MAIZE RESEARCH AND PRODUCTION IN UGANDA

by

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INTRODUCTION

Maize (zea mays L.), originally a New World crop, was introduced in Uganda in 1861 (Sprague, 1987) and by 1900 was already an established crop (Ministry of Agriculture 1988). The World Bank estimates that there are about 1.3 million ha. of land suitable for maize production in Uganda (World Bank, July 1984 p. 49).

DISTRIBUTION

Maize is grown in every district of Uganda (Table 1) but the main growing areas are:-

(a) The fertile crescent around the northern periphery of Lake Victoria extending to the central plateau north of Kampala, along both banks of the Nile, central Busoga and on isolated areas in the south-east. These area include the districts of Masaka and Mukono in the southern region, Iganga, Jinja and now Kamuli in the south-eastern region.

(b) The higher altitude areas of Kigezi and Kasese-Rwenzori, the western Nile plateau and Mt. Elgon. There is a further extension from the slopes and foothills of Mt. Elgon to the fertile Sebei plain to the north and north-west, from the western slopes of the Rwenzori range and to Bwamba and from the Kigezi highlands northwards as far as the volcanic soils bordering the Western Rift valley (Mc Master 1962). The areas described here include the following districts and regions:-

District	Region
Kasese	Western
Masindi	Mid-Western
Kapchorwa and Mbale	Eastern
Mbarara	North-Western
Gulu and Lira	Northern

There are several reasons for the distribution. The overriding factor must of necessity be the crop requirements, particularly moisture. For normal/medium term maize varieties (excluding short-term varieties) it is estimated that 25 in (635 mm) of rain are required during the growing season (Glover, 1948; Manning 1956). It is important that the crop is not subjected to water stress during the period of rapid vegetative growth and the tasselling, silking and grain filling phases. There must, therefore, be sustainable rains for some eight to ten weeks during the life of the crop. Apart from evapo-transpiration, there is a direct effect of temperature. The highest yields are obtained when the mean temperature during the growing season is in the range of 20-22 degrees centigrade. Yields are depressed when the mean temperature exceeds 27 degrees centigrade. It is only where these requirements are met that maize is successfully grown in Uganda.

The concentration of maize cultivation within the areas where the crop is satisfactorily grown was further determined by the ethnic nature of the population. The influence of immigrants was a big factor. Production of maize in these areas was also encouraged by the availability of the ready market for dried grain in the vicinity of large estates and urban areas where there is a large inflow of migrants from maize-eating communities, e.g. Banyarwanda and Lugbara on the two major sugar estates and Luo/Kenyans in Jinja and Kampala linked with acreage in Kyaggwe and Bugerere counties in Mukono District and Busoga (Jinja, Iganga, and Kamuli) District.

Table 1 Acreage of Maize by Districts in 1963/64 (in '000 acres)

Region/District	Pure	Mixed I	Mixed II	Total III	Total IV
Uganda(excluding Toro and Karamoja)	111	100	473	211	684
Buganda	30	33	120	63	183
West Mengo	11	7	19	18	37
East Mengo	16	18	41	34	75
Mubende	0	0	8	0	8
Masaka	3	8	52	11	63
Eastern Region	51	50	232	101	333
Busoga	11	9	172	20	192
Bukedi	6	3	28	9	37
Bugisu & Sebei	33	38	9	71	80
Teso	1	0	23	1	24
Western Region (excluding Toro)	20	6	28	26	54
Kigezi	18	3	14	21	35
Ankole	1	1	4	2	6
Bunyoro	1	2	10	3	13
Toro	n.a	n.a	n.a	n.a	23
Northern Region (excluding Karamoja)	10	11	93	21	114
Lango	2	1	52	3	55
Acholi	3	1	19	4	23
West Nile	5	9	22	14	36
Karamoja	n.a	n.a	n.a	n.a	5

Source: Uganda census of Agriculture 1963/64
I = Maize predominant
II = Maize not predominant
III = Pure plus mixed I
IV = Pure plus mixed II

Production of maize in Uganda currently is largely at subsistence level except for a few commercial farmers. Maize is produced with very few productivity enhancing inputs and yield is generally below 1.5 ton/ha. Yields are restricted by nitrogen and phosphorous deficiencies in the soil and by the prevalence of maize streak virus. Maize streak virus can reduce yields by up to 80%.

Maize was grown primarily as a food crop up to the 1970s. Throughout the 1970s production of maize for sale on the domestic market rose to meet increased consumption demand from urban consumers and institutions. However, due to political instability, production dropped significantly in 1979 and, as a result of poor price incentives and market structures, fluctuated within low output levels thereafter up to 1987. Production finally picked up in 1988 with production in excess of 550,000 m tons (Table 2). This is the highest annual production level since 1978.

Table 2 Maize Production 1970 - 1988

Year	Area ('000 ha)	Output	Yield M ton/ha
1970	300	389	1.30
1971	280	421	1.50
1972	415	500	1.20
1973	314	419	1.33
1974	388	430	1.11
1975	475	570	1.20
1976	527	674	1.28
1977	429	566	1.32
1978	450	594	1.32
1979	272	253	0.93
1980	258	286	1.11
1981	260	342	1.32
1982	285	393	1.38
1983	295	413	1.40
1984	346	280	0.81
1985	289	343	1.19
1986	322	286	0.89
1987	307	363	1.18
1988	393	560	1.42
1989	566	624	1.10
1990	409	614	1.50

Source: Ministry of Agriculture, Animal Industries and Forestry, Planning Division

Maize production has shown a rising trend through the second half of the 1980s despite the rather low profitability of the crop according to crop budgets.

Major causes for the production increase during the late 1980s include:

(i) Low initial production levels caused by 15 years of war and instability

(ii) Return of political and social security

(iii) Substantial improvement in infrastructure

(iv) Increased demand due to some increases in standards of living

(v) Increase in exports especially through barter trade

(vi) Relative profitability of food crops compared to cash crops (especially cotton).

Production in maize may have also risen due to maize being substituted for sorghum and millet in much of the northern part of the country, possibly due to its lower labor requirements.

VARIETY RELEASE

Since 1960 Uganda has released four maize varieties. These are: White Star, Western Queen, Kawanda Composite (A&B) and recently Longe 1. White Star and Western Queen were released in 1960 for the northern and western areas of Uganda respectively. White Star is still being recommended for its early maturity (115 days) specifically for short rain areas (e.g. Northern Uganda). Western Queen is said to have been discontinued (Sprague, op. cit.).

Kawanda Composite A was released in 1971. It has since dominated the improved seed multiplication programme. KWCA was specifically recommended for commercial production during the long rains in the maize growing areas. It is rather late maturing (133 days) and requires early planting.

A second Kawanda Composite (KWCB) was developed between 1972-1974, and was said to be ready for release to farmers by 1977. It was not, however, released due to lack of seed multiplication facilities. The degeneration of Kawanda Composite variety released 20 years ago has led to great heterogeneity at farm level and the following complaints:

- highly susceptible to streak virus and blight diseases
- tendency towards only one cob per plant
- excessive plant and cob height and hence lodging problems.

Substantial attention has of late been given to maize by researchers. Positive outcome from the high level of input into agricultural research, maize in particular, is the recently (1991) released variety, Longe 1, (formerly called Population 89) developed at Namulonge Research Station. Multiplication of this variety is already being carried out at the Uganda Seed Scheme farm in Masindi. To develop Longe 1 KWCA was sent to IITA in Nigeria where it was incorporated with genes resistant to maize streak virus after which it was crossed with another variety EV 8344-SR. This resulted in a variety which was shorter in stature and 14 days earlier in maturity than KWCA. Longe 1 has advantage over other open pollinated varieties because it is resistant to Maize Streak Virus and matures early (119 days). It is shorter than KWCA (2 mts), thus more resistant to lodging. It yields 4.0 ton/ha on average under good management. This is 1.5 tons/ha more than KWCA.

Uganda has not up to now developed any hybrid maize. Most of the hybrid maize seed planted in Uganda has been imported from Kenya.

Table 3 Characteristics of Ugandan Maize Varieties

	White Star	Western Queen	KWCA	Longe 1
Date Released	1960	1960	1971	1991
Height	-	-	3 mt.	240 cm.
Population/ha	-	37,000	37,000	53,000
Recommended Spacing	--------(90x30cm @ 1/hill)-----------		(75x50cm @1/hill)	
Maturity Period	115 days	-	133	119
Cobs/Plant	1	-	1-2	1-2
Resistance to Streak Virus	Susceptible	Tolerant	Tolerant	Resistant
Yield (mt/ha)	-	-	2.5	4.0

Source: Masindi Seed Scheme and Kawanda Research Station
Figures on population per ha and plants/hill for KWCA and Longe I were provided by the Namulonge Maize Agronomist

IMPORTANCE OF MAIZE IN UGANDA

Maize is one of the major food crops in Uganda. Staple food crops in Uganda include cooking bananas (matoke), beans, maize, cassava, sweet potatoes, sorghum and millet. These crops together accounted for 93% of the land planted in food crops in 1988 (Ministry of Agriculture 1990). Producers continue to grow more than subsistence needs even if prices are low in order to generate cash for essential consumer items. Hence, in a normal year they usually have at least a modest market surplus. Maize is a staple food which is both low cost and easy to prepare. For this reason demand by urban consumers and institutions has been rising. Nutritionally, maize has a high value. Whole grain of 100gm contain 10gm of protein (poor in trytophan and rich in leucine) and 4gm fat, and provides 360 calories; the germ (12% by weight of the whole grain)) contains 22% of the total protein and 80% of the oil (Burgess 1962).

While home consumption remains the main reason for producing maize, small farmers depend upon maize among other crops for a substantial source of farm income. It is estimated that about 0.2 pounds of rough maize is consumed per person per day by Ugandan farm families (Vanegas & Ngambeki, July 1991).

The majority of farmers also retain a portion of their produce for seed. Reliance upon purchased seed is not yet commonplace. Because of its excellent storage properties, maize is often saved for future use in case of drought or food shortage.

Though millet and sorghum are the main staple foods in Northern, Northeastern and some parts of Eastern Uganda, there are predictions that maize production may soon exceed millet production even in those areas as a result of the potential for superior maize production technology and changing consumer preferences. Maize has also become an important ingredient in the animal (maize bran) diets. Maize is being tried as a supplementary and/or alternative export crop in Uganda today. The advantage it has over the other crops introduced earlier on in the diversification programme (cocoa and tea) is that it can be successfully intercropped with many other food crops and thus save on land and not affect food security as it matures earlier than the other crops originally selected for diversification.

MAIZE RESEARCH AND VARIETAL DEVELOPMENT IN UGANDA

Agricultural research has been going on in Uganda since 1930. Initially the principal activity undertaken by the maize researchers was evaluation of materials introduced from SA, Kenya and Tanzania. Varietal evaluation was abandoned around 1946. All crosses that had been made were lost and breeding was paralysed. In 1945 seeds were imported from Kenya in bulk without first testing for varietal suitability under Uganda conditions. These Kenya maize varieties were late maturing and did not fit well in the double cropping system in Uganda.

Varietal evaluation was later resumed at Kawanda Research Station which became the principle maize testing and breeding station. Local materials were collected from all over Uganda for evaluation of yield and maturity period.

In 1951 a serious West African rust (Pecunia Polysora and P. Sorghi) outbreak gave added impetus to Ugandan maize research. It was feared that the East African states would face a similar epidemic. Comprehensive studies on breeding resistance to pecunia polysora were carried out. This research resulted in the development of White Star and Western Queen.

Between 1960 - 1967 there was no effective research conducted in Uganda because the country lacked a qualified maize breeder. Fortunately, however, one agricultural assistant continued to maintain the maize introductions for future breeding. During this period, it was only by chance that any new technologies were passed on to the farmers.

Transition to control maize research activities by Ugandans took place between 1968 - 1970. The maize program got its first full time Ugandan maize breeder in 1986. Research during this time centered on development of a Uganda composite and transference of the technology to farmers. First to be developed was Kawanda Composite A (KWCA). It was released to the farmers in 1971. 'Composite formation' is a long-term comprehensive breeding programme. Its objectives were 1) to create composites for use as commercial varieties and 2). to utilize the composites as the basis for the development of synthetic varieties, varietal crosses and conventional hybrids. This comprehensive breeding system is still being used in E. Africa and other parts of Africa. Currently researchers are attempting to apply a similar method to improve millet and sorghum in Uganda.

In the period between 1972 -1974 work proceeded on developing a second composite, Kawanda Composite B (KWCB) from CIMMYT materials. The break up of the East African Community in 1977, however seriously jeopardized maize research in Uganda. The best research facilities in East Africa were established in Nairobi, Kenya under the East African Community. Not only did the loss of collaboration opportunities demoralize Uganda breeders, but they suddenly had no access to such necessary facilities as cold storage, computer services, and multiplication facilities. Many of the accession lines which had been evaluated over the years were only kept in the Kenyan stores. As a result, valuable breeding materials were lost and others became irreparably damaged as a result of the breakup of the community. The Ugandan research program was virtually paralysed. In addition, worsening relations between Uganda and Great Britain led to the suspension of aid to the Uganda Seed Project and local multiplication facilities deteriorated in the face of increasing foreign exchange shortages. KWCB was judged ready for release by 1977 but by that time facilities for multiplication were inadequate. The seeds were not properly stored and were lost as a result.

Serious effort to reassemble a new stock of maize germplasm began in 1987. In addition to local varieties which were collected from all over Uganda, materials were also obtained from international institutions such as IITA and CIMMYT, and from other national programs.

In 1984 USAID signed an agreement with Uganda to carry out various activities to strengthen the Ugandan capacity for both teaching and research in agriculture under the auspices of the Manpower for Agricultural Development project. Support for maize research activities was included in this agreement. It was at this time that maize research activities were moved from Kawanda to Namulonge in line with government intention to concentrate annual food crop research at Namulonge where adequate land was available. In 1987 a short term consultant was brought in to advise the Ministry on the most efficient strategy for Maize research in Uganda. Then in 1988 Dr. C. Simkins was assigned to act as long term technical advisor to the Maize and Soybean programs under the MFAD project.

Two strategies are now being used to improve maize research and production in the country. The short run strategy is to test and evaluate open pollinated materials and hybrids developed from other institutions for suitability under Ugandan conditions and possible direct utilization. The long run strategy involves developing varieties, populations and inbreeds from both local and exotic germplasm. Studies are being conducted on the combining abilities of various materials and inbred extraction is underway as well.

RESEARCH PROGRESS

As a result of efforts at germplasm collection and evaluations, Uganda's germplasm base has been substantially broadened. Open pollinated populations evaluated include populations 28, 29, 49, Gusau, Across and Jos. The first three are joint products of CIMMYT and IITA. Since 1988, on-farm trials have been conducted to test the suitability of four of these varieties under farmer conditions. Population 29 and Gusau TZB SR did exceedingly well (Table 4). They could not be immediately released, however, because they are susceptible to Northern Corn Blight. Gusau was reported to have performed better than Population 29 in lowland areas such as Kasese (900 m). Population 29 performed better in mid-altitude areas such as Masindi (900-1500m).

With respect to KWCA improvement, the objective was to reduce plant and ear height in order to reduce the threat of lodging. Research also involved reducing the KWCA original maturity period (>4 months) and incorporating resistance to streak virus.

In the early 1980s KWCA materials were sent to IITA for incorporation of resistance to maize streak. In 1988 these resistant materials were tested at Namulonge and KWCA-SR was selected. In 1989 this material was crossed with a very short, streak resistant population (population 49) to form a new variety. As a result of the crossing, the height was brought down by 69 cm, ear placement by 41 cm and maturity by 14 days. It is a medium maturity variety (65 days to 50% silk) and is moderately resistant to Northern Corn Blight (Baguma, 1991). Because the initial crossing was done in 1989, the variety was initially named Population 89, but this was changed to Longe 1 at the time it was presented to the variety release committee for consideration. Longe 1 was released in September 1991 and it's now undergoing multiplication process.

Development of hybrid maize has not yet started in Uganda, but research has been conducted to screen and evaluate hybrids from cooperating international research centers which are suitable for Ugandan conditions and display good levels of resistance to major pests and diseases. Research is also underway on extraction of inbred lines directly from elite populations and identification of the combining abilities (GA & SCA) of various materials. This research forms the baseline for a strong future hybrid program.

Results from these evaluations show that two hybrids identified from IITA materials have had excellent performance, with the highest yields ever recorded in Uganda. One of these hybrids is 8556 -6, a Top cross. It gave a yield of 10 ton/ha during the 1988 inter-hybrid trial. The second hybrid 8535 -23 (a single cross) yielded the same. In the 1989/first season variety trial, the two still out yielded the other maize varieties. They are both resistant to maize streak virus, rust (pecunia polysora) and northern corn leaf blight.

Namulonge research station obtained the inbred lines for production of these two hybrids from IITA. Hybrid 8556-6 is undergoing advanced varietal trials and was also tested in farmer's fields in 1991. Single cross 8535 - 23 is to be continued in the variety trials and tried on farmers fields during 1992, first season. The Uganda seed project staff have received some training on how to develop and handle a pure hybrid using the seed increased from the inbred lines. Further multiplication of the in-bred lines and reconstitution of hybrids was done in 1991 and is ongoing.

Research is also being carried out on other aspects of maize production. Various pathology, agronomy, fertilizer and entomology trials are currently underway. The pathology trials are testing varieties for resistance to northern corn leaf blight (NCLB). Agronomy trials are testing which pre- and post-emergent herbicides are the most suitable and economically efficient under Ugandan conditions. As a result of these trials, researchers are now recommending Stomp 500E as a pre-emergent herbicide at an application rate of 3 liters/ha. Stomp was chosen because 1). it is inexpensive, 2) it can be used on a number of other crops such as cereals, legumes, and horticultural crops, and 3) it has no residual effect on the rotational crop. Buctil MC at 1.25

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liters/ha and Laddock at 3.5 liters/ha were recommended as post emergent herbicides. They proved economical to use with maize production as well as sorghum and other cereals.

Fertilizer trials to determine the most economical application rates for nitrogen and phosphorous fertilizer are being carried out. Earlier research had indicated that for soils with less than 10 ppm of available phosphorous, a blanket application of 60 kgs/ha P205 is economical. For nitrogen (urea), 90 kg/ha single application at knee height was recommended. More recent soil fertility trials, however, have demonstrated the need for multi-locational and on farm testing to confirm the economical efficiency of these recommendations. Entomology trials center on development of pest management strategies for the maize crop and evaluation of maize germplasm resistant to stem borers and maize streak virus. They are also testing the effects of plant population on yield.

Research in these four aspects is ongoing. Research has on the agronomy of intercropping has only recently been proposed and work in this area is just beginning. Researchers, however, continue to concentrate on monocropping systems despite the fact that 43.5% of the farmers surveyed usually intercrop their maize in order to conserve on labor, vary the family diet and spread their production risk. Another 22.1% intercrop at least some of the time.

RECOMMENDED PLANT DENSITY/POPULATIONS

Under normal farmer production practices in Uganda, maize is planted in rows more than 1 meter apart with a spacing of 1 meter between hills. Farmers usually plant 3-4 plants per hill and often interplant their maize with beans or other crops. This spacing results in a plant population of approximately 20,000 plants per hectare. Field observations (Ministry of Agriculture, 1988) indicate that this plant population is most suitable for the normal soil fertility levels in Uganda. With this plant population yields rarely go above 3 tons/ha. A higher plant population results in very small ears of maize and often many barren stalks. Under farmer's method a larger plant population than 20,000 plants/ha (in 1988/2), resulted in 1/2 the normal ear size.An average maize size of 250 grams is considered ideal for good maize production.

Shorter varieties are known to perform better at higher densities than tall ones. (Maize Agronomy Research, 1989). The tall KWCA is said to perform significantly better at 37,000 plants/ha with yields of greater than 7 tons/ha with fertilizer and very badly at higher plant populations. This may be partly because at higher densities KWCA has been observed to grow taller than when planted at a population of 37,000 plants/ha. The higher density and increased height results in a high incidence of lodging. When plants lodge before proper grain filling this contributes to low KWCA yields.

Plant population studies in 1988 and 1989 conducted at Namulonge Research Station and Kabanyolo Univ. farm concluded that, unlike KWCA, shorter varieties can produce higher yields at high plant densities than at lower densities. A plant population of 53,000 plants/ha achieved with a spacing of 75cm x 50 cm with 2 plants/hill was recommended as optimal. It was expected that altering the spacing to 75cm by 25 cm with one plant/hill (i.e the same plant population of 53,000/ha) would result in a comparable yield. This expectation, however, was not born out by trials at Namulonge Research Station. The 75cm by 25 cm spacing yielded less than 75 by 50 cm spacing with the improved/short varieties.

SEED MULTIPLICATION AND DISTRIBUTION.

To meet the second requirement of transferring technology to the farmer, the Ministry of Agriculture established a seed multiplication scheme for the production of seed of selected food crops including maize. Supplemental funding for this seed project was provided by the British government through its Overseas Development Agency (ODA). Facilities for seed multiplication, processing and distribution at Kawanda and Masindi were expanded with the ODA assistance. Two seed farms were established in Masindi after 1972 despite the rocky relationship between then President Idi Amin and the British Government. The success of maize seed production during the years 1970 - 1974 was largely attributed to the availability of inputs through the British government grant.

Maize seed production declined dramatically from 1975 -1982. The situation worsened during and after the liberation war when all stores, equipment, and records were looted. Research activities were at a standstill and no new breeders seed could be provided to the seed project. The Seed Project continued to multiply a limited quantity of certified seed but seed quality deteriorated rapidly as inspection and other quality control activities became suspended. The political instability in the Luwero triangle led to further destruction at Kawanda Research Station and eventual abandonment of the Station in 1985. This seriously delayed implementation of the EEC project to rehabilitate the Uganda Seed Scheme.

As a result of all these constraints, Uganda became increasingly dependent on imported maize seed (mostly hybrid) from Kenya (Table 5). The seed entered Uganda through both official and un-official channels with minimal quality control. Varieties unsuited to Ugandan ecological conditions, such as Katumania which is only suitable for semi arid places, were also imported and sold. Farmers here were unfamiliar with the new varieties and seed was often mishandled and of poor quality. The incidence of maize streak in Uganda significantly increased and production dropped throughout the country as a result of these circumstances (Rubaihayo et.al., 1985).

Significant improvement in the supply of improved maize seed did not begin until after the January 1986 coup which ushered in the NRM government. With the return to political security, the rehabilitation of the Seed Scheme was accomplished with the assistance of the EEC. Considerable progress has been made in seed production since that time as illustrated in Table 5 below.

Despite increased seed production, the Uganda Seed Scheme still faces a major problem in marketing the seed which it produces. Past attempts to sell seed through the District Agricultural Officers have resulted in much waste and loss to the scheme. All such sales have recently been suspended but no reliable alternative marketing channel exists. At present the Seed Scheme is largely dependent upon large scale orders from non-governmental agencies or donor projects. This means that distribution of improved varieties is uneven, depending largely upon the presence and objectives of such NGOs and donor projects.

Table 5 Improved Maize Seed Production and Importation in Uganda

Year	Area planted for KWCA seed (ha)	Quantity KWCA Produced (mt)	Quantity Improved Seed Imported (mt)
1970	160.0	16.8	-
1971	217.0	95.8	-
1972	49.4	14.3	-
1973	186.6	54.3	-
1974	783.7	1,012.0	84.1
1975	473.1	139.7	23.4
1976	118.5	70.8	40.3
1977	217.2	81.8	288.7
1978	460.0	104.2	810.8
1979	240.0	68.2	400.0
1980	7.0	14.0	1300.0
1981	20.0	40.0	1700.0
1982	10.0	20.0	-
1983	127.3	254.5	-
1984	142.4	600.5	200.0
1985	na.	554.315	na.
1986	na.	221.549	na.
1987	na.	270.935	na.
1988	na.	593.620	na.
1989	na.	331.121	na.
1990	na.	285.140	na.
1991	na.	334.200	na.

Source: 1970-84 figures are from "Report on Maize Research and Seed Production in Uganda" 1985. 1985-91 figures are from Masindi Seed Scheme.

a. Figures do not include areas and amount of seed produced by Karamoja Seed Scheme; area planted indicates Masindi Seed Project farms only. b. Seed production figures include quantities of certified seed from contract growers.

CULTURAL PRACTICES AND MAIZE YIELDS

If sown on new land, opening is done well before to avoid nitrogen deficiency during early stages of growth. Sowing should be done as early as possible at the beginning or even before the break of the rains (Manning 1956). This allows the crop to fully benefit from the rains during the crucial stages of growth. Early planting would also free the land earlier for second rains crop. There is no advantage in having a seed-bed with a fine tilth. In fact a coarse seed-bed is preferable provided that the land is free of weeds, particularly the blue couch grass (digtaria scalarum). A coarse seed-bed helps to prevent sheet erosion during the early life of the crop (Kerkham 1953).

The recommended spacing generally is 3x1 feet when hand sown in pure stands or 26x15 inches by mechanical seeders. This gives a plant population of 14,500-16,000 plants per acre. When interplanted with groundnuts or beans a distance of 6 feet is left between rows. Three seeds are sown in each hill and later thinning reduces the number of plants per hill to one or two; actual being determined by overall evenness of stand.

Weeding may be done twice or tree times. The first weeding is done as soon as the rows of young plants are discernible but this may be delayed until thinning - some 3 to 4 weeks after sowing. There may follow two other weedings when sown in pure stand but is not advisable to disturb the soil after the crops' roots have been laid down. When interplanted , two weedings are sufficient. Weed competition is not usually serious beyond the tasselling stage.

Systematic crop rotation does not exist. Generally, however, a tuber crop is followed by a legume and/or a cereal crop such as maize. This elementary system of cropping has been maintained fairly well by Ugandan farmers and yields have been sustained despite lack of fertilizer inputs.

Maize yields were estimated at 1.2 tons/ha (Uganda Master Plan and Investment Programme February 1992) and 1.5 tons/ha (Accelerated Food Crop Strategy April 1990). The Agricultural Secretariat (May 1991) however, estimated maize yields in Uganda to be 2.0 tons/ha. This could have reflected the yield of hybrid maize which has not yet been introduced on a larger scale. At the national level the peak yield to date is 1.34 tons/ha. Yield may vary with regions and across regions. In the Eastern region yields range between 0.87 and 1.18 tons/ha, while in the Northern region, it ranges from 0.90 to 1.20 tons/ha and goes as high as 1.50 tons/ha in Western regions. These figures include all cropping systems (pure stand as well as intercropping). At farm level generally (Western Uganda for instance), 40% of the maize is grown as a principal crop in pure stand while 60% is intercropped mainly with beans.

CONSTRAINTS TO MAIZE PRODUCTION IN UGANDA

Maize production in Uganda is constrained by several factors which include:
1. Lack of improved seed.
2. Pests (e.g stalk borers) and diseases (e.g streak virus and Norther Corn Blight).
3. Peak period labor constraints in the farming system.
3. Weed infestation.
4. A general decline in soil fertility.
5. Marketing constraints.

Because KWCA was until 1991 the only improved maize variety released in Uganda, many Ugandan farmers are still largely dependant on hybrids from Kenya. The cost of these hybrids is rather high for a peasant farmer and being imports which require foreign exchange to import, the quantity and timeliness of supply are not guaranteed. Peasant farmers usually plant retained seed of the previous crop which mainly consists of KWCA and local varieties. Many farmers actually prefer the local open-pollinated varieties due to their resistance to maize streak virus.

Maize streak is common with KWCA and Kenya hybrids. Streak can reduce maize yields by up to 80% (Min. of Agriculture 1988). Maize planted during the second rains is more seriously affected, and as a result, over 80% of the maize grown in Uganda is being sown in the first rains, thus reducing potential annual output of maize. Longe 1, a higher yielding variety than KWCA which has proven highly resistant to streak has only recently (Sept. 1991) been released and is just undergoing multiplication process.

It is nevertheless not as high yielding as Gusau and Population 29 (Table 4). These open-pollinated varieties yielded 3-4 ton/ha on-farm and 6-7 ton/ha on station (Table 4). Unfortunately they are not resistant to Northern Corn Leaf Blight (tolerance is only 25-30% depending on location). Gusau in particular is restricted in its use to Kasese District where the incidence of blight is limited. Because of its yield potential, however, researchers at the GTZ Legume Seed Project are recommending Gusau for farmers in Kasese even before its release.

To remedy the corn blight problem, Gusau is being crossed with Population 42 Eto Illinois to incorporate resistance to blight. It is expected to be stable after crossing. Despite the fact that Namulonge research station is short of manpower while staff are still undergoing higher training, final results on the suitability or otherwise of the new crosses from these two varieties are expected in late 1994. Release will depend largely on the success of blight resistance incorporation.

Resistance to stalk (stem) borers is not yet known and is still a challenge to entomologists. These pests are said to account for 10% loss in maize. Late planted maize is said to suffer much more than early planted maize. However studies on cultural practices, chemical treatment and population dynamics are being carried out at Namulonge research station.

Another serious constraint to maize production increases is the intense competition between crops and activities for available labor supply. The availability of labor for any farm activity is much more certain when farmers rely entirely on family labor. Farmers who hire no labor tend to ignore new techniques or enterprises that require more labor than is available within the family. They are reluctant to add another source of uncertainty to their operations. They also lack both the necessary capital to hire labor and the management experience to do so effectively.

Weeds rank second to pests and diseases in constraining maize production in Uganda. But seed-bed preparation and weeding of maize, especially in the medium potential growing areas of Uganda, are very labor intensive operations under small-holder conditions. Farmers are said to allocate about 50% of their seasonal farm inputs budget to these two activities. The cost of hand weeding a ha. of maize is between 12,000 - 20,000/Ush. For good yields, maize requires at least 3 weedings at about 5 cm, 45 cm and 90 cm in height (Maize agronomy Research - Annual report 1989 - Kabanyolo Station Namulonge) The third weeding is usually lighter due to less grass and weeds later in the season, but the total cost of weeding and land preparation makes maize growing rather expensive. The most noxious weeds are <u>Oxalis latifolia</u>, <u>Cyperus spp</u>, <u>Digitaria scalarum</u>, <u>Amarathus hybridus</u>, <u>Panicum maximam</u>, and <u>Bidens pilosa</u>. Unfortunately, some of these weeds like <u>Digiteria spp</u> , cannot be controlled by the available herbicides. This is probably due to its unevenness in distribution compared to other weed species. Weeds can cause crop losses of 25% or more under peasant or small scale farming in Africa (Terry, 1984).

While research has shown that the improved varieties yield better with closer spacing of plants (75cm x 25cm with 1 plant/hill), the farmer's traditional method of spacing is better suited to the tall traditional varieties. Adoption of the newer varieties will have less impact on yields if appropriate plant populations are not adopted together with the new varieties. When interviewed, however, farmers who participated in the on-farm trials did not favor the trial method of closer spacing, 75cm x 25cm, with 1 plant/hill. They complained that it is more cumbersome and requires more time and labor than the traditional method of 1m x 1m spacing with 2-3 plants per hill. Farmers say weeding with a hand hoe is difficult in the close spacing.

The question of what level of fertilizer application should be recommended to maize producers in Uganda is also still problematic. Nitrogen is generally the most limiting nutrient in Uganda soils followed by phosphorous. Nitrogen is easily leached and is extracted in great quantities by the crops for the formation and maintenance of different plant tissues. While Uganda has some alluvial, swampy and volcanic soils rich in organic matter which have high total phosphorous levels, 85% of Ugandan soils are either medium or low in phosphorous. A soil is considered deficient in phosphorous if it has less than 5 ppm of available phosphorous, but 10 - 20 ppm is adequate for most plants (Webster, C.C. and P.N. Wilson, 1980).

On farm trial results show that maize yields differ by geographical regions even though fertilizer and other agronomic practices were standardized. Rainfall and soil nutrients are two variables that are difficult to control under farmer's conditions. Since 1988 on farm trials have been carried out in the following Districts: Kabarole, Masaka, Masindi, Mubende, Luwero, Kasese and Mbale. These trials used improved seed, fertilizer and line planting with closer spacing to achieve higher plant populations. In the first two years of trials, these treatments were compared with local varieties using farmer's methods without fertilizer. The highest yields were reported in Luwero under both farmer's method and improved technology. This was because of adequate and well distributed rainfall. In contrast many plots in Kasese were abandoned during several years when there was reportedly a prolonged drought. The full extent of the impact of drought, however, is unknown since plots which yielded poorly were eliminated from the trials. Thus no data on the relative riskiness of the different varieties or their response to water stress is available.

Farmers participating in the USAID sponsored on farm trials program received improved seed and fertilizer free for the first two years. Urea, 100 kg/ha, and TSP, 100 kg/ha (45 kg N + 45 kg P205) were applied. When the free fertilizer was phased out in 1990 second season, however, none of the farmers bought the recommended fertilizer even though researchers felt they had proven its worth in the earlier experiments. What can explain this apparently illogical behavior?

Farmers complained that fertilizer is either not available or too expensive. Some maize varieties, especially hybrids, produce at optimal levels only with adequate moisture and high nutrient levels. When fertilizer is subsidized or given free, the new technology is adopted. Farmers are very enthusiastic about participating in trials especially when they are given free or subsidized fertilizer as part of the experiment. They clearly recognize that fertilizer improves yields significantly. (Seventy eight percent of the farmers interviewed said that the trial method yielded better than their traditional method). But once free fertilizer is not available, farmers generally do not invest the cash to purchase it. Such behavior clearly indicates that the real cost of fertilizer procurement and application per unit of yield increase has not been adequately accounted for by the researchers when fertilizer recommendations were being developed. Farmers have extremely limited cash reserves to meet basic family needs. The cost of foregoing essential consumption (such as medical care and school fees) is very high under such circumstances. Therefore, the returns to cash investment in agricultural production must also be very high to make the trade off attractive to the small farmer. Not only must the physical yield increase be high, but there must be an assured market for the surplus at attractive prices. The surveys show that only 43.9% of the farmers felt that the value of the additional yield from fertilizer application was enough to pay for the fertilizer.

Maize researchers at Namulonge recognize that blanket recommendations for fertilizer application fail to take into consideration real differences in soil fertility between locations. They say, however, that no real breakthrough in the development of fertilizer recommendations that are location specific (i.e. apply to a particular recommendation domain) can be achieved until the soil mapping exercises which are currently underway have been completed. They hope, however, that once more information is available about the soil quality and fertility in the different regions, that it will be possible to make more specific recommendations suited to actual soil conditions.

MARKETING CONSTRAINTS

The earlier discussion of fertilizer application clearly brings out the importance of markets and price in determining the most efficient level of input use in agricultural production. Up to the early 1970s maize was grown primarily as a subsistence food crop but it is now replacing the traditional cash crops such as coffee, cotton and tea in some areas. Maize has become the only cereal crop exported from Uganda in substantial quantities. Such trade in maize was specifically promoted by the policy of the NRM government in the mid-1980s to engage in barter trade. Beans and maize were the two key commodities which were bartered for essential inputs, especially from Eastern Europe and the Socialist block countries. It is expected that maize would become a significant regionally traded commodity. Potential markets exist in Tanzania, which has been an important importer of Uganda maize in the past, and in Kenya and Rwanda where income and man/land ratios (due to rapid population growth) are rising, creating a demand for food imports. Zimbabwe, Zambia and South Africa are also major consumers of white maize. In times of periodic drought, as is currently the case, Uganda's higher rainfall could put her in an excellent position to supply the Southern African market. The unpredictability of this market, however, is likely to contribute to considerable price instability to farmers. There was also hope that maize could become a major component of a national and regional food security strategy because it can be stored and transported at a lower cost with less spoilage than many other food crops.

Economic analyses so far, however, indicate that Uganda does not have an international comparative advantage in maize production and marketing. The low yields under current production methods, lack of adequate storage, poorly coordinated marketing structure and high transportation costs combine to make Ugandan maize rather expensive, quality poor, and supply unreliable. These factors make maize currently an internationally "non traded" item. This phenomenon implies that Uganda will be unable to capture a significant edge on the international market until such problems are solved (Min. of Agriculture, April 1990).

Ugandan producers usually sell maize in an unprocessed form and in small quantities. No farm level drying facilities exist. As a result, the moisture content of sun dried maize varies considerably depending upon local weather conditions and the period of storage. This lack of uniformity is a problem both for storage and for meeting the strict requirements of international markets. Very little grading or cleaning is carried out at the farm level.

The Produce Marketing Board (PMB) had a legal monopoly on the exportation of maize until 1987. This policy was specifically designed to facilitate the government policy of barter trade. While maize was sold on the open market domestically, an official floor price was announced by the government. Unfortunately, however, this floor price was in actual practice more like the ceiling price which PMB was allowed to offer. The price of maize was always fixed low (Table 6.) to keep down the cost of living for urban areas assuring cheaper labor for the formal sector. This discouraged farmers. Sales to PMB failed to meet the barter commitments that the government had made and several barter deals originally denominated in maize had to be paid off in coffee.

In 1987 the export monopoly of the PMB was lifted. Since then policies have been instituted to encourage private sector trade in nontraditional commodities such as maize. Problems still exist, however, in the grain marketing sector. Marketing of maize like many Uganda's food commodities is not streamlined. There is no standardized market chain. Maize passes through various uncoordinated channels before reaching the consumer. Maize may be sold to agents of the Produce Marketing Board, wholesalers, retailers, processors, or directly to consumers. Similarly, it can be sold at the farm gate, at roadside, rural or urban markets, or at the buyer's place of business.

Poor roads and the lack of an effective communications network means that local markets are isolated and very thin. Prices are highly volatile and respond to very localized supply and demand situations. There is very little arbitrage between rural areas. Maize flows primarily from the rural areas into the Kampala urban center. Price information is not readily available to either farmers or local traders. There is no system for price monitoring at the parish, village, subcounty and district level.

Maize prices have not risen significantly, even after the government allowed private trader participation in maize marketing. Farm gate prices are generally low compared to the price consumers in urban areas pay. Such high marketing margins are a result of a number of factors. The actual cost to first handlers of consolidating very small quantities of maize from a large number of isolated small producers is high. Insecurity and the lack of rural financial institutions, encourages farmers to sell indirect proportion to their immediate cash needs. Normal cash needs are small and thus small quantities are sold to meet them. When major cash needs arise the individual farmer has limited market opportunities for his maize. Financial pressures forced farmers to accept whatever price is offered at that moment rather than being able to wait for a better price. Poor on-farm storage facilities and the failure to use necessary insecticides to control weevil damage severely reduces the keeping quality of the product. Storage losses thus offset the price premium the farmer could secure by selling in the off season. Poor rural roads increase the wear and tear on the vehicle fleet and raise the cost of transportation. The majority of the maize is still transported by head-load from the farm to the nearest market.

Table 6 Nominal and Real Producer Prices (Sh/mt) of Maize 1970-1988

Year	Output mt	Nominal.price	Real.Price
1970	389	4.4	286.7
1971	421	6.4	376.5
1972	500	4.4	244.4
1973	419	7.9	395.0
1974	430	9.9	291.2
1975	570	12.9	314.6
1976	674	16.6	276.7
1977	566	20.0	177.0

1978	594	20.0	129.9
1979	253	20.0	41.1
1980	286	20.0	36.8
1981	342	130.0	130.0
1982	393	267.5	229.2
1983	413	500.0	322.8
1984	280	700.0	321.5
1985	343	885.0	151.4
1986	286	2200.0	162.3
1987	363	10000.0	228.5
1988	560	15000.0	114.7

Source: Ministry of Planning and Economic Development, Statistics Department. (a)-Planning Division, Entebbe 1989.

Use of chemicals for diseases and pest control is not common in Uganda. Agro-chemicals and fertilizer may be available in urban areas (towns) and some trading centers, but they are very expensive and there is no guarantee of continued supply of these very inputs at the original source. Besides, farmers are not ready to pay large premiums for a new seed variety when they are not sure of the market (i.e where to dispose it off) and price.

One farmer in Mubende said he could not participate in the on farm maize and soybean trial in 1990/1 even though he had been given free seed and fertilizer. He had planted a smaller plot of local maize which was adequate for home consumption. To plant a 1/2 acre of maize as part of the on farm trials implied an investment in land and labor which might not pay off. He complained that even if the improved method was better he feared there would be nowhere to sell the crop since he had failed to get a good price and market the previous season (1988/89).

While it is true that the lack of capital is a serious production constraint, credit alone is not a solution. Farmers who had gotten agricultural loans from UCB in 1988 for production of maize were unable to pay them back. As a result of a large bumper crop that year prices in 1988 dropped to half that of 1987. Many farmers failed to sell at any price. This greatly discouraged production the following year.

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