--	--
1-69, Konza	5.6	--	--	12.7	7.0	--

TABLE 84. Protein balance between milled fractions and whole grain.

	BRAN					POLLARD			
Sample No.	(a) Yield	% Protein	Amount of protein	% Total protein	% Yield	% Protein	Amount of protein	% Total protein	% Yield
1-70	18.4	12.7	2.3	20.0	33.5	15.9	5.3	45.4	10.3
2-70	20.3	14.0	2.9	25.7	32.2	14.8	4.8	43.1	9.6
4-70	20.7	13.8	2.9	26.1	38.7	13.1	5.1	46.3	6.9
5-70	27.8	14.4	4.0	31.5	21.6	20.5	4.4	34.9	15.6
6-70	21.3	10.9	2.3	20.2	41.6	14.6	6.1	52.6	7.9
7-70	22.3	14.6	3.3	27.1	27.6	16.5	4.6	37.8	4.7
8-70	28.2	16.4	4.6	36.7	16.2	10.4	3.2	24.8	18.7
9-70	14.4	12.0	1.7	16.2	46.9	12.5	5.8	55.2	5.8
12-70	25.8	13.9	3.6	28.5	19.5	20.1	3.9	31.1	15.3
13-70	21.0	14.8	3.1	24.9	35.6	16.2	5.8	46.1	8.1
14-70	18.8	13.7	2.6	24.0	28.9	13.7	3.9	36.8	15.5
16-70	19.2	12.7	2.4	32.1	35.2	13.0	4.6	45.4	9.8
19-70	20.1	13.9	2.8	23.2	40.1	15.3	6.2	50.9	10.4
20-70	24.9	13.5	3.4	31.9	22.2	11.8	2.6	24.8	14.7
21-70	21.9	13.1	2.9	26.0	34.7	14.4	5.0	45.2	9.2
27-70	18.2	13.0	2.4	19.2	45.3	16.5	7.5	60.5	8.4
28-70	21.7	13.3	2.9	23.0	27.5	16.1	4.4	35.1	12.8
59-70	19.6	15.7	3.1	26.6	29.0	15.0	4.4	37.7	10.6
60-70	17.1	14.6	2.5	20.2	30.5	18.4	5.6	45.3	12.1

(a) Milling yields from Buehler mill, samples tempered to 17% moisture

(b) Weighted average moisture content of mill products

(c) Value of % protein calculated at corresponding % weighted moisture

Table 84 (Cont'd.)

	BREAK FLOUR				REDUCTION FLOUR					
Sample No.	% Protein	Amount of protein	% Total Protein	% Yield	% Protein	Amount of Protein	% Total Protein	Total Protein	Weighted Moisture (b)	Proetin of unmilled grain (c)
1-70	8.1	0.8	7.1	37.8	8.5	3.2	27.5	11.6	13.7	11.5
2-70	5.0	0.6	5.2	37.9	7.6	2.9	26.0	11.2	14.5	11.1
4-70	6.5	0.5	4.1	33.8	7.6	2.6	23.5	11.1	15.3	11.0
5-70	6.7	1.0	8.2	35.1	9.2	3.2	25.4	12.6	13.3	12.4
6-70	6.5	0.5	4.3	29.4	9.0	2.6	22.8	11.5	13.9	11.3
7-70	7.7	0.4		34.4	8.5	3.9	32.1	12.2	17.4	11.5
8-70	7.2	1.3	[illegible]	36.9	10.2	3.8	29.5	12.9	12.6	13.2
9-70	6.9	0.4	3.8	34.3	7.3	2.5	23.9	10.4	13.9	10.6
12-70	7.2	1.1	8.7	39.5	10.2	4.0	32.0	12.6	12.6	12.3
13-70	6.9	0.6	4.5	35.4	8.6	3.0	24.4	12.5	12.9	12.0
14-70	5.9	0.9	8.5	36.8	8.9	3.3	30.7	10.7	14.0	10.8
16-70	6.3	0.6	5.6	35.9	8.0	2.9	26.0	10.5	15.8	10.0
19-70	6.7	0.7	5.8	29.4	8.3	2.4	20.1	12.1	16.2	11.7
20-70	8.9	1.3	12.3	38.2	8.6	3.3	31.0	10.6	15.3	11.0
21-70	6.2	0.6	5.2	34.2	7.6	2.6	28.6	11.1	16.8	11.1
27-70	5.6	0.5	3.8	28.2	7.2	2.0	16.4	12.4	15.8	11.8
28-70	5.8	0.7	15.7	38.0	8.7	3.3	26.2	11.3	15.1	10.7
59-70	6.5	0.7	6.0	40.8	8.4	9.4	29.8	11.6	13.0	11.4
60-70	5.8	0.7	5.7	40.3	8.8	3.5	28.7	12.3	12.2	12.3

TABLE 85. Yield and protein retention in flour.

Sample No.	Total Flour Yield	% of Total Protein in Flour	Ratio
1-70	48.1	34.6	.72
2-70	47.5	31.2	.66
4-70	4C.7	27.6	.68
5-70	50.7	33.6	.66
6-70	37.1	27.1	.73
7-70	50.1	35.1	.70
9-70	40.1	27.7	.68
14-70	52.3	39.2	.75
16-70	45.7	31.6	.69
19-70	39.8	25.9	.65
20-70	52.9	43.3	.82
21-70	43.4	28.8	.66
27-70	36.6	20.2	.55
28-70	50.8	41.9	.83
59-70	51.4	35.8	.70
60-70	52.4	34.4	.66
8-70	55.6	39.6	.71
12-70	54.9	40.7	.74
13-70	43.5	28.9	.66

TABLE 86. YIELDS OF PRODUCTS ON THE CECOCO RICE POLISHER

Our No.	% Whole on Mesh 8	Thru Mesh 8 and on 20 Mesh	Total Edible On 20 + 8	% Bran and Fines	% Recovery on 20 + 8 + Fines	Endosperm Type	Comments on: Appearance of whole kernel
1-70	51.8	30.2	82.0	13.8	95.8	Intermediate	Partially polished, white grains with purple spots
5-70	53.3	25.7	79.0	16.3	95.3	Floury	Skins removed, but reddish-brown pigment remained
6-70	82.8	8.0	90.8	6.8	95.3	Corneous	Slightly polished purple testa
7-70	66.0	26.2	92.2	5.6	97.6	"	Nearly completely debranned yellowish white product
9-70	44.8	40.0	84.8	9.8	97.8	"	Completely polished yellowish white product
10-70	49.6	28.1	77.7	20.1	94.6	Floury	Partially debranned grain with dark brown pigment
11-70	17-4	42.6	60.0	36.7	97.8	"	Completely debranned, many broken grains, brown pigments on grains
14-70	28.4	36.2	64.6	30.5	96.7	"	Completely debranned, many broken grains, brown pigments on grains
15-70	25.7	38.2	63.9	31.6	95.1	"	Completely polished. Purple pigments on outside of grains
16-70	73.3	15.6	88.9	9.3	95.5	Corneous	Skins removed, but purple testa persisted.
18-70	63.2	23.4	86.6	11.8	98.2	Floury	Slightly polished. Product has purple colour.
19-70	50.5	27.0	77.5	20.0	98.4	Intermediate	Nearly completely polished products of mixed brown and white grains
20-70	25.4	38.5	63.9	32.8	97.[illegible]	"	Completely debranned brown pigments on outside of grains
21-70	84.5	8.5	93.0	5.8	98.8	Intermediate	Nearly completely debranned purple pigment unremoved
22-70	88.0	7.5	95.5	3.7	99.2	Corneous	Nearly completely debranned, brownish white product
23-70	74.2	15.0	89.2	9.5	98.7	Corneous	Nearly completely debranned, brownish white product
24-70	70.0	17.5	87.5	6.5	94.0	Corneous	Completely polished product of mixed purple and white
25-70	42.5	36.2	78.7	18.9	97.6	Intermediate	Nearly completely polished purple pigments on outside of grain
26-70	35.0	39.8	74.8	24.4	99.2	Intermediate	Well-polished white grains

TABLE 86. (Cont'd.) YIELDS OF PRODUCTS ON THE CECOCO RICE POLISHER

Our No.	% Whole on Mesh 8	Thru Mesh 8 and on 20 Mesh	Total Edible On 20 + 8	% Bran and Fines	% Recovery on 20 + 8 + Fines	Endosperm Type	Comments on: Appearance of whole kernel
28-70	41.9	31.9	73.8	23.5	97.3	Corneous	Partially polished reddish brown pigment on the outside
29-70	75.5	16.5	92.0	6.7	98.7	Floury	Completely debranned brownish white product
30-70	57.8	31.0	88.8	9.8	98.6	Corneous	Completely debranned, yellowish white product
38-70	51.0	34.7	85.7	12.4	98.1	Corneous	Completely debranned, yellowish white product
43-70	41.0	41.7	82.7	12.8	95.5	Corneous	Completely debranned, yellowish white product
45-70	40.3	33.9	74.2	17.3	91.5	Intermediate	Completely debranned, a lot broken product mottled
52-70	42.8	27.1	69.9	26.9	96.8	Corneous	Partially debranned, purple pigment
56-70	37.5	26.5	64.0	29.0	93.0	Floury	Slightly polished
57-70	79.8	10.5	90.3	7.5	97.8	Corneous	Nearly completely polished, white grains with purple spots
59-70	64.0	21.5	85.5	12.8	98.3	Intermediate	Nearly completely polished, high percentage of broken grains spotted
61-70	43.2	35.5	78.7	17.5	96.2	Corneous	Completely polished, cream colored grains

Although large reductions appeared in lysine, the polished sample retained lysine concentration of nearly 2.0 gm/100 gm of protein. In general nonessential amino acids showed minor reductions on polishing but notable increases occurred in sample of Msumbini. Glutamic acid (20.2%) proline (46.5%) and alanine (4.5%). Tryosine in polished Karachi increased by 21.2%.

When the CeCoCo mill is used for larger sized samples (e.g. when preparing quantities of polished sorghum for the Saba Saba Show Demonstration), the appearance of the polished product appears as good as for the small samples but the milling losses to bran are considerably reduced. Therefore polished grain prepared in quantity would probably retain higher levels of the important amino acids. The start-up and shut-down period very likely causes unnecessary "overpolishing". For small samples the influence is very great.

Cooking Tests

In a cooperative effort with the Home Economics Department, University College, Nairobi, the 61 sorghum varieties were cooked in a standardized manner and the water uptake measured after 30, 45, and 60 minutes. For each cooking time 40 grams of well cleaned (hand-picked) but whole kernel grain was used with 120 mls of distilled water. The cooking time was also recorded by estimating the "doneness" of the three samples. The results are shown in Table 87 . The water uptake at 30 minutes seems to be inversely related to cooking time. No correlation was found between water uptake and grain hardness. Ugali from sorghum flours were prepared in a standardized fashion. A 50 gm portion of flour was mixed with 100 mls of boiling water and heated with continuous stirring for 20 minutes. Preparation of Ugali intensifies the color of the flour. Flours with a pink cast produce ugalis with an intensified pink or even purple color. Those samples which are off-white but with creamy casts also produce ugalis with more intense colors but these more nearly resemble ugalis prepared from maize flour.

Saba Saba Show: A sorghum cookery demonstration was featured in the East African Industrial Research Organization booth in the East African Community Compound at this once-a-year show in Dar es Salaam. This was more or less a report of the demonstrations at the Nairobi show, October 1969 where recipes utilizing four sorghum products polished whole kernel and cracked, semolina, and flour were demonstrated. The demonstrators for the Saba Saba show were elementary school teachers from Dar es Salaam area who were organized through the Ministry of Education, Republic of Tanzania.

The response to the exhibit by fair-goers was literally overwhelming particularly when small samples of the finished dish were passed among them for testing. Equally important from our point of view was the keen interest taken in our research on the part of the Ministry of Education personnel. They were so enthusiastic that they asked that the sizeable balance of the flour products be left with them for further experimentation of their own.

TABLE 87. PROTEIN AND AMINO ACID CONTENT (b) OF WHOLE GRAIN AND POLISHED WHOLE KERNEL SAMPLES

Sample	Sample No	% Protein (a)	% in 8 Mesh Fraction	Lysine (b)	Phenylalanine	Threonine	Leucine	Isoleucine	Valine	Histidine	Ammonia
Konza	1-69 Whole	10.5	-	1.8	5.6	3.2	16.6	4.3	4.5	2.0	2.6
	141-69 Polished	9.4	65.7	1.7	5.6	3.1	14.5	4.0	9.3	1.8	2.9
Msumbiji	91-69 Whole	10.4	-	2.4	6.1	3.7	16.5	4.5	5.8	3.4	3.1
	144-69 Polished	9.9	80.6	2.1	6.3	3.6	16.7	5.1	5.7	2.2	2.8
Lionja	122-69 Whole	9.8	-	2.4	5.6	3.4	15.4	4.4	5.5	2.5	2.8
	147-69 Polished	9.3	74.1	2.0	4.9	2.8	14.2	3.8	4.9	2.0	2.7
Karachi	62-70 Whole	9.9	-	2.3	5.7	3.3	19.5	4.4	5.2	2.2	2.6
	204-70 Polished	9.7	78.2	1.8	5.3	3.1	14.3	4.2	5.0	1.9	2.5

(a) Crude Protein (N x 6.25), 12% moisture basis

(b) Amino acid g per 16 g of nitrogen

TABLE 87. (Cont'd.)

Sample	Sample No.	Arginine	Aspartic Acid	Serine	Glutamic Acid	Proline	Glycine	Alanine	Trysoine
Konza	1-69 Whole	3.3	7.1	4.2	27.5	8.9	3.0	10.9	4.6
	141-69 Polished	3.4	6.6	4.6	25.4	7.9	3.1	10.1	4.5
Msumbiji	91-69 Whole	4.3	7.6	5.6	25.2	10.1	3.6	11.2	4.5
	144-69 Polished	4.3	7.3	5.2	30.3	14.8	3.4	11.7	4.2
Lionja	122-69 Whole	4.2	7.5	4.8	22.8	9.8	3.4	10.3	4.0
	147-69 Polished	3.5	6.6	4.0	20.7	8.8	2.9	9.2	3.7
Karachi	62-70 Whole	4.0	7.2	4.8	27.0	8.0	3.2	10.4	3.3
	204-70 Polished	3.9	6.6	4.4	26.3	8.2	2.9	9.9	4.0

Table 88. Water uptake of sorghum during cooking. Water uptake(grams)

Sample Number	After 30 Min.	After 45 Min.	After 90 Min.	Cooked at (min)
1-70	39.0	51.3	57.4	
2-70	28.3	38.1	46.7	45 - 60
3-70	46.3	57.0	72.2	60
4-70	24.8	31.5	37.7	45
5-70	31.0	37.1	39.2	60
6-70	24.7	29.3	36.2	60
7-70	33.9	46.7	49.2	60
8-70	40.2	50.7	52.5	60
9-70	40.0	53.7	68.3	45
10-70	29.7	40.3	44.0	60
11-70	26.6	32.3	37.7	60
12-70	37.0	46.2	47.0	60
13-70	24.6	33.8	51.3	60
14-70	29.2	35.0	45.3	60
15-70	33.7	45.6	52.0	60
16-70	26.3	34.3	42.0	60
17-70	38.1	56.0	77.0	45
18-70	13.0	42.2	46.8	60
19-70	32.0	38.0	46.0	60
20-70	35.5	44.5	49.3	60
21-70	25.8	31.3	40.2	60
22-70	22.0	28.5	35.6	60
23-70	25.7	33.0	41.1	60
24-70	29.3	42.5	56.0	60
25-70	30.7	37.5	43.7	60
26.70	37.7	50.1	70.0	60
27-70	25.7	30.3	37.7	60
28-70	34.3	40.3	50.0	60
29-70	25.8	34.3	35.0	60
30-70	33.2	47.3	62.2	45 - 60
35-70	29.8	36.0	44.5	60
37-70	24.5	32.0	39.5	60
38-70	37.6	52.5	71.2	45 - 60
40-70	33.0	39.1	45.6	60
41-70	32.2	37.5	43.3	60
42-70	32.3	41.5	57.3	60
43-70	33.7	49.0	67.0	45
44-70	31.7	39.1	47.6	60
45-70	26.4	33.2	39.8	60
46-70	40.5	55.0	78.5	45 - 60
47-70	37.8	44.5	55.0	60

Table 88 (Cont'd.)

Sample Number	After 30 min.	After 45 min.	After 90 min.	Cooked at (min)
48-70	35.3	46.8	63.0	45
49-70	35.0	50.8	66.1	45
50-70	40.3	46.8	50.7	60
51-70	32.6	40.7	47.3	60
52-70	30.6	34.4	41.7	60
53-70	38.6	53.5	71.5	45
54-70	31.6	44.3	57.5	60
55-70	27.0	33.2	37.9	60
56-70	40.5	46.0	50.2	60
57-70	25.1	31.6	38.1	60
58-70	43.2	49.3	61.8	45 - 60
59-70	29.0	33.7	42.0	60
60-70	23.6	41.0	49.5	60
61-70	29.1	39.1	50.0	60

UDY Protein and Lysine Analysis

Udy protein and lysine index analysis was carried out on 264 samples from various stations: Ilong (Kilosa), Kitale, Kumi, Ngora, Serere, and U.S.A. (Prof. Pickett).

Kitale and Ilong maize samples yielded comparatively good results. Normal gene samples gave low lysine index whilst opaque and floury gene samples gave high lysine index values. This is in argreement with results by other standard methods. Although no plot of lysine index against percent lysine was made for the Kitale and Ilonga maize samples for quantitative evaluation, it appears from inspection of the figures, that the correlation would be reasonably good. However, this is a qualitative evaluation.. We need samples of known lysine content to be able to quantitatively evaluate the UDY lysine index method.

We were fortunate to receive, courtesy of Dr. R. C. Pickett of Purdue University, a group of twenty sorghums with lysine content from 0.99 to 3.88 g/16g N. Udy lysine indices were determined on each sample but no usable correlation was obtained relating lysine content to Udy lysine index. The best fitting regression line was actually an inverse rather than a direct relationship. This situation is being investigated further.

Some of the maize samples from Kitale had such high protein contents that they required smaller samples size. Absorption of the dye by the 1000 mg sample was so high that the pointer needle or our colorimeter went off the scale. This necessitated using less of the sample (800 mg) and drawing up a conversion table based on the smaller sample size.

A smaller sample size than 1000 mg was also required for the bulrush millets and so 800 mg. of the sample was again used. Protein percent by Kjeldahl method was determined on 24 of the 72 bulrush millet samples. A plot of percent protein by Udy dye method against percent protein by Kjeldahl method enabled us to draw a calibration curve and hence compile a conversion table for the bulrush millet for the range of nine to fifteen percent protein.

Nothing much could be deduced from results on the 22 finger millet samples as these were the first lot we have analyzed. From these analyses, it could be seen that the protein content ranged from 6-10 which is rather low compared to other cereals we have analyzed. However, percent protein by Kjeldahl method was determined on 11 of these samples, and a calibration curve drawn and a conversion table compiled for this range of protein.

The lysine indices ranged from 0.24 - 0.31 for bulrush millets and 0.19-0.24 for the finger millets. Some of the bulrush millet samples were treated with DDT dust, but this treatment did not appear to affect the results by Udy dye method.

Maize, Sorghum, and Millet

William H. Judy

1. INTRODUCTION

The objectives for the new position of Field Trials Officer in Tanzania include obtaining the needed production research for maize, sorghum, and millet and improving the effectiveness of use of research in these crops. More than 90% of Tanzania's 12 million people live in rural areas and they depend on cereals, cassava, and bananas as primary food crops. Improving the efficiency of food crop production can leave more labour for production of crops for cash which normally comprises the only alternative source of income to the farmers.

2. SURVEY OF THE SITUATION

This officer travelled extensively throughout the country interviewing research, extension, and administrative personnel; talking to supply and marketing organization officials; and observing the production potential of land. The cropping pattern of Tanzania includes maize in every part of the country, often grown under unfavourable moisture conditions. Maize is primarily a food crop first and a cash crop second with a few scattered commercial areas. Low yields are usually the result of poor crop husbandry, unadapted variety, and low fertility. Low or poorly distributed rainfall often limits yields. Where crops such as tobacco or cotton are grown for cash, maize receives secondary attention. Research efforts have been directed almost exclusively to the development of varieties at Kitale, Kenya and Ukiriguru, Ilonga, and Mlingano and to testing adaptation of these varieties. Some fertility work was done in the Western Region several years ago. The potential for maize production is excellent in areas of sufficient rainfall, especially where excess production above food needs can be utilized for livestock and poultry feeding or for export.

Sorghum is adapted in all areas but it is not as widely grown as maize. The presence of grain eating birds limits production in Central Tanzania. Nonetheless, many areas of lower rainfall could be utilized more effectively for sorghum. Low yields are primarily the result of unadapted varieties. Brown and white varieties are grown and utilized for food and often for brewing. Research has been directed towards adapting varieties developed by the E.A.A.F.R.O. at Serere with some work on fertility. There is a great potential for extending sorghum growing areas as well as for increasing yields. Excess production above food needs can be utilized for livestock and poultry feeding or for export.

Millet is produced only in a few areas of Tanzania and is utilized some places for food and many places for brewing. Low yields are primarily the result of low yielding varieties and poor husbandry. Research has been directed to adapting varieties developed by E.A.A.F.R.O. at Serere. Millet for food has its greatest potential in areas of very low rainfall and short growing season.

Completed research projects, now underway, and planned research were reviewed. Weather patterns were studied. An analysis of needed research was made and then priorities for research was developed. Leadership for maize, sorghum, and millet research is assigned to the Ukiriguru Research Station (Mwanza); therefore the 1970-71 research was planned with the senior researcher along with associated research officers. This research plan was personally discussed with personnel at five stations and was then presented for adoption to the policy-making National Research Conference where all stations were represented by their directors.

Research at Stations has proceeded under the initiative of their officers, often with experimental designs and/or supplies furnished by E.A.A.F.R.O. and Ukiriguru. Additional assistance has been rendered by personal visits, letters, and telephone calls.

3. ANALYSIS OF CEREALS RESEARCH NEEDS

The following areas are proposed as the most urgently needed areas for maize, sorghum and millet research.

A. What are the highest yielding varieties for major ecological regions?

B. What are the crop husbandry techniques which will give the highest yields?

C. What is the soil nutrient requirement to maintain yields of grain?

D. Is animal manure effective in supplying nutrients to cereal crops?

E. What is the proper planting time for cereal crops?

F. What is the minimum cultivation necessary for seedbed preparation?

G. What are the storage conditions for cereal grains?

H. Are different crop husbandry techniques necessary for irrigation culture?

I. What is the cost of production of cereal grains?

J. How can utilization of research information by farmers be improved?

K. What is the protein yield per acre of cereal crops and how is this effected by ecological regions?

L. What is the effect of intercropping as opposed to monoculture of cereal grains?

From these 12 possible areas of research, eight research objectives were recommended to the National Research Conference for cereals research. These included:

A. Objective 1: To continue to develop high yielding and palatable varieties of maize, sorghum, and millet.

B. Objective 2: To determine the adaptability of maize, sorghum, and millet varieties to ecological regions of Tanzania.

C. Objective 3: To develop the best husbandry methods for production of maize and sorghum.

D. Objective 4: To increase the use of research information by farmers.

E. Objective 5: To determine the response of maize to continuous cropping, rotations and fertility levels.

F. Objective 6: To determine the most effective structures and pest control methods for storage of grains.

G. Objective 7: To determine the most effective methods for control of Striga.

H. Objective 8: To determine the minimal cultivation required for a maize crop.

A further recommendation was that cereals research be periodically evaluated in order to terminate, initiate, or alter research project as the situation demands.

4. SCOPE OF 1970-71 RESEARCH

The following research program was adopted by the National Research Conference:

A. Objective 1: To continue to develop high yielding and palatable varieties of maize, sorghum, and millet.

Scope:

1. Maize varietal development carried out at Ukiriguru, Ilonga, and Mlingano; at Kitale, Kenya.

2. Sorghum varietal development carried out at Serere, Uganda, at Ukiriguru.

3. Millet varietal development carried out at Serere, Uganda.

4. Palatability evaluation of varieties conducted at Nairobi, Kenya by EAIRO.

B. Objective 2: To determine the adaptability of maize, sorghum, and millet varieties to ecological regions of Tanzania.

Scope:

1. Maize: 20 EAAFRO variety trials. 30 Territorial variety trials of Tanzania - developed materials.

2. Sorghum: 18 EAAFRO variety trials. Several smaller varietal trials of Tanzania and Serere varieties.

3. Millet: 10 EAAFRO bulrush millet trials. 8 EAAFRO finger millet trials.

4. Maize, Sorghum, and Millet: Co-operative work with US/AID sponsored Seed Multiplication group beginning Feb. 1971. Cooperative work with State Production Farms, Schools, Ujamaa Villages, resettlement schemes, Tanzania Sisal Corporation, Tanganyika Wattle Co., Irrigation schemes, etc.

C. Objective 3: To develop the best husbandry methods for production of maize and sorghum.

Scope:

Date of planting, fertility, variety plots for maize and sorghum by experiment stations and other organizations.

D. Objective 4: To increase the use of research information by farmers.

Scope:

1. All practice demonstration plots

2. Crop husbandry plots. Every station and sub-station possible with maize plot designed as follows and invite in Extension District Coordinators and Field Officers.

   a. Plot 1: Bad husbandry
   b. Plot 2: Good husbandry with low cost inputs
   c. Plot 3: Bad husbandry with high cost inputs
   d. Plot 4. Good husbandry with all inputs

3. Fertility demonstrations by Tanzania Fertilizer Corporation.

4. Publication of research bulletin on maize and sorghum.

E. Objective 5: To determine the response of maize to continued cropping, rotations, and fertility levels.

Scope:

1. Continuous and rotational maize experiments at Isamani and Suluti.

2. Soil fertility, soil and tissue analysis, and residual fertility experiment at Morogoro, Mbeya, Chambezi, Ukiriguru and Mlingano.

3. Fertilizer placement experiment at Morogoro Faculty of Agriculture.

F. Objective 6: To determine the most effective structures and pest control methods for storage of grains.

Scope:

Experiments with storage structures, pesticides, and mechanical control procedures for safe storage of grains on the farm. Conducted at KATRIN and Mtwara.

G. Objective 7: To determine the most effective methods for control of Striga.

Scope:

Experiments in cooperation with T.P.R.I. at Mtwara on maize and sorghum.

H. Objective 8: To determine the minimal cultivation required for a maize crop.

Scope:

Experiment at Morogoro Faculty of Agriculture.

5. SELECTION OF RESEARCH AREAS

Many factors were considered during selection of sites for experimental work. Obviously, ecological conditions, land, buildings, and personnel were the primary factors.

Varietal adaptation trials were distributed into every major ecological region possible. Maize varietal trials were placed from the coast up to 2100 meters elevation; from 50 cm to 200 cm. rainfall; in one and two rainfall patterns; and rainfed and irrigated sites. Sorghum variety trials were placed at more arid locations; in both rainfall patterns; and on rainfed and irrigated sites. Millet variety trials were placed at the most arid locations but also some trials were located on moderate rainfed and irrigated sites.

The maize husbandry plots were distributed as widely as possible for easy access to visitors.

The Isamani site was chosen for the manuring and rotation experiment because this region is an important maize producing area and the experimental treatments approximate those of the local farmers.

The storage experiments had been initiated earlier at KATRIN and were expanded to Mtwara.

The rotation experiment at Suluti is based on a long term rotation experiment at that station which has been underway for seven years.

6. REPORT OF PROGRESS

At present time, research is underway on objectives 1, 2, 3, 4, 5, 6, and 8. Work on objective 7 has been deferred to 1971-72. Results of variety adaptation trials and agronomic factors will be available for analysis and interpretation by June and July 1971.