AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch #18

1. SUBJECT CLASSIFICATION

A. PRIMARY
Serials Y-AF00-0100-G110

B. SECONDARY
Agriculture--Plant production--Cereals--Africa south of Sahara

2. TITLE AND SUBTITLE
Annual report of the AID/ARS project,1971: major cereals in Africa

3. AUTHOR(S)
(101) USDA/ARS

4. DOCUMENT DATE
1971

5. NUMBER OF PAGES
243p.

6. ARC NUMBER
ARC AFR633.1.D419

7. REFERENCE ORGANIZATION NAME AND ADDRESS
USDA/ARS

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAB-060

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Africa south of Sahara
Grain crops

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA RA-4-00 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

AFR
633.1
D419
8th — 1971

EIGHTH ANNUAL REPORT

of the

AID-ARS Project

A.I.D.
Reference Center
Room 1656 NS

Major Cereals in Africa
1971

TABLE OF CONTENTS

	Page
GENERAL RESUME	1
WEST AFRICA	1
Regional Trials	1
Maize Breeding	2
Sorghum Breeding	2
Soil Management	2
Cereal Pathology	3
EAST AFRICA	4
UGANDA	
Sorghum Breeding	4
Bullrush Millet Breeding	4
Finger Millet Breeding	4
Cereal Agronomy	4
Regional Trials	5
Cereal Entomology	5
KENYA	
Maize Genetics	5
Cereal Processing	6
TANZANIA REGIONAL TRIALS	7
WEST AFRICA	
Regional Activities	8
J.P. 26 Biennal Conference	10
Regional Sorghum and Millet Trials - 1970	12
Regional Maize Trials	23
Level of Production trials with Maize and Sorghum	26
Maize and Sorghum Fertilizer and Yield Trials	26
Maize Breeding Work in Northern Nigeria	30
Maize Breeding in Southern Nigeria	41
Soil Management	47
Maize Date of Planting Experiments	47
Fertility Trials at Kano and Mokwa	51
Long Term Fertility Trials	52
Leaching	54
Work Planning Meeting in Dakar	55

Page

CEREAL PATHOLOGY-SAMARU

Sorghum ---------- 55
World Sorghum Collection ---------- 55
Leaf Diseases ---------- 56
Witchweed ---------- 57
Other Screening ---------- 58
Smuts ---------- 59

Millet ---------- 63

Maize ---------- 66

Training ---------- 69

Sorghum ---------- 69

ENTOMOLOGY - SAMARU ---------- 84

EAST AFRICA
Sorghum and Millets Unit, Serere, Uganda ---------- 96
Finance and Technical Assistance ---------- 97
Location of Field Activities in Uganda ---------- 98

Sorghum Breeding ---------- 100

Sorghum Variety Trials ---------- 107

Bulrush Millet Breeding ---------- 109

Finger Millet Breeding ---------- 111

Finger Millet Variety Trials ---------- 122

Finger Millet Sowing Date Trials ---------- 126

Cereal Agronomy ---------- 128

Cereal Entomology ---------- 137
Status of Economic Pests of Sorghum ---------- 137
Host Plant Resistance ---------- 138

Uganda Field Trials ---------- 148

Page

Maize Genetics Division ---------- 148
Maize Breeding Methods Study (MBMS) ---------- 150
Extraction of Lines from Breeding Populations---------- 164
Topcross Evaluation of SR52 and the Parents and Hybrids of the 611 and 613 Series ---------- 171
Plot Size and Uniformity Trial ---------- 177
Eastern African Maize Variety Trial ---------- 181
Commercial Seed Production and Sales ---------- 187
Regional Aspects ---------- 189

Joint EAC/USAID Cereal Processing Project ---------- 191

Regional Trials - Tanzania ---------- 222

EIGHTH ANNUAL REPORT

of the

AID-ARS Project

Major Cereals in Africa
G. F. Sprague

GENERAL RESUME

The objective of this section will be to provide a condensed version of research activities and progress achieved. Details can be found in the individual reports.

West Africa

Regional Trials:

Regional trials for the Sudan Savanna were grown in 8 countries. One of the most striking findings was the very narrow range of adaptation of the individual varieties and the relatively low yield levels of all entries. The three hybrids NK300, NK9357 and CK60 x SA 7706-5-1 performed relatively well at all locations but the first two of these would not be readily acceptable as food cereals.

Regional trials for the Guinea Savanna were grown in 6 countries. Individual and average yields were low and variety x location interactions very high. This means that heavy reliance must be placed on National programs to ensure adaptation to specific ecological requirements. The formation of broad-based composites will be helpful in providing the necessary genetic diversity and as an efficient vehicle for the incorporation of resistance to specific insects and diseases.

Regional trials of millet were grown in 6 countries. The highest yields were produced by Ex-Bornu (Samaru-Syn 2) and the hybrid 115-4 x 1067. Specific adaptation was highly important, again suggesting the need for stategically placed regional tests and a general strengthening of Country programs.

Regional maize trials were grown in nine countries. A series of hybrids produced by Pioneer Hybrids, Inc. in Jamaica performed well as did the intercomposite hybrid NCB x NCA. NCA and NCB are Caribbean-based composites which have been developed under the regional project and appear to have great potential both as breeding stocks and for direct commercial use throughout West Africa.

Maize Breeding

Maize has been shown to be much more responsive to improved management practices and fertilization than is sorghum. Work is progressing on population improvement in several populations including NCA, NCB and Biu Yellow. Encouraging progress is being achieved through both full-sib and S_1 recurrent schemes. Limited production of hybrid seed should be undertaken as soon as possible.

Close cooperation is maintained between the programs at Samaru and Ibadan. This permits the production of 2 or 3 generations per year thus greatly increasing the potential for progress.

Sorghum Breeding

Three main maturity groups must be recognized: (a) non-photosensitive early maturity for the Sahel and northern Sudan Savanna, (b) medium maturity for the Sudan zone, and (c) late maturity for the Guinea zone. Breeding work is being conducted within each maturity group. Development of suitable A lines is progressing and for the first time yields of hybrids have exceeded 5,000 kg/ha. The feasibility of hybrid seed production is being explored at Mokwa.

Random mating populations are being developed using ms7 (genic male sterility) to ensure cross-pollination. One of these (Composite 2) is now ready for selection and others are in an advanced stage of development.

Studies on intercropping have been of special interest. Combinations of sorghum and millet or sorghum, millet and cowpeas have given a greater total yield and greater stability of yield than any component grown in monoculture. An efficient intercropping system requires a genetic input as the yield of tall, late varieties are depressed more than the shorter earlier types under interplanting conditions.

Soil Management

Maize exhibits a marked reduction in yield with delays in planting date. This yield reduction appears to be related to a decrease in nitrogen supply and uptake brought about by leaching. Split applications of nitrogen will be tried to test this assumption.

No responses were obtained from applications of either zinc or boron at Samaru for any of the planting dates. In long-term fertility trials at both Kano and Mokwa additions of lime, potash and zinc were effective in increasing yields. The importance of N, P, K and zn will increase as higher levels of productivity are achieved.

Long-term fertility trials at Kano and Samaru were designed to study effects of continuous cropping at various fertility levels. Dung has been more effective than inorganic fertilizers and responses were obtained only with N and P. NP and K additions from dung were greater than from the inorganic additions. Several alternative explanations for the response data are under investigation. These include: (1) a slower rate of N release with dung, (2) the possibility that P conditions the immobilization or utilization of other essential elements such as My or Zn. A satisfactory regime for high levels of productivity requires further research.

Cereal Pathology

Some 3000 items from the World Sorghum collection have been screened on two occasions for leaf anthracnose (*Colletotrichum graminicola*), rough leaf spot (*Ascochyta sorghina*), sooty stripe (*Ramulespora sorghi*), zonate leaf spot (*Gloeocercospora sorghi*) and grey leaf spot (*Cercospora sorghi*). Natural epiphytotics for downy mildew (*Sclerospora sorghi*) have not provided adequate data on resistance and artificial inoculation techniques are not available.

Screening for resistance to witchweed (*Striga hermonthica*) is difficult and time consuming due to the uneven distribution of this parasite within the test field. The distinction between true resistance or escapes can be made only after repeated tests. Some 100 items have survived field screening and are being further evaluated in pot experiments.

Covered smut (*Spacelotheca sorghi*) is the most important of the smut diseases and is estimated to cause annual losses in excess of 5 percent. Among the collections studied most are similar to the previously described Race 4. Others, however, appear to be unlike any other reported races. Seed dressings provide adequate control but are little used. Resistance will be incorporated into the composites under development.

Head smut (*Sphacelotheca reiliana*) causes annual losses of about 2%; no method of control other than plant resistance is available. There appears to be a general relation between late maturity and susceptability to this disease. Only a very small percentage of late maturing varieties possess resistance. The head smut of West Africa is quite different from the 3 races known in the United States.

Long smut (*Tolyposporium ehrenbergii*) is a problem in the Sudan Savanna zone. As yet little is known about varietal resistance or mode of infection.

The three most important diseases of millet are downy mildew, (Sclerospora graminicola), long smut (Tolyposporium penicillariae) and ergot (Claviceps microcephala). Reliable artificial inoculation tecnhiques are not available and reliance must be placed on natural epiphytotics. A number of lines have been developed which possess good resis ance to these three diseases. Additional lines are available possessing moderate degrees of resistance.

The two most important maize diseases are leaf blight (Helminthosporium maydis) and southern rust (Puccinia polysora). Severe outbreaks of leaf blight occurred in 1970 and 1971 identified as Race T. Dr. Craig has identified good sources of resistance to both diseases and these are being incorporated into the breeding composites.

East Africa

Uganda

Sorghum Breeding. The sorghum breeding program was maintained on a reduced basis until the arrival of Dr. J. J. Kern. Seed of CK60 A and B lines have been released to the Uganda and Tanzania Seed Schemes. The two hybrids H x 57 (CK60A x SB65), H x 471D (CK60A x 5D x 36D) continue to perform well and should move into commercial production as ssed production facilities and competence develops.

Several composite populations are in various stages of development but intensive selection has not yet been initiated.

Bulrush Millet Breeding. Work has concentrated on the development of new A and B strains and in population improvement studies. The locally developed cytoplasmic sterile, 10LA gave somewhat higher yielding hybrids than the U.S. line Tift 23A. The second cycle of selection within Serere Composite 1 showed a 17.6% increase in yield.

Finger Millet Breeding. Finger millet is a self-pollinated crop so improvement has been sought by straight selection. Attempts to establish broad germplasmpools were initiated in 1968 using hot water emasculation. This work is being continued. Radiation has been used to induce genic male sterility as an alternative but so far without success.

Cereal Agronomy - Fertilizer trials with finger millet indicate that the most economical fertility treatment for all locations was 100 kg/ha N,

and 60-100 kg/ha P_2O_5. Nitrogen is relatively ineffective unless the P requirements are also met. With sorghum, dung may be an effective substitute for part of the N, P requirements when available.

A 2^6 factorial experiment comparing variety, population, planting date, fertilization, weed control, and shoot fly control was grown at six locations. The most important single factor was variety followed in decreasing order by planting date, plant population, fertilizer and weed control. Seed treatment for shoot fly control was least effective.

Regional Trials - Regional trials of 25 items were grown at 6 sites in Uganda and one in Kenya. The hybrid H x 467 produced the highest yield but the yield differences among entries was small.

Finger millet trials involving 25 entries were grown at 20 locations. Mean yield differences were small ranging from 25.0 to 30.1 g/ha. The varieties P336, P339 and P226 are new entries in 1971.

Cereal Entomology - Sorghum shoot fly (*Atherigona varia soccata*) and the stalk borers (*Busseola fusca* and *Chilo partellus*) are the most important insect pest of sorghum. Two types of resistance have been identified to the shoot fly; primary and recovery. Most of the work has been done on the 'recovery' type. In this type of resistance dead hearts occur from insect feeding but certain genotypes have the capability for the rapid production of new tillers. Recurrent selection for this type of resistance has been highly effective. Lines having primary resistance i.e. resistance to initial attack have recently been obtained from India. This type of resistance, in combination with recovery resistance should be quite effective.

The incidence of stem borers was quite high in several of the trial centers, causing losses ranging from 35 to 100%.

Kenya

Maize Genetics. This program was designed to provide information on the relative efficiency of breeding schemes suitable for the LDC's. The results obtained have been valuable from this standpoint but, equally important, have contributed greatly to the local hybrid program and the quality of hybrids used.

New material from the select on schemes appears to be superior to the currently grown standard hybrids. Increased emphasis must be placed on resistance to stalk and root lodging and on decreases in plant and ear height.

The adoption of hybrid maize continues to increase. Seed sales in 1971 would permit planting of 212,000 hectares. The total hectarage devoted to maize in Kenya has been estimated at approximately 500,000.

The Eastern Africa Regional maize trials are being continued with plantings in alternate years. Elevation and rainfall are the major factors delineating areas of adaptation. Kenya developed materials are being used in suitable areas from Ethiopia to Malawi. Of possible greater significance has been the advice and counsel provided which has resulted in the redirection of all of the maize programs within the region. Composites which have been developed have been widely distributed. Maize programs in some of the countries of the region have suffered from lack of continuity due to changes in personnel. The center at Kitale has provided facilities for storage for these breeding stocks.

Cereal Processing. White seeded sorghums are preferred for human food but these types are also most heavily damaged by birds. To minimize this problem brown-seeded types are commonly grown as a first-rains crop when bird depredations are usually most severe. Some evidence is available suggesting that high tannin content, characteristic of the brown seeded types, interfers with digestion. Data also indicates that corneous types are less digestable by ruminants than the softer kernel types. Whether the same relation holds for monogastrics has not been investigated.

As sorghum is the primary staple for a sizeable segment of Africa it is important to: (1) characterize existing varieties through physical and proximate analyses, (2) develop evaluation standards that may be useful to the plant breeder in selection, and (3) develop simple milling procedures which will increase the attractiveness and, hopefully the nutritional value of the crop as human food.

A large number of breeding samples of sorghum, bulrush millet and finger millet have been characterized for seed size, hardness and proximate analysis. A smaller number of samples have been analyzed for amino acid composition. Sizeable variation in protein percentage and lysine content were found. The Udy method, a simplified procedure for estimating lysine and other basic amino acids was found not to be satisfactory for sorghum.

Studies indicate that 'massa' (the dough from which tortillas are made) can readily be made from sorghum. This food use, however, is not native to Africa and the mechanical equipment available not well suited for its production.

Following extensive laboratory test village trials were made of a CeCoCo cereal polisher. The whole kernel polished product is similar to that made in a deep wooden mortar ("kinu") but with much less kernel breakage and loss. Under village trials cost of operation ranged from 35 to 65 cents per debbe (4 imperial gallons). The economics appears reasonable and the product fully acceptable.

Extensive cooperative recipe development has been continued with the Home Economic Department of the University of Nairobi. A revision of the sorghum recipe booklet is in draft form.

Tanzania Regional Trials

This new position was established in 1970 to give emphasis to: (1) evaluation of regional research under local conditions and (2) to promote the utilization of pertinent research by farmers. More than 90% of Tanzania's population live in rural areas but most of the research has been done on export crops. On the basis of a research planning conference held in August 1971 it was devided to place emphasis on (1) developing maize varieties, (2) regional testting of maize, sorghum and millet varieties and (3) obtaining additional data on fertility and date of planting responses.

Progress has been achieved in identifying maize hybrids and populations of promise for medium and high altitude areas. Promising populations have been identified for the coastal areas. Types suitable for coastal areas have received little attention until now.

Soil fertility data had been accumulated on low-yielding, short-season composites. This work is being extended to include potentially higher yielding types. Results to date indicate that if farmers adopted improved husbandry, with their local maize, yields could easily be quadrupled.

Multiplication of the sorghum varieties Serena and 5D x 36 has been initiated. Bulrush millet offers great promise in short rainfall areas and multiplication of Serere Composite 1 is in progress.

Increased agricultural production capabilities of Tanzania will be dependent upon a further strengthening of the research base, the Extension effort and liaison between these two groups.

WEST AFRICA

Regional Activities

Regional AID - Niamey

Sarah Jane Littlefield	-	ADO
Victor Lateef	-	Project Manager

AID/USDA PASA Staff at Institute for Agric. Res. Samaru, Zaria, Nigeria

L. A. Tatum	Agronomist and Res. Director J.P.26	Jan 1971
G. T. York	Entomologist	Feb 1966
K. R. Stockinger	Soil Scientist	Jun 1966
S. B. King	Plant Pathologist	Aug 1967

At Federal Research Station, Moor Plantation, Ibadan, Nigeria

J. Craig	Plant Pathologist-breeder	Sept 1965

Cooperators

D. J. Andrews	Cereal Breeder - Inst. for Agr. Res.	Samaru/Zaria
J. A. Awoniyi	" " " " "	Kano
D. Adedzwa	" " " " "	Mokwa
G. I. Adeniyi	" " " " "	Samaru
R. G. Heathcote	Soil Scientist " " "	Samaru
M. J. Jones	" " " " "	Samaru

In addition to the above staff, FAC has assigned two agronomists to Joint Project 26. Mon. Stephen Dumont is posted in Dakar, Senegal to give particular attention to Senegal, Mali, Upper Volta, Dahomey, Togo, Niger and Ivory Coast. Mon. Leger is posted in Maroua, Cameroun with responsibility for Camerouns, Tchad, Central African Republic and the Congo.

The "Field Trials Officers" should be an important factor in making the project more effective on a regional basis. They will provide liaison between the project and research and extension programs in countries of their respective areas. We expect them to contribute to a more effective exchange of information, varieties and crop germ plasm among member countries. We hope the usefulness of the regional variety trials will be increased and that there will be other forms of regional cooperation in cereal research.

The Brititsh Overseas Development Administration is making plans to assign two men to the project to perform similar functions in the Anglophone countries of West Africa. Logistic support for the FTOs is furnished by USAID through a grant to STRC.

Mr. Papa Diouf, Assistant Executive Secretary of OAU/STRC undertook the responsibilities of Coordinator of J.P. 26 in addition to his other duties when Dr. S. P. Barreto was unable to continue in that capacity. Mr. Diouf who is bilingual in French and English was particularly effective in handling arrangements for the cereal workers seminar in Dakar and in developing lists of prospective trainees for the Project in Francophone countries. We anticipate more active participation of the STRC staff as they assume some of the support functions now performed by USAID/Lagos. They now have a man assigned to expediting clearance and onward shipment of Project supplies and equipment arriving in Lagos. This position is funded under the grant to STRC. Mr. Diouf, Coordinator at OAU, Lagos and Mr. Lateef, Project Manager at the Regional AID Office in Niamey, Niger have relieved the PASA staff of responsibility for the Field Trial Officer and Training activities of J.P.26 so these will not be reported in detail here.

Mr. George Eason of the Agriculture Division of AID/Lagos, was outstanding in support of the Project until his departure in December 1971. Mr. Jack Francis, of the Program Office, AID/Lagos, has been designated to continue essential administrative support functions in Lagos. Mr. Ron Girling and staff in the AID/Zaria administrative support unit continued to perform vital services locally, especially in communications, vehicle maintenance, and travel arrangements. We have been advised that most of these services will be discontinued during 1972.

Administrative and service as well as research personnel of the Institute of Agricultural Research, ABU, Samaru, and Federal Ministry of Agriculture and Natural Resources of Moor Plantation, Ibadan, which served as host institutions for our staff cooperated fully with the project and provided vital facilities and services.

Important staff changes in the cooperating project at IAR were the departure of Dr. B. Bardwaj, Millet Breeder, at the Kano Branch Research Station to an FAO position in Cairo, the departure of Mr. Gideon Adeniyi, Research Assistant, on a one year study fellowship in Ames, Iowa, and the return of Mr. Daniel Adedzwa from a one year study fellowship in Ames, Iowa financed by a Rockefeller Foundation Grant.

A millet breeder to continue the breeding program at Kano is being sought by IAR. Mr. Adeniyi is expected back from Iowa next August to continue as a cereal breeder for IAR. Mr. Manzo will return from his study fellowship in Minnesota in April to conduct research on cereal diseases in the Institute of Agricultural Research, Samaru.

Mr. Fajemison, a plant pathologist studying at the University of Illinois, Mr. Adeoye, a soil scientist studying at Iowa State University, and Mr. Eckebil, a sorghum breeder from Camerouns studying at the University of Nebraska are the other trainees who have been assisted by PASA staff.

REGIONAL ACTIVITIES
J.P.26 - Biennal Conference of Cereal Researchers in W. Africa

Summary by Dr. K. Stockinger

There were 35 scientists from 17 countries (14 African countries) attending the 4-day planning session on environmental factors affecting yields of cereal crops in tropical Africa. The various aspects of the problem were discussed by the various other delegates.

The first session was on photosynthesis. It was shown that in much of West Africa there is enough incoming radiation to grow much larger crops than are now being produced. Also much of the incoming radiation is wasted during the dry season, because of lack of water. It was pointed out that plants should be spaced close enough together to capture more of the incoming light and that plants should be bred which can utilize more of the light and transfer it to the harvestable portions of the plant.

The session on date of planting showed that there are two effects from date of planting, one in which the optimum date ensures that the variety fits the length of growing season and the other with maize especially where delay in planting caused increased barreness and poor seed set. The causes of this effect appear to be associated with pollination.

The session on soil management included studies on the effect of tillage, erosion control, and rotations.

Deep tillage was shown to increase yields on both the sandy soils of the sudan savanna in Senegal and the heavier soils with more rainfall in the Ivory Coast. It is also necessary to do the plowing before the soils dry out in the fall so that rotations should be used which are harvested before the soil is completely dry. The effect of sorghum on the succeeding crops was shown to last for 3 or 4 years especially on sorghum. Use of small applications of manure to stimulate microbial activity seemed to help.

As the yield levels increase and continuous cropping is used it was shown in the fourth session that potassium and some of the minor elements begin to limit plant growth on many soils. This was shown to be true in a broad land across West Africa. In addition to potassium, sulfur, boron, zinc and molybdenum were shown to be limiting on some soils.

On Wednesday the group visited the IRAT station at Bambey and were shown the experimental work going on there. We were shown experiments ranging from laboratory and greenhouse experiments to determine which leaves produce the carbohydrates that go into the millet head to large plots on which all of the practices are tried out under farmer conditions to determine whether they are practical and economical. On millets the plant physiologists and geneticists were working together to determine what type of plant should be bred to maximize yields and make the most efficient use of water and sunlight. They also were farming their large-scale plots with oxen and horses for cultivations and not using ridges.

The next day we had a very interesting session on nitrogen and phosphorus fertility. These two elements were shown to be needed under a wide variety of conditions in Kenya as well as in West Africa. It was suggested that more work needs to be done to determine how much nitrogen is being fixed biologically by legumes and by soil microbes. Also are the legume rhizobia that are present in the soil efficient strains or could more efficient strains be introduced? Could rotations be devised so that more of the nitrogen needs would be supplied by residue from legumes?

The last session was concerned with applying what had been learned and a number of resolutions were passed urging additional work be done in the various fields which were covered. Another meeting was suggested to be held in two years on some phase of cereal production.

Participated in other conferences as follows:

1. Conference of Maize Workers' in Nigeria - Jan. 22, 1971
   Moor Plantation, Ibadan

   O. J. Webster
   S. B. King
   L. A. Tatum

2. Crop Protection Symposium - sponsored by IITA, Ibadan in May.

   S. B. King
   G. T. York

3. FAO Conference on the Establishment of Cooperative Agricultural Research Programs Between Countries with Similar Ecological Conditions - Guinean Zone, Africa - Ibadan, Nigeria, 23-28 August, 1971

L. A. Tatum

4. Other regional travel:

Drs. York and Tatum visited research stations in Niger and Mali during the first half of December. Details of this travel included in the October/December Quarterly report will not be repeated here. Other outside contacts of the Project were with numerous visitors to Samaru.

REGIONAL SORGHUM AND MILLET TRIALS - 1970

L. A. Tatum

A complete report of the 1970 trials has been assembled and distributed to cooperators. One of the most conspicuous features of the results was the indication of rather narrow adaptation of most varieties. The local variety frequently is highest in yield. It appears that the true merit of entries will be determined only if the trials are grown at a series of latitudes. Prospects for a non-day-length sensitive variety that can be used over a wide zone are not encouraging. The photo-sensitive mechanism is the means of assuring that heading will occur at the end of the rains so the grain fills and ripens in dry weather. Earlier flowering and non-sensitive varieties may yield well but fungi seriously damage the grain during wet weather. Some of the brown seeded sorts are weather resistant but are not generally acceptable as human food. They may be useful as poultry feed. The US hybrids, NK300 and C9357, are outstanding examples of this type adapted in the short season zones of the Sudan Savanna. A white seeded hybrid CK-60 x SA 7706-5-1, yields approximately the same and would be more readily accepted as food. Mr. Dave Andrews of IAR has several hybrids such as 93 x 5764 which was in the Guinea Savanna trial which are adapted to approximately the Samaru latitude of the Guinea zone. These hybrids with suitable cultural practices would greatly increase sorghum yield levels on a large acreage of West Africa. We hope to find a favorable location and develop acceptable technics of seed production to make these strains available for production in the region. The Sudan Savanna sorghum data are summarized in tables 1 to 3. Those for the Guinea zone trials are in tables 4 to 6. The millet trial data are in tables 7 to 9. As with the sorghums, adaptation of the millets seems to be rather local.

The problem of breeding improved varieties of sorghum and millet is a formidable one because of the narrow zones of adaptation. The relatively small number of breeders do not begin to cover all the zones.

A promising method of breeding would be use of a broad based composite with a gene for male sterility to assure intercrossing and recombination as successive generations of recurrent selection are carried out. From such a heterogeneous population varieties of the desired maturity on flowering dates could be selected for each ecological zone with a minimum of time and effort. Such a composite developed by Mr. Dave Andrews was distributed in 1971 and we know that some use was made of it. We believe that a much more systematic and widespread effort of this sort is needed. This is an activity on which the FTOs could be helpful.

A selection station or evaluation site would be needed each 50 to 75 mile zone of latitude but a complete network would not be necessary in every country. With appropriate coordination the necessary coverage might be accomplished by the combined efforts of two or more countries. For example material selected and found to be superior at Samaru might have the correct flowering date for other points in West Africa at 10° 30' or 11° north latitude. Samaru material might be intensively tested in approximately a 100 mile zone at the same latitude but there might be little merit in testing it for adaptation outside this zone. This zone would of course be modified in relation to the date when the rains are expected to end as interaction between flowering date and end of the rains is crucial.

Table 1. Yields reported from Sudan Savanna sorghum trial-1970, kg/ha.

Entry	Senegal Richard Toll	Ugandan Soroti	Cameroun Guetale	Upper Volta Saria	Nigeria Ilela	Gambia Yundum	Mali Bamako	Ghana Manga
NK 300	4270	2616	3088	3378	2304	2283	2530	3680
CK-60 x SA7706-5-1	4438	3448	2422	0	2101	2706	2290	2135
NK 9357	3355	2275	4100	3803	1966	2468	2840	4486
Local Variety	2911	--	--	--	1762	1902	1375	--
Damougari No.55	2368	945	5055	2993	1626	2199	1905	2673
IS 9290	1786	2546	3155	1318	1355	2041	2105	2221
Serena	1112	3351	3744	2640	1084	1538	1900	656
137-36	--	--	--	--	1084	--	--	--
SH-11-D-1	2160	1523	3178	2795	949	2056	1920	1256
CE 90	1948	420	2966	453	881	2095	1310	1354
Sorgho 29	1076	1523	3544	3912	813	1995	1090	1251
5D x 36/1/2	1455	2853	3611	3742	678	1590	1545	646
Zauna Inuwa	--	1313	2022	--	--	182	0	--

Table 2. SORGHUM HEIGHTS REPORTED FROM SUDAN SAVANNA REGIONAL TRIAL-1970 (cm)

Entry	Senegal Richard Toll	Uganda Soroti	Cameroun Guetale	Upper Volta Saria	Upper Volta Farako-ba	Nigeria Ilela	Nigeria Kano	Gambia Yundum	Mali Bamako	Ghana Manga	- Station Average
NK 300	135	148	154	189	152	53	97	205	120	71	133
CK-60 x 7706-5-1	145	148	154	187	159	62	118	200	114	71	136
NK 9357	140	130	147	145	144	57	66	176	120	72	119
Local Variety	140	-	-	-	-	99	-	543	88	-	218
Damougari No. 55	210	148	177	212	208	98	99	162	140	92	155
IS 9290	130	115	124	151	134	44	72	136	110	56	107
Serena	155	148	177	194	183	57	116	194	150	73	145
137-36	-	-	-	-	-	66	-	-	-	-	66
SH-11-D-1	305	213	318	404	-	109	124	409	260	155	279
CE - 90	145	149	158	163	170	70	105	176	130	74	134
Sorgho 29	370	208	377	433	417	121	127	443	340	160	299
5D x 35/1/2	215	150	203	223	243	57	97	151	170	76	159
Zauna Inuwa	-	130	157	-	196	49	122	188	170	-	145

Table 3. SORGHUM DAYS TO BLOOM REPORTED FROM SUDAN SAVANNA TRIAL - 1970 (days)

Entry	Senegal Casamance	Senegal R. Toll	Uganda Soroti	Cameroun Guetale	Upper Volta Saria	Upper Volta Farako-ba	Nigeria Samaru	Nigeria Kano	Gambia Yundum	Mali Bamako	Ghana Manga	-Station Average
NK 300	69	70	49	69	66	68	57	83	61	70	73	67
CK - 60 xSA7706-5-1	61	65	57	69	65	71	61	83	61	70	73	67
NK 9357	69	70	49	69	66	70	61	88	61	74	73	78
Local Variety	69	71	-	-	-	-	57	-	-	81	-	67
Damougari No.55	72	70	66	-	74	79	61	88	61	68	81	72
IS 9290	70	77	57	81	70	85	76	94	65	80	83	85
Serena	81	74	65	88	86	92	82	91	67	82	94	82
137-36	-	-	-	-	-	-	76	-	-	-	-	76
SH-11-D-1	75	78	70	77	83	-	61	87	61	76	92	76
CE-90	69	68	67	76	72	79	56	86	65	74	81	73
Sorgho 29	85	86	70	80	86	93	72	96	65	78	101	74
5D x 36/1/2	86	79	68	91	88	92	80	124	78	91	98	89
Zauna Inuwa	-	-	72	109	118	130	92	123	85	99	-	104

Table 4. YIELDS REPORTED FROM THE GUNIEA SAVANNA REGIONAL SORGHUM TRIAL, 1970 (kg/ha)

Entry	Senegal Sefaaa	Cameroun Guetale	Nigeria Samaru	Gambia Yundum	Mali Bamako	Ghana Nyankpala
Basso		1055	204	2003	-	394
CE 83-174	610	733	350	1630	-	964
93 - 5764	1050	1566	2492	1015		1312
69 ZI	530	1100	1865	941		760
Kinto	-	800	423	764		638
1879 GSK-RC	340	1211	2638	708	500	1303
CKx 299b6	1276	600	2638	657		952
2347 SK-MDW	700	1466	2594	548	1250	1129
2123 CK-FF	540	1033	2813	428	90	1481
5912 SK	980	1155	3498	424		485
1904 (CK-SK)SK	500	766	1618	311	355	1600
CK - 1216-9	1300	422	1413	246		1052
FFBL 3-1-6	674	722	1705	97		225
Toko Bessonou	0	777	477	16		0

Table 5. HEIGHTS REPORTED FROM GUINEA SAVANNA REGIONAL SORGHUM TRIAL, 197[illegible], (cm)

Entry	Senegal Sefa	Cameroun Guetale	Nigeria Samaru	Gambia Yundum	Mali Bamako	Ghana Nyankpala	Station Average
Basso		270	[illegible]	216		164	389
CE 83-174	340	47	133	15[illegible]		6[illegible]	147
93 - 5764	17[illegible]	14[illegible]	163	171		7[illegible]	145
69 - ZI	180	1[illegible]	28[illegible]	178		71	173
Kinto		2[illegible]	3[illegible]	344		109	290
1879 GSK-RC	140	12[illegible]	15[illegible]	179	11[illegible]	70	1[illegible]9
CK x 29966	18[illegible]	149	18[illegible]	170		71	15[illegible]
2347 SK-MDW	155	125	135	155	122	69	129
2103 CK-FF	125	102	135	167	118	60	118
1912 SK	183	162	280	196		10[illegible]	184
1904 (CK-SK)SK	120	91	125	97	120	54	102
CK 1216-9	145	127	125	112		54	113
FFBL 3-1-5	455		512	478		176	405
Toko Besso ou			493	430		168	364

Table 6. NUMBER OF DAYS TO BLOOM FROM THE GUINEA SAVANNA REGIONAL SORGHUM TRIAL, 1970

Entry	Senegal Sefa	Cameroun Guetale	Nigeria Samaru	Gambia Yundum	Mali Bamako	Ghana Nyankpala	Station Average
Basso	-	108	108	99	-	104	104
CE 83-174	104	85	94	91		84	92
93-[illegible]74	92	113	119	108	-	106	109
69-ZI	92	144	119	110	-	105	114
Kinto	-	111	-	110	-	104	108
1879 GSK-RC	104	120	116	115	121	108	116
CK x 99b6	92	121	114	108	-	107	109
2347 SK-MDW	96	123	98	115	122	112	111
2123 CK-FF	92	121	119	110	118	107	112
5912 SK	92	122	108	117	-	113	115
1904 (CK-SK)SK	100	121	122	121	120	107	115
CK-1216-9	92	120	122	121	-	113	114
FFBL 3-1-6	97	126	128	119	-	112	117
Toko Bessorou	-	118	140	125	-	123	127

Table 7. YIELDS REPORTED FROM REGIONAL MILLET, 1970, (kg/ha)

Entry	Nigeria Samaru	Senegal Bambey	Mali Bamako	Ghana Manga	Cameroun Guetale
Ex-Bornu (Samaru Syn-2)	2670	1577	1682	2480	2239
Kano Syn-1	1971	1115	2537	2299	1579
115-4 x 1067	1578	2967	2295	1930	1866
P-3	1513	1596	2122	1625	1315
Zongo	1232	1409	2530	1089	861
Souna-2	1019	2454	2257	1738	1736

Table 8

HEIGHTS REPORTED FROM REGIONAL MILLET TRIAL, 1970 (cm)

Entry	Nigeria Samaru	Upper Volta Farako-Ba	Ghana Manga	Cameroun Guetale	- 4 Station Average
Ex Bornu (Samaru Syn-2)	213	220	100	262	199
Kano Syn-1	200	208	90	242	185
115-4 x 1067	228	195	114	242	195
P-3	255	218	106	283	216
Zongo	270	202	102	288	216
Souna-2	238	140	86	253	182

Table 9

DAYS TO BLOOM FROM REGIONAL MILLET TRIAL, 1970, (days)

Entry	Nigeria Samaru	UPPER Volta Farako-ba	Senegal Bambey	Mali Bamako	Ghana Manga	Cameroun Guetale	- 6 Station Average
Ex Bornu (Samaru Syn-2)	54	53	51	65	59	60	57
Kano Syn-1	47	43	48	67	44	60	52
115-4 x 1067	62	57	51	70	58	62	60
P-3	58	55	55	7[illegible]	58	66	66
Zongo	58	54	55	71	60	67	66
Souna-2	63	56	51	67	59	60	59

REGIONAL MAIZE TRIALS

J. Craig

In 1971 the maize improvement project at Ibadan, Nigeria was engaged in the conduct of regional maize trials, improvement and popularization of maize composites and research on maize diseases.

Uniform Maize Trials:

The West African uniform maize trials were started in 1967 to evaluate maize cultivars, derived from tropical maize improvement programs, at different sites in west Africa. Seed of the trial entries are supplied by west African countries and other organizations engaged in tropical maize improvement. These seeds are collected at Ibadan and then distributed to participating countries.

The trials are supervised by a maize improvement specialist in each country using agronomic practices which he considers optimum for his area. Observations are made on yield, maturity time, standability, and disease resistance and the results are sent to the ARS-AID project at Ibadan for compilation and distribution.

The number of countries participating in these trials has increased from four in 1967 to 11 in 1972. Trial results have acquainted maize workers with the maize cultivars of other countries and increased exchanges of seed among the various maize improvement programs.

Nine countries, Nigeria, Senegal, Upper Volta, Gambia, Ghana, Mali, Niger, Dahomey and Ivory Coast participated in the 1971 uniform maize trial.

Reports to date have been received from Ivory Coast, Nigeria, Gambia and Upper Volta and are presented in Table 10. The report of the 1970 uniform maize trials was completed and distributed in 1971. The 1970 trial yields are shown in Table 11.

Three of the 1971 trial entries, XB101, X306A and X306 are F_1 hybrids produced by the Pioneer Seed Company in Jamaica. One of these hybrids XB101 performed extremely well equalling or exceeding the yield of any other trial entry at the four trial sites reported to date. Differences, between the yield of the hybrid of the Nigerian Composites (NCA x NCB) and XB101 were statistically significant at Ibadan only (Table 10). Unfortunately the viability of the NCA seed used in the 1971 trials was poor and the fault was not discovered until after distribution. As a result the yields of NCA in the 1971 trials are poor and in marked contrast to the promising performance of this Composite in 1970 (Table 11.)

Table 10. Yields of entries in 1971 uniform maize trial at 4 sites in West Africa.

Entry	Origin	Sites and Yields*				
		Ivory Coast	Ibadan Nigeria	Gambia	Upper Volta	Entry Mean
XB101	Jamaica	61.3A	40.8A	30.6 ABCDE	43.5A	44
NCA x NCB	Nigeria	52AB	33.9BC	34.7 ABC	38AB	39.6
NCB	Nigeria	46.8BCD	32.7C	38.A	30.1BCDE	36.9
X306A	Jamaica	48.3BC	37AB	25.9CDEF	35.4ABC	36.7
GC-3	Ghana	52.8AB	28.5D	30.6ABCDE	34.4BCD	36.6
CDN	Ivory Coast	52.4AB	32.4CD	18.7F	34.2ABCD	34.4
X306	Jamaica	44.7BCD	33.2BC	30.4ABCDE	26.9CDEF	33.8
CJI	Dahomey	39.9CDE	24.2E	36AB	29.5BCDE	32.4
CJB	Ivory Coast	35.9DEF	22.6E	22.4DEF	23EF	26
BDS	Senegal	30.9EF	12.1G	31.1ABCDE	25.4DEF	24.9
NCA	Nigeria	37.5CDEF	19.1F	26.CDEF	18.6[illegible]	24
P_3KOLO	Niger	27F	11.6 G	29.4ABCDEF	19.2 F	21.8
Trial Mean		44.1	27.3	29.5	29.4	

* Yields are given in quintals of shelled grain per hectare at 12% moisture. Yields that do not have an alphabetical letter in common are significantly different at the 5% level. Yields that have <u>any</u> alphabetical letter in common are <u>not</u> significantly different at the 5% level.

Table 11. Yields of West African uniform maize trial entries at 10 sites in 1970.

Entry	Origin	Sites and Yields*										
		Dschang Cameroun	Sefa Senegal	Saria U.Volta	Farako-Ba U.Volta	Yundum Gambia	Bouake Iv.Coast	Ferkesse-dougou Ivory Coast	Ibadan Nigeria	Mokwa Nigeria	Samaru Nigeria	Entry Mean
094	Nigeria	31.7A	35.7BC	13.8	52.7A	21.5B	40.3D	48A	41A	38.4AB	60.1A	38.3
NCA	Nigeria	29.7AB	40. BC	21.4	41.9BC	18.8BC	48.5A	44.5Ab	30.6BC	39.5AB	64.8A	38.
NCB	Nigeria	27.5BC	43.1B	26.1	46.7ABC	19.2BC	44.5BC	39.8BC	32.4B	41.5A	62.2A	38.3
Comp.2	Ghana	24.3C	32.2C	18.5	49.3AB	21.6B	44.8BC	48.3A	26.6BCD	40.5AB	63.1A	36.9
Comp.3	Ghana	23.c	32.6BC	16.6	45.2ABC	21.5B	47.5AB	41.5BC	24 D	31. CD	61.4A	34.4
BDS	Senegal	10.9E	50.1A	35.6	41.4BC	29.4A	37.7DE	31.8D	16.9E	---	64.6A	35.4
Jaune hatif	Upper Volta	6.1F	34.9C	30.4	36.8C	15.2BC	26.5F	31.D	11.3E	28 D	52.2A	27.2
CJI	Dahomey	16.6D	34.3C	20.2	41. BC	17.4 BC	35. E	38.3C	24.6CD	36 BC	55.8A	31.9
Trial Mean		21.2	37.9	22.8	44.4	20.6	40.6	40.4	25.9	36.4	60.5	

* Yield in quintals of dry shelled grain per hectare. Yields at any trial site 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.

LEVEL OF PRODUCTION TRIALS WITH MAIZE AND SORGHUM

D. J. Andrews

We recognized a need for further data on the responsiveness of maize to levels of inputs in the northern regions of Nigeria where we believe it should become an important crop. The general relationships established there are expected to prevail through a considerable part of the Northern Guinea zone of West Africa where rainfall is uni-modal at the 30 inch or greater level. Tatum and Stockinger, after consultation with interested staff of IAR, conducted a series of trials at three levels of productivity selected on the basis of experience of the past several years. Sorghum was included in some of the trials in order to obtain direct data on the relative responsiveness of maize and sorghum. The highest level was not designed to determine maximum possible yields. Rather it was at the level considered to be most practical and feasible in the light of previous experience. The following statement describes the trials in more detail and summarizes the results in table 12.

A series of plantings arranged by Mr. D. J. Andrews, IAR, substantiated the general picture of fertilizer responsiveness and productivity of maize in the northern region of Nigeria.

MAIZE AND SORGHUM FERTILIZER AND YIELD TRIALS

Experiments:	Daudawa	BO 291(71)
	Gusau	GN 289(71)
	Kano	KM 287(71)
	Maigana	AR 290(71)
	Pankshin	
	Ramaha (mile 34 Z/Jos)	AP 288(71)
	Riyom	DM 70(71)
	Shika	AO 292(71)

Object: Determine performance of 096 maize at different levels of production inputs at several sites and compare response with local and improved sorghum to assess the potential of maize in the region.

Site: Daudawa, Gusau, Kano, Maigana, Shika, Ramaha mile 34 Zaria/Jos road). Riyom and Pankshin.

Design. Randomized block with 2 or 4 replications.

Plot size: Gross : 6 rows x 10 yards

Net : 4 rows x 8 yards

Treatments: Maize (096) Bulk 3, Improved sorghum, and local sorghum each at 3 levels of inputs.

Farmers' level - 8000 plants per acre

No fertilizer

Intermediate level - 14,500 plants/acre

Sorghum N	22 lbs/acre	(112 lbs nitrochalk)
P_2O_5	22 lbs/acre	(112 lbs single superphosphate)
Maize N	56 lbs/acre	(280 lbs nitrochalk)
P_2O_5	40 lbs/acre	(200 lbs single superphosphate)

Advanced level - 20,000 plants/acre

Sorghum and Maize

N -	150 lbs/ acre	(750 lbs nitrochalk)
P_2O_5 -	80 lbs/acre	P_2O_5 (400 lbs single superphosphate)
K -	50 lbs/acre	K (100 lbs KCL)
	Minor elements	Mn, B, Zn

Spacing - Rows generally 28" apart.

Plants 28" to 9" apart in row to achieve prescribed density.

Seed bed - Low ridges or flat.

Fertilizer broadcast and worked in before planting except 2/3 of N side-dressed about 4 weeks after planting.

Discussion

(1) The 096 variety is high yielding and well adapted in the region covered by the trials. It is responsive to added fertility and has a capacity for quite high yields when conditions are favorable. (2) the highest level of inputs generally produced a distinct gain over the intermediate level. This tends to confirm the suggestion of 1970 that failure to obtain positive response to an added increment of nitrogen might be due to insufficient phosphorus or potash in the soil. The high level treatment in 1971 was designed to correct such deficiencies and remove them as limiting factors. (3) the results

from Kano, Shika and Riyom show that on some soils and under some conditions we still are not achieving the yields expected. Intensive work on the problems of these sites is needed. Waterlogging of the soil in Riyom late in the season has been suggested as a factor. At both Kano and Shika unexplained variability within the plots was pronounced.

Conclusion

The first increment of fertilizer (intermediate level) gave an average gain of 38 lbs of grain per pound of the 56 lbs of N applied. The second increment (94 lbs N) gave an average gain of 20 lbs of grain per pound of N. The cost of a 21:14:14 fertilizer delivered to Zaria is about ± per 2000 lbs or 2.5 shillings per pound of N. The price of maize is about 4 pence per pound of ± 33 per ton.

At these price relationships use of about 700 lbs per acre of 21:14:14 fertilizer on well grown maize should be profitable.

Table 12. YIELDS IN MAIZE AND SORGHUM LEVEL OF PRODUCTION TRIALS 1971

	BO 291(71) Daudawa kg/ha-1	GN 289(71) Gusau kg/ha-1	KM 287(71) Kano kg/ha-1	AR 290(71) Maigana kg/ha-1	AP 288(71) Ramaha kg/ha-1	AO 292(71) Shika kg/ha-1	Pankshin kg/ha-1	DM 70(71) Riyom kg/ha-1
Maize								
Low level	2040	1483	386	1832	1309	767	61	0
Intermediate level	4525	3175	761	3825	4483	2729	1888	1714
Advanced level	7271	5599	2535	4795	6549	2625	4284	2665
Local Sorghum								
Low level	1154	965	447	1682	1700			
Intermediate level	1205	1343	824	3095	1350			
Advanced level	1587	2149	1465	1936	2443			
Improved Sorghum								
Low level	1507	430	325	1309	292			
Intermediate level	2774	1012	417	1232	566			
Advanced level	3684	2217	569	1841	452			

MAIZE BREEDING WORK IN NORTHERN NIGERIA

The demonstration that maize yields of 600 to 700 lbs per acre can be obtained regularly with the better varieties at Samaru is of great significance for the northern guinea zone of West Africa. Such yields were undreamed of a few years ago. Progress to date has to a large extent been due to a better understanding of how to fertilize the crop along with more adequate plant populations and improved practices such as avoiding high sharp ridges. Some of the newer varieties show improvement over the earlier ones but progress through breeding has not been dramatic. The broad based breeding populations established during the past few years are expected to respond rapidly to the full-sib and S_1 testing methods of recurrent selection being used.

Table 13. Performance trials conducted at Samaru in 1971.

	No. of Entries
National Zonal	14
West African Regional	17
Composites and Intercrosses	12
East African Maize Variety Trial	15
Variety Hybrids and Parents	121
Single Crosses	15
S_1 Progenies from NCA 1970 Main Crop	131
1970/71 Irrigated Crop	197
1970 IITA	283
S_1 progenies from NCB - 1970/61	136
2nd cycle NCB from Ibadan	128
S_1 Progenies of Biu Yellow from Ibadan	64
Full-sib 3rd cycle Samaru 3	49
S_1 Samaru Comp. 1	58
S_1 Samaru Comp. 2	152
S_1 Samaru Comp. 3	134
Crosses of NCA and NCB with Central American varieties and hybrids	49
Top crosses of Samaru 3 to Biu Yellow	10

National Zonal Maize Variety Trial

This trial is coordinated by the Federal Ministry of Agriculture, Moor Plantation. It includes the currently recommended varieties and promising candidate varieties and is grown at about 15 locations in six ecological zones of Nigeria. Samaru data for 1971 are given in Table 14. Of particular interest is Bulk 3 which is now recommended throughout the country.

Table 14. NATIONAL ZONAL MAIZE VARIETY TRIAL - SAMARU 1971

Variety	No. of plants	Days to tassel	Days to silk	Lodged root	Plants stalk	Blight* score 5	Ear ht. cm	Shell %	Moist %	Yield of 12% grain kg/ha[1]	lbs/acre
NS-1	244	61	63	20	11	15	230	75.5	31.6	5914	5276
NS-5	196	59	61	29	11	2.0	203	76.6	24.6	6015	5366
Eafro 231	228	62	64	37	24	2.0	223	76.3	38.9	6011	5362
H 503	231	61	63	21	16	0.3	208	74.2	34.7	6680	5959
H 507	93	61	63	8	7	0.5	200	73.0	42.3	3811	3400
Diacol V-153	154	61	63	12	17	1.5	185	71.6	41.3	4632	4132
Bulk 3	238	60	62	14	5	1.8	213	75.4	31.6	7704	6872
NCA	243	59	61	20	7	1.5	195	75.4	33.3	7171	6397
NCB	235	58	61	12	11	1.8	195	78.6	28.2	6753	6024
NCC	237	59	62	13	12	1.8	198	81.1	26.2	6739	6012
NCD	230	59	62	17	19	1.3	198	76.7	28.6	6144	5481
Columbia Composite	239	59	61	19	9	2.0	200	75.7	22.7	7689	6859
A 306	234	59	61	31	18	1.8	180	77.5	22.3	7237	6456
C10 x BY	243	58	60	17	5	1.5	155	76.2	28.6	8022	7156

*Blight score 0 = none
5 = severe

Table 15. WEST AFRICAN MAIZE TRIAL 1971 - SAMARU

Variety	Days to tassel	50% silk	Lodged root leaning	(No)stalk (broken)	Barren	Ear height	Blight* Scored(1-5)	No.of plants	No.of Ears	Shell	Moist	Yield of 12% grain	
	no.					cm				%	%	kg/ha	lbs/acre
P3 Kolo	56	58	11	3	0	168	2.0	96	130	91.0	14.9	6234	5561
CDN	57	60	5	0	0	175	1.0	95	118	80.8	35.6	7956	7097
XB101	58	61	5	2	0	160	1.0	95	137	85.2	28.6	9734	8683
NCB X NCA	56	59	1	7	1	173	1.75	92	105	80.7	28.2	8119	7243
X306A	58	61	4	2	0	158	1.0	97	126	80.8	27.8	8160	7279
NCB	56	58	2	5	0	190	1.75	87	109	80.9	26.2	7723	6889
X306	57	60	2	0	0	153	0.75	93	123	79.6	29.9	8131	7253
CJB	57	59	4	6	0	183	1.5	75	100	80.0	18.0	6284	5606
NCA	58	60	4	5	0	183	2.0	77	95	79.8	29.9	5836	5206
CJI	55	57	4	4	0	168	1.75	94	106	82.1	19.0	7132	6362
GC 3	58	61	1	1	0	198	1.75	94	136	79.2	28.6	9404	8289
BDS	55	57	7	0	1	153	1.75	94	94	83.0	19.4	6445	5749
SC 3 (original)	55	57	8	0	0	158	2.0	92	95	79.1	25.0	6966	6214
SC 3 (Dis. res)	55	58	5	0	1	160	1.5	94	106	78.9	23.8	7618	6796
096	59	62	11	3	0	193	1.75	99	139	83.2	32.0	9137	8151
C10X BY	57	59	2	1	0	163	2.0	92	93	78.9	27.4	7957	7098
A49 X C33	58	60	2	2	0	170	1.75	95	111	77.6	27.4	8476	7561

*Blight score 0 = immune
5 = severe

Table 16. IV COMPOSITES and INTERCROSSES

Entry No.		Date tassel	Date silk	Lodged Root no	Lodged stalk no	Barren	Ear height cm	Blight score 1-5	No.of plants	Ears no	Cobs wt	Shell %	Moist %	Yields kg/ha	Yields lbs/ac
1	Comp. A	58	61	7	2	3	182	1.25	98	108	55.6	79.8	33	6980	6227
2	Comp.B-4	56	58	5	8	0	182	2.0	93	115	54.4	79.8	25	7269	6484
3	Comp. C	55	57	3	7	0	190	1.75	96	116	52.0	74.3	24	6520	5816
4	Comp. D	59	61	4	2	0	190	1.25	94	118	61.2	81.6	32	7913	7059
5	NS-1	59	62	3	0	0	222	1.5	94	130	63.7	78.6	31	7990	7128
6	A x B	55	57	3	4	0	175	2.0	95	101	51.8	80.0	25	6938	6189
7	A x C	57	59	1	5	0	185	2.0	94	107	54.8	80.3	23	8237	7348
8	A x D	57	59	4	3	0	175	1.75	94	105	53.5	81.0	28	7086	6321
9	B x C	55	57	2	6	0	182	1.25	93	115	53.1	79.8	25	7093	6327
10	B x D	56	59	3	3	0	185	1.5	96	112	57.8	79.6	27	7582	6764
11	C xD	56	58	4	4	1	177	1.25	95	113	55.1	79.0	25	7288	6501
12	A-49 x C33	57	59	1	2	0	172	0.75	93	100	63.0	71.5	34	7037	6277

Table 17. EAST AFRICAN MAIZE VARIETY TRIAL - SAMARU 1971

Variety	Blight Score	Stand count	Days to tassel	Ear height	Lodged plants	Bare tips	Usable ears	Harvest wt usable grain	Leaning plants	Moist --	Shell	broken plants	Yield of 12% grain	
										%	%		kg/ha	lbs/acre
H 611C	1.0	79	62	252	0	3	78	53.1	7	42.9	70.7	3	5500	4906
H 613B	1.5	92	62	220	2	5	90	56.5	10	39.9	74.7	5	6313	5632
H 632	0.75	93	61	185	1	1	93	58.9	7	39.9	74.8	4	6593	5881
H 511	1.5	88	59	180	5	4	82	39.2	6	26.6	77.3	13	5010	4469
H 512	1.0	91	59	185	3	1	86	51.2	7	29.0	80.3	8	6669	5949
UCA C4 X UCB/W C1	1.0	87	62	213	1	1	94	70.2	2	44.9	72.4	3	7340	6548
ICA X ICB/Full (White)	1.5	89	59	200	2	1	101	62.1	6	31.6	77.1	6	7609	6788
Ukiriguru Composite AC3	1.5	87	61	208	4	5	79	57.1	10	39.9	74.7	6	6381	5692
Ukiriguru Composite B/W C1	1.5	92	61	200	1	0	103	67.5	3	35.1	77.3	2	8084	7211
Ilonga Composite A	2.0	93	59	192	1	4	103	52.0	4	28.2	74.2	9	6299	5619
Kawanda Composite A	1.25	85	60	213	7	4	74	49.7	9	31.6	76.6	9	6055	5401
S.V.28	0.75	96	61	198	3	3	105	57.4	4	32.5	78.7	3	7136	6366
S.R.52	1.0	85	59	178	0	0	87	59.2	0	37.0	81.9	11	7408	6608
096	1.5	94	61	195	0	0	109	60.6	3	31.6	77.7	3	7489	6681
096	2.0	93	59	185	0	0	105	52.9	4	29.9	79.0	8	6649	5931

096, a selection of it made by Dr. Craig was used extensively in our trials with outstanding results. The highest yield was 7156 lbs/acre by the variety cross, C10 x Biu Yellow which has consistently done well.

West African Regional Maize Trial:

This trial sponsored by Dr. Craig of J.P.26 is grown in 10 countries of the region. Samaru results are given in Table 15. Pioneer XB101 and X306 are hybrids imported into Nigeria and sold by a poultryman who contracts to buy the grain from growers. This is reported to be a very successful operation. XB101 was the outstanding entry in our trials this year with 8683 lbs per acre and 160 cm ear height.

Composites and Intercrosses:

Seed for this experiment was prepared and furnished by Dr. Chedda of the University of Ibadan. The composites are those being used in breeding programs in Nigeria. They were not outstanding in performance relative to the NS-1 check. A x C exhibited a fair amount of heterosis. The data are presented in Table 16. It will be interesting to test their performance after a few cycles of recurrent selection.

East African Maize Variety Trial:

Seed for this test was furnished by Dr. L. Darrah of Kitale, Kenya. We grew 4 replications in Samaru at about 2000 feet elevation and 4 replications in Riyom at about 4000 feet. Kenya material usually does relatively better in eastern Nigeria at higher elevations than at Samaru. This year the Riyom trial was planted late and ran out of water before ripe. Fertility level probably was inadequate as well. The highest yield at Riyom was 2211 lbs per acre by S.R.52 from Zambia. The same entry at Samaru yielded better than 096 and had a 20 cm lower ear placement and high shelling percentage. The appearance of the grain of SR 52 was very favorably received. It seems that adaptation of East African material may not be limited to high altitude regions of Nigeria. The entries from Tanzania also did well. The data from Samaru are reported in Table 17.

Central American Crosses:

Mr. Harrison of IITA supplied a selected group of Central American Varieties and hybrids crossed to NCA and NCB. This group of crosses has a good yield level and general agronomic merit. NCB nicked especially well with Poey T88, Honduras 10 x 11, Honduras 6 x 7, Pioneer x B101 and Rocamex 507, Poey T80, Pioneer 306, Poey T25. The highest yielding NCA crosses were with ESH5, Poey T86, Poey T25, Pioneer x 332B, Pioneer XB101 and Rocamex 507.

Variety Hybrids and Parents:

Results of an early and a late planting of a variety cross diallel and their parents (121 entries) are being summarized by Mr. Daniel Adedzwa for his M.S. thesis and are not ready to be reported at this time.

Single Crosses:

An attempt was made in the 1970/71 irrigated nursery to cross in all combinations the 10 inbred lines that had combined best in top-cross trials in 1970. Seed was obtained on only 13 of the crosses. Four of these yielded more than 6000 pounds per acre while 096 yielded 5624 pounds and NCA 4572 pounds. We plan to do further crossing among the better inbred lines available and with some of the more outstanding S_1 and full-sib progenies. There is incipient interest in a seed production enterprise in Nigeria which could make use of such material if it is good enough.

Topcrosses of Samaru 3 lines x Biu Yellow:

Eight of these crosses had been made. High yields were 8311 pounds and 8252 pounds while Biu Yellow yielded 6816 pounds and disease resistant Samaru 3 yielded 7474 pounds.

Brief summary of performance trials of other selections:

Only a summary paragraph about each of the trials of S_1 and full-sibs will be presented here. Tables of data showing performance for individual selections are given in the separate detailed report of maize investigations.

S_1 Progenies from NCA:

The 328 Samaru S_1 progenies tested gave a very wide range of performances for selection. Twenty-eight of them were selected and are being grown in a diallel to make full sibs in the 1971/72 dry season nursery for testing in the 1972 main season.

In Addition to preparing full sibs for the second cycle of yield testing it seemed advisable to make an initial multiplication of a bulk from remnants of the elite S_1 lines. Seed used was from selfed ears made in the S_1 progenies grown during the 1971 main crop.

Table 18. CENTRAL AMERICAN CROSSES TRIAL 1971 - SAMARU

Variety	Blight score	Planting to 50% pollen %	Planting to 50% silk %	Lodging root No.	Lodging stalk No.	Count at harvest	Ear height	No. of Ears	Yield 12% moisture grain kg/ha^{-1}
NCB x Poey T80	0.75	58	61	1	1	96	153	109	7231
NCB x Pioneer x 342	1.25	58	61	1	1	95	153	114	6521
NCA x NCB	1.0	57	61	1	1	94	148	102	6428
NCA x Poey T82	0.50	61	63	0	1	59	165	86	5699
NCB x Pioneer x 306	0.75	58	61	3	0	95	145	115	7269
NCB x E.S. H5	0.75	59	62	1	0	98	145	107	6764
NCA x Horduras 18 x 21	1.0	60	62	4	1	94	158	97	6148
NCA x Horduras 8 x 10	0.75	59	62	5	2	64	148	68	5083
NCB x Panuna SM-1	1.0	59	61	1	0	95	150	108	6596
NCB x Poey T86	1.50	59	61	5	3	97	170	105	6970
NCA x Pioneer x 330	1.75	60	61	2	2	72	145	89	5699
NCA x Poey T85	1.25	59	63	0	4	95	160	105	6690
NCB x Rocamex H507	1.0	62	64	2	1	101	178	107	7474
NCB x Pioneer x B101	1.50	58	61	0	1	97	138	119	7512
NCA x Poey T86	1.50	61	61	0	0	97	155	106	7063
NCA x NCB	0.75	59	62	2	1	68	153	79	7001
NCB x Poey T82	1.50	59	63	0	1	95	165	106	6914
NCB x Pioneer XV 103B	1.75	58	61	0	5	92	135	94	5176
NCA x Poey T80	0.25	59	61	1	1	90	150	90	5811
NCB x Poey T88	1.50	59	62	1	5	95	155	119	7643
NCA x Pioneer X342	1.25	59	61	2	0	52	135	64	4503
NCA x Pioneer x 332B	1.25	59	62	0	1	95	150	95	6802
NCA x Rocamex H507	0.25	63	65	1	0	96	158	109	6652
NCA x Pioneer x 306A	0.75	59	62	3	3	75	143	77	4410
NCA x NCB	1.75	58	62	2	3	94	158	96	5624
NCA x Poey T87	1.0	60	63	2	1	85	156	89	5587
NCB x Poey T85	1.25	60	63	2	0	96	155	99	7131
NCB x Honduras 10 x 11	1.75	60	62	3	2	95	158	106	7643
NCB x Pioneer x 306A	1.0	58	61	1	0	98	140	113	6652
NCB x Hondurax 8 x 10	0.75	59	62	1	5	97	163	107	6802

Table 18 Cont'd. CENTRAL AMERICAN CROSSES TRIAL 1971 - SAMARU

Variety	Blight score	Planting to 50% pollen	silk	Lodging root	stalk	Count at harvest	Ear height	No. of Ears	Yield 12% moisture grain
		%	%	No.	No.				kg/ha^{-1}
NCA x Pioneer x 332	1.0	57	61	0	1	95	138	92	6559
NCB x Honduras 6 x 7	0.75	60	63	2	2	93	153	107	7138
NCB x Pioneer x 330	1.50	58	61	0	1	97	133	111	6260
NCB x Pioneer x 332B	1.25	58	61	1	3	97	150	105	6802
NCA x Pioneer xy 103B	1.50	58	61	2	1	91	143	91	6054
NCA x Pioneer x B101	0.75	57	61	1	0	92	148	108	6577
NCB x Pioneer x 332	1.25	59	61	4	2	92	145	103	6409
NCB x Honduras 18 x 21	0.50	59	61	2	3	98	150	112	6858
NCA x Honduras 6 x 7	0.75	60	63	0	2	82	148	92	5830
NCB x Honduras Sin. Tuxpeno	0.50	61	64	2	1	98	170	192	6914
NCA x E.S. H5	1.50	60	62	0	2	93	148	115	7344
NCB x Honduras H5	0.50	60	63	2	0	95	153	95	6017
NCB x Poey T27	0.75	59	62	2	1	94	140	101	5886

2 x 6 hills) area factor = 166.69 x 1.121 kg/ha^{-1}
4 reps.) area factor to kg/ha^{-1} = 186.859

The 20 selections used gave most emphasis to yield and less to ear height and other factors given consideration in choice of lines for the full-sibs. Those used for the bulk were:

1970 Exp. 7 Entry No. 11 x 11		1970/71 Exp. 8 Entry No. 9 x 9		Entry No. 11 x 11	
27	170 grams	5	200 grams	22	250 grams
35	100 "	10	50 "	27	200 "
42	150 "	23	50 "	30	100 "
59	50 "	44	200 "	40	100 "
69	50 "			55	200 "
112	150 "			62	200 "
119	100 "			66	200 "
				93	100 "
				71	50 "

Those used for making the full-sibs were:

1970/71 S1's Exp. 8 Entry No. 11 x 11			1970/71 S1's Exp. 8 Entry No. 9 x 9
2	71	66	20
22	89	114	2
83	55	62	53
31	23	95	10
35	85		45
51	101		23
19	68		
39	30		
27	40		

Arrangements were made to have the NCA bulk grown for a winter crop on the Kadawa Irrigation Scheme but through an oversight the planting was not made when scheduled. It may be planted later in hopes that seed can be obtained for a late main season planting. In any event, we hope to plant part of the bulk for the rainy season at Samaru.

NCB second cycle S_1 progenies:

Dr. Craig recombined the 14 best progenies from the 1970 Samaru trial and sent us 128 S_1 progenies from the new population. Most of the 22 entries selected for recombining to start the third cycle, yielded more than 5000 pounds per acre. Two exceeded 580 lbs while NCB yielded 6182 lbs. Dr. Craig will send S1's for the 3rd cycle testing.

NCB S_1 progenies from Samaru 1970/71 Winter Nursery:

Yields of the 12 progenies selected among the 136 tested ranged in yield from 7713 kg/ha to 5501 kg/ha and most of the ear heights were under 150 cm. Remnants of the 12 selected progenies are being increased in an open pollinated bulk in the irrigated nursery.

Biu Yellow 3rd cycle S_1 trial:

Dr. Craig sent 63 of the third cycle S1's for testing. Five of them equalled the yield of Biu Yellow at 6577 lbs/acre. Most of the ear heights were under 110 cm. About 1/3 of the S1's exceeded 5000 lbs/acre. Dr. Craig is making 4th cycle S1's and will send them for evaluation in 1972. The better selections should be bulked and multiplied for use as a parent in crosses with varieties that have combined well with Biu Yellow. The variety is highly susceptible to rust and has a fairly high frequency of male sterile plants so will have to be used with some caution. It is unlikely that we shall continue the S_1 selection beyond the 4th cycle without a major infusion of outside germ plasm.

Full-sib 3rd cycle of Samaru 3:

The strains that were high yielding and blight resistant were identified in the 1970 trial of full-sibs. A diallel among these was tested in 1971. Excellent progress is being made in the population. Susceptibility to Race T of leaf Blight has been eliminated. In this trial the disease resistant mass selection of Samaru 3, NCA, and 096 yielded respectively 6637, 6996, and 7235 kg/ha. Two of the full sibs exceeded 8000 kg/ha and 9 of them exceeded the 7235 kg/ha of the 096 check. About 1½ tons of mass selected disease resistant Samaru 3 was produced in 1971. This is being used for further increase and wide-scale testing. We propose to start a new increase using about 5 of the elite full sibs. There is a strong general relationship between yield level and number of ears per plot, raising a question as to whether comparable progress might have been made by a simpler and less expensive procedure of selection for prolificacy. We urgently need the results of the sort expected from Adeniyi's thesis research to guide us in making synthetics from the breeding populations as they undergo successive cycles of selection.

S1 progenies from the Composites, Samaru 1, 2, and 3:

Trials of S1 progenies from these populations included 58 from Samaru 1, 152 from Samaru 2 and 134 from Samaru 3.

It seems clear that there should be consolidation of some of the populations being used in recurrent selection programs or elimination of the less promising ones.

Trials planned for 1972 should indicate which materials should be consolidated or dropped. The trials will include full sib sets among the best 5 lines from the 3rd full-sib cycle of Samaru 3, the best 5 lines from the trial of Samaru 1 S1's, the best 15 lines from the Samaru 2 S1's, and the best 15 lines from the Samaru 3 S1s. Not more than one of these populations or a consolidation of the best of all 4 will be continued. Consideration is being given also to bringing into the same picture NCA and Columbia Composite from Mokwa which have a considerable degree of relationship to the Samaru Composites. A diallel among the various breeding populations is being made in the 1971/72 irrigated plot. A test of these crosses should provide guidance in the consolidation of populations and streamlining of the breeding program as discussed during Dr. Eberhart's visit in November, 1971.

In order to take immediate advantage of the considerable advance expected from the 1971 trials of S1s from the Samaru Composites we bulked remnant seed of Samaru 1, 2, and 3, and are making an initial multiplication in the Shika winter irrigated plot. The bulk included seed from three of the Samaru 1, eight of the Samaru 2 and five of the Samaru 3 superior strains identified in the 1971 trials of S1s. We hope to have the seed from this isolated planting under further multiplication and in performance trials during the rainy season.

MAIZE BREEDING IN SOUTHERN NIGERIA

J. Craig

The maize breeding work in 1971 was concerned with modifications of the maize composites NCA and NCB. These composites were designed to serve as source populations for recurrent selection programs in west Africa. The characteristics desired in a maize cultivar will differ in different areas dependent upon the environment and the preferences of the breeder; for this reason the range of variability for many of the characters involved should be wide to insure the utility of the composite over a wide geographic area. However, certain characteristics are considered desirable at all locations, e.g. high level of disease resistance, and homogenization of the composites for such characteristics would increase their value to breeders.

Back-crossing programs utilizing the maize selection Rb which has hypersensitive resistance to Puccinia polysora (maize rust) and chlorotic lesion resistance to Helminthosporium maydis (southern maize leaf blight) as the non recurrent parent and the composites NCA and NCB as the recurrent parents to produce disease resistant versions of these composites were completed in 1971. Progenies of

the third back-cross were selfed and segregants exhbiting resistance to both P. polysora and H. maydis were recombined to form disease resistant versions of NCA and NCB, named NCARb and NCBRb respectively.

When NCBRb was grown and artificially inoculated with H. maydis and P. polysora 99% of the plants were resistant to H. maydis and 80% were resistant to P. polysora. The failure to eliminate a higher percentage of rust susceptibility was caused by the intermediate dominance of rust resistance which makes identification of the heterozygotes difficult. It is expected that complete elimination of the susceptible plants and partial elimination of heterozygotes in each generation will bring NCBRb to near homogeneity for rust resistance in a few generations. NCB and NCBRb do not differ significantly in population means for maturity and plant height and it is probable that these composites are similar in gene frequencies at loci other than those conditioning reaction to H. maydis and P. polysora.

The composite NCB and its disease resistant version NCBRb were compared for yield and disease damage in 1971. Damage from rust on susceptible plants in the trial plots was severe but the incidence of leaf blight was extremely low. The results of this trial are shown in Table 19.

Table 19. Yield and maize rust damage of the maize composites NCB and NCBRb.

Entry	Yield Q/ha	Rust damage
NCB	20	5.8*
NCBRb	33.3 **	2.9

* Differences between entries significant at the 5% level. Rust damage scores represent mean number of leaves per plant with 1/3 or more of leaf killed by rust.

** Differences between entries significant at the 1% level. Yields are in quintals of dry shelled grain per hectare at 12% moisture content.

NCBRb was superior to NCB in both yield and resistance to disease damage. Most of the disease damage observed was caused by maize rust. The 66% increase in yield of NCBRb over NCB points out the importance of this disease and the value of a high level of rust resistance.

In addition to production of NCARb and NCBRb a high lysine version of NCBRb, named $NCBRbo_2$, was produced. The composite $NCBRbo_2$ should be extremely useful as a source of improved maize for Southern Nigeria. In this area a floury grain maize is preferred for human consumption and the damage from both rust and blight is usually severe. The Opaque-2 factor in $NCBRbo_2$ gives a floury grain and the high level of resistance to blight and rust will prevent disease losses.

After formation of $NCBRbo_2$ I observed that grain of $NCBRbo_2$ had a lower specific gravity than grain of NCBRb. This has been noted by others in maize cultivars converted to the Opaque-2 grain type. A study was made at Ibadan of the variability for specific gravity of seed among S_1 lines of $NCBRbo_2$ and NCBRb. The results are shown in Table 20.

Table 20. Specific gravity of seed* of S1 lines from NCBRb and $NCBRbo_2$ maize composites.

Specific gravity	Frequency in sample	
	$NCBRbo_2$	NCBRb
	Pct.	Pct.
0.9	7	-
1	55	6
1.2	38	78
1.5	--	16

* Moisture content of $NCBRbo_2$ seed was 8% and of NCBRb seed 10%

Variability for specific gravity of seed is wide in NCBRb and $NCBRbo_2$. The degree of heritability for specific gravity of grain in these populations is not known but the variability present indicates the possibility of increasing specific gravity of grain in these populations by selection.

During the development of NCBRb and $NCBRbo_2$ a simultaneous program to produce upright leaf versions of these composites was undertaken. This program was completed in 1971 with the production of upright leaf composites named $NCBRbo_2U$ and NCBRb U. It is assumed that the errect leaf arrangement will provide more efficient distribution of light through the leaf canopy and reduce shade stress in high density populations. Trials to test this assumption are planned for 1972.

In November of 1971 maize breeders in west Africa were offered seed of NCARb, NCBRb and $NCBRbo_2$ for use in their maize improvement programs. Seeds of these composites have been sent to Gambia, Mauritius, Upper Volta, Jamaica and the Rivers State, Southeastern state and East Central State of Nigeria. In addition NCARb and NCBRb have been entered in the 1972 uniform maize trial in 11 west African countries. I believe that the performance of these composites will arouse considerable interest and increase their utilization in maize improvement programs in tropical areas.

Maize Composite Correlations:

Recurrent selection programs utilizing the Nigerian composites will be interested primarily in yield but the range of variability for other characters in these composites will offer opportunity to select for additional characteristics. Assuming that simultaneous or alternating selection for yield and other characters will be practiced, knowledge of the relationship between yield and these other characters is needed.

A study undertaken to determine the relationships between ear weight and the characters of plant height, ear number, maturity time, ear angle and husk coverage in NCB was completed in 1971. The results of this study are shown in Tables 21 and 22. The negative correlation between ear weight and days to silking is probably the result of drought stress which occurred 2 months after planting and had more adverse effect on the later maturing plants than on ones which flowered earlier.

As shown in Table 22 positive correlations were found between ear weight and the characters of plant height and poor husk coverage of the ear tip. These correlations indicate that selection programs to reduce plant height and improve husk coverage of the ear tip should be carried out with care to avoid deleterious effects on ear weight.

A highly significant negative correlation was found between the drooping ear position with ear tip pointing downward and ear weight. Some maize breeders prefer plants with the droping ear character because such ears are not damaged by rain water entering at the ear tip after maturity. The results of this study indicate that strong selection pressure for drooping ears will result in reduced ear weight in maize composite NCB.

Table 21. Variability for certain agronomic characters in the maize composite NCB

Character	Range	Mean	Frequency *
Plant height	150-300 cm	225 cm	
Days to silking	49-71	61	
Total ear wt./plant	15-468 gm.	207 gm.	
Top ear wt./plant	15-353 gm.	176 gm.	
Ears per plant	1- 3	1.4	
Exposed ear tip	-	-	13%
Drooping ear	-	-	38%
Single eared plant	-	-	66%

Percent of population of 400 plants showing the character.

Table 22. Correlations between ear weight and selected agronomic characters in the maize composite NCB

Character	Correlation Coefficients	
	Total ear wt.	Top ear wt.
Plant height	+ . 11*	-
Days to silking	- . 44**	-
Ears per plant	-	.001
Drooping ear	-	- .44**
Exposed ear tip	-	+ .132*

* Significant at the 5% level

** Significant at the 1% level

Environment and Yield Relationship:

For several years maize entries in the Nigerian zonal maize trials and the West African uniform maize trials have given much higher yields at Samaru, Nigeria than at Ibadan, Nigeria (Tables 23 and 24). I believe that identification of the causes of this difference may provide information which could be used to improve yields at Ibadan and other sites of similar environment. A project to identify causes of yield differences between Ibadan and Samaru will be started in 1972.

Table 23. Yields of top entry in Nigerian zonal maize trial at Samaru and Ibadan 1967 - 1970

	Year, entries and yields (lbs/acre)							
Trial Site	1967		1968		1969		1970	
Samaru	(NS-5)	5310	(AxB)	5997	(AxB)	6570	(NCA)	5632
	(H507)	4980	(A)	5784	(H507)	5650	(H503)	5048
Ibadan	(H507)	3480	(A)	4508	(H507)	2744	(H503)	2410
	(NS5)	2730	AxB	4388	(AxB)	1807	(NCA)	1739

Table 24. Yields of top entry in West African uniform maize trial at Samaru and Ibadan 1967-1970

	Year, entries and yields (lbs/acre)							
Trial Site	1967		1968		1969		1970	
Samaru	(CJI)	4855	(NS4)	6316	(GC.2)	5900	(NCA)	5750
			(HJ)	4296			(094)	5350
Ibadan	(CJI)	3488	(H.J)	3382	(GC.2)	1980	(094)	3640
			(NS4)	2244			(NCA)	2720

Maize Diseases:

The investigation of the new maize leaf blight that was observed in Nigeria in 1970 has been completed[1/]. The blight was identified as the ract T strain of Helminthosporium maydis. This blight caused severe losses in plantings of NS5 maize. The blight resistance present in the maize breeding composites NCARb and NCBRb is effective against Race T blight.

A severe attack of Storey's streak, a virus disease of maize occurred in maize plots planted in late September and early October on Moor Plantation. Yield trials, seed increase and evaluation plots were so badly damaged that in many cases neither seed nor information was obtained.

1/ Craig, J. 1971. Occurrence of Helminthosporium maydis race T in west Africa. Plant Disease Reporter 55:672.

Storey's streak has not been of importance in commercial maize production because the usual time of heavy disease occurrence (November-February) does not coincide with the maize growing season. However the adoption of new breeding techniques by maize breeders in Nigeria make production of maize during the November-February period mandatory if the most efficient rate of maize improvement is to be attempted.

A cooperative project with the Nigerian Federal Department of Agricultural Research entomologist to identify streak resistant strains of maize and to transfer this resistance to maize composites is planned for 1972.

SOIL MANAGEMENT

During the past year various phases of soil management were investigated in cooperation with different individuals and are reported below. The fertility-maize-sorghum trials are reported in the breeding section since they were intended to test the yield potentials of maize and sorghum at locations other than Samaru at various productivity levels.

MAIZE DATE OF PLANTING EXPERIMENTS

K. R. Stockinger and M.Jone

Three dates of planting experiments were carried out during the past cropping season to determine the cause of the decline in yield when the planting is delayed.

The experiment reported last year was repeated again this year with a blight resistant variety 096. Maize was planted on four dates from mid-May to mid-July, under five fertilizer regimes, NPK, NP, NK, PK and control, replicated three times. Growth and development were followed by plant sampling, measurement of leaf area, visual observations and chemical analysis of plant samples.

Im the table below the mean yields of the NPK and NP plots are compared to the mean yields of the PK and control plots. Yields are given in quintals per hectare:

Date of Planting	NPK and NP	PK and Control
May 24	66.7	20.8
June 3	72.6	15.8
June 27	48.5	21.0
July 16	28.7	14.5

In all treatments that included nitrogen yields declined markedly with lateness in planting. Where no nitrogen was applied yields were generally lower but almost unaffected by planting date. In part, the lower yields of the later plantings were accounted for by the low percentage transfer of dry matter into the cob, but unlike the previous year, there was also an actual decline in total dry matter production, although this did not start until after silking. Because August and early September have the most rains it has been suggested that the decline in yield is due to lower amount of sunlight and consequently less photosynthesis during this period. A measure of this is the dry matter production during the same stage of development before silking. This is shown in the table below in quintals per hectare per day for the period of 6 weeks after planting to silking for the calendar period covered for the mean of the NP and NPK treatments. Also the total dry matter production was the same for all planting dates except the first one and effectively the rate of dry matter production was the same from mid-July to the third week in September. Sunshine records as measured with a pyroheliometer also bear this out.

Date planted	6 weeks	Silking	Prod/day	Total D.M. for season
May 24	July 7	Aug. 3	1.8	148
June 3	July 15	Aug. 13	2.3	184
June 27	Aug. 7	Sept. 7	2.1	125
July 16	Aug. 25	Sept. 23	2.2	90

The yield and dry matter production of the first planting was reduced because of a severe drought during June and of the last planting by the rains stopping shortly after silking. However, moisture was not limiting for the second and third plantings.

All of the nitrogen was applied at the time of planting at a rate of 168 kg/ha. Nitrogen uptake figures for the treatments receiving nitrogen are given below in kg/ha:

Date Planted	Before Silking	After Silking	Total
May 25	101	45	146
June 3	115	33	148
June 27	93	19	112
July 16	59	35	94

As can be seen from these figures the amount of nitrogen taken up by plants was much less for the third and fourth plantings indicating that less nitrogen was available for plant uptake. Also very little was available in the third planting after silking. Because the intensity of the rains was greatest during August and early September, leaching would be greatest during this period and the amount of nitrogen taken up after silking progressively decline with days in planting. Hanway (Agron. J. 54:217-222 (1962) showed that about a third of the total nitrogen is taken up after silking.

All of this nitrogen plus about a half of the nitrogen taken up before silking was translocated to the grain. If similar conditions prevail in the tropics yields would be limited if the amount of nitrogen available after silking was low. The results in the table above indicate that the second and third plantings yield were probably limited by lack of nitrogen after silking. The results for the fourth planting are distorted by the rains stopping at about silking time and do not fit the pattern of the earlier plantings. If the yields of the first-three plantings are calculated by the relation suggested above, that is: (one half of the nitrogen uptake before silking + nitrogen uptake after silking) ÷ the percent nitrogen in the seed = yield of grain, the yields of 66, 71, and 48 quintals per hectare are obtained which are almost identical to the yield reported earlier.

This suggests that yields are limited by lack of nitrogen especially after silking. The lack may be due to insufficient nitrogen applied, leaching, and denitrification. Since only 168 kg/ha of nitrogen was applied and the soil supplied 40 kg/ha (control plot uptake) the 146-148 kg/ha uptake of the first and second plantings was probably the limit of efficiency of fertilizer usage (60 to 70% efficiency is good for such large applications). Deep percolation losses of water started about the end of July and leaching is removing nitrates from the soil profile and is probably the cause of the lower uptake of nitrogen in the third planting. Denitrification is usually caused by anaerobic conditions prevailing in the soils causing some bacteria to use the oxygen from the nitrate for respiration and releasing the nitrogen as a gas. It is thought that 10-15% of the nitrogen is lost in this way under normal conditions. With more rain anaerobic conditions might prevail in more of the soil for longer periods and appreciably increase this loss and it might be the cause of the losses observed. However the losses, occur, additional nitrogen applied just before silking should alleviate this condition. Split applications of nitrogen fertilizer will be tried this year to see if it will remedy this condition and increase the yields of late plantings.

Last year's results had indicated that the zinc content of the ear leaf was low on late planting and that boron was also low on all planting dates. Also the late plantings had many barren plants and small poorly filled cobs indicating boron deficiency or too dense a stand for the light conditions. Another experiment with three dates of planting, with and without boron, with and without zinc, and two plant populations was carried out at a high level of nitrogen and phosphorus fertility. The yields for these treatments are given below in quintals per hectare:

Planting date	May 27	June 24	July 16
No boron	50.0	29.6	9.7
1.2 kg/ha boron	50.1	31.9	10.4
No zinc	51.1	30.1	8.9
2.5 kg/ha zinc	49.0	31.4	11.4
24,000 plants/ha	46.2	27.3	9.0
48,000 "	53.9	34.3	11.1

Neither zince nor boron application gave any significant increase in yield at any of the planting dates. Leaf analysis for zinc indicated that the zinc content was above 15 ppm on all treatments and was significantly increased by the soil application of 2.5 kg/ha of zinc. The boron analysis have not been completed.

Higher plant population increased yield on all planting dates although the increase was not significant on the July 16th planting. Since the pattern of response was the same at all planting dates, thinner stands will not overcome the date of planting effect. Since the increased light due to thinner stands had no additional effect on the late plantings, it corroborates the plant growth results reported earlier.

A third experiment with weekly planting dates was carried out to see when the date of planting effect occurred and how rapidly the yields declined. All plots received 168 kg/ha of nitrogen 45 kg/ha of phosphorus. Yields for the various planting dates are given below:

Planting date	Yield
May 19	48.7
May 26	42.2
June 2	34.8
June 9	34.3
June 16	18.1
June 30	13.5
July 7	18.4
July 14	7.3

Stands of the June 2 and 9 plantings were poor because of inadequate rains and soil moisture. The June 30 planting was planted on June 23 but did not germinate until a rain on June 30 germinated the seed so it was called the June 30 planting. Yields declined very sharply with the June 16 planting. This planting had good stands on all plots so the decline in yield must be real. Since drought conditions prevailed until early July excess water was not a problem until end of July. These results bear out the observations that the effect is caused by the August and September rains and that early plantings escape these adverse effects. The early plantings suffered from drought and were wilted for long periods of time. They recovered and made good yields. The last planting silked

just before the last rain and its yield was reduced even further by the lack of moisture during the grain formation period. Adverse effects at the end of the season appear to have a greater effect on yield than those at the beginning of the season.

In conclusion, lack of nitrogen during anthesis and grain formation stages of plant growth may be the cause of the decline in yield caused by delayed planting. The lack of nitrogen is the result of excessive rain during August and September resulting in the loss of nitrogen by leaching and/or denitrification. The date of planting effect does not seem to be due to deficiencies of phosphorus, potassium, zinc, or boron. The amount of light available was the same for all planting dates in 1971 and is not the cause of the effect.

FERTILITY TRIALS AT KANO AND MOKWA

K. R. Stockinger and R. Heathcote

Long term fertility trials have been conducted at Kano and Mokwa on sandy soils to study the fertility problem with continuous cultivation. The effects of nitrogen, potassium, lime and trace elements at adequate levels of phosphorus are being studied. The yield response of sorghum to nitrogen and potassium at Kano is given in the table below in quintals per hectare:

	58 kg/ha^{N}	116 kg/ha^{N}
0	10.6	9.2
55 kg/ha^{K}	16.7	21.1

There was also an additional response of 2.4 quintals per hectare from lime. There was no effect from trace elements at Kano.

At Mokwa 90 kg/ha of potassium increased maize yield by 17.5 quintals per hectare. In addition soil application plus foliar spraying of zinc increased grain yield by 6.5 quintals per hectare. The untreated maize plants showed marked zinc deficiency symptoms as young plants. Although zinc deficiency has been observed before, this is the first measured yield response for zinc in northern Nigeria. Each year the responses at Mokwa become greater but yields are also actually increased.

As yield levels are raised throughout Nigeria by use of improved varieties and increased use of nitrogen and phosphorus, potassium and zinc will become the limiting elements on many soils especially the more sandy soils.

LONG TERM FERTILITY TRIALS

K. R. Stockinger

The long term fertility trials at Kano and Samaru were designed to study the effects of continuous cropping at various fertility levels and to compare inorganic fertilizers with dung under these conditions. The trials have been carried out for 23 years and have shown that dung was much more effective than inorganic fertilizers especially at Kano. Yields in recent years on the no dung plots were very low and were complete failures on some plots. With dung responses were observed from nitrogen and phosphorus but not with potassium. Soil analysis revealed that nitrogen in the form of ammonium sulfate was acidifying the nitrogen treatments and one effect of dung was to reduce this effect. It was also found that the amount of nitrogen, phosphorus and potassium being added by the dung was much larger than the fertilizer treatments. Also the crops being used had a low yield potential. Several changes were introduced in recent years such as liming the plots at Samaru, using nitrochalk (ammonium nitrate with lime added) as the nitrogen source, increasing fertilizer rates, and switching to maize as the test crop.

Some of the yields at Kano are given in the two tables below. The fertilizer rate for N and P_2O_5 are given in kg/ha and for dung (D) in metric tons per hectare. The yields are in quintals per hectare.

D	0 N	86 N	172 N	Mean (D)
0	5.1	14.5	17.4	12.3
2.5	17.4	28.8	29.3	25.1
5.0	15.4	33.7	38.6	29.2
Mean (N)	12.6	25.6	28.3	

N	0.P	79 P_2O_5	158 P_2O_5	Mean (N)
0	16.1	13.3	8.5	12.3
86	21.0	27.0	26.6	25.1
172	27.2	34.1	28.9	29.2
Mean(P_2O_5)	21.4	25.1	20.2	

The dung, nitrogen, and phosphorus main effects and the nitrogen phosphorus interaction were all statistically significant. However, the size of the increase of yield due to nitrogen is small considering the amount of nitrogen applied and the much higher potential yield

Since all of the nitrogen was put on 6 weeks before silking and with the porous Kano soils and heavy rainfall much of the nitrogen may have been leached below the root zone. The lack of response and actual decrease in yield at the higher rates of phosphorous fertilizer indicates an immobilization or lack of some other essential element. This could be zinc whose uptake is known to be depressed by phosphorus fertilizers or magnesium which is associated with the translocation of phorphorus in the plant. Exchangeable magnesium is very low in Kano soils and both nitrogen and phosphorus treatments over the years have significantly decreased the level of exchangeable magnesium. Since the maximum level of phosphorus fertilizer was only 26 kg/ha of P_2O_5 in earlier years the effect did not show up until this year when the rates were raised. Potassium gave a small yield increase which was not significant but would probably be more important if other limiting factors were eliminated.

At Samaru the old low rates were again used with maize as the test crop. Some of the yields are given in the table below. The fertilizer rates for N and $P_2O_5$are given kg/ha and for dung (D) metric T/ha.

The yields are in quaintals per hectare.

D	0 N	13 N	26 N	Mean (D)
0	4.3	9.0	14.0	8.7
2.5	14.7	27.4	32.7	24.9
5.0	29.4	35.9	41.0	35.4
Mean (N)	16.1	24.1	29.3	
	0	12 P_2O_5	24 P_2O_5	
Mean P	20.0	24.4	25.1	

The only significant effects were from dung, nitrogen and phosphorus which all gave excellent responses. Potassium gave a slight decrease in yield which was not significant. Chemical analysis of the index leaf (leaf opposite and below the top ear) gave a very low magnesium content with the highest mean value of less than 0.15%. The critical value given in the literature is 0.25% and other experiments at Samaru have shown values ranging from 0.20 to 0.30%. Nitrogen and phosphorus fertilization tends to increase the percentage while dung and potassium decreased its uptake. The phosphorus content of the leaves was also very low ranging from 0.09 to 0.18%. Dung, nitrogen and phosphorus fertilization increased the index leaf phosphorus content but all values were below the critical value 0.25%.

The yields were low but much better than in preceding years. Leaching losses of nitrogen may be high especially at Kano and split applications may be necessary to get the maximum benefit from it. Manure may be releasing its nitrogen more slowly and supply more nitrogen during the latter part of the growth cycle of the plant when fertilizer nitrogen would have been lost by leaching.

LEACHING

A small lysimeter study using ten gallon drums for lysimeter was set up with four fertilizer levels and bare fallow versus a maize crop. Sodium chloride was added to all treatment as a tracer. With no fertilizer added 65% of the chloride was lost by leaching. When single superphosphate was applied 89% of the chloride was lost by leaching. This shows that the soil which was used adsorbed chloride and that the sulfate and phosphate displaced the chloride and accelerated its loss. The soil used was a mixture of surface and subsoil and contained more clay than is normally present in the surface soil. This illustrates that many of the tropical soils adsorb anions and will inhibit leaching losses of chloride and nitrate. Also the amount of leaching depends not only on the amount of water passing through the soil but also on the kind of soil and the other soluble anions which have been added to the soil. Further work needs to be done to characterize this property of various soils in the tropics and to use this information to apply nitrogen fertilizers more economically.

WORK PLANNING MEETING IN DAKAR

A work planning meeting on environmental factors affecting yield of cereal crops in tropical Africa was organized and set up in Dakar, Senegal on July 25-29, 1971, under the sponsorship of the Scientific and Technical Research Commission of the Organization of African Unity. There were 35 scientists from 17 countries (14 African countries) participating in the session. Sessions on the following topics were held during the meeting and past research work and work now in progress was reviewed.

1. Photosynthesis
2. Date of planting
3. Soil management including tillage, erosion control, and rotations.
4. Potassium and the minor elements
5. Nitrogen and phosphorus

One day was devoted to a visit to the IRAT station at Bambey to observe the experimental work going on there. The final session involved discussion of the need for additional work in the various fields. It was also suggested that another meeting be held in two years on some other phase of cereal production.

CEREAL PATHOLOGY - SAMARU

S. B. King

Work continued on the pathology of sorghum, millet, and maize, with sorghum receiving about 70 percent of the research effort. Extra research time was given to witchweed resistance work in sorghum, and this effort will continue and likely increase in 1972. Head smut and long smut research received more attention in 1971, and the long smut work will be increased in the coming year. Covered smut, loose smut, and disease screening in the world sorghum collection will decrease in 1972. Experiments designed to study the cause of sorghum root rot have been initiated recently in collaboration with the soil scientist. A disease resistant millet composite will be initiated in 1972, drawing on disease resistant lines identified and developed during the past few years. In maize, particular attention will be given to selection for witchweed resistance within existing composites.

SORGHUM

1. World sorghum collection

Part of the world sorghum collection was scored for reaction to six naturally occurring leaf diseases and to witchweed. Results are discussed later in this report. Observations were also recorded for each entry on plant height, number of days to 50 percent anthesis, panicle type and density, seed color and size, and plant pigment color. Entries which flowered after September 26 were screened for potential midge resistance. Seed of these entries will be given to the entomologist for further testing.

Four panicles of each entry were again bagged to obtain selfed seed. Selfed seed could not be obtained from several hundred entries primarily because of stem borer injury. Open pollinated panicles were harvested in as many of these cases as possible.

Screening for disease reaction will continue in the world collection in 1972. Seed of over 700 entries not previously tested in Nigeria has already been received from India. Several hundred more entries are expected to arrive in the near future from Puerto Rico.

A concerted effort is being made to consolidate all data obtained over the years at Samaru on the world sorghum collection. Data will be punched onto 80 column computer cards, one card for each entry. Each card will hold information pertaining to: I.S. number, Samaru row number, country of origin, plant height, number of days to 50 percent anthesis, panicle density and type, seed size and color, plant pigment color, disease reaction data for each year recorded, and a disease reaction summary. All disease reaction data will be recorded on a 1 to 3 scale: 1 = resistant (little or no infection symptoms), 2 = moderately susceptible, and 3 = highly susceptible. The disease summary scale will be enlarged to include more reaction categories and values will be calculated by the computer, giving more weight to data of some years than to that of others. Classification of entries according to the new system of sorghum classification will also be included on the cards when this information becomes available. It is hoped that this work can be completed sometime within the coming year.

2. Leaf diseases

A total of 3,322 entties of the world sorghum collection were scored on two occasions for their reaction to leaf 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). Epiphytotics of all these occurred during the season with the possible exception of oval leaf spot. Disease reaction of entries is summarized in Table 25.

Table 25. Summary of reaction of part of the world sorghum collection to leaf diseases in 1971.

Disease	Percent of 3,322 entries showing:	
	Resistant or escape reaction	Definite susceptible reaction
Anthracnose	67.1	32.9
Rough leaf spot	50.8	49.2
Sooty Stripe	15.5	84.5
Oval leaf spot	97.4	2.6
Zonate leaf spot	23.0	77.0
Grey leaf spot	34.2	65.8

An additional 1623 entries, for which disease data was obtained in 1970, were also planted in event that an epiphytotic of downy mildew would occur. However, due to insufficient challange by Sclerospora sorghi, no data were obtained.

3. Witchweed

A program has been initiated to identify resistance to witchweed (Striga hermonthica) within the world sorghum collection. The first stage involves preliminary screening at the same time entries are being scored for reaction to leaf diseases. Susceptibility is based on appearance of chlorotic or necrotic flecking in host leaves. A large number of escapes go undetected in the first stage of screening because of the fields where the collection is grown do not have an even distribution of Striga infestation. The second stage involves further screening of all entries which remain symptomless during the preliminary screening. These entries are planted in a field known to have a fairly even distribution of heavy Striga infestation. Additional Striga seed is added to the seed furrow during planting to further ensure against the possibility of escape. Entries in the second phase are observed 2 to 3 times during the season for the appearance of Striga symptoms in host leaves and also for the emergence of Striga plants within each row.

In 1970, 56 percent of 4,000 entries were eliminated from further screening. The remaining entries, with exception of about 50 for which seed supply at the time was exhausted, were tested in the second phase of screening during the 1971 rainy season. Of these, 103 entries (2.5 percent of the original 4,000 entries) remained free of both leaf symptoms and emerged Striga plants; 193 entries (4.8 percent) remained free of Striga plants, but showed leaf symptoms; and 183 entries (4.6 percent) remained free of leaf symptoms, but not emerged Striga plants.

The 103 entries which remained free of both Striga plants and symptoms are presently undergoing a third phase of screening. This involves: (1) pot studies in which observations are made of the sorghum roots for Striga attachment and subsequent Striga plant development and parasitism, and (2) studies to determine which entries, if any, do not produce the stumulant necessary for germination of Striga seed. In 1972, all the entries included in the above 3 resistant or tolerant categories will be tested again in a replicated trial in a Striga infested field at the University Farm. Observations will not only be made of Striga reaction, but also of certain agromomic characters.

Forty-three percent of the entries which underwent preliminary screening in 1971 remained free of Striga symptoms. These entries will be passed through the second phase of screening in 1972. Also, progeny of crosses between Combine Kafir 60 A and several apparently resistant entries will be studied under Striga attack to gain some understanding of the genetics of resistance. Plans for 1972 also include the initiation of work toward developing a Striga resistant sorghum population.

4. Other screening

Sixty-three lines from the sorghum conversion program in Puerto Rico and Texas were scored for their reaction at Samaru to 4 leaf diseases and witchweed. An overall summary of disease reaction is found in Table 26.

Table 26. Summary of disease reaction of 63 converted sorghum lines tested at Samaru in 1971.

Disease	Number of lines		
	Resistant	Possibly Resistant	Susceptible
Leaf Anthracnose	47	7	9
Rough Leaf Spot	30	22	11
Sooty Stripe	0	6	57
Zonate Leaf Spot	4	33	44
Witchweed	0	6	57*

* Twenty-two entries in this category showed possible tolerance to witchweed.

The data show that this group of sorghums is generally resistant to leaf anthracnose and rough leaf spot and susceptible to sooty stripe, zonate leaf spot, and witchweed. Lines which showed resistance or possible resistance to all 4 leaf diseases coupled with possible resistance or tolerance to witchweed were: 1598C, 3063C, 3579C, 12622C, and 12645C. Lines selected by the sorghum breeder at Samaru for potential use in the breeding program were: 2266C, 2403C, 2579C, 7007C, 12569C, 12610C, and 12648C. Lines selected for further witchweed resistance screening were:2801C, 3579C, 6729C, 7502C, 12605C, and 12684C. Both selfed and open pollinated seed was saved of each line except 2 lines which did not produce seed. This material will likely be planted again in 1972 for further observation.

The International All Disease Nursery from Dr. R. A. Frederiksen, Texas A&M, was also planted and scored for reaction to leaf diseases and witchweed. The nursery was comprised of 25 dwarf, photopheriod

insensitive lines. Twenty of these lines came from early stages of the conversion program and had been subsequently selected for disease resistance. Thirteen of these lines were derived from the Zerazera group of sorghums. This nursery in general showed less susceptibility to leaf diseases than the nursery of converted lines. Fifteen entries showed combined resistance to all four leaf diseases, and 3 entries showed potential resistance to witchweed. These will be further tested in 1972.

5. Smuts

a. Covered smut - Covered smut (Sphacelotheca sorghi) is the most important smut disease of sorghum and is found throughout West Africa. In Nigeria it causes average annual losses estimated to exceed 5 percent. The research program on this disease in the past has dealt primarily with gaining information pertaining to virulence of the pathogen.

A total of 12 Nigerian isolates of covered smut were tested in 1971. As in previous years, the reaction produced by most of these was either identical of similar to that resulting from infection by Race 4. Virulence of a few isolates was quite different from anything previously reported in the literature. In 1971, seed for a covered smut virulence study was sent to interested persons in other sorghum-growing areas of West Africa. Results on this trial will be reported when more data become available.

The West African sorghum nurseries were tested for their reaction to covered smut using two Nigerian isolates of S. sorghi. In the Sudan zone nursery, only I.S. 9290 from the Sudan was completely resistant. In the guinea zone nursery CK x 299b6 from Cameroun and FFBL 3-1-6, line 453, and SKMDW 2347 from Nigeria showed no infection. Detailed results will appear in a separate report on these nurseries.

Covered smut can be controlled easily and with little expense by use of seed dressings. However, relatively few farmers in West Africa use seed dressings. Hence, research plans for 1972 include starting a selection program for covered smut resistance within the sorghum composite which has been developed at Samaru.

b. Loose smut - Studies on loose smut (Sphacelotheca cruenta) have been focused on virulence of the pathogen and mode of infection. An additional 5 isolates from various parts of Nigeria were tested against 6 differential hosts during the past year. All of these isolates behaved the same as or very similar to Race 2. These results are in agreement with similar tests previously conducted with Nigerian isolates of loose smut, and they indicate that varieties of sorghum having resistance to Race 2 of S. cruenta will likely be resistant to the pathogen in Nigeria. Virulence of S. cruenta has not been studied in other parts of West Africa.

Studies on mode of infection were continued. The purpose of this is to gain an understanding of how plants arising from thiram treated seed and producing healthy primary heads, but infected tillers, become infected. This phenomenon has been noted on several occasions on late maturing Nigerian sorghums during the rainy season and on short season exotic types, especially during the dry season under irrigation. Experiments on this in 1971 again did not produce conclusive results. Loose smut infection is frequently found to occur in ratooned plants, but there was no evidence of loose smut in the ratoon crop of a ½ acre plot of sorghum hybrid C-9357 in 1971.

c. Head smut - Head smut (*Sphacelotheca reiliana*) at present is not a serious problem in West Africa, with average annual losses estimated at less than 2 percent. Host resistance appears to be the only satisfactory method for control. Seed dressings are ineffective.

The research program involves studies both on resistance of the host and virulence of the pathogen. An attempt is being made to establish a head smut nursery with a high soil inoculum level for testing resistance in sorghum, but a sufficiently high inoculum level has not yet been attained for reliable screening. Hence, the hypodermic injection technique of inoculation is being used almost exclusively in the head smut research program, although other simpler methods of inoculation are being investigated.

In 1970, all 5 long season Nigerian varieties tested were found highly susceptible to head smut, whereas most short season exotic types showed little or no infection. These results raised the question as to whether susceptibility to the Nigerian form of the pathogen is characteristic of sorghums of Nigerian origin regardless of maturity length, or whether susceptibility is a character inherently associated with long season sorghums regardless of origin. To investigate this, both early (45 to 79 days to anthesis) and late (156 to 204 days to anthesis) maturing Nigerian selections and late (101 to 190 days to anthesis) maturing selections from other parts of of Africa and India were inoculated and observed for development of smutted panicles. A summary of these data are presented in Table 27.

Table 27. Reaction of early and late maturing Nigerian sorghums and late maturing sorghums from other parts of Africa and India to head smut in Nigeria.

Infection class	Nigeria				Other	
	Early Maturity		Late Maturity		Late Maturity	
	Frequency	% of total	Frequency	% of Total	Frequency	% of total
0.0	3	12.0	1	3.0	2	5.0
0.1 to 5.0	4	16.0	0	0.0	0	0.0
5.1 to 25.0	10	40.0	0	0.0	3	7.5
25.0 to 50.0	3	12.0	3	9.7	12	30.0
50.1 to 75.0	3	12.0	9	29.0	19	47.5
75.1 to 100.0	2	8.0	18	58.1	4	10.0
Total	24	100.0	31	100.0	40	100.0

Relatively few selections showed 5 percent or less infection. Whereas over 60 percent of the early maturing selections showed less than 25 percent infection, over 90 percent of the late maturing types showed more than 25 percent infection. Most late maturing Nigerian sorghums showed more than 75 percent infection, and most late maturing types from other parts of Africa and Asia showed more than 50 percent infection. These data together with those from 1970 suggest that there is a direct relationship between susceptibility and both late maturity and sorghums of Nigerian origin. This relationship will be further studied in 1972.

Both the sudan savanna zone nursery and the guinea savanna zone nursery were tested for their reaction to head smut. Detailed results will appear in a separate report for these nurseries and only a brief report is given here. A fairly high level of infection occurred in both nurseries, with the sudan zone nursery showing slightly less susceptibility than the guinea zone nursery. Within the sudan zone nursery, only S. 9290 from the Sudan showed no infection; CK60 x 7706-5-1 and Dwf. C[illegible] x SA7706-5-1, both white seededtypes developed in Nigeria and similar to NK 300, showed less than 5 percent infection. Within the guinea zone nursery, only entries 453 and 93 x 2083, both from Nigeria showed no infection, whereas all other entries showed 46 to 76 percent infection.

During the past year, virulence of the Nigerian form of head smut was studied by testing it against: (1) four head smut differential varieties used to identify virulence in the U.S.; (2) a uniform head smut nursery (13 entries) from the U.S. which was to have been tested in 1971 at several locations throughout the world; and (3) a set of 59 U.S. sorghums, many of which have a known head smut reaction to races 1 and 3 in the U.S. Data obtained from these tests indicate that head smut which occurs in Nigeria is an altogether different race from that which occurs in the U.S. Of the four head smut differentials, Spur Feterita (F.C. 6606) was the only one which became infected in Nigeria. One or more of the other 3 differentials are infected by each of the 3 races reported in the U.S., and Spur Feterita is the only one which remains free of infection in the U.S. In the uniform head smut nursery, only 4 entries became infected; two of these do not become infected in the U.S. but they showed 85.7 and 90.2 percent susceptibility to the Nigerian form of head smut. Check varieties which give a susceptible reaction to one or more of the races in the U.S. did not become infected in Nigeria. For 39 of the 59 other sorghums tested, a reaction of races 1 and 3 was known in the U.S. The reaction of 14 of these selections was clearly different from that reported in the U.S. For lack of information, the virulence of Nigerian head smut cannot be compared with virulence in other parts of the world aside from the U.S. It is obvious, however, that information pertaining to head smut reaction in the U.S. is of little value to a breeding program in Nigeria which includes head smut resistance as one of its objectives. Resistance to be used in Nigeria must be identified in Nigeria.

d. Long smut - Long smut (*Tolyposporium ehrenbergii*) commonly occurs on sorghum through much of the sudan savanna zone of Africa. Although annual overall yield losses in this zone do not exceed 2 percent, localized infection resulting in losses in the order of 10 percent have been observed. Very little research attention has been given to long smut. Virtually nothing is known about varietal resistance; and the mode of infection, though generally thought to occur through flowers by air-borne sporidia, is not clearly understood.

During the 1971 season a trial was planted at Kano to obtain information on varietal reaction and mode of infection under conditions of natural infection. A total of 50 sorghums, including 44 exotic types representing most of the major grain sorghum types and 6 Nigerian varieties which are commonly planted in the sudan savanna zone, were planted on two different dates: one at the beginning of the rains on July 1 and the other 19 days later. Infection in the Nigerian varieties was not as high as anticipated, indicating less than optimal conditions for infection. However, data suggested that resistance is not uncommon in sorghum, as about half the entries tested showed little or no infection. Lack of infection was not clearly associated with any

of the major grain sorghum types. Four highly susceptible exotic sorghums were identified and will be useful in future studies on the mode of infection. Date of planting had a marked influence on the incidence of infection. About 7 times more infection occurred in the first planting than in the second. This difference could not be entirely attributed to differences in heading dates, and it suggests that some infection might occur during early stages of plant growth. The fact that some farmers interviewed in the Northeast State last August indicated that they obtained some control of long smut by using seed dressings that would lend support to the hypothesis for early infection. Covering panicles with pollinating bags, whether at booting or anthesis, also generally increased the rate of infection.

Research during the coming year will be focused on gaining a better understanding of infection. This type of information could be useful in developing methods for control. Mr. S. K. Manzo will be pursuing some aspect of this for his M.Sc. thesis.

MILLET

The millet pathology program is concerned with the identification of resistance to downy mildew (Sclerospora graminicola), smut (Tolyposporium penicillaria), and ergot (Claviceps microcephala). Because there are no reliable artificial inoculation techniques for these diseases, one must depend on natural inoculum and suitable natural environmental conditions for creating sufficient disease pressure to identify resistance. Conditions for high disease incidence do not occur annually, and even weekly fluctuations in disease pressure within any given season may occur. Weekly fluctuations in disease pressure are likely a significant handicap in accurate screening for smut and ergot resistance, since the period of infection is thought to be limited to a few days during the early stages of flowering.

Some techniques are being used to encourage high disease pressure, although these by no means guarantee increased challange by the pathogen. In downy mildew, chances for disease escape are generally reduced by delaying planting till late June. By this time, the rainy season is generally well established and chances of a long dry spell during early plant growth are less likely. Moist conditions during the first few weeks after planting generally encourage primary infection by soil-borne oospores and subsequent early development of the sporangial stage which might be important in secondary spread of the pathogen to healthy plants. The incidence of smut is dramatically increased by covering spikes with pollinating bags immediately prior to floral opening. This tends to reduce chances for disease escape and helps to differentiate resistant material from moderately susceptible material. Late planting generally insures a higher incidence of ergot infection. By the time this material flowers, an abundant supply of inoculum is available in the form of spores from the honey dew phase on early planted millet growing in the area.

Over 1,000 S_2 and S_3 lines which previously had been selected for smut resistance were again evaluated for smut reaction as well as downy mildew and ergot. Six spikes on separate plants within each 25 ft. row were bagged for smut evaluation. Twelve lines showed excellent smut resistance coupled with excellent seed set in all bagged spikes. In addition, 29 lines showed good smut resistance coupled with excellent to fair seed set. Data pertaining to these 41 smut resistant selections has been summarized in Table 28 according to their combined reaction to downy mildew and ergot.

Table 28. Summary of disease reaction of 41 millet lines showing a high type of smut resistance.

Downy mildew reaction:	R	R	S	S	
Ergot reaction:	R	S	R	S	Total
Excellent smut resistant plus excellent seed set.	3	4	3	2	12
Very good smut resistance plus excellent to fair seed set.	8	8	3	10	29
Total:	11	12	6	12	41

Eleven lines showed resistance to all three diseases. However, most lines in their present form are too susceptible to either downy mildew or ergot, or both, to be of immediate use in a breeding program. Seed was also obtained of selected spikes from over 100 additional lines which showed at least moderate smut resistance coupled with at least fair seed set and promising resistance to either downy mildew or ergot, or both. These lines will be further tested in 1972.

A total of 800 inbred millet lines, which were selected by the millet breeder at Kano during the past 4 years from a collection of 2500 lines, were scored for reaction to downy mildew and ergot. Six bagged spikes harvested from each are presently being scored for smut reaction. This material had been selected in the past primarily because of desirable agronomic characters. There was also some selection for both downy mildew and smut resistance, but selection pressure was not of sufficient intensity to ensure selection for a high type of resistance. Twenty-nine lines showed promise for having a high

type of resistance to both downy mildew and ergot. An additional 168 lines showed a slightly lower level of resistance to both diseases. Lines to be studied further in 1972 will be selected after evaluation for smut reaction is complete.

Twenty-two dwarf selections of pearl millet which show little or no infection by downy mildew in Bambey, Senegal, were tested under rather high downy mildew pressure at Samaru. Nineteen of these gave a highly susceptible reaction and the others were moderately susceptible. Most of the material was also susceptible to both smut and ergot. Six lines which showed resistance to downy mildew in Saria, Upper Volta, were also tested. Two of these, which were late maturing photoperiod sensitive types, showed some resistance. Both Bambey and Saria have less rainfall than Samaru, and I suspect that the reason for a higher incidence of downy mildew at Samaru was primarily due to a higher disease pressure, rather than to a more virulent form of the pathogen. Resistant material from Samaru will likely be sent to both of these locations for testing in 1972.

Seed of a millet composite being developed in Senegal was grown at Samaru in 1971. The most encouraging feature about this composite is the high frequency of dwarf plants, each having several long (18 to 30 inch) spikes. The composite looked favorable with respect to downy mildew resistance, but appeared to be highly susceptible to both smut and ergot. Selections from this composite might be included in materials used to develop a disease resistant composite at Samaru.

The West African Regional Millet Trial was planted at Samaru and scored for disease reaction under fairly high disease pressure. As a whole, the nursery was moderate to highly susceptible to all three diseases. Two entries showed possible resistance to smut and ergot. Detailed results will appear in a separate report on this trial.

Several different types of minor millets were grown in S. graminicola infested soil to gain some understanding of the host range of this organism in Nigeria. Several selections of each of the following were planted: fox-tail millet (Setaria italica), finger millet (Eleusine coracana), barnyard millet (Echinochloa sp.), little millet (Panicum miliare), common millet (P. miliacium) and kodo millet (Paspalum scorobiculatum). Downy mildew infection was observed in a few lines, all of them foxtail millet. Foxtail millet has been reported as a host for S. graminicila in India.

MAIZE

At present, fewer diseasc problems are associated with maize in West Africa the farther north it is grown. This relationship is likely due to climatic differences between savanna and forest or riverine areas, and to the fact that relatively little maize is presently grown in the savanna zone. Data accumulated over the past several years in Nigeria indicate that the savanna zone has a potential for maize production which is presently not being realized. Because of this potential, maize is likely to become far more important in this area in the future and the acreage of maize could increase dramatically as the country comes to recognize this potential. With this increase in maize production, disease problems are likely to become more important and control measures more necessary in savanna areas.

Maize pathology has received little research attention in the savanna zones of West Africa. The report presented here in essence is the same as that included in a report prepared for the meeting of maize workers in Ibadan in February 1972. It gives an overall general picture of maize pathology in northern Nigeria, including areas of special research interest.

1. Blight

The blight which occurred in 1970 was the most dramatic diesase ever reported on maize in northern Nigeria. Samaru Composite III, Mexico 5, and NS-5 were especially susceptible at Samaru. The same blight occurred at Samaru in 1971, and the potential for damage appeared to be about equal to that of 1970. However, the incidence of blight was lower in 1971 because relatively less susceptible material was planted.

It seems certain that the blight of 1970 and 1971 was caused by Race T of Helminthosporium maydis. Diseased leaf samples sent to the United States following the 1970 growing season indicated the presence of Race T. Progeny tests both at Mokwa and Samaru indicated that susceptibility was carried in susceptible female parents, which lends support to the theory that Race T was the causal agent of blight in the north. This was further confirmed in 1971 by the reactions of the normal (resistant) and Texas male sterile cytoplasm (susceptible) versions of inbred line CI 64 to natural infection. CI 64 Tms was highly susceptible and was defoliated prematurely by blight, whereas CI 64 (normal) was hardly affected.

The extent of Race T throughout the north is not clearly understood. In 1970, typical Race T symptoms were observed on maize at Mokwa, Samaru, and Kano, and diseased leaf samples from Samaru Composite III and Mexico-5 growing at several Farm Centers indicated that the pathogen was fairly widespread throughout the north in 1970. In 1971,

the disease occurred on susceptible material at Samaru, but was apparently not serious in other locations, although this might have been due to the use of resistant material in 1971 rather than absence of the pathogen. It is believed that much of the local material planted by farmers is resistant to Race T, and because of this farmers were not affected much by blight. During the course of travel(Samaru-Jebba-Jos-Mubi-Kano-Samaru) in August, 1971, typical Race T symptoms were observed on some plants in farmers' fields only in Mokwa area. However, most plants appeared resistant and yield losses were likely not significant. Farmers gave the impression that the disease caused greater loss in 1970 and several indicated that seed for the 1971 planting had been selected from ears of plants which showed little or no disease in 1970.

If natural infection by Race T occurs at Samaru in 1972, information will be obtained on the reaction to blight of progeny of several crosses, mostly reciprocal crosses, within and between several maize populations. Parents of these crosses represented the entire range of reaction types from highly susceptible to highly resistant in 1971. Blight reaction for each parent was scored separately for the leaf blade, leaf sheath, and husk.

Observations made during 1970 and 1971 indicate that within Nigeria altitude is a factor in determining the species of Helminthosporium which causes blight. On the Jos Plateau at altitudes over about 3000 feet, H. turcicum is common and can be severe, whereas H. maydis is practically absent. At somewhat lower elevations both pathogens are present and at elevations of less than about 2000 ft. H. maydis is the common species. At these lower elevations, H. turcicum is practically absent on maize, although it can be prevalent on adjacent sorghum. Plans include planting a trial on the Jos Plateau during 1972 to obtain information on virulence of H. turcicum in Nigeria as compared with virulence of this pathogen in other parts of the world.

2. Rust

Rust (P. polysora) occurs annually in northern Nigeria and has been observed on maize as far north as the Nigeria-Niger boarder. Initial infection likely depends on the annual northward movement of urediospores from southern parts of Nigeria. Rust pustules are generally not observed on maize in the Samaru area earlier than mid-August. However, climatic conditions during the season favor the disease and once the inoculum arrives inoculum increase can be rapid and yield reduction significant in susceptible material. With the increase in maize acreage, there will be fewer gaps in the maize "bridge" which will likely enhance movement of urediospores from south to north. The result could advance the time of initial attack

of rust in the north to the extent that rust resistance will become a more significant objective in the development of maize for the north. In the Samaru area at present, farmers' maize, though susceptible to P. polysora, is generally not seriously affected by rust since plants attain a sufficiently high level of maturity before initial attack. Some selection for rust resistance has been carried out in the breeding program at Samaru.

Observations during August, 1971, suggested that altitude also influences the species of Puccinia which occur on maize in Nigeria. Typical P. sorghi pustules were observed on NS-1 and local maize varieties on the Jos Plateau. A few such pustules were also observed near Biu. A P. sorghi virulence trial will be planted on the Jos Plateau in 1972.

3. Streak Virus

A disease thought to be caused by the maize streak virus commonly occurs in maize in northern Nigeria. In the past, this disease has been thought to be of little consequence and as a result has received virtually no attention. During the above mentioned travel, streak was observed everywhere maize was growing, although losses were generally estimated at less than 5 percent. However, 5 to 10 percent losses were commonly observed in fields along the Abuja-Akwanga-Jos road, and a few fields in this area showed over 50 percent of the plants infected, causing estimated yield losses in the order of 25 percent. Farmers in the area indicated that the disease was more severe than in previous years.

This disease should probably receive some attention in the future. The cause of the disease needs to be identified with a greater degree of certainty, and studies on transmission and varietal response are needed.

4. Witchweed

Witchweed (Striga hermonthica) occurs throughout most of northern Nigeria and can cause severe damage to maize. Symptoms of Striga attack were observed in most areas visited in the northern states in 1971, and yield losses in the neighbourhood of 50 percent were observed in some fields along the Mokwa-Bida-Abuja road. Observations at Samaru suggest that Striga damage can be reduced considerably by using high levels of fertility. However, there is also evidence to indicate that significant yield loss can occur even at high levels of fertility if the soil contains a high infestation of Striga seed.

Virtually nothing is known about genetic resistance to Striga in maize. Attempts to identify genetic resistance within several hundred inbred lines in the U.S. failed. A similar search for resistance to Striga asiatica met with little success in South Africa.

In 1972 an attempt will be made to identify resistance in composites 096, SC_3, NCA, and NCB. If successful, consideration will be given to developing a witchweed resistant version of one or more of these composites.

5. Downy Mildew

There are no confirmed reports of downy mildew on maize in West Africa although two graminicolous downy mildew fungi, Sclerospora sorghi and S. graminicola, commonly occur on sorghum and pearl millet, respectively. During the 1971 growing season, however, symptoms typical of downy mildew were observed on maize at Samaru. Three infected plants were observed under conditions of natural infection in maize breeding plots, and several more were observed in a field having soil artificially infested with oospores. Symptoms, including sporulation of the fungus, were most obvious on young plants and closely resembled those caused by S. sorghi. Infected plants could only be identified with increasing difficulty as they approached tasseling. Oospore formation and leaf shredding were never observed in infected plants. More observations will be made during the 1972 growing season.

TRAINING

A part II student in the Faculty of Agriculture, A.B.U. was given some training in cereal pathology during the long vacation last year. I anticipate having another student work with me during the coming growing season. Mr. S. K. Manzo is expected to return in April from 15 months coursework and training in the United States. He will be devoting most of his attention during the coming year to research on long smut of sorghum. The research results will be used in a thesis for the M.Sc. degree from A.B.U.

SORGHUM

D. J. Andrews

Dwarf varieties and hybrids of acceptable grain type, which are capable of giving higher yields under good cultural conditions are being bred for the main sorghum growing areas in Nigeria. Three main plant maturity groups may be recognised:

(a) Non-photosensitive and early maturing, for use in the Sahel and northern Sudan Savannas. Some direct introductions have been found suitable here.

(b) Of medium maturity (95-110 days to flower) for the Sudan zone. Breeding work at Kano is mainly concerned with this group.

Table 29. SELECTED F6 LINES (CK 60 x LOCAL VARIETIES) COMPARED WITH TWO LOCAL VARIETIES, GRAIN YIELD, 50% BLOOM AND PLANT HEIGHT

TREATMENT	PLANT HEIGHT(cm)	DAYS TO 50% BLOOM	GRAIN YIELD kg/ha^{-1}*
A	206	97	1,722
B	208	97	1,741
C	207	95	1,645
D	241	96	1,598
E	241	97	1,636
F	225	96	1,271
G	225	105	795
H	448	99	1,534

Fertilizing 56 kg/ha^{-1} N
45 kg/ha^{-1} P_2O_5
26 kg/ha^{-1} Muriate of Potash

KEY TO TREATMENTS

A = CK 60 x H-21-3-5-5-1-11-1-1
B = CK 60 x H-21-2-5-5-1-11-2-1
C = CK 60 x A 21-2-5-5-1-11-2-1
D = CK 60 x A 21-3-5-5-2-5-4-1
E = CK 60 x H-21-2-5-5-2-5-1-1
F = CK 60 x A 21-2-5-5-2-5-5-1
G = Zauna Inuwa
H = Yargunki 5760-3-10

* GRAIN YIELD

SE ± 152
LSD 5% = 447

* GRAIN YIELD
SE ± 152
LSD 5% = 447
Nett Plot Size = 21.60sq m.

(c) Of late maturity (120-130 days to flower) for the Guinea zone, which are bred at Samaru.

Subsidiary investigations are also being made on the use of early varieties planted in mid-season in Sudan and Guinea zones and under irrigation and also the use of Guinea zone varieties further south. The sorghums of (b) and (c) groups are frequently grown intercropped (thereby contributing to a more productive crop mixture over the whole season). Dwarf sorghums are therefore being evaluated for their intercropping propensities (see below).

Early varieties.

Fourteen introductions of early sorghum varieties with good grain quality characteristics were grown at Samaru compared with NK 300. Yields were severely reduced by stem borer and the best variety yielded 2,230 kg/ha^{-1} of grain compared to 2,700 kg from NK 300. A small collection of early maturing varieties with floury red or brown grains (or white with a black subcoat) were grown. These would be suitable for poultry food and can be grown under irrigation in the warmer part of the dry season, as birds tend to dislike this grain type before maturity. The best yield of 3,590 kg/ha^{-1} was obtained from variety Damogari No. 55.

Trials and breeding at Kano

1. Six new lines in F_6 generation were put into a yield trial with two improved local varieties (Zauna Inuwa and YG 5760-3-10) to evaluate their yield performance. There were 6 row plots and four replications in a randomised block design.

   Table 29 shows that the highest grain yield of 1,741 kg/ha^{-1} was obtained from treatment B which also had the best performance amongst the new lines the previous year. All the new lines significantly outyielded Zauna Inuwa. Treatment B significantly outyielded only one of the new lines (treatment F). The performance of the new lines was generally better than the previous year. Zauna Inuwa, being late maturing, did not do well this year when the rains stopped early. Many heads were only partly filled. Zauna Inuwa flowered long after the rains had stopped. All the new li · s matured earlier than Zauna Inuwa.

Table 30. NK 300, Zauna Inuwa and YG 5760-3-10 trial grain yield, days to 50% bloom, plant height and threshing percent.

Treatment	Grain yield kg/ha^{-1}	Days to 50% bloom	Plant height cm	Threshing %
NK 300	3,275	65	192	71
Zauna Inuwa	694	105	202	41
YG 5760-3-10	1,842	95	446	63

SE (Yield	+ 195	Fertilizing	56 kg/ha^{-1} N
LSD 5%	= 615		45 kg/ha^{-1} P_2O_5
LSD 1%	= 875		26 kg/ha^{-1} Muriate

2. Yield trial of Zauna Inuwa, YG 5760-3-10 and NK 300.

The trial was initiated in 1969 to compare the grain yield performance of a U.S. hybrid (NK 300) and two improved local varieties (Zauna Inuwa and YG 5760-3-10). There were 6 row plots and six replications in a randomised block design. Table 30 shows that the best grain yield was obtained from the hybrid sorghum NK 300. There were highly significant differences in the grain yield of the 3 entries and the superiority of the hybrid over the local varieties was well demonstrated as could be seen from Table 30. Zauna Inuwa was particularly low in yield. Generallybetter results were obtained this year then the previous years.

Table 31. 1970 Dwarf Sorghum Lines Trials (State Sites)
Grain Yields in kg/ha^{-1}

Line and type	Tumu	Zuru	Fulatan	Bauchi	Mubi	Zonkwa	Mean
1904 (CK-SK) SK	439	655	2,489	658	781	2,151	1,195
1682 "	1,107	1,773	2,489	686	1,014	2,208	1,546
1143 (CK-FF)	121	1,537	2,264	241	643	2,038	1,141
1018 (CK-Kur)	1,210	1,918	2,378	1,532	1,031	1,698	1,628
2123 (CK-FF)	1,104	1,613	2,264	208	557	2,264	1,335
1879 (CK-RC)	933	783	2,264	786	933	1,925	1,271
1878 (CK-SK) SK	974	1,137	2,038	1,400	1,003	1,869	1,403
2141 (GSK-WX)	1,226	2,315	1,811	778	658	1,755	1,424
1685 (CK-SK) SK	1,352	1,508	2,264	983	1,032	2,038	1,529
60 WX	1,368	2,241	1,585	1,060	982	1,869	1,517
5912 Short Kaura	1,752	2,304	2,038	1,082	977	2,264	1,736
1208 (gSK-WX)	1,401	1,638	1,811	693	897	1,585	1,337
Trial Mean	1,082	1,618	2,141	842	876	1,972	1,422

Fertilizer: 50 kg/ha^{-1} P_2O_5
80 kg/ha^{-1} N (Split)

Plot size: 10.00 m^2
Population 48,000 ha^{-1}

3. Breeding material

One hundred nineteen F_5 lines were grown in unreplicated plots for observations on desirable characters such as disease resistance, lodging resistance, good panicle size and seed quality. Many of the lines were found susceptible to weathering thus resulting in unacceptable grain quality and those lines that matured late had a few scattered grains on the heads. This could be due to the fact that they flowered long after the rains had stopped. Forty-two lines were selected for further observation and yield evaluation. Eighteen F_2 populations from Samaru were grown and 118 promising single plant selections were made.

Trials and Breeding at Samaru

1. Variety trials

Eight dwarf varieties were tested in the 1971 Dwarf Lines trial located at 4 sites near Samaru and 9 locations in the States. Since the results from the State trials are not yet complete, the 1970 results, not previously reported, are shown in Table 31. The yields were poor in this series, the average yield in trial being only 1,422 kg/ha^{-1}. The yields from the 4 trials of the 1971 series planted near Samaru (Table 32) were high in spite of the rains ending early. A new entry, line 529 performed well, giving a slightly higher mean yield than Short Kaura. This line is shorter (1.75 m), has the ability to tiller, and gave as good a yield as any under severe striga infestation (site 1). Line 453 gave a rather poor yield, though in a reselection trial and in the intercropping trial (Table 32) it gave a yield comparable to Short Kaura. Both 529 and 453 have grain qualities superior to that of Short Kaura. Twenty-one observation plots comparing dwarf varieties with recommended Local varieties were also planted at State sites in 1971. In some of these experiments the sorghum plots were divided for with and without an intercrop of early millet (ex Bornu) or early maize (Bomo Local improved). The results shown in Table 32 indicate that at four out of the five sites intercropping gave 20 to 40% more yield than if sorghum is grown alone. Two dwarf varieties, 2123 and 2141, gave larger gains with intercropping than the tall varieties.

Table 32. 1971 Dwarf Sorghum Lines Trials (4 Sites Samaru area) Grain Yields in kg/ha^{-1}

Line and type	(1(* U. Farm	(2) Field X5	(3) Shika E	(4) X3	Mean Yield (2)+(3)+(4)
Dwarf Lines					
1143 CK-FF	313	4,938	3,345	3,709	3,997
2123 CK-FF	540	4,233	3,033	3,952	3,739
756 (WX-ISN7)	426	2,331	2,435	1,322	2,029
1161 CK-FF	924	3,582	2,671	3,483	3,245
Semidwarf Lines					
453 S/K (SK-MDW)	1,336	2,430	2,759	3,184	2,791
5912 Short Kaura	2,545	4,376	3,719	4,051	4,049
529 (WX-SK)	2,473	4,534	4,305	4,349	4,396
2141 (gSK-WX)	2,360	3,894	4,307	3,653	3,951
Trial Mean Yield	1,366	3,790	3,322	3,463	3,525

* This trial was badly damaged by Striga

Fertilizer: 50 kg/ha^{-1} P_2O_5
80 kg/ha^{-1} N (Split)

Plot size: 11.70 m^2/(1) 7.80 m^2) Site

Plant population 59,000 ha^{-1}

Table 33. Sorghum intercropping observation plots at S[illegible]
Yields of sole and intercropped sorghum, intercropped millet (or early maize) and total intercrop yields in Kg ha
Ratio in Intercrop - 2 sorghum plants: 1 millet (or maize) plant

Sorghum variety	Zuru Sole	Zuru Int.	Bauchi Sole	Bauchi Int.	Tumu* Sole	Tumu* Int.	Hong* Sole	Hong* Int.	Nubi* Sole	Nubi* Int.	Means Sole	Means Int.	% Gain of Int.
Local (Tall Farafara)		760		814		1,435		998		1,266		1,055	
Interplanted millet		109		217		253		852		434		373	
Total	760	869	664	1,031	1,796	1,688	1,217	1,850	1,446	1,700	1,177	1,428	+ 21
FF[illegible]-1-6 (Tall farafara)		741				1,003		1,555		1,308		1,277	
Interplanted millet		145				398		1,121		741		601	
Total	723	886	-	-	1,542	1,401	1,699	2,676	2,079	2,549	1,511	1,878	+ 24(1)
SK 5912 (semi-dwarf)		416		1,067		1,595		1,356		1,808		1,208	
Interplanted millet		905		362		796		693		976		746	
Total	860	1,321	1,494	1,429	1,942	2,[illegible]	1,772	2,049	2,260	2,784	1,667	1,954	+ 17
2123 (dwarf)		307		1,246		1,511				1,212		1,019	
Interplanted millet		723		416		1,157				1,483		945	
Total	723	1,030	1,670	1,662	1,596	2,668	-	-	1,665	2,695	1,413	1,964	+ 39
423 (semi-dwarf)				923								923	
Interplanted millet				180								180	
Total	-	-	1,428	1,103			-	-			(1,428	1,103	- 23)
2141 (semi-dwarf)								2,135				2,135	
Interplanted millet								1,194				1,194	
Total	-	-					2,396	3,329			(2,396	3,329	+ 39)
Means	768	1,026	1,314	1,306	1,606	1,935	1,771	2,475	1,862	2,431			
% Gain of Intercrop		+ 34		- 1		+ 20		+ 40		+ 31			

Plot sizes: 240 m^2.
Fertilizer: 46 Kg ha P_2O_5: 79 Kg ha [illegible].

*Early maize used instead of millet.
(1) Mean of 4 sites only.

5912 showed less gain, this result being at variance with the result of the intercropping trial (below). Six progeny or reselection trials were carried out on promising lines emerging from the breeding material. In particular these identified the best reselections of the 529 and 453 types noted above. The West African Guinea zone yield nursery (ex STRC/JP.26) was grown with 10 entries. The best three yields were given by Nigerian material viz.: hybrid 93 x 2083, 3081 kg/ha^{-1}; Short Kaura 2848 kg/ha^{-1} and Line 2123, 2587 kg/ha^{-1}.

2. Hybrid trials

Four hybrid trials were carried out at Samaru in 1971, with the objective of testing various specific combinations and identifying which families of material among the Samaru stocks combine best. Crosses between Farafara and Kaura derivatives usually show good vigour and an elite grain type. Experimental hybrids have now been made and tested over the past 5 years and the results are summarized in Table 33. In 1971 a yield of over 5,000 kg/ha^{-1} was recorded for the first time in trial from a hybrid, and the average yield levels were also higher than before. Till now one female only (no. 93) was available for making hybrids. This however was very susceptible to damage from Striga which tended to carry over into hybrids made on it. (The 1970 trial was infested by Striga which caused the enhanced variety yield by lack of competition). However, in 1971 five groups of new B lines of diverse origins were identified. These are known as (i) RCS (ii) RCF (early and late lines) (iii)ISN x 2123 (iv) CKB x 3952 and (v) CKB x Kurgi. Plantings have been made (11/12/71) at the newly developed irrigation area at Mokwa with the intention of producing enough hybrids to fully explore the potential of these new seed parents. Hybrid tests will be conducted at a limited number of State sites in 1972.

3. Breeding

Selection was continued within the pedigree nursery containing lines from F_4 on. Nine acres of F_2's were grown both from hand emasculations and specific crosses onto genetic male sterile plants. The composite breeding work, using the male sterile factor ms7, has been enlarged assisted by the facility of a new irrigated area at Shika.

Table 34. Sorghum Variety x Intercropping Yield Trial 1971

Grain Yields in kg/ha^{-1}, and intercropped sorghum yields as a percentage of the variety sole crop yield

Treatment	Farafara BL3-1-6 (Tall - 4.5 m)		Short Kaura 5912 (Semi-dwarf - 2.2m)		Line 453 (Semi-dwarf - 2.0m)		Line 2123 (Dwarf - 1.2 m)	
	Kg ha^{-1}	%	Kg ha^{-1}	%	Kg ha^{-1}	%	kg ha^{-1}	%
Sole Crop Sorghum	1662	100	2763	100	2796	100	2600	100
Sorghum) Millet) alternate rows	1165) 1613) 2778	70	1829) 1718) 3547	66	1766) 1753) 3519	63	1511) 2069) 3580	58
Sorghum, alternate rows not planted	1845	111	2755	100	2147	77	2477	95

Fertilizer: 50 kg ha P_2O_5, 80 kg ha^{-1} N (split). **Net plot size:** 23.4 m^2

This permits a second generation of the composites to be grown each year. The original bulk (now designated Composite Z) will give selfs this dry season so that S_1 testing can commence in 1972. Two new composites, Composite Y and the West African Base Composite are in their second recombination generation (F_3). Seed of these will provide suitable material for other locations as a wide range in maturity has been retained.

4. Sorghum Variety Response to Intercropping.

Four sorghum varieties, comparing the tall local type (Farafara) with semi-dwarf (Short Kaura and Line 453) and dwarf (2123) varieties were planted in a randomised split-plot design with 5 replicates. The sorghum variety plots were split into sole crop sorghum, sorghum interplanted with millet on alternate rows, and sorghum with alternate rows unplanted. All crops were planted on the same day at a spacing of 23 cm x 71 rows (61,000 plants per hectare) except for Farafara at 30 x 71 cm (47,000 plants per hectare).

The yields obtained (Table 34) show that the intercrops using the dwarf varieties gave about 750 kg/ha^{-1} (27 percent) more grain than with the tall local type. The contribution to the increased yield came both from the dwarf sorghum and the millet. In the case of the latter it can be seen that the yields increase the shorter the variety of sorghum used. Conversely, among the dwarf sorghums the shorter (less competitive) varieties showed more yield reduction, though even the shortest, 2123, still gave 346 kg/ha^{-1} (30 percent) more grain than Farafara when intercropped.

5. The use of Samaru dwarf varieties at Mokwa.

It has been found possible to plant Guinea zone (Samaru) dwarf sorghums in the 'dry period' (late July) in the bimodal rainfall pattern at Mokwa, which then grow on the second rains and mature in December, at the same time as the Mokwa local sorghum planted in May. Though inadequately investigated as yet, plantings made later than early August suffer increasing shoot fly attack, thus making the use of sorghums of shorter duration difficult.

Mokwa is representative of large areas of the southern guinea and derived savannas in Nigeria where, if sorghums could be found to grow on the 'second rains' they would be of great use since second crop maize is usually poor. Experimentation on this aspect has been conducted at Mokwa since 1969 (though experiments failed in 1970 due to a poor site) using both variety comparisons and planting date tests.

In 1969 the best variety yielded 1,680 kg ha and a hybrid 2,370 kg ha. Stem borer damage was noted and in 1971 the experiments were conducted with and without a single application of Thiodan (± 11 kg/ha 5% granules). The results of the variety comparison, a semi-dwarf variety (5912) versus the dwarf variety 2123 are shown in table 35. On variety 5912 the use of Thiodan increased the grain yield by 84% (1,133 kg ha).

The same effect was noted in the 1971 planting sequence using variety 5912 (Figure 1) which also shows the untreated 1969 yields. The first 3 plantings 19, 26 July and 2nd August all flowered within 4 days of each other (23-27 October) due to photoperiodic response, which is the optimum time of flowering at Mokwa. It appears that the use of Thiodan allows planting to be made over a three week period with this variety.

Further investigations will involve later planting of quicker maturing varieties (including a variety showing recovery resistance to shootfly) and more than one application of Thiodan.

Table 35. Sorghum variety x Thiodan Trial - Mokwa 1971
Grain yeilds and other data

Treatment	Grain yield kg/ha	Ave. No. of heads/plot	Ave. height (cm)
Variety short Kaura 5912			
with insecticide	2,489	315	172
without "	1,356	199	155
Line 2123			
with insecticide	1,594	279	107
without "	1,296	272	100
S.E.	+ 112	–	–
LSD 5%	- 288		

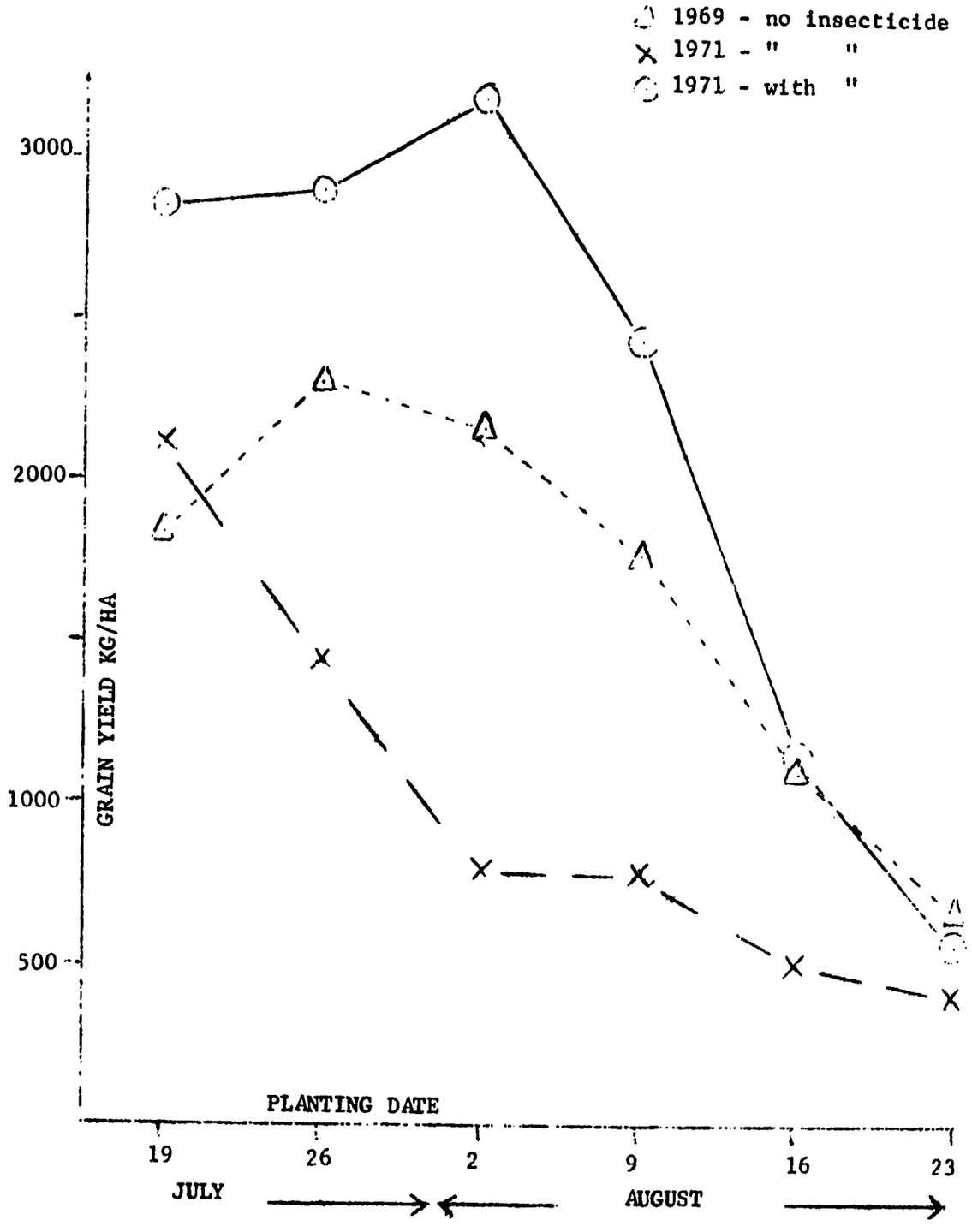

FIG.1
Effect of planting date on sorghum grain yields at Mokwa 1969 and 1971.

Millet Breeding

In the absence of a millet breeder at Kano the 1971 programme was reduced to maintenance of stocks and the continuance of breeding material. Inbreeding in 800 selected gero lines was continued, originating from Nigeria, Senegal, Mali and the world collection. 880 Maiwa inbred lines were carried through to S_4's. Lines from both these collections, and other synthetics will be used to form future breeding composites. Male sterile A and B populations, both of the gero type (GA1, GB1) and of the maiwa type (MA1, MB1) were grown and mass selection continued within the B populations. Hybrids will be produced on these steriles for testing in 1972. Improvement work on the "ex Bornu" type of millet continued at Samaru where one S_1 cycle of testing was completed. In a yield trial (Table 36) first cycle material was only slightly better than the parent bulk for yield, but the wild type "chibre" characters has been completely eliminated by the one cycle of breeding. It is possible that recombination among the S_1's, attempted in the dry season, was incomplete. Each bulk was therefore grown again in the wet season 1971 and S_1 testing will be continued from these.

Table 36. "Ex Bornu" millet composites yield trial Samaru 1971.

Treatment	Grain yield (Kg ha)
1. Short composite C_1 (S)	2,288
2. Yield " "	2,142
3. Mass selection 1970 C_7(M)	2,114
4. Non-lodging composite C_1(S)	2,105
S.E.	± 119

Table 37 Columbian Composite S_1 Trial Mokwa 1971

Yield of dehusked cobs in kg ha^{-1} of 20 selected S_1's and 3 checks (C_2)

	Location means				
Entry	Reps 1 & 2	Reps 3 & 4	Reps 5 & 6	Reps 7 & 8	Overall mean
11	7584	3971	7051	3823	5607
12	8295	6329	7322	5008	6739
13	9097	4150	6961	3058	5817
24	8326	5506	5062	2509	5401
28	8272	4964	7413	5439	6522
51	9175	4076	7684	4353	6322
77	13385	8408	12386	7909	10522
85	10378	4867	8317	4345	6977
93	9419	3427	9493	4079	6605
100	8311	4251	6961	3621	5787
103	13446	7416	12204	4408	9369
107	7454	5010	8950	3922	6334
115	8126	4875	7051	2226	5570
121	9246	7319	7233	3873	6918
137	10864	3797	6871	2380	5973
138	8543	5883	7774	4623	6706
142	6597	3172	73222	3291	5096
162	8284	4717	8770	3121	6223
163	9198	4889	8408	3208	6426
164	8412	3992	7322	4275	6000
Checks					
39	13100	8582	12024	6892	10150
49	11316	6433	11301	6977	9007
81	12727	6955	11030	6040	9188

Maize Breeding - early varieties

Sixty-four S_1's made from Samaru Synthetic were tested at Samaru in 1971. Samaru Synthetic was made several years ago from early maturing U.S. types, and like Bomo Local, a more uniform type, is intended for use as a vegetable maize. The S_1's showed much useful variation for earlyness, cob height and number, disease resistance and yield. Twelve were selected ranging from 3,500 kg ha^{-1} dry cobs.

Bomo local, unselected Samaru Synthetic and the variety hybrid were compared in a yield trial and gave, respectively 4350, 3400, and 4890 kg dry grain perhectare in 96 days.

6. Breeding at Mokwa

At Mokwa in the absence of a maize breeder work was kept to the maintenance of varieties except for the Mokwa Colombian composite. This is thought to be the most promising material and two cycles of full sib testing have been completed on it. In 1971 an S_1 trial of 169 entries was planted at 4 locations, 2 replications per location. The 20 best S_1's were selected and planted (11/12/71) to make full sibs in diallel for 1972. The yields (dehusked cobs) were rather high as shown in Table 37. The mean yield of the check (i.e. cycle 2) was equal to 6,600 kg dry grain per hectare.

ENTOMOLOGY - SAMARU

G. T. York

Insect problems associated with cereals production were similar to those of previous years. Probably the most interesting happenings were the abundance of stem borers in certain limited areas, as well as the lack of them in another area. At one field north of Funtua a local variety of sorghum was virtually destroyed by first brood stem borers *Busseola fusca*. This was the first time in six years that such destruction of early local sorghum has been seen. Later in the season another field east of Funtua was destroyed by second brood borers. The variety was an improved dwarf but we have not been able to determine its exact identity. However it served to emphasize the point that if high yielding dwarf varieties are planted and pests become numerous on them it is essential to control these pests with chemicals to obtain a satisfactory yield.

Shoot flies

Work on the taxonomy of the genus *Atherigona* was completed by Mr. J. C. Deeming and has been published as follows: "Some species of *Atherigona* Rondani (Diptera, Muscidae) from northern Nigeria, with special reference to those injurious to cereal crops" in the Bulletin of Entomological Research 61:133-190, 1971.

Mr. Deeming's summary follows to give a brief idea of the scope of the work; "In this taxonomic study of the genus Atherigona, an important group of cereal pests, 50 species and one subspecies collected in northern Nigeria are systematically treated; of these 23 species are described as new. A subspecies from Uganda of one of the new species is described as new. Two Ethiopian and three Malgasian species are redescribed from type material. Two species are revised from synonymy. Partial redescriptions of many species are given. Descriptions of immature stages are given where known, and host plants and parasites recorded. Brief notes are given on other Diptera which cause deadhearts in cereals in northern Nigeria.

Chemical control. Several trials were made on different phases of chemical control. Most of these were on seed treatment as this seemed to be the simplest and most feasible control practice.

Previous work in 1970 had indicated that one gram of the 75% carbofuran wettable powder to 25 grams of sorghum seed gave good control of shoot flies, whereas only one gram of insecticide to 50 grams of seed gave some control but less than the stronger dosage. All work thus far carried on with the wettable powder has been to use it as a dry powder and rely on the sticking quality of the powder to cover the seed. Observations indicated that the one part powder to 25 parts seed was near the maximum amount of insecticide that could be expected to adhere to the seeds. All work in 1971 with carbofuran was at this dosage of one part insecticide to 25 parts seed.

Due to circumstances beyond our control the seed of NK 300 and C9357 for the 1971 season did not reach Samaru. It had been planned to use some of this for testing the carbofuran seed treatment in two or four row mechanical planters. Lacking these seeds the variety which is presently under the designation U10 was used. U10 is a selection from the Uganda material that was tested for shoot fly tolerance. The U is for Uganda, and 10, the tenth selection in the 1970 test under the variety designation 158-P-1-1-SB 79. This variety was selected as the most promising for shoot fly tolerance, growth habits and yield. Seed of such a variety would not normally be used for checking yield potential of seed treatments but since it was the only thing available it was used.

The planting was made on August 14, 1971 with a two row tractor drawn planter. Treated seed was put in one seed box and untreated in the other. This accordingly put two rows of treated seed together and two untreated together. In determining shoot fly attack only two rows of each were sampled. Infested plants were removed from the sampled rows. Counts of infested plants were as follows:

Date	Treated	Untreated
Planted Aug. 14		
Sept. 4	3	63
Sept. 11	166	275
Sept. 18	106	87

It may be noted that three weeks after planting (Sept. 4) there was a decided difference in infestation. At the four weeks period infestation in treated seed had increased considerably. Total infestation for the two periods is twice as much in the untreated as in the treated. The higher count on the fifth week may be accounted for by the fact that in the untreated portions plants had been removed when infested and there were no more available plants to attack.

In the remaining portion of the field where no plants were removed there was quite a difference in the visual appearance of treated and untreated portions. However, as plants neared the heading stage there was little or no perceptible difference. This was of course due to the fact that the variety U10 has the ability to tiller well and tillers reach a uniform height comparable to that of an uninfested stem. Early dry weather prevented a valid checking of yield differences. Of course, as mentioned earlier, one would not particularly care to check seed treatments on this variety, but would need to determine its usefulness on more susceptible varieties, in comparisons with tolerant varieties.

Several other plantings were made by hand using treated and untreated seed of three varieties, NK 300, U10 and CK60. Planting was in late August and early September. Early draught permitted only check of infestations during the early stages of growth. Infestations that were recorded were as follows:

Variety	Treated			Untreated			Total
	R1	R2	R3	R1	R2	R3	
NK 300	0	0	0	41	51	56	148
U10	0	0	0	63	75	60	198
CK60	0	0	0	21	60	32	113
Total	0	0	0	125	186	148	459

This shows excellent control in the early stages of plant growth. Later counts would undoubtedly have shown infestations in the treated material.

Treatment of the ratoon crop was tried in a very preliminary way on three occasions. These were in conjunction with soil science work in trying to increase total dry matter.

In the first instance a small section of the variety NK 300 was cut rather early to get some idea of tillering and regrowth. At the first examination, following a report of poor growth, it was noted that shoot fly injury was severe. Side dressings of phorate granules at ten pounds per acre were made on six plots of four rows each, leaving an equal amount untreated. Continued observations through the growing season failed to show any visual difference between the treated and untreated areas. Injury from shoot flies remain high and only scattered heads of sorghum reach maturity.

Another block of sorghum (dwarf farafara) was cut a bit later. A section of this 30 yards long by 12 rows wide was treated in the same manner as the NK 300. Severe shoot fly injury was again noted, with no apparent difference between treated and untreated portions.

In the last tests the NK 300 was cut when the grain had matured. Treatments were 10, 20 and 50 pounds per acre of phorate granules in plots four rows wide and 20 yards long. Again there was no noticeable reduction in shoot fly infestation even at the high and uneconomical rate of 50 pounds per acre. (Two rows of the high rate look good but the four rows of the adjacent check plot were just as good).

From this preliminary work it was concluded that treatment of mature sorghum plants with phorate granules as a side dressing was not possible.

During 1970 a side dressing of phorate granules was used on young plants and this appeared to give very satisfactory control (Seventh Annual Report of the AID-ARS Project, Major Cereals in Africa 1970, p. 86). Although there was no plot work for comparative results in 1971, the method was used by Dr. King on late season nursery work, and a small trial for Mr. Andrews and in both cases satisfactory results were obtained.

Plant Resistance

Seed from the 1970 International testing program was saved and replanted in 1971. Differences in the amount of shoot fly infestation were noted as in the 1970 trial. However, these differences do not seem to be sufficiently clear cut and distinct as to warrant a breed program for incorporating this resistance into local varieties at least under the present conditions and facilities at Samaru.

Recently Dr. W. R. Young of the Rockefeller Foundation of India has suggested a somewhat smaller scale trial for 1972. Seed for this test has already been subjected to one cycle of selection pressure under greenhouse conditions at Hyderabad, India. Such a procedure should increase the effectiveness of the resistance. Arrangements are being made to import this seed so that it can be tested at Samaru in 1972.

Plant Tolerance

Plant tolerance differs from plant resistance in that there is no particular concern as to the amount of shoot fly infestation. The emphasis is on the ability of the infested plants to send up uniform sized tillers that mature within a relatively short period of time to the uninfested stem and thus produce a good crop of a uniform maturity date. The first test of such material was in 1970 with seed from Uganda (Seventh Annual Report 1970). It was reported that the final outcome of the test was quite satisfactory and one selection, 158-P-1-1-SB79 was selected for more extensive testing.

Seed from the experiment was planted on the 1970-71 irrigation plot. This was a small planting six rows wide by 10 yards long. Even though shoot flies were not a problem during the dry season, the growth and development of the plants was very good. Some 20 pounds of seed was collected from the plot. A few heads which did not completely exsert from the sheath were eliminated.

The seed from the irrigation plot was planted at two different dates during the 1971 rainy season, July 24 and August 14. Planting was done with a two row, tractor drawn planter. Both plantings were heavily infested with shoot flies, estimates being from 90 to 98 percent of the plants infested.

The July 24th planting had an extremely poor appearance with the high shoot fly infestation. There was a strong feeling to say "Lets plow it under and forget the whole thing". Then by September 20 many tillers were growing well and the general situation was vastly improved. Quite uniform height of plants developed and started flower in early October. A yield estimated between 1000 and 1500 pounds per acre was produced in spite of the early cessation of rain. About 300 pounds of seed was taken from a portion of the field for future work. This variety looks very promising from the standpoint of shoot fly tolerance and its ability to produce a respectable crop in spite of the shoot fly infestation.

The second planting made on August 14 also made a good recovery from the shoot fly infestation. However with the early stoppage of rain in late September the yield was quite light. It was however considered sufficient to be combined harvested and used for stock feed on the farm.

Incidentally this variety U10 has not been considered or tested for human food, but would be used as a livestock feed.

The tolerance experiment for 1970 consisted of 48 entries. Of these, two were selected for additional testing. One is quite similar to U10 while the other is somewhat shorter in height and has a larger and slightly more open head. Many of the entries had the poor character of short peduncle with only partial head exsertion.

Stem borers

The most abundant and destructive stem borer on sorghum in the Samaru area is Busseola fusca Fuller. This statement should be qualified to state that it is destructive only during the rainy season. In the dry season it is in larval diapause hence causes no damage. In addition to sorghum it is occasionally found on millet and corn.

The principal stem borer of millet throughout West Africa is Coniesta ignefusalis. There is apparently some confusion on the generic name as it has recently been referred to as Acigona as well as Haimbachia. Both have retained the species name ignefusalis. Infestations are extremely variable, ranging from nothing up to 30 or 40 borers per stem. Damage is generally light. Infestations of 10 to 20 borers per stem have been noted with little or no injury to the head.

Several species of Sesamia are present in the Samaru area. Since they do not have the larval diapause during the dry season they infest corn, sorghum and millet that is grown under irrigation. Experimental plantings of corn appear to be the preferred host. Farther south where corn is the main cereal crop Sesamia spp. are the most destructive pests.

The Sorghum Stem Borer Busseola fusca. Population studies.

This work has dealt primarily with populations as they affect the growing crop. It has been carried on for several years but a general summary of the situation seems in order now. Previous workers felt that the destruction of stalks during the dry season and certainly before the emergence of moths at the beginning of the rainy season, would materially reduce the borer population for the coming season. However, due to the many uses for the stalks such as fencing, fuel, bedding, livestock food and others, the local populations was not inclined to follow the recommendation of destroying the stalks. It was thus assumed moths emerging from these stalks were responsible for the continuation of borer populations in an area. It was felt that populations were high around villages where the stalks were more abundant.

In 1966 there was an attack of stem borers on sorghums late in June. Webster (Third Annual Report 1966, p. 11) reported "This is the most severe damage which borers have caused at Samaru". Attempts to control this infestation with five percent DDT dust were not effective. (Same Report P. 17, York). One point not recorded was the fact that this infestation was uniform over the entire experiment area. It was the practice at that time to destroy all sorghum, maize and millet stalks by burning, hence there was no chance of the infestation from an immediate local source. Moth flights from an unknown source were accordingly responsible for this infestation.

In 1967 three light traps were operated during the rainy season to obtain information on the flight pattern of Busseola moths. Data obtained indicated the early flights were from an outside source and were generally distributed over the Samaru area. The 1968 infestation was as severe as that of 1966. Plant damage was first noted in early July and control experiments were started on July 12. This period of infestation did not correspond with moth emergence from stalks since it was too late for the emergence and too early for a generation to be produced. It was accordingly assumed that the 1968 infestation was also from an outside source.

The 1969 infestation was quite low and no pertinent data were obtained on flight activities.

The 1970 infestation was again very light during the period when infestation can cause the most damage. By early August heavy infestations were noted. Late infestations as in 1969 and 1970 might be caused from local sources but the intensity and general uniformity still points to migratory moths.

During 1971 additional points of interest were noted. In previous years an occasional stem borer was found on young sorghum. Since these plants did not have the usual leaf feeding characteristics of Busseola and larval habits were typical of Sesamia it was assumed these were larvae of Sesamia. (In the larval stage the two species are almost identical, separated only by setae arrangement on the ninth abdominal segment. K. M. Harris, Lepidopterous Stem Borers of Cereals in Nigeria; Bul. Ent. Res. 53:1 April 1962). Thus the fact that Busseola can reproduce on very small sorghum plants adds some evidence to the possibility local sources serving as an important source of the borer infestation. On the other hand Harris (same publication) records the light trap catch in May, 1960 as 40 males and 258 females, July 21 males, 13 females, August 41 males and 15 females and September 62 males and 51 females. He attributes the high female catch in May to greater attractiveness to light by females at this time of year.

One might, with equal assurance, assume there was a migration of females into the area from an outside source. Lacking further evidence one can only say there is a good possibility that migrant moths are the main source of the early and most destructive populations of Busseola fusca in the Samaru area.

In 1971 the first case was observed of almost complete destruction of early local sorghum by stem borers. This was near Funtua some 45 miles northwest of Samaru. Ordinarily local sorghums are only lightly attack, presumably having a fair degree of resistance through centuries of selection. Another field in the same general area suffered a similar fate at a later date when borers are more common. This field was planted to one of the improved varieties, but the precise variety has not been determined. Some 100 miles farther northwest no borers were found.

Light traps have been used for the past five years to give information on flight activity of Busseola and Coniesta. It was felt that information was fairly reliable as catches followed a similar pattern at the three locations although not necessarily of the same magnitude. During 1971 three virgin female traps were obtained for comparative testing with the light traps. It seems sufficient to say that results with these traps were very poor and no further work is planned with this type of trap.

Chemical Control

The work on chemical control of the stem borer Busseola fusca was limited to two insecticides endosulfan, and pyrimphos methyl. Most of the work was with endosulfan. Six tests using pyrimphos methyl were for comparing results with endosulfan which is now used as the standard control. Results of these tests are shown below.

An average was made of the first three tests to show differences of the hybrids which matured toward the end of the rainy season and had fairly high yields. The variety 2123 is a long season late maturing sorghum that had the yield drastically reduced by lack of late rains. All six tests indicated a marked improvement in yield by the endosulfan treatment over that of the pyrimphos methyl. And in five of the six tests pyrimphos methyl increased yield over that of the untreated check plots. In all of these tests only one application of granular insecticide was made.

Yields in pounds per acre from stem borer control tests in 1971.

Location	Variety	No. of samples	Treatments endosulfan	pyrimphos methyl	check
Samaru - BP4	C 9357	2	1937	1031	601
" "	NK 300	2	2190	1520	1182
" "	"	2	2574	1255	824
Average			2234	1269	869
Samaru Zed	2123	1	522	346	302
" "	2123	1	447	382	185
" "	2123	1	464	180	206
Average			478	303	231

At the start of the stem borer season the granular applicators previously used (Annual Report 1969, p. 78 and 1970 p. 88) were again used. However, requests for treating experimental plots were high and it was difficult to cover all the area when the requests were made. It had been previously noted that the endosulfan granules were of very good free flowing quality. Often the hand crank of the applicators was not used since the rate of flow was uniform anyway.

With the need for additional applicators and the free flowing quality of the granules, it was decided to check the possibility of simply making holes in some sort of container. A number of plastic containers suitable for food storage in refrigerators were on hand, having been previously purchased for seed storage. Various sized holes were drilled in these. Placement of the holes was also varied. The final outcome of these testings was an eleven sixty fourth inch hole in the lower level of the container. The size selected was the largest available on the hand punch drill. One fourth inch size would undoubtedly work just as well. One, two and three holes per container were tried. Limited trials indicated one hole delivered sufficient insecticide for adequate control.

The versatility of this applicator has turned out to be quite useful. When placed on a long stick it can be used to treat plants of uneven height from two to twelve feet such as one might encounter in the World Collection. Placed on a short stick it can be used for soil applicators such as side dressings for shoot fly control. Another important feature is the fact that the container can be flipped to the upright position with no leak or dribble, and no valves or moving parts to get out of order.

After working with the single applicators for a short time it was decided to place two of these at proper row distance and have a two row applicator. This proved quite satisfactory for uniform height plants. The next step was to place two of the two row applicators together for a four row applicator.

This four row applicator proved to be quite successful. Held in the position shown it automatically swings to a point where the holes are at the lowest point thus assuring a continuous flow of practically all of the insecticide. At the end of the field it is flipped to the upright position thus causing a complete shut off of all insecticide. If two men work together with four extra containers one man can fill the containers while the other is making an application. When a round is finished the somewhat emptied containers are slipped off, the full ones attached and the man who has done the filling takes off on the next round.

At the University Farm (formerly the NTC or Nigerian Tobacco Company Farm) our preliminary testing of the four row applicator on a large field planting of sorghum appeared quite promising. A request was made by the farm manager, Mr. D. Couper for additional insecticide to treat a more extensive area of the field. One hundred pounds of endosulfan granules, and the four row applicator were delivered to the farm. A laborer was given some 15 or 20 minutes instructions and the work was then turned over to him. No record was made of time involved or area covered. Results at the end of the season from the one application were sufficiently outstanding to have an order placed for sufficient insecticide to treat all sorghum if stem borer infestations warrant it.

Our test at the University Farm, based on yield expressed as pounds per acre were as follows:

Endosulfan		Untreated
1	1784	833
2	1208	640
3	1231	395
4	1363	614
Average	1396	620

It is obvious that with yield differences of this magnitude one can readily see the advantage of treating for control of the stem borer.

Ten tests were made on the variety 2123 using different applicators, and amounts of insecticide at different periods during borer development. Marked differences in plant growth and head emergence could be noted between treated and untreated portions during the growing season.

One trial was made to obtain information on early and late applications of endosulfan on two varieties of sorghum, Dwarf Farafara and Short Kaura. This work was in cooperation with Mr. Andrews who planted and took care of the plots, while we made the insecticide applications.

Results indicated an appreciable yield increase on the Dwarf Farafara from the early application with only minor differences in the late and double applications. With the Short Kaura there were no differences; in fact the untreated checks were in the higher catagories. Observations had indicated there would be no differences on the Short Kaura.

Andrews in his report to the Cropping Scheme (March 6, 1972) reported, "At Mokwa Short Kaura yields were increased from 1,210 to 2,220 lbs/acre by one application (of endosulfan granules)".

This work, along with numerous other tests and observation, emphasize the fact that there is no hard and fast rule for determining yield increases from insecticidal treatments for stem borer control. Undoubtedly the most important factors concerned are the time and intensity of the infestations in relation to the stage of growth of the sorghum. Contrary to what might be expected the major damage by stem borers is not in their actual boring in the stem but by their feeding in the growing tip of the plant and eventually killing this portion. It is true that boring in the peduncle can cause an appreciable loss but this is usually minor in comparison to the earlier damage. There are undoubtedly differences in varieties in their resistance to stem borers but this phase of the work needs more study. Thus far we have never found a variety that is immune to attack.

To sum up the chemical control of stem borers, one application of five percent endosulfan granules has given excellent control. The need for control depends on the time and intensity of the infestation in relation to plant growth with some consideration being given to varieties. Under conditions where severe injury is likely, control measures are essential to produce an acceptable yield. A cheap, feasible, and efficient hand applicator for five percent endosulfan granules was developed and used during the 1971 season.

Sorghum Midge

One hundred and five varieties of sorghum were selected from a part of the World Collection grown at Samaru in 1970. This selection was on the basis of possible resistance to the sorghum midge *Contarinia sorghicola*. Seeds were planted in the spring of 1971, with border and intermediate rows of the hybrid NK 300 for developing a high population of the midge to insure proper testing. Unfortunately the NK 300 was all planted at one time and, although there was some cutting of plants to produce tillers, there was not a sufficient carry-over of host material for infesting all of the varieties. Thus, although some selections look promising, the good seed development may be due to a low midge population rather than resistance to the insect.

This matter of developing a good midge population has been troublesome ever since the work was started several years ago. Presumably sequential plantings of NK 300, protected against shoot flies and stem borers, could produce the desired midge population if it was grown in sufficient quantity. Other factors that could further disrupt an experiment might be early cessation of rain, and damage by striga. The problem warrants continued and intensified study.

EAST AFRICA

E.A.A.F.R.O./A.I.D.
Sorghum and Millets Unit
Serere, Uganda

1. Staff

* L. V. Peters, B.Sc., M.S., Ph.D.	Plant Breeder/Geneticist
** J. J. Kern, B.Sc., M.S., Ph.D. arrived 1-12-72	Plant Breeder
* B. D. Barry, B.Sc., M.S., Ph.D., departed 10-7-71	Entomologist
* J. L. Overman, B.Sc., Ph.D., arrived 8-7-71	Entomologist
* R. J. Davis, B.Sc., M.S., Ph.D., departed 12-9-71	Soil Scientist/ Agronomist
* L. E. Allison, B.Sc., M.S., Ph.D., arrived 11-11-71	Soil Scientist/ Agronomist
* D. K. Whigham, B.Sc., M.S., Ph.D., arrived 4/17/71	Trials Officer, Uganda
S. Z. Mukuru, B.Sc.	Research Officer (Trainee)
R. E. Okello	Scientific Assistant
S. E. Odelle	" "
P. A. Ajau, Dip. Agric.	" "
S. Ogolle	" "
B. Okwi	" "
**** E. Atadan, Dip. Agric. (E.A.)	" " (Trainee)
**** B. A. Opolot, Dip. Agric.	Asst. Agric. Officer
**** C. D. Muhwana, Dip. Agric.	" " "
J. W. Oposia	" " "
P. A. Opolot	Laboratory Assistant
J. Epeju	" "
C. Alibet	" "
S. L. Kasule	" "
G. Epeduno	" "
E. Okare (dismissed 6-7-71)	" "
J. W. Etengu	" "
A. Dikan, Teaching Cert. Dip. in Social and Political Science (Lond.)	" "
F. Amito-Eringu, Secretary Diploma	Executive Officer
J. Ochom	Sec'y./Stenographer
J. W. Ocakara-Orone	Clerical Officer/Copy Typist
F. Wasonga-Ongaro	Clerical Officer
P. Mukiibi	" "
	Driver

Key: * United States Agency for International Development
** United States International Institute of Education
**** Uganda Department of Agriculture

2. Administration

At the close of the calendar year 1971, the Sorghum and Millets Unit at Serere Research Station is again back at full staff.

The position of Trials Officer for Uganda was filled in April with the arrival of Dr. D. K. Whigham. Dr. J. L. Overman replaced Dr. B. D. Barry as Entomologist in July, and Dr. L. E. Allison arrived in November as the Soil Scientist/Agronomist, replacing Dr. R. J. Davis who returned to the U.S.A. in September. Dr. L. V. Peters was on Home Leave in the U.S.A. from June until September.

Dr. J. J. Kern arrived in December as Sorghum Breeder under the International Institute of Education contract with U.S.A.I.D. and E.A.A.F.R.O. The sorghum programme had been continued on a maintenance basis as the project was without a Plant Breeder. The trials, both regional and district, selection of progeny row material, continuation of the crossing programme, maintenance and increase of bulks, and the increase of hybrids and varieties had been continued with the assistance of Mr. Okello and Mr. Ajau.

The construction of a new seed laboratory and cold seed storage unit, financed by a Rockefeller and U.S.A.I.D. grant, began in July and is nearing completion. This structure will provide space for the millet project which has thus far been supplied by the Uganda Government. Release of this space to the Uganda Trials Officer will greatly assist his programme.

Finance and Technical Assistance

In the vote allocations for 1971/72, the following new posts were established for the Sorghum and Millets Unit: three Research Officer posts to accommodate local counter-parts to U.S.A.I.D./A.R.S. Millet Breeder, Agronomist and Cereals Entomologist; transfer of five Scientific Assistants, six Laboratory Assistants, one Executive Officer, two Clerks, one Secretary/Stenographer, one Copy Typist, one Driver, and twenty-two minor employees to the main establishment, and two new posts of Artisans.

Financial support for the Sorghum project is covered mainly by a Rockefeller Foundation Grant.

The United States Agency for International Development (U.S.A.I.D.) has provided funds for operating expenses and labour for the Millets, Cereal Agronomy and Sorghum Entomology work.

All transportation expenses was met by E.A.A.F.R.O. in 1971, and all operating expenses of the Unit will be assumed by E.A.A.F.R.O. in 1972.

Conferences

The fourth East African Cereals Research Conference held in Ethiopia in late October was attended by Drs. J. L. Overman, L. V. Peters and D. K. Whigham.

Dr. L. V. Peters attended the Annual Meeting of the American Society of Agronomy held in New York City from August 15-20.

Conferences attended by other members of the Unit are mentioned in their reports.

Location of Field Activities in Uganda

Sorghum Variety Trials

Leader	Location
Dr. J. J. Kern and Dr. D. K. Whigham, assisted by Mr. P. Ajau and Mr. R. E. Okello	Abi, Nebbi, Pakelle, Labora, Kitgum, Patongo, Ngetta, Aduki, Arapai, Kaberamaido, Kuju, Katakwi, Kumi, Bukedea, Nabbongo, Tororo, Mubuku, Kibale, Nakasongola, Bale, Ikulwe, Bugaya, Moroto, Kotido, Iriri, Namalu, Ngenge, Kakumiro, Namulonge, and Serere.

Finger Millet Variety Trials

Leader	Location
Dr. L. V. Peters, Dr. D. K. Whigham, assisted by Mr. S. E. Odelle and Mr. E. Atadan	Abi, Nebbi, Pakelle, Labora, Ngetta, Aduku, Arapai, Kaberamaido, Kuju, Katakwi, Kumi, Bukedea, Nabbongo, Tororo, Iki-Iki, Kibale, Nakabango, Bukula, Bugaya, Iriri, Namalu, Namulonge, and Serere

Bulrush Millet Variety Trials

Leader	Location
Dr. L. V. Peters, Dr. D. K. Whigham, assisted by Mr. S. E. Odelle and Mr. E. Atadan	Abi, Nebbi, Pakelle, Labora, Kitgum, Patongo, Ngetta, Aduku, Arapai, Kaberamaido, Kuju, Katakwi, Nabbango, Bugaya, Moroto, Kotido, Iriri, Namalu, Ngenge, and Serere.

Agronomy Sowing Date Trials

Leader	Location
Dr. D. K. Whigham	Nebbi, Pakelle, Labora, Kitgum, Patongo, Ngetta, Aduku, Arapai, Kaberamaido, Kuju, Katakwi, Bukedea, Nabbongo, Tororo, Ike-Iki, Nakabango, Vukula, Ikulwe, Bugaya, Moroto, Kotido, Iriri, Namalu, Ngenge, and Serere.

Sorghum Entomology Trials

Leader	Location
Dr. J. L. Overman Dr. D. K. Whigham	Serere, Ngetta, Tororo, Nakabango

Cereal Agronomy Trials

Leader	Location
Dr. L. E. Allison, Dr. D. K. Whigham, assisted by Mr. S. Ogolle and Mr. B. A. Opolot	Katakwi, Patongo, Kaberamaido, Pakelle, Kuju, Serere, Kumi, and Ngora.

3. Technical Report.

Sorghum and Millets

Growing Condition at Serere. The rainfall for the 1970-71 dry season was the lowest on record for a number of years. The first rainfall of any significance fell on March 27th which is about three to four weeks later than average. The first cereal planting at Serere were finger millet, which was during the first week of April. Although total rainfall in 1971 was 162 mm. less than the long time average, most it lay within the confines of the upper and lower 1:1 confidence limits throughout the two rain seasons.

SORGHUM BREEDING

J. J. Kern, R. E. Okello, P.A. Ajau, B. Okwi, and J. Epeju

The absence of a sorghum breeder at the Serere station from mber 1970 until December 1971 caused a considerable reduction he sorghum breeding programme, especially with regard to the lation breeding work initiated by Dr. Doggett. However, the f still conducted extensive sorghum breeding and testing work.

In addition to an explanation of breeding work accomplished ng 1971, this report includes data from 1970 second rains onal trials, and 1971 first rains regional trials. Data from 1971 Serere second rains trials of breeding material is included, results of most of the 1971 second rains regional variety trials not been received at the time of this writing.

releases

Seed of CK 60A and B lines was supplied by Serere to the Uganda s Scheme for multiplication during 1972 first rains. Subsequently 57 (CK 60A x SB 65) will be produced in the 1972 second rains. od supply of Serena sorghum is available through the Seeds Scheme increases made in 1971. Tanzania continues to be interested in white grain line 5DX 36D and it's hybrid on CK 60A, H x 471D. ng 1971 Serere supplied 90 kg of 5DX 36D to the seed multiplica- scheme in Tanzania, and the Uganda Seeds Scheme supplied them a metric ton of Serena. The hybrid H x 467 (CK 60A x 5DX 61/6/2) formed very well again this year, and may well replace H x 57 in future. An atap evaluation test will be conducted in 1972 in h the new hybrid H x 467 will be included.

onal trials

Results of regional trials conducted in Uganda and Kenya are given he section entitled Sorghum Variety Trials which follows the hum Breeding Section. Data from five Tanzania trials and one a trial grown in 1970-71 are shown in Table 38 of the Breeding ion. The hybrids H x 467 and H x 57 exhibited the highest mean ds over all locations. The performance of the white variety 36/1/2 and its hybrid H x 471 depends upon the incidence of bird ge. These two entries performed well at two locations, but were low at the three remaining sites. The mean yield of a white hum entry is not a good indication of its potential at relatively d free" locations.

Yield trials at Serere

Sorghum at Serere during the second rains of 1971 suffered from both drought and a heavy infestation of the maize stalk-borer, Buseola fusca. Yields consequently were quite low. Results from a trial of 49 lines and hybrids are presented in Table 39 . In general, the entries producing the highest yields were those which were relatively early-flowering. Those lines which flowered later possibly suffered more from drought and stalk-borer attack. Five sub-lines of 5DX135 performed very well in the test, as did the hybrids H x 471, H x 467, and H x 57. This 7 x 7 trial will be repeated in both seasons of 1972 if sufficient seed is available. Several of the entries in the test were quality grain lines from the collection.

Table 40 gives the results of a 6 x 6 lattice trial grown at Serere in the 1971 second rains. All entries except 5DX 36D are B lines, the IS lines being from India. Yields again were relatively low, but several of the 7DMS lines performed well, as did 5DX 87 (Kafinam) and some of the IS lines. The short stature of most of these B lines would be advantageous if their male-sterile equivalents were to be used in the production of hybrids. Some of the B lines from India have tan straw, an additional advantage. Flour milled from the white grain of plants with tan straw is of higher quality than that from plants with purple colour. Test crosses will be made in 1972 onto the 7DMS and Indian male-steriles, particularly onto those with tan plant colour.

World collection

Approximately 1700 World Collection lines were grown and evaluated during the first rains, 1971. All of the World Collection entries received at Serere now have been evaluated once. Many of the lines with desirable characteristics have been incorporated into populations, and many have been utilized in the conventional breeding programme. In order to maintain viable seed of the Collection entries, and to evaluate them further, we will grow approximately 1000 entries each season, beginning in the first rains of 1972.

Progeny rows

Progeny rows were grown from individual heads selected from several sources. Brown grain types were grown in the first rains, and white grain types in the second rains, since bird damage generally is less severe in the second rains. Numerous selections were made in these head rows, and they will be grown in the 1972 seasons. Material from which selections were made included derivatives of 5DX crosses, short lines from the Puerto Rico conversion programme, entries from Dr. Pickett's protein nursery and the International sorghum nursery, B lines from India and Serere 8MSC crosses, and earlier selections from Dr. Doggett's restorer and non-restorer composite populations.

Crossing Programme

Individual plants of SB 65 and 5DX 61/6/2 were crossed onto CK 60 to observe the variability in these two lines, and possibly find a pollinator which would produce a shorter version of H x 57 and H x 467, respectively. These crosses were grown in the second rains, along with the pollinator rows. Generally the hybrids were quite uniform, with only slight differences observed. Crosses also were made of 5DX 157 and 5DX 142 onto CK 60, the purpose again being to find plants which produce shorter hybrids. All 5DX 157 hybrids were tall, and all 5DX 142 hybrids were sterile. If the height of 5DX 142 can be reduced, it may be a good B line.

Crossing and backcrossing of quality grain Collection lines with the genetic male-sterile was carried on in both seasons. Seed from these backcrosses now will be bulked and randommated for the next three seasons. The programme of reducing height in some of the good Collection pollinators and 8MSC lines by backcrossing was continued. Selection within the advanced generations of these backcrossed will continue and testcrosses will be made of both the pollinators and the 8MSC male-steriles. All possible crosses were made between 12 pollinators and five male-sterile lines, to be used in a 1972 combining ability study.

Tetraploids

Selections were made in tetraploid material developed by Dr. B. N. Majisu. Population work involving tetraploids will be resumed in 1972.

High altitude sorghums

During the first rains, three bulk populations were grown from the cross of Serena with E 1291, but unfortunately these were not harvested. Remnant seed of one of the populations has been found, and this population will be planted for selection in the first rains of 1972. The original cross was made to introduce into E 1291 the "juicy" character (green midrib) from Serena. Kenya and southwest Uganda are quite interested in both forage and grain sorghums adapted to high altitudes. A number of collection entries introduced from high altitude areas will be sent to Kitale, Kenya, for evaluation in 1972. If sufficient seed of these lines is available, we will try to locate a high elevation site in southwest Uganda for evaluating them.

Increases

Bulk increases of promising lines and hybrids to be included in 1972 variety trials were made in the second rains. Most increases are produced in the second rains since drying conditions are much better and bird damage less severe than in the first rains. Small bulks of 84 collection lines from Ethiopia and India were grown. This is the material which was analyzed for protein content in 1970-1971 by Mr. Shepherd of U.S.A.I.D./A.R.S. at the Cereals Laboratory of E.A.I.R.O. in Nairobi. Many of these lines have good quality, corneous grains, and have been used in both the population breeding work and the conventional breeding programme. As was mentioned in the 1970 E.A.A.F.R.O. annual report, the protein levels from the first 61 varieties analyzed ranged from 10.1 to 17.2 per cent. Data from the 1971 analyses are not available at this time.

Future Work

During 1972 the population breeding work initiated by Dr. Doggett will be resumed. This material was kept in cold storage during the absence of a sorghum breeder. It is felt that much emphasis should be placed in the breeding of good quality, white, corneous types for food varieties. This will be stressed in both the population work and in the conventional programme. Hopefully some high yielding good quality varieties will come from the 9DX series of crosses. Selections from the F_4 and F_5 generations of these crosses will be made this year. If these lines are fairly uniform, they will be testcrossed onto several male-sterile.

Table 38. Yields of grain and heights of 18 sorghum entries in 1970-71 Tanzania and Kenya regional trials.

Entry	TANZANIA SITES					Mean Yield (q/ha)	Mean height (cm)	Yield at Kampi ya Mawe, Kenya
	Suluti	Nyegezi	Ukiriguru	Mwalmala	Mwamhala			
5DX 142/4	28.9	17.4	18.8	26.9	21.7	22.8	128	22.5
5DX 156/3	30.3	19.9	22.4	23.5	20.6	23.3	113	22.3
5DX 142/9	28.9	16.4	21.7	24.1	15.5	21.3	93	22.3
H x 57	38.8	17.2	28.4	27.2	21.8	26.7	131	27.3
5DX 61/6/2	33.7	16.8	21.2	25.4	22.1	23.8	112	21.2
3DX 57/1H (white)	30.6	7.1	19.9	28.9	16.6	20.6	121	20.4
5DX 162/1	31.6	14.9	20.6	23.9	17.2	21.6	135	16.3
Dobbs	33.7	18.8	19.6	24.4	14.7	22.2	131	17.7
4DX 34/1/4C	32.3	16.7	21.4	23.8	18.1	22.4	108	24.2
5DX 61/2/1	34.0	18.6	16.9	22.9	16.7	21.8	105	21.9
5DX 144/1	27.2	21.3	18.2	26.9	21.7	23.1	101	20.7
3DX 57/1H (Brown)	30.6	19.8	23.2	27.8	18.8	24.0	112	21.9
Serena	28.9	11.1	22.4	28.0	19.7	22.0	123	23.0
H x 60/7/2A	35.0	16.2	19.4	25.4	25.0	24.2	115	20.3
H x 467	39.4	27.4	22.9	26.6	16.9	26.6	128	26.0
5DX 160/4/1	29.9	18.9	22.7	26.6	18.5	23.3	132	18.7
5DX 36/1/2	27.9	8.7	14.2	29.5	10.3	18.1	132	13.6
H x 471	38.1	6.6	16.7	27.5	7.5	19.3	150	25.7
L.S.D. (P = 0.05)	8.1	6.3	6.1	4.9	7.1	4.5	12.7	4.8
C. of V. per cent	17.9	27.4	21.0	13.2	27.7			15.7

Table 39. Grain yield, height, and days to flower of grain sorghums grown at Serere in a 7 x 7 balanced lattice trial, 1971 second rains.

Entry	Yield (q/ha)	Height (cm)	Days to flower	Entry	Yield (q/ha)	Height (cm)	Days to flower
5DX 76/3/3/13E	9.2	95	72	5DX 157/19/4/2	12.0	141	74
E 6954 27	10.3	166	69	H x 467	25.9	142	63
H x 57	24.6	148	59	Serena	17.3	132	62
5DX 50/4/2/7	8.0	114	74	5DX 135/13/1/3/1/4	23.0	141	66
5DX 108/2/1/1	13.3	147	69	5DX 160/4/(Dobbs Bora)	16.0	146	73
6 DX 9/2/2	16.7	119	73	6 DX 10/1/2/3/8/1	9.2	129	72
5DX 135/13/3/3/1/1	32.9	139	66	5DX 136/1/2/1	11.4	147	73
5DX 142/4	22.1	135	69	6DX 2/2/5/1	16.0	140	70
5DX 76/3/3/13/C	13.5	129	73	5DX 157/19/3	14.5	138	71
6DX 9/1/1/3/1	14.5	130	70	E 285	13.8	201	63
5DX 135/13/E	27.1	135	64	3DX 57/1/11/17/2	19.3	141	66
5DX 142/4/1/1	15.0	135	72	6DX 9/2/4	20.6	157	71
E 6952	8.0	170	71	5DX 142/5/13	22.6	150	68
E 6338	10.3	196	72	6DX 10/3/3/4/1	11.2	152	71
5DX 135/13	21.8	141	64	IS3404	17.4	146	65
E 1069	10.7	221	90	5DX 36 (Dwarf)	13.6	100	70
E 6454	14.6	146	57	5DX 135/13/1/3/E	21.4	138	64
6DX 10/1/3	15.2	147	73	IS 9533	12.7	153	67
E 6953	13.1	167	69	3DX 57/1H/8	18.1	114	69
5DX 76/3/3/11/A	18.2	133	67	5DX 136/13/2	18.4	146	67
5DX 61/6/2	15.7	128	70	5DX 11/4/1/10	20.6	141	65
5DX 157/2/2/1	10.3	147	74	H x 471	27.9	145	62
E 6949	11.0	163	70	6DX 10/1/4	18.3	124	70
5DX 76/3/3/11/B	14.5	126	68	6DX 2/2/4	13.7	136	71
IS 2771	14.7	120	71				
L.S.D. (P = 0.05)	6.6	16.2	1.9				
C. of V. (per cent)	31.9	9.0	2.2				

Table 40. Yield, Height, and days to flower of 36 sorghum lines grown at Serere, Second Rains 1972

Entry	Yield (q/ha)	Height (cm)	Days to flower	Entry	Yield (q/ha)	Height (cm)	Days to flower
7DMS 2/9 P 11	17.4	99	67	IS 10594B	15.7	86	66
IS 10578 B	19.7	106	65	7DMS 6/1 P 12	17.7	85	63
7DMS 8	16.9	94	69	7DMS 5/2 P 13	21.1	121	67
7DMS 3/6 P 9	13.8	93	69	7DMS 6/14 P 8	21.1	93	67
7DMS 6/14 P 3	19.1	103	67	7DMS 6/8 P 4	14.0	96	69
IS 10362 B	20.8	99	66	7DMS 2/3 P 10	14.5	92	70
IS 10440 B	15.9	84	66	IS 10598 B	19.2	133	64
IS 10582 B	17.8	94	66	IS 10568 B	16.1	102	65
IS 10448 B	21.8	107	66	IS10408 B	16.8	116	65
7DMS 6/2 P 1	25.1	103	64	5DX 87 B (Kafinam)	22.3	126	70
7DMS 2/5 P 11	12.1	87	68	7DMS 3/6 P 8	18.4	111	69
IS 10572 B	18.9	98	68	7DMS 3	19.4	101	69
7DMS 2/11 P 11	11.5	81	69	7DMS 2	23.5	87	66
IS 10558 B	18.8	76	64	7DMS 6/2 P 7	20.2	94	64
7DMS 5/2 P 8	20.7	117	67	5DX 36 D	18.8	100	70
IS 10493 B	13.2	92	64	IS 10586 B	18.6	107	66
IS 10348 B	12.2	87	64	CK 60B	20.8	104	65
7DMS 2/9 P 7	15.7	90	69	IS 10566 B	21.5	107	65
L. S. D. (P = 0.05)	5.0	13.2	2.1				
C. of V. (per cent)	16.8	8.2	1.9				

SORGHUM VARIETY TRIALS

D. K. Whigham, J. J. Kern, and P. A. Ajau

Grain yield and mean plant height for the sorghum variety trials grown during the first rains 1971 in Uganda and Kenya are shown in Table 41.

H x 467 produced the highest yield in the trials, followed closely by 3DX 57/1/K, 5DX 135/13/1/3/1, H x 57 (Hijak), 5DX 111/2/2/2, 5DX 160, Serena and 3DX 57/1/H/4. In general, the highest yielding sorghums were medium to tall in height and the short lines yielded less.

Serena and Hijak are the two sorghums being distributed for farmer use by the Uganda Seed Scheme.

The majority of the sorghum variety trials were carried out during the second rains in 1971 and the results are not available at this time.

Table 41. Yields of grain in q/ha., and heights in cm of 25 entries in 1971 first rains regional trials.

Entry	Uganda Sites						Kambi Ya Mawe Kenya	Mean Yield	Mean Height
	Serere	Kotido	Kumi	Moroto	Katakwi	Iriri			
6DX 2/2	51.9	57.9	50.6	36.0	34.8	8.0	39.6	39.8	139
5DX 157/19/3	37.9	63.7	48.8	30.2	32.6	10.0	31.4	36.4	148
5DX 142/4	50.2	57.4	52.8	40.2	31.4	10.7	39.7	40.3	150
5DX 107/3/2/10	42.2	67.5	49.0	23.8	35.1	4.0	32.8	36.3	154
Serena	45.6	63.9	49.8	43.7	35.0	5.3	39.8	40.5	143
5DX 135/13	48.9	68.3	53.7	34.5	29.1	7.3	39.5	40.2	148
6DX 10/1/X	40.3	61.9	46.1	39.7	38.6	12.7	38.2	39.6	165
5DX 142/2/2/4	47.0	58.6	47.5	42.4	39.2	8.0	37.5	40.0	141
3DX 57/1/H/4	51.2	64.5	50.8	45.3	25.4	8.7	38.0	40.5	133
H x 467	41.3	59.6	50.6	53.2	37.1	17.4	38.4	42.5	161
5DX 61/6/2	45.6	50.6	59.9	48.1	38.9	6.7	25.9	39.4	133
6DX 10/1/X	44.1	59.3	41.3	40.5	37.0	12.0	35.9	38.6	158
5DX 93/3/4/4	38.6	54.0	59.3	22.9	35.8	9.3	37.5	36.8	153
4DX 34/1/4C	41.5	52.5	57.2	36.1	37.9	10.7	37.6	39.1	131
H x 471D	43.2	49.0	55.0	20.4	37.4	7.3	39.4	36.0	155
Makerere 16	42.5	61.0	47.6	15.8	26.2	9.3	31.4	33.4	101
5DX 36D	37.5	53.0	49.8	32.7	32.7	13.4	32.9	36.0	109
5DX 135/13/1/3/1	53.0	61.9	49.9	52.6	37.5	8.0	31.9	42.1	138
3DX 57/1/H	44.9	55.4	47.3	52.3	38.1	10.0	34.9	40.4	139
Dobbs Bora	40.7	51.7	41.5	36.2	32.5	14.0	35.0	35.9	145
5DX 156/3	44.7	54.0	49.1	24.3	29.3	8.7	39.1	35.6	127
3DX 57/1/K	47.0	62.2	54.8	50.8	34.1	14.0	33.9	42.4	141
5DX 160	40.4	55.5	58.9	45.8	34.6	13.4	36.8	40.7	147
H x 57	36.5	47.4	54.5	56.6	39.9	6.7	49.0	41.5	155
5DX 111/2/2/2	48.5	59.5	47.8	51.0	37.9	8.7	36.3	41.4	149
L.S.D. (P = 0.05)	7.4	14.6	9.5	17.4	10.8	5.8	8.6	6.3	
C.V. (%)	11.9	17.8	13.1	31.6	22.1	42.3	16.7		

BULRUSH MILLET BREEDING

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

Regional Trials. Results of the regional trials of bulrush millet for the second rains of 1970 in Uganda and first rains of 1971 in Tanzania are shown in Table 42. Trials were also carried out at three additional sites in Uganda and one in Tanzania, however due to extremely dry weather at one site, excessive bird damage at another, and poor management at the other two, no yield data were received.

Significant differences in yield are noted at 8 of the 20 sites as well as on the combined analysis. Rainfall over most of Uganda during the second rains season was above average and yields approached or exceeded 20 q/ha., for the best trials.

These trials were designed to evaluate the performance of Serere 10LA, the new cytoplasmic male-sterile seed parent in comparison with the other seed parent, as well as the Composites which are being developed. From 14 of these 20 trials we note that the average yields of the 10LA hybrids were slightly larger than that from the Tift 23A hybrids. Yields of the 10LA hybrids were also greater than the pollinator parents at 18 sites. Average yields of the Tift 23A hybrids were greater than their pollinator parents at only 9 sites. The average performance of Serere 10LA hybrids over all trials was about 7% better than either Tift 23A hybrids or their pollinator parents. Similar trials are also being carried out during the second rains of 1971 and will be reported next year.

Screening Trial. The grain yields for 49 entries grown at Serere during the second rains of 1970 are shown in Table 43. The entries in this trial consist of the strains, hybrids and more advanced composites developed at Serere, plus introductions from Nigeria. The average performances of the seven Serere 10LA hybrids and seven Tift 18A hybrids, showed these hybrids yielding 10.7 and 12.5 per cent more respectively than the pollinator parents. Tift 18A seed parent was developed in the U.S.A. as a possible seed parent for the grain producing types of bulrush millet.

The Serere Composites entries in this trial are being developed either through S_1 testing (S) or mild mass selection (M). The number after the method, indicates the cycle of improvement or selection. The second cycle of improvement for Serere Composite 1 showed a 17.6% increase in yield over the first cycle. Composite 2 is a bristle type and Composite 3 is non-bristle, both being selections from Serere bulks which made up the initial entries of Composite 1. Figure 2 illustrates the source of the germ plasm for the other Composites.

Diallel Crosses. Five selected strains were crossed with each other in all possible combinations, and evaluated in grain yield trials during the second rains of 1970 and 1971 at Serere. 1970 yields for this diallel scheme are shown in Table 44. The data shown illustrates that both Nos. 1 and 5 are good yielding strains. Also No. 1 combined well as a seed parent with Nos. 3, 4, and 5, and No. 5 with Nos. 1, 2, and 3 as either a pollinator or seed parent. No. 1 developed from India strains showed the poorest combinability. Other selected diallels will be made and tested in 1972.

India Introductions. As with the world collection accessions, we are interested in classifying the new India introductions as either the restoring and non-restoring type. In the grow-out of 1661 crosses in which Tift 23A was the seed parent, 86.3% were classified as restorers, 7.2% as non-restorers, with the others being mixed. Most of these accessions have the dwarf genes and the best will be further tested as either seed or pollinator parent in 1972.

Development of Adapted Male-steriles. Final selection has been made with the A and B lines developed from eight Serere strains which showed to be non-restorers. We hope to have adequate seed from at least seventy-five to one-hundred selections for making crosses for combinability studies in 1972.

Height Reduction. A genetic dwarf stock has been crossed and backcrossed into the Serere material in order to incorporate shorter genes to help reduce lodging and also to increase the ease of harvesting of this crop. Selection and selfing was carried out this year in the 397 selections made in 1970. Testing and evaluation will be carried out in 1972.

Serere Composite Populations. Selection and selfing was carried out during the first rains season of 1971 in three of the Serere Composite Populations (Nos. 1, 3 and 10) shown in Figure 2.

The fourth cycle of S_1 yield testing was carried out in Composite 1 during the second rains season of 1971. Five 11 x 11 lattice trials were used in testing the 605 S_1 selections. However, due to an accidental error in the seed treatment mixture, germination was greatly reduced, thus the stand was not as good as desired. Although 87 selections were made and remnant seed planted for recombination during the 1971-72 irrigated season, we may also select from the cycle two seed source which is being grown at the same time. Cycle three recombination was also lost due to the seed treatment error.

S_1 tests were also attempted for Composite 3 and 10 during the second rains. Two 11 x 11 lattice trials were planted for each, however, both were abandoned due to poor germination caused by the seed treatment.

All of the Composite Populations have been grown during the second rains and some during the first rains where land and isolation were available. Only mild mass selection was carried out as mixing is still desired within each of these populations.

FINGER MILLET BREEDING

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

Screening Trials. Table 45 gives grain yields for some of the finger millet selections which have been included in the larger evaluation trials at Serere from 1968 to 1971. New selections which have shown good yield potential in these trials are included in the regional trials. Entries in the regional trials for 1972 will remain the same as in 1971, however, as new selections are made we will increase them for testing under a wider range of climatic conditions.

A number of selections from the programme for resistance to lodging and blast, *Pyricularia oryzae* will be included in the 1972 screening trial.

Improvement Programme. The development of the broad gene pool of the collection which was initiated during the first rain season of 1968, was continued during 1971. The outline for this programme as illustrated in Figure 3, shows the progress which has been made.

The most advanced crosses made in 1971, those crosses with 8 and 16 genotypes, were planted in early December of 1971 for the purpose of selection and testing in 1972. Selection will be made on an individual plant basis for testing at a minimum of three locations during the first rain season.

Another attempt was made to introduce male-sterility into some of the finger millet lines. Thirty-two selections which had received four dosage rates of fast neutron were planted at Serere on April 7. Early plant vigour, total plant growth and height were greatly reduced with increased treatment rate, however, no sterility was observed. Seed was harvested and will be planted in 1972 for observation and crossing should male-steriles be found.

Grain Study. A considerable amount of interest in finger millet nutrition has been initiated at Makerere University, Kampala, by the Norwegian Aid personnel. Therefore a cooperative trial consisting of the most diverse genetic germ plasm of finger millet, was grown at four levels of nitrogen. Other elements were adequate or above optimum amounts. This trial was carried out at Serere Research Station during the first rain season of 1971 and seed from this trial has been supplied to Dr. Heidi at Makerere for complete chemical analysis. A more thorough understanding of genetic-fertility-maturity-etc., interaction should become evident from this study. This information will assist us in future research on this, the most important cereal crop in Uganda.

Yield data shown in Table 46 shows that the N_3 nitrogen rate was probably optimum for yield purposes, however, the additional amount supplied at N_4 may greatly influence some of the amino acids. The complete analysis will be reported when available.

Table 42. Grain yields in q/ha. from the regional bulrush millet trials, second rains 1970 in Uganda and first rains 1971 in Tanzania.

Entries	UGANDA									
	Teso District						Business District	Karamoja District		
	Kabera-maido	Kuju	Arapai	Serere	Katakwi	Kumi	Nabbongo	Namalu	Iriri	Kotido
Varieties										
Serere 2A	30.5	25.6	20.7	25.9	35.2	23.8	6.1	30.4	30.1	27.2
Serere 3A	26.7	27.9	18.7	25.2	31.6	24.8	7.6	27.9	22.3	25.2
Serere 6A	27.3	25.2	19.6	27.3	35.9	25.3	7.6	27.9	23.4	29.0
Serere 17	27.6	24.1	19.8	26.5	29.4	25.3	7.4	25.3	31.2	25.8
Serere 30	23.0	25.2	16.3	31.9	32.3	21.3	9.8	25.3	27.9	25.6
Hybrids										
Tift 23A x Serere 2A	33.9	25.2	18.3	23.3	37.4	29.9	12.2	25.3	29.0	28.3
Tift 23A x Serere 3A	25.9	24.5	19.4	28.3	35.2	24.3	8.9	27.9	31.2	25.8
Tift 23A x Serere 6A	31.0	21.4	19.8	26.7	31.2	27.9	13.4	27.9	25.6	25.8
Tift 23A x Serere 17	30.1	27.4	18.9	28.1	29.2	27.9	8.6	27.9	33.4	28.3
Tift 23A x Serere 30	27.6	22.3	20.3	27.2	31.6	23.3	6.6	25.3	24.5	25.0
Serere 10LA x Serere 2A	32.8	29.0	18.7	26.9	35.0	25.3	10.1	27.9	30.1	29.0
Serere 10LA x Serere 3A	31.2	27.6	20.5	29.4	32.5	24.3	10.4	22.8	31.2	27.9
Serere 10LA x Serere 6A	31.6	26.5	20.5	26.5	31.6	26.9	15.0	25.3	33.4	26.3
Serere 10LA x Serere 17	30.1	24.5	20.3	32.2	29.6	26.4	13.9	27.9	33.4	23.2
Serere 10LA x Serere 30	28.3	25.4	22.1	30.1	36.3	24.3	8.4	30.4	29.0	27.0
India Bajar Hybrid No.1	28.8	23.4	19.4	27.1	26.1	27.9	11.7	22.8	23.4	17.4
Composites										
Serere Composite 1	25.1	27.0	19.2	26.3	30.3	26.9	5.6	27.9	26.7	27.4
Serere Composite 2	33.9	24.3	24.3	29.9	31.2	21.3	8.6	27.9	26.7	28.5
Serere Composite 3	33.7	29.0	17.8	25.0	35.7	25.3	7.6	27.9	27.9	26.5
Serere Composite 10	24.8	24.5	18.5	27.3	26.9	26.9	9.6	25.3	30.1	24.3
Variety Mean	27.2	25.6	19.0	27.4	32.9	24.1	7.7	27.4	27.0	26.6
Tift 23A Hybrid Mean	31.7	24.2	19.3	26.7	32.9	26.7	9.9	26.9	28.7	26.6
Serere 10LA Hybrid Mean	30.8	26.6	20.4	29.0	33.0	25.4	11.6	26.9	31.4	26.7
Serere Composite Mean	29.4	26.2	20.0	27.4	31.0	25.1	7.9	27.3	27.7	26.8
Site Mean	29.7	25.5	19.7	27.6	32.2	25.5	9.5	26.9	28.5	26.2
L.S.D. (P = 0.05)	6.6	n.s.	n.s.	n.s.	6.4	n.s.	n.s.	n.s.	n.s.	4.8
C.V. percent	15.79	17.56	22.57	13.45	14.01	18.99	56.17	23.60	23.17	13.01

Table 42 (Cont'd.)

Entries	UGANDA							TANZANIA			Entry Mean
	Lango District		Acholi District			Madi District	W. Nile District				
	Aduku	Ngetta	Labora	Patongo	Kitgum	Pakelle	Nebbi	Lubaga	Ukiriguru	Mtwara-Naliendele	
Varieties											
Serere 2A	20.1	9.6	26.7	12.7	5.6	15.8	28.5	29.4	23.8	18.5	22.3
Serere 3A	22.1	14.7	23.8	13.6	7.2	19.9	24.7	33.2	23.3	20.1	22.0
Serere 6A	21.5	10.3	28.7	11.4	9.5	17.4	29.2	37.0	23.8	16.4	22.7
Serere 17	24.2	6.7	21.4	6.5	3.6	16.7	22.5	28.1	22.8	20.5	20.8
Serere 30	20.6	5.8	13.6	11.4	2.9	12.2	26.3	28.5	21.3	20.3	20.1
Hybrids											
Tift 23A x Serere 2A	23.4	4.9	24.3	8.7	4.2	19.6	34.3	25.6	16.2	21.7	22.3
Tift 23A x Serere 3A	21.8	3.3	24.1	10.7	3.3	18.5	28.7	27.6	21.3	20.4	22.1
Tift 23A x Serere 6A	22.7	7.8	24.3	9.8	6.2	15.6	30.3	31.6	23.8	21.2	22.2
Tift 23A x Serere 17	18.5	3.3	19.4	6.0	3.3	18.0	28.3	27.0	22.3	18.7	21.2
Tift 23A x Serere 30	18.3	3.8	25.6	9.4	5.6	17.6	29.4	27.0	18.3	18.2	20.3
Serere 10LA x Serere 2A	20.9	9.1	26.1	12.7	12.3	20.5	31.2	29.9	27.4	18.7	23.7
Serere 10LA x Serere 3A	20.9	12.5	24.5	14.7	8.5	18.0	27.9	28.1	21.8	18.2	22.6
Serere 10LA x Serere 6A	25.0	12.3	28.5	11.6	8.5	16.9	27.0	25.6	27.9	17.6	23.2
Serere 10LA x Serere 17	22.5	8.7	25.6	11.1	9.4	16.7	27.2	31.2	27.9	18.6	23.0
Serere 10LA x Serere 30	20.1	9.8	24.7	12.5	5.8	15.8	26.3	34.8	27.4	21.3	23.0
India Bajar Hybrid No.1	19.2	2.5	21.2	12.0	1.1	17.5	18.7	25.4	23.3	11.9	19.0
Composites											
Serere Composite 1	20.1	6.2	21.6	12.3	6.6	16.5	29.9	36.5	28.4	18.2	21.9
Serere Composite 2	24.4	13.1	24.5	11.4	13.6	16.5	27.6	25.0	20.8	21.0	22.7
Serere Composite 3	21.5	5.1	22.5	16.0	2.5	15.8	25.0	34.5	24.8	23.8	22.4
Serere Composite 10	12.2	8.0	16.7	14.9	3.6	17.7	28.1	21.4	20.8	19.6	20.1
Variety Mean	21.7	9.4	22.8	11.1	5.8	16.4	26.2	29.3	23.0	19.2	21.6
Tift 23A Hybrid Mean	20.9	4.6	23.5	8.9	4.5	17.9	30.2	27.8	20.4	20.0	21.6
Serere 10LA Hybrid Mean	21.9	10.5	25.9	12.5	8.9	17.6	27.9	29.9	26.5	18.9	23.1
Serere Composite Mean	19.6	8.1	21.3	13.7	6.6	16.6	27.7	29.4	23.7	20.7	21.8
Site Mean	21.0	7.9	23.4	11.5	6.2	17.2	27.6	29.4	23.4	19.2	21.9
L.S.D. (P = 0.05)	n.s.	4.1	5.8	4.6	4.3	n.s.	n.s.	8.5	n.s.	n.s.	1.7
C.V. per cent	22.13	36.94	17.44	28.61	49.65	18.95	20.61	20.39	25.55	21.47	

Table 43. Grain yield in q/ha from the 7 x 7 triple lattice screening trial of bulrush millet at Serere, Second rains 1970.

Source	As a pollinator strain	As Serere 10 LA hybrid	As Tift 23A hybrid	As Tift 23D hybrid	As Tift 18A hybrid
Serere 2A	26.1	31.3	28.1	31.4	28.7
Serere 3A	27.9	27.4	27.3	26.6	33.0
Serere 6A	28.7	32.5	23.5	30.8	29.8
Serere 17	30.3	32.4	28.7	28.9	32.3
Serere 26/9	31.2	30.5	26.2	30.2	36.0
Serere 26/19	22.6	30.8	31.6	28.0	29.9
Serere 30	30.0	32.5	29.6	32.9	31.5
Mean	28.1	31.1	27.9	29.8	31.6
Serere Composite 1 (S) 1	28.4				
Serere Composite 1 (S) 2	33.4				
Serere Composite 2 (M) 4	29.1				
Serere Composite 3 (M) 4	27.4				
Serere Composite 6 (M) 2	23.3				
Serere Compoiste 9 (M) 2	27.7				
Serere Composite 10 (M) 3	27.6				
Serere Composite 11 (M) 2	22.0				
Nigerian Ex. Gashau	28.6				
Nigerian Ex. Riyom	34.8				
Nigerian Ex. Audu	31.4				
Nigerian Ex. Ajingi	34.3				
Nigerian Ex. Tukuru	32.1				
Nigerian Samaru xB (M)C7	30.0				
Entry Mean	29.6				
L.S.D. (P = 0.05)	5.6				
C.V. per cent	11.50				

Table 44. Grain yield in q/ha from a diallel of five bulrush millet strains at Serere, second rains 1970.

Seed Parent*	Pollinator Parent*					Seed parent mean
	No. 1	No. 2	No. 3	No. 4	No. 5	
No. 1	27.8	20.1	25.6	25.1	26.4	25.0
No. 2	25.1	22.0	24.5	21.7	25.7	23.8
No. 3	23.4	25.4	21.0	23.2	25.4	23.7
No. 4	21.3	18.6	22.5	21.5	19.1	20.6
No. 5	25.8	26.3	27.5	21.3	26.3	25.4
Pollinator Parent Mean	24.7	22.5	24.2	22.7	24.6	23.7
L.S.D.(P = 0.05)	4.8					
C.V. (per cent)	12.52					

*No. 1 East African Strain.

No. 2 World Collection Non-restorer Strain.

No.3 World Collection Restorer Strain.

No. 4 India Strain.

No. 5 West African Strain.

Table 45. Some grain yields in q/ha from the screening trials of finger millet at Serere, first rains 1968-1971.

Entry	9 x 9 Trial 1968	10 x 10 Trial A 1969	10 x 10 Trial B 1969	11 x 11 Trial 1970	8 x 8 Trial 1971	1968-1971 Entry Mean	Rank	1969-1971 Entry Mean	Rank
Eding	30.1	30.5	29.6	48.4	31.7	34.1	1	35.1	1
P 247		31.5		43.2	27.9			34.2	2
P 238			32.0	45.8	24.2			34.0	3
Engom	37.4	32.2	29.2	38.2	31.7	33.7	2	32.8	4
P 339		29.3		42.0	26.0			32.4	5
5 EX 26 P 11		27.4		43.5	25.8			32.2	6
WC 93		33.9		44.4	17.3			31.9	7
Serere 104	41.4	29.0	25.8	43.0	28.5	33.5	3	31.6	8
WC 97			28.6	40.7	25.1			31.5	9
WC 25		32.4		40.2	21.8			31.5	9
5 Ex 22 P 6		32.7		36.6	25.3			31.5	9
P 265		30.8		39.2	24.0			31.3	12
Serere 12	36.1	27.1	30.1	44.3	23.0	32.1	6	31.1	13
5 Ex 25 P 1		28.5		37.2	27.7			31.1	13
WC 92			34.8	38.0	20.1			31.0	15
Gulu E	30.4	29.9	27.5	39.4	26.8	30.8	14	30.9	16
P 336			27.8	41.8	22.8			30.8	17
WC 489			31.6	39.4	21.1			30.7	18
Serere 119	44.3	28.8	22.4	49.1	22.2	33.4	4	30.6	19
5 Ex 12 P 2	21.7	32.0		37.3	22.2	28.3	24	30.5	20
Elaba	36.1	30.8	25.1	43.6	21.4	31.4	8	30.2	21
WC 91		30.4		38.5	21.0			30.0	22
Serere 358	33.3	26.7	24.8	38.3	30.2	30.2	15	30.0	22
Serere 152	37.1	30.7	25.1	39.2	24.4	31.3	9	29.9	24
5 Ex 13 P 6	40.7	31.2	25.0	38.7	24.3	32.0	7	29.8	25
Serere 1	27.4	28.3	26.2	37.4	27.0	29.3	19	29.7	26
P 210		26.3		35.8	26.9			29.7	26
Serere 82	40.0	25.5	25.9	47.6	17.4	31.3	9	29.1	28
Serere 312	30.9	21.2	27.2	41.1	27.0	29.5	17	29.1	28
Engenyi	29.3	23.9	29.1	38.2	25.2	29.1	21	29.1	28
5 Ex 12 P 5	44.7	27.6	22.7	37.0	29.2	32.2	5	29.1	28
5 Ex 25 P 3			25.9	36.8	24.0			28.9	32
P 284		25.6		32.7	28.0			28.8	33
WC 251			32.9	34.8	18.2			28.6	34
Serere 148	41.8	26.9	20.0	40.7	26.5	31.2	12	28.5	35
P 226			24.5	39.9	21.0			28.5	35
Serere 91	33.2	27.1	28.3	33.9	24.7	29.4	18	28.5	35
WC 105			27.3	36.2	21.5			28.3	38
WC 94			32.1	35.0	17.9			28.3	38
Serere 149	35.8	23.5	25.1	38.3	25.7	29.7	16	28.2	40

Table 45. (Cont'd.)

Entry	9 x 9 Trial 1968	10 x 10 Trial A 1969	10 x 10 Trial B 1969	11 x 11 Trial 1970	8 x 8 Trial 1971	1968-1971 Entry Mean	1968-1971 Rank	1969-1971 Entry Mean	1969-1971 Rank
Serere 21	42.7	22.1	31.0	36.0	23.5	31.1	13	28.2	40
Serere 101	33.4	24.0	26.7	35.2	26.7	29.2	20	28.2	40
Serere 116	44.6	25.0	27.4	38.2	21.4	31.3	9	28.0	43
WC 31			31.4	31.8	20.7			28.0	43
WC 85			33.5	33.5	16.8			27.9	45
WC 637			34.8	32.2	16.7			27.7	46
Serere 117	31.7	25.3	27.4	32.1	26.1	28.5	23	27.7	46
WC 86		30.1		35.2	17.6			27.6	48
WC 703		30.5		35.2	15.7			27.1	49
WC 545		27.9		34.3	18.8			27.0	50
P 302			24.2	34.3	22.1			26.9	51
WC 495		26.4		37.3	16.6			26.8	52
WC 550			31.8	32.1	16.3			26.7	53
WC 293		26.7		37.4	15.6			26.6	54
WC 113		28.6		32.5	18.3			26.5	55
Okiring	40.5	18.4	23.0	38.5	25.1	29.1	21	26.3	56
WC 130		29.1		34.6	14.8			26.2	57
WC 83		29.8		31.3	16.0			25.7	58
WC 499			31.2	31.1	14.7			25.7	58
WC 141		28.7		31.9	15.7			25.4	60
WC 290			25.7	33.4	16.2			25.1	61
WC 509		26.9		34.4	13.3			24.9	62
WC 694		25.8		33.0	14.7			24.5	63
WC 543			30.6	30.8	8.2			23.2	64
L.S.C.(P = 0.05)	6.4	8.5	7.3	6.8	5.9				
C.V. per cent	16.21	21.25	18.81	13.34	16.40				

Table 46. Grain yield in q/ha of thirty-six selected genotypes of finger millet at Serere, first rains 1971.

Source	Grain yield in q/ha at four rates of nitrogen fertilization[a]				Mean Grain Yield q/ha	Days to Anthesis
	N_1	N_2	N_3	N_4		
P 251	28.6	32.0	32.3	31.7	31.2	74
Eding	25.2	32.9	30.8	31.4	30.1	67
P 238	26.3	30.0	30.8	30.3	29.4	74
P 247	23.5	29.7	31.2	30.2	28.6	66
Okiring	18.9	26.8	35.9	32.0	28.4	74
Serere 82	24.1	26.8	30.4	30.7	28.0	69
Serere 358	22.6	28.2	31.1	30.3	28.0	72
Serere 148	22.6	30.2	27.8	29.6	27.5	73
P 265	23.5	30.9	28.6	25.8	27.2	66
Serere 116	20.9	27.8	27.8	29.9	26.6	70
Gulu E	22.8	30.0	24.9	28.7	26.6	72
Serere 119	24.7	27.7	25.7	26.5	26.2	66
Serere 1	21.2	30.4	30.7	22.5	26.2	70
Serere 312	21.8	25.6	28.0	29.0	26.1	73
P 302	19.4	24.7	31.0	28.8	26.0	75
WC 31	18.4	30.7	29.1	24.0	25.6	57
Serere 21	21.8	24.6	27.5	26.7	25.1	75
Engenyi	20.4	27.7	26.5	25.3	25.0	73
WC 114	20.6	22.3	28.5	23.3	23.7	72
P 339	18.9	24.1	21.2	26.4	22.6	73
WC 509	19.2	19.9	26.2	21.7	21.8	75
WC 603	20.9	18.7	21.1	24.1	21.2	55
WC 490	17.2	18.9	28.9	19.4	21.1	56
WC 241	18.7	21.2	23.1	21.2	21.0	55
WC 706	19.6	22.0	21.5	18.4	20.4	73
WC 89	17.7	25.8	19.3	16.5	19.8	56
WC 90	17.0	20.8	21.6	18.4	19.4	57
WC 67	19.9	20.1	20.6	16.2	19.2	86
WC 248	15.3	19.0	21.6	18.3	18.6	70
WC 251	18.1	17.2	17.6	21.1	18.5	69
WC 607	14.3	14.1	22.2	19.8	17.6	66
WC 46	13.3	17.2	17.2	22.1	17.4	56
WC 247	15.1	14.9	21.4	18.1	17.3	68
WC 77	14.2	18.6	14.8	17.0	16.2	71
WC 276	12.3	14.1	15.9	14.3	14.1	57
WC 717	6.7	6.2	7.7	2.5	5.8	86
Mean	19.6	23.7	25.0	23.7	23.0	69
L.S.D. (P=0.05)	5.9	6.8	7.2	8.1	3.6	2
C.V. percent	14.93	14.30	14.28	17.16		

[a] Nitrogen application in kg/ha at five growth stages.

	5 cm. ht.	15 cm. ht.	30 cm. ht.	Boot/ Head	Anthesis	Total
N_1	0	0	0	0	0	0
N_2	25	25	0	0	0	50
N_3	25	25	25	25	0	100
N_4	25	50	50	50	25	200

Serere Synthetic Strains	Serere Composite Populations
Serere 2A	Serere Composite 1 - Developed from 12 Syn. Strains from Serere.
Serere 3A	Serere Composite 2 - Developed from 68 bristle selections from Serere.
Serere 6A	Serere Composite 3 - Developed from 67 non-bristle selections from Serere.
Serere 17	Serere Composite 4 - Developed from best restorer selections of the World Collection.
Serere 26/9	Serere Composite 5 - Developed from best restorer selection from Serere germ plasm.
Serere 26/19	Serere Composite 6 - Developed from a mixture of the restorer lines going into Composite 4 and 5.
Serere 30	Serere Composite 7 - Developed from best non-restorer selections of the World Collection. Both B- and A-line development.
Serere 31	Serere Composite 8 - Developed from best non-restorer selections from Serere germplasm. Both B- and A-line development.
Serere 32	Serere Composite 9 - Developed from a mixture of the non-restorer lines going into Composite 7 and 8. Both B- and A-line development.
Serere 33	Serere Composite 10 - Developed from strains from West Africa.
	Serere Composite 11 - Developed from a bulk population from India.
	Serere Composite 12 - Developed from selections from the U.S.A.
	Serere Composite 13 - Developed from *P. maiwa* selections from W. Africa.
	Serere Composite 14 - Developed from the West African Strain-Samaru x B(M)C7 Gero.

Figure 2. Serere Bulrush Millet Strain and Composites Under Development

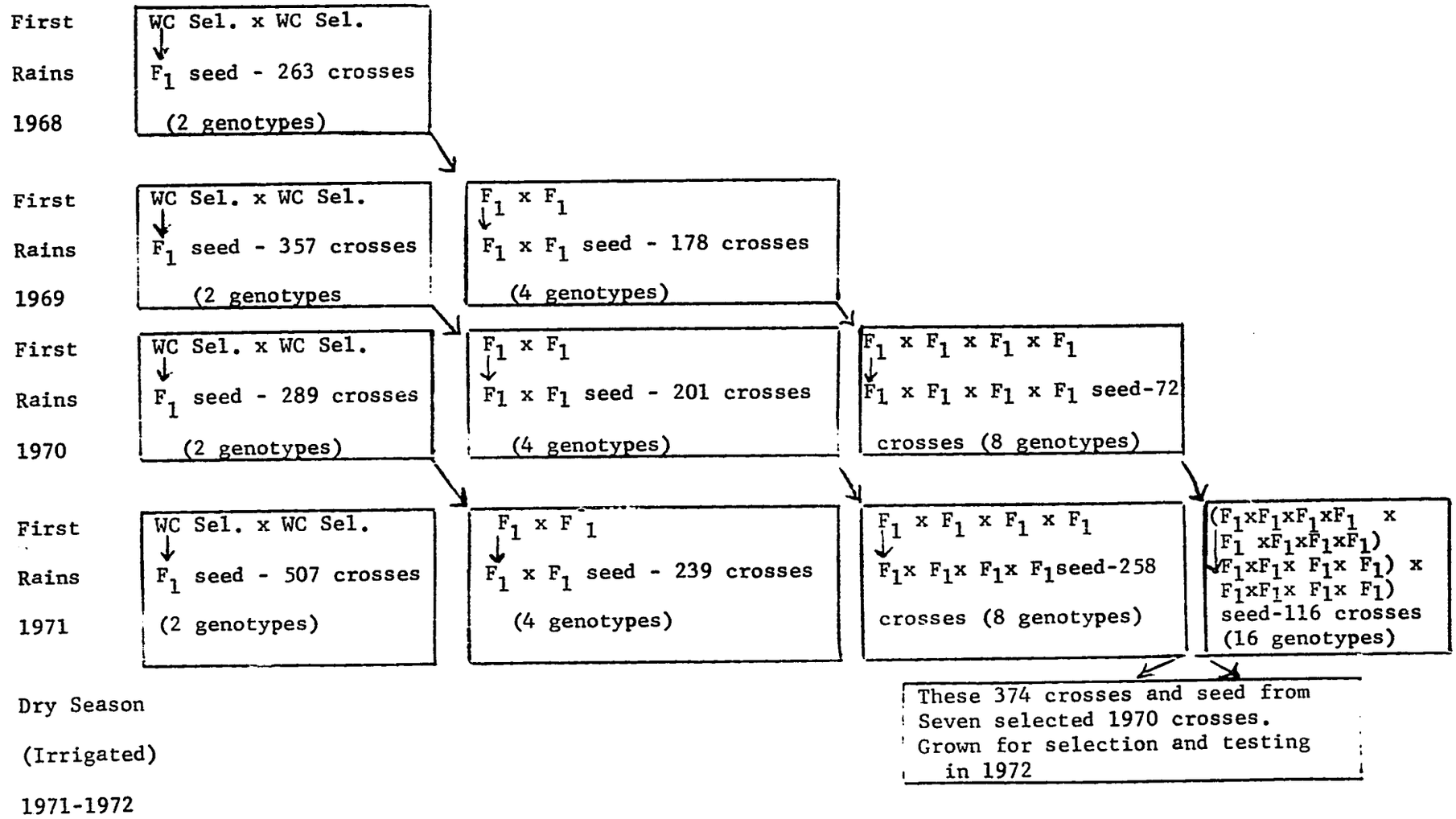

Figure 3. Outline of finger millet breeding programme

FINGER MILLET VARIETY TRIALS

D. K. Whigham

The results and analysis of the 1971 variety trials are presented in Table 47.

When comparing yield on entry means the top 14 entries were not significantly different. The mean yield between the high and low entry was only 5.1 q/ha. Significant differences in yield were found at 16 locations.

Okiring was not among the top yielders in 1970, but performed well in 1971. Serere 104, Gulu E, Serere 148 and Serere 1 were varieties which yielded high in 1970. Other high yielding varieties such as P 339, P 336, and P 226 are new entries in 1971.

At the present time Engenyi is being marketed by the Uganda Seed Scheme for use by the farmer. In 1971 seed from varieties Serere 1 and Gulu E are also being increased for future distribution.

Table 47. Grain yields in q/ha. from the Uganda finger millet variety trials, first rains for 1971.

Varieties	Teso District					
	Serere	Bukedea	Kumi	Arapai	Kabera-maido	Kuju
P 238	23.1	32.4	36.1	19.6	34.2	28.3
Serere 104	27.8	28.1	33.7	23.3	36.6	30.6
WC 93	19.7	37.9	39.2	22.4	35.6	25.9
Eding	25.2	32.4	29.8	18.7	33.8	25.4
P 247	24.9	35.7	35.3	18.7	34.4	27.0
Okiring	23.7	36.6	37.7	26.3	37.4	28.6
P 339	23.6	33.6	40.0	23.7	33.1	28.5
Serere 119	24.4	27.5	34.5	14.5	34.4	27.1
Serere 358	27.2	33.2	36.1	19.5	36.6	26.8
Serere 12	24.3	32.0	36.1	22.3	35.1	27.6
P 336	21.7	33.7	34.5	20.9	36.2	28.0
WC 97	20.3	32.7	33.7	24.6	34.8	27.2
WC 25	21.3	26.0	31.4	10.4	35.5	22.8
Serere 148	24.2	29.8	39.2	29.2	35.4	28.0
Engenyi	22.4	29.0	35.3	20.5	37.3	28.5
P 226	23.7	33.4	39.2	22.9	34.6	26.1
Gulu E	24.9	30.4	35.3	15.4	36.8	27.5
Serere 116	24.4	31.7	33.7	21.1	36.5	23.4
WC 489	20.8	32.1	37.7	15.4	34.1	21.4
Serere 1	26.5	33.1	33.7	19.8	35.4	27.8
Elaba	23.2	31.6	36.9	18.9	34.8	29.4
Serere 149	25.6	33.7	35.3	22.2	36.0	25.1
P 265	26.1	31.0	37.7	20.7	34.5	25.4
Engom	25.8	30.3	34.5	22.3	33.1	27.7
WC 91	19.1	34.9	33.7	21.0	30.6	26.1
Site Mean	23.75	32.11	35.61	20.57	35.07	26.81
L.S.D.(.05)	3.58	4.36	7.47	8.27	5.73	4.29
C.V. (%)	13.06	11.77	18.33	34.81	14.16	13.85

Table 47 (Cont'.d).

Varieties	Busoga District			Karamoja District	
	Bugaya	Vukula	Naka-bango	Namalu	Iriri
P 238	22.2	31.2	37.1	32.0	27.9
Serere 104	22.6	38.6	41.9	37.5	31.6
WC 93	19.8	27.2	46.3	32.0	21.1
Eding	27.4	35.2	39.7	30.2	23.2
P 247	23.9	35.9	47.3	30.2	23.5
Okiring	20.2	41.6	48.6	35.6	31.9
P 339	25.2	40.0	45.2	32.0	30.5
Serere 119	17.5	38.5	40.8	28.4	23.3
Serere 358	24.1	34.1	41.0	35.6	29.6
Serere 12	23.6	34.8	45.2	33.8	25.5
P 336	21.0	35.8	40.7	37.4	27.4
WC 97	23.0	33.0	41.3	28.4	24.0
WC 25	13.2	27.9	46.2	33.8	24.1
Serere 148	26.1	35.3	42.5	32.0	26.4
Engenyi	24.2	35.9	45.7	35.6	28.4
P 226	25.6	34.7	40.3	33.8	30.2
Gulu E	25.9	33.6	49.7	41.0	27.6
Serere 116	27.5	36.3	39.0	32.0	25.4
WC 489	20.9	22.3	42.6	24.8	23.4
Serere 1	26.7	31.4	39.6	39.2	27.3
Elaba	24.5	35.4	45.7	35.6	22.9
Serere 149	26.2	29.7	43.6	32.0	24.5
P 265	25.5	33.3	45.2	35.6	26.5
Engom	30.1	32.8	42.2	32.0	23.5
WC 91	19.1	26.9	44.2	23.0	23.7
Site Mean	23.45	33.66	43.26	32.96	26.13
L.S.D.(.05)	5.23	6.93	6.05	7.71	5.15
C.V. (%)	19.31	17.83	12.11	20.25	17.07

Table 47 (Cont'd.)

Varieties	Lango District		Bukedi District		Madi	Acholi	West Nile	East Buganda		Entry Means	Entry Rank
	Ngetta	Aduku	Tororo	Iki-Ike	Pakelle	Labora	Abi	Bugisu Nabbongo	Namulonge		
P 238	19.5	32.4	26.8	25.5	17.1	30.1	23.6	26.3	20.4	27.3	21
Serere 104	17.6	34.4	27.5	32.1	26.5	27.7	21.7	32.9	21.5	29.7	3
WC 93	22.6	35.2	31.2	23.6	28.6	35.3	19.3	27.1	27.9	28.9	9
Eding	20.6	31.1	29.4	32.6	23.8	30.6	21.6	30.3	20.0	28.1	18
P 247	17.0	33.9	32.0	30.1	20.9	26.6	21.7	25.6	16.6	28.1	18
Okiring	21.0	32.9	24.0	29.0	23.6	31.0	24.7	27.2	19.7	30.1	1
P 339	17.2	35.2	30.1	28.3	23.4	30.5	22.6	31.0	22.1	29.8	2
Serere 119	17.2	32.2	26.7	33.1	21.3	29.4	13.6	25.2	18.6	26.4	22
Serere 358	21.8	33.1	24.0	30.0	21.5	30.5	20.7	26.3	26.2	28.9	9
Serere 12	20.2	35.3	22.3	28.7	24.9	29.1	24.9	30.0	21.5	28.9	9
P 336	18.6	33.3	26.2	30.0	26.1	29.1	27.2	30.6	23.4	29.1	7
WC 97	17.7	32.8	24.0	30.2	21.5	29.5	21.5	25.9	21.7	27.4	20
WC 25	20.8	32.6	26.8	25.5	21.7	24.6	17.6	25.5	11.7	25.0	25
Serere 148	19.6	32.1	22.3	28.9	22.2	29.4	31.5	31.1	23.9	29.5	5
Engenyi	16.0	29.3	26.8	28.4	25.2	30.3	29.8	27.1	16.2	28.6	15
P 226	18.8	30.3	30.4	27.8	27.7	28.5	28.7	27.2	18.6	29.1	7
Gulu E	17.9	34.2	25.0	32.3	24.3	31.7	29.4	31.1	18.5	29.6	4
Serere 116	20.0	34.3	25.0	31.8	25.9	31.2	24.2	27.9	19.5	28.5	17
WC 489	23.0	34.5	25.8	28.8	28.9	25.8	15.8	26.4	14.5	25.9	23
Serere 1	16.6	34.7	29.4	28.4	30.4	34.2	30.2	27.3	11.5	29.2	6
Elaba	16.8	35.3	26.7	31.8	22.7	29.0	23.6	26.7	24.1	28.8	12
Serere 149	20.0	34.1	34.7	28.8	23.8	28.3	18.5	31.4	21.1	28.7	13
P 265	19.3	34.7	26.8	28.9	23.2	31.3	19.2	31.3	17.7	28.7	13
Engom	20.0	34.7	24.0	30.7	24.3	34.3	19.1	30.0	21.3	28.6	15
WC 91	23 1	33.8	29.8	23.0	19.3	26.3	17.5	22.6	19.4	25.9	23
Site Mean	19.32	33.46	27.10	29.13	23.95	29.77	22.73	28.16	19.91	28.00	
L.S.D.(.05)	3.34	4.36	8.98	5.09	6.33	5.68	5.23	4.63	6.17	1.44	
C.V. (%)	14.97	11.29	28.68	15.13	22.89	16.53	19.94	14.23	26.84		

FINGER MILLET SOWING DATE TRIALS

D. K. Whigham and S. Ogolle

The results of the effect of different sowing dates on finger millet yield at 14 variety trial centers in Uganda are shown in Table 48. The first rains of 1971 were later than usual at most sites in the North and East Regions of Uganda. The first sowing date occurred soon after the rains began. However, date 1 was early in March at some centers and late in April at other sites. The sowing dates were at 2 week intervals.

Date 1 trials yielded most at 11 of the sites. The mean yield for each date indicates the importance of farmers sowing finger millet soon after the beginning of the rains. In general, a delay in sowing will result in a reduction in yield.

Table 48. Finger millet sowing date trials in Uganda for first rains 1971.

	Site	Date 1	Date 2	Date 3	Date 4	Site Mean	L.S.D. (.05)	C. V. (%)
Eastern Region	Arapai	29.1	29.8	20.8	17.0	24.15	4.56	14.94
	Bukedoa	35.6	38.6	14.0	6.8	23.76	2.62	8.73
	Iriri	29.2	28.0	21.1	6.4	21.17	3.92	14.65
	Kaberamaido	33.6	21.6	16.2	9.3	20.20	3.02	11.81
	Kuju	47.4	31.4	23.3	18.9	30.24	4.94	12.91
	Tororo	29.9	24.0	12.7	12.0	19.66	3.45	13.86
	Vukula	15.7	15.1	10.4	5.8	11.76	2.11	14.18
Northern Region	Abi	20.9	28.5	19.7	22.6	22.91	4.62	15.94
	Aduku	22.1	18.4	11.1	12.5	16.04	4.38	21.57
	Kitgum	17.7	10.4	7.1	7.8	10.73	3.35	24.68
	Labora	14.5	9.1	10.5	0.0	8.52	3.71	34.40
	Ngetta	13.1	2.8	6.8	0.0	5.64	2.71	37.93
	Pakelle	21.3	10.6	11.9	13.4	14.30	1.02	5.62
	Patongo	20.8	18.8	15.3	9.8	16.20	2.82	13.78
	Date Mean	25.06	20.51		14.35	10.16		

CEREAL AGRONOMY

R. J. Davis, B. A. Opolot,
S. Ogolle, and L. E. Allison

The agronomy program conducted in 1971 was a continuation of some of the work started previously, but with some changes. A new type of experiment dealing with "inputs" or management factors was conducted at several locations. Sorghum date of planting trials and also herbicide trials for weed control were conducted at Serere. Fertilizer trials were conducted on farmers fields in Kumi and Ngora counties to determine optimum nutrient requirements for sorghum and finger millet. No minor element studies were conducted this year, but new experiments are planned for the 1972 season. In November, L. E. Allison replaced R. J. Davis as cereal agronomist.

Date of Planting Trials - Five varieties of sorghum were planted at Serere at two-week intervals, during the first rains with results shown in Table 49. The yield trend was H x 57 > Serena Makerere 105 > Makerere 16 > Taylor's. The first planting on April 26 gave the highest yields for all varieties except Taylor's which yielded poorly at all planting dates. It is significant that the hybrid H x 57 appreciably outyielded Serena in this trial, as it did in a previous 1st rains trials at Kumi and Kitgum in 1970.

Yield data for Serena and H x 57 at Kumi, given in Table 50 show that highest yields were obtained for the early planting of July 21 during the second rains of 1970, but for the third planting on May 7 during the first rains of 1971 at this location. These two varieties gave lower, but quite comparable yields during the first rains of 1971, probably due to the irregular rainfall pattern.

Fertility Trials

Finger Millet. Fertilizer trials using various combinations of N and P_2O_5 were conducted during the first rains at four locations, two in Ngora county and two in Kumi county. The data in Table 51 indicate generally that, in the absence of at least 50 kg/ha of P_2O_5, high levels of 100 and 150 gh/ha of N were relatively ineffective in improving yields. Under the conditions of the trials, the most economical fertility treatment for all locations appeared to be 100 kg/ha of N and from 50 to 100 kg/ha of P_2O_5. Mean yields were higher at Ngora (19.6 kg/ha) than at Kumi (13.9 kg/ha), which probably reflect differing rainfall conditions at these two locations. However, in the 1968 and 1969 trials conducted in the same general areas, higher millet

yields were obtained at Kumi than at Ngora. The millet was planted at Ngora this season during mid-March when the soil was dry which delayed germination but heavy rains soon followed. At Kumi, planting was in mid-April when soil moisture was adequate but dry conditions prevailed during the last week of June and the first two weeks of July when the crop was at the flowering stage. This dry condition probably caused reduced yields at Kumi as compared to Ngora.

Sorghum. Experiments with various levels of N, P_2O_5, and farm manure were conducted during the first rains at two locations each in Kumi and Ngora counties. Similar experiments were conducted in the same counties during the first rains of 1970. The data in Table 52 indicate that, as also in 1970, farm manure is an effective substitute for commercial fertilizers containing N and P_2O_5. Sorghum yields at Ngora and Kumi were appreciably higher in 1970 than in 1971, probably due to a less effective rainfall pattern during the first rains of 1971.

Inputs Experiment - A series of experiments was conducted at six locations during the first rains season to measure the effect of various agronomic, or general husbandry inputs on sorghum yields. It consisted of six factors (variety, population, planting date, shoot fly control, fertilization and weed control) each at two levels, the first being an approximation of current farm practice and the second level being an improved practice based on past research but still within the farmers ability to execute. The data in Table 53 indicate that considerably high yields were obtained by the use of a good sorghum variety (Serena) as compared to a local farmer's variety both with and without the benefit of the other improved practices. Moreover, Serena resistance to stalk borer damage greatly exceeded that of the local varieties, especially at Kaberamaido and at Serere where yield losses accurred due to this pest, mainly for the late plantings. Appreciably higher yields were obtained for the other "inputs", fertilization vs no fertilizer, early vs late planting, high vs low population density, and seed treatment vs no treatment for shoot fly control. Based on the average yields for all locations, seed treatment for shoot fly control was generally the least effective of all treatments. These experiments were also conducted during the second rains of 1971 but the data were not available for this report.

Weed Control Experiments - Five herbicides were tested at Serere on sorghum during both growing seasons of 1971. The data in Table 54 indicate that herbicidal action was greatest during the second rains than the first rains season. Lack of good weed control during the first rains was probably due to two factors; first, the site location was in an area of high weed infestation and, secondly, lack of sufficient rainfall during a critical period to render the herbicides fully effective. Additional herbicides will be tested during the 1972 seasons.

Table 49. Grain yields of five varieties of sorghum at Serere, first rains 1971.

Planting Date	Variety				
	H x 57	Serena	Makerere 105+	Makerere 16+	Taylor's++
26 April	49.6	39.2	33.7	26.4	10.2
10 May	45.7	34.9	24.0	21.1	20.9
24 May	9.0	4.5	4.9	1.9	9.0
Mean	34.8	26.2	20.9	16.5	13.4
L.S.D. 05	5.1	7.1	2.2	9.7	6.6
CV	9.0	16.7	6.5	36.1	30.4

+ Obtained from Makerere University

++ Obtained from Dr. Martin Taylor, Muguga

Table 50. Yield of sorghum at Kumi, 2nd rains 1970 and 1st rains 1971.

Yield (q/ha)					
2nd Rains 1970			1st Rains 1971		
Planting Date	Serena	H x 57	Planting Date	Serena	H x 57
21 July	21.1	34.4	9 April	6.4	7.0
4 August	13.8	19.8	23 April	22.0	18.7
18 August	15.6	21.3	7 May	28.4	28.6
1 September	0.0	0.0	21 May	22.5	18.5
Mean	12.6	18.7	Mean	19.8	18.2
L.S.D.(.05)	8.8	9.5	L.S.D.(.05)	3.8	7.6
C.V.(%)	42.9	31.3	C.V.(%)	11.8	25.5

Table 51. Finger millet grain yields at Ngora and Kumi, 1st rains 1971.

Treatment kg/ha		Yield (q/ha)					
		Ngōra		Treatment	Kumi		Treatment
N	P_2O_5	1	2	Mean	1	2	Mean
0	0	12.5	4.9	8.7	4.2	6.3	4.2
50	0	17.4	19.2	18.3	8.8	14.0	11.4
100	0	18.5	15.1	16.8	10.5	13.9	12.2
150	0	16.5	13.3	14.9	8.3	13.6	10.9
0	50	11.2	5.2	8.2	5.6	9.9	7.8
50	50	22.5	24.2	23.4	10.9	18.2	14.6
100	50	22.4	29.5	26.0	14.3	18.3	16.3
150	50	24.4	32.2	28.3	13.0	23.9	18.5
0	100	14.0	5.5	9.7	5.6	8.1	6.9
50	100	21.0	23.5	22.3	10.5	19.7	15.1
100	100	23.9	31.5	27.7	12.3	25.5	18.9
150	100	25.5	16.4	20.9	15.8	25.3	20.6
0	150	12.9	6.2	9.5	4.2	8.5	6.4
50	150	21.7	22.3	22.0	13.3	19.3	16.3
100	150	24.1	33.0	28.6	11.9	22.8	17.4
150	150	22.5	34.2	28.4	17.4	30.0	23.7
Mean		19.4	19.7	19.6	10.4	17.3	13.9
L.S.D. .05		4.8	10.1	13.8	4.1	4.1	7.3
C.V. %		12.3	25.6		19.6	11.8	

Table 52. Sorghum grain yields, variety Serena with various fertility treatments at Ngora and Kumi, first rains 1971.

Treatments N (kg/ha)	P_2O_5	FYM (q/ha)	Yield (q/ha) Ngora 1	Ngora 2	Ngora Treatment Mean	Kumi 1	Kumi 2	Kumi Treatment Mean
0	50	0	8.2	24.0	16.1	19.0	14.9	17.0
50	50	0	22.9	36.6	29.7	35.7	29.8	32.2
100	50	0	24.5	33.5	29.0	41.4	30.0	35.7
0	50	0	12.4	27.9	20.1	20.1	15.6	17.8
0	50	100	20.2	32.5	26.3	29.6	19.2	24.4
0	50	200	30.2	31.1	30.7	29.1	21.5	25.3
0	0	0	8.0	27.5	17.7	19.3	16.5	17.9
0	0	100	21.5	25.4	23.5	26.8	20.2	23.5
0	0	200	17.6	26.3	22.0	28.6	20.8	24.7
Mean			18.4	29.4		27.7	20.9	
L.S.D. .05			9.7	9.1		11.2	7.9	
C.V. %			26.3	15.4		20.1	18.9	

Table 53. Grain yields in (q/ha) of sorghum variety Serena vs. Local varieties in relation to various management practices at six locations in Uganda, first rains 1971.

Variety	Spacing	Seed treatment	Fertilizer	Weed Control	Kumi	Ngora	Serere	Katakwi	Kabera-maido	Patongo
	Treatments or Inputs				Location.....					
Early Planting Date					May 5	May 3	April 23	May 5	May 5	April 30
Serena	60 x 60	+	+	Complete	22.5	23.3	27.9	10.6	6.8	24.1
Serena	"	+	+	Partial	18.3	10.3	28.6	4.6	11.5	24.1
Serena	"	+	–	C	15.7	12.3	27.1	9.1	3.8	14.0
Serena	"	+	–	P	9.5	5.7	24.8	8.3	3.2	11.8
Serena	"	–	+	C	25.5	19.0	33.8	7.6	2.8	19.1
Serena	"	–	+	P	17.6	14.7	24.8	3.8	9.7	18.5
Serena	"	–	–	C	11.0	13.8	29.8	3.0	6.5	7.5
Serena	"	–	–	P	11.7	5.2	20.0	2.3	5.7	8.3
Local	"	+	+	C	32.6	20.8	27.5	3.0	0.0	11.3
Local	"	+	+	P	17.5	14.5	30.1	3.0	0.0	13.7
Local	"	+	–	C	9.2	3.2	19.1	3.0	0.0	6.8
Local	"	+	–	P	3.3	5.8	24.5	3.8	0.0	5.3
Local	"	–	+	C	7.0	22.8	23.8	5.3	0.0	16.6
Local	"	–	+	P	10.0	6.3	28.0	6.0	0.0	17.8
Local	"	–	–	C	12.3	9.2	20.0	8.3	0.0	12.5
Local	"	–	–	P	8.0	3.3	24.1	0.8	0.0	6.2
Serena	40 x 20	+	+	C	31.1	40.6	30.0	12.9	18.5	22.3
Serena	"	+	+	P	29.5	23.8	31.0	7.6	23.8	29.5
Serena	"	+	–	C	21.0	21.0	24.5	9.8	11.3	14.0
Serena	"	+	–	P	12.5	8.2	32.0	0.8	10.8	12.0
Serena	"	–	+	C	28.5	25.1	29.1	9.8	9.7	28.8
Serena	"	–	+	P	27.5	19.0	34.0	8.3	16.5	26.8
Serena	"	–	–	C	20.0	16.6	22.5	6.0	9.2	12.5
Serena	"	–	–	P	15.2	8.2	38.3	7.6	12.5	14.0
Local	"	+	+	C	27.0	30.1	20.6	4.6	0.0	15.2
Local	"	+	+	P	22.1	11.5	28.8	12.1	0.0	14.7
Local	"	+	–	C	5.5	6.5	23.5	2.3	0.0	9.5
Local	"	+	–	P	6.7	7.0	29.3	10.6	0.0	15.5
Local	"	–	+	C	30.5	28.5	26.6	4.5	0.0	14.3
Local	"	–	+	P	22.6	9.2	29.1	2.3	0.0	12.8
Local	"	–	–	C	8.0	11.0	18.3	4.6	5.3	8.3
Local	"	–	–	P	7.2	4.0	23.6	6.0	2.3	13.2

Table 53. (Cont'd.)

Variety	Treatment Means for					
	Weed Control	Ferti-lizer	Seed Treatment	Variety	Plant Spacing	Planting Date
Serena	19.1					
Serena	16.2	17.7				
Serena	13.7					
Serena	10.6	12.2	14.9			
Serena	18.0					
Serena	14.9	16.5				
Serena	11.9					
Serena	8.9	10.4	13.4	14.1		
Local	15.9					
Local	13.1	14.5				
Local	6.9					
Local	7.1	7.0	10.8			
Local	12.6					
Local	11.4	12.0				
Local	10.4					
Local	7.1	8.8	10.4	10.6	12.4	
Serena	25.9					
Serena	24.2	25.1				
Serena	16.9					
Serena	12.7	14.8	19.8			
Serena	21.8					
Serena	22.0	21.9				
Serena	14.5					
Serena	16.0	15.3	18.6	19.2		
Local	16.3					
Local	14.9	15.6				
Local	7.9					
Local	11.5	9.7	12.6			
Local	17.4					
Local	12.7	15.1				
Local	9.3					
Local	9.4	9.4	12.2	12.4	15.8	14.1

Table 53. (Cont'd.)

Late Planting date																	
					May 25	May 26	May 20	May 25	May 25	May 22							
Serena	60 x 60	+	+	Complete	8.3	31.8	10.7	1.5	0.0	15.8	11.4						
Serena	"	+	+	Partial	2.5	10.0	12.2	3.8	0.0	14.7	7.2	9.3					
Serena	"	+	–	C	4.7	11.2	9.7	1.5	0.0	9.3	6.1						
Serena	"	+	–	P	1.5	6.5	12.0	0.8	0.0	7.7	4.8	5.5	7.4				
Serena	"	–	+	C	3.8	29.3	7.5	0.8	0.0	13.5	9.2						
Serena	"	–	+	P	3.8	13.2	7.8	1.5	0.0	22.8	8.2	8.7					
Serena	"	–	–	C	5.3	8.5	7.3	1.5	0.0	9.2	5.3						
Serena	"	–	–	P	1.8	6.3	8.2	2.3	0.0	9.0	4.6	5.0	6.8	7.1			
Local	"	+	+	C	3.5	16.3	0.0	0.0	0.0	16.0	6.0						
Local	"	+	+	P	1.0	10.0	0.0	0.8	0.0	14.7	4.4	5.2					
Local	"	+	–	C	4.5	6.3	0.0	0.0	0.0	10.7	3.6						
Local	"	+	–	P	0.8	4.8	0.0	2.3	0.0	8.0	2.7	3.1	4.2				
Local	"	–	+	C	3.5	10.2	0.0	2.3	0.0	13.7	5.0						
Local	"	–	+	P	1.8	7.2	0.0	0.8	0.0	16.3	4.4	4.7					
Local	"	–	–	C	2.5	5.2	0.0	0.0	0.0	9.5	2.9						
Local	"	–	–	P	0.7	3.0	0.0	0.8	0.0	10.7	2.5	2.7	3.7	3.9	5.5		
Serena	40 x 20	+	+	C	10.0	33.5	15.8	3.8	0.0	20.1	13.9						
Serena	"	+	+	P	9.8	21.1	19.0	3.8	0.0	23.1	12.8	13.4					
Serena	"	+	–	C	7.2	23.0	13.8	4.5	0.0	9.8	9.7						
Serena	"	+	–	P	2.2	8.8	18.8	2.3	0.0	9.8	7.0	8.4	10.9				
Serena	"	–	+	C	7.8	35.3	13.2	8.3	0.0	17.3	13.7						
Serena	"	–	+	P	7.3	16.5	17.5	4.5	0.0	20.8	11.1	12.4					
Serena	"	–	–	C	8.5	8.0	7.3	6.8	0.0	12.2	7.1						
Serena	"	–	–	P	3.8	9.2	13.2	3.8	0.0	9.0	6.5	6.8	9.6	10.3			
Local	"	+	+	C	1.5	19.5	0.0	1.5	0.0	13.0	5.9						
Local	"	+	+	P	1.8	8.0	0.0	2.3	0.0	14.0	4.4	5.2					
Local	"	+	–	C	1.3	11.2	0.0	1.5	0.0	9.5	3.9						
Local	"	+	–	P	0.8	7.5	0.0	0.8	4.7	11.7	4.3	4.1	4.6				
Local	"	–	+	C	3.8	22.3	0.0	0.0	0.0	14.3	6.7						
Local	"	–	+	P	0.8	8.8	0.0	0.0	0.0	13.3	3.8	5.3					
Local	"	–	–	C	3.7	7.8	0.0	0.0	0.0	13.7	4.2						
Local	"	–	–	P	0.8	3.3	0.0	1.5	0.0	13.7	3.2	3.6	4.5	4.6	7.5	6.4	

‡ Means fertilizer applied, - unfertilized ‡‡ Partial weed control means two weedings, one at thinning and one at flowering

Table 54. Effect of various herbicides on weed control and yield of Serena sorghum at Serere, 1971.

Treatments		kg/ha	First Rains Yield q/ha	First Rains Percentage of weeds remaining	Second Rains Yield q/ha	Second Rains Percentage of weeds remaining
Atrazine	Pre	2.75	13.6	34	23.5	16
Atrazine	Pre	4.00	8.9	50	23.9	17
Atrazine	Post	2.75	8.5	52	16.2	40
Atrazine	Post	4.00	7.8	50	18.0	29
Maloran 6313	Pre	2.75	15.1	53	19.5	42
Maloran 6313	Pre	4.00	14.2	48	17.9	29
Dicuran 2242	Pre	2.75	16.5	47	21.1	32
Dicuran 2242	Pre	4.00	17.0	29	22.2	22
Dicuran 2242	Post	2.75	7.4	53	16.5	46
Dicuran 2242	Post	4.00	10.9	37	18.3	25
GS 13529	Pre	2.75	9.3	46	22.0	14
GS 13529	Pre	4.00	13.2	43	23.7	4
Butasan (BAS 2900)	Pre	6.00*	7.8	40	20.9	39
Butasan (BAS 2900)	Pre	9.00*	10.5	45	21.2	36
Hand Weeding			24.7	00	29.7	00
No weeding			3.0	100	8.8	100
Mean			11.8		20.2	
L.S.C. .05			6.9		3.5	

CEREAL ENTOMOLOGY

James Overman, C. D. Muhwana,
P. A. Opolot and J. W. Etengu

Dr. Dean Barry finished his tour on July 8, 1971 and was replaced by James Overman. The work plan for the remainder of the year has been that set forth by Dr. Barry.

At Serere the sorghum insect pests have demanded nearly all of our attention although the stalk borer, Buseola fusca, was prevalent on bulrush millet in the second rains. Finger millet continues to be relatively free of serious insect pests.

Heavy infestations of the corn leaf aphid, Rhopalosiphum maidis, were observed on the female parent (A x F) of a three way maize cross at Kitale, Kenya. The aphids were negligible on the tassels of the male parent (Inbred G). Heavily infested female parents had poor seed set but it was not determined whether the aphids were the causal agent.

Status of Economic Pests of Sorghum

Sorghum Shoot Fly - The sorghum shoot fly, Atherigona varia soccata, was recorded at most of the sorghum variety trial centers in the first rains. The mean seedling dead hearts for the variety trials were unusually low (less than 5% of the stand). It is felt that taking of entomological data needs reviewing at the next workshop for Variety Trials Officers.

Shoot fly traps at Serere were tested for their effectiveness in sampling the seasonal occurrance of Atherigona sp. Vials of ammonium sulfate or meat meal were used as fly attractants with meat meal proving more satisfactory.

Stalk borers - Buseola fusca was the most important stalk borer of sorghum in the first and second rains. Heavy infestations were noted at Serere, Moroto, Kotido and Patongo. The borer caused complete destruction of several plots at Serere and 39.5% loss at Patongo (Table 55). Chilo partellus were found in dissected plants at all variety trial centers that were visited.

Other Insect Pests - The false coddling moth, Cryptophlebia leucotreata and the American bollworm, Heliothis armigera, were prevalent in sorghum heads in the first rains. Poor exsertion of the sorghum head from the flag leaf is one of the characters related to grain loss from larval feeding.

Plant bugs occurred in large numbers on sorghum heads in the first rains. It was not unusual to find nymphs and adults in excess of 100 on a single head. The quantitative relationship of plant bugs to grain yield and quality requires further investigations.

Infestation of sorghum by R. maids was observed in the input trials at Serere in the second rains. Quantitative data on yield reduction from these insects was not determined.

Host Plant Resistance

Sorghum Shoot Fly - The recurrent selection for recovery resistance was continued in two experiments of 26 lines and 46 lines (Tables 56 & 57, Tables 58 & 59). These lines have undergone respectively five and six generations of selection. Additional selection for resistance within these lines does not seem warranted. The better lines based on recovery resistance and yield will be included in yield trials for 1972.

Coes genetic male sterility was introduced into all of the above lines. The second backcross to the parent line was completed in the first rains and selfed in the second rains. All lines will be backcrossed for the second time in the first rains of 1972.

Composite Populations - Mass selection for recovery resistance was continued in two composite populations which contain the Coes genetic male-sterile. The breeding cycle involves an alternate selection of taking selected male-sterile heads the first generation (recombining generation) followed by selecting male fertile heads the next generation. The populations are currently in their third cycle with male-sterile heads being selected in the first rains of 1972. Genetic advance in recovery resistance needs to be determined by comparing the resistances of the remnant seed from the previous cycles of selection.

International Trial - Sorghum entries from Uganda, India, and Israel were tested at Serere during both rains. Results are reported in Table 60.

Primary Resistance - Primary resistance to the sorghum shoot fly has been identified in ten sorghum lines from India. Seeds of these lines were obtained from Dr. Bill Young, Rockefeller, India and were crossed onto Coes genetic male-sterile. In addition these ten lines were crossed onto composite population 110 which are being selfed and will be recombined by selecting male-sterile heads for three generations.

Selection Indices - The evaluation of host plant resistance to the sorghum shoot fly was analyzed using four indices: % primary resistance, % stand harvested, % recovery from dead hearts, recover resistance index. These values are obtained by the following formulae.

1. % primary resistance = 100% - % Seedling dead hearts.

2. % stand harvest = $\frac{\text{number plants with harvest heads}}{\text{stand count at thinning}}$

3. % recovery = $\frac{\text{Index 2} - \text{Index 1}}{\text{\% Dead hearts}}$

4. Recovery resistance index = % Dead hearts + Index 2.

Indices 1 and 2 are valid for assessing primary resistance whereas 2, 3, and 4 may be used for rating recovery resistance.

Stem borers - Coes genetic male sterility was introduced into five sorghum lines previously selected for resistance to *Chilo partellus*. These crosses were selfed in the first rains and backcrossed with the five parent lines in the second rains.

Meetings attended: The following conferences were attended in 1971.

1. Fourth Eastern African Cereals Conference held in Ethiopia.
2. International Sorghum Symposium held at Hyderabad, India.
3. Sorghum Shoot Fly Workshop held in Hyderabad, India.
4. XVI Annual East African Entomology Conference held in Nairobi, Kenya.

Table55. Incidence of stem borer, Buseola fusca, damage at Patongo variety trial center.

Entry	Percentage of heads without grain	Kg/Ha
5DX 107/3/2/10	75.5	801
5DX 160	58.5	801
5DX157/19/3	51.5	1,202
6DX 10/1/X	50.8	1,068
5DX 142/4	50.0	868
6DX 2/2	49.3	868
6DX 10/1X White	47.3	1,202
Dobbs Bora	46.5	1,202
5DX 135/13/1/3/1	45.8	868
Makerere 16	45.5	1,135
3DX 57/1/H Brown	40.5	868
4DX 34/1/4C	39.5	1,202
3DX 57/1/K	39.0	1,001
3DX 57/1/11/4	37.5	1,135
5DX 61/6/2	33.8	1,335
5DX 93/3/4/4	33.8	1,202
H x 57	33.3	1,402
5DX135/13	33.0	1,135
H x 471 D	30.0	1,202
5DX 11/2/2/2	29.8	1,469
H x 467	27.3	1,469
5DX 142/2/2/24	26.0	1,402
5DX 156/3	25.5	1,602
Serena	20.5	1,535
5DX 360	18.0	1,402

Table 56. Evaluation of 26 sorghum lines in the fourth generation of selecting for recovery resistance to the sorghum shoot fly (*Atherigona* sp.) at Serere, Uganda

Entry	Percent dead hearts	Percent Primary Resistance	Percent stand harvested	Percent Recovery	Recovery Resistance Index	Yield kg[a]
V-5-1-1-1	60	40	75	34	134	1.11
V-19-1-1-1	70	30	87	60	160	1.73
V-20-1-1-1	67	33	78	45	145	1.20
V-37-1-1-1	60	40	72	37	137	0.96
V-39-1-1-1	64	36	89	53	153	1.07
V-47-1-1-1	64	36	54	21	117	0.81
V-61-1-1-1	56	44	85	41	141	1.10
V-64-1-1-1	78	22	68	46	146	0.87
V-70-1-1-1	65	35	91	55	155	1.42
V-71-1-1-1	52	42	78	31	130	1.23
V-73-1-1-1	77	23	82	58	158	0.82
V-74-1-1-1	63	37	82	45	145	1.29
V-92-1-1-1	65	35	88	53	153	1.29
V-99-1-1-1	56	44	80	49	135	1.19
1-106-1-1-1	59	41	76	35	135	1.09
8-P-1-CK2 x Nam-1-1	66	34	75	41	141	1.35
183-P-Serena-1-1	65	35	76	42	141	1.14
157-P-2-SB 79-1-1	47	53	81	28	128	0.92
216-P-1-Serena-1-1	79	21	71	49	149	0.51
45-P-5-CK2 x Nam-1-1	54	46	69	40	124	0.75
165-P-2-Serena-1-1	52	48	84	35	135	1.10
156-P-5-Serena-1-1	70	30	79	47	147	1.18
62-P-1-CK2 x Nam-1-1	68	32	89	56	157	1.15
41-P-2-CK2 x Nam-1-1	79	21	75	54	154	1.08
Serena	68	32	87	55	155	1.58
CK-60	60	40	41	8	101	0.23

(a) Yield for single rows 5 meters long

Table 57. Evaluation of 26 sorghum lines in the fifth generation of selecting for recovery resistance to the sorghum shoot fly (Atherigona sp.) at Serere, Uganda.

Entry	Percent dead heart	Percent primary resistance	Percent stand harvested	Percent Recovery	Recovery Resistance Index	Yield Kg[a]
V-5-1-1-1	74	26	57	35	131	0.41
V-1-9-1-1-1	72	28	74	47	147	0.64
V-20-1-1-1	69	31	68	38	137	0.42
V-37-1-1-1	74	26	56	31	131	0.44
V-39-1-1-1	66	34	68	34	134	0.64
V-45-1-1-1	72	28	41	16	113	0.30
V-61-1-1-1	33	67	66	33	99	0.23
V-64-1-1-1	81	19	52	37	134	0.26
V-70-1-1-1	82	18	71	53	153	0.40
V-71-1-1-1	78	22	66	44	144	0.53
V-37-1-1-1	74	26	48	25	122	0.47
V-74-1-1-1	75	25	65	40	140	0.47
V-92-1-1-1	74	26	60	34	134	0.58
V-99-1-1-1	73	27	61	34	134	0.62
V-106-1-1-1	82	18	62	44	144	0.43
8-P-1-CK2 x Nam-1-1	67	33	71	40	138	0.75
183-P-Serena-1-1	82	18	61	44	144	0.73
157-P-2-SB 79-1-1	76	24	57	33	133	0.35
216-P-1-Serena-1-1	77	23	47	30	124	0.21
45-P-5-CK2 x Nam-1-1	85	15	63	49	149	0.61
165-P-2-Serena-1-1	71	29	57	31	128	0.20
156-P-5-Serena-1-1	69	31	59	27	127	0.37
62-P-1-CK2 x Nam-1-1	80	20	60	40	140	0.43
41-P-2-CK2 x Nam-1-1	73	27	61	34	134	0.33
Serena	86	14	66	52	152	0.50
CK 60	73	27	56	29	129	0.16

(a) Yield for single rows 5 meters long.

Table 58. Evaluation of 46 lines in the 5th generation of selecting for recovery resistance to the sorghum shoot fly (Atherigona sp.) at Serere, Uganda.

Entry	Percent dead hearts	Percent primary Resistance	Percent stand Harvested	Percent Recovery	Recovery Resistance Index	Yield Kg[a]
1-P-4-1-1	59	41	79	64	164	1.29
2-P-2-1-1	67	33	90	85	185	1.38
2-P-1-2-1	76	24	91	88	188	1.06
3-P-5-1-1	72	28	93	90	191	1.10
7-P-1-1-1	49	51	69	37	136	0.46
12-P-1-2-1	63	37	81	70	170	0.93
14-P-4-2-1	70	30	86	80	181	1.13
V-2-1-1	68	32	90	85	186	1.08
14-P-3-2-1	57	43	73	53	153	0.64
15-P-1-1-1	64	36	73	58	158	0.78
25-P-3-1-1	58	42	67	43	148	0.46
26-P-2-1-1	59	41	73	54	155	0.56
28-P-1-1-1	58	42	72	52	152	0.41
28-P-4-1-1	62	38	71	53	153	0.62
29-P-1-1-1	62	38	64	42	141	0.60
V-4-1-1	63	37	78	65	165	0.90
V-30-1-1	66	34	80	70	170	0.75
Serena	63	37	84	75	175	0.95
33-P-3-2-1	58	42	69	47	146	0.58
35-P-5-2-1	66	34	74	61	160	0.79
35-P-2-1-1	64	36	88	81	181	0.80
37-P-3-2-1	56	44	79	63	162	0.52
37-P-1-1-1	60	40	80	67	166	0.89
39-P-4-2-1	59	41	79	64	164	0.90
45-P-2-2-1	64	36	80	69	168	0.98
45-P-1-1	68	32	68	53	153	0.70

Table 58. (Cont'd.)

Entry	Percent dead hearts	Percent primary Resistance	Percent stand Harvested	Percent Recovery	Recovery Resistance Index	Yield Kg[a]
48-P-1-1-1	63	37	82	71	171	0.72
50-P-2-1-1	63	37	73	57	157	0.51
71-P-1-2-1	61	39	67	46	146	0.59
71-P-2-2-1	71	29	72	61	161	0.72
78-P-2-2-1	69	31	81	72	172	0.72
V-63-1-1	80	20	83	79	179	0.64
107-P-6-1-1	73	27	75	66	166	0.85
135-P-5-1-1	57	43	66	40	140	0.52
135-P-5-2-1	66	34	78	67	166	0.73
CK - 60	61	39	26	0	114	0.12
143-P-2-2-1	69	31	70	57	157	1.23
156-P-5-2-1	68	32	70	56	156	0.85
157-P-3-1-1	49	51	87	73	173	0.91
165-P-6-2-1	63	37	73	57	158	0.80
210-P-5-2-1	73	27	77	68	169	0.88
210-P-4-1-1	62	38	78	65	165	0.66
211-P-3-1-1	57	43	73	53	153	0.67
211-P-1-2-1	63	37	80	68	168	0.61
217-P-1-2-1	63	37	63	41	140	0.65
218-P-3-2-1	66	34	82	73	173	0.83
V-100-1-1	70	30	92	89	188	0.49
234-P-5-2-1	67	33	71	57	156	0.62

(a) Yield for single rows 5 meters long.

Table 59. Evaluation of 46 lines in the 6th generation of selecting for recovery resistance to the sorghum shoot fly (Atherigona sp.) at Serere, Uganda.

Entry	Percent dead hearts	Percent primary Resistance	Percent stand Harvested	Percent Recovery	Recovery Resistance Index	Yield Kg[a]
1-P-4-1-1	58	42	70	28	128	0.68
2-P-2-1-1	67	33	69	37	136	0.71
2-P-1-2-1	64	36	62	31	126	0.37
3-P-5-1-1	66	34	77	43	143	0.90
7-P-1-1-1	61	39	53	32	114	0.16
12-P-1-2-1	54	46	57	23	110	0.17
14-P-4-2-1	64	36	59	27	122	0.37
V-2-1-1	62	38	74	40	136	0.84
14-P-3-2-1	59	41	68	34	127	0.44
15-P-1-1-1	64	36	61	31	125	0.54
25-P-3-1-1	64	36	57	33	121	0.28
26-P-2-1-1	64	36	71	40	135	0.45
28-P-1-1-1	66	34	65	38	131	0.29
28-P-4-1-1	65	35	74	39	139	0.41
29-P-1-1-1	67	33	59	26	126	0.42
V-P-4-1-1	65	35	67	32	133	0.54
V-30-1-1	59	41	69	29	128	0.58
Serena	73	27	73	45	145	0.58
33-P-3-2-1	68	32	66	34	134	0.47
35-P-5-2-1	66	34	74	39	139	0.71
35-P-2-1-1	65	35	60	26	126	0.51
37-P-3-2-1	72	28	61	34	133	0.52
27-P-1-1-1	62	28	62	25	124	0.64
39-P-4-2-1	63	37	65	28	128	0.49
45-P-2-2-1	72	28	76	48	148	0.40
45-P-2-1-1	77	23	68	45	145	0.68

Table 59. (Cont'd.)

Entry	Percent dead Hearts	Percent primary Resistance	Percent stand Harvested	Percent Percent Recovery	Recovery Resistance Index	Yield Kg[a]
48-P-1-1-1	67	33	70	40	138	0.42
50-P-2-1-1	65	35	70	35	135	0.37
71-P-1-2-1	60	40	56	21	116	0.37
71-P-2-2-1	70	30	74	44	144	0.79
78-P-2-2-1	63	37	68	31	132	0.77
V-63-1-1	67	33	56	26	123	0.39
107-P-6-1-1	73	27	71	44	144	0.55
135-P-5-1-1	62	38	57	22	119	0.41
135-P-5-2-1	59	41	65	24	125	0.44
CK - 60	63	37	66	46	129	0.31
143-P-2-2-1	71	29	61	33	132	0.85
156-P-5-2-1	64	36	64	28	128	0.51
157-P-3-1-1	61	39	67	30	128	0.66
165-P-6-2-1	53	47	71	25	112	0.46
210-P-5-2-1	66	34	62	31	128	0.64
210-P-4-1-1	74	26	79	53	153	0.69
211-P-3-1-1	64	36	82	47	147	0.95
211-P-1-2-1	74	26	78	52	153	0.90
217-P-1-2-1	69	31	80	49	150	0.48
218-P-3-2-1	69	31	69	39	139	0.53
V-100-1-1	56	44	62	31	118	0.31
234-P-5-2-1	64	36	70	33	133	0.57

(a) Yield for single rows 5 meters long.

Table 60. Evaluation of international trial at Serere, Uganda 1971

Entry	First Rains					Second Rains				
	Indices of Resistance					Indices of Resistance				
	1[a]	2[b]	3[c]	4[d]	5[e]	1[a]	2[b]	3[c]	4[d]	5[e]
164-3-1-Serena	47	53	68	32	115	70	30	59	30	130
161-3-1-SB 79	54	46	64	33	118	70	30	63	32	132
82-2-1-CK 2 x Nam	55	45	84	72	139	72	28	68	40	140
35-5-1-CK 2 x Nam	48	52	80	59	128	73	27	69	42	142
27-1-1-CK 2 x Nam	45	55	77	49	122	67	33	73	40	140
89-5-1-Serena x Nam	55	45	70	47	125	67	33	65	30	132
IS 5801	46	54	78	51	123	52	48	68	23	119
IS 2269	43	57	87	69	130	60	40	49	25	109
IS 5633	41	59	87	67	130	48	52	68	22	115
IS 5470	37	63	80	47	117	50	50	65	17	116
IS 1560-1-1-2	40	60	65	13	105	40	60	37	6	75
CK 60						59	41	53	23	112
Serena						74	26	68	42	142
V-73-1-1-1						81	19	57	35	138
62-P-1-CK 2 x Nam-1-1-1						75	25	61	26	136
V-19-1-1-1						56	44	57	21	113

(a) Index 1 = % Dead hearts
(b) Index 2 = % Primary resistance
(c) Index 3 = % Stand harvested
(d) Index 4 = % Recovery from dead hearts
(e) Index 5 = Recovery resistance index

UGANDA FIELD TRIALS

D. K. Whigham

The new position of Uganda Field Trials Officer was filled on April 17, 1971 by Dr. D. K. Whigham, stationed at Serere Research Station, Soroti, Uganda.

An objective of the Field Trials Officer is to improve the efficiency of the cereal trials by closer supervision of such trials. Maize, sorghum, and millet variety trials plus cereal agronomy and entomology trials at the outlying stations are being supervised.

Cereal demonstrations, to inform the farmer of research results, are an important responsibility of the Trials Officer. Unless research results are put to practice by farmers a research program is incomplete. The Government of Uganda has accepted a proposal that each (15) District Farm Institute demonstrate two cereal crops each season in 1972. The demonstrations will compare good versus poor management, different dates of planting and local versus improved varieties. Maize, sorghum, and millet are the cereals to be demonstrated.

Since the Uganda Seed Scheme are interested in demonstrating the improved varieties they are multiplying, the Trials Officer is cooperating in all cereal demonstrations. The Agricultural Extension Service staff in Uganda are working with the Trials Officer where cereals are being demonstrated on private farms.

MAIZE GENETICS DIVISION

L. L. Darrah, E. Mwenda and B. A. Omolo

Permanent and pensionable Maize Genetics positions were established by the East African Legislative Assembly during 1971. These are for a Scientific Assistant, four Laboratory Assistants, twelve Sub-ordinate Staff, and one Clerical Officer. These positions are to be fully funded by the East African Community beginning in 1972. Actual transfer of the Kenya Government personnel was not effected in 1971, but is expected in early 1972. A position for a Research Officer Trainee is not yet on the record, however, indications are that it will become reality in FY1973, which will be in sufficient time to accomodate the candidate under consideration.

Mr. E. Mwenda, the Maize Genetics Assistant seconded from the Kenya Ministry of Agriculture, departed to attend an F.A.O. Maize, Sorghum, and Millet Training Conference 1 June 71. Since the Conference was to run for six months, he was replaced by Mr. B. A. Omolo, a recent Egerton College graduate. Other staff positions have remained unchanged during 1971.

USAID has continued to reimburse EAAFRO for operating expenses and labor costs, with the exception of vehicle charges. All operating costs will be assumed by EAAFRO in January 1972.

The 1971 growing season began about a month late due to the rains starting in early April instead of the usual March. Much difficulty was experienced in land preparation as plowing couldn't be done. With no rain, in any significant amount, from the middle of January to early April, the plows just were not able to penetrate. Some of our fields were not plowed until after the beginning of the rains. Planting was finished up on 5 May 71 and resultingly, harvesting continued until the middle of January 1972. Despite the late start, the 1971 season was very good generally. Yields exceeded the levels obtained in 1970. Stands, however, were poor in the ear-to-row experiments and were substandard in all trials. Rainfall at the National Agricultural Research Station, Kitale is given in Table 61. The usual June-July depression did not occur and the curve is fairly normal appearing. Severe storms early in the season caused extensive root lodging in experiments at Kitale. There was evidence of a lack of nitrogen at the Endebess location, but elsewhere, no deficiencies were noted.

Trials were grown at eight locations in Kenya for the Maize Breeding Method Study (MBMS) and evaluation trials. These sites and their approximate altitudes are listed below.

Location	Altitude (m)
Kitale (National Agr. Res. Sta.)	1865
Endebess (W.E.Strong Farm)	1860
Kakamega (Western Agr. Res. Sta.)	1580
Njoro (Plant Breeding Station)	2133
Kitale (Top Farm, N.A.R.S.)	1910
Endebess (Merrow Down Farm)	1890
Mt. Elgon (Chorlim ADC Farm)	2134
Busia (Experimental Sub-Sta.)	1280

Fertilizer was applied in the amount of 104kg/ha of Nitrogen top-dressing when plants were 30cm high; and 115kg/ha of P_2O_5 at planting. All plots were over-planted and thinned to the desired stand. The standard spacing was 80 x 26.6cm, giving a population of 46,876 plants per hectare. Two or three hand weedings were done as required and pre-emerge 2-4-D herbicide was applied to all trials. All plants had a pinch of 5% DDT applied at thinning for the prevention of stalk borer damage.

Table 61 Annual rainfall at the National Agricultural Research Station, Kitale. (mm)

Month	1966	1967	1968	1969	1970	5 Year mean	1971
Jan.	9.2	2.8	1.1	61.6	105.7	36.1	9.1
Feb.	45.9	20.8	146.6	57.7	8.7	55.9	0.3
Mar.	106.2	103.8	68.6	107.2	226.4	122.4	21.2
Apr.	269.8	223.9	200.6	54.1	198.7	189.2	147.8
May	79.6	259.8	94.5	214.6	135.7	156.8	118.4
Jun.	182.6	144.0	127.2	49.0	62.6	95.1	207.5
July	182.3	190.0	176.3	101.5	177.3	165.5	180.6
Aug.	197.4	113.7	121.0	176.2	214.1	164.5	166.9
Sept.	187.8	58.3	60.4	115.6	86.1	101.6	75.3
Oct.	62.5	230.2	87.6	119.2	82.7	116.4	170.6
Nov.	98.6	83.8	57.1	58.1	32.4	66.0	57.9
Dec.	13.7	6.9	17.8	6.2	13.6	11.6	56.5
Total	1335.6	1438.0	1158.8	1121.0	1344.0	1281.3	1212.1

Maize Breeding Methods Study (MBMS)

The Maize Breeding Methods Study in 1971 continued as originally laid down by Dr. S. A. Eberhart in 1964. New in 1971 is experiment S22 in Kitale Composite A (KCA). This involves S_1 testing to complement the existing comparisons of ear-to-row and reciprocal recurrent selection. The analog in Ecuador 573 (Ec573) will be grown in 1972. Trials include comparisons of ear-to-row, mass, S_1, half-sib, full-sib, and reciprocal recurrent selection with some comparisons being made within a given method. These comparisons include population, male selection, selection intensity, experiment size (number of entries), and type of tester.

The results from this Maize Genetics Breeding Study from 1964 to 1970 were summarized and a manuscript "Preliminary results from a maize breeding method study in Kenya" has been submitted to the Crop Science Journal for publication. These results were also presented at the Eastern African Cereal Research Conference, October 17-23, 1971, in Ethiopia.

Average estimates of variance components, heritabilities, and selection differentials obtained for the various populations from their selection trials from four locations in 1964 to 1970 are presented in Table 62. Predicted gain per year was estimated to be highest for S_1 line selection and half-sib selection using an inbred line as tester. Relatively low gains per year were predicted for the ear-to-row selection method. Expected gain from mass selection within families in the isolation fields of the ear-to-row experiments was not included in Δ G. Estimates of genetic variance varied widely between experiments; this variation emphasizes the need for extensive trials to obtain reliable estimates of variance components. The regression of the estimates of each type of variance component on the cycle of selection for each subpopulation indicated there were no significant changes in any individual experiment or when averaged over experiments. Hence, averages over cycles with the observed standard errors are presented in Table 62.

Pooled estimates of the variance components were obtained also for the 28 KCA (3,5,6,7,14) experiments by pooling degrees of freedom and sums of squares to obtain the pooled mean squares. The variances of these estimates were computed as $[\sum(2MS_i^2/df_i)]/k^2$. The pooled estimates of the variance components are similar to the average estimates and the standard errors differ only for the pooled error, s_e^2. Heterogenity of error mean squares among environments probably contributed to the larger standard error for the average estimate since it was derived empirically.

Means for the different experiments in Table vary greatly because of the type of material in the yield trials as well as the variation in environmental conditions in different years. The Ec573(R12) and KII(R11) experiments are representative of the yield level to be expected in the variety-cross hybrid. Values for the ear-to-ear experiments are representative of the KCA population as are H14 and F18, but HL15 and HI16 yields may be reduced slightly by the lower yielding testers. Since S_1 lines per se were tested in S13, yields are considerably lower.

The least-squares estimates of observed gain from selection and their standard errors obtained from the evaluation trials grown during 1966-1970 are given in Table 63. Appropriate predictions could not be made for all methods. Most of the improvement in the H611(R) variety-cross seems to have come from improvement in Ec573(R12). Although improvement in E1 versus R11 and E2 versus R12 is similar, improvement of H611(%) was much greater than H611(E). Selection in KCA, which is the advanced generation of the original H611, has been effective in E5, E6, and E7, but not in E3. The basis difference between these is an additional two cycles of random mating in E5, E6, and E7. Observed gain from selection in KCA (E5, E6, and E7) is similar to the observed gain in H611(%), but the initial mean was much lower. Since no improvement has been made in KCA(M9) and (M10) at 46,880 plants/ha, a new experiment (M17) was initiated to evaluate mass selection in KCA at 23,440 plants/ha.

Selection in the ear-to-row and mass selection experiments is solely for yield, except where the 50% male selection is done. Some agronomic characters can be evaluated at that time. During the recombination and the selfing or testcrossing phases in the remaining schemes, agronomic selection is practiced. Lodging has not changed except in H611(R), where the reduction is more than twice the standard error. Mean lodging is still unacceptably high, however. Ear height and lodging increased in both M9 and M10.

Increases in ears per 100 plants were associated with all yield increases. The greatest progress has been made in Ec573(R12) and (E2). Ec573(R12) also shows a slight reduction in ear height and in blight score. H611(R) showed improvement in lodging resistance, reduced ear height, and blight resistance, whereas H611(E) increased in ear height. Mass selection for yield was ineffective in improving agronomic traits or in improving yield.

Since the inbreds F and G are selections from two of the S_1 lines used to synthesize K II, H613 would be expected to improve somewhat as Ec573 improved. Improvement in E2 produced no improvement in H613(E) for any character, whereas H613(R)C2 was higher yielding with more ears per plant than H613B.

Comparisons of observed and predicted values from four years of selection are compared with the original variety in Table 64. In three of four instances, observed gain is greater than the predicted gain. Within K II and Ec573, the ear-to-row method and reciprocal recurrent selection produced similar improvement. But in the variety-cross, H611(R)C2 exceeded H611(E)C4 by 8.1 q/ha.

KCA(E) showed more gain than H611(E), but H611(E)C4 still yields slightly more than KCA(E)C4 because of the heterosis between K II and Ec573. No improvement was obtained in the yield of H613(E) even though E2 had been improved by four cycles of ear-to-row selection, whereas H613(R)C2 showed a 7.8 a/ha gain over unimproved H613.

Gains in commercial versions of these hybrids were evident in the 1970 Maize Genetics evaluation trials as shown in Table 65. 'H611C' differs from H611(R)C2 by using Kitale III as the female parent versus K II (R)C2. K III was developed from K II by one cycle of half-sib selection. 'H613C' is H613(R)C2. Gains of 26 and 24% have been made in H611 and H613, respectively. A significant improvement in lodging has been made for H611, and some improvement may have occurred in H613. Changes in ear height have been nominal.

Table 66 presents results of the 1970 Kenya Late Maturity Maize Variety Trial from 28 locations. Local farmer's maize is represented by K II, and the remainder are either commercial or experimental hybrids. Substantial improvements in yield are evident in all hybrids over K II, but the greatest gains have been made by using Ec573(R)C2 as the pollinator in H611 and H613. Small overall improvements have been made in the remaining characters shown. The primary concern, currently, is ear height reduction and associated improvement in lodging resistance.

Discussion

Yield trial information currently available from the breeding method study permits direct comparisons only between ear-to-row and reciprocal recurrent selection. Evaluation trials involving S_1 line testing and half-sib or full-sib selection methods have not been grown.

During the last two years, observations have been made in Ec573(E2) which suggest that introgression of other germplasm may have occurred because complete isolation could not be obtained in the ear-to-row trials. Should this be so, interpretation of these comparisons becomes difficult, and caution must be exercised. The full extent of the problem should be resolved by observations on material now being grown. Observed gain per cycle from reciprocal recurrent selection in BSSS(R) x BSCB1(R) was reported to be 1.7% by Penny and Eberhart in Iowa and was reported to be 3.5% in Jarvis(R) x Indian Chief (R) by Moll and Stuber in North Carolina. The 10% gain per cycle in KII(R) and Ec573(R) was considerably greater than in either of the USA experiments.

The large improvement in both Ec573(R) and Ec573(E) as well as in KCA(E) suggests that many loci may be showing partial to complete dominance. If the observed gains from selection in the more effective intrapopulation selection methods such as half-sib (HI4, HL15, and HI16) and S_1 selection (S13) are as good as the predicted gains, some of the improved KCA varieties may approach the yield of H611(R) by the 4th or 5th cycle, and variety crosses of these improved KCA strains with other improved varieties may give even higher yields than the improved parental varieties.

These preliminary results are very encouraging because they show that rapid improvement is being made, not only in the varieties, but also in the variety-cross and top-cross commercial hybrids. The lack of changes in the estimates of s_g^2 in any of the populations suggests that this rapid rate of improvement is not expected to decline in the near future. More extensive evaluation trials will be needed with the products of all methods of improvement before any general recommendations can be made as to the most effective method of selection.

Table 62. Average estimates of variance components, heritability, and selection differential for various populations obtained from yield trials grown at four locations in western Kenya 1964-1970.

	No. of estimates	$\bar{x}$ q/ha	^2_e	$^2_{ge}$	^2_g	H	D	G per year
KII(E1)	7	52±3	122±12	26±4	13±4	.34±.22	9.6±.4	1.7±.5
KII(R11)	3	62±5	130±20	23±4	8±1	.24±.02	8.5±.1	3.0±.8
Ec573(R12)	3	61±6	134±16	24±6	16±8	.36±.13	10.3±.7	
EC573(E2)	7	48±4	91±10	14±4	17±2	.52±.03	10.1±.2	2.6±.2
KCA(E4)	6	42±3	40±8	8±3	8±1	.50±.06	6.6±.7	1.7±.2
KCA(S13)	3	35±1	63±6	28±1	53±11	.77±.04	14.0±1.3	5.4±.7*
KCA(HL15)	3	57±1	130±8	16±4	16±3	.42±.06	9.8±.2	4.2±.5
KCA(HI16)	2	53±1	112±5	18±3	30±4	.55±.03	12.2±.6	6.7±.7
KCA(F18)	2	52±8	129±4	30±1	29±1	.49±.08	12.9±1.2	3.2±.8
KCA(E3)	7	52±3	111±11	28±3	20±4	.45±.05	10.0±.8	2.4±.4
KCA(E5)	6	50±3	91±8	23±7	14±2	.44±.03	9.6±.8	2.1±.3
KCA(E6)	6	51±3	106±14	19±3	14±4	.39±.09	9.5±.9	1.9±.5
KCA(E7)	6	54±4	106±10	28±3	21±4	.48±.06	10.4±.3	2.5±.3
KCA(H14)	3	62±2	118±18	10±5	13±1	.43±.03	9.9±.5	4.2±.2
KCA (3,5,6,7,14)								
Average	28	53±2	105±5	23±2	17±2	.44±.03	9.9±.3	2.2±.2
Pooled**			106±2	23±2	17±1			

* AG is for the mean of S_1's from the improved population.

** Degree of freedom and sums of squares from the 28 experiments were pooled to obtain the pooled mean squares, and the standard errors were computed as $[\sum(MS_i^2/df_i)]/k^2$.

Table 63. Least squares estimates of gain per year from selection from combining results of evaluation trials grown in western Kenya 1966-1970.

Population Method	Yield (q/ha) Predicted	Yield (q/ha) Observed	Observed gain for other agronomic characters: Lodging	Ears per 100 plants	Days to tassel	Ear height	Blight	Rust
KII								
E1	1.7±.5	.9±.7	-.8±.7	1.4±.7	.0±.4	1±1	.0±.1	.1±.1
R11	----	.6±.9	-1.7±.8	2.5±.8	-.5±.4	-3±1	-.2±.1	-.2±.1
Ec573								
E2	2.6±.2	3.2±.7	1.0±.7	2.7±.7	-.8±.4	-1±1	-.2±.1	.0±1
R12	----	3.0±.9	.5±.8	3.1±.8	-1.1±.4	-2±1	-.3±.1	-.1±.1
H611								
E1xE2	----	1.3±1.0	.1±1.0	1.8±.9	.2±.4	1±2	---	---
R11xR12	3.0±.8	3.3±.7	-2.0±.7	2.6±.7	-.6±.3	-2±1	-.4±.1	-.1±.1
KCA								
E4	1.7±.2	2.5±1.1	-1.1±1.1	1.8±1.1	-.3±.5	1±2	---	---
E3	2.4±.4	.1±.7	- .3±.7	.3±.7	-.1±.4	1±1	.0±.1	.0±.1
E5,6,7	2.2	2.9±.8	.3±.8	1.9±.8	-.5±.3	0±1	.1±.1	.0±.1
M9	2.4	.9±.9	1.0±.8	.7±.8	.8±.4	2±1	.0±.1	-.1±.1
M10	1.8	.8±.9	1.2±.8	.3±.8	.1±.4	3±1	.0±.1	.0±.1
H613								
(FxG)xE2	----	-.6±1.0	.1±1.0	-.6±1.0	.0±.4	1±2	-.1±.1	.1±.1
(FxG)xR12	----	2.0±1.0	-.7±1.0	2.0±1.0	-.4±.4	-2±2	-.1±.1	.1±.1

Table 64. Comparisons of predicted and observed yields and gain from four years of selection in Kenya maize breeding material.

Population Method	Yield		Gain	
	Observed	Predicted	Observed	Predicted
KII	46.9(100)	--------		
(E1)C4	50.4(108)	52.1(111)	3.6	5.2
(R11)C2	49.4(105)	--------	2.6	
Ec573	33.6(100)	--------		
(E2)C4	46.6(139)	44.1(131)	13.0	10.5
(R12)C2	45.6(136)	--------	11.9	
KCA	50.6(100)	--------		
(E5,6,7)C4	62.2(123)	59.6(118)	11.6	9.0
H611	65.2(100)	--------		
(E)C4	70.2(108)	--------	5.1	
(R)C2	78.3(120)	77.1(118)	13.1	11.9
H613	69.0(100)	---------		
(E)C4	66.4(97)	--------	-2.6	
(R)C2	76.8(111)	--------	7.8	

Table 65. Hybrid performance from original hybrids and the improved version developed by the ARS-USAID-EAAFRO maize breeding program at nine locations in western Kenya in 1970.

Hybrids	Yield q/ha	%	Lodging %	Ear Height cm
H611 (original hybrid)	54.8	100	67	253
H611C(improved version)	69.2	126	57	245
H613B (original hybrid)	54.9	100	78	241
H613C (improved version)	68.2	124	72	238
H632 (traditional hybrid)	46.0	---	82	203
LSD (P = .05)	7.5	---	9	8

Table 66. Performance of hybrids in the Kenya Late Maturity Maize Variety trial at 28 locations in western Kenya in 1970.

Variety	Yield		Lodging	Ears/ 100 plants	Bare tips	Diseased ears	Ear height*
	q/ha	% of KII	%		%	%	
KII	40.1	100	47	75	13	7	214
H622	51.2	128	51	86	13	11	193
H632	46.9	117	58	81	17	12	190
H613B	57.0	142	48	84	24	7	231
H613(R)C2=H613C	66.7	166	41	95	18	6	223
H611B	52.7	131	43	80	21	5	238
H611C	61.3	153	39	88	18	5	241
H611(R)C2	64.4	161	37	93	13	4	235
L.S.C. (.05)	5.1	---	6	6	5	3	11

* Ear height data were only collected at 11 locations.

Lodging data taken in Eastern Africa show it is of prime importance. Percent lodging in the trials often exceeds 50%. To further refine the extent of the problem, data have been taken on root and stalk lodging in selected trials in 1971. Since R11 and R12 are important commercially, data was taken on root and stalk lodging, and ear heights, as this is closely related. Data in Table 67 give the agronomic information on the selected entries of R11 and R12. In both experiments the mean of the selected entries was less than the overall mean for stalk lodging, but the selected mean was greater than the overall mean for ear height. The mean of selected entries for root lodging in R11 was less than the overall mean, while in T12, it was more. Differences were small, except for stalk lodging in R11.

Ten entries have been selected for recombination to continue R11 and R12. Three of these ten were selected for recombination to form an elite population for possible commercial use. Selection of the entries for this population took the agronomic data into consideration, whereas selection for R11 and R12 did not. The entries selected for elite recombination in KII(R11)C3 were 61, 58, and 30. In Ec573(R12)C3 the elite entries were 42, 1, and 57. The elite Ecuador population could be used for the male pollinator in commercial hybrids 611, 612, and 613. The KII(R)C3 lines 61, 58, 30, 13, and 75 will be topcrosses to the Ec573(R)C4 elite synthetic to develop new lines for the female KII single cross.

Table 67. Yield and agronomic data on the selected entries from R11 and R12 grown in 1971.

Experiment	Entry No.	Yield q/ha	Stand %	Root* lodg. %	Stalk* lodg. %	Ear * height cm
KII(R11)C3	61	92.7	92.6	3.9	18.6	230.2
	58	90.4	92.0	3.9	14.1	219.3
	30	89.6	94.3	5.2	10.3	243.1
	65	89.5	92.6	7.9	18.6	250.7
	7	88.1	89.8	9.8	15.7	244.6
	13	86.6	95.5	3.3	14.3	237.0
	88	86.1	92.0	1.0	28.2	244.6
	75	85.6	90.9	9.6	8.7	235.5
	72	85.4	91.5	12.8	28.9	250.2
	37	85.0	89.8	0.0	29.1	233.2
Mean of Sel.		87.90	92.10	5.74	18.65	238.84
Mean of R11		78.75	91.59	6.07	24.70	236.37
LSD .05		11.80	7.38	10.67	15.42	15.05
Ec573(R12)C3	42	95.5	89.8	7.4	23.8	241.9
	1	94.8	91.5	7.4	24.6	237.9
	53	93.1	94.3	5.7	29.0	235.9
	86	92.6	89.8	4.0	36.2	239.7
	57	91.5	92.0	1.7	15.8	230.3
	93	90.9	96.0	4.9	23.8	244.7
	17	90.6	92.6	6.6	16.4	235.3
	51	88.8	92.0	8.3	34.6	242.3
	4	88.0	93.8	4.0	36.2	244.4
	66	87.8	93.8	5.2	18.4	252.5
Mean of sel.		91.36	92.56	5.52	25.88	240.49
Mean of R12		81.47	92.02	5.04	28.64	239.09
LSD .05		12.11	7.07	9.08	16.93	14.33

* Data available from Kitale, Endebess and Jnoro only.

Since root and stalk lodging data were available, a slight modification of the RBMN program enabled pheotypic and genetic variances and covariances to be calculated. These statistics are presented in Tables 68 and 69 for R11 and R12, respectively. From these variances and covariances, a selection index will be derived which should be useful in improving the net worth of the population. Economic weights will be determined by selecting the desired rate of lodging improvement when selection is on the index. Note that the program calculated the components on pounds per plot and percent lodging, so the statistics can not be directly applied to the data of Table 68 Linear regression coefficients may be calculated from Tables 68 and 69.

Theaverage regression coefficient for three locations for R11 and R12 for root lodging was -0.046 and for stalk lodging -0.028. Thus a 10% increase in root lodging would result in a yield decrease of approximately 3.2 q/ha, using a pounds per plot conversion of 7 to obtain q/ha. On an average yield in R11 and R12 of approximately 91 q/ha, this represents a loss of some 3.5%. Though the coefficient for stalk lodging is less, the amount is more than double, hence, the loss experienced is more than for root lodging.

Table 68. Phenotypic and genetic variances and covariances for KII(R11)C3 from data taken at three locations. Yields are in pounds per plot and lodging scores in percent. Correlations are given in parentheses.

Trait	Phenotypic statistics			Genetic statistics		
	Yield	Root lodg.	Stalk lodg.	Yield	Root lodg.	Stalk lodg.
Yield	.73	-.42	-1.91	.27	.33	- 1.35
Root lodg.	(-.09)	19.64	-3.16	(.14)	5.42	- 2.46
Stalk lodg.	(-.23)	(-.34)	67.75	(-.22)	(-.37)	38.04

Table 69. Phenotypic and genetic variances and covariances for EC573(R12)C3 from data taken at three locations. Yields are in pounds per plot and lodging scores in percent. Correlations are given in parentheses.

Trait	Phenotypic Statistics			Genetic Statistics		
Yield	.94	-.20	-.55	.43	.08	-.46
Root lodg.	(-.02)	12.26	-2.81	(.03)	1.95	-1.92
Stalk Lodg.	(-.01)	(-.04)	65.78	(-.02)	(-.06)	29.97

Extraction of Lines from Breeding Populations

While population improvement continues, it is possible to extract selected lines from each cycle of selection for the formation of conventional three-way and double-cross hybrids. The initial results of the MBMS were such that the population improvement discouraged the additional work necessary to extract and evaluate individual lines. In 1970, the selected C2 lines were selfed in experiments R11 and R12. S_3 x S_3 crosses of selected C2 lines of R11 and R12 were made in August of 1970 and evaluated in 1971 as a 10 x 10 square lattice at four locations. The object was to be able to predict the best three-way cross involving a KII x KII female parent and an Ec573 male pollinator. The best predicted three-way crosses would be made up during 1972 and tested in 1973. Of interest besides a possible commercial release, is the level of the variety-cross hybrid H611(R)Cn available at the time that the extraction and evaluation is completed. Consideration must also be given to specific agronomic characters, such as ear height, which might be fixed more favorably in the three-way cross. The combined mean yields for the S_3 x S_x crosses are given in Table 70. Crosses with no yield entry failed to produce sufficient seed for the trial and check entries were substituted in place. There were 28 of the crosses which exceeded the best check (H611(R)C2) and all of the crosses exceeded H632, the only conventional hybrid check included. Ec573(R12)C2 lines 50 and 100 performed well when averaged across all their single-crosses. Likewise, KII(R11)C2 lines 38, 64 and 75 did well on a general performance basis. The top cross yielded 97.2 q/ha and seven crosses were greater than 90 q/ha.

Predicted three-way crosses above 88 q/ha in yield are listed in Table Root and stalk lodging, and ear heights were taken at three locations and tassel dates were obtained only at Kitale. The predicted value for each of these characters is also given in Table 71. The LSD shown is appropriate for comparing the predicted values for each character. Levels of root lodging were quite low and entirely acceptable. Stalk lodging, however, was unacceptably high and room was available for selection for less stalk lodging. The range on tassel dates was from 99.8 days to 107.0 with the majority falling between 102 and 104. Differences among ear heights were statistically significant, but they were not practically of importance. None of the predicted three-way crosses came within 20 cm of the level of H632. A drop of 100 cm would be necessary to put the ears at a height comparable with commercial hybrids in other parts of the world.

Table 70. Combined mean yields, adjusted for stand, from the S_3 x S_3 crosses of KII(R11)C2 and Ec573(R12)C2 selected entries grown as experiment 28 at four locations.

	Yields (q/ha) Ec 573(R12)C2										
	-3	-31	-43	-45	-50	-54	-64	-69	-70	-100	Row mean
KII(R11)C2- 5	86.4	86.3	78.7	75.7	95.9	81.2	76.5	75.7	76.1	84.4	81.7
-30	80.5	----	----	79.1	87.7	74.9	90.1	82.5	----	81.1	82.3
-35	73.7	80.6	75.7	78.7	86.8	83.5	85.7	88.7	78.0	83.2	81.5
-38	86.4	84.7	82.3	79.1	85.1	87.8	86.2	----	86.7	92.7	85.7
-47	80.0	75.6	----	65.6	83.5	75.9	85.1	86.4	85.9	92.7	81.2
-49	74.2	73.5	80.4	66.4	80.3	70.6	75.8	74.2	71.2	83.0	75.0
-64	91.1	84.0	85.1	79.4	97.2	83.1	86.1	79.5	90.8	88.4	86.5
-66	80.1	88.3	74.8	76.9	75.1	86.5	80.7	88.4	79.5	78.4	80.9
-69	81.3	79.2	----	78.3	85.3	78.0	85.7	77.0	77.2	84.4	80.7
-75	84.8	----	84.5	84.6	83.2	89.0	86.0	----	82.4	88.1	85.3
Column mean	81.9	81.5	80.2	76.4	86.0	81.0	83.8	81.6	80.9	85.6	
L.S.D. .05	14.4										

Checks:				
	H611(R)C3	80.7	H632	52.9
	H611C Commercial	84.6	H611(R)C2	85.2
	H613(R)C3	71.6	Bulk of R11C2S4 lines	23.4
	H613C Commercial	75.6	Bulk of R12C2S4 lines	16.4

Table 71. Predicted yields and agronomic characters from the S_3 x S_3 crosses of KII(R11)C2 and Ec573(R12)C2 selected entries grown as experiment 28. Number of locations for each character is shown in parentheses.

(KII x KII) Ec573 Three-way cross			Yield* q/ha (4)	Root ldg. % (3)	Stalk ldg. % (3)	Date of tassel (1)	Ear Height cm (3)
64	5	50	96.55	2.40	12.80	103.8	267.0
38	47	100	92.70	1.20	12.10	101.8	239.3
64	30	50	92.45	2.75	9.75	104.0	236.7
64	35	50	92.00	4.30	15.20	104.3	240.9
5	30	50	91.80	2.75	11.85	102.8	248.1
5	35	50	91.35	4.30	17.30	103.0	252.3
64	69	50	91.25	1.95	14.15	104.0	242.2
64	38	50	91.15	2.75	15.80	106.3	223.3
5	69	50	90.60	1.95	16.25	102.8	253.6
38	64	100	90.55	2.40	11.45	102.3	226.1
47	64	100	90.55	3.60	14.45	102.8	243.1
5	38	50	90.50	2.75	17.90	105.0	234.6
38	75	100	90.40	3.20	11.30	104.0	222.9
47	75	100	90.40	4.40	13.30	104.3	239.8
64	47	50	90.35	1.20	22.00	106.0	247.3
64	75	50	90.20	2.70	16.55	107.0	231.8
5	47	50	89.70	1.20	24.10	104.8	258.7
64	5	3	88.75	3.85	12.95	102.0	249.9
64	38	3	88.75	3.85	21.75	99.8	233.4
64	38	70	88.75	0.00	15.60	100.5	216.8
64	49	50	88.75	1.95	16.60	106.8	237.8
35	66	69	88.55	0.40	19.60	104.8	239.4
38	5	100	88.55	5.50	11.90	103.8	242.4
47	5	100	88.55	6.70	14.90	104.0	259.3
38	69	100	88.55	5.95	14.70	100.3	229.6
47	69	100	88.55	7.15	17.70	100.5	246.6
75	38	54	88.40	5.90	23.4	102.8	223.9
64	47	70	88.35	0.00	21.30	101.8	223.5
64	75	100	88.25	5.60	13.65	104.8	226.7
30	38	64	88.15	2.15	20.10	102.8	230.6
30	64	64	88.10	3.70	12.80	103.0	234.9
5	49	50	88.10	1.95	18.70	105.5	249.2
H611C			84.60	3.60	32.50	107.5	253.0
H632			52.90	3.80	45.60	109.5	202.4
L.S.D.	.05		10.00	6.72	12.39	4.5	10.3

* All three-way crosses with yields predicted to be greater than 88.0 q/ha.

Index selection will also be applied to these predicted three-way crosses. The necessary variances and covariances are given in Table 72. The linear regression coefficients averaged from three locations were -0.057 for yield and root lodging and 0.027 for yield and stalk lodging. As with R11 and R12, yield for these statistics is in pounds per plot and the lodging data in percent. The larger reduction in yield is again effected by increased root lodging, but the actual reduction is greater for stalk lodging because of higher frequency.

Lines were also extracted from the Kenya Maize Research Section's breeding populations of Kitale Composites B and E (KCB and KCE). The lines were from cycle 0 of an S_1 testing program. The single-crosses made were of S_2 lines. Twenty-four lines were selected from each composite for recombination and selfing. Due to restriction of nursery space, a modified crossing structure was imposed and four 6 x 6 diallels were made of KCB(S)C0 x KCE(S)C0 lines. The resulting 144 possible single-crosses were then grown in a single trial at four locations. Checks were inserted where insufficient seed was made. Table 73 presents the yield obtained. Only one cross exceeded the H611(R)C3 check and most did far worse. It seems the material is not yet ready for extraction of lines which will recombine to give superior hybrids. The lines will be selfed one more generation to S_5 and then be turned over to the Kenya Maize Research Section. It is noted that several of the crosses gave greater than a 25% increase over the KCB(S) x KCE(S) C1 variety-cross. Thus, it will likely be profitable to extract lines from later cycles after the populations have been improved so they compete with current commercial variety-cross parents.

Table 72. Phenotypic and genetic variances and covariances for the S_3 x S_3 crosses of KII(R11)C2 and Ec573(R12)C2 selected entries from data taken at three locations in experiment 28. Yields are in pounds per plot and lodging scores in percent.

Trait	Phenotypic statistics			Genetic statistics		
	Yield	Root ldg.	Stalk ldg.	Yield	Root ldg.	Stalk ldg.
Yield	3.63	-.51	-8.87	2.95	.37	-8.08
Root ldg.	(-.03)	15.78	-6.03	(.05)	4.26	-2.33
Stalk Ldg.	(-.07)	(-.04)	130.50	(-.09)	(-.02)	91.35

Index selection will also be applied to these predicted three-way crosses. The necessary variances and covariances are given in Table 72. The linear regression coefficients averaged from three locations were -0.057 for yield and root lodging and 0.027 for yield and stalk lodging. As with R11 and R12, yield for these statistics is in pounds per plot and the lodging data in percent. The larger reduction in yield is again effected by increased root lodging, but the actual reduction is greater for stalk lodging because of higher frequency.

Lines were also extracted from the Kenya Maize Research Section's breeding populations of Kitale Composites B and E (KCB and KCE). The lines were from cycle 0 of an S_1 testing program. The single-crosses made were of S_2 lines. Twenty-four lines were selected from each composite for recombination and selfing. Due to restriction of nursery space, a modified crossing structure was imposed and four 6 x 6 diallels were made of KCB(S)C0 x KCE(S)C0 lines. The resulting 144 possible single-crosses were then grown in a single trial at four locations. Checks were inserted where insufficient seed was made. Table 73 presents the yield obtained. Only one cross exceeded the H611(R)C3 check and most did far worse. It seems the material is not yet ready for extraction of lines which will recombine to give superior hybrids. The lines will be selfed one more generation to S_5 and then be turned over to the Kenya Maize Research Section. It is noted that several of the crosses gave greater than a 25% increase over the KCB(S) x KCE(S) C1 variety-cross. Thus, it will likely be profitable to extract lines from later cycles after the populations have been improved so they compete with current commercial variety-cross parents.

Table 72. Phenotypic and genetic variances and covariances for the S_3 x S_3 crosses of KII(R11)C2 and Ec573(R12)C2 selected entries from data taken at three locations in experiment 28. Yields are in pounds per plot and lodging scores in percent.

Trait	Phenotypic statistics			Genetic statistics		
	Yield	Root ldg.	Stalk ldg.	Yield	Root ldg.	Stalk ldg.
Yield	3.63	-.51	-8.87	2.95	.37	-8.08
Root ldg.	(-.03)	15.78	-6.03	(.05)	4.26	-2.33
Stalk Ldg.	(-.07)	(-.04)	130.50	(-.09)	(-.02)	91.35

Table 73. Combined mean yields, adjusted for stand, for the S_2xS_2 crosses of KCB(S)CO and KCE(S)CO grown as experiment 29 at four locations in 1971. Four restricted diallels were made of the 24 selected entries in the CO of each composite.

	Yields (q/ha) KCE(S)CO						
	-38	-189	-160	-113	-207	-241	Row mean
KCB(S)CO- 1	68.5	55.6	74.2	53.7	66.5	73.3	65.3
- 2	57.6	49.9	70.5	54.8	67.8	69.3	61.7
- 3	49.7	----	63.1	56.4	64.1	67.2	60.1
- 4	54.7	60.8	66.0	45.5	64.4	56.2	57.9
- 6	57.7	56.9	60.0	40.2	55.7	61.3	55.3
- 7	61.5	51.5	62.9	65.2	60.2	65.7	61.2
Column mean	58.3	54.9	66.1	52.6	63.1	65.5	60.2

	KCE(S)CO						
	-178	-223	-115	-307	-142	-206	Row mean
KCB(S)CO- 9	52.2	60.5	51.6	53.3	56.4	---	54.8
- 10	59.1	59.0	56.9	70.8	61.6	62.0	61.6
- 11	64.8	61.4	69.5	55.0	59.7	48.2	59.8
- 12	54.5	54.8	46.1	52.4	64.2	----	54.4
- 13	56.3	51.8	60.5	55.7	62.4	57.2	57.3
- 14	57.8	61.7	60.3	57.6	62.0	61.5	60.2
Column mean	57.5	58.2	57.5	57.5	61.1	57.2	58.1
LSD .05	14.5						

Checks H611 (R)C3 75.5
H613(R)C3 64.8
KCB(S)C1 x KCE(S)C1 48.7

Table 73. (Cont'd).

	Yields (q/ha) KCE(S)CO						
	-97	-202	-22	-312	-183	-344	Row mean
KCB(S)CO-15	48.9	65.1	60.1	46.0	62.3	62.7	57.5
-16	60.9	67.2	59.6	53.5	58.5	51.3	58.5
-18	62.4	75.1	58.3	60.4	63.6	64.4	64.0
-20	62.8	63.7	61.8	62.8	77.8	70.9	66.6
-21	57.0	49.0	52.6	59.7	55.9	55.9	49.2
-23	51.3	55.1	57.7	56.7	58.8	57.3	56.2
Column Mean	57.2	63.5	58.4	56.5	62.8	59.3	59.5

	KCE(S)CO						
	-327	-245	-324	-208	-108	-203	Row Mean
KCB(S)CO-25	50.9	49.0	52.7	60.8	40.7	44.2	49.7
-26	64.2	55.5	56.7	60.2	45.7	59.7	57.0
-27	56.2	61.7	61.0	48.4	44.0	51.3	53.8
-28	48.7	48.9	53.0	51.8	39.3	49.9	48.6
-29	60.1	68.2	68.3	67.4	49.7	59.1	62.1
-30	55.8	66.5	64.7	61.9	43.1	47.0	56.5
Column Mean	56.0	58.3	59.4	58.4	43.8	51.9	54.6
LSC .05	14.5						
Checks:	H611(R)C3			75.5			
	H613(R)C3			64.8			
	KCB(S)C1 x KCE(S)C1			48.7			

Topcross Evaluation of SR 52 and the Parents and Hybrids of the 611 and 613 Series

Experiment 24 of 1971 compared different top-crosses of the Zambian single-cross SR 52. Top-crosses were made to various composites, populations, and female seed parents of commercial hybrids. Further, comparisons were made of progress in the KII(R11) and Ec573(R12) populations and the derived variety-cross H611(R) and the variety x single-cross hybrid 613(R). Commercial checks that are analogs to these hybrids were also included.

The trial was grown at seven sites in Western Kenya at elevations above 1550 meters. The design was a 6 x 6 square lattice in three replications. A standard plot size (22 plants) was used and competitive effects disregarded. Yields were adjusted for stand level and are presented in Table 74.

Results of the 1970 evaluation trial and the Kenya Late Maturity Maize Variety Trial showed SR52 x Ec573(R12)C2 to be the top yielder. Also, SR52 x H511 gave commercial hybrid 512. Combined yields of the top-crosses again showed the cross to Ec573(R12) to be superior, however, it did not exceed the commercial checks. Cycle 3 was used in this year's test and C2 in the 1970 evaluation. A gain from C2 to C3 is found only in the variety cross hybrid 611(R); the top-cross hybrid 613 showed a decrease in yield as did the commercial version of 611 using Ec573(R12)C3 as the male. It is likely some of the general combining ability of the Ec573 has been lost in favor of specific combining ability with the KII(R11) tester in the reciprocal recurrent selection experiment. Of the remaining top-crosses to SR52, KCF and KCE did best. Since KCF is not in any intensive selection program, half-sib testing with SR52 could produce a short maturity top-cross hybrid.

SR52 x Embu 11 and SR52 x Embu 12 lead to a predicted yield for H512 of 57.5 q/ha, however the cross SR52 x H511(H611 female) yielded only 52.8 q/ha. These are not statistically different, but higher yields would be expected. Even in the Kakamega area, H512 predicted or actual were among the poorest performers and they should have been much better. (Note H511 = Embu 11 x Embu 12, and H512 = H511 x SR52).

Hybrids with Ec573(R)C2 and C3 (H611(R)C2, H611(R)C3, H611C, H613(R)C2, H613(R)C3, H613C) yielded considerably more than the original commercial hybrids H611(R)CO, H632). If farmers will use improved cultural practices with the improved new hybrids, they can expect very great increases in yield over local maize grown with traditional practices.

Table 74. Yields* (q/ha) obtained at seven locations in the topcross evaluation of SR52 and the parents and hybrids of the 611 and 613 series.

Entry	Kitale N.A.R.S.	Endebess Strong's Farm	Kakamega	Njoro	Kitale Top Farm	Endebess Ken. Seed Company	Mt. Elgon Chorlim Farm	Combined
SR52 x KCE	58.7	86.1	56.7	52.0	48.9	78.4	68.4	64.2
SR52 x KCF	52.2	79.5	50.8	71.1	62.2	75.4	72.9	66.3
SR52 x KII(R11)C3	57.6	81.7	54.0	48.2	62.5	72.7	57.1	62.0
SR52 x Ec573(R12)C3	81.9	96.3	77.4	79.2	79.3	89.2	102.6	86.6
SR52 x Embu I(MC)C5	36.7	62.1	53.9	40.6	40.9	42.7	25.8	43.3
SR52 x Embu II(C)C5	32.1	67.3	66.1	43.5	50.3	49.6	42.7	50.2
SR52 x Embu 11	37.1	72.6	48.2	54.4	53.7	62.7	55.7	54.9
SR52 x Embu 12	53.4	67.8	61.3	49.8	48.9	66.0	72.6	60.0
SR52 x H511	42.3	70.3	43.8	45.5	52.3	61.4	53.8	52.8
SR52 x (F x G)	39.5	92.2	50.2	48.1	48.0	69.8	51.8	57.1
SR52 x (A x F)	49.2	83.5	58.7	50.0	55.0	81.5	58.8	62.4
SR52 x UCA (F)C3	47.0	91.7	58.6	55.1	51.9	84.2	56.4	63.5
SR52 x UCB-W(F)C1	34.1	71.0	50.0	44.2	55.4	54.0	43.0	50.2
SR52 x ICA	31.1	62.6	43.0	30.6	37.4	48.1	43.9	42.4
SR52 x Kaw. CA(MC)C3	41.2	74.2	52.2	43.7	58.7	49.1	38.0	51.0
SR52	34.8	86.2	48.0	42.0	55.9	63.0	44.6	53.5
H611(R)CO	64.6	94.9	53.1	76.0	63.5	68.0	86.3	72.3
H611(R)C1	79.3	103.0	61.4	89.3	78.1	86.2	106.6	86.3

Adjusted for stand level

Table 74. (Cont'd.)

Entry	Kitale N.A.R.S.	Endebess Strong's Farm	Kakamega	Njoro	Kitale Top Farm	Endebess Ken. Seed Company	Mt. Elgon Chorlim Farm	Combined
H611(R)C2	86.0	111.6	75.1	80.3	72.7	102.6	105.0	90.5
H611(R)C3	90.0	105.0	76.1	91.4	73.4	110.2	94.1	91.5
H611C	85.0	102.5	78.5	93.5	74.7	107.4	117.5	94.2
KIII x Ec573(R12)C3	80.3	101.3	81.2	91.4	72.7	100.5	105.0	90.3
H613(R)CO	68.1	96.5	58.9	78.6	71.4	102.7	98.2	82.0
H613(R)C1	67.0	74.1	70.9	73.6	68.3	96.8	92.2	77.6
H613(R)C2	97.4	104.8	85.9	87.1	73.8	86.8	105.0	91.5
H613(R)C3	77.8	100.2	68.8	82.2	88.5	90.1	80.6	84.0
H613C	82.6	93.4	67.2	92.2	61.4	105.1	105.3	86.8
Ec573CO	34.7	55.9	19.5	56.5	40.3	43.6	43.5	42.0
Ec573(R12)C1	46.3	54.8	29.1	52.4	39.6	61.0	61.1	49.2
Ec573(R12)C2	42.2	55.7	33.3	41.0	40.3	49.1	47.4	44.1
Ec573(R12)C3	43.6	63.2	35.6	47.8	43.1	56.4	49.7	48.5
KIICO	60.9	66.2	39.8	43.5	42.4	73.6	72.0	56.9
KII(R11)C1	57.1	74.2	37.8	43.2	36.5	60.4	51.5	51.5
KII(R11)C2	45.5	64.4	42.1	42.9	34.5	68.5	73.7	53.1
KII(R11)C3	50.2	71.1	40.4	47.9	46.8	63.4	53.7	53.4
H632	61.6	74.9	41.8	56.1	39.6	73.9	71.8	60.0
Mean	56.9	80.9	54.7	60.1	56.2	73.7	69.7	64.6
LSD .05	16.6	18.9	15.7	12.9	19.7	18.5	21.7	9.2
C.V. %	18	14	18	13	21	15	19	

Agronomic data for experiment 24 are in Table 75. Among the SR52 top-crosses, SR52 x KCF was reasonably short, early and still had high yield. SR52 x Ec573(R12)C3 was 20 cm higher and 8 days later in maturity. Lodging scores were similar among these two top-crosses. The rest of the top-crosses were unremarkable.

KII(R11) showed an overall decrease in ear height and tendency toward earlier maturity with a slight improvement in root and stalk lodging. Other characters were unchanged. Ec573(R12) decreased in ear height in excess of 25 cm, and had improved root lodging resistance. A small increase in percent usable ears was noted. In most characters, the greatest improvemnt came in going from C0 to C1, with small changes thereafter.

Hybrid 611(R)C3 shows lower ear height, slightly earlier maturity a reduced number of bare tips, and improvement in lodging resistance when compared to the original 611. In most aspects except yield, H611(R)C3 was more desirable than H611C. The 'improved' commercial version of H611C had a little better lodging resistance, fewer bare tips and less usable ears. It was also slightly earlier and shorter.

There were fewer bare tips in H613(R)C3 than in earlier cycles and a slight increase in [illegible]ole ears. Ear height also moved in a favorable direction, wh[illegible] other characters remained the same.

H632, a commercial three-way cross, did not compare favorably with any of the 611 or 613 series with respect to yield. H632 had more lodging, fewer bare tips, less usable ears, more diseased ears, and lower ear height than the 611 and 613 hybrids. Surprisingly, maturity was about the same in this evaluation. Disease susceptibility varied little among the hybrids.

Table 75. Combined means for yield and agronomic traits from a top-cross evaluation of SR52 and the parents and hybrids of the 611 and 613 series. (Number of locations is shown in parentheses).

Entry	Yield* q/ha (7)	Stand % (7)	Lodg-ing % (1)	Root lodg.% (6)	Stalk ldg. % (6)
SR52 x KCE	64.2	91.8	3.2	21.0	37.6
SR52 x KCF	66.3	92.6	4.8	11.1	40.6
SR52 x KII(R11)C3	62.0	90.0	3.2	16.1	31.8
SR52 x Ec573(R12)C3	86.6	92.4	6.2	14.3	32.7
SR52 x Embu I(MC)C5	43.3	90.3	3.2	17.1	53.5
SR52 x Embu II(MC)C5	50.2	85.7	0.0	16.2	50.9
SR52 x Embu 11	54.9	93.3	0.0	14.9	39.7
SR52 x Embu 12	60.0	89.0	4.7	17.9	36.3
SR 52 x H511	52.8	93.3	10.9	13.4	43.2
SR52 x (F x G)	57.1	91.3	13.0	11.2	39.7
SR52 x (A x F)	62.4	88.1	9.1	15.6	40.8
SR52 x UCA(F)C3	63.5	90.0	5.6	17.0	29.8
SR52 x UCB-W(F)C1	50.2	91.8	3.1	18.4	50.9
SR52 x ICA	42.4	91.8	10.6	10.3	50.1
SR52 x Kaw. CA(MC)C3	51.0	88.7	7.6	18.5	40.2
SR52	53.5	91.3	7.6	18.9	35.2
H611(R)CO	72.3	88.1	4.8	24.4	23.9
H611(R)C1	86.3	89.8	6.1	14.3	19.3
H611(R)C2	90.5	90.5	10.6	10.6	18.4
H611(RO)3	91.5	88.5	3.0	10.7	19.0
H611C	94.2	89.4	0.0	15.8	22.9
KIII x Ec573(R12)C3	90.3	92.4	0.0	6.9	25.1
H613(R)CO	82.0	81.4	3.3	11.3	29.0
H613(R)C1	77.6	87.2	6.8	20.8	31.1
H613(R)C2	91.5	93.5	10.8	10.6	26.4
H613(R)C3	84.0	88.5	6.1	13.0	23.3
H613C	86.8	86.8	12.2	15.9	28.4
Ec573CO	42.0	82.9	6.1	31.6	23.1
Ec573(R12)C1	49.2	87.0	6.3	22.2	27.5
Ec573(R12)C2	44.1	78.4	10.5	19.4	24.2
Ec573(R12)C	48.5	85.9	11.1	12.9	29.1
KIICO	56.9	87.0	1.5	30.0	39.6
KII(R11)C1	51.5	85.3	9.2	20.1	29.3
KII(R11)C2	53.1	83.3	0.0	26.3	33.0
KII(R11)C3	53.4	85.9	3.0	16.9	31.1
H632	60.0	91.3	3.0	23.5	45.2
Mean	64.6	88.7	5.8	16.9	33.4
LSD .05	9.2	8.6	10.5	12.5	10.7

* Adjusted for stand level.

Table 75. (Cont'd.)

Entry	Bare tips % (7)	Usable ears % (7)	Diseased ears % (7)	Days to tassel (6)	Ear height cm(7)	Blight 0-5 (7)	Rust 0-5 (7)
SR52 x KCE	10.0	87.7	2.7	111.8	219.7	1.1	2.0
SR52 x KCF	11.3	98.3	4.1	102.4	195.7	1.1	1.7
SR52 x KII(R11)C3	6.3	92.7	3.3	111.8	200.1	1.0	1.9
SR52 x Ec573(R12)C3	6.1	103.3	1.6	110.4	214.9	1.1	1.3
SR52 x Embu I(MC)C5	3.4	83.0	3.6	108.5	190.6	1.2	2.6
SR52 x Embu II(MC)C5	8.3	87.7	1.5	106.5	186.8	1.1	2.3
SR52 x Embu 11	6.0	90.7	3.2	105.5	180.8	1.1	2.0
SR52 x Embu 12	12.0	92.2	2.3	101.9	181.3	1.1	1.9
SR52 x H511	8.5	88.3	3.4	103.6	186.4	1.1	2.0
SR52 x (F x G)	10.9	93.7	4.3	111.7	196.9	0.9	2.1
SR52 x (A x F)	3.0	94.4	2.4	111.7	194.0	1.0	2.0
SR52 x UCA(F)C3	9.4	92.3	3.0	110.6	208.4	1.1	2.0
SR52 x UCB-W(F)C1	6.1	90.7	3.7	109.3	195.5	1.1	2.2
SR52 x ICA	3.1	84.5	2.5	108.4	188.6	1.1	2.5
SR52 x Kaw.CA(MC)C3	7.6	84.4	3.3	109.8	197.1	1.2	2.3
SR52	3.3	87.7	2.2	104.5	180.9	1.0	2.3
H611(R)CO	12.0	90.2	2.9	118.2	241.8	1.0	1.1
H611(R)C1	14.8	101.5	1.1	115.2	235.6	1.0	1.1
H611(R)C2	9.4	109.3	0.7	115.4	242.2	1.0	1.1
H611(R)C3	8.2	113.4	1.2	114.1	231.1	0.9	1.1
H611C	17.6	109.0	1.5	116.3	245.0	1.0	0.9
KIII x Ec573(R12)C3	14.2	102.2	1.5	114.9	239.3	1.0	0.8
H613(R)CO	23.9	109.8	2.5	114.6	236.3	0.9	1.3
H613(R)C1	11.7	108.1	0.7	114.5	230.2	0.8	1.0
H613(R)C2	14.5	106.7	1.1	112.8	228.4	0.7	1.1
H613(R)C3	9.6	112.7	1.8	114.5	223.9	0.8	1.0
H613C	13.5	112.7	2.9	113.9	231.9	0.8	1.0
Ec573CO	13.2	72.2	1.5	122.7	256.9	1.6	1.1
Ec573(R12)C1	6.3	88.1	2.1	118.9	231.5	1.5	1.1
Ec573(R12)C2	2.5	84.5	1.2	119.2	228.4	1.2	1.0
Ec573(R12)C3	5.0	89.0	4.5	120.6	223.0	1.4	0.9
KIICO	3.7	91.2	5.8	117.8	223.4	0.9	1.5
KII(R11)C1	3.4	90.1	5.5	119.5	216.3	0.9	1.6
KII(R11)C2	3.1	89.1	4.0	115.0	195.8	0.8	1.6
KII(R11)C3	6.0	92.0	5.6	114.9	200.7	1.0	1.8
H632	6.7	102.2	7.2	115.0	200.4	0.8	1.7
Mean	8.7	95.2	2.9	112.7	213.3	1.0	1.6
LSD .05	5.4	10.6	2.9	2.2	9.3	0.3	0.4

Plot Size and Uniformity Trial

As a result of significant statistical differences between duplicate entries in trials in 1970, a plot size investigation was done in 1971 with a uniform entry, H613C. Five plot sizes were considered, using nine hills per row. They were 11, 22, 28, 40, and 46 plants per plot. The 11 plants per plot were a single row with two plants in the end hills and one in between. Twenty-two plants per plot were obtained by using two row plots of 11 plants each. Spacings for the first two sizes were 80 x 26.6 cm. Twenty-eight plants per plot were obtained by using two rows planted in a 2-1-2 pattern at 80 x 40 cm to maintain plant population. A 3-2-------2-3 pattern planted at 80 x 53.3 cm gave 40 plants per two row plot. Using the same spacing and planting in a 3-2-3 pattern gave 46 plants per plot. The last size was at a slightly higher plant population than the first four sizes.

Table 76 presents the yield statistics for this trial. Only one instance of a significant entry mean square occurred; that was at Endebess in 22 plant plots adjusted for stand. A sizable reduction in the error mean square occurred in all cases when yields were adjusted for stand. The C.V.'s reacted similarly. Unless stand is a criteria of selection, the covariance with stand should be run and yields adjusted, due to the difficulty of obtaining uniform stands in our trials.

Figure 4 presents graphically the decrease of the LSD .05 when plants per plot are increased. Figure 5 shows the change in C.V. % with change in plants per plot. Both figures indicate a large drop from 11 to 22 plants and a smaller drop in going to 28 plants. There was little gain in using 40 to 46 plants. A three row plot of nine hills with a 2-1----1-2 planting pattern will be used in the 1972 evaluation trials. This involves the least change in planting and laying out the field and does give more leeway if missing hills do occur.

Table 76. Yield (q/ha) statistics from a uniformity trial grown in 1971. H613C was used in five plot sizes; each size being a separate 5 x 5 square lattice in three replications at two locations. Statistics are shown raw and adjusted for stand.

Plants/ Plot	Statistic	Kitale Raw	Kitale Adj.	Endebess Raw	Endebess Adj.	Combined Raw	Combined Adj.
11	Mean	74.2	74.2	85.0	85.0	79.6	79.6
	Error MS	189.8	156.7	446.8	396.9		
	LSD .05	22.5	20.4	34.5	32.5	23.1	21.1
	C.V. %	18.6	16.9	24.9	23.4		
	F	0.6	0.7	1.5	1.3	1.0	0.9
22	Mean	75.8	75.8	83.6	83.6	79.7	79.7
	Error MS	203.5	133.5	284.5	114.8		
	LSD .05	23.3	18.9	27.5	17.5	19.3	16.4
	C.V. %	18.8	15.3	20.2	12.8		
	F	0.8	1.0	0.9	1.9*	0.5	0.8
28	Mean	80.2	80.2	98.4	98.4	89.3	89.3
	Error MS	164.6	99.2	126.0	97.1		
	LSD .05	21.0	16.3	18.3	16.1	13.1	8.7
	C.V. %	16.0	12.4	11.3	10.1		
	F	0.9	0.7	0.9	0.5	1.0	1.1
40	Mean	72.5	72.5	89.1	89.1	80.8	80.8
	Error MS	153.6	117.5	234.0	97.4		
	LSD .05	20.2	17.7	25.0	16.1	11.7	9.7
	C.V. %	17.1	14.9	17.2	11.1		
	F	0.8	1.1	0.5	0.4	1.2	1.4
46	Mean	82.4	82.4	98.1	98.1	90.2	90.2
	Error MS	213.9	76.8	112.3	105.1		
	LSD .05	23.9	14.3	17.3	16.7	15.0	11.7
	C.V. %	17.8	10.6	10.8	10.5		
	F	1.2	1.5	1.0	0.8	1.2	1.0

* Indicates significance at P=.05

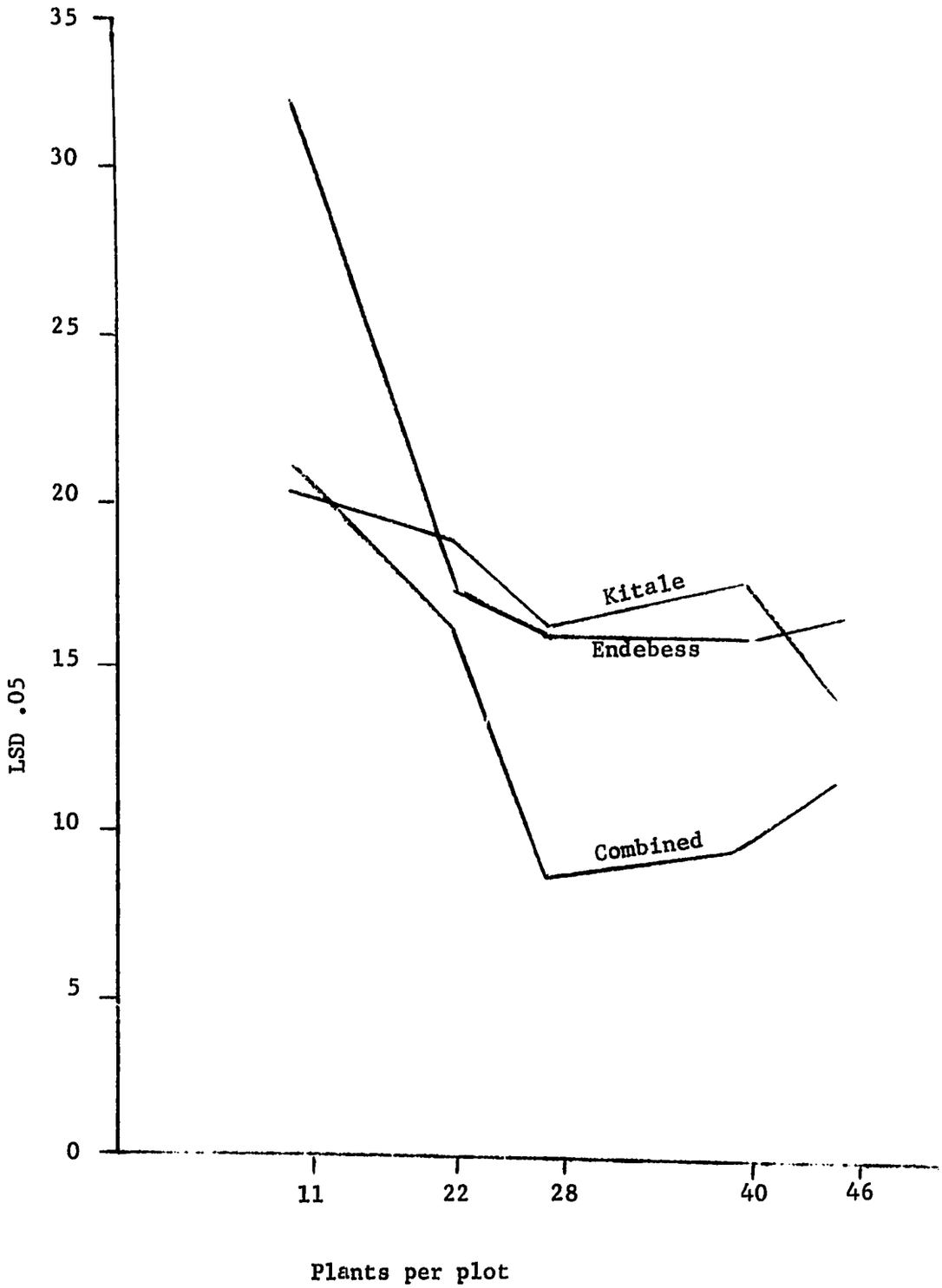

Figure 4. LSD .05 versus plants per plot from the uniformity and plot size trial

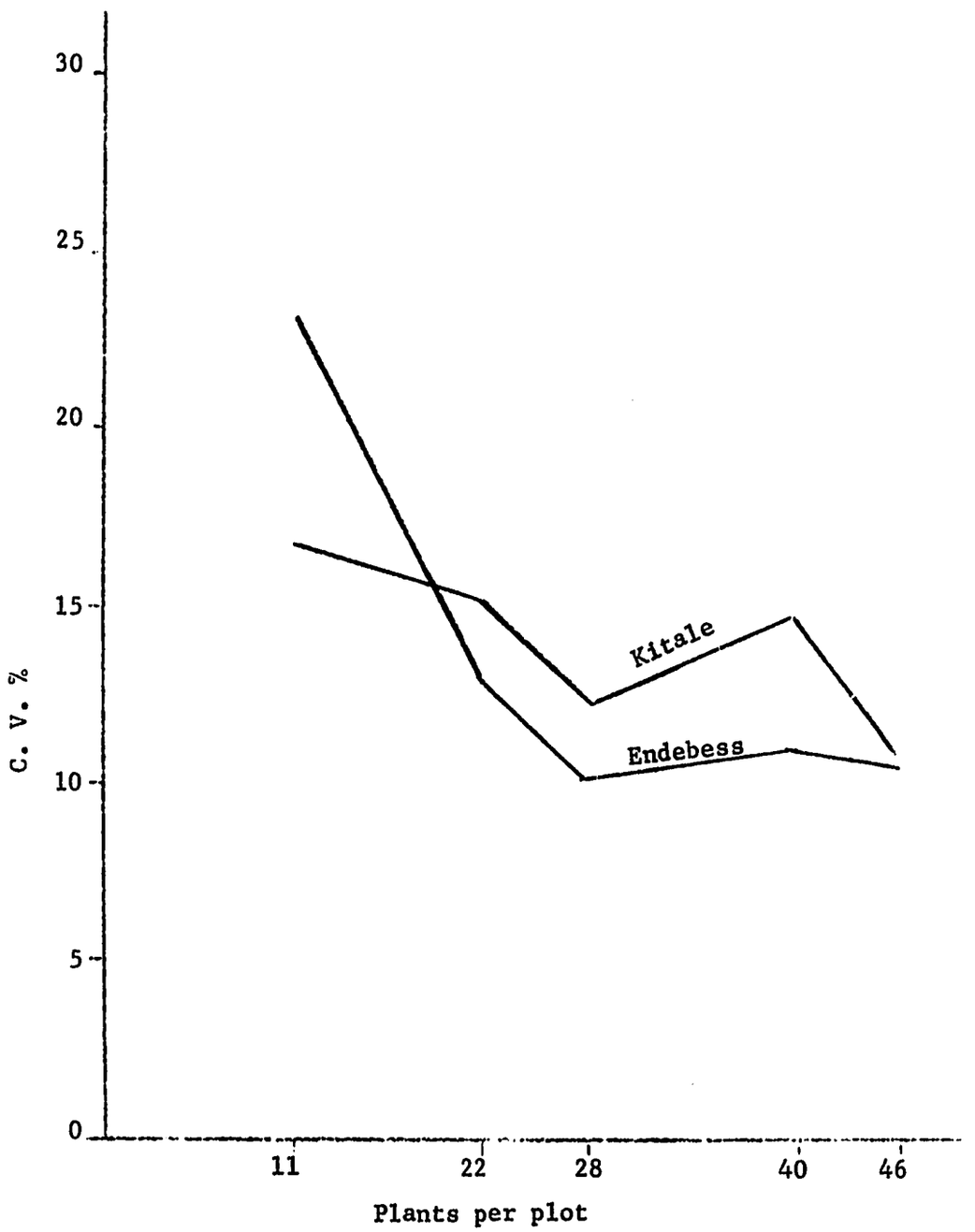

Figure 5. C.V. % versus plants per plot from the uniformity and plot size trial

Eastern African Maize Variety Trial

The 1970-71 Eastern African Maize Variety Trial consisted of 15 entries: five were commercial hybrids from Kenya; Ukiriguru and Ilonga composites and their crosses from Tanzania, Kawanda Composite A from Uganda; SV 28 from Malawi; and SR 52 from Zambia. Eighty seven sites were sent out to ten countries including Burundi, Zaire (Democratic Republic of the Congo), Ethiopia, Kenya, Madagascar, Malawi, Nigeria, Tanzania, Uganda, and Zambia. Some results have been received from all but Zaire, Madagascar, and Zambia. They were sent 15, 1, and 2 sites, respectively. Other sites were received too late for inclusion in this report, but will be in the full report of the EAMVT to be published in April 1972. Unfortunately, only about one third of the sites dispatched have been returned, but more should be forthcoming.

Table 77 givesthe yields from seven sites in Kenya and Table 78 contains the agronomic data for those sites. At elevations of 1650 meters or more, H611C performed best followed closely by H613C. Then there was a big drop down to the next best. H611C, H613C, and H632 did well between 900 and 1600 meters, but again H611C had an adge. UCA C4 x UCB/W C1 did relatively well at the lower elevations and was not statistically different from the Kenya hybrids. There was no difference between H512 and H511 at the higher elevations, but H512 had a distinct edge at lower elevations.

All entries lodged badly in this year's trial with H611C and H613C suffering less root and stalk lodging. SR 52 had the best record where lodging per se was taken. Prolificacy was found mainly in the higher yielding entries discussed earlier. H511 was the shortest and earliest entry. H512 was a couple of days later and the same height. ICF(M) was also early maturing, but some 20 cm higher than H511 or H512. SR 52 tasselled in less than 100 days and had an ear height of 172 cm. Blight and rust were noticeably worse in the Tanzanian ccmposites and SV 28; and SR 52 was susceptible to rust.

Table 79 contains yields for some sites in Tanzania and Uganda. At the medium altitudes (900-1600 m) in Tanzania yields were very low. Only about six q/ha separated the top and bottom entries. The UCA x UCB cross yielded best at 23.0 q/ha and three of the Kenya hybrids and SR 52 exceeded 20 q/ha. In the southern highlands, the story was the same as in Kenya with H611C and H613B out yielding the rest. At tne one coastal site received, H611C was the best yielder giving 37.6 q/ha followed by Ilonga Composite at 35.8 q/ha.

Table 77. Yields (q/ha) obtained at seven locations in Kenya in the 1970-71 Eastern African Maize Variety Trial. (Approximately altitudes (meters) are shown in parentheses).

Variety	Kitale NARS (1865)	Endebess Strong (1860)	Njoro (2133)	Kitale Top Farm (1910)	Mean above 1650	Kakamega (1580)	Embu (1350)	Busia (1280)	Mean 900-1600
H611C	78.2	90.2	96.9	83.0	87.1	73.5	86.1	68.1	75.9
H613C	82.2	83.6	90.4	83.6	84.9	76.0	87.0	53.0	72.0
H632	40.5	95.6	60.4	33.1	57.4	70.4	82.3	56.1	69.6
H511	31.6	68.2	57.7	42.7	50.1	62.2	59.3	44.1	55.2
H512	36.4	70.9	46.4	46.9	50.2	65.6	65.5	58.5	63.2
UCA C4 x UCB/W C1	41.0	85.3	58.2	53.8	59.5	62.9	82.2	60.1	68.4
ICA x ICB/Full (W)	17.6	51.4	29.7	25.2	31.0	53.3	53.2	48.8	51.7
Ukiri. Comp. A C3	41.3	74.8	59.6	61.3	59.3	61.4	62.7	59.1	61.1
Ukiri. Comp. B/W C1	31.6	63.9	48.7	39.2	45.9	53.5	75.1	53.8	60.8
Ilonga Comp. A	16.3	49.7	29.7	30.4	31.5	44.9	49.3	43.1	45.8
Kawanda Comp. A	32.4	62.0	48.2	41.2	45.9	56.3	80.3	60.6	65.7
SV 28	16.0	35.9	15.4	19.7	21.7	33.5	52.2	55.5	47.1
SR 52	22.4	70.5	24.4	47.1	41.1	65.8	74.5	53.5	64.6
KCE(M)	40.7	77.9	65.6	55.1	59.9	62.5	48.7	48.4	53.2
KCF(M)	29.3	71.3	69.4	50.0	55.0	51.7	39.6	37.6	43.0
Mean	37.2	70.1	53.4	47.5	52.0	59.6	66.5	53.3	59.8
LSD .05	14.8	13.0	13.8	14.2	12.1	12.2	16.7	16.1	12.9
C. V. %	28	13	18	21					

Table 78. Agronomic data obtained in Kenya in the 1970-71 Eastern African Maize Variety Trial. (Number of locations for each character is shown in parentheses)

	Yield q/ha (7)	Lodg. % (3)	Root lodg. % (4)	Stalk lodg. % (4)	Bare tips % (6)	Ears/ 100 plts. (7)	Disd. ears % (7)	Days to tassel (7)	Ear height cm (6)	Blight score 0-5 (6)	Rust score 0-5 (4)
H611C	82.3	41.8	17.1	21.7	17.3	101.9	1.7	106.2	246.2	1.1	0.9
H613C	79.4	44.6	16.1	22.0	16.0	106.3	4.8	104.2	231.5	0.8	1.2
H632	62.6	47.9	28.8	27.5	11.1	102.3	6.1	104.1	184.4	0.9	1.6
H511	52.3	35.2	22.8	39.2	27.0	93.3	3.5	91.4	160.0	1.2	1.7
H512	55.8	41.2	21.2	38.6	15.5	88.3	3.1	94.0	161.2	1.3	2.0
UCA C4 x UCB/W C1	63.3	42.0	18.7	32.2	12.3	104.5	3.4	105.4	207.4	1.2	1.7
ICA x ICB/full (W)	39.9	41.9	19.3	54.7	8.1	86.9	6.0	99.9	182.2	1.9	2.8
Ukiri. Comp. A C3	60.0	39.0	23.6	25.6	11.9	95.1	5.0	104.8	212.3	1.2	1.7
Ukiri. Comp. B/W C1	52.3	53.9	23.6	46.4	13.2	93.8	5.2	102.6	190.8	1.4	2.0
Ilonga Comp. A	37.6	34.8	21.8	38.9	10.0	82.3	4.2	99.9	173.9	1.9	3.0
Kawanda Comp. A	54.4	48.3	26.2	31.6	7.7	90.1	4.4	102.1	208.3	1.3	1.9
SV 28	32.6	35.8	16.1	47.4	5.8	75.4	5.6	101.6	182.6	2.1	3.1
SR 52	51.2	29.2	16.1	32.9	7.7	88.4	4.7	97.7	172.1	1.4	2.7
KCE(M)	57.0	37.1	39.4	23.3	16.1	88.9	4.8	104.8	228.4	1.2	1.4
KCF (M)	49.9	37.3	21.4	27.2	18.2	87.7	7.4	91.7	179.0	1.6	1.3
Mean	55.4	40.7	22.2	34.0	13.0	92.1	4.7	100.7	194.7	1.3	1.9
LSD .05	11.1	16.1	12.6	12.6	5.6	12.5	3.9	3.8	18.2	0.6	0.3

The sites in Uganda were both about 1000 meters and as in the past, H632 proved best, yielding 53.0 q/ha. SR 52 and H512 were second and third, just below 50 q/ha. Kawanda Composite A yielded 46 q/ha and the variety-cross from Ukiriguru, UCA C4 x UCB/W C1, gave 41.4 q/ha. Considering elevations and climate, it was expected that the Ukiriguru cross would have done better. The Ilonga variety cross of ICA x ICB/Full (W) did in fact yield close to the top at 47.7 q/ha.

Agronomic data for countries other than Kenya is not presented in this report, but will be given by country in the report of the EAMVT to be issued later.

Yield results from Ethiopia and Malawi are in Table 80. Two of Ethiopia's sites are very similar to those in Kenya, however, there was more than 65 q/ha difference in mean experiment yields. The Bako location reported the highest yields to date in the EAMVT. H632, H511, H512, UCA C3, Kawanda Comp. A, and SR 52 all were shown to exceed the yields of H611C and H613B. That is most unusual and normally would cause one to be suspicious about the yield and entry correspondence. Barring any further information, one should just be cautious about basing too much on these data. Yields at the other two sites show no problems. The low elevation site at Bambella had the expected poor performance of the high altitude material and SV 28 was best.

Malawi was the only other country to turn in acceptable data for all sites. Overall, SR 52 performed best followed by H512, H511, and H632, all over 50 q/ha. The Malawi entry SV 28 did relatively better at the lower elevation site, but was still beaten by SR 52, the top yielder.

Table 79. Some yields (q/ha) obtained in Tanzania and Uganda in the 1970-71 Eastern African Maize Variety Trial. (Approximate altitudes (meters) are shown in parentheses).

Variety	Tanzania						Uganda	
	Tanga (200)	Mwamala (1110)	Bwanga (1198)	Ukiriguru (1200)	Mbimba (1600)	Njombe (2000)	Labora (914)	Serere (1067)
H611C	37.6	6.0	33.5	12.3	21.3	64.4	41.9	39.8
H613B*	27.6	9.2	28.3	17.8	16.3	58.6	39.6	41.7
H632	32.7	6.5	37.3	19.9	17.4	43.0	49.4	56.7
H511	27.3	5.1	36.2	21.1	19.5	44.1	42.3	41.5
H512	31.7	9.8	36.1	26.7	14.8	47.0	45.7	52.0
UCA C4 x UCB/W C1	28.4	11.1	41.4	19.3	20.0	35.6	40.2	42.6
ICA x ICB/Full (W)	33.5	8.8	30.4	21.2	10.8	22.5	45.2	50.1
Ukiri. Comp. A C3	25.2	7.4	28.7	22.6	11.8	47.6	41.6	39.8
Ukiri. Comp. B/W C1	25.1	4.6	41.4	20.6	13.0	38.5	52.9	42.6
Ilonga Comp. A	35.8	11.5	33.9	21.1	7.4	15.9	47.1	39.9
Kawanda Comp. A	24.7	10.5	34.2	16.9	10.1	39.8	45.2	46.8
SV 28	30.1	7.4	28.2	21.8	9.8	21.8	40.5	40.2
SR 52	24.9	9.3	41.1	23.4	13.1	33.2	51.4	48.5
Local entry	28.8	10.6	36.0	19.9	9.5	58.1	40.6	35.7
Local entry	27.4	7.0	23.7	22.7	10.3	29.8	47.1	44.2
Mean	29.4	8.2	34.0	20.5	13.7	40.0	44.7	44.2
LSD .05	9.0	6.9	10.9	9.4	9.1	7.4	13.9	15.1
C. V. %	22	59	23	32	42	13	25	27

* H613C was used in Uganda

Table 80. Some yields (q/ha) obtained in Ethiopia and Malawi in the 1970-71 Eastern African Maize Variety Trial. (Approximate altitudes (meters) are shown in parentheses.)

	Ethiopia			Malawi		
	Gambella (539)	Bako (1650)	Melko (1750)	Makanga (76)	Chitedze (1149)	Mbawa (1244)
H611C	20.1	103.5	40.1	25.4	58.5	57.5
H613B	11.0	106.9	42.7	17.0	61.6	47.6
H632	17.3	112.6	34.9	35.0	82.9	38.4
H511	25.3	114.9	33.9	35.1	64.4	61.3
H512	37.0	124.5	33.2	31.8	75.7	56.7
UCA C4 x UCB/W C1	28.0	103.5	37.9	32.7	59.5	42.7
ICA x ICB/Full (W)	28.3	90.1	38.9	41.9	47.4	40.2
Ukiri. Comp. A C3	34.5	115.4	37.4	23.4	64.1	44.1
Ukiri. Comp. B/W C1	30.9	89.5	42.2	28.1	52.9	38.0
Ilonga Comp. A	38.9	80.3	32.3	29.6	40.3	26.2
Kawanda Comp. A	14.7	109.9	34.7	33.5	54.2	36.8
SV 28	43.7	82.3	27.5	33.9	41.3	33.5
SR 52	34.1	116.4	25.0	37.4	69.8	62.6
Local entry	16.0	94.9	29.4	31.7	55.6	42.3
Local entry	27.6	101.1	38.0	35.0	55.9	32.3
Mean	27.2	103.1	35.2	31.4	59.0	44.0
LSD .05	17.3	14.9	14.9	8.5	18.6	14.4
C.V. %	45	10	30	19	19	23

Commercial Seed Production and Sales

Seed production by the Kenya Seed Company in 1971 was approximately 2632 hectares, up 30% from 1970. No major changes in seed production were made in 1971 and none are anticipated in 1972. All of the H613 sold in 1971 utilized Ec574(R12)C2 as the pollen parent, completing the conversion begun in 1970. H612 has now picked up the 'C' designation indicating that it has the newer version of the Ec573 used as the male.

Cooperation between the Maize Genetics Division and the Seed Company has continued in 1971 with one of our evaluation trials and one site of the Eastern African Maize Variety Trial being grown on their Merrow Down Farm in Endebess. Following discussion of the results of 1970, the Seed Company will undertake improvement in their KIII female parent by S_1 testing. Thus, both parents of H611 will be under recurrent selection and more rapid improvement, particularly of agronomic characters, should be made.

Hybrid maize sales to small scale farmers are presented in Table 81. 148,746 hectares planted by small scale farmers in 1971 represented a 53% increase over the 1970 season. The largest increase was in H622, where more than twice the hectareage was planted. Only H612C decreased in use; and in fact, the Seed Company would prefer to phase out production of H612C completely. H613C and H622 both had gains of about 20,000 hectares. H613C continued to be the most popular hybrid, accounting for 40% of the hybrid seed sold to small scale farmers. Sales to large scale farmers were 63,538 hectares worth, but a breakout by varieties was not available. Based on past records, H613C would have been the primary hybrid in use. Information in this table and in Table 82 is furnished by the Kenya Seed Company and hectareages are calculated from sales, based on a planting rate of 10 kg per acre (25 kg/ha).

The Fourth Eastern African Cereals Research Conference was held in October in Ethiopia. During the Conference papers were presented detailing the progress in cereals programs and the Ethiopians concerned with the particular crop described the work at the stations visited. Participants attended from all of Eastern Africa, except Zaire, Rwanda, Somalia, and Burundi. Further conferences were scheduled for Uganda, Tanzania, and Kenya in the coming years.

Three researchers from East Africa attended a Maize Workshop held by CIMMYT (International Maize and Wheat Improvement Center) in Mexico during September. USAID sponsored the Maize Geneticist and CIMMYT sponsored Mr. Festus Ogada, the Kenya Senior Maize Research Officer. Dr. J. Monyo of the Division of Research in Tanzania was sponsored by CIMMYT. The only other participant from Eastern Africa was Ato Biru Abebe of the Institute of Agricultural Research in Ethiopia.

Contacts have been established with all Eastern African countries except Zaire and Zambia. No results of the Eastern African Trial have been returned, nor is correspondence answered. Further efforts may result in productive cooperation with the maize workers in these two countries.

Ideally, on site contacts should be made two or three times a year with Uganda and Tanzania, and once a year with the other Eastern African countries. Visits will be made on request at any time.

Personnel changes in Malawi and timing of the beginning of the Maize Geneticist's tour made a March visit unfeasable in 1971, but preliminary plans have been made for 1972.

Composite formation has been undertaken as one of the roles of the large international institutes. The Maize Genetics Division also has a contribution in composite formation. Available are CBW I and CBW II for release to any interested breeder. They have had four generations of synthesis and consist mainly of South and Central American materials. Grain color is variable and maturity is shorter than local Kenya material. More information will be available after the 1972 season when they will be in top-cross trial. Both composites will be carried on by mild mass selection here at Kitale and the Syn 4 or the current mass selection cycle can be requested.

JOINT EAC/USAID CEREAL PROCESSING PROJECT

Allan D. Shepherd, John Fred Okorio and A. H. Woodhead

In the introduction to our annual report for 1970 we make a case that sorghum grain for food use should have a white seed coat and flinty endosperm and be from stock of tan plant colour. A number of reasons were given. They will not be repeated now but it might be stated that we believe the reasons are still valid and we have no new evidence which would alter our original opinion.

As a matter of fact our position may be strengthened by new considerations. We do not see that the breeding of dark seed coated sorghum really provides control of losses to birds over the long haul. Dark seeded sorghums are less taken by birds in the presence of alternate more desirable food sources. However, as larger and larger acreages are planted to sorghum alternate food sources for the birds will diminish so that even exclusively dark seeded planting will suffer losses to birds. The true control of bird damage to sorghum requires control of birds. Bird irradication methods are available. They should be used.

Recently research in the United States has questioned if the tannin content of sorghum may be responsible for reduced nutritional value. If tannin content is found to be detrimental in this regard then the position for white sorghums may be further enhanced.

Early in the year we received some quantities of sorghum and millet samples of diverse types from the quality grain collection at Serere Agricultural Experiment Station, Uganda. These we have characterized for proximate analyses and, in some cases, physical characteristics and amino acid composition.

Forth-two of the 83 sorghum varieties received are different from those provided in 1970. These 42 have completely characterized for proximate analyses and physical characteristics. The remaining 41 sorghums were done less completely but enough to show seasonal variation in physical characteristics.

Thirty of the 112 finger millets received were selected for high yield and have been analyzed for proximate analyses together with the 94 bulrush millets representing substantial genetic variability.

Assays of the 1970 sorghum samples for amino acids has been completed. Also 12 selected millets (6 bulrush and 6 finger) for amino acid contents were assayed. Comparisons of proximate and amino acid analyses for the sorghums, bulrush and finger millets have been made.

Sorghum and maize samples were processed by wet-milling for the preparation of massa or "chapati" dough.

We also report progress on the cooperative grain polisher trials in Tanzania and product testing throughout East Africa.

A revision of the Sorghum Recipe Booklet is in progress.

Comparisons Between 1970 and 1971 Samples of Forty-one Sorghum Varieties

The forty-one 1971 samples which are duplicates of the 1970 samples were studied and compared with the original 1970 results to see the effect of yearly seasonal variations on their physical characteristics. Table 83 shows the comparisons in mean kernel weights and mean breaking forces. There is a considerable weight increase of 1971 over 1970 in 95% of the samples. Sample 45-71 (56-70), for example, more than doubled its weight from 21.2 to 46.8 mg/kernel. This particular sample had also the highest percent protein of 14.5 in the 1970 batch. Other notable weight increase was observed in sample 77-71 (58-70), from 28.5 to 53.1 mg/kernel. The overall range was from 19.8 to 53.1 in 1971 compared with 13.6 to 40.3 for the original 1970 varieties.

Kernel hardness was measured on a hardness tester. Twenty grains, previously dried in an oven at 70°C for 48 hours, were tested for each variety. Here again the mean breaking force for each of the samples has considerably increased. Last year kernel hardness was found to be inversely correlated to its size. This appears not to be the case here. The entire range of the hardness was found to lie between 5.2 and 15.2 this year compared with 2.0 and 10.2 kg for the 1970 original samples. Samples 56-70, 40-70 and 47-70 had more than 300 percent increase in their mean breaking forces. Visual examination of these 41 samples would show they are much more fully matured and healthier than the comparable 1970 samples.

The flinty whites - Karachi, Mbangala, Mngindo, Kionja, Msumbiji, Konza - were all classed corneous. These corneous varieties have high characteristic values of mean breaking force, on average of 15.7 kg. Their mean kernel weights are low and average about 22.0 kg/kernel.

A very floury white, sagana, had a very low mean breaking force, 5.6 kg.

Physical Characteristics of the 1971 Sorghum Samples

These 42 samples were classed for the endosperm type obtained by individually cutting several grains and visual examination. Only 8 varieties are floury, Table 84 Most of them (20) were classed as corneous and the rest (14) as intermediate. Average kernel weights were obtained on 300 representative kernels of each variety. These values ranged from 19.5 to 52.1 mg/kernel. Seventy-five percent of the corneous samples weigh above 35.0 mg/kernel.

In our earlier reports it was possible to predict the corneousness or flouriness of a sorghum variety. The small light kernels were noted to be corneous while the majority of the large kernels were floury. This observation does not hold with this batch of samples. In fact a number of corneous samples are amongst the heavier grains.

Endosperm Characterization of 7x7 Series Bulrush Millet

The endosperm texture of bulrush millet samples was estimated visually on hand cut central transverse sections of individual kernels. Individual kernels were scored on the scale of 1, fully floury, to 5, fully corneous. Five kernels from each entry were inspected and scored and the results are shown in Table 85.

An extreme variability between individual grains was very apparent and in complete contrast to sorghum varieties. In the case of sorghum all kernels within a variety were very nearly uniform in endosperm texture.

It is now understood that an individual bulrush millet entry does not in fact represent a variety but is a composite. Therefore kernel to kernel variation in all characteristics including endosperm texture is to be expected.

The variability within composites makes it very difficult to select bulrush millet for desirable processing and food quality attributes. Some bulrush millet varieties are available and they will be provided to us in the future.

Kernel Hardness of Some Finger and Bulrush Millets

Table 86 shows that the mean breaking forces for the finger millets are very low. Our aim was to use "hardness" to grade these samples into corneous, intermediate, and floury varieties. From the data it is clear that for finger millets hardness measurements will have no value.

In Table 87 are the mean breaking forces of the bulrush millets. Although these values are much higher than those of the finger millets, (Table 86), their range is narrow (4.5-8.9). Consequently these data will have limited value for grading purposes.

Proximate Analyses

Proximate analyses on the sorghums and the millets (finger and bulrush) consisted in determining the major classes of chemical components, which include moisture, crude protein, crude fat, fiber and ash. Protein in sorghum and the millets is approximated by multiplying the Kjeldahl nitrogen analyses by the factors 6.25 and 5.83 respectively. Crude fat is measured by petroleum ether extractable material. Crude fiber refers to combustible organic matter not solubilized by either hot dilute sulfuric acid or sodium hydroxide solutions. Ash is determined by igniting samples until free of carbon.

Proximate analyses provide a good initial impression of the relative nutritive values and allow a basis for comparison between different samples. We have expressed all proximate analyses data on a moisture-free basis.

Proximate Analyses of the New 1971 Sorghum Varieties

Proximate analyses have been run on these 42 samples that are not duplicates of the 1970 sorghum varieties. Their protein, moisture, crude fat, ash and crude fiber contents are given in Table 88. The protein contents ranged from a low value of 8.9 to a high one of 16.6 in sample 14-71. Fats ranged from 2.5 to 5.1 percent and the ash levels from 1.8 to 2.7 percent. Amongst these samples we noted sample 1-71 had the highest values of fiber (3.8%), ash (2.7%) and fat (5.1%).

Proximate Analyses on the 1971 Bulrush Millets

A. The 5x5 Series: These 25 samples have been run completely and Table 89 gives the values of the analyses. The percent protein values (dry basis) lie between 9.4 and 13.8, the highest value being in sample Entry 2. Almost all of these samples (22) gave protein values which lay between 12.0 - 13.8%. Fiber levels ranged from 1.0 - 3.8%, the highest being in sample Entry 10.

Sample Entry 2 stands out in this varieties as it has the highest protein (13.8%) and fat (9.2%), which may be indicative of a relatively large embryo.

B. The 7x7 Series Bulrush Millets: In Table 90 are proximate analyses on these 49 bulrush millets. Of interest here was sample Entry 18 with the highest protein in 14.5 percent. Protein content ranged from 9.3 - 14.5 percent but only two entries were below 11.5

Highest fiber was 3.3 percent in sample Entry 49. This sample was noted as having a lot of small and shrivelled kernels. The Fiber range was 1.0 - 3.3 percent. Mositure, fat and ash ranges were 7.0 - 11.6 percent, 4.8 - 6.9 percent, and 1.3 - 2.1 percent respectively.

C. The District Variety Trials Series Bulrush Millets; Table 91 shows the values for the proximate analyses on these 20 bulrush millet samples. All the samples have protein contents above 10 percent and 19 of them have values near or above, 12 percent, ranging up to 14.0 percent for entries 6 and 9.

Fat levels are steady at 5.4 - 6.2 percent, but entry 10 gave a low value of 5.0 percent. Fibers do not show any striking difference from other bulrush millets analyzed before, their values lying between 1.1 - 2.1 percent. Like other bulrush millets analyzed before the ash values are low and range from 1.4 percent to 2.0 percent.

Some Selected Finger Millets: Of the 112 finger millets received, 30 of the highest yielding were chosen for proximate analyses. The analyses data are shown in Table 92.

Protein levels lie between 7.0 - 8.9 percent, the highest value being for Entries 73 and 43. Half of these samples have protein at, or above, 8.0 percent.

Comparison of Proximate Analyses of Sorghum, Bulrush and Finger Millet:

This comparison is shown in Table 93. It is clear that among the samples analyzed finger millet has a considerably lower protein content than the other cereals tested. It is so much lower that the range of its protein content does not overlap any of the range for the other cereals. The mean values for sorghum and bulrush millet are probably not significantly different. The range of protein contents for the sorghum studies (7.7) is much greater than the range for bulrush millet (5.2). The range for finger millet seems extremely small (1.9) even though this is for 80 samples to 103 for sorghum and 94 for bulrush millet.

The factors used to convert nitrogen content to protein are those given in "Composition of Foods", Agriculture Handbook No. 8, Revised Dec. 1963, page 161 and differs between sorghum (6.25) and millets (5.83). The validity of this difference may be questioned. If 6.25 were used throughout, the protein contents for the millets would be

increase by about 7% and this would put the means for bulrush millet slightly above those for sorghum but not by a meaningful amount. The protein values for finger millet would still be decidedly low.

For the cereal samples analyzed it appears there are interesting differences in crude fat contents with bulrush millets having rather high values, sorghums having intermediate levels and finger millets very low values.

In the case of crude fibers it seems clear that finger millet values are higher than the others. One would immediately be inclined to say the samples were not cleaned of adhering glumes properly, which as discussed in another part of the report, is a practical problem. However, great pains were taken to hand clean the samples analyzed. We are inclined rather to the opinion that because of the small seed size the seed coat constitutes a larger proportion of the grain.

Ash content seems to be roughly related to crude fiber content.

Amino Acid Analyses: Amino acid composition of protein in the sorghum varieties, bulrush and finger millets was determined as outlined below. Representative samples of the cereals were chosen for the analyses. All extraneous and foreign material was removed by hand from all samples previous to any analyses. The cleaned samples were ground in a laboratory cutting mill and Kjeldahl nitrogen determined on them. For amino acid analyses, we further ball-milled the ground samples to fine flours.

Ball-milled, whole grain flours were throughly mixed and single proteins of each were weighed out to contain 10 mg $\pm$ 0.5 mg of protein. These were then hydrolyzed with 6^N HCL in sealed evacuated test tubes at 110 $\pm$ 1°C for 24 hours. The tube contents were filtered, and the filtrate evaporated to dryness. Excess hydrochloric acid was removed by repeated dilution with distilled water and evaporation to dryness. The hydrochloric-acid-free residues were made up to 10.0 ml in 0.20 N sodium citrate buffer, pH 2.2.

Aliquots of the hydrolysates were taken, and amino acid analyses were conducted by ion exchange chromatography on a Beckman model 120C amino acid analyzer.

Results were calculated and expressed as grams of amino acid per 16 grams of nitrogen. Cystine, methionine and tryptophan have been omitted because they are nearly completely destroyed during acid hydrolysis.

Nitrogen recovery was calculated by dividing the sum of the nitrogens from each of the amino acids in the sample plus ammonia by the amount of nitrogen in the sample, as determined by the semi-micro Kjeldahl procedure. There were, however, appreciable differences in the percent nitrogen recoveries; they ranged 8.0-110.8. We hoped to improve the recoveries by more attention to hydrolysis methods and frequent calibration runs.

The amino acid analyses for individual entries are given in Table 94 for sorghum and Table 95 for finger and bulrush millets. The means and ranges for individual amino acids for each grain are given in Table 96. These results show that the first limiting amino acid in cereals, lysine, to be lowest for the sorghums examined (range 1.1 - 2.8) with the values for finger millet and bulrush millet considerably higher (2.7 - 3.3. and 2.6 - [illegible] respectively). The means for either millet is in the acceptable range and two individual bulrush millet entries run very high at 3.6 and 3.9 grams lysine per 16 grams of nitrogen.

Udy Protein Method: During the year we analyzed the protein content of 56 sorghum samples by both the Kjeldahl and Udy methods. Comparisons have been drawn between the analyses.

The differences between methods showed that the values by Udy exceeded the Kjeldahl values 43 times (range 0.1 - 2.4% protein, average 1.0%). The values by Kjeldahl exceeded the Udy values only 13 times (range 0.1 - 1.3% protein, average 0.5%). These differences were based on a conversion table for milo provided by the Udy Analyzer Company, no doubt prepared by analyses of United States grain. However, with these new data we have prepared our own conversion table for local grains.

We also analyzed for protein in 39 of the 1971 sorghum samples which were duplicates of the 1970 varieties. Protein values obtained (Table 97 did not differ very much from the values for the duplicate 1970 samples - all calculated using the newly established conversion table. This agreement was however surprising since average seed weight showed great difference between the two years for many of the samples shown in Table 83.

Udy Lysine Index

Udy lysine indices were determined on the 1970 sorghum varieties. A quantitative comparison was possible with these samples for which we had determined lysine in the amino acid analyzer. A comparison between the lysine analyses and the Udy lysine indices are shown in Table 98.

There seems to be no correlation between the lysine analyses and the indices. A similar lack of correlation was found previously for the sorghum samples provided to us by Dr. R. C. Pickett of Purdue University. It appears that an alternative to the Udy method will be required for screening for lysine in sorghum samples.

A modification of the method which had been used for wheat was suggested to us by Mr. P. J. Mattern, U. of Nebraska. In this version Kjeldahl nitrogens are run and a sample containing 65 mg. of protein based in the Kjeldahl is used in the Udy method and a colorimeter reading obtained. These readings were found to be correlated with lysine content for wheat. We found no such correlation for sorghum.

There are other alternative methods which could be tried. However, a consideration of priorities makes it seem doubtful that with our present resources we should continue these efforts.

Preparation of Massa by Wet Milling of Maize and Sorghum

A protessor Expeller was tried to provide the wet milling action required for development of dough characteristics exhibited by massa (the dough from which tortillas are made). Maize was used to establish the process because it is the traditional ingredient used in Central and South America. Subsequently sorghum was substituted and seemed to produce an equally satisfactory massa. The soaking time required was substantially reduced over that required for maize and became very short indeed when polished sorghum was used.

However, the Protessor Expeller was found to be less than ideal as a mill for this purpose. It was difficult to keep in adjustment and it tended to dirty the product. So further work has been deferred until a more suitable piece of equipment is available.

Recently Dr. Warren Harrison of Africa Basic foods expressed an interest in developing new products which he might make. We suggested the possibility of preparing massa in the Wenger cooker-extruder which he has for soy bean processing. We suggested process possibilities for him to discuss with his food technologist.

Grain Polisher Trials in Tanzania

A second CeCoCo cereal polisher of the same size that has been used in the laboratory was obtained and provided with a 7½ H.P. petrol engine drive. (A 3 H.P. motor is recommended for electricity). This was loaned to the Research and Training Division of the Ministry of Agriculture, Food and Cooperatives of Tanzania and delivered to the Ministry of Agriculture Training Institute (MATI) in Morogoro.

The first test was made in July for two days at Kingolwira, a nearby village, under our supervision. Some trouble was encountered: a leak in the petrol tank had to be repaired and belt slippage corrected. When these were overcome, operation went reasonably smoothly. During one four hour period lots from 32 people estimated as 25.6 debes were run. A debe is a 4 imperial gallon measure which contains about 16 kg of sorghum. The thoroughput rate was 102 kg per hour for this period and the petrol cost was calculated to be 63 cents (E.A.) per debe.

The machine was transported to four different villages all within 20 miles of Morogoro and operated by the MATI personnel during the period August to November. A summary of these trials are shown in Table 99.

The whole kernel "polished" product is similar to that which is traditionally made in a "kinu" (a deep wooden mortar). However, machine operation provides better control and causes less kernel breakage. Interest on the part of the villagers was great as indicated at each location by a long standing queue of ladies and children with containers of sorghum awaiting their turns. This interest is understandable since a debe of sorghum is said to require about four hours of labor to process by "kinu". This same quantity requires on an average about 12 minutes of machine operation.

On the whole the quality of the debranned product was pronounced quite acceptable by the villagers. However, the products from some sorghums were less desirable than from others. Some samples appeared dirty apparently because in threshing, fine particles of dark soil adhered to the waxy coat. Such samples did not achieve the desirable degree of whiteness usually obtained with the limited (around 6-8%) seed coat removal. Such samples would seem to be avoidable by altering threshing methods. Some villagers seemed to desire a greater amount of seed coat removal. This can be achieved in the machine but at greater cost and at a greater loss of nutritional value.

At the last four locations the average cost per debe (16 kg) for petrol was under thirty five cents (E.A.) Table 99. The cost of the machine with petrol engine mounted was 5,200 shillings. Charges that would have to be made to amortize that cost will depend on the amount the machine is used. It seems likely that no single location will be able to support a machine, but it may be reasonable to move the machine between locations within a region. The maintenance cost likewise cannot be estimated yet but to date it has been very low. So the economics of the situation while uncertain definitely does not rule out the process.

Evaluation will continue for the next season under the direction of the Chakula Bora group at Ilonga Research and Training Institute.

Cooperative Product Development and Testing

Cooperative recipe development with the Home Economics Department of the University of Nairobi has produced a revision of the Sorghum Recipe Booklet in draft form. Principal improvements are uniform and more useful system of measures for ingredients and the addition of a number of more commonplace local recipes.

Over the years of the project we have managed to maintain working relationships with members of the Chakula Bora Group at the Research and Training Institute at Ilonga despite a considerable number of changes in personnel. The most recent change has brought a new Director to Ilonga, Mr. A. C. Mosha, who recently received a Master's degree in Food Science from U.K. Mr. Mosha has expressed a great desire to revitalize the Chakula Bora Group and is very interested in promoting the expanded use of sorghums and millets. An engineer, Mr. J. Vellani has joined the group which should be very helpful to the program. To assist in this program we have prepared 2 kg of flour from each of several flinty white sorghums and from one we have prepared 2 kg each of (1) polished whole kernel (2) cracked and (3) semolina in addition to the flour. It is this group that will take over the operation of the Cereal Polisher Trials in Tanzania.

The CeCoCo polisher has been found to be useful too, in removing the flumes from finger millet grain. Good acceptance of a porridge made from flour of grain precleaned in this fashion was obtained among the girls at Gayaza Girls' School. Additional samples of finger millet flour has been furnished to Dr. James MacDowell who is in charge of this testing. Additional testing will be delayed until he returns from home leave, however.

Commercial production of finger millet flour has been impeded we are told until a satisfactory method has been found for glume removal to replace the laborious traditional method of heating, hand rubbing, and winnowing of the grain. On a recent trip to Kampala, Dr. Warren Harrison of Africa Basic Foods was contacted. He has a CeCoCo polisher which he uses for hulling soy beans for full fat soy production. He expressed interest in cleaning finger millet and preparing a flour. The flour could be used in place of maize in some of his blended food products with soy or he would sell it unmixed in packages if there were a demand.

Table 83. Physical characteristics of some sorghum grain varieties. Comparisons between 1970 and 1971 samples.

Number 1971	Number 1970	Other Description	Endosperm type	Mean kernel wt. (mg) 1970	1971	Hardness Mean Force (kg) 1970	1971	Range 1971
43-71	33-70	E 6305	Int'mediate	30.3	32.1	7.4	13.0	4.6-16.9
44-71	8-70	E 605	Floury	25.5	36.6	4.1	6.9	2.1-10.4
45-71	56-70	E 6075	"	21.2	46.8	2.0	7.2	5.7-9.6
46-71	18-70	Is 2260	"	20.5	32.5	4.6	11.3	8.6-14.8
47-71	23-70	Is 956	Corneous	25.9	39.1	8.6	14.0	9.4-16.6
48-71	55-70	E 6953	"	30.9	40.7	7.7	11.2	5.2-16.4
49-71	10-70	Is 9462	Floury	19.5	28.5	3.7	7.5	6.1-10.0
50-71	28-70	E 6992	"	23.7	38.4	4.6	10.9	5.1-16.4
51-71	6-70	E 6955	Corneous	32.1	32.0	8.6	14.8	10.2-16.9
52-71	40-70	E 2891	Floury	31.7	45.7	4.9	14.2	11.0-16.4
53-71	34-70	E 6432	"	35.2	27.8	4.2	5.2	3.0-7.0
54-71	24-70	E 280	Corneous	23.8	26.5	8.6	12.4	8.0-17.1
55-71	44-70	E 145	Int'mediate	30.1	42.1	3.8	7.6	3.6-13.0
56-71	7-70	Is 2771	Corneous	13.6	19.8	4.7	11.3	6.4-16.2
57-71	13-70	E 6900	"	22.5	29.9	5.1	9.1	5.5-15.3
58-71	11-70	Is 9898	Floury	37.5	49.8	4.3	13.1	7.6-16.8
59-71	26-70	E 6454	Corneous	25.9	35.9	8.8	15.1	10.2-16.4
60-71	2-70	Is 3404	Int'mediate	19.1	29.2	4.0	9.2	6.8-13.4
61-71	36-70	E 6022	"	23.8	34.8	6.6	12.1	7.6-16.6
62-71	12-70	Is 2341	Floury	27.3	37.3	4.4	11.6	6.3-14.5
63-71	35-70	E 6382	"	36.7	46.4	4.6	13.0	8.2-16.7
64-71	16-70	Is 9671	Corneous	23.7	31.9	7.8	15.2	10.6-16.5
65-71	50-70	E 6025	Int'mediate	19.8	32.7	4.0	11.3	6.2-16.6
66-71	59-70	E 6954	"	27.2	34.9	8.3	14.8	10.1-16.8
67-71	15-70	E 6374	Floury	32.1	44.0	5.1	10.8	7.2-13.8
68-71	19-70	E 253	Int'mediate	22.6	34.1	4.1	9.9	6.8-15.9
69-71	57-70	E 6338	Corneous	29.9	30.0	10.2	14.5	9.2-17.1
70-71	14-70	E 2334	Floury	30.9	40.7	4.4	13.1	8.9-16.5
71-71	51-70	E 142	Int'mediate	33.0	47.8	3.7	11.1	8.1-16.5
72-71	47-70	E 6321	Floury	29.0	32.3	2.8	11.1	7.6-15.8
73-71	22-70	Is 2328	Corneous	29.5	32.5	8.5	14.3	8.9-16.9
74-71	45-70	E 6977	Int'mediate	35.9	37.5	6.8	10.6	7.4-14.2
75-71	52-70	E 6225	Floury	29.2	33.2	7.4	14.8	11.3-16.6
76-71	25-70	E 6974	Int'mediate	25.9	30.7	3.2	6.9	4.6-9.9
77-71	58-70	E 6396	Floury	28.5	53.1	4.2	14.3	9.2-16.6
78-71	29-70	E 3155	Corneous	23.5	35.4	4.8	12.9	11.7-16.4
79-71	32-70	E 6030	"	24.4	39.0	6.7	9.2	5.6-12.7
80-71	37-70	E 9533	Int'mediate	35.0	23.8	4.2	7.6	6.5-9.8
81-71	41-70	E 6433	Floury	40.3	43.7	3.7	10.2	7.0-16.3
82-71	21-70	E 928	Int'mediate	22.5	29.8	5.1	11.1	8.0-14.8
83-71	20-70	Is 3565	Int'mediate	20.3	33.8	6.7	12.5	9.0-16.2

Table 84. Physical characteristics of the 1971 sorghum grain varieties.

Our Number	Other Description	Color of Seed Coat	Endosperm type	Hardness Test(a) Breaking Force) Mean Force (Kg)	Force Range (Kg)	Average weight mg/grain (b)
1-71	E 6116	Yellow	Corneous	6.8	4.8-9.0	45.1
2-71	E 6267	White; Red-brown patches	Intermediate	6.7	4.4-9.1	45.3
3-71	E 6048	White; purple spots	Floury	7.8	5.8-9.5	37.1
4-71	E 7461	Yellowish white	Corneous	10.8	7.2-13.7	52.1
5-71	E 6341	White; red spots	Floury	9.0	5.8-16.4	39.2
6-71	E 6485	Greyish-white; purple spots	Corneous	8.1	6.0-9.8	28.8
7-71	E 6378	Whitish-yellow; red spots	Intermediate	8.2	5.9-12.8	35.5
8-71	Is 9569	Reddish Brown	Floury	5.9	3.0-7.7	34.5
9-71	Is3562	Whie; red patches	Intermediate	12.0	7.4-16.2	29.3
10-71	E 6952	White; purple spots	Corneous	13.9	8.8-16.5	33.0
11-71	E 6434	Yellowish white; brown patches	"	10.0	7.4-12.5	35.1
12-71	Is 9890	Yellowish white	"	12.8	8.0-16.3	35.7
13-71	E 6095	Yellow; brown patches	Floury	8.0	5.2-14.2	24.8
14-71	Is 815	Yellowish white	Intermediate	7.7	4.4-10.2	35.5
15-71	E 6139	Reddish-brown; yellow patches	Floury	6.8	4.6-8.2	33.4
16-71	E 6113	Yellowish brown; purple spots	Corneous	12.8	8.0-16.4	36.0
17-71	E 6137	White; reddish spots	"	8.1	4.0-11.9	27.8
18-71	E 6492	White; purple sp ts	"	9.4	4.8-12.8	29.7
19-71	E 3351	Cream-colored; purplish spots	"	6.9	4.8-9.1	24.3
20-71	E 6120	Whitish-yellow; red-brown patches	Corneous	8.3	3.6-12.8	40.7
21-71	E 6107	Yellowish white; purple spots	Intermediate	6.8	3.6-8.6	41.8
22-71	E 6136	White; red-brown spots	Floury	8.5	5.2-12.4	42.9
23-71	E 6989	Yellow; red-brown spots	Intermediate	9.7	6.0-12.9	42.4
24-71	Is 9455	White; red patches	Corneous	9.4	6.2-12.0	24.6
25-71	E 6223	Yellowish-white; purple spots	"	7.1	6.0-9.5	22.1

Table 84. (Cont'd.)

Our Number	Other Description	Color of Seed Coat	Endosperm type	Hardness Test(a) (Breaking force) Mean Force (Kg	Force Range (Kg)	Average weight mg/grain (b)
26-71	E 6432	Yellowish; red brown spots	Intermediate	9.3	6.4-13.9	33.2
27-71	E 6494	White; red-brown spots	Intermediate	7.5	6.1-11.0	27.7
28-71	E 6330	Yellowish brown	Floury	10.1	7.1-14.1	35.0
29-71	E 6482	Yellowish-white; purple spots	Intermediate	9.1	6.9-11.0	35.7
30-71	E 6111	Yellow; red brown patches	Intermediate	6.1	3.7-8.4	26.3
31-71	E 6129	Yellowish white; red-brown patches	Corneous	9.9	6.8-15.2	42.0
32-71	Is 9816	Grey; reddish-brown spots	Intermediate	8.5	3.8-13.1	41.0
33-71	E 6058	Greyish-purple;brown patches	Floury	10.2	7.2-14.6	41.4
34-71	E 6950	Yellow; red, brown patches	Intermediate	11.6	8.2-15.2	32.3
35-71	E 6976	Yellow; red, brown patches	Corneous	8.3	3.8-13.9	38.6
36-71	E 6114	Whitish-yellow;purple patches	"	6.8	4.0-9.6	19.5
37-71	E 6101	Tan; red-brown patches	Intermediate	4.6	3.0-6.7	32.5
38-71	Is 9896	Greyish-purple; red-brown spots	Corneous	12.8	7.6-16.6	47.0
39-71	Is 2584	Yellow; reddish-brown spots	"	8.8	7.1-10.9	38.0
40-71	E 6088	White; reddish-brown spots	"	16.2	13.0-17.4	36.0
41-71	E 285		Intermediate	8.8	3.8-13.0	42.1
42-71	E 6949	Yellowish white, brown patches	Corneous	13.1	9.9-16.4	38.3

(a) Obtained by individually breaking 20 kernels dried for 48 hrs. under bacuum at 70°C in an oven with a hardness tester - Ogawa Soiki Co. Ltd., Tokyo.

(b) Determined by weighing 100 kernels in triplicate.

Table 85. Endosperm texture of 49 bulrush millets 7x7 series

Entry Number	Average endosperm Texture (a)	Entry Number	Average endosperm Texture (a)
1	3	45	3
2	4	46	4
3	4	47	4
4	3	48	3
5	3	49	4
6	5		
7	3		
8	3		
9	2		
10	3		
11	2		
12	4		
13	3		
14	3		
15	3		
16	4		
17	4		
18	3		
19	2		
20	2		
21	2		
22	2		
23	4		
24	4		
25	3		
26	3		
27	4		
28	4		
29	3		
30	3		
31	4		
32	3		
33	3		
34	3		
35	3		
36	4		
37	3		
38	3		
39	3		
40	3		
41	3		
42	4		
43	2		
44	4		

(a) A rating of 5 is all corneous; 1 is all floury.

Table 86. Breaking force of 30 selected finger millets.

Entry Number	Mean Breaking (a) Force (Kg)	Range (Kg)
1	1.0	0.6-1.7
6	1.3	0.6-2.7
8	1.3	0.5-1.7
15	1.5	0.6-2.4
16	1.2	0.8-1.6
21	1.5	0.6-2.6
22	1.5	0.5-3.0
24	1.3	0.8-2.0
27	1.2	0.7-2.4
42	1.3	0.6-2.4
43	1.2	0.5-2.0
44	1.8	0.5-3.2
53	1.6	0.5-2.8
56	2.4	1.0-4.5
63	1.1	0.5-2.2
66	1.0	0.3-1.6
71	1.3	0.6-2.4
73	1.0	0.4-1.8
91	1.5	0.6-2.7
99	1.4	0.4-3.1
101	1.3	0.7-2.3
102	1.5	0.6-3.8
106	1.2	0.8-1.9
107	1.5	0.4-3.9
112	1.7	0.6-3.0
114	1.6	0.7-3.2
116	1.2	0.7-2.2
119	1.5	0.8-2.4
120	1.2	0.6-2.2
121	2.0	1.0-3.4

(a) Obtained by individually breaking 20 kernels dried for 48 hours under vacuum at 70°C in an oven with a hardness tester - Ogowa Soiki Co. Ltd., Tokyo.

Table 87. Breaking force of the 49 bulrush millets (7x7 series)

Entry Number	Mean Breaking Force(a)(Kg)	Range	Entry Number	Mean Breaking Force(a)(Kg)	Range
1	7.5	4.7-9.4	26	7.8	3.8-11.5
2	8.6	6.0-16.2	27	7.7	2.6-13.0
3	7.9	4.5-14.6	28	6.0	3.0-12.1
4	8.0	4.2-13.8	29	7.2	4.8-9.8
5	7.1	3.2-10.6	30	7.3	4.6-14.8
6	6.9	4.8-10.0	31	6.1	3.8-12.6
7	6.5	2.6-12.2	32	7.4	4.8-12.8
8	8.9	3.2-13.0	33	7.0	2.8-12.6
9	5.8	2.6-8.7	34	5.9	2.8-8.3
10	6.6	2.8-11.8	35	6.8	3.4-14.4
11	5.7	2.8-8.0	36	8.5	4.3-14.0
12	8.7	4.0-16.0	37	6.7	3.6-11.0
13	7.3	2.6-11.7	38	6.4	3.6-10.2
14	8.1	4.9-13.7	39	7.1	3.4-12.3
15	7.5	5.5-10.3	40	7.0	3.9-16.1
16	9.3	5.3-15.8	41	7.7	4.2-14.6
17	7.4	4.4-12.6	42	7.0	3.9-12.9
18	6.8	2.3-16.3	43	6.6	3.4-11.8
19	8.0	3.5-11.6	44	7.1	5.6-14.4
20	8.3	6.2-10.6	45	8.0	4.2-11.8
21	7.5	3.2-11.4	46	6.9	4.9-12.5
22	4.5	2.1-7.0	47	7.6	4.2-9.2
23	7.5	4.3-12.3	48	6.9	4.2-9.2
24	8.2	5.3-12.5	49	8.2	4.8-12.9
25	6.8	4.2-12.6			

(a) Obtained by individually breaking 20 kernels dried for 48 hours under vacuum at 70°C in an oven with a hardness tester - Ogowa Soiki Co. Ltd., Tokyo.

Table 88. Proximate analyses of 1971 sorghum samples.

Our Sample No.	Other Description	% Moisture	% Protein (a) (N x 6.25)	% Fat (a)	% Ash (a)	% Fiber (A)
1-71	E 6116	9.8	13.1	5.1	2.7	3.8
2-71	E 6267	9.9	12.7	4.6	2.4	2.6
3-71	E 6048	10.0	14.1	3.2	1.7	2.0
4-71	E 7461	10.3	10.9	3.7	1.3	1.6
5-71	E 6341	9.9	11.3	4.0	1.4	1.8
6-71	E 6485	10.6	12.9	3.0	1.8	1.9
7-71	E 6378	9.6	12.3	3.9	2.0	2.2
8-71	Is 9569	9.7	13.4	3.7	1.8	2.0
9-71	Is 3562	9.8	11.2	3.9	1.0	2.3
10-71	E 6952	9.4	11.7	3.8	1.4	2.2
11-71	E 6434	9.4	13.4	5.1	1.5	2.0
12-71	Is 9890	9.4	10.9	3.2	1.4	1.9
13-71	E 6095	8.4	13.2	3.5	1.9	2.1
14-71	Is 815	10.5	16.6	3.8	2.3	2.8
15-71	E 6139	11.3	14.3	3.9	1.8	2.9
16-71	E 6113	10.6	14.7	4.0	1.8	1.7
17-71	E 6137	11.2	14.8	3.5	2.1	3.0
18-71	E 6492	9.7	11.7	3.8	1.6	2.5
19-71	E 3351	10.9	14.7	4.5	1.7	1.6
20-71	E 6120	10.8	15.2	4.0	2.1	2.7
21-71	E 6107	10.0	15.7	3.6	1.9	2.4
22-71	E 6136	11.2	13.5	3.8	1.4	2.4
23-71	E 6989	10.8	10.8	4.0	1.5	2.4
24-71	Is 9455	10.9	13.0	3.7	1.6	1.8
25-71	E 6223	11.6	13.0	2.8	2.0	2.4
26-71	E 6432	11.4	12.2	2.5	1.6	1.8
27-71	E 6494	11.4	13.8	3.8	1.9	2.3
28-71	E 6330	11.2	13.1	3.4	1.6	1.7
29-71	E 6482	11.2	13.3	3.7	1.8	2.4
30-71	E 6111	14.9	12.8	3.1	2.1	2.2
31-71	E 6129	11.4	15.5	2.8	1.6	3.5
32-71	Is 9816	10.8	11.2	5.0	1.1	1.3
33-71	E 6058	14.7	13.0	3.6	2.1	1.8
34-71	E 6950	9.7	12.4	3.4	1.2	2.2
35-71	E 6976	10.6	12.2	5.0	2.1	3.2
36-71	E 6114	11.0	13.7	3.7	1.9	3.3
37-71	E 6101	8.4	11.8	4.0	2.0	2.1
38-71	Is 9896	10.6	10.5	3.4	1.6	1.9
39-71	Is 2584	10.6	8.9	4.0	2.1	3.0
40-71	E 6088	11.7	13.8	4.3	1.7	2.6
41-71	E 285	10.4	15.2	2.9	1.1	2.2
42-71	E 6949	10.8	13.8	3.5	1.3	2.1
Average		10.6	13.0	3.8	1.7	2.3

Table 89. Proximate analyses of 1971 bulrush millet 5 x 5 series.

Entry Number	% Moisture	% Protein (a)	% Fat(a)	% Fiber(a)	% Ash(a)
1	10.3	13.5	7.8	2.6	1.9
2	9.3	13.8	9.2	3.2	2.1
3	9.8	12.9	7.9	2.8	1.8
4	8.9	12.7	8.9	2.3	2.4
5	9.4	13.1	8.3	2.3	2.0
6	10.4	12.2	7.1	1.9	1.5
7	10.0	12.2	7.7	1.9	1.9
8	9.4	13.1	8.2	1.8	1.7
9	10.7	12.4	5.6	2.2	1.6
10	10.4	12.8	5.6	3.8	1.6
11	10.1	11.6	6.3	3.2	1.4
12	9.7	11.3	8.4	2.4	2.1
13	10.1	13.0	6.9	2.7	1.3
14	9.8	12.6	6.7	2.8	1.8
15	9.7	12.2	6.6	2.0	1.7
16	8.6	13.1	6.0	1.9	1.5
17	9.9	12.1	6.1	2.0	1.8
18	10.0	13.1	5.6	1.3	1.6
19	9.9	9.4	6.5	1.8	1.7
20	10.2	12.8	4.9	1.4	1.6
21	9.7	13.5	5.3	1.3	1.3
22	9.8	13.0	5.5	1.3	1.4
23	10.2	13.1	6.3	1.1	1.6
24	9.8	12.6	5.3	1.0	1.4
25	10.4	13.2	6.3	1.5	1.5
Average	9.9	12.6	6.8	2.1	1.7

(a) Mositure-free basis

Table 90. Proximate analyses of the 1971 bulrush millets 7x7 series.

Entry Number	% Moisture	% Protein(a)	% Fat(a)	% Fiber(a)	% Ash(a)
1	8.5	13.7	6.3	1.4	1.5
2	8.2	13.5	6.9	1.9	1.5
3	8.2	12.1	5.8	1.1	1.4
4	8.3	13.1	5.5	1.5	1.5
5	8.3	12.4	6.9	1.4	1.4
6	8.3	13.2	6.0	2.2	1.4
7	9.9	11.8	5.5	2.0	1.4
8	8.1	13.1	5.7	1.4	1.5
9	10.1	12.5	4.9	1.1	1.4
10	7.9	13.4	5.4	1.2	1.4
11	6.9	13.9	5.2	1.3	1.5
12	7.5	13.8	5.7	1.4	1.3
13	9.9	12.8	5.8	1.9	1.4
14	9.3	12.8	5.6	1.5	1.5
15	9.5	13.3	5.6	1.4	1.4
16	9.0	14.0	5.4	1.8	1.4
17	10.0	13.7	5.7	1.2	1.4
18	9.0	14.5	5.7	1.4	1.5
19	9.7	11.7	5.5	1.1	1.3
20	9.2	12.0	5.6	1.2	1.5
21	8.2	9.3	5.7	1.4	1.4
22	10.3	12.8	5.5	1.2	1.7
23	10.0	12.3	5.4	1.4	1.6
24	9.3	13.7	5.5	1.0	1.5
25	8.0	11.5	5.4	1.4	1.3
26	7.7	9.9	5.4	1.2	2.1
27	7.9	13.7	5.1	1.2	1.4
28	7.3	13.4	5.4	1.3	1.5
29	7.5	12.5	5.7	1.4	1.5
30	7.4	11.9	5.4	1.5	1.3
31	7.1	12.9	5.6	1.1	1.5
32	8.4	12.2	5.1	1.4	1.3
33	11.6	12.8	6.1	1.5	1.6
34	8.0	12.7	5.4	1.1	1.4
35	7.2	12.3	5.3	1.4	1.4
36	8.3	13.1	5.0	1.1	1.4
37	8.2	12.1	5.2	2.0	1.6
38	8.2	13.2	5.1	1.3	1.4
39	8.3	11.7	5.0	1.4	1.4
40	8.2	12.4	4.8	1.4	1.4
41	8.1	12.8	5.6	1.5	1.5
42	7.0	12.5	5.5	1.2	1.6

Table 90. (Cont'd.)

Entry Number	% Moisture	% Protein(a)	% Fat(a)	% Fiber(a)	% Ash(a)
43	8.0	11.5	5.2	1.3	1.6
44	7.1	12.2	5.5	1.3	1.3
45	6.9	11.9	5.3	1.4	1.5
46	9.6	13.1	6.0	1.4	1.8
47	10.0	12.2	5.3	1.6	1.4
48	9.9	13.3	5.3	1.4	1.6
49	8.9	13.0	5.2	3.3	1.5
Average	8.5	12.7	5.5	1.4	1.5

(a) Moisture-free basis

Table 91. Proximate analyses of bulrush millet district variety trial series.

Entry Number	% Moisture	% Protein(a) (N x 5.83)	% Fat(a)	% Fiber (a)	% Ash(a)
1	8.6	11.9	6.0	1.1	2.0
2	8.9	12.4	5.7	1.2	1.4
3	8.7	12.3	5.9	1.2	1.5
4	9.0	12.6	5.9	1.2	1.1
5	8.5	13.3	5.8	1.3	1.6
6	8.6	14.0	5.5	1.4	1.5
7	8.4	10.3	5.8	1.3	1.6
8	10.4	12.3	5.9	1.2	1.6
9	8.5	14.0	5.7	1.2	1.4
10	8.5	12.4	5.0	1.3	1.5
11	8.0	13.9	5.4	1.7	1.7
12	7.9	12.6	5.6	1.8	1.8
13	8.5	12.0	5.9	2.1	1.6
14	7.8	12.2	6.2	1.6	1.4
15	8.2	13.2	5.6	1.6	1.7
16	10.3	11.9	5.8	2.0	1.6
17	8.1	12.4	5.5	1.7	1.6
18	8.1	12.2	5.7	1.6	1.5
19	8.6	13.3	6.1	1.6	1.6
20	8.4	12.7	5.9	1.7	1.5
Average	8.6	12.6	5.8	1.5	1.6

(a) Mositure-free basis

Table 92. Proximate analysis of finger millets (30 selected samples)

Entry Number	% Moisture	% Protein(a) (N x 5.83)	% Fat(a)	% Fiber(a)	% Ash(a)
1	8.4	8.8	0.9	3.8	2.1
6	7.8	7.7	0.9	2.9	2.4
8	11.3	8.0	0.9	3.3	2.3
15	8.8	7.1	0.9	2.6	2.2
16	9.5	7.5	0.8	3.1	2.3
21	8.6	7.7	0.9	3.8	2.4
22	7.5	7.6	1.0	3.4	2.4
24	7.1	7.9	1.0	2.9	2.2
27	8.9	8.5	0.9	3.2	2.7
42	8.8	7.7	0.9	3.3	2.4
43	9.1	8.9	0.8	3.7	2.4
44	7.6	7.9	1.4	3.4	2.8
53	8.9	8.1	1.2	3.5	2.4
56	7.9	8.0	1.3	3.1	2.4
63	9.3	8.3	1.7	4.2	2.2
66	9.1	8.0	1.2	4.1	2.4
71	9.0	7.0	1.3	3.0	2.4
73	8.6	8.9	0.9	4.1	2.4
91	8.3	7.6	1.1	3.2	2.1
99	11.1	8.7	0.8	3.6	2.2
101	7.9	7.7	1.3	3.0	2.0
102	8.9	7.2	0.9	3.3	2.4
106	8.8	8.7	1.0	3.9	2.4
107	8.8	8.0	0.9	3.5	2.3
112	8.2	8.4	0.8	3.4	1.7
114	8.8	7.6	0.8	2.9	2.3
116	8.5	8.3	1.0	3.6	2.2
119	11.2	7.9	1.0	3.1	2.3
120	11.0	7.8	1.1	4.2	2.1
121	10.4	8.6	0.7	3.1	2.0
Average	8.9	8.0	1.0	3.4	2.3

(a) Moisture-free basis

Table 93. Comparison of proximate analyses of sorghums, bulrush and finger millets.

Cereals	% Moisture Range	% Moisture Mean	% Crude Protein[a] Range	% Crude Protein[a] Mean	% Crude Fat[a] Range	% Crude Fat[a] Mean	% Crude Fiber[a] Range	% Crude Fiber[a] Mean	% Ash [a] Range	% Ash [a] Mean
61 Sorghums, 1970	10.0-14.5	11.7	11.4-16.3	13.4	2.1-4.5	3.5	0.8-3.4	2.1	0.9-2.4	1.7
42 Sorghums, 1971	8.4-14.7	10.6	8.9-16.6	13.0	2.5-5.1	3.8	1.6-3.8	2.3	1.0-2.7	1.7
25 Bulrush millets, 5x5	8.6-10.7	9.9	9.4-13.8	12.6	4.4-8.3	6.8	1.0-3.8	2.1	1.2-2.4	1.7
20 Bulrush millets, DVT	7.9-10.4	8.6	9.4-12.8	12.6	5.0-6.2	5.8	1.0-1.9	1.5	1.0-1.8	1.6
49 Bulrush millets, 7x7	7.0-11.6	8.5	9.3-14.5	12.7	4.8-6.9	5.5	1.0-3.3	1.4	1.3-2.1	1.5
30 Finger millets	7.1-11.3	8.9	7.0-8.9	8.0	0.7-1.7	1.0	2.6-4.2	3.4	1.7-2.8	2.3

(a) Moisture-free basis

Table 94. Amino acid composition of protein ins orghum. (Grams amino acid per 17 grams of nitrogen

Sample No.	% Protein in Sorghum(d)	Lysine	Phenyla-lanine	Threonine	Leucine	Isoleucine	Valine	Histidine	Ammonia	Arginine	Aspartic Acid	Serine	Glutamic Acid	Proline	Glycine	Alanine	Tyrosine	% Nitrogen Recovery
1-70	13.3	2.0	5.2	3.1	18.4	3.9	4.8	1.9	3.4	3.1	7.2	4.0	21.7	8.4	3.0	10.1	4.8	97.2
2-70	13.0	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	99.8
3-70	13.0	1.5	4.6	2.5	14.5	3.6	4.6	1.5	1.9	2.8	5.7	3.1	22.5	7.4	2.7	9.4	3.6	80.0
4-70	12.9	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	101.4
5-70	14.9	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	82.6
6-70	13.1	2.2	5.6	3.5	19.6	4.7	5.0	2.3	3.2	4.1	8.1	4.3	24.4	10.6	3.3	10.6	4.3	106.7
7-70	13.9	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	97.8
8-70	13.1	2.8	5.9	3.5	14.8	4.4	5.7	2.2	3.3	4.0	10.1	4.4	22.8	10.2	3.4	10.3	4.0	103.5
9-70	12.4	2.0	5.1	3.4	14.0	4.1	5.6	2.1	2.0	4.0	6.7	4.6	27.0	9.8	3.6	10.5	3.9	94.8
10-70	12.5	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	91.1
11-70	13.0	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	95.6
12-70	13.1	1.9	5.5	3.1	10.8	4.7	4.9	1.6	3.0	3.2	7.5	4.4	26.4	7.8	2.8	9.9	3.7	91.1
13-70	12.7	2.5	6.1	4.0	16.4	5.1	6.8	2.4	2.9	4.4	9.8	5.6	30.6	10.4	3.9	12.6	4.6	100.4
14-70	12.7	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	105.7
15-70	15.0	2.3	4.6	3.6	14.1	4.2	5.2	2.3	2.1	2.4	7.4	3.7	24.3	8.3	3.2	9.8	3.6	85.2
16-70	11.8	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	96.7
17-70	13.0	2.3	6.9	3.3	16.0	5.9	5.0	2.6	3.8	4.7	8.4	4.9	26.6	9.9	3.5	12.0	4.4	101.0
18-70	13.4	2.5	4.2	2.7	12.3	4.2	6.2	2.1	2.9	3.7	7.4	3.1	23.4	8.9	3.2	8.4	4.0	98.4
19-70	13.7	2.1	5.4	3.3	14.2	4.2	4.9	2.2	3.5	4.0	7.5	4.9	25.1	7.8	3.2	10.1	3.9	99.6
20-70	13.1	2.2	5.8	3.2	13.8	4.1	6.0	2.2	3.4	3.7	8.1	4.6	24.5	8.2	3.2	10.5	3.9	105.3
21-70	13.4	2.2	5.2	3.4	14.7	4.1	4.8	2.1	3.4	3.8	7.3	5.0	24.4	9.0	3.6	10.2	4.1	99.2
22-70	15.3	2.1	5.4	3.7	15.3	4.3	5.9	1.8	3.3	4.1	8.4	5.3	36.0	9.2	3.3	10.8	4.3	108.7
23-70	13.5	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	4.5	94.8
24-70	12.7	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	4.1	99.7
25-70	13.8	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	4.0	103.8
26-70	12.7	2.3	5.6	3.6	12.5	4.3	4.9	2.7	3.3	4.2	6.7	4.7	20.4	8.2	3.4	8.6	3.5	94.8
27-70	14.4	2.3	5.5	4.0	15.6	4.5	5.8	2.4	2.8	4.8	7.8	5.4	30.1	11.4	3.5	10.9	4.2	107.5
28-70	12.7	2.1	4.7	2.8	14.4	3.9	4.6	2.2	2.5	3.0	6.4	4.5	22.3	8.5	3.1	9.1	3.7	87.3
29-70	13.3	2.2	4.4	3.8	15.7	4.0	4.8	2.4	3.4	4.1	6.8	4.8	23.9	7.8	3.0	9.9	3.8	98.0
30-70	13.8	1.6	5.4	2.7	15.5	4.1	5.3	2.0	2.6	2.6	7.3	4.9	26.5	8.7	3.0	10.9	3.9	95.3

Table 94. (Cont'd.)

Sample No.	% Protein in Sorghum (a)	Lysine	Phenyla-lanine	Threonine	Leucine	Isoleucine	Valine	Histidine	Ammonia	Arginine	Aspartic Acid	Serine	Glutamic Acid	Proline	Glycine	Alanine	Tyrosine	% Nitrogen Recovery
31-70	13.4	1.8	5.3	3.4	14.7	3.3	5.3	2.1	3.3	3.2	7.1	6.7	24.7	8.5	3.3	10.3	3.4	99.5
32-70	12.6	2.1	4.9	3.3	12.8	3.8	5.0	2.2	3.6	4.3	7.6	4.4	23.2	6.5	3.2	10.0	3.5	98.0
33-70	14.1	2.3	6.4	3.1	13.7	4.0	4.8	2.4	3.4	4.1	7.9	5.0	24.3	8.4	3.0	9.3	3.7	100.4
34-70	13.2	1.9	4.0	2.9	12.2	3.4	4.3	2.1	2.0	3.4	6.7	3.9	26.4	8.9	2.7	8.4	3.2	86.0
35.70	14.5	1.8	5.3	3.3	15.5	4.4	4.9	2.0	2.2	3.6	7.0	4.6	27.9	9.6	2.9	9.4	4.0	95.3
36-70	12.1	2.4	4.5	3.0	11.4	3.6	4.8	1.9	3.4	3.2	6.4	4.3	21.0	5.7	2.7	9.1	4.7	89.3
37-70	15.2	1.9	5.2	3.5	12.3	4.1	5.1	1.9	2.4	3.9	6.4	4.6	21.3	8.5	3.3	8.8	4.1	89.5
38-70	11.4	2.1	4.7	2.9	12.6	3.5	4.5	2.1	3.4	3.5	6.5	4.2	21.2	6.2	3.1	8.1	3.4	89.8
39-70	13.0	2.3	4.6	3.1	12.1	3.6	4.8	2.0	3.7	3.7	7.7	3.1	24.7	6.7	3.2	9.7	3.6	95.9
40-70	14.2	2.4	6.0	3.4	13.6	5.6	5.6	2.7	2.9	2.8	7.1	4.9	21.7	7.9	3.4	9.9	4.2	96.2
41-70	14.2	1.8	7.2	3.2	13.5	3.8	4.7	1.9	2.2	3.4	6.7	4.3	26.2	9.1	2.8	9.0	3.9	91.4
42-70	13.8	2.3	4.7	3.4	14.1	4.4	4.3	2.3	2.7	2.7	6.1	3.6	24.2	8.5	3.3	9.6	4.4	91.9
43-70	13.1	2.1	5.0	3.1	13.0	3.6	4.7	2.2	2.0	3.0	6.0	3.7	27.6	8.0	3.0	8.4	4.0	87.4
44-70	14.3	2.4	5.4	2.6	13.1	4.1	3.4	2.0	1.6	3.5	5.9	3.9	22.9	8.4	2.9	8.6	3.5	83.1
45-70	12.4	2.1	5.1	3.2	13.5	4.2	5.3	2.6	2.4	3.9	6.5	4.5	25.5	8.9	3.0	9.4	3.7	93.3
46-70	11.4	2.3	7.6	3.7	16.9	5.8	6.1	2.5	2.1	4.4	10.0	6.2	36.1	8.3	3.9	13.6	4.0	110.8
47-70	16.1	2.4	5.3	2.8	12.4	3.6	5.0	2.6	4.0	5.0	6.7	4.1	23.6	7.3	3.2	7.0	4.7	97.7
48-70	11.7	2.2	6.0	3.4	11.9	4.4	4.9	2.2	2.4	3.4	5.9	4.6	22.9	7.9	3.8	11.4	3.8	90.8
49-70	12.3	1.8	4.7	3.1	13.2	3.8	8.1	2.0	1.7	2.6	6.1	4.2	25.1	8.8	2.9	9.0	3.8	86.9
50-70	15.1	2.3	4.7	2.8	10.8	3.0	4.6	1.6	1.9	3.7	7.1	3.9	28.4	8.9	3.0	2.7	3.8	85.6
51-70	14.8	1.9	4.8	2.6	11.9	3.5	4.6	1.7	1.8	3.1	7.4	3.5	28.6	8.2	3.8	8.9	3.7	85.1
52-70	13.5	1.9	5.6	3.2	14.2	4.5	6.8	1.7	2.0	4.1	6.9	4.2	25.5	10.0	3.2	9.9	4.3	92.9
53-70	12.5	2.2	4.9	3.3	13.3	4.4	5.1	2.1	1.2	4.5	6.5	4.6	24.1	9.2	3.3	7.3	3.5	84.2
54-70	12.2	2.7	4.5	3.1	13.0	3.6	4.0	1.9	2.1	3.3	6.1	3.9	25.5	8.5	3.4	7.0	3.5	84.0
55-70	13.4	2.4	5.4	2.7	11.7	3.5	4.3	2.1	2.8	3.7	7.7	3.7	23.6	8.8	2.7	7.3	3.6	87.4
56-70	16.3	2.5	6.4	3.3	12.4	4.3	4.0	1.7	2.9	4.3	9.1	3.5	25.3	8.1	2.4	7.1	3.6	91.8
57-70	13.0	2.6	5.7	4.1	14.5	4.5	6.4	2.1	3.3	4.7	8.3	4.6	27.1	9.6	3.6	10.9	4.2	106.4
58-70	15.3	1.1	5.2	3.0	13.4	4.1	5.2	1.4	1.9	1.8	6.5	4.1	27.7	8.9	2.6	9.8	4.1	83.2
59-70	13.1	2.1	5.4	2.7	15.2	3.8	4.6	2.0	2.1	2.5	6.8	4.1	22.7	6.1	2.2	8.7	3.4	81.4
60-70	14.0	2.2	4.8	3.0	12.3	3.9	4.9	2.2	2.3	3.0	6.3	4.0	23.4	8.4	2.4	9.7	4.0	85.5
61-70	12.3	1.6	4.9	3.2	14.6	3.7	5.0	1.6	2.6	2.2	6.7	4.5	25.9	10.6	3.1	10.7	3.4	91.4

Table 95. Amino acid composition of protein in some millets. (grams amino acid per 16 grams of nitrogen)

Sample No.	% Protein in Sorghum(a)	Lysine	Phenyla-lanine	Threonine	Leucine	Isoleucine	Valine	Histidine	Ammonia	Arginine	Aspartic Acid	Serine	Glutamic Acid	Proline	Glycine	Alanine	Tyrosine	% Nitrogen Recovery
FINGER MILLETS																		
6	7.7	2.7	5.6	4.4	10.6	5.0	7.5	2.5	1.9	3.7	6.1	6.4	29.1	7.0	3.8	7.0	3.5	91.9
15	7.1	3.1	5.0	4.8	10.4	5.4	8.4	2.7	2.2	4.7	6.5	4.9	28.4	8.0	3.6	8.4	3.2	97.4
27	8.5	3.0	5.5	4.4	10.6	4.6	7.9	2.6	2.3	5.0	7.0	5.5	29.4	7.7	3.7	8.6	3.9	99.4
42	7.7	3.2	5.7	4.2	10.8	4.5	8.1	2.5	2.0	5.7	6.6	5.1	27.0	7.6	3.4	8.0	3.7	96.2
71	7.0	3.3	5.2	4.5	10.2	4.8	7.2	2.6	2.4	5.2	6.0	4.8	29.0	7.2	3.2	8.6	4.0	97.4
120	7.8	2.9	5.8	4.6	10.7	4.2	7.9	2.4	2.1	4.6	6.8	6.0	28.7	7.6	3.9	7.9	3.6	96.3
BULRUSH MILLET, 7x7 SERIES																		
7	11.8	2.6	5.1	3.9	11.2	4.0	6.4	1.9	1.8	3.7	8.5	5.1	23.8	5.9	3.3	9.1	3.2	86.3
10	13.4	3.1	5.5	4.2	14.0	5.3	8.3	2.1	2.3	4.0	9.7	7.7	27.7	7.0	3.6	12.0	3.4	104.4
26	9.9	3.4	5.0	4.0	12.7	5.0	8.1	2.4	2.2	3.9	9.2	5.4	24.7	8.4	3.4	10.2	3.0	97.8
30	11.9	3.9	6.1	3.5	13.6	5.8	7.4	2.6	2.4	6.4	10.8	5.7	29.4	8.1	3.8	12.1	3.8	112.2
37	12.1	3.6	4.8	3.7	10.7	4.8	6.4	2.4	2.1	5.4	11.3	4.9	26.3	6.2	2.8	10.7	3.6	97.8
43	11.5	3.0	4.3	4.9	9.0	3.8	5.4	1.4	1.9	4.4	12.4	5.0	20.7	7.8	2.9	9.0	3.1	87.3

(a) Mositure-free basis

Table 96. Comparison of amino acid content (grams/16 grams N) of sorghum, finger and bulrush millets.

Amino Acid	Sorghums Mean	Sorghums Range	Finger millets Mean	Finger millets Range	Bulrush millets Mean	Bulrush millets Range
Lysine	2.1	1.1- 2.8	3.0	2.7- 3.3	3.3	2.6- 3.9
Phenylalanine	5.4	4.0- 7.6	5.5	5.0- 5.8	5.1	4.3- 6.1
Threonine	3.2	2.5- 4.1	4.4	4.2- 4.6	4.0	3.5- 4.9
Leucine	14.0	10.8-19.6	10.6	10.2-10.8	11.9	9.0-14.0
Isoleucine	4.2	3.0- 5.9	4.8	4.2- 5.6	4.9	3.8- 5.8
Valine	5.2	3.4- 8.1	7.8	7.2- 8.4	7.0	5.4- 8.3
Histidine	2.1	1.4- 2.7	2.6	2.4- 2.7	2.1	1.4- 2.6
Ammonia	2.7	1.2- 4.0	2.2	1.9- 2.4	2.1	1.8- 2.4
Arginine	3.6	1.8- 5.0	4.8	3.7- 5.7	4.6	3.7- 6.4
Aspartic Acid	7.3	5.7-10.1	6.5	6.0- 7.0	10.3	8.5-12.4
Serine	4.4	3.1- 6.7	5.5	4.8- 6.4	5.6	4.9- 7.7
Glutamic Acid	25.3	20.4-36.1	28.6	27.0-29.1	25.4	20.7-29.4
Proline	8.6	5.7-11.4	7.6	7.0- 8.0	7.2	5.9- 8.4
Clycine	3.1	2.4- 3.9	3.6	3.2- 3.9	3.3	2.8- 3.8
Alanine	9.6	7.0-13.6	8.1	7.0- 8.6	10.5	9.0-12.1
Tyrosine	3.9	2.5- 4.8	3.7	3.2- 4.0	3.4	3.1- 3.8

Table 97. Udy protein analysis. (Comparison between 1970 and 1971 sorghum samples).

Lab. Sample No.		% Protein (U)	
1970	1971	1970	1971
2-70	60-71	11.5	10.9
6-70	51-71	12.0	12.5
7-70	56-71	11.7	11.3
8-70	44-71	12.3	12.5
10-70	49-71	12.7	11.8
11-70	58-71	11.8	11.5
12-70	62-71	11.6	11.6
13-70	57-71	11.7	11.3
14-70	70-71	12.1	12.1
15-70	67-71	12.3	12.0
16-70	64-71	11.8	11.5
18-70	46-71	12.5	12.1
20-70	83-71	11.9	11.5
21-70	82-71	12.1	11.7
22-70	73-71	12.4	12.4
23-70	47-71	12.2	11.8
24-70	54-71	10.7	10.8
25-70	76-71	12.2	12.0
26-70	59-71	11.4	12.2
28-70	50-71	11.6	11.6
29-70	78-71	11.8	12.2
32-70	79-71	12.3	12.0
33-70	43-71	12.3	12.5
34-70	53-71	11.6	12.4
35-70	63-71	12.0	11.9
36-70	61-71	11.9	11.4
37-70	80-71	11.9	11.5
40-70	52-71	12.4	12.3
41-70	81-71	12.0	12.0
44-70	55-71	12.1	12.0
45-70	74-71	11.6	11.6
47-70	72-71	12.2	12.2
50-70	65-71	13.0	12.0
51-70	71-71	12.2	12.8
52-70	75-71	12.5	12.5
55-70	48-71	11.8	12.2
56-70	45-71	13.8	12.2
57-70	69-71	11.8	11.4
59-70	66-71	11.7	11.6

Table 98. Comparison of lysine content with Udy lysine index for sorghums.

Sample No.	Lysine Per 16 q N	Udy Lysine Index
1-70	2.0	0.20
2-70	2.4	0.19
3-70	1.5	0.20
4-70	2.5	0.21
5-70	2.0	0.09
6-70	2.2	0.14
7-70	2.1	0.19
8-70	2.8	0.16
10-70	1.6	0.14
11-70	2.1	0.10
12-70	1.9	0.15
14-70	2.3	0.16
15-70	1.3	0.17
16-70	2.2	0.18
17-70	2.3	0.21
18-70	1.2	0.19
21-70	2.2	0.18
22-70	2.1	0.21
23-70	2.0	0.26
24-70	1.7	0.21
25-70	2.1	0.23
26-70	1.7	0.21
28-70	1.1	0.20
29-70	1.2	0.21
30-70	1.6	0.27
31-70	1.8	0.12
36-70	2.4	0.14
37-70	1.5	0.18
39-70	2.3	0.16
40-70	1.6	0.16
42-70	1.3	0.23
59-70	1.1	0.23

Table 99. Summary of polisher trials in Tanzania, August - November 1971

Village/Variety	Quantity (debes)	Time (min.)	Rate (kg/hr)	Petrol Consumed (Litres)	Petrol Cost (cents/ debe)
Mangai					
Jebere	9.6	100	92		
Mbangala	16.9	139	116		
	26.5			6.8	29.5
Kizinga					
Mbangala	52.0	660	76	13.5	29.9
Kauzeni					
Mbangala	16.9	159	102	4.4	29.9
Mbangala	5.6	89	61		
Songee	2.2	40	52		
	7.8			2.8	41.3
Mali					
Mbangala	22.5	249	87	8.7	44.4
Mbangala	4.5	83	52	1.1	28.0
TOTAL	130.2	1,519		37.3	
Average			82		33.0

REGIONAL TRIALS - TANZANIA

1. Introduction:

The post of EAAFRO Regional Trials Officer in Tanzania was established within the Major Cereals in 1970. The officer is posted in the Ministry of Agriculture, Division of Research, which provides logistical and field support. The primary objectives of this position include (1) translating regional research into local conditions, and (2) promoting the utilization of research by farmers.

2. Situation

More than 90% of Tanzania 12 million people live in rural areas and depend on agriculture. Virtually any crop can be grown but farms are small. Maize, sorghum, and millet along with bananas, cassava, rice, and beans make up the primary food sources.

Research stations are well distributed and generally well equipped, but few senior staff are available. Much research information has been generated in export crops, but until recent years, little work was done with subsistence crops. The body of knowledge which has accumulated has not been effectively distributed to farmers.

3. Planning and implementation

The initial survey of research information available indicated the need for improved cooperation between regional and country projects and for establishing research project to fill in gaps in existing knowledge of maize, sorghum, and millet production. To accomplish both these objectives as well as tomake the most efficient use of the scarce resources of money and personnel, Tanzania and regional research personnel held a research planning conference in August, 1971. The proceedings of this conference, Maize, Sorghum and Millet Research, forms the basis for the 1971-72 Tanzania research in these crops.

In brief, these researchers elected to place emphasis on (1) developing maize varieties, (2) testing maize, sorghum, and millet varieties and (3) obtaining fertility and date of planting data. Lesser emphasis was to be placed on pesticides, cultivation methods, interplanting, and rotation studies. A summary of the main experiments is included in section 4.

To improve evaluation of research projects, computerized data analysis programs were obtained from EAAFRO and set up on the Treasury computor in Dar es Salaam. All randomized block and lattice designed experiments were analyzed using this system.

Thirty-two research stations where cereals projects are conducted were visited. During these visits, first-hand information was obtained about experiments and problems. Also, 43 workers were advised on experimental techniques for conducting research.

Experiments in soil fertility and rotations which were designed and implemented at five stations in 1970-71 were expanded to seven stations in 1971-72.

Regional research specialists were invited to Tanzania to evaluate and help develop research. These visits included one by maize geneticists on maize breeding program; two visits by food technologist on cereal quality; one visit by entomologist on development of shoot fly resistant sorghum and other insects; one visit by agronomist on maize and sorghum fertility; and one visit by researcher to discuss data analysis.

The delegation to the biennial East African Cereals Research Conference in Ethiopia included four Research Officers and one Production Division officer from Tanzania. Papers were presented by all delegates on cereals research. Cereals research at four locations in Ethiopia was studied and conference proceedings were received by each delegate.

In September 1971, a conference on fertilizer use in Tanzania was attended at Ifakara. Out of this conference has grown the conviction that closer cooperation is needed among all Tanzania and regional researchers concerned with the fertility of plant. One very encouraging result of this conference has been the committee to agree on uniform methods to be used by laboratories in Tanzania for analyzing farmer's soil samples.

The Seed Multiplication Project has been consulted with frequently. The Project Farm this year will grow out all cereal variety trials. Recommendations were made to the project concerning varieties to maintain and bulk among which are maize, sorghum, and millet.

Six off-station research demonstrations were designed and initiated in two regions using maize, sorghum, and millet.

One very significant responsibility is that of improving communication within Tanzania research and between regional and country projects. This year 8 bulk samples of maize, 3 samples of sorghum, and 3 samples of millet were transmitted to stations for formulating trials. Within Tanzania, 29 maize, 30 sorghum, 24 bulrush millet, 17 finger millet, 7 soybean, and 4 sunflower trials have been transmitted to stations. Trials have been analyzed and data returned to researchers.

4. Results of Experiments

The results of experiments reported are the culmination of the supervision and labour of many researchers at 36 stations. Without their dedication to obtaining valid data, trials oould not have been conducted.

4.1. East African Maize Variety Trials

In 1970-71, 21 trials were planned. Data from 12 trials are included in Table 100. No trials will be conducted in 1971-72.

4.2. East African Sorghum Variety Trials

In 1970-71, 14 trials were planned. Data from 11 trials are included in Table 101. In 1971-72, 23 trials are to be conducted using 25 varieties, including a local variety.

4.3. East African Bulrush Millet Variety Trials

In 1970-71, 10 trials were planned. Data from 7 trials are included in Table 102. In 1971-72, 18 trials are to be conducted, using 22 varieties which include a Tanzania variety from Mbeya and a local variety.

4.5. East African Shoot Fly Sorghum Variety Trial

In 1970-71, 2 trials were conducted with 48 varieties which are reported in Table 103. Nine varieties were selected out of the 48 and trials are planned for 2 sites in 1971-72.

4.6. Long Term Soil Fertility with Maize

In 1970-71, 4 trials were conducted and yield data were obtained at 3 sites, as reported in Table 104. Experiments will be continued in 1971-72 at these four sites and another trial initiated at Arusha which is one of three commercial major maize producing areas in Tanzania.

4.7. Rotation - Manure - Fertilizer with Maize Experiment

This experiment was initiated at Ismani and results of fertilizer and manure are reported in Table 105. The trial is being continued at Ismani for at least five years. Another rotation trial including tobacco, maize, cassava, and legumes was begun at Suluti this year.

4.8. Tanzania Maize Variety Trials

The 26 Tanzania Maize variety trials were planned and coordinated from Ukiriguru in 1970-71. Results of these trials are in appropriate station reports and are reproduced in Tables 107, 108, and 109 merely for convenience of reference. The cereals planning committee proposed 27 trials for 1971-72. The high altitude trials are organized from Ukiriguru and the low altitude trials from Illonga.

5. Other Work Planned for 1971-72

The cereals research committee planned the following:

4.1. 4 CIMMYT maize trials
4.2. 3 Maize variety - spacing-fertility experiments
4.3. 3 Low altitude maize trials - Jamaican varieties
4.4. 3 Herbicide experiments
4.5. 3 Maize interplanting experiments
4.6. 6 Sorghum fertility experiments

In addition, the Ilonga station agreed to organize a soybean, variety trial which will be conducted at 12 sites.

A sunflower variety trial will be conducted at four sites.

6. Conclusions

Development of varieties and yield testing are proceeding at a good pace.

At high altitude, H632, H613, H611, and UCA are all good yielding varieties. The SR 52, though more susceptible to some diseases, has yielded well, also. At medium altitudes, the two lines UCA and UCB are yielding near H632, and the cross UCA x UCB exhibits equivalent or better vigor.

At the medium altitude, IC and ICA yield well as does the ICA x ICB cross. Both lines have considerable streak resistance. Both H511 and H632 are high yielding, especially when there is a full growing season.

Considerable development work must be done on coastal varieties. Both IC and the Muheza composites show promise.

The opaque varieties are not high yielding enough to compete at this time.

There is considerable demand for yellow maize for animal feed and some requests as a human food source also. Yellow lines are being maintained in the Ukiriguru, Ilonga, and Muheza composites. Nigerian composites, both yellow, have been introduced into the breeding program.

Some soil fertility data had been accumulated at Ukiriguru and Lyamungu using the low yielding short season composites. Work is now proceeding using higher yielding, more uniform varieties.

To choose but one example of what research has shown; if farmers used fertilizer and improved husbandry with their own maize, yields could be doubled; using improved varieties, yields could be increased four to six fold.

The sorghum yields are most encouraging with the main problem being bird damage, especially on white varieties. Pending further evaluation to include the 1971-72 data, multiplication of Serena and 5D x 36 has begun.

Bulrush millet, though subject to bird damage, has been most impressive in short rainfall areas. Multiplication of Serere Composite 1 has begun. Finger millet yields are good but no variety has been selected for multiplication. A better evaluation of both bulrush, and finger millet is expected this year since local varieties have been included in trials.

Research efforts have to be maintained and more senior researchers are needed to sustain research with cereals which are so critical to Tanzania food supply. At the same time, more and better avenues of getting information to the farmer must be found and he needs to be motivated to use the information.

Table 100. Yield of grain of East African Maize Varieties in 1970-71 trials in Tanzania.

Variety	Yield of grain - quintals/hectare					
	Moshi (Miwaleni)	Bagamoyo (Chambeze)	Mbeya (Nordic-Tanz.)	Mbeya (Mbimba)	Biharamulo (Bwanga)	Mwanza (Ukiriguru)
H632	40.6	3.0	66.2	27.0	39.6	14.9
S.V. 28	41.1	2.5	54.9	20.9	31.4	22.5
ICA	44.4	13.9	48.1	21.5	52.0	24.5
ICA x ICB/FW	31.8	7.7	71.9	24.7	48.1	26.7
SR 52	43.0	8.0	56.8	18.6	47.0	33.3
KaCA	54.1	11.9	62.0	24.9	52.8	23.6
H 511	46.3	12.5	62.8	13.6	41.6	26.8
H 512	68.4	5.3	53.8	15.1	39.6	28.6
UCA/C4 x UCB/W/C1	46.0	14.0	61.1	16.5	46.7	26.0
UCB/4/CI	53.7	16.8	55.5	8.7	44.3	26.1
UCA/C3	40.4	12.9	57.1	12.5	38.7	21.5
H 613B	54.8	12.3	50.4	12.8	33.7	27.2
H611C	26.0	11.0	53.0	16.8	55.8	29.6
Local Farmers	53.7	10.6	49.4	7.8	45.9	24.6
Local Farmers	43.9	16.2	54.9	12.5	21.2	28.1
LSD (0.05)	19.4	6.7	N.S.	10.0	15.8	N.S.
C.V.	29.8	45.1	30.7	41.7	26.3	32.4

Table 100. (Cont'd.)

Variety	Yield of grain - quintals/hectare					
	Iringa (Ismani)	Kilosa (Ilonga)	Morogoro (Wami)	Gairo (Gairo)	Nachingwea (Nachingwea)	Muheza (Hale Est).
H 632	15.3	37.7	48.2	73.8	29.8	41.8
SV 28	12.4	41.4	36.3	77.2	21.5	37.6
I C A	24.2	42.2	38.7	56.4	28.4	40.1
I C A x ICB/FW	32.2	32.1	41.8	75.4	28.4	32.8
SR 52	33.2	32.3	48.2	68.6	33.0	38.7
Ka CA	18.2	48.0	37.6	61.6	20.5	34.7
H 511	23.7	40.0	44.6	78.3	23.3	44.2
H 512	16.1	56.2	47.2	80.9	18.6	32.2
UCA/C4 x UCB/W/C1	21.5	43.6	51.6	59.1	23.0	31.5
UCB/W/C1	20.8	39.0	22.4	65.4	30.1	46.1
UCA/C3	20.9	49.2	42.0	66.9	27.7	31.8
H 613B	29.2	48.8	39.7	65.3	20.6	36.9
H 611C	32.1	39.2	51.0	69.1	37.4	32.8
Local Farmers	23.4	46.6	45.9	69.0	22.7	33.8
Local Farmers	16.2	43.8	50.3	68.0	23.5	32.7
LSD (0.05)	5.0	N.S.	12.5	N.S.	9.7	N.S.
C.V.	15.6	28.2	20.6	24.6	26.5	24.7

Table 101. Yield of grain of East African sorghum varieties in 1970-71 trials in Tanzania.

Variety	Yield of grain - Quintals/ hectare					
	Kilosa (Ilonga)	Mtwara (Naliendele)	Muheza (Hale Estate)	Tanga (Mlingano)	Songea (Suluti)	Morogoro (Wami)
5Dx142/4	20.7	6.3	33.1	17.9	31.3	23.0
5Dx 156/3	26.8	3.3	39.4	19.5	32.7	23.6
5Dx 142/9	23.9	6.5	27.6	16.5	31.3	28.0
Hx 57	17.3	7.6	30.5	15.1	41.6	27.2
5D x 61/6/2	25.8	5.9	36.5	13.6	36.4	24.2
3D x 57/1H/White	21.9	3.9	29.7	17.3	33.1	24.8
5D x 162/1	27.6	8.5	33.0	13.4	34.2	24.1
Debbe	22.8	7.6	30.7	11.2	36.4	25.0
4D x 34/1/4C	24.0	4.1	32.1	8.6	35.0	27.6
5D x 61/2/1	24.9	3.9	35.7	13.9	36.8	25.6
5D x 144/1	23.0	2.0	34.7	16.4	29.4	25.2
3D x 57/1H/Brown	21.1	4.3	34.5	13.2	33.1	26.7
Serena	23.9	4.1	29.8	16.9	31.3	26.0
Hx60/7/2A	23.9	2.2	35.8	11.4	37.9	18.4
Hx467	27.0	3.0	35.6	12.6	42.6	23.4
5Dx160/4/1	25.8	5.0	37.1	18.5	32.3	25.1
5Dx36/1/2	25.7	5.4	31.3	15.7	30.2	25.7
Hx471	21.1	3.7	38.6	15.7	41.2	25.2
LSD (0.05)	N.S.	2.9	N.S.	N.S.	N.S.	N.S.
C.V.	27.7	42.0	19.9	47.7	17.9	16.8

Table 101. (Cont'd.)

Variety	Yield of grain - quintals/hectare				
	Shinyanga (Mwangala)	Mwanza (Nyegezi*	Shinyanga (Mwamala)	Mwanza (Ukiriguru)	Tanga (L.B.Station)
5Dx142/4	21.9	13.8	27.2	20.4	27.1
5Dx 156/3	20.9	15.7	23.7	24.3	25.1
5Dx 142/9	15.7	12.9	24.4	23.5	24.9
Hx 57	22.1	13.6	27.5	30.8	30.5
5Dx 61/6/2	22.4	13.3	25.7	23.0	29.7
3Dx 57/1H/White	16.8	5.6	29.2	21.5	25.6
5Dx 162/1	17.4	11.7	24.2	22.4	24.5
Dobbs	14.8	14.9	24.7	21.2	28.4
4Dx34/1/4c	18.3	13.2	24.0	23.2	38.1
5Dx 61/2/1	16.9	14.7	23.1	18.3	26.4
5Dx 144/1	21.9	16.8	27.2	19.8	36.3
3Dx 57/1H/Brown	19.1	15.6	28.1	25.1	25.7
Serena	20.0	8.8	28.3	24.3	27.7
Hx 60/7/2A	25.3	12.8	25.7	21.1	29.0
Hx 467	17.1	21.6	26.9	24.8	35.8
5Dx 160/4/1	18.8	15.0	26.9	24.6	26.2
5Dx 36/1/2	10.4	6.8	29.8	15.4	23.3
Hx 471	7.6	5.2	27.8	18.2	26.0
L.S.D. (0.05)	7.1	5.0	N.S.	8.9	N.S.
C.V.	27.7	27.4	13.2	21.0	28.9

Table 102. Yield of Grain of East African Bulrush Millet Varieties in 1970-71 Trials in Tanzania.

Variety	Yield of grain - quintals/hectare						
	Kilosa (Ilonga)	Shinyanga (Lubaga)	Mtwara (Naliendele)	Mwanza (Ukiriguru)	Tanga (Mlingano	Morogoro (Wami)	Bagamoyo (Chameezi)
Serere 2 A	37.8	19.8	18.9	24.0	14.6	24.2	9.5
Serere 10 LAxSerere 30	40.4	23.4	22.0	27.6	10.5	25.8	11.3
Serere Composite 1	34.7	24.6	18.9	28.6	14.6	27.2	7.4
Serere 30	32.4	19.2	21.0	21.5	13.7	22.3	6.4
Serere Composite 10	26.3	14.4	19.4	20.9	19.7	12.5	9.3
Tift 23AxSerere 2A	29.1	17.3	21.5	16.4	12.8	17.0	8.4
Serere 10LA x Serere 6A	30.2	17.3	17.9	28.1	13.7	28.1	11.1
Serere 6A	26.9	24.9	16.9	24.0	13.2	25.3	10.1
Tift 23A x Serere 17	29.8	18.2	18.9	22.5	13.2	16.7	5.9
Serere 10LA x Serere 3A	30.9	18.9	18.9	22.0	12.0	28.1	11.2
Tift 23A x Serere 3A	30.6	18.6	20.4	21.5	15.5	11.6	9.6
Serere Composite 3	32.6	23.3	24.0	25.1	14.3	28.6	9.6
Serere 17	30.3	18.9	21.0	23.0	12.2	32.7	12.0
Serere 10LA x Serere 17	34.5	21.0	18.9	28.1	12.8	22.1	7.7
Tift 23A x Serere 30	24.8	18.2	18.4	18.4	15.7	24.8	6.9
Serere 3A	27.1	22.4	19.9	23.5	9.8	23.7	7.3
Serere Composite 2	29.9	16.8	21.0	20.9	12.9	26.3	11.4
Serere 10LA x Serere 2A	30.7	20.1	19.4	27.6	12.1	27.4	11.1
Bajar Hybrid No. 1	34.5	17.1	11.8	23.5	10.0	7.7	9.5
Tift 23A x Serere 6A	27.8	21.3	22.0	24.0	14.8	27.8	8.1
LSD (0.05)	N.S.	5.7	N.S.	N.S.	N.S.	7.7	N.S.
C.V.	22.2	20.4	21.8	25.6	34.7	23.6	32.2

Table 103. Yield of grain of East African finger millet varieties in 1970-71 - Trials in Tanzania.

Variety	Yield of grain - quintals/hectare				
	Kilosa (Ilonga)	Mtwara (Naliendele)	Moshi (Miwaleni)	Mbeya Nordic Tanz.)	Shinyanga (Mwamala)
Serere 312	41.7	16.7	18.5	19.5	3.6
Serere 104	45.8	20.8	27.6	27.0	3.7
Serere 152	43.1	18.5	26.3	21.3	4.5
Eding	49.5	18.9	19.3	20.0	4.0
5 E x 13P6	60.0	18.2	20.1	16.0	1.8
Okiring	64.6	17.2	27.1	21.1	2.4
Serere 91	50.5	18.5	26.5	28.9	3.6
Serere 119	54.9	16.9	23.9	22.5	3.7
Serere 358	55.6	18.0	21.8	22.0	3.2
Serere 12	38.7	16.8	22.2	25.7	4.4
5 Ex12P1	61.3	25.3	25.0	19.7	2.4
Serere 82	51.2	18.5	22.1	26.0	3.5
Serere 117	44.2	18.3	22.9	26.9	3.1
Serere 148	53.5	18.0	26.1	26.1	3.3
Engeny	50.0	18.0	24.1	29.6	3.0
Serere 66	45.5	21.3	26.7	27.2	3.6
Gulu E	47.7	15.5	26.1	26.6	3.5
Serere 116	38.2	19.4	23.9	29.7	3.0
Serere 101	52.8	17.0	27.4	26.8	3.9
Serere 1	44.7	16.3	25.6	28.9	3.9
Elaba	46.1	19.7	22.9	25.5	3.4
Serere 149	47.2	18.7	25.8	21.1	3.5
5E x 12P5	44.2	22.5	23.9	19.5	2.7
Engom	54.9	21.0	19.6	20.9	4.1
Serere 21	44.7	19.3	24.4	15.9	2.5
LSD (0.05)	N.S.	N.S.	5.2	N.S.	1.1
C.V.	27.6	28.6	18.7	13.4	27.7

Table 104. Yield of grain of sorghum varieties bred for shoot-fly resistance in 1970-71 in Tanzania.

Variety	Yield of grain - quintals/hectare	
	Kilosa (Ilonga)	Bagamoyo (Chambezi)
1-P-4-1-1	27.9	26.8
2-P-2-1-1	31.1	37.9
2-P-1-2-1	26.1	38.8
3-P-5-1-1	31.7	26.7
7-P-1-1-1	26.3	8.7
12-P-1-2-1	27.8	36.6
14-P-4-2-1	26.4	27.1
V-2-1-1	28.1	41.6
14-P-3-2-1	30.9	10.6
15-P-1-1-1	33.9	32.7
25-P-3-1-1	18.3	25.0
26-P-2-1-1	21.7	17.0
28-p-1-1-1	22.8	24.9
28-P-4-1-1	20.1	17.1
29-P-1-1-1	20.6	24.3
V-4-1-1	24.1	32.1
V-30-1-1	25.6	27.2
Serena	28.9	28.5
33-P-3-2-1	24.5	22.8
35-P-5-2-1	24.9	27.1
35-P2-1-1	19.0	32.1
37-P-3-2-1	26.8	29.4
37-P-1-1-1	22.4	36.0
39-P-4-2-1	26.3	29.0
45-P2-2-1	26.2	14.4
45-P-2-1-1	24.6	27.8
48-P-1-1-1	20.4	16.6
50-P-2-1-1	28.0	17.4
71-P-1-2-1	23.4	25.3
71-P2-2-1	24.3	21.7
78-P-2-2-1	24.0	27.0
V-63-1-1	25.4	33.5
107-P-6-1-1	29.1	37.5
135-P-5-1-1	18.7	14.5
135-P-5-2-1	21.4	6.3
CK-60	14.5	11.2
143-P-2-2-1	20.6	31.8
156-P-5-2-1	34.2	33.5
157-P-3-1-1	27.3	26.3
165-P-6-2-1	30.8	16.8
210-P5-2-1	25.3	30.2
210-P-4-1-1	24.6	19.0
211-P-3-1-1	27.9	28.3
211-P-1-2-1	26.7	28.8
217-P-1-2-1	26.3	18.2
218-P-3-2-1	30.3	34.2
V-100-1-1	25.0	28.6
234-P-5-2-1	20.0	18.4
L.S.D. (0.05)	9.2	13.1
C.V.	28.8	40.6

Table 104. Yield of maize grain as affected by nitrogen phosphorus, and potassium fertilization, 1970-71.

Treatment Kilograms/ Hectare			Yield of grain - quintals/hectare		
			Mbeya (Nordic-Tanzania)	Morogoro (Faculty of Agric.)	Tanga (Mlingano)
N	P	K			
0	0	0	24.9	20.2	19.4
0	0	25	24.4	16.7	16.6
0	0	50	26.6	21.2	26.6
0	22	0	30.1	18.9	26.2
0	22	25	26.1	20.5	23.4
0	22	50	25.3	19.3	21.8
0	44	0	30.6	18.9	20.6
0	44	25	28.0	18.0	21.8
0	44	50	27.1	19.0	22.8
80	0	0	39.1	21.2	19.2
80	0	25	36.9	16.3	14.6
80	0	50	42.2	20.2	22.8
80	22	0	49.3	18.3	19.9
80	22	25	48.8	19.7	23.9
80	22	50	48.0	18.9	19.9
80	44	0	49.3	20.6	15.3
80	44	25	55.1	16.3	26.1
80	44	50	55.1	19.3	23.4
160	0	0	39.1	22.2	22.8
160	0	25	39.1	15.3	12.2
160	0	50	45.7	17.2	14.6
160	22	0	55.1	22.0	20.2
160	22	25	59.1	16.3	17.7
160	22	50	56.8	18.9	20.1
160	44	0	60.8	17.7	23.3
160	44	25	62.1	16.5	14.0
160	44	50	63.9	16.7	22.0

Table 105. Yield of maize grain as affected by nitrogen, phosphorus, and potassium fertilization 1970-71.

Treatment	Yield of grain Quintals per hectare		
	Mbeya (Nordic - Tanzania)	Morogoro (Faculty of Agric.)	Tanga (Mlingano)
All 0 N	27.0	19.2	22.1
All 80kg/ha N	47.1	19.0	20.6
All 160kg/ha N	53.5	18.1	18.5
All 0 P	35.4	18.9	18.8
All 22kg/ha P	44.3	19.2	21.5
All 44kg/ha P	48.0	18.1	21.0
All 0 K	47.0	20.0	20.8
All 25kg/ha K	42.9	17.3	18.9
All 50kg/ha K	42.7	18.7	21.6

Table 106. Yield of maize as affected by nitrogen and phosphorus fertilization and by application of cattle manure at Iringa (Ismani) in 1970-71.

Fertilizer Treatment Kilograms/Hectare N	P	Yield of Grain quintals/hectare
0	0	10.8
45	10.9	12.3
90	21.8	12.7
LSD (0.05)		N.S.
C.V.		18.2

Manure Treatment Tons/Hectare	Yield of grain quintals per hectare
0	11.6
3.8	12.5
11.4	14.3
LSD (0.05)	N.S.
C.V.	17.1

Table 107. Yield of grain of Tanzania territorial maize varieties at sites below 300 meters in 1970-71.

Variety	Yield of Grain - Quintals/Hectare				
	Tanga (L.B.Sta.)	Tanga (Mlingano)	Muheza (Haleest)	Bagamore (Chambezi)	Nachingwea (Nachingwea)
ICA	29.5	21.7	33.3	19.2	15.7
ICAxICB/W	27.0	24.4	23.8	20.7	18.2
MCB/FW	28.1	22.2	34.9	11.9	11.7
MCB/W	18.6	22.0	31.2	10.8	20.8
H632	34.6	16.7	30.9	11.1	20.0
Local Farmers	13.0	12.1	30.4	3.4	13.8
UCA/C2	31.8	8.5	31.4	8.5	15.2
UCA/C3	30.4	11.3	38.3	10.6	21.5
UCB/W/CO	26.2	20.1	27.9	8.6	19.2
UCB/W/C1	32.0	24.7	22.1	8.3	18.4
UCA/CAxUCB/C1	26.0	11.8	34.8	10.9	22.5
Ilonga Opaque 2	25.2	29.8	31.4	16.9	17.7
ICB/W	27.0	21.7	29.4	14.0	14.1
MCB.FY	20.0	28.2	27.5	13.1	18.5
IC	22.1	24.2	35.7	20.0	19.9
ICB/FW	38.9	29.0	24.6	23.6	20.1
LSD (0.05)	11.6	7.9	N.S.	N.S.	N.S.
C.V.	34.0	30.3	27.4	26.2	30.9

Table 108. Yield of grain of Tanzania territorial varieties at sites between 300 and 900 meter in 1970-71.

Variety	Yield of grain - Quintals/Hectare		
	Morogoro (Wami)	Kilosa (Ilonga)	Songea (Suluti)
I.C.A.	52.2	19.3	36.0
ICA x TCB/W	57.5	20.9	33.5
MCB/FW	48.2	13.2	24.1
MCB/W	39.9	9.1	22.7
H632	58.8	19.3	36.7
Local Farmers	38.5	15.1	19.2
UCA/C2	44.9	12.9	29.2
UCA/C3	45.5	13.6	32.9
UCB/W/CO	50.9	16.8	36.0
UCB/W/C1	47.9	16.1	38.0
UCA/C4xUCB/C1	51.6	13.2	29.8
Ilonga Opaque 2	38.9	13.3	20.9
ICB/W	55.5	19.2	33.5
ICB/FW	41.0	19.4	38.9
ICAxICB	56.7	19.4	38.9
MCB/FY	51.2	16.2	23.3
LSD (0.05)	9.8	3.2	8.0
C.V.	15.0	15.9	20.5

Table 109. Yield of grain of Tanzania territorial maize varieties at sites above 900 meters in 1970-71.

Variety	Yield of grain - quintals/hectare						
	Mwanza (Ukiriguru)	Shinyanga (Mwamala)	Biharamulo (Bwanga)	Bukoba (Muruku)	Gairo (Gairo)	Iringa (Ismani)	Mbeya (Nordic-Tan)
ICA	20.0	10.3	38.4	31.9	57.2	18.4	28.5
ICA xICB/W	22.7	10.2	36.5	40.2	61.5	19.2	36.1
MCB/FW	16.5	3.7	27.0	36.0	51.9	20.7	29.5
MCB/W	17.3	6.1	15.8	27.4	44.1	18.2	21.5
4632	20.5	8.4	31.9	42.4	74.6	11.3	36.0
Local Farmers	23.7	8.1	21.2	12.2	49.1	18.0	19.4
UCA/C2	10.6	12.2	27.1	37.9	62.1	14.6	40.8
UCA/C3	15.8	17.5	40.5	36.9	59.2	19.4	46.3
UCB/W/CO	23.7	12.2	28.2	43.6	67.5	19.8	45.6
UCB/W/C1	16.6	11.1	28.8	48.5	66.4	19.4	39.3
UCA/C4xUCB/C1	13.7	14.4	28.9	49.4	71.2	13.8	39.0
Ilonga Opaque 2	16.3	3.8	26.0	29.4	35.7	23.3	17.9
UCB/FW	14.2	5.4	34.6	33.6	67.0	16.9	40.0
Ec573 x UCB/W/C1	11.8	10.2	28.1	41.5	67.1	22.1	42.0
UCA/C4	17.9	12.3	41.8	48.4	57.9	21.6	49.3
UCB/W/C2	16.5	10.6	38.3	55.3	60.4	19.3	11.0
LSD (0.05)	6.1	5.9	8.4	14.8	9.7	5.2	17.8
C.V.	27.9	47.5	21.7	30.6	12.9	22.2	41.6