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Abstract: This report of the adoption of maize production technologies in Southern Tanzania forms part of a larger study to evaluate the impact of maize research and extension throughout Tanzania over the past 20 years. Using a structured questionnaire, researchers and extension officers interviewed farmers in June–November 1995. Maize is the major food and cash crop in the study area. Farmers have easily adopted improved maize technologies that required little cash (row planting, weeding), but only a few farmers had adopted the more costly technologies such as fertilizer, herbicide, and disease control measures. Additional efforts by research and extension are important for increasing the adoption of improved maize technologies. Research should give high priority to developing varieties that yield well, tolerate drought stress, and resist field pests. More research should be conducted on soil fertility and conservation practices, because the use of chemical fertilizer is likely to remain low in the foreseeable future. Many respondents in the sample were unaware of improved maize technologies, especially the use of fertilizers, use of ox-drawn implements, herbicide use, and disease control measures. Farmers' low rate of contact with the extension service and agricultural research may be a constraint on the use of these technologies. Communication between farmers, research, and extension could be improved through on-farm trials and field days. Poor infrastructure and untimely delivery of inputs were also important constraints on the adoption of improved maize technologies in Southern Tanzania. Policy makers should support the promotion of an efficient marketing system (especially rural access roads) for outputs and inputs. Such a system would offer higher maize prices to farmers and reduce the cost of fertilizers. Also, studies on the economics of fertilizer use should be undertaken, especially now that input and output markets have been liberalized. Formal credit is not available to farmers, although providing credit to farmers becomes incresaingly important with rising input prices. The formal credit system needs to address the credit problems faced by small-scale farmers, especially their lack of knowledge (information) of formal credit systems.

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Acronyms and Abbreviations

CAN	Calcium ammonium nitrate
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
DALDO	District Agricultural and Livestock Development Officer
DIVEO	Division Extension Officer
DRT	Department of Research and Training
FSR	Farming systems research
ICW	Ilonga Composite White
Masl	Meters above sea level
MAC	Ministry of Agriculture and Cooperatives
MSV	Maize streak virus
NMRP	National Maize Research Programme
OPVs	Open pollinated varieties
RALDO	Regional Agricultural and Livestock Development Officer
REDSO/ESA	Regional Economic Development Services Office for East and Southern Africa
RIDEP	Regional Integrated Development Programme
SA	Sulfate of ammonia
SACCAR	Southern Africa Centre for Coordination of Agricultural Research
SARI	Selian Agricultural Research Institute
ST	Streak resistant
TANSEED	Tanzania Seed Company
TFA	Tanganyika Farmers' Association
TMV	Tanzania maize variety
Tsh	Tanzanian Shillings
UCA	Ukiriguru Composite A
ULVA	Ultra Low Volume Applicators
USAID	United States Agency for International Development
VEO	Village Extension Officer

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Executive Summary

Maize provides 60% of dietary calories and more than 50% of utilizable protein to the Tanzanian population. The crop is cultivated on an average of two million hectares, which is about 45% of the cultivated area in Tanzania. Recognizing the importance of the maize crop to the lives of Tanzanians, the government has committed human and financial resources to developing the industry. A National Maize Research Programme (NMRP) was started in 1974 with the broad objective of developing cultivars suitable for major maize-producing areas. The NMRP and maize extension services have made a considerable impact in increasing food production.

This report forms part of a larger study to evaluate the impact of maize research and extension in Tanzania over the past 20 years. The Department of Research and Training (DRT) conducted the study in collaboration with the Southern Africa Coordination Centre for Agricultural Research (SACCAR) and the International Maize and Wheat Improvement Center (CIMMYT). To increase data validity and reliability, researchers and experienced extension officers used a structured questionnaire for interviewing farmers. Interviews were conducted in all seven agroecological zones of the country between June and November 1995. This report covers survey findings in the Southern Zone, which includes Mtwara, Lindi, and part of Ruvuma regions.

Household heads in the sample had a mean age of 47 years with an average of five years of formal education. Sample households had about five family members comprising at least one male, two female adults, and two children. Land was not a constraint, and the average farm size was 6.5 acres. Livestock ownership was not common. Hand hoes were the major farm tool.

Maize is the major food and cash crop in the study area. Most farmers (77.1%) intercropped maize with legumes, although 22.9% grew maize as a single crop. Recommended varieties for the Southern Zone are Ilonga Composite White (ICW), Tuxpeño, Staha-St, Kito, and Katumani. Most farmers grew CG4141 (61.8%), and about 36% of the sample farmers grew UCA-St. UCA-St was the preferred variety because of its high yield and tolerance to maize streak virus (MSV).

Land preparation, which was done mainly by hand hoe, depended on the onset of the rains in each zone. Maize was most often planted in rows at the recommended spacing. Farmers weeded their maize plots at least twice. Only 3% of the farmers used inorganic fertilizer. Farmers' main reasons for not using fertilizer were that they had no need for it (52.6%) and lacked cash to purchase it (21.1%).

About 49% of farmers said their maize was affected by vermin, 30% had problems with cutworms, and 21% said they had problem with stalk borers. Only 14% of the farmers controlled vermin. Fourteen percent of the farmers regarded maize streak virus as the most important disease.

Most farmers selected maize seed in their homes (82%), and large cobs with undamaged and mature grain were the criteria for seed selection.

None of the farmers had obtained credit, and all reported that credit was not available. Farmers regarded bureaucratic obstacles (37%) and lack of knowledge about credit (14%) as the major constraints to obtaining credit. Most farmers had received information on improved maize practices such as improved maize seed,

planting method, weeding, pest management, and storage. Less information had been disseminated about fertilizer, herbicides, ox-drawn implements, and disease control methods. The most important sources of information on maize practices were research, extension, and other farmers.

Erratic rainfall and declining soil fertility is increasing the risk of maize production in Southern Tanzania. Farmers easily adopted technologies that required little cash. For example, all sample farmers adopted row planting, mainly because it was not costly and had the added advantage of simplifying weeding. Most farmers also adopted the recommended weeding practices. Only a few farmers had adopted the more costly technologies such as fertilizer, herbicide, and disease control measures.

Large areas of Southern Tanzania are prone to drought that can destroy the maize crop or reduce yields and increase stalk borer attacks. Research should give high priority to developing or screening varieties that yield well, tolerate drought stress, and resist field pests. Research to identify measures for controlling storage pests should also be undertaken.

Most improved varieties are fertilizer responsive and economic yields are usually obtained after fertilizer application, but the use of fertilizer is constrained by its high price and unavailability. Policy makers should support the promotion of an efficient marketing system for outputs and inputs, which would offer higher maize prices to farmers and reduce the cost of fertilizers. More research should be directed to soil mining, supplementation of chemical fertilizer with different sources of organic manure, crop residue management, and soil conservation. Additional soil fertility research will be particularly relevant because the use of chemical fertilizer is likely to remain low in the foreseeable future because of its rising price. Also, studies on the economics of fertilizer use should be undertaken, especially now that input and output markets have been liberalized.

Both research and extension are important for adoption of improved maize technologies. Many respondents in the sample were unaware of improved maize technologies, especially the use of fertilizers, use of ox-drawn implements, herbicide use, and disease control measures. Farmers' low rate of contact with the extension service and agricultural research may be a constraint on the use of these technologies. Research and extension must strengthen the flow of information to farmers. Communication between farmers and extension could be improved through on-farm trials and field days.

Poor infrastructure and untimely delivery of inputs were also important constraints on the adoption of improved maize technologies in Southern Tanzania. Investment in infrastructure, especially rural access roads, will enable inputs to be transported to farmers more efficiently and at lower transport costs, resulting in lower input prices.

Formal credit is not available to farmers. With rising input prices, providing credit to farmers becomes increasingly important. In collaboration with the government and other stakeholders, the formal credit system needs to address the credit problems faced by small-scale farmers, especially their lack of knowledge (information) of formal credit systems. Cumbersome bureaucratic procedures for obtaining credit should be amended. The formation of farmer credit groups should be encouraged, because lending to groups tends to reduce transactions costs and improve the rate of loan recovery.

Adoption of Maize Production Technologies in Southern Tanzania

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1.0 Introduction

1.1 Motivation and Objectives for this Study

Maize is the major cereal consumed in Tanzania. It is estimated that the annual per capita consumption of maize in Tanzania is 112.5 kg; national maize consumption is estimated to be three million tons per year. Maize contributes 60% of dietary calories to Tanzanian consumers (FSD 1992, 1996). The cereal also contributes more than 50% of utilizable protein, while beans contribute only 38% (Due 1986). Maize is grown in all 20 regions of Tanzania. The crop is grown on an average of two million hectares or about 45% of the cultivated area in Tanzania. However, most of the maize is produced in the Southern Highlands (46%), the Lake zone, and the Northern zone. Dar es Salaam, Lindi, Singida, Coast, and Kigoma are maize-deficit regions. Dodoma is a surplus region during good growing years, and in years following a plentiful rainfall the region is the number one supplier of maize to Dar es Salaam (FSD 1992; Mdadila 1995).

Maize is not only a staple crop in surplus regions but a cash crop as well. For instance, in the Lake zone, maize competes aggressively with cotton for land, labor, and farmers' cash. Realizing the importance of the maize crop to lives of Tanzanians, the government has been committing human and financial resources to develop the industry. Research and extension efforts in maize started in 1960. Breeding efforts in the 1960s resulted in the release of Ukiriguru Composite A (UCA) and Ilonga Composite White (ICW). Between 1973 and 1975 Tanzania experienced a severe food shortage because of drought and the "villagization" campaign, which displaced farmers (Maliyamkono and Bagachwa 1990). The food crisis prompted the nation to launch several campaigns with the objective of food self-sufficiency, including "agriculture for survival" (*kilimo cha kufa na kupona*). The country also initiated a maize project in 1974 with assistance of the U.S. Agency for International Development (USAID). The project's objective was to promote maize production in pursuit of food self-sufficiency. The National Maize Research Programme (NMRP) was launched, with the broad objective of developing cultivars suitable for major maize-producing areas.

The NMRP and maize extension have made a considerable impact in increasing food production. A study was conducted to evaluate that impact during the past 20 years. Conducted by the Department of Research and Training (DRT) in collaboration with the Southern Africa Coordination Centre for Agricultural Research (SACCAR) and the International Maize and Wheat Improvement Center (CIMMYT), the study included the nation's seven agroecological zones. The study was conducted between June and November 1995. This report covers survey findings from Southern Tanzania. The objectives of the survey were to describe the maize farming systems in the Southern Zone, evaluate the adoption of improved maize production technologies, and, in light of the findings, identify future themes for research.

1.2 The Study Area

Southern Zone comprises Mtwara and Lindi regions and Tunduru District in Ruvuma region (Figure 1). The zone covers 103,478 km^2, including 17,750 km^2 for Mtwara, 66,950 km^2 for Lindi, and the remaining 18,778 km^2 for Tunduru District. About two million people live in the zone. Mtwara region has more than 50% of the population, as evidenced by its high population density of 53 persons/km^2 compared to 10 persons/km^2 for Lindi and Tunduru.

Southern Tanzania is characterized by mixed farming systems whose elements change with variations in climate and environment. Southern Zone has two main seasons: a humid and hotter wet season (November–May) and a cooler, less humid dry season (June–October). Mean annual rainfall ranges from about 800 mm in inland and central areas to 1,200 mm in the hills and plateaux near the coast. Soils are variable, ranging from the deep, well-drained, but not very fertile sandy soils of the sedimentary zones to the deep, well-drained, and somewhat more fertile red clay soils of Nachingwea and Masasi Districts (FSR 1992).

The most important crops grown in this zone are starchy staples (sorghum, maize, rice, cassava, and millet), leguminous food crops (pigeon peas, cowpeas, *fiwi* beans, green gram, and bambara nuts), vegetables and oilseeds (groundnuts, sesame, soybeans, sweet potato, onion, and tobacco) and tree crops (cashews, coconuts, oranges, bananas). Livestock (goats, cattle, sheep, and poultry) are also part of the farming systems in the zone. The main cash crops, in order of importance, are cashews, cassava, sesame, maize, coconuts, and groundnuts (Lamboll 1991). Most cultivated area is rainfed. A number of valley basins periodically experience uncontrolled flooding.

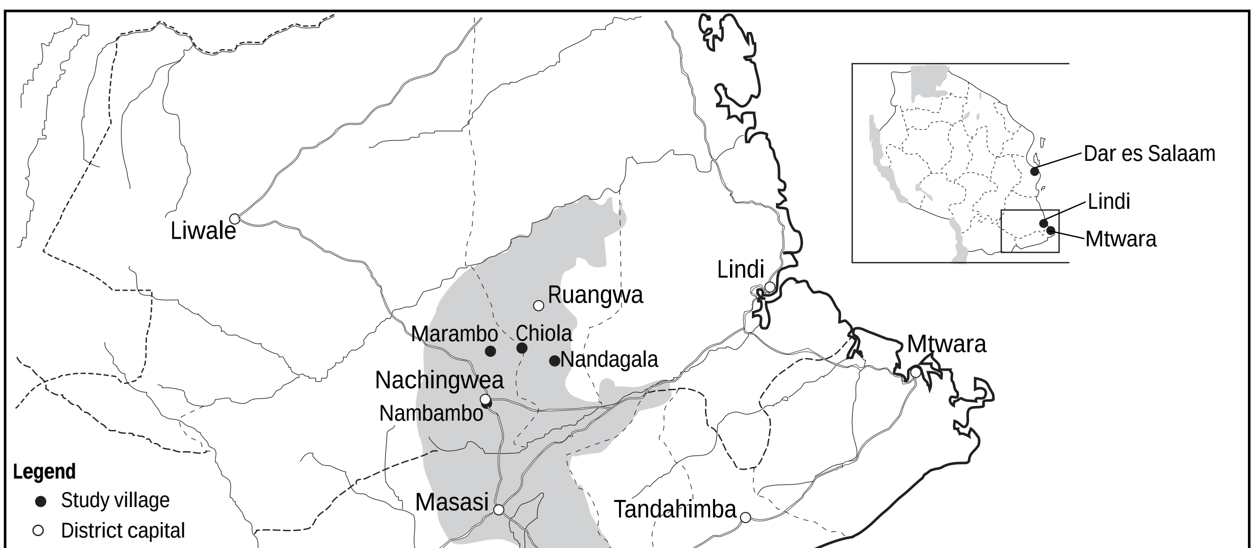

Figure 1. The Southern Zone of Tanzania and villages sampled for the maize impact study.

A study of the farming systems in Southern Zone by the Regional Integrated Development Programme (RIDEP) in the late 1970s identified 14 “Farming Systems Zones” (FSZs). These zones were defined according to soil type and rainfall, population distribution, and the relative importance of major food and cash crops. The survey described in this report concentrated on the West Lindi/ East Nachingwea/Northeast Masasi FSZ, commonly known as FSZ 8 (Figure 1). This FSZ contains the “maize belt,” which produces grain for the whole of the Southern Zone. Elevation in the zone varies from 400 to 500 meters above sea level (masl).

Farming systems zone 8 is characterized by red clay soils, particularly in the central and northern part of the zone, and a fairly high population density in relation to Nachingwea, Masasi, and Lindi. Agricultural potential also appears to be higher than in most other areas, probably because of the combination of adequate rainfall (900–1,000 mm/yr), fairly fertile soils, and the presence of valleys watered by streams from the plateaux.

Land is generally available for agriculture, but labor tends to be a limiting factor. The family provides most of the labor requirements, although if cash is available hired labor may be used for such tasks as clearing bush and weeding. The availability of agricultural inputs is limited. A small number of hand tools are used, but these are not always available in the villages. Farmers use small amounts of fertilizer and improved seed because they lack cash to purchase them or they are not available.

The importance of food and cash crops in the study area is shown in Tables 1 and 2. Maize and cassava are the main food crops, while sesame, cashews, and groundnuts are the most important cash crops. Pigeon peas are the main legumes, followed by cowpeas and (of roughly equal importance) by *fiwi*, green gram, groundnuts, and bambara nuts.

Table 1. Relative importance of food crops in Southern Tanzania

Rank	Crop	Number of farmers cultivating	Percentage of farmers cultivating
1	Maize	106	88.0
2	Cassava	90	75.0
3	Pigeon peas	71	59.1
4	Sorghum	63	52.5
5	Rice	35	29.1
6	Bambara nut	20	16.6
7	Green gram	8	6.6
8	Millet	2	1.6
9	Fiwi	1	0.8

Source: FSR (1992).

Table 2. Relative importance of cash crops in Southern Tanzania

Rank	Crop	Number of farmers cultivating	Percentage of farmers cultivating
1	Sesame	49	40.8
2	Cashew	32	26.6
3	Groundnuts	20	16.6
4	Maize	10	8.3
5	Cassava	9	7.5
6	Rice	3	2.5
7	Onion	3	2.5
8	Sweet potato	1	0.8
9	Banana	1	0.8
10	Coconut	1	0.8

Source: FSR (1992).

1.3 Sampling and Survey Procedures

The number of farmers interviewed in the nationwide survey was determined by the importance of maize production in a given zone. About 1,000 maize farmers were interviewed nationwide. The Southern zone was allocated 36 farmers, or approximately 3.6% of the national sample. At the zonal level two districts were purposively selected based on their importance in maize production. At the district level, two villages were purposively selected, and in each village a subsample was allocated proportionally to its population ratio. The distribution of selected villages is shown in Table 3.

In each village, local authorities provided a list of all farmers. This list was arranged serially in a ten-cell format from the first to the last villager. Respondents were drawn from the list by "systematic random sampling technique." The population size (sampling frame) was divided by required sample size so that every k^{th} member was drawn to be included in the sample. In cases where the selected farmer was not available or absent, the next person on the list was interviewed.

To increase data validity and reliability, farmers were interviewed by researchers and experienced extension officers using a structured questionnaire developed by a panel of the zonal farming systems research economists, CIMMYT and SACCAR economists, and national maize breeders and agronomists. The interviews were conducted between June and November 1995. To maintain uniformity, data from all zones were compiled at Selian Agricultural Research Institute (SARI) and then sent back to the respective zones for analysis and completion of the reports.

Table 3. Sampled villages, Southern Tanzania

District	Village	Population	Respondents
Ruangwa	Chimbila	348	6
	Nandagala	864	12
Nachingwea	Marambo	645	10
	Chiola	388	8
Total		2,245	36

2.0 Maize Research and Development in Tanzania and the Study Area

2.1 Maize Research in Tanzania

About 85% of the maize produced in Tanzania is grown by peasants whose farms are less than 10 ha. Ten percent of maize production occurs on medium-scale commercial farms (10-100 ha), and the remaining 5% occurs on large-scale commercial farms (>100 ha). Between 1961-65 and 1985-95, national maize production is estimated to have grown by 4.6%, of which 2.4% can be attributed to growth in area and 2.2% to growth in yield. Despite this yield growth, average yields are less than 1.5 t/ha, although grain yields tend to be higher in high-potential areas such as the Southern Highlands (Moshi et al. 1990).

Maize breeding and agronomy trials have been conducted in Tanzania for more than 20 years. The improved open pollinated varieties (OPVs) ICW and UCA were developed, tested, and released in the 1960s and are still widely used. During the same period, a few research stations undertook agronomy research, which later formed the basis for recommendations that were applied to the entire country.

In 1974, the NMRP was launched to coordinate maize research and encourage the better utilization of some resources. The program is responsible for coordinating all phases of maize research, from varietal development and maize management research on station to verification on farmers' fields. The NMRP has divided the country into three major agroecological zones for varietal recommendations:

- The highlands (elevations above 1,500 masl), with a growing period of 6-8 months.
- The intermediate (or midaltitude) zone (900-1,500 masl), which is further subdivided into "wet" (>1,100 mm rainfall, with a 4–5 month growing period) and "dry" subzones (<1,100 mm rainfall, with a 3–4 month growing period).
- The lowlands (0-900 masl), with a 3–4 month growing period.

To date, several breeding populations have been developed and are being improved through recurrent selection for specific traits. Since 1974, two hybrids and six OPVs have been released. In 1976, Tuxpeño was released for the lowland areas. Hybrids H6302 and H614, suitable for the highlands, were released in 1977 and 1978, respectively. In November 1983, three OPVs were released: Kito, Kilima, and Staha. Staha is characterized by its tolerance to maize streak virus (MSV) disease, whereas Kilima was recommended for the midaltitude zone. Kito is an early maturing variety adapted to both lowland and midaltitude zones. In 1987 two OPVs, TMV1 and TMV2, were released. TMV1 has white, flinty grain, is streak resistant, and has intermediate maturity. It is recommended for the lowland and midaltitude zones. TMV2 is also a white flint maize and is recommended for the high-altitude and high-potential maize-producing areas.

In 1994, the NMRP released versions of Kilima, UCA, Kito, and Katumani that are resistant to MSV: Kilima-St, UCA-St, Kito-St, and Katumani-St. Around the same time, two foreign seed companies, Cargill and Pannar, introduced or released seven hybrids for commercial use. For improvement of husbandry practices, the NMRP conducted off-station agronomy trials that in 1980 resulted in maize production recommendations specific to 11 regions. The recommendations related to choice of variety, plant spacing, plant density, fertilizer rate, weeding regime, and pesticide use.

2.2 The Maize Seed Industry in Tanzania

The hybrid CG4141 is multiplied and distributed by Cargill Hybrid Seed Ltd., which is based in Arusha. About 19% of the farmers in the Southern Zone grew H614, because it is late maturing. Locally bred cultivars have flint grain and good pounding and storage qualities, and they yield as well as CG4141. They are marketed mainly by the Tanzania Seed Company (TANSEED), which has not done well in the newly competitive seed industry. This has contributed to reduced adoption of locally bred hybrids. Before input markets were liberalized in 1990, locally bred varieties were almost the only improved maize seed planted in Tanzania.

After market liberalization, private companies not only engaged in seed multiplication but conducted trials to evaluate the adaptability of imported varieties to the local environment. The varieties deemed suitable are subsequently released to farmers. CG4141 is competing aggressively with the locally bred cultivars multiplied and sold by TANSEED. Pannar started producing and marketing maize seed in 1995. The new companies have recruited chains of stockists who sell their seed in villages and towns, and TANSEED has followed suit. Farmers have reported that seed sold by private companies is purer, more uniform, and higher yielding than seed from TANSEED, which has reduced demand for TANSEED products.

The drawbacks of the new varieties sold by Cargill and Pannar are their high price, poor storability, poor pounding quality, and unsatisfactory taste. Pounded maize is used to make a local dish prepared from grain from which the seed coat has been removed (*kande*). Some farmers also pound their maize before milling to make a whiter and softer dough (*ugali*). When pounded, maize seed with a soft seed coat breaks, and flour losses before milling are greater. This underscores the importance of the flint trait in farmers’ varietal preferences.

The latest development in the maize seed industry is the resumed importation of a once-famous hybrid, H511, from Kenya, by the Tanganyika Farmers’ Association (TFA). H511 yields as well and matures as early as CG4141; its advantage over CG4141 is its flinty grain. The 1994/95 price for Cargill maize seed (CG4141) and Pannar seed (PAN 6481) was Tanzanian shillings (Tsh) 650/kg, while Kilima, a composite, sold at Tsh 450/kg. The high prices of maize seed have forced many farmers to recycle hybrid seed.

Before market liberalization, quasigovernmental institutions and cooperative unions monopolized input marketing. These institutions were inefficient in delivering inputs to farmers. They suffered from chronic liquidity problems, because they depended on borrowing money for buying inputs. This led to delayed input supply and chronic shortages that served as a disincentive to farmers (Mbiha 1993; Nkonya 1994). Market liberalization has led to a rapid increase in the number of private businesses that engage in input marketing. Farmers could obtain inputs from village stockists who are located much closer to them than prior to 1990. Inputs have also become readily available on time in villages. As expected, the price of inputs has increased sharply, wiping out the shortages that existed before.

2.3 Maize Technology Recommendations

2.3.1 Variety

The choice of maize variety is determined by farmers' objectives, the length of the growing season, elevation, and rainfall at a given locality. Recommended varieties with their expected yields for the Southern Zone are ICW (4 t/ha), Staha (4.5 t/ha), Tuxpeño (4 t/ha), Kito (3.5 t/ha), and Katumani (3 t/ha).

2.3.2 Planting time, method, and spacing

Planting early in the maize growing season has been observed to be the most important single factor for increased grain yields (Goodbody 1990). With delayed planting, yields are lower and damage by insects and diseases is greater. Varieties susceptible to maize streak virus (MSV) suffer more when planted late. In some parts of the study area, however, planting with the first rains poses a high risk of crop failure because water stress occurs later at the critical flowering stage. In Mtwara and Nachingwea the recommended planting time is in December-January, depending on rainfall. The adequate seed depth is 5–7 cm, as deeper planting retards germination. In dry areas, maize seed may be planted more deeply and then covered with soil.

The best way to get uniform plant stands is to plant in regularly spaced rows and at regular intervals within the row. The recommended spacing for full-season varieties (H6302, H632, H622, Kilima, UCA, ICW, Tuxpeño, and Staha) is 75 x 30 cm with one plant per hill, resulting in a plant population of 44,000 plants/ha. Results from the Maize Research Programme show that in the Southern Highlands (>1,500 masl) similar yields were produced by planting two seeds per hill at 90 x 50 cm, three plants per hill at 90 x 75 cm, or a single seed per hill at 90 x 25 cm. In the dry, intermediate altitude areas, similar yields were obtained by planting two seeds per hill at 75 x 60 cm or one seed per hill at 75 x 30 cm. For short-statured varieties (Kito and Katumani), farmers are recommended to sow two seed per hills at 75 x 40 cm.

2.3.3 Fertilizer type and timing and method of application

The maize plant has a relatively high demand for nutrients, particularly nitrogen (N), phosphorus (P), and potassium (K). These nutrients may be obtained through applications of farm yard manure (FYM) and/or inorganic fertilizer. Fertilizers recommended for Southern Tanzania include urea, calcium ammonium nitrate (CAN), or sulfate of ammonia (SA). In the high altitude and intermediate high rainfall zones where moisture is reliable, use of inorganic fertilizer results in greater economic returns. In the intermediate low rainfall and coastal zones, response to fertilizer depends to a great extent on sufficient moisture. The recommended fertilizer rate for Southern Tanzania is about 20 kg N/ha and 20 kg P_2O_5/ha.

Fertilizer is normally placed 5 cm below the depth of the seed and about 5 cm to the side at the time of planting. This is accomplished by digging a single hole beside each seed, placing fertilizer in the hole, and covering it with soil. Alternatively, a continuous furrow is made along the length of the planting row. Fertilizer is placed in the furrow and covered with soil. The seed is planted on top of this soil and covered properly.

2.3.4 Weed control

Weed control is important to reduce competition for water, soil nutrients, and light. It is important that the field should be free of weeds in the first 40 days after germination. Two hand weedings are recommended at all altitudes. However, the recommended time between the first and second weeding varies by location. In Southern Tanzania, the first and second weedings should be done at two and four weeks after planting, respectively.

Weeds may also be controlled by herbicides. Commercial herbicides that will effectively kill broadleaf weeds and grasses without injuring maize are available. The following herbicides have been recommended for use in monocropped maize: atrazine (Gesaprim), atrazine and metalachlor (Primagram), alachlor (Lasso/atrazine), and pendimethalin (Stomp). If maize is intercropped, alachlor plus linuron (Lasso/Linuron) and metabromuron and metoalachlor (Galex) are recommended.

2.3.5 Pest and disease control

The most important field pests in maize are stalk borers and armyworms. Damage by all stalk borers is hard to see at first, and by the time a severe attack is noticed, many plants may already have been killed and many others damaged beyond recovery. The three most economically important stalk borers in Tanzania are *Chilo partellus, Busseola fusca,* and *Sesamia camistis.*

Chilo partellus (the spotted stem borer) is found in the low elevations of Tanzania. A small brown moth lays eggs on the leaf surface and the small larvae move down into the leaf whorl and feed on the new leaves. *Busseola fusca* damage is easier to see. The moths deposit eggs on the outer leaves on the stem and the larvae bore through the leaf bundle into the stem. When this occurs, holes appear in a line when the leaf emerges. With *S. calamistis* (the pink stalk borer), the initial damage is also not easily detected. This borer causes the same damage as *C. partellus* and *B. fusca,* penetrating into the center of the stalk and destroying the growing point. Stalk borers can be controlled fairly easily with Endosulfan, Malathion, Sevin, and Sumithion, if these chemicals are applied at the correct time. When plants have about seven leaves a small amount of dust should be sprinkled into the leaf whorl. Night dew and rain will wash the chemical down into the plant. About two weeks after the first dusting, a second application is done. Only in cases of extreme attack is a third application needed. It is recommended to dust all plants in the field.

Armyworms (*Spodoptera exempta*) are soft-bodied caterpillars up to 5 cm long, green to almost black, and marked with two longitudinal greenish stripes. They invade the crop, moving through vegetation at very high infestation rates. Outbreaks usually occur during the rainy season. Armyworms can be effectively controlled by aerial spraying. Individual farmers can use hand sprayers such as knapsack sprayers or ultra low volume applicators (ULVA). Infestations can be controlled with Malathion, Fenitrothion, Permethrin, Endosulphan, and Cypermethrin.

It is estimated that about 30% of the stored maize in Tanzania is eaten by insects and rodents each year. Some insects, such as *Sitophilus zeamais*, are brought to the storage area with the harvested maize. The most serious insect pests attacking stored maize are weevils, especially *Sitophilus* spp. and *Tribolium* spp., Angoumois moths, and the larger grain borer (*Prostephanus truncatus*) or *Dumuzi*, a storage pest that has recently become very important in Tanzania for the substantial damage it causes.

Insecticides such as Malathion and Actellic, used as per manufacturer's instructions, may control maize weevils and moths. The larger grain borer can be controlled with a preformulated mixture of Permethrin 0.5% and Primiphos methyl 2% (Actellic Super dust) applied at 100 g per 90–100 kg of grain. If insecticides are not available, shelling of maize grain and storing the grain in airtight containers such as steel drums or the traditional bin (*kilindo*) is recommended.

Five major leaf diseases attack maize in Tanzania: common rust (*Puccinia sorghi)*, lowland rust (*Puccinia polysora)*, *Helminthosporium turcicum*, *Helminthosporium maydis*, and MSV. None of these diseases can be controlled economically by chemical means. Biological control through breeding for disease resistance or tolerance is the only feasible economic control.

Maize streak is a viral disease transmitted by a small green leafhopper (*Cicadulina* spp.). If the disease occurs early in the life of the plant, the plant will be stunted and will not produce a normal ear. Maize streak is not very common in Southern Tanzania. Chemical control of leafhoppers is not economic, but maize that is planted early suffers less from MSV because the population of leafhoppers is still low. The variety Staha is tolerant to MSV, but most other commercial varieties are susceptible.

The three most common cob diseases are caused by *Gibberella* spp., *Fusarium* spp., and *Diplodia* spp., which attack the grain as well as the cob. Birds, animals, and insects often damage the husks, and the pathogens enter the cobs as secondary infections. If the maize lodges, the pathogens may be transmitted from the soil. All diseased cobs should be destroyed at harvest. Diseased plants and husks should be burned to prevent the pathogens from being carried over to the next year's crop.

2.3.6 Harvesting and storage

Physiological maturity in maize occurs at 35–40% moisture content in the grain. Harvesting of maize is not so closely tied to a particular time as with other cereals. Generally, it is necessary that the harvest should coincide with the dry season to avoid the danger of grain rotting, growth of mold, or germination on the cob. Harvested maize is usually left out for further drying. Maize to be stored should not contain more than 13% moisture, and farmers are advised to store maize on open cribs or in sacks. Cribs should not be wider than 1 m, and a depth of 60–100 cm is considered good for storage on drier cribs. The narrow width helps maize to dry more quickly. This means of storing maize while it dries helps protect maize from mold. When the maize is dry enough, it may be shelled and the grain can be stored in sacks or bins.

3.0 Demographic and Socioeconomic Characteristics

Table 4 summarizes the family characteristics of sample households in southern Tanzania. The mean age of the household head was about 47 years, and the average level of formal education was 4.6 years. The mean amount of adult laborers was three, of which 60% was female labor. About 64% of sample households hired labor for farm operations.

The average farm size was 6.5 acres, of which 5.5 acres were under cultivation. Table 5 shows upward trends in total farm size and maize area. In Southern Tanzania land is abundant, and maize production increases are achieved by bringing more land into production. The major reason that farmers gave for increasing farm size was higher demand for land (35.7%), while about 21% of the farmers said they increased their farm size to earn more money. Similar reasons were given for increasing maize area. Thirty-three percent of the sample farmers said that the demand for land was higher and 20% said they wanted to earn more money.

A very low livestock population exists in Southern Tanzania. No cattle were found in the sampled villages. Only five households owned goats, and two farmers owned sheep. The average number of poultry owned by most of the households was about 12 (N=30). Low livestock populations could be the result of insufficient pasture, particularly during the dry season. Most cultivated land is used for cropping and little grazing area is available.

Farmers owned an average of 2.5 cutting implements, such as machetes, knives, sickles, and axes, which they used for different farm operations. Only hand hoes were used for land preparation, and on average farmers owned three hand hoes.

Table 4. Demographic characteristics of sample households, Southern Tanzania

	Southern Zone (n=36)
Mean of:	
Age of household head (yr)	46.7
Number of male adults	1.2
Number of female adults	1.8
Number of children	2.1
Education of household head (yr)	4.6

Table 5. Trends in farm size and maize area, Southern Tanzania

	1974	1984	1994
Farm size (ha)	1.64	1.86	2.24
Maize area (ha)	1.09	1.13	1.31

4.0 Farmers' Maize Production Practices and Adoption of Recommendations in the Study Area

4.1 Crops and Cropping Systems

Most farmers grew maize as a single crop on their first plot (45%), while 40% grew maize intercropped with legumes on the first plot. About 10% of farmers grew tubers, and 5% grew orchard crops. On the second plot, 47% of farmers grew tuber crops, 17.6% grew either sole maize or sorghum, about 12% raised oil crops, and 5.9% intercropped maize on their second plot.

Maize was intercropped with legumes by 77.1% of the farmers, while 22.9% monocropped maize. The major reason for intercropping maize was to obtain more money or food (50%); other reasons were the lack of good quality land (15%), labor shortages (15%), and crop diversification (15%).

4.2 Adoption of Improved Maize

4.2.1 Varieties currently grown and seed sources

Most farmers grew UCA-St (56.3%), although about 19% of the sample grew H614. Table 6 lists all of the improved varieties that farmers said they had grown between 1972 and 1993. Nearly all (94.7%) farmers said that they used maize seed obtained from previous crops, while the remaining 5.3% obtained seed from their neighbors. A large proportion of farmers recycled hybrid seed (58.3%), and 25% got improved seed from the Kilimo office. Other sources of improved seed were the crop society (8.3%) and stockists (8.3%). About 52% of the farmers did not grow the recommended variety because it was unavailable. Almost half (48.3%) said that they had lost their seed to drought.

4.2.2 Varietal preference and disadoption

The most preferred variety was UCA-St for about 89% of the sample farmers, while 11% preferred TMV1. The main reasons for preferring a variety were yield (50%) and availability of the seed (37.5%). Only one farmer disadopted H614 because its yield was low.

4.2.3 Trends in use of improved and local maize varieties

Table 7 shows trends for total and average area under improved and local varieties for 1974–94.

Table 6. Improved maize grown by sample farmers, Southern Tanzania

Variety	Percentage of farmers (n=36)
H614	18.8
UCA	6.3
Katumani	6.3
TMV1	12.5
UCA-St	56.3

Table 7. Total and average area (acres) under improved and local maize, 1974-94, Southern Tanzania

	Area under local maize		Area under improved maize	
Year	Total	Mean	Total	Mean
1974	6.5	3.04	1.00	–
1980	17.0	2.43	4.25	2.13
1985	19.0	2.11	11.50	2.88
1990	30.5	2.54	24.30	4.04
1991	20.5	1.86	29.50	3.69
1992	23.0	2.09	35.30	3.53
1993	25.0	2.08	34.80	3.86
1994	40.5	2.70	42.30	3.52

Since 1990, larger areas have been planted to improved maize compared to local maize. About 42% of sample farmers said they would increase the area under local varieties; their reasons for doing so included higher demand for land (9.8%) and higher income (28.6%). About 54% reported they would not change the area under local varieties because they would not be able to manage a larger area (24%), no land was available (19%), and the current area was large enough (10%). Finally, one farmer would reduce the area, because he was not able to manage a larger area.

About 47% of sampled farmers said they would increase the area under improved varieties to obtain higher yields and more money. Also, 47% would not change the area currently planted to improved varieties because of land shortages (18.2%) and higher labor requirements (18.2%). One farmer would reduce the area sown to improved maize, but gave no reason for this choice.

The production levels of local and improved maize are shown in Table 8. Improved maize yielded better than local maize.

4.3 Maize Crop Management Practices

4.3.1 Land preparation

Most sample farmers undertake land preparation from mid August to December with the majority preparing land between September and November (Table 9). Land preparation depends on the onset of the rains, which usually start in late October. Most land is prepared for maize planting by hand hoe. Of the sampled farmers, 85.7% used a hand hoe, 8.6% practiced zero tillage, and 5.7% used a tractor.

4.3.2 Seedbed type, planting pattern, and spacing

All farmers in the study area used a flat seedbed. Farmers grew maize continuously on the same plot from a period ranging from 2 to 25 years, with an average of 12 years. Most farmers planted between the end of October and the end of December (Table 10). The majority of farmers (75.6%) chose the planting date to coincide with the rains, as these farmers depend entirely on rainfall. Other reasons to plant at that time

Table 8. Production (90 kg bags/ha) of local and improved maize, Southern Tanzania

	Local maize		Improved maize	
Year	Total	Average	Total	Average
1974	25.0	5.0	5.0	5.0
1980	43.0	7.2	12.0	6.0
1985	70.5	10.1	26.5	8.8
1990	29.0	5.8	41.0	10.3
1991	42.5	6.1	73.0	10.4
1992	57.3	8.2	95.7	11.9
1993	67.3	6.7	97.0	12.1
1994	66.0	6.0	98.0	9.8

Table 9. Time of land preparation for maize, Southern Tanzania

Month	Number of farmers	Percentage of farmers
August	2	5.5
September	10	27.7
October	13	36.1
November	9	25.0
December	2	5.5

Table 10. Time of maize planting, Southern Tanzania

Month	Number of farmers	Percentage of farmers
September	1	2.8
October	4	11.1
November	14	38.9
December	14	38.9
January	2	5.6
February	1	2.8

included labor constraints (13%), better yields (5.4%), and avoidance of pests and diseases (5.4%). All of the sampled farmers planted in rows, largely because this practice made crop management easy (a reason given by 67% of farmers). Other farmers chose to plant in rows because of the high yield associated with this practice (14%) and because it was what the extension service advised (8%).

Table 11 shows the plant spacing practiced by sample farmers. The spacing between rows varied from 60 to 200 cm, and the spacing between hills ranged from 30 to 120 cm. Fifty-five percent of the sample farmers planted two seeds per hill, 42% planted three seeds per hill, and 3% planted only one seed per hill.

4.3.3 Fallowing and crop rotation

Only 17% of farmers fallowed their land, mainly to replenish soil fertility. The fallow generally lasted one to three years. Crops planted immediately after fallow included maize, cassava, and oil crops, which were selected because they would provide higher yields and incomes. Most farmers (74.1%) could not fallow their land because land was scarce. About 26% saw no need to fallow land. Only two respondents had stopped fallowing.

Nineteen percent of the farmers rotated their crops; five farmers planted cassava after maize, and three planted legumes after maize. The main reason for crop rotation was to take advantage of fertilizer applied to the previous crop. Most farmers (44%) did not rotate crops because they were not aware of the benefits of the practice, because they lacked land to do so (36%), or because of disease and pest cycles (20%).

4.3.4 Fertilizer use and crop residue management

About 6% of the farmers used fertilizer; 3% used organic fertilizer (FYM) and 3% used inorganic fertilizer (SA). Most farmers said that they did not use fertilizer because they did not need it (52.6%) or lacked cash to buy it (21.1%). Crop residues were used as soil amendments by 61% of farmers, who plowed the residues back into the soil. Thirty-six percent reported burning crop residues, and only 3% fed residues to livestock.

4.3.5 Weed control

All farmers weeded fields manually with a hand hoe. No mechanical or chemical weed control practices were used in the study area. Most farmers weeded from the first week of November to the third week of February, although some weeded between the first week of December and the second week of January (Table 12). An equal percentage (44%) of farmers weeded twice and three times. Only 9% weeded just once; 3% weeded four times.

Table 11. Spacing of maize plants by sample farmers, Southern Tanzania

Spacing (cm)	Percentage of farmers
100 x 200	5.9
90 x 75	5.9
90 x 60	23.5
90 x 45	5.9
90 x 30	23.5
60 x 30	14.7
Other	20.6

Table 12. Time of weeding maize, Southern Tanzania

Month	Number of farmers	Percentage of farmers
November	5	13.9
December	18	50.0
January	9	25.0
February	4	11.1

4.3.6 Pest and disease control

As mentioned previously, insect pests, including stalk borers, are among the main production constraints in Tanzania, and several cultural and chemical control measures have been recommended (Nyambo and Kabissa 1990). About 49% of farmers said their maize was affected by vermin; 30% reported problems with cutworms, and the remaining 21% reported problems from stalk borers. Fourteen percent of the farmers controlled pests by scaring vermin or guarding the crop.

Maize streak virus was the most important disease affecting maize in the study area. Katumani was the most susceptible variety, whereas local varieties were not affected. Farmers seemed to have no means of controlling MSV.

4.3.7 Harvesting, transportation, and storage of maize

The maize harvest in the study area stretches from the first week of March to the last week of July; more than half (64%) of the maize is harvested in May and June (Table 13). All maize was harvested by hand. Farmers picked the maize off of the stalk or cut it with a portion of the stalk and transported the harvest to the homestead for drying and storage.

As shown in Table 13, head loads were the most common method for transporting harvested maize from the field to the homestead for postharvest processing and storage. Other farmers used bicycles and tractors. Wealthy farmers who can afford to hire a tractor mostly used tractors. It is also likely that the same farmers hire tractors for plowing their fields.

Most farmers (70%) stored maize on cribs, and 10% of the farmers shelled and stored maize in an airtight container (*ngokwe*). Other storage methods included putting unhusked maize in a walled structure (*ng'huta*). Only 14% of the farmers treated their maize, generally with ash or other local materials. Only two respondents used chemicals to protect their shelled maize. Thirty-seven percent of the farmers felt that there was no need to treat harvested maize, while 37% mentioned the unavailability of pesticides as the reason for not treating seed. About 21% of farmers said they lacked money to buy pesticides.

4.3.8 Maize cropping calendar

The cropping calendar occupies the whole year (Table 14), starting with land preparation/ planting from the second week of August to harvesting in the fourth week of July. In many cases land preparation and planting are done at the same time. Other cropping activities are shown in Table 14.

Table 13. Maize harvesting and transportation, Southern Tanzania

	Number of farmers	Percentage of farmers
Month of harvest		
March	1	2.8
April	5	13.9
May	13	36.1
June	10	27.8
July	7	18.9
Method of transporting harvested maize to homestead		
Head load	25	73.5
Bicycle	3	8.8
Tractor	6	17.6

4.3.9 Seed selection

About 82% of the farmers selected maize seed in their homes, while the remainder selected seed in the field. A large cob and undamaged, mature grains were the important criteria for seed selection (Table 15).

4.4 Maize Marketing

Marketing data available from 1985 onwards show that approximately half of the maize produced in the study area was sold and the rest was left for home consumption. Most sales transactions (46%) were conducted immediately after harvest. Relatively few (18%) took place prior to the next harvest; the remainder (36%) occurred between those two times of the year (Table 16). The maize price immediately after harvest varied from Tsh 1,600 per bag in 1974 to Tsh 3,200 per bag in 1994, but the number of farmers responding to these questions was very low. Most respondents sold their produce from their homes, either to traders or consumers within and beyond their villages. Only five respondents sold their maize in town or nearby trading centers. Both improved and local maize varieties were sold.

4.5 Credit

None of the farmers interviewed had ever used credit for maize production. All agreed that credit was not available. Thirty-seven percent felt that the problem in obtaining credit was the bureaucratic procedures, while 14% said they simply did not know how to get credit or lacked the required collateral. The remaining 37% had other reasons for not using credit to grow maize.

Table 14. Maize cropping calendar, Southern Tanzania

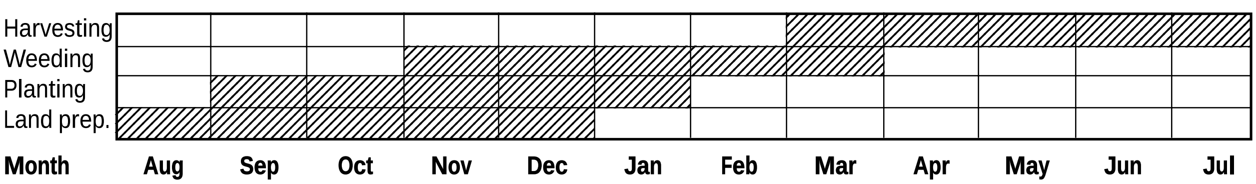

Table 15. Farmers' criteria for selecting maize seed, Southern Tanzania

Rank	Criterion	Number of responses	Percentage of farmers
1	Large cob	31	43.1
2	Undamaged grain	25	34.7
3	Mature grain	16	22.2

Table 16. Maize sales and consumption, Southern Tanzania, 1974-94

	Maize sold		
Year	Local maize (bags)	Improved maize (bags)	Bags retained
1974	3	2	2
1980	5	4	4
1985	20	21	20
1990	30	50	75
1991	35	110	90
1992	40	80	110
1993	47	55	155
1994	35	25	145

5.0 Adoption of Recommended Maize Practices

About 75% of farmers had heard about the recommended maize management practices. Their main sources of information were extension, other farmers, and radio. Adoption of these recommendations and farmers' sources of information are shown in Table 17.

Table 17. Farmers' adoption of recommended maize practices, Southern Tanzania

Practice	Received information (N=36)	Adopter	Nonadopter	Reason for not adopting	Main source of information
Improved variety	16	14	6	Unavailable, expensive	Extension
Planting method	36	22	3	–	Extension, other farmers, radio
Fertilizer use	2	4	11	Expensive, unavailable, no need	Extension, other farmers
Weed management	12	10	3	Used to own ways	Extension, other farmers, radio
Herbicide use	5	0	16	Expensive, unavailable, no need	Extension, radio
Ox-drawn implements	4	0	15	Unavailable, expensive, not used to practice, unsuitable land	Extension, radio
Pest management	10	4	15	Expensive, unavailable, not used to practice	Extension, radio
Disease control	6	0	15	Unavailable, expensive	Extension, radio
Storage practices	11	3	12	Chemicals unavailable, not used to practice	Extension, radio, other farmers

6.0 Factors Affecting Farmers' Adoption of Maize Technology

Farmers in Southern Tanzania are interested in improving maize production at all levels by adopting improved maize production techniques. However, several factors limited their ability to do so.

Most of the farmers reported that **unavailability of inputs** (Table 17) was a great constraint on adopting improved maize technologies. Fertilizer, improved maize seed, insecticide, and herbicide are not available in the Southern Zone. Farmers cannot purchase these inputs if they are not available. Most inputs must be transported by road to the farmers, and the condition of roads in Southern Tanzania is poor. When inputs are delivered, they often arrive at the wrong time (farmers need inputs during the maize selling season).

The **cost of technology** is another important factor affecting adoption. Farmers easily adopt practices that require little cash outlay, such as row planting. All farmers surveyed had adopted row planting, mainly because it was less costly and had the added advantage of simplifying weeding. Most farmers also weeded maize at the recommended times. More costly technologies, however, such as fertilizer, herbicide, and disease control measures, were adopted by only a few farmers. Most farmers said they did not need fertilizer (52.6%) or lacked cash to purchase it (21.1%). Table 18 shows the costs of technologies along a continuum and the percentage adoption of each technology.

Environmental factors also play a role in the adoption of technology. Maize production in Southern Tanzania is a risky business because of erratic rainfall. Maize is susceptible to drought, and the performance of drought-tolerant cultivars such as Staha and Katumani is still poor. Many respondents in the study area also reported declining soil fertility, which is aggravated by the low rate at which soil nutrients are replenished. Declining soil fertility results in low maize yields and discourages farmers from growing maize.

With respect to farmers' **sources of information** about improved maize technologies, the survey found that many respondents were unaware of the improved maize technologies, especially use of fertilizers, the use of ox-drawn implements, herbicides, and disease control measures. The extension service and agricultural research organizations are charged with extending information about these technologies, but their low rates of contact with farmers may constrain the use of these technologies.

Table 18. Costs of improved maize technologies, Southern Tanzania

Cost	Technology	Percentage of adopters
Cheapest	Row planting	88
	Weed management	76
	Improved maize seed	70
	Fertilizer	27
	Pest management	21
	Storage	20
	Use of herbicides	0
	Ox-drawn implements	0
Most expensive	Disease control	0

7.0 Conclusions and Recommendations

7.1 Conclusions

The mean age of the household heads in the sample was 47 years; the level of formal education averaged about five years. Sample households had about five family members, including at least one male adult, two female adults, and two children. Land was not a constraint, and the average farm size was 6.5 acres. Livestock ownership was not common. Hand hoes were the major farm tools used.

Maize is the major food and cash crop in the study area. Most farmers (77.1%) intercropped maize with legumes, and 22.9% grew maize as a single crop. Recommended maize varieties in the Southern Zone are Ilonga Composite White (ICW), Tuxpeño, Staha-St, Kito, and Katumani. Most farmers grew CG4141 (61.8%); about 36% of the sampled farmers grew UCA-St. UCA-St was the preferred variety because of its high yield.

Land preparation, which was mostly done by hand hoes, depended on the onset of the rains. Maize was mostly planted in rows at the recommended spacing and weeded at least twice. The dates of the first and second weedings depended on sowing dates and arrival of the rains. Only 3% of farmers used inorganic fertilizer, largely because farmers felt there was no need for it (52.6%) or because they lacked cash to purchase this input (21.1%).

Almost half (49%) of the farmers said their maize was affected by vermin, 30% reported problems with cutworms, and 21% said they had problems with stalk borers. Only 14% controlled vermin. Maize streak virus was the most important maize disease for 14% of the farmers.

Most farmers selected maize seed in the home (82%). A large cob and undamaged, mature grain were the criteria used for seed selection.

No farmer had obtained credit. All reported that credit was unavailable. Bureaucratic obstacles (37%) and lack of knowledge (14%) were the major constraints on obtaining credit. Most farmers had received information on practices such as improved maize seed, planting method, weeding, pest management, and storage. Less information was disseminated about fertilizer, herbicides, ox-drawn implements, and disease control methods. The important sources of information were research and extension, and other farmers.

Poor infrastructure and untimely delivery of inputs were important constraints to the adoption of improved maize technologies in the Southern Zone. Also, erratic rainfall and declining soil fertility contributed to the risk of maize production in Southern Tanzania. Farmers had easily adopted technologies that required little cash, such as row planting. This practice was less costly than other improved management practices and had the added advantage of simplifying weeding. Weeding was also adopted by most farmers. The more costly technologies, such as fertilizer, herbicides, and disease control measures, were hardly adopted.

Another important factor in farmers' lack of adoption of improved technologies was that many respondents simply did not know about them, especially use of fertilizers, use of ox-drawn implements, herbicides, and disease control measures. The extension service and agricultural research organization are charged with extending information about these technologies to farmers, but their low rates of contact with farmers may be a constraint to the use of these technologies.

7.2 Recommendations

Both research and extension are important for adoption of improved maize technologies. Efforts need to be strengthened to increase the flow of information to and from farmers, particularly through on-farm trials and field days.

More research should be directed to strategies for avoiding soil nutrient mining, supplementation of chemical fertilizers with different sources of organic manure, crop residue management, and soil conservation. Additional fertility research will be particularly relevant because use of chemical fertilizer is likely to remain low in the foreseeable future as fertilizer prices rise further.

Large areas of Southern Tanzania are prone to drought, which can destroy the maize crop or chronically reduce yields and increase stalk borer attacks. Research should give high priority to developing or screening varieties that are high yielding and that can tolerate drought stress and field pests. Research to identify measures for controlling storage pests should also be undertaken.

Most improved varieties are responsive to fertilizer, and farmers usually obtain economic yields with fertilizer. But use of fertilizer is constrained by its high price and farmers' lack of knowledge about how to use this input. An efficient marketing system for inputs and outputs will benefit farmers by paying higher prices for maize and reducing the cost of fertilizer. Investment in infrastructure, especially rural access roads, will enable inputs to be transported to farmers more efficiently and at low transport costs, resulting in reduced input prices. Such a system cannot be established without policy support from the government, however. Studies on the economics of seed and fertilizer use should also be undertaken, especially now that input and output markets have been liberalized.

Formal credit is not available to maize farmers. With rising input prices, credit becomes increasingly important for farmers. In collaboration with the government and other stakeholders, the formal credit system needs to address the credit problems faced by small-scale farmers, especially their lack of knowledge (information) about formal credit and the bureaucratic procedures for obtaining credit. The formation of farmer groups should be encouraged, because lending to groups tends to reduce transactions costs and improve the rate of loan recovery.

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