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TERMINAL REPORT (1973 - 1982)

USAID/IITA TANZANIA AGRICULTURAL RESEARCH PROJECT

with

(CIMMYT AND ICRISAT PARTICIPATING)

IN COOPERATION WITH

THE MINISTRY OF AGRICULTURE

OF THE UNITED REPUBLIC OF TANZANIA

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE
IBADAN, NIGERIA

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INTRODUCTION

In the 1960s, major socio-economic changes in Tanzania shifted the nation's research emphasis to food crop production. Self-sufficiency in food supplies has become the central thrust of the national agricultural research program. The research strategy features a strong multidisciplinary approach aimed at developing self-sustaining food production units with research carried directly to the villages.

To help the United Republic of Tanzania strengthen its agricultural research program, USAID and the Government of Tanzania entered into an agreement launching USAID Agricultural Research Project 107. This agreement was to provide technical and material assistance to the Ministry of Agriculture in developing an appropriate agricultural research program and in training the researchers needed to stimulate greater food production in Tanzania.

USAID contracted with the International Institute of Tropical Agriculture (IITA) to provide technical assistance in food legume breeding and agronomic research, and to administer the project in cooperation with the Tanzanian Ministry of Agriculture. IITA, in turn, signed an agreement with the International Maize and Wheat Improvement Center (CIMMYT) in 1973 to develop a maize breeding and agronomic research program for high, medium, low, and coastal areas of Tanzania and to test elite varieties and management practices at selected stations and in farmers' fields. In 1978, IITA signed another agreement with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to develop a program for sorghum and millet breeding and agronomic research in the semi-arid areas of Tanzania.

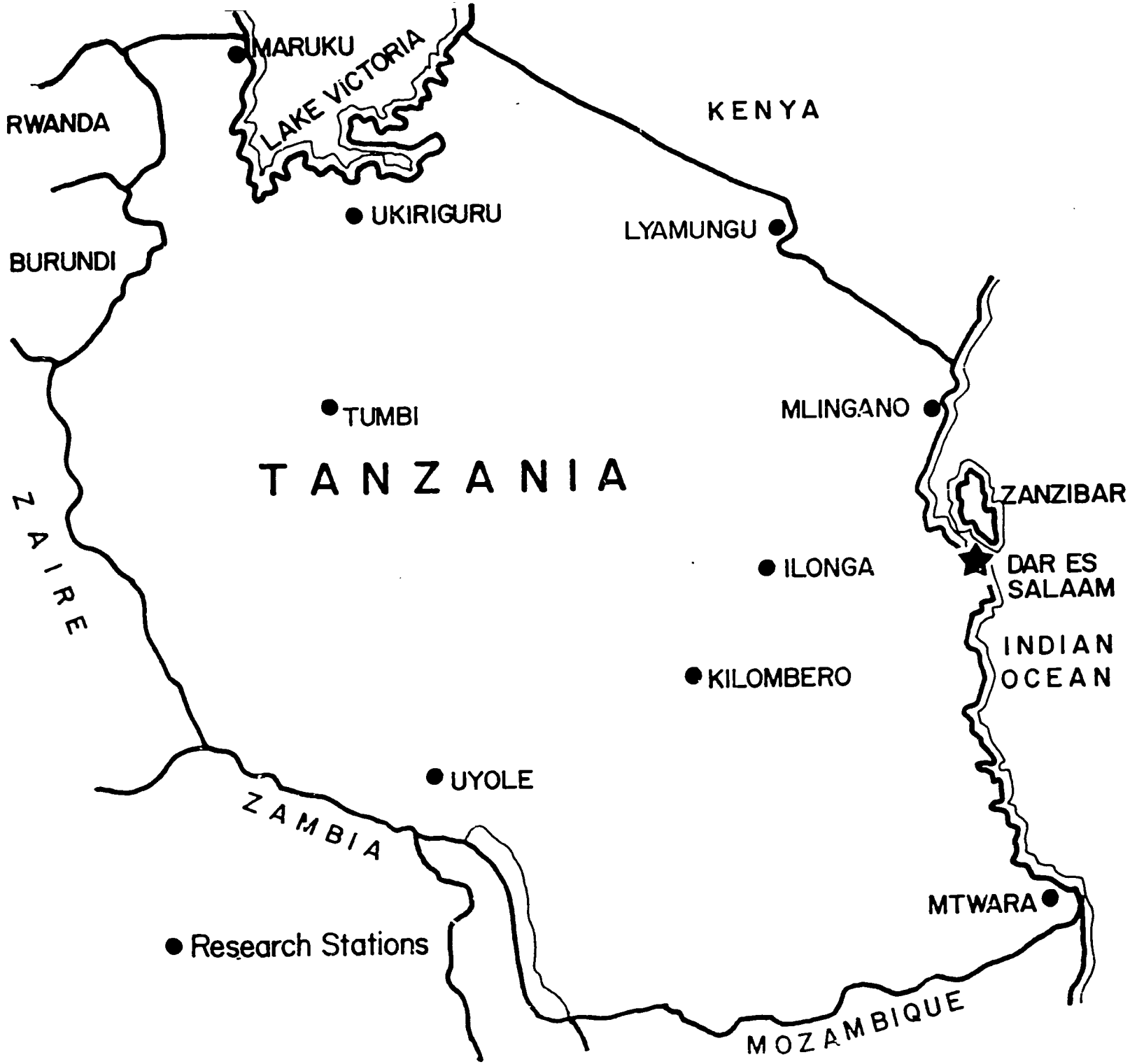
The overall objective of the project was to help Tanzania become self-sufficient in food production through research planning and administration; genetic improvement of and agronomic research in maize, grain legumes, and sorghum/millet; research on agricultural economics/farming systems; and training.

The work was carried out at the Ilonga Agricultural Research Institute (ARI), located 300 kilometers west of Dar es Salaam. As the national centre for food crops research, Ilonga ARI has nationwide responsibility for improving certain food crops and traditional farming systems in Tanzania's different agroecological zones. It is part of a network of nine agricultural research institutes, with an additional 20 field or experimental stations. Overall planning and integration of crop research in Tanzania is carried out by 17 Coordinating Committees of the Ministry of Agriculture.

Field research was begun on maize during the 1973-74 season, on grain legumes during the 1974-75 season, and on sorghum/millet during the 1977-78 season. Training followed three approaches: on-the-job training of Tanzanian staff by experienced contract staff; in-service-training at the international agricultural centres; and degree training, primarily at universities in the United States.

This termination report describes the project's accomplishments in each of these areas, its progress in meeting the objectives stated in the original contract, and problems it has encountered since its beginning in 1973. Recommendations for future action are offered by the project staff at the end of each chapter.

For more details, consult the annual and semi-annual reports listed in Appendix 2 at the end of this report.


MARUKU
LAKE VICTORIA
RWANDA
KENYA
UKIRIGURU
LYAMUNGU
BURUNDI
TUMBI
MLINGANO
TANZANIA
ZANZIBAR
ZAIRE
ILONGA
DAR ES SALAAM
INDIAN OCEAN
KILOMBERO
UYOLE
ZAMBIA
MTWARA
Research Stations
MOZAMBIQUE

OVERVIEW

The USAID agricultural research project was launched with the signing of a program agreement by the United Republic of Tanzania and USAID. The agreement intended to provide technical and material assistance to the Ministry of Agriculture in developing an appropriate agricultural research program and in training the research staff required to stimulate greater production of food crops in Tanzania. USAID contracted with the International Institute of Tropical Agriculture (IITA) to provide technical assistance and administer the project in cooperation with the Ministry of Agriculture.

The research program started in November 1973 with the arrival of two contract scientists, a maize breeder and an agronomist from the International Maize and Wheat Improvement Centre (CIMMYT). In 1974 a legume agronomist was added and, in 1975 a legume breeder/pathologist and a project coordinator from IITA joined the project. A sorghum breeder from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) joined the program in 1978. Although there was a shortage of Tanzanian field officers when the project was initiated, the Ministry of Agriculture assigned some of its promising field officers to work with the contract staff. New staff were eventually assigned as they became available from the university and training centres.

Maize

Maize research was assigned the highest priority in 1974, and it continued to receive special consideration throughout the project.

A new variety (Tuxpeno) was released for low-medium altitudes in 1976-77. Tuxpeno yielded about the same as Ilonga Composite, which was the variety widely used by farmers in the Morogoro Region. It matured

slightly earlier, however, had a stronger stalk, and was shorter (which made ear harvesting easier) than Ilonga Composite. But Tuxpeno was highly susceptible to maize streak virus and when seriously attacked suffered relatively high yield losses. It was, therefore, eventually withdrawn. Maize streak disease remains one of the most serious contraints to maize production in the lowlands of Tanzania.

Two maize hybrids, H614 and H6302, were also tested and released by the maize program for the high altitude and long season areas of Tanzania. These hybrids were initially developed and released by the former East African Agriculture and Forestry Research Organization (EAAFRO) in Kenya. H614 and H6302 are still performing well in the highlands of Tanzania. In addition, the maize program has developed and is testing several promising maize populations for the lowlands.

Considerable data on agronomic inputs and improved management practices for many of the different ecological areas where maize is grown have been accumulated. Management practice studies carried out determined what maize variety or hybrid should be used, necessary fertilizer levels, effective insecticide regimes, adequate weed control, and optimum plant density. An extension-type handbook on maize production has been published and more up-to-date packages of recommendations are being assembled for publication in the near future.

Grain legumes

Grain legume research was begun in 1975. The legume program worked with a number of different legume species and therefore faced a variety of problems. However, the program has made enormous progress although it suffered a temporary set-back in 1977 when an improved cowpea variety which was to be released was suddenly devastated by a destructive new

virus disease called top necrosis. This problem was overcome in 1979 when resistant varieties were developed at Ilonga. During that same year, a new high-yielding green gram variety (Nuru) was released, and the introduced soybean variety, Bossier, was found to be superior over a wide range of ecological conditions. By 1982, two high-yielding disease resistant cowpea varieties -- Tumaini (meaning "hope") and Fahari (meaning "pride") -- had been released. High-yielding, disease resistant, and extra-early maturing (60 days) dwarf cowpea varieties had also been developed and tested throughout the cowpea growing areas of Tanzania.

More than 1600 local and introduced cowpea, 400 soybean, 500 green gram, and 300 pigeon pea germplasm accessions have now been assembled and the majority evaluated for yield, and disease and insect resistance. Bean research was initiated at Ilonga in 1977, but because beans are the preferred grain legume in Tanzania, the Ministry of Agriculture transferred responsibility for this program to Lyamungu Agricultural Research Institute where it was staffed and funded from a separate budget.

In the area of legume agronomy, the management factors investigated were variety response to locations, time of planting, spacing, pest control, etc., for sole and intercropping systems. In addition to on-station trials, data on management practices and inputs were collected through off-station trials (village trials). These data were compiled and two bulletins containing cowpea production recommendations were published. One cowpea fact-sheet has also been published.

Sorghum/Millet

Sorghum breeding research started in 1978 with the arrival of a sorghum breeder from ICRISAT. Initially, efforts were directed at

evaluating a wide range of sorghum germplasm and breeding lines from all over the world. A total of 3000 germplasm and breeding lines were maintained at Ilonga. High-yielding white-seeded sorghum varieties that consistantly and significantly outyielded Lulu D, the recommended white-seeded sorghum variety, are currently being considered for release and recommendation to farmers.

For all of the food crop varieties released, the project breeders have produced enough seed each year for the seed farms. The seed farms in turn produce foundation seed for seed companies. The released and improved varieties are also used by the research agronomists in farmers' field trials and demonstrations.

Research on millet did not get underway as planned because of ICRISAT's inability to recruit a millet scientist.

Land and station development

The Ilonga Agricultural Research Institute has been designated the national centre for food crop research. Thus, the institute has nationwide responsibility for improving food crops and traditional farming systems. Planning for the development of the land and for new physical facilities at Ilonga was started early in the project.

The technical specialist for land and station development arrived in 1980. Because of his late arrival and the difficulties encountered with delivery of machines and equipment, progress has been slower than expected. Although most of the equipment ordered for land development has now arrived, progress was hampered in 1981 by the lack of funds from the government. Assuming adequate financial support, the Ilonga development project should be completed by mid-1985.

Agricultural economics

A study of smallholder farming systems in Tanzania began with the arrival of a production economist in June 1979. The major objectives of the study were: to evaluate the economic viability of improved cultural practices developed for maize, grain legume, and sorghum varieties; to design and test economically-feasible packages of practices and inputs; to study pricing policy and price variation in order to evaluate the responses of small farm production to price fluctuations; and to establish baseline data for production, cultural practices, and inputs for small farmers in order to measure the spread and acceptance of new technology and recommendations. Since the economist prematurely left the project in early 1981, none of these objectives was met. However, the results of the surveys conducted provide some insights into traditional farming systems in Kilosa District.

Training

Training Tanzanian scientists so they can assume responsibility for the research program was the agricultural research project's highest priority. Training was carried out by the contract staff through on-the-job instruction, through short in-service courses at international centres, and through formal degree programs, many at American universities.

The major thrust of degree training began in 1976 when five B.Sc. and one M.Sc. candidates were sent to the USA. By 1982, 33 Tanzanians had either finished or were completing their degree programs, and 80 Tanzanians had finished in-service programs at the international centres.

RESEARCH PLANNING AND ADMINISTRATION

Among the project's objectives was the design of a national food crops research system, including facilities, research locations, trained personnel, and administrative and financial requirements.

Before the project's inception in 1973, communication and coordination among Tanzania's nine agricultural research institutes was inadequate. Dissemination of research results and research strategies was rare. One of the major accomplishments of the IITA/USAID/Tanzania Agricultural Research Project has been to establish a coordinated research system through which research experiments are designed and conducted in Tanzania's different agroecological zones.

Designed in cooperation with research officers at stations in the various agricultural ecological zones, these research experiments are examined by the National Coordinating Committee to ensure that the objectives are relevant to the particular area of the country where they are carried out. The Committee meets once a year to review the results and to formulate the coming year's work plan. To ensure that the research data collected from the various institutes are standardized, it was necessary for each contract staff to train the research officers from the various research institutes in field techniques.

Facilities and equipment

Concurrent with research activities and manpower training, the project made good progress in developing appropriate facilities and acquiring equipment. In 1974-75, funds were allocated from various sources: $141,000 was provided for equipment from the project budget; $150,000 from the Agricultural Project Support Loan (AID Loan 621-H-017); and 7,900,000/-T.S. from AID Loan 621-H-018 for general crop research

development. The Ford Foundation also provided funds enabling high priority items to be purchased locally thus avoiding the usual delays.

The minimal equipment required to start the project at Ilonga ARI was ordered in 1974-75 and arrived in 1976-77. A list of some of this equipment, as well as later purchases, is provided in Appendix 1.

Land and station development

The Ilonga Agricultural Research Institute plays a major role in agricultural research in the country. It is the headquarters and coordinating centre for the nationally-coordinated food crop research programs.

The infrastructure and physical development work aimed to establish a 200 ha; fully mechanised modern research experimental farm with 50 ha. of irrigated land, adequate drainage systems, soil and water conservation structures, access roads, and barbed wire fencing.

Physical plant support facilities are also being built on 4.84 ha. of land. These facilities will include buildings housing administrative and scientific offices, as well as laboratories; scientific work buildings; stores; warehouses; workshops; farm offices; and machinery sheds. A plan of the facilities is included in Appendix 1.

When completed, the new physical plant and farm will provide facilities for maintaining the national collection of genetic material under appropriate storage conditions, and will permit year-round genetic improvement and breeder seed increase work in precisely and intensively managed and controlled irrigated experimental plots. Limited computer facilities are also anticipated which will enable scientists to rapidly analyse data and formulate recommendations for immediate utilization. Such a system will increase the overall efficiency of research at Ilonga several-fold.

The land and station development activities began with the arrival of the technical specialist in late 1980. Because of his late arrival and difficulties encountered with equipment delivery, progress has been slower than expected. Most of the needed equipment had arrived by September 1982, however. The land use plan has been drawn-up and implemented on the 200 ha. experimental farm area. Land clearing and levelling operations are still in progress, but 25% of this work has been completed as has 33% of the lake dam and 20% of the service reservoir. Road construction and fencing are more than half finished. The irrigation system materials have been ordered and are expected to arrive shortly. It is anticipated that all activities will be completed by mid-1985.

Realizing these objectives was by no means easy. During the first few years the project faced serious problems such as insufficient and inadequate housing and transport, as well as a shortage of field equipment and laboratory facilities. Some of these problems were partially solved when funds provided by USAID in 1974-75 permitted the purchase of materials to meet minimum research needs. The slow procurement of equipment and spare parts has always been -- and probably will remain -- a thorny problem, however. Moreover, adequate financial support for research and land and station development was sometimes slower than expected in arriving and often inadequate.

Recommendations

1. Equipment and spare parts should be quickly purchased to avoid unnecessary delays in research development activities.

2. Increased priority and assistance from the Tanzanian Agricultural Research Organization/Ministry of Agriculture should be given to Ilonga's research activities and land and station development.

3. An assessment should be made of the support provided to contract staff.

MAIZE IMPROVEMENT

The maize breeding and agronomic research program of the Tanzanian project is intended primarily to benefit small farmers. Its main objectives are: to develop high-yielding hybrids and varieties suitable for high, medium, low, and coastal attitudes; develop improved maize agronomic practices; and test these varieties and practices in selected sites.

Background

Maize is the staple food of Tanzania. It is eaten in the form of ugali, a thick flour porridge. At current consumption levels, some 225 kg of maize are needed annually for each adult and half that for children.

Maize breeding and agronomy has a long history in Tanzania. The improved open-pollinated varieties, Ilonga Composite (ICW) and Ukiriguru Composite A (UCA), were tested and released in the 1960s and are still widely used. Both varieties yield well, but they are tall and only moderately disease resistant.

Because the highland areas of the country are similar to those in Kenya, inbred development was entrusted to the East African Agriculture and Forestry Research Organization (EAAFRO) operating from Kitale, with Tanzania acting as a cooperating station. Before the start of the project, hybrids H622, H613, and H632 had been tested, released, and accepted in the highland areas of Tanzania. Although these varieties are high-yielding and have good foliar disease resistance, they are tall and, according to farmers, their soft grain is prone to insect damage during storage.

During the 1960s a few Tanzanian stations also undertook agronomic research. Production recommendations were made and applied to the entire country. Due to national policy and environmental changes, however, these recommendations are now economically and technically unsound for farmers.

Since 1974, the maize program has been headquartered at the Ilonga Agricultural Research Institute near Kilosa. Staff assigned to the National Maize Research Program (NMRP) are also located in all ARI's and at several Agricultural Experiment Stations (AES) in Tanzania to facilitate maize research on a national level. A NMRP Coordinating Committee meets yearly to discuss research results and problems, plan new trials, draw up the budget, and set maize research priorities and goals for the coming season. These yearly meetings enable staff to learn of maize production problems in other parts of the country and foster a spirit of national cooperation to solve them.

Breeding and variety development

To date, the breeding program has been based on population improvement and on the development of synthetic varieties through multilocational testing of progenies in order to improve adaptation and yield stability. Four ecological zones were defined for varietal development:

- The highland zone at an attitude of more than 1500 m, has a growing season of 6-7 months. Full season materials require more than 100 days to silking.
- The "wet" intermediate zone, at 900 - 1500 m. elevation, has a 4-5 month growing period.

- The "dry" intermediate zone, at 900 - 1500 m elevation, has a 3-4 month growing period. Annual rainfall is below 1100 mm and is unreliable.
- The low coastal zone at an elevation below 900 m has a 3-4 month growing period.

These zones were designated mainly in order to develop varieties with disease resistance and maturation times appropriate to each. In general, material developed for one zone adapts sufficiently to be grown in the zone immediately above it.

As illustrated in Table 1, the breeding program maintains a set of progeny families through recombination of the best 20-25. The selection of families is based on the results of the progeny trials.

A parallel population is maintained through half sib selection and recombination. New germplasm can be introgressed into these populations through the female rows without fear of introducing undesirable genotypes. A small number of families can be used directly in progeny trials or crossed with the full-sib progeny families to maintain genetic diversity.

Populations and progenies currently used in program are listed in Table 2. Populations 62, 76, 90, and 92 are based on maize germplasm from Tanzania although substantial exotic germplasm (obtained from CIMMYT) has been introgressed into populations 62 and 76. All other populations are from material obtained originally from CIMMYT.

In 1974, five other populations were used in the program: 78 (ICW); 86 (Katumbali); 84 (Katumani); 81 (white quality protein); and 83 (yellow quality protein). The first three were withdrawn from active breeding work in 1979 when better material was obtained for replacement and/or recombination. Based on the decision that high yield, not quality, was the

Table 1

Schematic of Maize Improvement Program

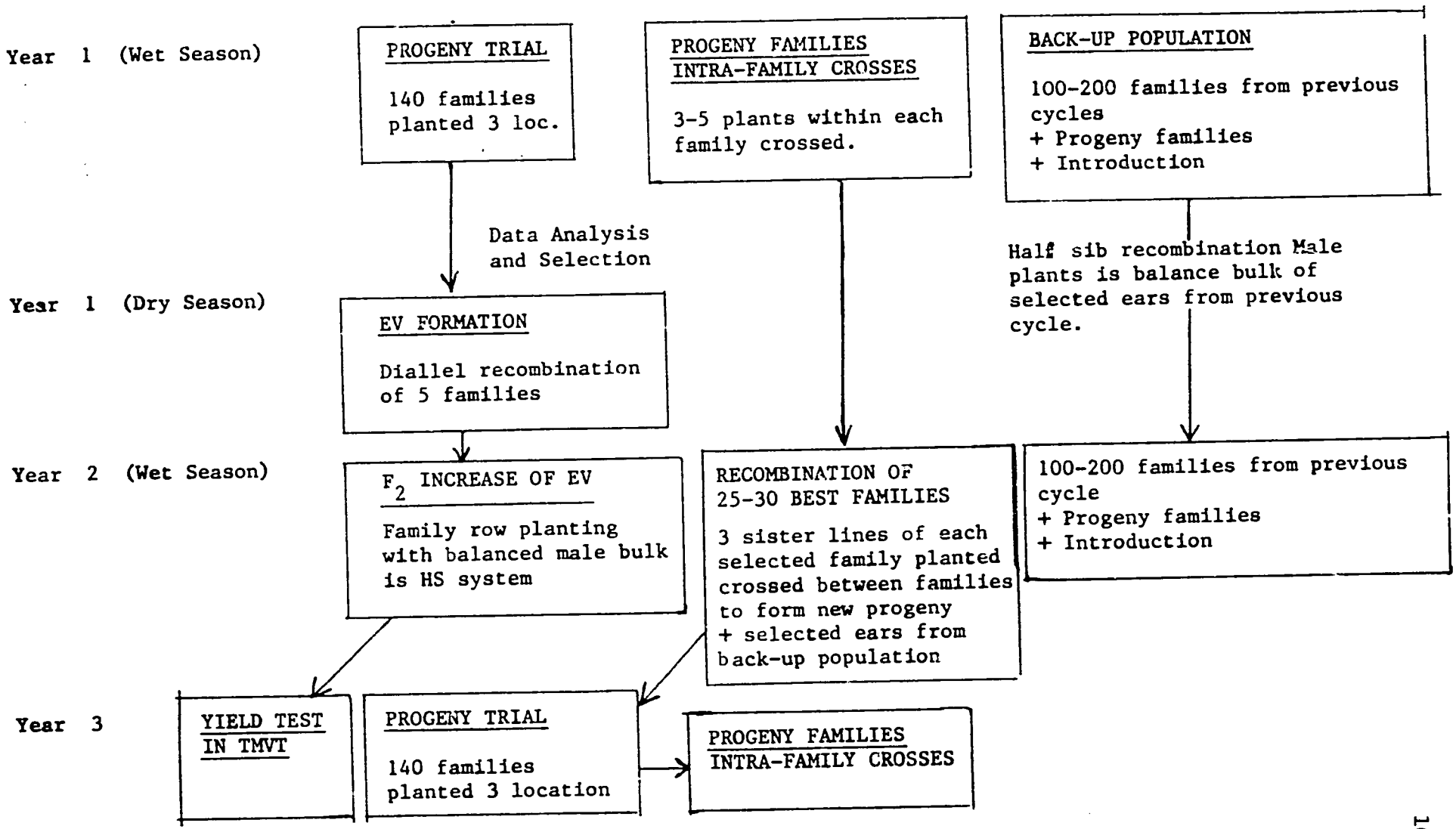


Table 2: Populations of maize being improved by the National Maize Research Program

Population	Days to Silk	Elevations at which the population should be grown	Grain Type	Pedigree	Outstanding Characterists/ comments
76	60-65	Low	White flint/dent	Recombination of Tuxpeno crosses	Tolerant to streak and stalk rot diseases; tall plants; good stalk quality.
80	60-63	Low	White flint/dent	Derived from Pop. 21 (Tuxpeno) Cycle 7	Resistant to leaf diseases and tolerant to streak.
88	45	Low and intermediate	White flint	Derived from CIMMYT IPTT 30	Short plant but strong stalk.
90	110-120	High	White dent/flint	Recombination of hybrids	Progeny being evaluated for good agronomic characters and disease resistance.
92	75	Intermediate	-	Derived from combinations of UCA-CS	Progeny being evaluated for good agronomy characters and disease resistance.
96	70	Intermediate	-	Derived from Tuxpeno	Short plant and strong stalk.
10	63-66	Low and intermediate	White dent	Selections from CIMMYT	Population in recombination.
11	55-58	Low and intermediate	White flint	Selections from CIMMYT	Population in recombination.
12	60-70	Low and intermediate	Yellow flints and dents	Selections from CIMMYT	Population in recombination

Table 2 continued:

Population	Days to Silk	Elevations at which the population should be grown	Grain Type	Pedigree	Outstanding Characteristis/ comments
62	105-115	High	Mixture of white and yellow dents and flint.	Recombination of Mexican, Guatamelean and Andean materials.	Population in recombination.
72	45	Low and intermediate	Mixture of white and yellow flints and dents.	Recombination of Katumani crossed with CIMMYT materials.	Low levels of streak tolerance and good stalk quality.
84	70	Intermediate and high	-	Exotic germplasm from CIMMYT.	Population in recombination.
81	-	-	White	-	High quality protein.
83	-	-	Yellow	-	High quality protein.
82	Early maturing	-	White floury dent	-	Resistant to maize streak.
84	Early maturing	-	White dent	Derived from Katumani	Population in recombination.
86	-	-	White fint	Derived from Katumbali	Population in recombination.

major breeding objective in the country, the two quality protein populations were set aside in 1979.

When planted in the appropriate zone, the varieties and populations used in the program have good resistance to most foliar disease. None, however, had good field resistance to maize streak virus disease (MSV). The disease resistance program therefore emphasized improving MSV resistance.

In cooperation with CIMMYT, three broadly based populations (10, 11, and 12) were exposed to field infestation of MSV. Within each population, plants from the selfed families that showed the most resistance were crossed during the next selection cycle. We have thus developed populations that show a high degree of resistance under field conditions using germplasm not generally recognized as being resistant.

Farmers often complained that the grain of available hybrids was too soft and susceptible to weevil damage during storage. During recombination of the populations, harder grain (i.e. flint type) and tighter husk cover became two of the primary selection criteria.

Since 1974, three varieties have been released through the breeding program. In 1976, the NMRP released the Tuxpeno variety, a selection from CIMMYT population 21 cycle 5. Both on-station and off-station, the variety out-yielded local varieties by 5-8%, was 35 cm shorter, and matured one week earlier.

In 1977, two hybrids were released for the southern highlands -- H6302 and H614. Inbreds for the hybrids were developed by the EAAFRO program at Kitale, but were tested in cooperation with Tanzania and other East African countries. Until their release, the primary hybrid for the area was H613. H614 has the same yield as H613 but is 10% shorter, three days earlier, has

10% better standability, and better ear rot resistance. In 1979, an improved version of H614 was developed using an advanced generation of the male parent. The use of the improved male gave a 10% yield increase without affecting the other characteristics.

H6302 yields 10% more than H614 with field production of 9.3 tonnes of grain under good management. Compared to H614, H6302 is 12% taller, three to five days later to silking, and has similar standability. It is also more resistant to ear rot. H614 and H6302 have replaced H613 as the preferred hybrids. A total of 400-500 tonnes of seed are now sold annually.

Three additional synthetic varieties for intermediate and low elevation zones -- EV 7992, EV 8188, and EV 8076 -- are now in their final year of testing and the program hopes to release them at the end of the 1982-83 cropping season. EV 7992 is an improved variety similar to UCA, the most widely used variety in the intermediate zone. The yield of 4.8 - 5.3 T is 5-8% higher on average than UCA. Under less favourable conditions, EV 7992 shows a 10-12% yield advantage. It is also 30 cm (15%) shorter and has better standability.

EV 8188 is a short season variety adapted to both low and intermediate elevations. Maturation is similar to Katumani, the only short season variety now available. The variety has an 8-10% higher yield potential (3.0-3.3T/ha.) and greater yield stability. Its husk cover and grain quality are also superior.

EV 8076 is a full season variety for low elevation areas or a mid-season variety for the dry intermediate zone. Its yield potential (4.3 - 4.8 T/ha) is 5-8% better than ICW, the standard variety for the low elevation zone. It is also 10% shorter, three days earlier to silking, shows better tolerance to MSV and has greater yield stability.

Agronomy

Before 1973, each research station was responsible for formulating production recommendations for the zone in which it is located. But as the recommendations made by stations possessing more expertise were often transferred to other zones, by 1973 a standard set of maize production recommendations was being applied to the entire country.

At the beginning of the project it was decided to concentrate the agronomy trials off-station, in villages, in order to test the packages being recommended before embarking on new research at the stations. In the fertilizer and management trials the best variety was used. The highest economic fertilizer level was compared to no fertilizer or farmer level fertilization in the variety and management trials. The best management -- weeding, plant density etc. -- was used in the fertilizer and variety trials. In 1977 preliminary recommendations were made. A maize production handbook was published, defining the various zones and providing recommendations specific to each.

These off-station trials raised questions that could only be answered by carrying out on-station trials. A series of trials looking at plant arrangement, plant density, time of planting, and stalk borer control was therefore planned and conducted throughout Tanzania.

These trials showed that:

1. A plant density of 40-50,000 plants/ha results in optimum yields in all varieties except Katumani: 65-70,000 plants/ha is optimum for Katumani.
2. Plant arrangement and number of plants per hill can vary considerably without affecting yield as long as a uniform density is maintained. In the dry intermediate as well as low and coastal zones, more than

two plants per hill can cause lower yields, presumably because of competition for water. In the high and wet intermediate zones, up to four plants per hill can be maintained without affecting yield.

3. In the high elevation zone, a delay in planting the hybrids results in yield reductions of 50 kg for each day delayed. In other areas, planting with the first rains can pose a high risk of crop failure because of water stress at the critical pollination time. Planting should be delayed so that pollination occurs when rainfall is most probable.

4. Stalk borers can be controlled with any of several insecticides, but their use appears to be for cosmetic rather than yield reasons. Only in the highland zone did borers cause any significant reduction in yield, making insecticide use marginally economic. If trade-offs must be made between inputs, fertilizer will give a much greater return than insecticide.

These results, combined with data from additional village trials, form the basis of production recommendations for 11 agro-political zones in the country (Table 3). Further recommendations will take into account the findings of socio-economic research as they become available.

New varieties with better yield stability and greater tolerance to MSV may permit greater flexibility in the planting schedules. The "time of planting" trials will help establish these schedules.

In addition to the standard village trials, the NMRP has been carrying on demonstration trials with farmers. The main purpose is to compare the performance of the new varieties against the farmers' variety, under farmer management. The results, although few, show that they are maintaining their yield advantage.

Table 3 : Maize Production Recommendations

ZONE	VARIETY[1]	PLANTING DATE	FERTILIZER[2]	WEEDING[3]	REMARKS
Mbeya Region 1500 m Iringa Region 1400 m	H6302 H614 UCA	with first rain until Dec. 20	AP 3-4 bags SA + 2 bags TSP AP SD 5-6 bag SA	2 weedings 3 WAP 6 WAP	
Mbeya Region 1500 m	H632 UCA	with first rain until Jan 20	AP 2-3 bags SA + 2 bags TSP SD 3-4 bags SA	2 weedings 2 WAP 5 WAP	
Ruvuma Region	H614	with first rain until 10 Dec 10 Dec - 15 Jan.	AP 3-4 bags + 2 bags TSP 5-6 bags SA	2 weedings 3 WAP 6 WAP	
Morogoro Region	ICW TUXPENO KATUMANI	Jan 15 - Mar 1 Feb 10 - Mar 1	AP 1 bag TSP SD 2-3 bag SA if moisture sufficient	2 weedings 2 WAP 4 WAP	
Tanga Region 900 m and Lindi Region	TUXPENO ICW KATUMANI	Jan 15 - Mar 15 Feb 15 - April 1	AP 2 bag TSP SD 2-3 bags SA if moisture sufficient.	2 weedings 2 WAP 4 WAP	

Zone	Variety	Planting Date	Fertilizers	Weeding	Remarks
KILIMANJARO REGION 900m	H632 UCA	with first rains after Jan 15 - Mar 15	AP A2 bags TSP + 1 bag SA SD 2-3 bags SA	2 weedings 2 WAP 5	
KILIMANJARO REGION 900m	KATUMANI	with first rains until Novemver 15	AP 2 bags TSP SD 112 bags SA	2 weedings 2 WAP 4 WAP	
	TUXPENO ICW	with first rains after January 15	AP 2 bags TSP SD 2-3 bags SA		
.WANZA GEITA DISTRIC		with first rains	AP 2 bags TSP 1-2 bags SA SD 2-4 bags SA if sufficient rainfall	2 weedings 2 WAP 5 WAP	
MWANZA EXCEPT GEITA DISTRICT	TUXPENO	after 15 Jan.	AP 2 bags TSP 1-2 bags SA SD 2-3 bags SA if sufficent rainfall	2 weedings 2 WAP 4 WAP	

cont ..... Table 3

1. All varieties except Katumani should be planted at 40-50,000 plants/ha. Katumani should be planted at 60-70,000 plants/ha. Row spacing can be either 75 or 90 cm: Within row spacing is 60 or 50 cm respectively with 2 plants/stand.

2. AP - at planting

   SD - side dressing when the plant has 8-10 leaves

   TSP - triple superphosphate

   SA - sulphate of ammonia

   Bags - refers to a 50 kg of the formulated fertilizer

3. WAP - weeks after planting.

In the future, the program should investigate intercropping with legumes or sorghum in order to maximize both maize and intercrop yields.

Recommendations

The project has succeeded in developing maize varieties for Tanzania's main ecological zones that are superior to the previously grown cultivars. The agronomic research will make it possible to recommend cultural packages for each zone.

To consolidate the gains made so far toward a sustained increase in maize production, it is recommended that future research activities focus on:

1. The improvement of the selection technique for resistance to maize streak virus.
2. The development and implementation of a standard recurrent selection program to allow continuous improvement in yield and agronomic characteristics of maize populations as well as periodic extraction of experimental varieties for subsequent testing and release to the farmers.
3. Agronomic research on the most appropriate planting time, plant density, fertilizer application, and weed control -- particularly on the use of herbicides in various ecological zones and/or seasons.
4. On-farm testing of improved varieties and cultural practices in order to accelerate their large scale adoption and give direction to research for continued technological improvement.

GRAIN LEGUME IMPROVEMENT

As with maize, legume breeding and agronomic research is intended to benefit the small farmer. The program's objectives are to maintain a collection of genetic material of potential value in Tanzania; develop high-yielding, disease and insect resistant, well accepted varieties; improve agronomic practices; and test these varieties and practices in selected stations and farmers' fields.

The grain legume research emphasizes cowpeas (*Vigna unguiculata*), soybean (*Glycine max*), and green gram (*Vigna aureus*).

Before the program began in 1974-75, only limited varietal improvement work had been carried out in Tanzania, with the exception of soybean breeding. The few cultivars that had been identified as promising were tested at only a few sites which were not representative of most agro-ecological conditions under which the crops were grown. Only a few soybean and bean varieties had been released officially. Very little breeding work had been conducted on cowpeas, green gram, beans, and soybeans in order to improve yields and resistance to important pests and diseases responsible for poor and unstable performance of the cultivars.

The first tasks of the program were to test all the high-yielding cultivars that had been previously identified in Tanzania, and develop promising new cultivars. A series of multilocational yield evaluation trials were required to identify widely-adapted and high-yielding cultivars for later release through official channels. Breeder's seed would then be provided to seed farms so that improved varieties could be promptly delivered to the farmers.

It was hoped that through these basic activities, a solid foundation could be laid for a long-term, sustained breeding program. This program could produce additional high-yielding, stable cultivars. Through further manipulation of plant structure and physiological functions, the specific requirements of Tanzanian farmers would be incorporated.

Cowpeas

More than 1600 local and introduced cowpea germplasm accessions -- the majority from IITA - were assembled, and most were evaluated for disease and insect resistance, seed size, and color. The plant characters for these lines were also described. Many of the promising lines were used in variety trials and as parents in the breeding program.

One of the major objectives of the breeding program was to stabilize the high-yielding varieties' resistance to insect pests and diseases. The desired plant type, seed color and size, and leaf quality could then be incorporated. The breeding program has been successful in developing several varieties that combine high yield, disease resistance, and wide adaptability.

Two high-yielding, disease resistant, and widely adapted full season cowpea varieties have been released by the legume program. They are Tumaini (TKI or TKx 9-11D) and Fahari (TK 5 and TVx 1948-01F). Resistant to cowpea aphid-borne mosaic virus, bacterial blight, and bacterial pustule, these varieties have yielded as much as 2200 kg/ha. at Ilonga and have consistently out-yielded the local controls both on-station and off-station for several seasons at nine locations in Tanzania. Breeder's seeds of Tumaini and Fahari were supplied each year to the seed farms by the legume improvement program. Over 50 kg of improved seeds of these varieties were available for distribution in 1982.

High-yielding, disease resistant, and extra-early maturing (less than 60 days) dwarf cowpea varieties have been developed. Two of them are Cross 1-6E-2 and TKx 133-16D-2. Two medium maturity (65-70 days) cowpea varieties, IET 120-4 and M66, have also been developed. Both have excellent seed and leaf quality.

In addition to early maturity, these varieties are resistant to cowpea aphid-borne mosaic virus, cowpea mosaic virus, top necrosis, rust, bacterial blight, and bacterial pustule. Development of these extra-early cowpea varieties has permitted double-cropping in the bimodal rainfall areas of Tanzania. Planted in the Morogoro, Tanga and Coast Regions during the short rainy season, a time of the year when food is scarce, they can yield over 1.5 T/ha.

Four early maturing cowpea varieties with excellent leaf and seed qualities have also been developed and are in the final stage of testing.

Sources of resistance to some of the most devastating cowpea diseases -- top necrosis, cowpea aphid-borne mosaic virus, bacterial blight, bacterial pustule, and phytophthora stem rot -- have been identified and maintained by the breeding program (Table 4).

Soybeans

The first attempt to establish soybeans as a crop in Tanzania probably dates back to 1907. The first breeding program started in 1955, followed in 1973 by the program at Ilonga.

The main objectives were to develop high-yielding, early and late maturing varieties with good seed quality and the ability to nodulate with indigenous strains of *Rhizobia*.

Table 4. Sources of resistance to different diseases in cowpea.

Disease	Resistant breeding lines
Top Necrosis	TVx 966-01B, TVx 1193-54C, TVu 3629, TVx 1836-397, Cross 3-13-E-2, 1ET-120, TKx 528-06D, TVx 3747-02D, TKx 43-06E-2, TVx 3780-10, TVx 2907-02D, 8R-43-03E, Cross 1-6E-2.
Cowpea Aphid-Borne Mosaic Virus	Fahari, TVu 410, 8R-43-03E, Cross 1-6E-2, TKx 133-16D-2, Tumaini TKx 133-35D-3, TKx 133-43D-2, Cross 3-13-E-2, 1ET-120, TKx 179-04D-5
Bacterial Blight	Cross 3-13E-2, Cross 1-6E-2, TKx 133-43D-2, TVx 3866-06D, 1ET-120, TKx 177-10D-2, TKx 133-35D-3, TKx 179-04D-5.

Over 600 soybean germplasm lines from various sources were evaluated and the best selected for testing. Multilocational variety trials were carried out: the introduced variety, Bossier, emerged superior in terms of yield.

New breeding lines were developed and tested, a number of which significantly out-yield Bossier (Table 5). Some of them are also free nodulators and have good to excellent seed viability. Now in the final stage of yield evaluation, they should be released in few years.

Green gram

A native of India, mung bean or green gram is gaining in popularity in Tanzania although it is more expensive than other pulses. It is grown wherever cowpea is cultivated.

The research aimed to develop extra-early, high-yielding varieties resistant to cercospora leaf spot and scab.

Following the screening and evaluation of germplasm lines, variety trials were carried out. One high-yielding cultivar, TVau 81 popularly called Nuru (meaning "bright"), was released in 1978: 70 kg of breeders' seed was supplied to seed farms.

In the course of subsequent research, two early-maturing large-seeded varieties (V. 2007 and V. 1380) were developed: both yield about 20% more than Nuru and have superior cooking qualities. Hybridization of Nuru and other varieties is continuing in order to incorporate disease resistance into the improved varieties.

Agronomy

Agronomy research carried out under the national grain legume research program is directed at the identifying critical management factors and developing practical and economical means of cowpea, bean, green gram,

Table 5. Performance of best 11 soybean lines selected from 60 lines evaluated at Ilonga 1980-81.

S.N.	Variety	Yield (kg/ha)
1	79S0047 F4	2043
2	GPM L-2	2302
3	S1-4	2945
4	59S0057 F4-1	2171
5	TGM 622	2605
6	TGM 737 x 80	1962
7	S3-2	2136
8	79S0018 F4	1964
9	GPM L-4-2	1973
10	Bossier	1241
11	3H/1	2133

and soybean production. Trials were carried out in both stations and villages. Demonstration plots were established during the 1980 season at several locations in Kilosa and Miwaleni districts.

The legume program has identified ten distinctly different agroecological zones in Tanzania in which legumes are grown (Fig. 1 and Table 6). Since the beginning of the project in 1974-75, a number of trials have been conducted in each of these zones to determine what combination of factors in a mono-or intercropping system was best for legume and/or cereal yields.

The management factor studies included, among others: varietal response to location; time of planting; plant population and spacing; fertilizer requirements; insecticide spray schedules; and pest control practices.

Recommended management practices for cowpeas were compiled and published for extension personnel. Research on cowpeas has clearly established that the present farmers' yield of 200 kg/ha. could be raised to 1800-2000 kg/ha. through the use of improved varieties and better management.

Two cowpea production handbooks and one fact sheet on cowpeas were published to assist farmers in selecting the best varieties and the most appropriate cultural package for their region (see Appendix 2).

A program of village trials was started in 1975-76. These trials were basically simplified versions of the management trials conducted at the research stations as part of agronomic trials, using three to five elite varieties developed in the breeding program. The village sites represented a wide range of micro-ecological environments found within a region or district and in which the desirable crop variety management practices could be further improved. The sites were usually selected

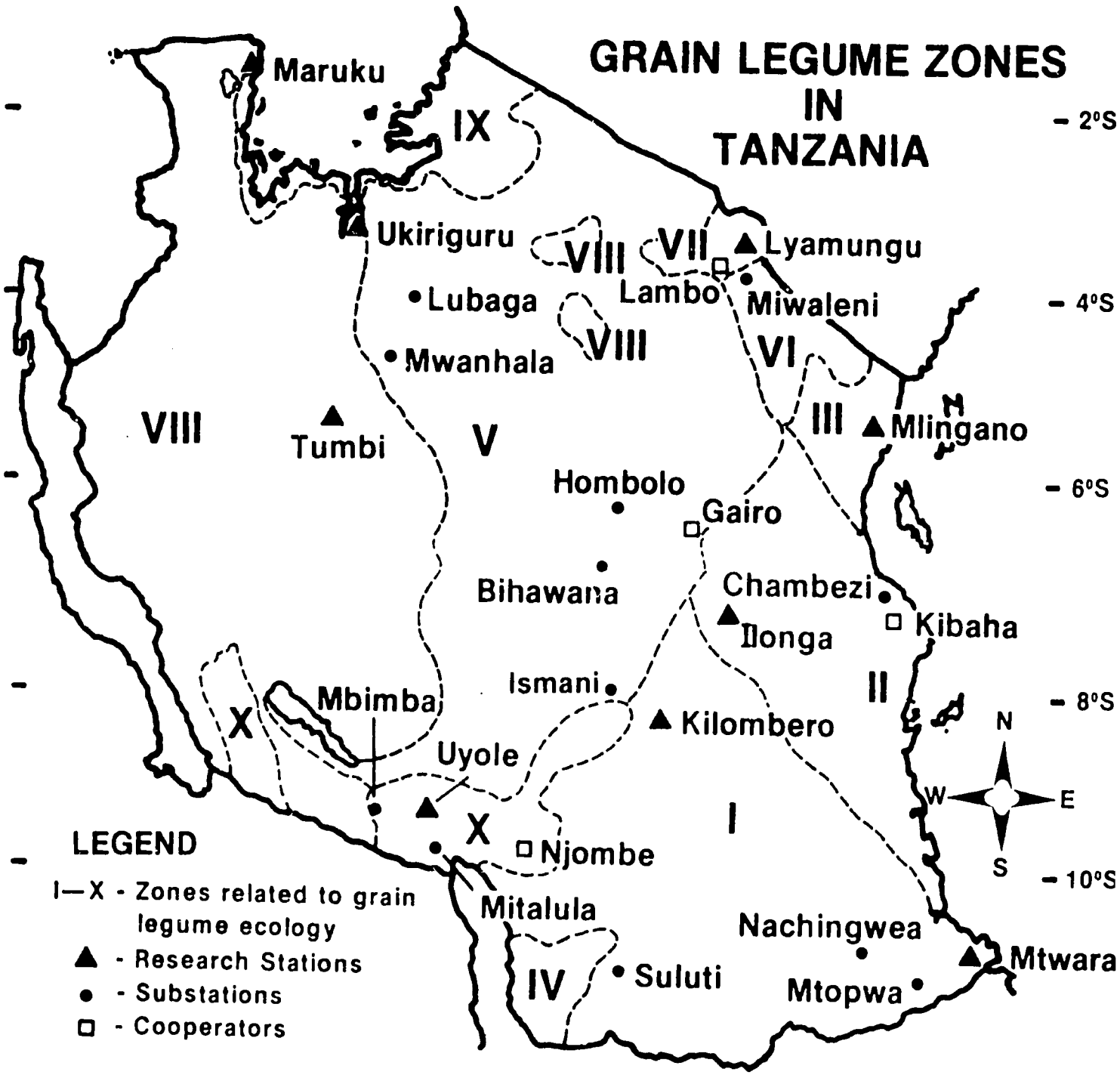

GRAIN LEGUME ZONES
IN
TANZANIA
2°S
4°S
6°S
8°S
10°S
Maruku
IX
Ukiriguru
VIII
VII
Lyamungu
Lambo
Miwaleni
Lubaga
Mwanhala
VIII
VI
VIII
Tumbi
V
III
Mlingano
Hombolo
Gairo
Bihawana
Chambezi
Ilonga
Kibaha
Ismani
II
Mbimba
X
Kilombero
Uyole
X
I
Njombe
Mitalula
Nachingwea
Mtwara
IV
Suluti
Mtopwa
N
W
E
S
LEGEND
I—X - Zones related to grain legume ecology
▲ - Research Stations
● - Substations
□ - Cooperators

FIG. 1

TABLE 6. Varying Conditions in Zones Related to Grain Legume Ecology

Rainfall Pattern	Elevation m	Rainfall mm	Rainy Season	Grain Legume	Cereal	Station
I. Low, moist, monomodal	0-800	1000	Dec.-April	Cowpea	Maize Sorghum	Kilombero Mtwara
II Low, moist, weakly, bimodal*	500-800	1000	Dec.-April	Cowpea	Maize Sorghum	Ilonga
III Low, moist, bimodal	0-800	1000	Oct.-Nov (Mar.-May)	Cowpea	Maize	Mlingano
IV. Medium, wet monomodal	800-1500	1200	Dec.-April	Beans, Cowpea	Maize	Suluti
V. Medium, dry, monomodal, early	800-1500	800	Dec.-March	Cowpea	Sorghum Millet	Hombolo Ismani
VI Medium, dry, monomodal, late	800-1500	800	March-May	Cowpea	Maize Sorghum	Miwaleni
VII. Medium, moist, monomodal, short duration	800-1500	800-1000	March-May	Bean	Maize	Lambo Tengeru
VIII. Medium, moist, monomodal	800-1500	800-1000	Nov.-April	Beans/ Cowpea	Maize Sorghum Millet	Ukiriguru
IX. Medium, very wet, monomodal	800-1500	1400	Oct.-May	Beans	Maize	Maruku
X High, wet, monomodal	Above 1500	1400	Dec.-April	Beans	Maize	Uyole

*In Zone II there are two to three weeks between seasons.
In Zone III there is at least one month between seasons

Table 6

near a primary or secondary school as children participated in the activities from planting to harvesting. The legume village trial officers showed the head teacher and students what management practices were required for high crop yield.

After testing the varieties and management practices in the village trial program, they were used in demonstration plots in farmers' fields. The demonstration program was started in 1980 in two regions only, Morogoro and Kilimanjaro. It was successful in developing a feedback system between farmers and researchers and in demonstrating to farmers the financial gains that could be made by using improved varieties and management practices.

Recommendations

1. The on-going food crop research being conducted at Ilonga ARI and at the other research institutes in different agro-ecological zones should continue.

2. One of the first priorities of the cowpea breeding program should be to incorporate aphid, bruchid and thrip resistance in promising varieties like Tumaini, Fahari, IET-120-4, and TKX 133-16D-2. Efforts should also be made to breed for resistance to phytophthora stem rot which caused severe damage on large areas of land at Msimba farm. It is feared that the disease may spread rapidly.

3 The research on time of planting, spacing, intercropping, fertilizer use, etc. should continue because present recommendations may vary depending on the variety used, location, etc.

4. The demonstration program should be expanded to include agronomic practices. Such demonstrations should be carried out in every region with the help of extension staff.

SORGHUM/MILLET IMPROVEMENT

The purpose of the sorghum/millet breeding and agronomic research program is to help the small farmer by developing high-yielding varieties with disease and insect resistance and market acceptance; developing improved cultural practices that are applicable to Tanzanian conditions; and testing these varieties and practices in selected stations and farmers' fields.

Background - sorghum

Sorghum, one of the most important cereals in Tanzania, is cultivated mainly by traditional peasant farmers for home consumption as Ugali porridge or local brew. Sorghum production is concentrated in the semi-arid areas where variable, erratic rainfall results in long periods of moisture stress during the cropping season. Serious insect and disease problems affect production and depredation by birds, particularly *Quelea*, is severe.

Most of the preferred sorghums are local types. They are extremely tall, late maturing, and low-yielding, but are palatable and have hard flinty grain which stores well. The improved, high-yielding varieties available are not widely accepted by traditional sorghum growers and consumers because they lack the hard flinty grains and store poorly.

Screening and development

When the sorghum breeding program began in 1978, much effort was made to evaluate a wide range of sorghum germplasm and breeding lines from the world over. The bulk of this germplasm was introduced from the sorghum and millet research unit at Serere, Uganda; ICRISAT, Hyderabad, India;

Texas A & M and Purdue universities in the USA; and from sorghum breeding programs in Kenya and the Sudan. More than 3000 germplasm and breeding lines were evaluated and selected in 1978 and 1979. The promising varieties selected were extensively tested in multilocational trials in Tanzania, and the selected germplasm or breeding lines are being utilized in the breeding program.

A total of 306 indigenous sorghum cultivars were also collected from Tanzania's main sorghum producing areas, evaluated, and screened at Ilonga. Most of the local varieties are tall (four metres), have loose panicles, and are late maturing (five months). This germplasm varies considerably in grain size, shape and color; endosperm hardness and texture; plant and glume pigmentation; etc. Several germplasm lines with valuable agronomic traits were selected and used in the cross-breeding program. The indigenous germplasm collection is maintained at Ilonga and at ICRISAT's Genetic Resources Unit in Hyderabad.

A multilocational national variety trial was initiated in 1979, composed largely of promising 2KX derivatives from Serere, Uganda. This was repeated in 1980 and 1981 at several locations in the main sorghum producing areas of Tanzania. Three white-seeded varieties -- 2KX 89, 2KX 97, and 2KX 17/B/1 -- have consistently and significantly out-yielded Lulu D, the recommended white-seeded variety. They are currently being considered for release to farmers.

A cross-breeding program was initiated in 1978 to incorporate desirable traits from the late-maturing local sorghums into the improved varieties. The program was intensified in 1979. Genetically diverse segregating material derived from these crosses was selected and advanced and is now in the fourth, fifth and sixth generations of selfing. The most advanced selections are now ready for yield and adaptation testing.

Several introduced sorghum A & B lines were evaluated and screened at Ilonga. The most promising male steriles are: ATX 623 and ATX 624 from Texas, A & M; IS 2077 and IS 2219 from India; and MSC 23A and MSCIA from Serere, Uganda. These were evaluated in hybrid combination with local pollinators at Ilonga and, later, at key locations in the main sorghum areas. The results thus far indicate that sorghum hybrids are significantly superior to sorghum varieties: ATX 623, in particular, has given outstanding hybrids.

Agronomy

Trials were launched in 1977-78 to determine the optimum plant density for different varieties in different locations, as well as the best row spacing for intercropping. The results showed that density could exceed 160,000 plants/ha. without yield reductions. And while the results of spacing trials are not yet conclusive, it would appear that, at high plant density, increasing the inter row spacing reduces yields. In "time of planting" experiments, the best yields were obtained when the sorghum was sown at the earliest possible planting date except in areas of prolonged rainfall when farmers could plant until the third recommended date.

Millet

The millet program did not get underway because of a lack of trained staff to carry out the research and ICRISAT's inability to recruit a millet scientist. Nonetheless, a number of millet accessions were received from ICRISAT, EAAFRO, and other institutes. Local varieties were also collected.

Agronomic trials were carried out to determine optimum fertilizer application rates for bullrush millet and best time of planting for pearl millet.

Recommendations

Diverse material has been derived from crosses of local cultivars and improved varieties. Selection within the segregating material in early generations should be continued. Promising derivatives in the advanced generations have been identified and need to be extensively tested for yield and adaptation throughout Tanzania's main sorghum producing areas.

2. The most promising derivatives do not possess the high grain quality characteristics of the local cultivars. A backcrossing program involving the most promising derivatives and local cultivars with good grain quality should be initiated to improve derivatives.

3. A large number of promising males steriles have been identified, in particular ATX 623, 8 MSC 1A, and IS 2077A. Extensive testing for yield and adaptation throughout the country is recommended.

4. A large quantity of local sorghum germplasm has been collected and evaluated. Further collections of local germplasm should be made from areas not yet covered, especially in the Mtwara, Lindi, and Ruvuma regions.

5. A large quantity of germplasm has been introduced and evaluated, and is presently maintained at Ilonga. As this material can easily be lost if extra care is not taken to preserve it, it is vital for the sorghum program's future that it be properly maintained.

AGRICULTURAL ECONOMICS

The agricultural economics/farming systems component of the project was intended to assist agrobiological scientists in generating technologies relevant to the means and needs of the small farmers. The research aimed to evaluate the economic viability of improved cultural practices; design and test an economical package of practices and imputs; study pricing policy and price variations in order to evaluate small farmers' production responses to price fluctuations; and establish baseline data on these factors in order to measure the acceptance of new technologies.

A study of smallholder farming systems began with the arrival of a production economist in mid-1979. Unfortunately, because of the economist's departure early in 1981, as well as the lack of transportation and staff shortages, the agricultural economics research objectives were not met. The results of the surveys conducted, however, do provide some insights into traditional farming systems in the Kilosa district. As the following summary shows, the findings helped dispel the myth that a high people/land ratio is a serious constraint to agricultural development in the area. In Kilosa, the useable land is a direct function of labour availability in the family. Any technological innovation that further strains the seasonally-scarce labour supply will therefore not find favour with the farmers.

TRADITIONAL FARMING SYSTEMS IN TANZANIA

A study of smallholder farming systems in the Kilosa area of the Morogoro region in Tanzania was conducted from June 1979 to May 1981. The study aimed to better understand traditional farming systems and use this

information to help generate new technologies adapted to the means and needs of small farmers. The investigations were largely focussed, therefore, on technological aspects of traditional farming systems.

The need for a clearer understanding of smallholder farming systems greatly influenced the investigations' approach and methodology. A number of methods were used to obtain information, and to verify and quantify the data, including group discussions, sample surveys, case histories, monitoring of plots, interviews, and the simulation of smallholder farming systems. Agroclimatic and institutional factors such as Ujjama, the technological environment, and farmers' resources were also investigated. Some 40 traditional farming practices were examined. Finally, the role played by various farm practices in meeting the farmers' objectives -- subsistence, risk and resources management -- was studied.

Methodology

Because of the lack of transport and shortage of investigators, we carried out in-depth studies in a limited area rather than a broad-based survey. Table 7 summarizes data-gathering activities. Briefly, they include:

Group discussions: Informal discussions with farmers in four selected villages started in early 1980. District extension officials helped establish contacts. The discussions continued at an interval of 15-60 days until March 1981, past the pre-survey stage. Because of the shortage of investigators, work was concentrated in four villages.

Sample survey: A formal survey of 40 farm households in each of the four villages was conducted from September 1980 to May 1981. An equal number of households was randomly selected among small, medium, and large farmers.

Table 7: Data gathering methods

Method/Source (a)	Coverage and unit of observation	Duration (months)	Frequency of contract	Factors influencing choice of method: Limitations of structured/pure number surveys	Verification/ cross-checking	Generalization of results	In-depth under-standing	Quantification needs	Resource constraints (c)
Group discussions with farmers	4 villages	4	M(b)	x	x	x	x		
Sample survey	154 farmers	10	2-3		x			x	
Sub-sample survey	38 farmers	10	M		x			x	
Case histories	27 farmers	13	M	x		x			x
Physical monitoring	56 plots	9-13	M/s(b)	x	x	x			x
Non-farmer interviews	61 persons	6	1		x	x			x
Part-time farmers interviews(d)	40 employees of Inst.	8-10	1-3		x	x			x
Plots surveyed (part-time farmer)	65 plots	9-14	M/S		x				x
Institutional farm records	6 farms	8	M		x	x			
Simulation of small holder's system	0.8 ha.	3 sea-sons	M/S		x		x		x

a. Only the first three were confined to the selected four villages.

b. M = multiple frequency (3 - 10 visits). S = seasonal, i.e. as and when necessary.

c. Resource constraints (transportation and investigators) which prevented movement to wide areas).

d. Part-time farmers are employees of various agricultural institutions in Kilosa who also farm.

Shares in the community farm (Ujjama Shamba) was not considered in the selection. As the data from six households was later found to be incomplete, 154 were included in the final analysis.

The information collected included: household demographic features; non-land assets; land size; topography, soil type, crop and land use; crop production; food consumption patterns by season; risk management, subsistence, labour, employment, etc. Questions relating to the farmers involvement in market transactions, knowledge and use of the new technologies, and preferred characteristics of new technologies were also asked.

The survey aimed to quantify and verify information gathered during group discussions. Most heads of households were contacted twice during the survey period, although some were contacted up to as seven times.

Sub-sample survey: This survey was conducted to solve the problems of recall and quantification in the sample survey. Although aware that it could bias the results, we chose the 40 most cooperative and communicative farmers from the original sample. The questions receiving special attention were input-output details of crop production, use of family labour, and the commercialisation of farming. Two cases were eliminated from the analysis because of incomplete data.

Farmers' case histories: The long group discussions enabled us to identify some farmers willing to describe their past and present economic circumstances. Some case histories of farmers not in the four selected villages were also prepared (Table 8).

Table 8: Case histories of households in Kelosa villages

Details	Households in the villages:									
	A		B		C		D		Others[a]	
	Poor	Rich	Poor	Rich	Poor	Rich	Poor	Rich	Poor	Rich
No. of respondents	1	2	2	2	4	2	3	2	6	3
Average age of respondent	60	48	53	50	59	51	49	46	58	52
Average no. of literate respondents	0	2	0	2	1	2	1	2	2	3
No. of dependents per worker in family	4	1	3	2	44	1	5	1	3	2
Average land of family (Acre)	4	21	7	25	3	17	4	16	6	32
Average No. of occupations of family	1	4	1	3	2	4	2	5	2	5
Average No. of sources of non-farm income	0±	1	0	2	0	3	0	2	0	2

a. There were four.

44.

Monitoring of plots: Observation of a large number of plots was an important part of our field investigations, enabling us to verify information provided by the respondents and to obtain additional information on questions which the respondents could at best only partially answer. Some of these questions were too specific to be incorporated in the structured schedules.

Two types of plots were observed: those of employees of various organizations at the Ilonga complex --part-time farmers-- and those belonging to villagers. The first type of plots were observed more frequently and their cultivators were interviewed: 64 were included in the study. The plots in the second category were selected on the basis of curiosity and convenience. A large number therefore did not belong either to sample households or selected villages: 40 of the 56 belonged to villages surrounding the research station or were located en route to study villages.

Because the plots were selected largely for agronomic/physical observation and on the basis of location, socio-economic data and information on operation could not be collected for most of them. The frequency of observation also varied from plot to plot depending on the information to be gathered.

Non-farmer interviews: The interview format applied to sample farmers in selected villages was also applied to employees and students of various institutes at Ilonga, as well as to a few students of the Faculty of Agriculture, Forestry and Veterinary Sciences in Morogoro. Only those employees and students with rural backgrounds, able to communicate in English, and coming from outside the Kilosa district were included.

Part-time farmer survey: This survey included male and female employees at the Ilonga complex who cultivated some land in addition to the kitchen garden: 48 households were covered but only 40 could provide complete information. Besides structured and unstructured interviews, detailed monitoring of plots was carried out. The same questions and criteria were also used for a short survey of institutional farms. Although these farms do not face the same constraints as small farmers, they were included in order to compare farming practices.

Farming systems

Located in Kilosa district, in the western part of the Morogoro region, the four villages selected were 55 and 60 km south and 30 and 35 km north of the town of Kilosa. Agroclimatic conditions in the two zones are similar. According to the District Agricultural Development Officer (DADO), the average annual rainfall is 984 mm in the north and 1036 in the south. There are two rainy seasons: the first rains usually last from late November to early January, the second from late January to early May. The first short rains are unreliable. No irrigation is practiced.

The soils in the selected villages range from light sandy loam to thick clay with occasional alluvial deposits. The soils are generally quite fertile and suitable for a number of crops including maize, sorghum, cotton, cassava, groundnut, sisal, legumes, and a variety of vegetables. Although the area is good for rough grazing, few villagers raise cattle except for the Masai. The south zone is slightly hilly while the north is flat with occasional valley-like depressions.

Despite good crop potential, low population density, and the absence of cattle raising, only a very small part of the land is cultivated. According to the Tanzania Statistical Abstract (1970), only 5.2% of the Morogoro

Table 9. Land resources of sample households

Details	Villages in		
	South Zone	North Zone	Average
Total sample household[a]	74	80	
Average land per household (Ha.)	2.9	2.7	2.8
Population per 4 ha.	8.1	8.1	8.1
Av. land per worker (Ha.)	0.81	0.85	0.85
Av. plots per farm (No.)	3.7	3.0	3.3
Share of flat land (%)	20	53	37
Share of valley bottom land (%)	25	20	22
Households with valley bottom land (%)	38	22	30
Households with fruit trees (%)	74	41	57
Ave. fruit trees per household (No.)	12	6	9
Ave. per ha. value of non-land assets(b) (US $)	273	298	285
Share of agricultural implements in assets (%)	7	9	8

a. The original sample was 160 households. However, six households were excluded from the analysis because of inconsistent and incomplete data.

b. Non-land assets include farm implement, livestock and consumer durables.

region is under cultivation. The same figure applies to the Kilosa district although accurate statistics are not readily available. Fuel gathering is widespread and fruit trees, bushes and creepers are maintained to ensure a steady supply.

Agricultural technology: Farming systems in Kilosa are ruled by traditional wisdom. Human labour continues to be the main source of draft power. Traditional crop varieties are planted and management practices aim at security of subsistence. Few farmers are able to rent a tractor for land preparation and few use pesticides, except on the cotton crop. Although some farmers do know about the improved crop varieties developed at research stations, few plant them. Many, in fact, believe that the new technologies are only suited to large estates and parastatal farms. The lack of technologies adapted to the means and needs of small farmers is the main cause of technological stagnation.

Farm resources: Because of the absence of draft animals, the low level of mechanical technology, and the overall low economic status of farmers in the area, family labour is the key element of the farm resource base.

Land: Average family landholdings were 2.8 ha. excluding the family's share in the Ujjama farm. Eight people depended on four hectares of cultivated land, usually divided into three or more plots. In Tanzania, all lands belongs to the State and are available to anyone who wants to cultivate them. Only the permission of the Ujjama village committee is required. A family's landholdings are therefore limited by its ability to manage the land rather than the availability of capital.

Because of the south's undulating topography, more of the sample households (38%) had access to valley bottom lands than in the north (22%). The pattern of toposequential planting possible in the valleys enabled farmers to grow more than one crop a year. The greater percentage of flat land in the north (53%), however, led to more frequent use of tractors in field preparation (Table 11).

The worth of non-land assets of sample households was estimated at more than US $250 per household. This included consumer durables, livestock (goats, pigs and chickens), and farm implements. The meager investment in farm implements and tools (8% of total non-land assets) is an indication of the low level of farm technology in the area. Implements consisted of a Panga, hoe, and a few wood or iron hand tools.

Labour: In both north and south zones, families averaged 5.6 people of whom 3.3 worked. Most of the households face serious labour shortages, particularly during weeding. And so although it is illegal to hire labourers to work on private land, one quarter of the sample households -- mainly those who earned incomes from temporary or permanent work outside the villages-- employed labourers. Table 10 details the number of households having earning members, sources of incomes, and literacy rates.

Farming systems

Land use: Of the total cropped area, 13% was under perennial crops such as fruits creepers and bushes. Annual crops occupied the remainder. There were no irrigation facilities, but the use of residual soil moisture and short season crops permitted double-cropping on 15% of the land, particularly in

Table 10: Labour and related aspects of sample households

Details	Villages in		
	South zone	North Zone	Average
Total households	74	80	
Members per household	5.8	5.4	5.6
Workers per household	3.6	3.1	3.3
Dependents per worker	1.6	1.8	1.7
Households hiring labour (%)	21	28	25
Households with earning member outside (%) (a)	13	16	15
Literates per household	1.2	0.9	1.0
Household with literate member (%) (b)	58	49	53
Sources of income per household (c)	2.4	3.1	2.5

a. Family member working outside the village on temporary or permanent basis.

b. Literates include school children.

c. Includes petty trading, repair of public roads, etc.

valley bottoms. Human labour and seed were the only important inputs. Although tractors could be rented from Ujjama farms, they were used for land preparation on only 9% of the cultivated area (3% in the south and 14% in the north). Only 2% of the area was planted to new or improved varieties of crops and 1% of the land in the north was chemically fertilized. A small area (12%), particularly compound plots around houses, was fertilized with household wastes and animal droppings, but in most cases this was not intentional. Similarly, the farmers did not consider crop rotation or fallowing to be important. Most, in fact, believed that their soils were sufficiently fertile not to need additional fertilization.

Seasonal land use: The short, early rains are low and undependable. Consequently, only 33% of the total land area was planted at this time. In the valleys where better use could be made of these rains, 56% of the lands were planted while only 17% of flat, upland areas were cultivated. During the long rains, however, most of uplands were planted.

In the plots around houses, better water conservation measures were practiced --furrowing, mulching, etc-- permitting planting during the short rains. Even if these rains failed to produce mature crops, they helped smallholders bridge the gap between harvests. But because the farmers could not count on the rains to bring crops to maturity, more "salvage crops" were grown, legumes, for example, whose leaves and green pods are eaten or local maize that is eaten fresh. Mixed or intercropping --an age-old defense against weather-- accounted for 95% of short season planting as compared to 76% during the long rains.

Cropping pattern: Because land and input apportioning is difficult to determine in inter or mixed cropping, Table 12 does not detail the area

Table 11: Use of land and other resources

Details	Villages in		
	South zone	North zone	Average
Total area cropped (ha.)	250	249	
Percentage			
. Under perennial crops	18	9	13
. Planted to annual crops	82	91	87
. Planted more than once a year	16	14	15
. Prepared by tractor	3	14	9
. Sown with improved seeds	2	2	2
. Manured (a)	13	10	12
. Chemically fertilized	-	2	1
. Under pesticide (b)	9	7	8
. Under crop rotation (c)	15	10	13
. Fallowed (d)	9	11	10

a. Mostly plots around farmhouses.

b. Cotton crop where spraying is done through TCA.

c. Area in which current crops were different from last year's

d. This area is not included in the total area cropped.

occupied by different crops in each plot. For example, if maize is intercropped on 72% of the land, it is reported as such without indicating the actual proportion of the area it occupies. Only cotton and rice were monocropped.

It will be noted from the table that maize was the most important crop, covering 72% of the total area intercropped and 69% of total plots.[1] The predominance of grain crops is a clear indication of subsistence-level farming in the area.

According to labour use figures, the busiest months are February, January, March and December. Field preparation, planting, weeding, and harvesting during this time account for 67% of total labour use. Of the total work days, 41% are devoted to weeding, mainly in January, February and March, and 25% are devoted to field preparation. Harvesting is spread over nine months because a mixture of early and late maturing crops is planted during the short and long rains and different parts of the plants are harvested at different growth stage.

Farming practices

Farming practices include methods of field preparation and water conservation, fertility management, planting methods, weed management, harvesting, and postharvest techniques.

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1. According to farmers and village records, part of the area under maize has recently been shifted to other food crops, mainly grain legumes, that are included in the government's marketing system. Farmers are therefore not obliged to part with surplus produce. Prices for these crops are also higher than for government-controlled maize.

Table 12: Cropping patterns

Crop	Share of crop in:		
	Total area[a] as:		Total plots
	Sole crops (%)	part of intercrops (%)	
Maize	1	72	69
Sorghum	2	48	51
Bullrush millet	-	20	23
Rice	2	5	3
Cowpea	-	51	67
Pigeonpea	-	43	54
Beans	-	62	65
Green gram	-	28	37
Cassava		57	58
Oilseeds (b)	1	31	28
Cotton	11	6	27
Others (c)	-	40	39
Overall	17	83	100
Actual area (ha.)	73.3	359	206

a. Area under perennial crops is not included.

b. Includes sunflower, sesame, groundnut, and soybean.

c. Includes banana, sweet potato, vegetables, etc.

d. Total intercropped area exceeds 83% because the same area is counted as many times as there are crops planted on it. The same applies to the number of plots.

Field preparation and water conservation: Slash and burn was the primary method of field clearing, being practiced by 79% of the sample farmers on 71% of the land. Of the part-time farmers, 69% practiced slash and burn on 88% of their plots. Although the practice is discouraged by the government and the fires destroy fruit trees and perennial crops, it remains an important means of weed and pest control, of labour management, and --according to some farmers-- of fertilization.

Hoeing was the only method of soil preparation in over 80% of the cases. Only 11% of farmers, mainly in the north, practiced zero tillage (planting without soil preparation) on 8% of the cropped area. The part-time farmers differed from sample farmers in that they used rented tractors to prepare 40% of their plots. Only 27% of farmers did so.

Ridging was confined largely to villages in the south, covering 17% of the land, 16% of monitored plots, and 24% of part-time farmers' plots. The use of ridging was determined by soil type, slope and crop: sweet potato, vegetables and cassava were usually planted in ridged fields.

Farmers in the south were more aware of water conservation techniques. Ridging was practiced by 32% of sample farmers; planting across slopes by 21%. Mulching using weeds was followed by 32% of farmers, particularly for banana and fruit trees. According to some farmers, mulching helped increase soil fertility but they report that the practice is declining.

Soil fertility management: Farmers indicated little concern about soil fertility, believing that their land was fertile enough not to need additional fertilization. Fertility gains were therefore obtained unconsciously, as a side effect of other activities such as intercropping

with legumes and other crops, mulching, and accidental manuring.

Fallowing and crop rotation covered only 10% and 13% of the area respectively.[1] The use of chemical fertilizers was negligible.

Planting methods: Planting includes field preparation, seeding methods, seed rate and crop combinations, among other factors. As detailed in Table 13, flat planting was the most popular among sample farmers, being used on 60% of their fields. Some farmers, particularly in the south, planted in furrows for better moisture conservation during the short rains and planted on ridges during the long rains to prevent waterlogging and to channel runoff.

Sowing in rows using a hoe was the most popular method of seeding, being practiced by 89% of the farmers on 66% of the area. Broadcast seeding was very limited and confined to small-seeded crops such as sesame and millet. Tractors were used for sowing in the north only, mainly by part-time farmers. Transplanting was almost solely confined to crops like sweet potato and cassava, totalling 19% of the cropped area. Staggered planting was popular among farmers as was the practice of sowing many seeds per hole. The distance between holes was about 50 cm. Inter-row distance varied from 50 to 80 cm. depending on the crop. Depending on the availability of valley bottom lands and moisture, a second crop --sweet potato, vegetables and legumes-- was planted after the harvest.

Weed management: Weeding is the most important operation in the study area and accounts for the largest use of labour. Family size therefore determines the area cultivated. Multiple weeding was practiced by 83% of households

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1. Farmers reported that years of continuous soil preparation led to the emergence of new types of weeds. They then left the land fallow. The same argument was used against tractor use.

Table 13: Planting methods and practices

Farming methods and practices	Extent of coverage indicated by: Sample Survey: Cropped area (%)	Sample Survey: Farmers (%)	Monitored plots (%)	Part-time farmer plot (%)	Remarks
Flat planting	60	86	60	47	
Planting on ridge	27	29	26	35	
Planting in furrow*	13	17	14	18	*During short rains
Broadcast sowing*	8	10	3	5	*Mostly for small seeded varieties
Line sowing by hoe	66	89	85	76	
Sowing by tractor*	7	23	2	34	*Largely in North Zone
Transplanting	19	75	17	21	
Staggered planting	53	81	57	48	
Single seed/hole	21	29	18	30	
Multiple seeds/hole*	79	99	82	70	*3-5 seeds usuall
Mixed or intercropping	83	100	81	79	
Sole cropping*	17	21	19	21	*Cotton and rice mostly
Sequential relay cropping	15	24	7	36	
Use of improved seed	2	11	0	41	

on 62% of land area. The first weeding usually occurs 1-2 weeks after planting, the second, two week later. Depending on crop and weed growth, some farmers weeded up to four times.

Only 9% of households thinned and replanted crops in response to mid-season moisture fluctuations. None used herbicides, and pesticides were sprayed only by a few farmers on cotton crops, by arrangement of the Tanzania Cotton Authority.

How and when the crops were harvested depended on the families' needs, the food use of ripe or unripe crops, and weather conditions. The harvesting of green cobs or pods was common: multiple harvesting of grain legume leaves and cassava was carried out by all farmers, on 49% of the crop.

Postharvest practices: In the study villages, threshing was not confined to the immediate postharvest period, but was carried out whenever time allowed or food and cash was needed: 52% of the total crops produced were threshed in this way. The remainder of the crops (48%) were threshed immediately after harvest by 54% of the households. This is mainly because village cooperatives, on behalf of the National Milling Corporation (NMC), have recently insisted that crops, particularly maize, be threshed soon after harvest for sale to the NMC.

Farmers' responses and village cooperative records indicated that 83% of households sold crops to parastatal organizations through their village cooperative. About 22% of the total produce, with the exception of fruit and cassava, was sold to these agencies. Other sales of agricultural products accounted for only 7% of total crops.

Farmers stored produce for future consumption, seed, and contingency sales. Over 80% of stored products were kept under controlled conditions to avoid depredation by rats and other pests. In many cases, bundles of cobs were tied and hung in dry smoky areas.

Motivating factors

According to the study, a high degree of variation in resource base, resource use and consumption patterns characterizes the area's households. Fewer than 25% of sample households rely on annual crops as their main source of sustenance. In 22% of households they were the major source of food or income for less than five months. Perennial crops, including fruit trees, sustained close to 64% of household for 1-4 months. Despite village committee restrictions, food and fuel gathering from common properties --hills, forests and rivers banks-- helped sustain some 40% of farmers for up to four months. Wage employment, particularly road repairs, helped 23% of them for 1-2 months. Equally important was petty trading, practiced by 21% of families for up to two months.

This same diversity can be found in the reasons why farmers followed different farming practices although most related to security of subsistance, risk minimization, and resource management. They are summarized in Table 14. Only those reasons given by 30% of farmers are included.

New technologies: The most important features of new crop varieties perceived by farmers are insect and disease resistance (61% of farmers), storing qualities (15%) and high yields (12%), a clear indication of the importance of crop protection, both before and after harvest. Some farmers stated, in fact, that high yields will be of no assistance unless the entire

Table 14: Motivating factors

Practices and (%) farmers following them	Farmers attempting management of (%)[a]: Subsistence through:		Risks/hazards due to:				Resource scarcity of:		
	Continuity/security of food	Food diversity	Moisture	Weeds	Pest/disease	Erosion/fertility	Labor	Land	Capital (cash)
Dominance of food crops (100)	100	71	35	-	45	-	-	-	38
Planting differentiated by (short/long) rains and topography	39	48	70	-	-	-	48	36	-
Slashing and burning (79)	-	-	-	47	32	27	92	-	39
Hoeing (87)	-	-	27	-	-	-	37	-	89
Staggered planting (81)	32	-	62	-	43	-	35	-	-
Multiple seed/hole (99)	-	20	45	-	58	-	18	-	-
Intercropping (100)	28	39	58	17	67	-	22	30	-
Multiple weeding (83)	-	-	42	62	-	-	-	-	-
Weed burying (43)	-	-	33	-	-	49	-	-	-
Mulching (32)	-	-	48	-	-	39	-	-	-
Crop rotation (32)	-	42	35	12	22	46	-	-	-
Harvest of green cobs/leaves (100)	48	37	58	-	47	-	-	-	-
Threshing in instalments (98)	56	-	-	-	-	-	62	-	-
Storage in cobs (89)	17	12	-	-	85	-	-	-	-
Ridging/planting across slope (30)	-	-	37	11	-	74	-	-	-

a. Because of multiple responses by individual farmer the total may exceed 100%

crop can be harvested and protected. Drought resistance and multiple use of crop were cited by respondents as desirable characteristics in 8% and 4% of cases respectively.

Implications for future research

The purpose of this study was to better understand the traditional farming system in order to identify relevant research issues. The findings show that:

1. Kilosa is characterized by considerable variation in rainfall and topography. Just as farmers try to make maximum use of this environmental diversity, the agricultural research strategy should be multi-focused. Emphasis on a limited number of annual crops may prove inadequate.

2. Smallholder farming systems operate under severe constraints. Even the most promising technologies may therefore be unsuited to the farmers' needs and means. This once again points to the need for low-cost, relevant technologies

3. The development of these technologies should include regular programs of experimentation and testing in farmers' fields.

4. In order to be accepted, technologies will need to take into consideration the constraints and risks faced by the farmers.

5. Even if their economic returns are low, marginal technological improvements that address specific constraints may prove more valuable than large-scale innovations that do not get applied at farm level.

PERSONNEL TRAINING AND DEVELOPMENT

In Tanzania, as in many other developing countries, the shortage of qualified scientists is a major handicap to the pursuit of research. For that reason, the agricultural research program emphasized the development and training of Tanzanian researchers in modern crop research and production techniques, as well as in research planning and administration.

When the training efforts began in 1973-74, it was projected that a corps of Tanzanian scientists capable of taking full responsibility for the project would be available by 1985. That goal has almost been achieved.

Training was carried out at three levels:

1. Apprenticeship under highly trained and experienced contract staff at field stations in Tanzania;
2. Short-term in-service training at an international agricultural research centre;
3. Degree training at an internationally-recognized university in preparation for a specific assignment within the research scheme.

Since 1973, 33 Tanzanians have undertaken degree programs; some 80 have followed short-term, in-service programs at international research centres; and many others have trained under the apprenticeship program. When all the degree trainees return from their studies in 1983, the cadre of trained Tanzanian scientists should be adequate to continue the food crop research program (participants are listed in Appendix 4).

The success of the training program is without doubt the most important contribution made by the project to increasing food crop production in Tanzania.

Recommendations

1. Both the Ministry administrative officers and contract field staff should work closely with participants planning M.Sc. and Ph.D. degree programs to insure that the study program and thesis subject are relevant to Tanzania's agricultural problems.

2. Participants working on post-graduate degrees should have some knowledge of the positions for which they are preparing or competing, and should be kept abreast of developments at home while they are completing their studies.

3. Tanzanians returning to programs after degree training must be given responsibility for appropriate areas of the program, and should receive the funding and material support that will make it possible for them to succeed.

4. Attention must be given to upgrading the housing facilities, furnishings and recreational facilities at Ilonga so that staff and their families are happy to reside at the Institute.

5. Tanzanians returning from training should serve the project for a minimum of three years after an M.Sc. degree and five years after a Ph.D. An agreement to this effect should be signed before proceeding on training.

Appendix 1

CALENDAR OF EVENTS, CONTRACT STAFF, AND LIST OF EQUIPMENT PURCHASED

CALENDAR

Date	Action	Responsible Organisation
Dec. 1973	First contract signed between USAID and IITA	USAID/IITA
Nov. 1973	Arrival of maize agronomist and maize breeder	Contractor
Dec. 1974	Arrival of legume agronomist	Contractor
1974-75	Initiation of training program	Contractor
Oct. 1975	Arrival of project coordinator and legume breeder	Contractor
1976	Second contract	USAID/Contractor
1977	First project paper amendment	USAID/Contractor
1980	First extension	USAID/Contractor
1981	Second extension	USAID/Contractor

CONTRACT STAFF

Project Coordinator - P.C. Duffield, August 75 - September 80

Acting Project coordinator and legume breeder/agronomist - M. Price, October 80 - October 82.

Maize breeder - D.W. Sperling, November 73 - September 80.

Appendix 1 (cont.)

Maize agronomist	-	M. Colegrove, November 73 - November 75
	-	J.A. Deutsch, February 77 - October 82
Legume breeder	-	P.N. Patel, May 75 - July 79
	-	B.B. Singh, May 79 - September 81
Legume agronomist	-	F.E. Brockman, December 74 - November 78
Sorghum breeder	-	S.Z. Mukuru, February 78 - September 80
Production economist	-	N.S. Jodha, May 79 - June 81
Technical specialist	-	C.B. Buyyala, May 80 - October 82

EQUIPMENT PURCHASED

1974 - 75

- sprinkler irrigation system
- farm tractors
- disk plow, harrow, planter-fertilizer
- farm wagons
- Jeep Wagoneers and bicycles
- platform scale
- laboratory equipment: hydrothermographs, microscope, culture chamber, refrigerators.

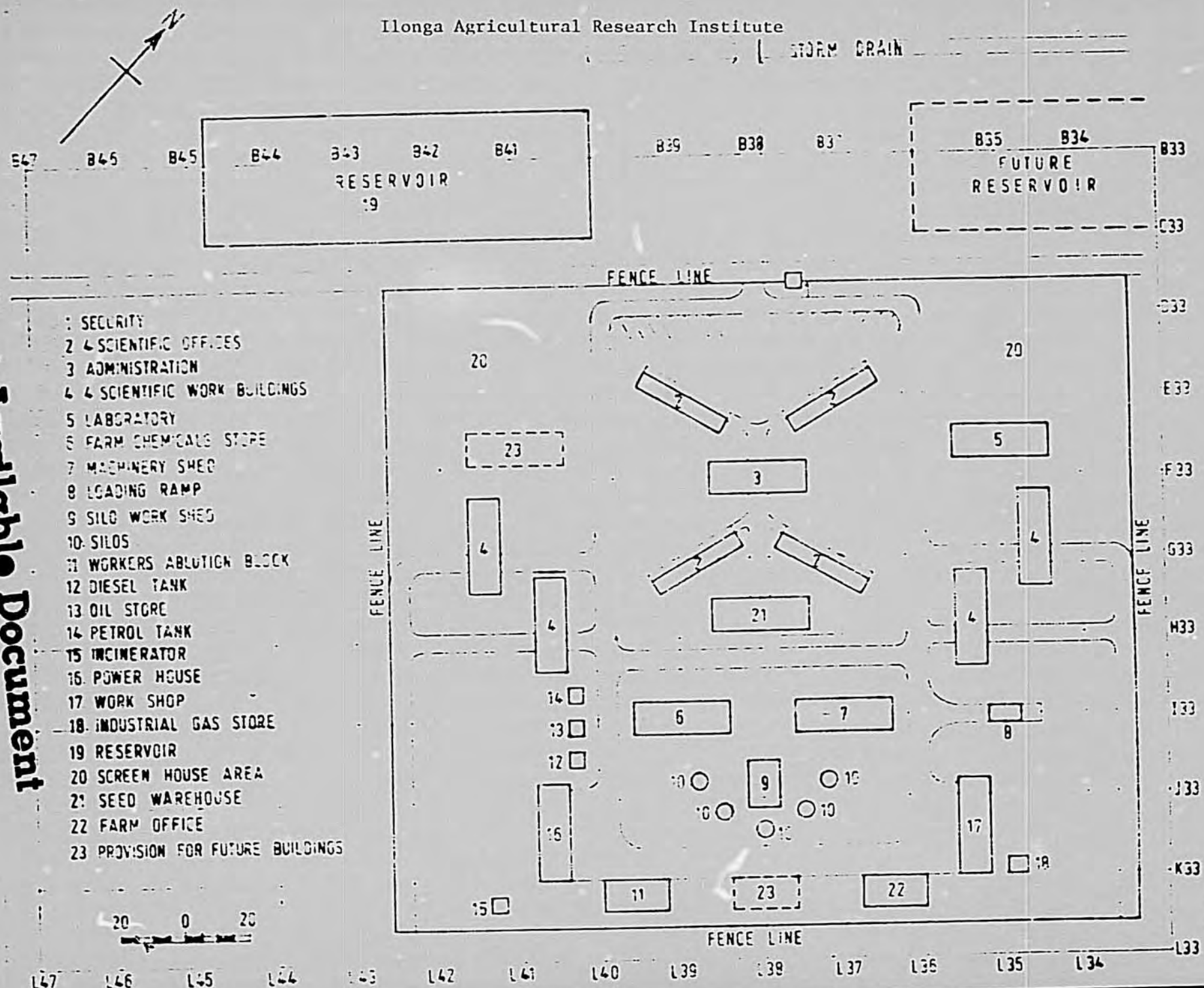
1978 - 82

- one D7E bulldozer, and one D5 bulldozer;
- one motorgrader;
- one bucket loader;
- one backhoe;
- four dump trucks;
- one truck-tractor;
- one truck-tractor wrecker;
- one concrete mixer;
- one motorized road roller;
- one shop equipment van;

Appendix 1 (cont.)

- compressors and generators;
- nine tractors;
- scrapers, land levellers, disc harrows, mould board plow, fertilizer spreaders and applicators, furrow and ridging implements, bed formers, cultivators, rotary cutters and shredders, seed dryers, threshers, and cleaners, planting equipment;
- six motorcycles;
- eight Land Rover station-wagons, four Land Rover pick-up trucks;
- laboratory and workshop equipment;
- water tankers and fork lift;
- tractor-mounted and hand sprayers.

Ilonga Agricultural Research Institute



Best Available Document

Appendix 2

PUBLICATIONS

Annual Reports

1. IITA/USAID/Tanzania Project, 1976. Annual Progress Report.

2. IITA/USAID/Tanzania Project, 1977. Annual Progress Report.

3. IITA/USAID/Tanzania Project, 1978. Annual Progress Report.

4. IITA/USAID/Tanzania Project, 1979. Annual Progress Report.

5. IITA/USAID/Tanzania Project, 1980. Annual Progress Report.

6. IITA/USAID/Tanzania Project, 1981. Annual Progress Report.

Mid-Year Reports

7. Mid-Year Report, 1978. Agricultural Research Project 107. IITA/USAID/Tanzania Project (CIMMYT and ICRISAT Participating).

8. Mid-Year Report, 1979. Agricultural Research Project 107. IITA/USAID/Tanzania Project (CIMMYT and ICRISAT Participating).

9. Mid-Year Report, 1980. Agricultural Research Project 107. IITA/USAID/Tanzania Project (CIMMYT and ICRISAT Participating).

10. Mid-Year Report, 1981. Agricultural Research Project 107. IITA/USAID/Tanzania Project (CIMMYT and ICRISAT Participating).

11. Mid-Year Report, 1982. Agricultural Research Project 107. IITA/USAID/Tanzania Project (CIMMYT and ICRISAT Participating).

Other

12. Couper, D.C. and Craig J.G.H. Report and Proposals to National Agricultural Research and Training Institute of Tanzania.

13. Karel, A., Ndunguru, B., Price, M., Semuguruka, G., and Singh B.B. Bean production in Tanzania. Regional workshop on potential for field beans in Eastern Africa, Blantyre, Malawi, 1979.

14. IITA. Report on the Development of the Ilonga Research Station. 1977.

15. Ministry of Agriculture, Crop Development Division. Maize Production Handbook. 1977.

16. Grain Legume Improvement Report (1975-78) (in cooperation with IITA and USAID, Tanzania).

17. Cowpea Production Fact Sheet, 1981.

18. Price, M., Asenga, J., and Machange, F. Improved cultivation of cowpea in Tanzania. Ministry of Agriculture Booklet No.1. 1982.

19. Growing cowpeas in the Morogoro Region (Tanzania). Ministry of Agriculture Booklet No.1. 1982.

20. Price, M., Asenga, J., and Mamkwe, C. Evaluation of five insecticides on insect damage and yield of cowpea in Tanzania. Crop Research Bulletin (Tanzania), 1981.

21. Price, M., Chambuya, R., and Machange, F. Insecticide evaluation and timing of spray application for insect control in cowpea in Tanzania. Submitted to Tropical Grain Legume Bulletin. 1982.

22. Price, M. and Dunstan, W.R. The effect of four insecticides on leaf miner damage of cowpea in Tanzania. Tropical Grain Legume Bulletin, (27): 23-26. 1983.

23. Price, M., Singh, B.B. and Mamkwe, C. The role of early maturing cowpea varieties in Tanzania. Tropical Grain Legume Bulletin, (27): 8-11. 1983.

24. Singh, B.B. A miniature mutant of cowpea. Tropical Grain Legume Bulletin, (22): 13-14. 1980.

25. Wild cowpeas of Tanzania. Tropical Grain Legume Bulletin, (22): 10-14, 1981.

26 Singh, B.B. and Marrett, P.J. Leaf miner -- A new pest of cowpeas. Tropical Grain Legume Bulletin, (21): 15-17. 1980.

27. Singh, B.B. and Mligo, J.K. Yield stability of newly developed cowpea breeding lines, Tanzania. Crop Research Bulletin, (1): 1-4. 1981.

28. Free nodulation of local soybean lines in Tanzania. Crop Research Bulletin, (1). 1981.

29. 'TK-1' and 'TK-5' --New varieties of cowpea of Tanzania. Tropical Grain Legume Bulletin, (22): 14-16. 1981

30. Singh, B.B., Mligo, J.K., Marenge, E.T., and Ibrahim, J.A. Sources of resistance to Phytophthora stem rot in cowpea. Tropical Grain Legume Bulletin, (25): 17-20. 1982.

Appendix 3

EVALUATIONS

Every two years USAID evaluates the projects funded to determine whether or not the projects' aims and objectives remain valid and to monitor progress.

Three such evaluations of the IITA/USAID Agricultural Research Project were carried out: in 1976, 1978, and 1981. In addition, an evaluation was carried out in 1977 on behalf of the Tanzanian Ministry of Agriculture.

These evaluations' main conclusions and recommendations are summarized below. Complete reports are on file at the USAID Mission Office and IITA's offices in Dar es Salaam.

1976

The USAID's evaluation team, composed of a plant breeder, an agronomist an experienced research administrator and a team leader, reviewed the project's research, strategy, and methods, its personnel resources and administration and its goals and purpose. It concluded:

"After considerable delay, the project was started up in 1973, short of programmed inputs but with a scientifically sound approach. Due to the astuteness and good fortune of the scientists, the project has produced highly significant outputs in its first two years' operation. The project is progressing well in spite of the lack of continuity in the maize agronomist position."

1977

The Director of the Crop Development Division, Mr. David D. Masanja, requested through Dr. P.C. Duffield --then project coordinator-- that IITA

provide an outside consultant who would recommend to the Ministry of Agriculture means of maximizing the returns from its limited resources and explain why the research section's output was slower than expected. After five weeks of study and a review of agricultural research in the country, Dr. H. Albrecht recommended that:

- Research staff be relieved of responsibilities for the production phase of institute or station programs.
- The Ministry should state its research policy more clearly, tying it in with national policies, and should ensure that research workers are kept informed of the Ministry's mandates.
- Budget disbursements should fully protect the institutes' research enterprises, freeing it from competition with production for funds, personnel, equipment, and space.
- Adequate attention be given to strenghtening scientific disciplines complementing the research and production programs. Of special importance are plant pathology, entomology, plant physiology, and soil fertility.
- Training of research officers at the graduate level should forge ahead regardless of the fact it could possibly aggravate the staff shortage in the short run.
- Training should be provided to upgrade the skills of junior staff, especially mechanics, field, laboratory and maintenance workers.
- Spare parts should be systematically reordered to avoid the problem of inoperative equipment.

1978

An evaluation carried out on behalf of USAID by an agricultural information specialist, a food legume agronomist and a maize breeder, as well as a team leader, concluded that the project was progressing toward the realization of its broad objective of assisting the government of Tanzania achieve food self-sufficiency.

It also noted the following significant achievements:

1. One composite variety of one maize hybrid was developed, released to seed farms and distributed to small farmers. Breeders' stock of three other improved composites was provided to seed farmers.
2. A maize production handbook was written for extension personnel and small farmers.
3. Three varieties of food legumes were developed and released to seed farms.
4. Information necessary for the production of a food legume handbook has been obtained and a handbook is to be printed during 1978.

The project objective of providing training for Tanzanian personnel in order that they might successfully direct and conduct a national research program, is well underway. Although the program is slightly behind schedule the team commends the Tanzanian government, contract expatriates, and USAID/Dar es Salaam for their accomplishment to date. The team recognized the need to expand the training of Tanzanians to include other disciplines that are essential to a balanced research program.

Visits to on-and off-station trials made it obvious that Tanzania's two major agricultural problems are plant disease and insects. Therefore, the team strongly recommended that the project be amended to provide leadership to and training of Tanzanians in this vital speciality.

Although a significant number of small farmers were planting the new varieties and following the technical production recommendations developed for maize and legumes, the team recommended that the project be expanded to include an expatriate extension agronomist specialist with four Tanzanian counterparts in order to establish better communication between research and extension staff.

The team advanced 17 specific recommendations, summarized below. Recognizing that the implementation of these recommendations would require considerable time and effort on the part of all parties concerned; the team recommended that the economist assume the responsibility of Field Team Leader.

Summary of recommendations

A. Implementation of Project

Training

1. Major emphasis should be placed on the selection and training of a greater number of Tanzanians and, when feasible, steps should be taken to shorten the time lapse between selection and completion of formal training.

2. The project's training program should be expanded to provide multi-disciplinary support for the National Research Program by providing academic training for Tanzanian personnel in disciplines such as entomology, plant pathology, plant physiology, agricultural engineering, weed control, agricultural economics and soils.

Staffing

1. The production economist to be stationed at Ilonga should have sufficient administrative experience and training to enable him to assume the added responsibility of Team Leader.

2. The position of an expatriate plant protection specialist should be created.

3. High priority should be given to the creation of a position of expatriate extension agronomist specialist with a minimum staff of four Tanzanians responsible for establishing and maintaining effective communication between researchers, District and Regional Agricultural Development Officers (RADO and DADO) and their respective staffs.

4. A second program should be created by posting a legume breeder/agronomist at the Lambo Estate.

Research facilities and programs

1. High priority should be accorded to the completion, by the end of 1981, of the approved plan for the much-needed development of the Ilonga ARI.

2. Libraries of all participating ARIs should be stocked on a continuing basis with pertinent scientific publications.

3. Following the Tanzanian government's decision to initiate a hybrid maize breeding program, this program should be launched during the 1978-79 cropping season.

4. Village trials should only be conducted in major ecological areas and the number of trials should be limited so they can be adequately supervised and carried to completion.

B. Support to project

Training

1. Greater use should be made of Kilombero ARI personnel and facilities for maize and legume research, and qualified Tanzanian personnel should have greater opportunities to participate in the project's training program.

Staffing

1. Necessary action should be taken to transfer administrative responsibilities for project research to Tanzanian personnel.

2. DADOs and RADOs should be involved in planning seminars and workshops for extension personnel.

Research facilities and programs

1. A substation of the Lyamungu ARI should be developed and established on the Lambo Estate for research on beans/phaseolus.

2. A detailed soil survey should be made at each participating ARI and their sub-stations.

3. The Kilombero ARI should be seriously considered as the possible location for the National Centre for Rice Research.

4. Participating ARI budgets should contain line items for research approved by the National Coordinating Committee to ensure that funds are sufficient to carry out the research program.

1981

Under the leadership of David Redgrave of Colorado State University, the USAID evaluation team assessed the project's progress and constraints in order to provide a basis for the design and implementation of a proposed farming systems research project (621 - 0156). To prepare for the new project, this evaluation also reviewed and delineated those components of the present project that should be considered in the development of the second phase of agricultural research extension services.

At the input level the evaluation team recommended, in order of priority, that:

1. Resources be reallocated so that research results can be compiled in publishable form, facilitating the dissemination of relevant information to farmers through extension services.

2. Station development at Ilonga, be expedited. A critical review needs to made of the construction of residential facilities including provisions for social, health, and school facilities.

3. Donor assistance be provided to plan, organize, and administer an in-country training program for researchers and extension personnel in order to promote the dissemination of research results to villages and farmers.

4. Management be modified at Ilonga to promote coordination among various crop research programs, research planning, and programming by Tanzanian scientists, and ensure rapid equipment procurement, staff recruitment, and training of support staff.

5. Greater attention be given to properly maintaining the genetic stock, particularly of indigenous materials.

6. USAID and the Ministry of Agriculture increase their support and monitoring of research activities, including station development at Ilonga.

At the output level it was concluded that:

1. Research facilities appear to be inadequate for a station accorded the important role of being a major food crop experimental station.

2. Planning and coordination among scientists at the station has been lacking because of inadequate administration.

3. While some new high-yielding maize varieties have been developed and tested, less has been accomplished with local varieties. The premature release of new varieties should be avoided.

4. The sorghum breeding program is screening several high-yielding, early-maturing, improved varieties but due to the lack of qualified Tanzanian staff, no off-station agronomy trials have been conducted.

5. No research has been conducted on millet because of a lack of qualified scientific staff.

6. The grain legume program has developed several new varieties using both indigenous and exotic lines. New varieties and cultural practices are being tested in farmers' fields in all zones.

7. It is uncertain whether recommended cultural practices are passed on to extension workers for diffusion to farmers.

8. Since 1976, training has been provided for 17 agricultural scientists. By 1983, 39 will have been trained. Six of the 17 returned participants have left the project. Little training has been provided in supporting disciplines and in technical fields.

9. In-service training programs have not been undertaken on a regular and formal basis.

10. Linkages with extension and other supporting institutions at the regional, district, and village level are weak or non-existent.

11. The feedback system between researchers and farmers is weak and the village trial program has not been adequately supported.

At the <u>purpose level</u> it was concluded that:

1. Tanzanian scientists who have been trained are not sufficiently involved in research planning and administration.

2. Other than in the farming systems research program and in the village trials, there is no regular feedback from villages to ensure an awareness of farmer problems.

3. Because of the insufficient number and type of trained Tanzanians available to the project, continued donor assistance will be required to sustain effective research in food crops. This assistance should make greater use of short-term consultancies.

4. Seed farms have not been supplied with an adequate amount of seed of improved high-yielding varieties of maize, legume, and sorghum.

5. Physical facilities, machinery, and equipment are not sufficient to fully support the research programs.

6. Land presently used for research has not been properly graded and irrigated.

7. A national crop research coordinating committee has been established but if does not yet make an effective contribution to annual national research plans

8. Tanzanian government contributions to maize research have increased annually, but the total research effort at Ilonga and other sub-stations has not been sufficiently supported.

The evaluation concluded that the project's goal of "developing the capacity to plan, organize and administer research for maize, legumes and sorghum/millets" has only been partly achieved. Nonetheless the project has helped to lay a firm foundation for a strong food crop research program in Tanzania.

At a goal level, it was concluded that due to the weak institutional linkage among all components of the agricultural service and support system, villages and farmers have not fully benefited from this project. Food crop research has benefited considerably, however, especially in the areas of human resource and station development.

The lesson learnt which has implications for this and future projects is that future assistance to food crop research must be based on an assessment of the recommendations generated by research in Tanzania and elsewhere and which can be disseminated to farmers in production packages. Assistance to agricultural extension services in packaging the pertinent research results for dissemination to farmers must now be given top priority.

Appendix 4

PARTICIPANTS SENT FOR DEGREE TRAINING

Station/ Program	Name	Discipline	Degree completed	Degree completion date
Legume Program	H.K. Leyna	Breeding		Ph.D. (1983)
	J.K. Mligo	"		M.S. (1982)
	C.A. Kuwite (Ms)	Pathology	M.S.	
	F.Z. Machange	Agronomy	M.S.	
	F.F.A. Mbowe	"	M.S.	
	J.A. Asenga	"	M.S.	
	A.E.M. Temu	"	M.S.	
	C.S. Muhalet (Mrs. Madata)	Breeder/ Pathology	M.S.	
	E.M. Mbaga	Agronomy	M.S.	
	R.I. Chambuya	Entomology	M.S.	
	E.M.K. Koinange	Breeding	M.S.	
	E. Kaiiriti	Breeding		B.S. (1982)
	M. Mgonja (Mrs.)	Breeding/ Agronomy		M.S. (1983)
	J. Kabissa	Entomology/ Agronomy	B.S.	M.S. (1983)
Maize Program	A.S. Moshi	Breeding	Ph.D.	
	T.A. Mtui	Agronomy	M.S.	
	N.G. Lyimo	Breeding	M.S.	
	Z.O. Mduruma	Breeding		M.S. (1983)
	C.D.K. Kitundu	Agriculture	B.S.	

Station/ Program	Name	Discipline	Degree completed	Degree completion date
Maize Program	W. Mgema	Agronomy		B.S. (1982)
	P. Matowo	Agronomy	M.S.	
	B. Lontu	Breeding		M.S. (1983)
	S. Haule	Agronomy	B.S.	
	C.J. Ndunguru	"	B.S.	
Sorghum Program	C.M. Mitawa	Agronomy	M.S.	
	H.M. Saadan	Breeding		M.S. (1982)
	S.F. Lubinza	Gen. Agric.		B.S. (1982)
	E.S. Monyo	" "		B.S. (1982)
	C.S. Mushi	Agronomy	B.S.	
	M.M. Mkuchu (Mrs)	"	B.S.	
Economics Program	M. Polepole			M.S. (1983)
Service Station	E.E. Mlay	Farm Management	M.S.	
	N.R.C. Katuli	Agric. Mechanic	B.S.	