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The use of improved maize varieties in Tanzania

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Maize is the most important food crop in Tanzania, covering 45% of the cultivated area. Maize farmers have adopted many improved maize varieties but different studies have produced different estimates of adoption rates. A survey was, therefore, conducted in 2001 to estimate the area in improved maize seed, to collect opinions regarding maize recycling, constraints to production and strategies to obtain improved maize seed. The seed sector sold an average 7,750 tons of improved maize seed per year from 1997 to 2000, but also indicate a clear negative trend in sales. While during the 1997/1998 season 9,500 tons were sold, it was reduced to 6,660 tons in the last season. Although the amount of hybrid seed sold was roughly the same for the three seasons, it was the sales of open pollinated varieties (OPVs) that decreased to less than a half in the third year. Based on an estimated national maize area of 2 million ha and a seed rate of 15 kg/ha, the estimate of the area planted with fresh improved maize seed was 26%. Considering the use of OPVs that have been recycled for two years, the area grown with improved maize seed was 46%. Drought, low prices of the produce, pests and diseases, and high input prices were mentioned by the extension officers as the most important constraints for maize production. The high costs of improved seed, poor availability and lack of knowledge were some of the reasons why farmers did not use improved seed. The major strategies farmers use to obtain improved seed were purchase from agro-dealers, recycling of their own seed, and the formation of Savings and Credit Cooperative Societies (SACCOs). Since the survey, seed sales have increased but this increase is mostly in hybrids, and has been accompanied by an increase in area , so the proportion of maize area in improved varieties remains at a low 27%. Research and development efforts should, therefore, be directed to solve the farmers' major production constraints such as drought, lack of markets and low produce prices, and pests and diseases. Knowledge of how to obtain and grow improved varieties, including good husbandry practices, is critical in adopting improved varieties.

Key words: Survey, improved maize seed, adoption rate, Tanzania.

INTRODUCTION

Maize is the most important staple food crop grown in Tanzania. Other staples are sorghum, millet, cassava, sweet potatoes, bananas, pulses, paddy and wheat. Food crops dominate the agricultural economy, accounting for as much as 50% of the agricultural Gross Domestic Product (Ministry of Agriculture and Cooperatives, 2001; ASDP, 2003). Over 80% of the population depends on maize as a food crop as well as for cash (Moshi, 1997: 141), and it is grown on more than 45% of the total cultivated area (Nkonya et al., 1998; United Republic of Tanzania, 2006). Between 1990 and 1993 maize occupied about 59% of the total area under cereals (Moshi, 1997: 141). The National Maize Research Programme (NMRP) has divided the country

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into three major agro-ecological zones for varietal recommendations: the highlands, the mid-altitudes, and the lowlands. The highlands have elevations of 1,500 meters above sea level (masl) with a growing period of six to eight months. The mid-altitudes are situated between 900 and 1500 masl and can be subdivided into wet mid-altitude, areas with more than 1,100 mm annual rainfall and a growing period of four to five months, and dry mid-altitudes, areas with less than 1,100 mm rainfall and with a three to four month growing period. The lowlands have an altitude of 0 to 900 masl with a growing period of three to four months (Kaliba et al., 2000). About 85% of maize in Tanzania is produced by resource-poor small-scale farmers, while the remaining 15% is produced by public and private large scale farmers (Moshi, 1997: 141). Most of the maize is produced in the Southern Highlands, the Lake and the Northern Zones. Dar es Salaam, Lindi, Singida, Coast and Kigoma are deficit regions. Dodoma is a surplus region in good growing years (Mdadila, 1995; Moshi, 1997: 141).

The total area under maize has been estimated by various authors to fall between 1.7 and 2.0 million hectares (Mayagilla, 1988; Nkonya et al., 1998; Pingali, 2001). According to the National Food Security Department, the annual production of maize in the country has hardly gone beyond three million tons during the period 1982/1983 to 1992/1993. The production had generally fluctuated between 2.0 and 2.4 million tons per annum and had been declining since 1989/1990 (Mdadila, 1995; Pingali, 2001). A slight increase in yield of 10 to 20% was, however, reported in the 1994/1995 and 1995/96 seasons (Moshi, 1997: 141). Most of the maize produced (85%) is consumed at the household level. Surpluses are bought by other farmers, by urban dwellers and by maize-deficient regions. Only about 5% of the maize produced in the country is used as animal feed (Pingali, 2001). The per capital utilization of maize stands at about 114 kg per year and it contributes an estimated 61% of the total calories in the people's diets (Moshi, 1997: 141; Kirway et al., 2000).

Maize farmers in Tanzania have benefited from the investments in maize research through increased maize yields. These yield gains are attributed to the adoption of improved maize varieties as well as management practices (Moshi, 1997: 141). An impact study showed that the observed 38% increase in maize yield, as well as the greater proportion of maize being marketed, could largely be attributed to the improved varieties and management practices (Moshi, 1997: 141). Currently, maize is the only food crop stored by the Strategic Grain Reserve (SGR) program in Tanzania, which stores the surplus maize production. This reserve has increased from 26,000 metric tons in 1990/91 to 70,000 metric tons during the 1992/93 seasons. Thus, the maize program has contributed to both household and national food security (Moshi, 1997: 141).

A study in Northern Tanzania found that the adoption of improved maize seed was positively affected by the amount of nitrogen use per acre, farm size, farmer education attainment level, and visits by extension agents (Nkonya et al., 1997: 1-12)

Different studies led to different estimations of adoption rates for improved maize varieties in Tanzania. By conventional definition, an improved variety is that which has been improved by formal plant breeding. This would include recycled varieties that have not yet lost their desirable attributes and, hence, perform better than unimproved varieties. The adoption rate of improved varieties for the various zones in the country was estimated at 28% for the Central Region, 66% for the Eastern Region, 44% for the Lake Region, 66% for the Northern Region, 24% for the Southern Region, 81% for the Southern Highlands and 36% for the Western Zone (Moshi, 1997: 141). Another study, based on seed sales, estimated the total national maize area planted to improved OPVs and hybrids at only about 4% (Hassan et al., 2001). Those rates might be misleading in terms of the contribution of improved maize varieties to both household and national food security, as well as in the country's economy. The study might have failed to reveal the actual contribution of the different partners in the supply of improved seed to the farming communities, as well as the importance of recycling. In Northern Tanzania, adoption rates based on the number of farmers planting certified seed were estimated at 52% (Nkonya et al., 1997: 1-12), while adoption rates based on both certified seed and recycled seed from improved varieties was estimated at 94% (Nkonya et al., 1998).

Given the importance of maize in the country and the various sources of improved maize seed for farmers, it was important for the research scientists, extension and development agents, and their partners in the maize industry to obtain good estimates of the acreage grown to improved maize varieties. These data are important in the preparation, formulation and implementation of agricultural policies to enhance maize production in the country. Therefore, a survey was conducted country-wide to estimate the area grown in improved maize, as well as to collect opinions regarding maize recycling, constraints to maize production, and strategies used in obtaining improved maize seed. This survey was complemented with a literature review and secondary data.

METHODOLOGY

A survey was conducted in the whole country to estimate acreage grown to fresh improved maize seed in the period 1996/1997 to 1999/2000. The information was obtained using two different types of questionnaires, which were prepared in May 2001 and submitted to clients to fill in the required data. The first type of questionnaire was sent to seed companies and institutions producing or selling seed, while the second one was sent to agricultural extension agents. The checklist for seed companies was sent to all private seed companies operating in the country: Tanseed headquarters in Arusha; Tanseed branches in Iringa, Mbeya and Morogoro; the East African Seed Company (an agent for Pannar); Monsanto; Kenya Seed Company (KSC); Bytrade; Tanganyika Farmers

Association (TFA) headquarters in Arusha; TFA branches in Dar es Salaam, Iringa, and Mbeya; Mukpar stockist in Arusha; Kibo Trading Company in Moshi; Zenobia Seed company in Arusha; the Seed Unit in the Ministry of Agriculture and Food Security; Msimba, Dabaga, Mwele and Arusha foundation seed farms; and the Tanzania Official Seed Certification Agency (TOSCA) in Morogoro. The questionnaires for extension agents were sent to agents in all twenty regions in the Tanzania mainland. Responses were received from 15 regions. Secondary data were collected from various sources such as the Statistics Unit of the Ministry of Agriculture and Food Security and various publications. Informal discussions were held with some of the seed companies, extension agents and stockists visited during distribution of the questionnaires.

Seed sales were subdivided into those by the public sector and those by the private sector to estimate the relative contribution of the two sectors to the seed industry. Seed sales were categorized into OPVs and hybrids to determine the adoption of hybrids in the country. Total sales for both OPVs and hybrids were calculated for each year and for the three seasons to show the use of the two categories by farmers. According to the regional varietal catalogue for the East African Community, the average seed rate for most maize varieties monocropped is 17 to 20 kg/ha (TOSCA, 2001). However, most of the resource-poor farmers, who produce about 85% of the maize in the country, intercrop their maize with a legume, resulting in a reduced seed rate. They also use hand hoes for planting, which reduces the seed rate as compared to using tractors or oxen (Kirway et al., 2000). Field experience shows that, when resource-poor farmers plant improved varieties, they have a tendency to use lower seed rates due to the high prices of seed. For these reasons, we assume a general seed rate of 15 kg/ha. This is slightly lower than the average seed rate of 17.5 kg/ha that has been used elsewhere for all countries in Southern Africa with the exception of South Africa and Lesotho (Hassan et al., 2001). Using the estimated seed rate of 15 kg/ha, the total area planted to both OPVs and hybrids for each year was then calculated. The percentage of area grown with fresh improved seed, both OPVs and hybrids for each year was calculated based on an estimated total area of 1.8 to 2.0 million hectare (Moshi, 1997: 141; Pingali, 2001). A mean percentage of the area grown in improved maize for the three seasons was also calculated.

Seed produced in a certain season or year is not necessarily sold in the same season. Therefore, production data from the seed companies was not used for estimating the use of improved maize seed or the area planted in them. As well, several seed companies do not produce their seed in the country, but import them. Therefore, only actual seed sales data were used to estimate the area grown in improved seed.

The number of years that farmers recycle either OPVs or hybrids was obtained from the extension officers' estimates, using the figure most mentioned by the different respondents. Production constraints and farmers' strategies were obtained by first listing all constraints or strategies mentioned by the different extension officers, and then ranking them in order of frequency. Because of the time lag since the collection of the primary data, an update of the seed sector based on recent literature and secondary data has been added, including an update on the number and types of maize varieties released, the number and types of seed companies active in the maize sector, the adoption rate and the constraints.

RESULTS AND DISCUSSION

The maize seed sector in Tanzania

Realizing the importance of the maize crop to the lives of Tanzanians, the government committed human and financial resources to develop the maize sector. Research and extension efforts in maize started in the 1940s. Breeding efforts in the 1960s resulted in the release of Ukiriguru Composite A (UCA), and Ilonga Composite White (ICW). The government launched a Maize Project in 1974, with assistance from the U.S. Agency for International Development (USAID), to promote maize production in pursuit of food self-sufficiency. The National Maize Research Program (NMRP) was launched with the broad objective of developing cultivars suitable for the major maize producing areas (Nkonya et al., 1998). Since the mid-1970s to the mid-1990s, about 15 improved maize varieties (hybrids and OPVs) have been released by the NMRP.

When a public variety is released by the National Seed Release Committee, some breeders' seed is given to national foundation seed farms that produce foundation seed of the released varieties. Before the liberalization, the foundation seed was then sold to the state-owned parastatal company, Tanzania Seed Company (Tanseed) which had the monopoly to produce and distribute certified seed. Tanseed contracted various institutions and farmers to produce the certified seed (Moshi and Nnko, 1989: 268-273; Ministry of Agriculture and Cooperatives, 1994). Tanseed had been the sole or main supplier of improved maize for the farmers up to the mid-1990s, when private seed companies from the region were allowed to bring in their materials.

Since the trade liberalization and initiatives under the structural adjustment programs, multinational seed companies are actively involved in seed distribution. Some of the main private seed companies currently operating in the country are DeKalb/Monsanto, Pannar (South Africa), Kenya Seed Company, and Pioneer/Bytrade. Seed Co. (Zimbabwe) has also started testing its materials recently. The private companies are mainly selling hybrids. Pannar and Monsanto are also selling some varieties released by the NMRP. By the time of our survey, in 2001, the NMRP had released 15 varieties (Table 1), while the private seed companies had released 12 varieties (Table 2). The year of release, characteristics, potential yield and the recommended agro-ecological zones or altitudes for the varieties are presented in the respective tables. The year after the survey, both the NMRP and the private sector released several more varieties, in particular: Lishe 1, Lishe 2, Lishe K1, Situka 1, Situka M1, PAN 15, PAN 691, PhB 30 H83, PH4, SC 627, and CRN 3891.

Recently, a number of non-governmental organizations (NGOs), churches, individual farmers, farmer groups and other organizations have started community-based seed production in a number of regions in the country. Examples of such organizations are the Christian Council of Tanzania (CCT), the Diocese of Central Tanganyika (DCT) and Zoissem-LVIA in Kongwa in Dodoma, HIMA in Iringa, Mara Farmers' Initiative Project supported by

Table 1. Maize Varieties Released by the Maize Research Programme in Tanzania from 1974 to 2000.

Variety	Year released	Characteristics	Yield potential (ton/ha)	Target zone/Agro-ecological zone
Tuxpeno	1976	Open pollinated, white dent, good standability	5.5	Low altitude (0-900 masl)
H 614	1977	Top cross hybrid, white dents, large cars	10.0	Over 1500 masl
H 6302	1977	Three-may; Cross hybrid, white flint, and good standability	11.0	Over 1500 masl
H614	1979	Top cross hybrid, white dent, good standability	11.5	Over 1500 masl
Staha	1983	Open pollinated, white flint/dent streak tolerant	6.5	Low altitude
Kilima	1983	Open pollinated, white flint/dent good standability	7.5	Medium and high altitude
Kito	1983	Open pollinated, white flint early maturity	6.0	Low altitude 0-900 masl
TMV-1	1987	Open pollinated, white flint, medium maturity, streak resistant	6.3	Low and medium altitude
TMV-2	1987	Open pollinated, white flint, large ears	9.0	Medium and high altitude
CH-1	1992	Single cross hybrid, white flint.	6.8	Low and medium and altitude
CH-3	1992	Three - way cross hybrid white flint	6.9	Low and medium altitude
Kilima-ST	1994	Open pollinated white flint/dent, good standability, and streak tolerant.	7.5	Medium and high altitude
UCA-ST	1994	Open pollinated white flint, streak tolerant	7.5	Medium altitude
Kito-ST	1994	Open pollinated, white flint, early maturity, streak tolerant	6.3	Low and medium altitude
Katumani-ST	1994	Open pollinated white dent early maturity, streak tolerant	4.3	Low altitude

Sources: Moshi (1997: 141), Kirway et al. (2000) and TOSCA (2001).

IFAD, ICRISAT/SADC, FINACO in Dodoma, Mtumba Women Rural Training Centre in Dodoma, Sokoine University of Agriculture (SUA) in Morogoro, and others. These organizations are playing a significant role in the production of Quality Declared Seeds (QDS) of the improved varieties. All of them are producing OPVs (Lumbadia and Granqvist, 2001; Mongo, 2001; Natai, 2001).

Seed companies survey

Improved maize seed sales

Most respondents could not provide information for the 1996/1997 season, so these were not included in the analysis and, during those early years of the liberalization, many of the private seed companies were not yet well established. Furthermore, most of the organizations involved in community-based seed production of the so-called Quality Declared Seed (QDS) only started doing so in the last two to three seasons. Improved seed distributed or sold to farmers by extension agents could not be used to verify or crosscheck data provided by seed companies, because these companies do not channel their sales through the extensionists. In some cases, the extensionists are not even aware of the existence of either the seed companies or the materials they sell, since the companies do not have branches or stockists in all towns.

In the 1997/1998 to 1999/2000 seasons, the seed sector sold, on average, 7,750 tons of seed per year (Table 3). A clear negative trend in the sales of improved varieties can be observed over the three seasons: from 9,500 tons during the 1997/98 season to only 6,660 tons in the 1999/2000 season. Several factors influenced this evolution. The very heavy El-Nino rains in 1997/1998 left the farmers without much of a harvest, so they faced a money shortage to buy improved seed in the following season, 1998/1999. In that season, drought occurred in most parts of the country, which also resulted into low yields and reduced income for the farmers to purchase improved maize seed for 1999/2000 season.

The use of fresh OPVs over the three years has declined drastically to less than half in the last two years compared to the first year (Table 3). This was mainly caused by the decreased production from Tanseed over the years, as this company was the main or sole producer of seed, especially OPVs, for the whole country. At the time of the survey, Tanseed was undergoing divestiture and, hence, was producing small quantities of seed. Otherwise, past experience shows that most

Table 2. Maize varieties released by Private Seed Companies in Tanzania from 1992 to 2000.

Variety	Year released	Company	Characteristics	Yield potential (t/ha)	Target zone/Agro-ecological zone /Altitude
CG 4142	1993	CARGIL	Hybrid with white flint/dented kernels	-	Mid altitude
C 6222	1994	CARGILL	White with flint/dented kernels and good standability	10.0	Medium altitude
PhB 3253	1994	PIONEER	Hybrid white and hard flint kernels, good poundability and standability	8.5	Low and medium altitude
PAN 6549	1995	Pannar	Hybrid, white, hard flint and good standability	7.5	Medium altitude
PAN 695	1995	Pannar	Hybrid, white, hard flint and good standability	-	Medium altitude
PAN 6481	1995	Pannar	Hybrid, white with flint/dented grains and good standability	-	Medium altitude
PAN 6195	1995	Pannar	Hybrid, hard flint and very good standability and tolerance to maize streak virus	-	Medium altitude
CG 4141	1997	CIBA-GEIGY	Hybrid, white soft dented and good standability	7.0	Low and medium altitude
C 5121	1997	CARGILL	Hybrid with white flint kernels and good standability	Over 10.0	Medium altitude
C 5051	1999	CIBA-GEIGY	Hybrid, white hard dented and good standability and poundability	Over 10.0	Medium altitude
Phb 30A15	1999	PIONEER	Hybrid, white flint/dented kernels with good standability	8.0	Medium altitude
CRN 3631	1999	CARGIL	Hybrid with white flint/dented kernels	7.0	Medium altitude
DK 8071	2000	DeKalb	Hybrid, white dented kernels good standability and poundability	8.0	Low to medium altitude but preferably medium
PAN 6243	2000	Pannar	Hybrid, white and flint/dent kernels, good standability	9.0	Medium to high altitude
PAN 67	2000	Pannar	Hybrid, white and flint kernels, good poundability, early maturity	7.0	Low to medium but preferably low
H 513	2000	Kenya Seed	Hybrid, white, flint/dent, good standability and poundability	6.5	Low to medium
PAN 77	2000	Pannar	Hybrid, white flint kernels with good poundability and standability	7.0 – 8.0	Medium

Sources: Kirway et al. (2000) and TOSCA (2001).

Table 3. Improved maize seed sales in Tanzania in 1997/1998 - 1999/2000 crop seasons (tons/year).

Years	Public sector		Private sector		Total		Grand total
	OPVs	Hybrids	OPVs	Hybrids	OPVs	Hybrids	
1997/1998	1,183	749	3,506	4,058	4,689	4,807	9,495
1998/1999	974	437	1,160	4,522	2,135	4,959	7,094
1999/2000	478	360	1,637	4,184	2,114	4,545	6,659
Mean					2,979	4,770	7,749

Table 4. Area grown to improved maize seed in Tanzania in 1997/1998 - 1999/2000 crop seasons.

Period	Area under improved maize varieties (ha)			% of total maize area (estimated at 2 million ha)		
	OPV's	Hybrids	Total	Improved OPV's	Hybrids	Total IMV
1997/1998	312,580	320,453	633,033	15.7	16.0	31.7
1998/1999	142,313	330,600	472,913	7.1	16.5	23.6
1999/2000	140,967	302,993	443,960	7.0	15.2	22.2
Mean	198,620	318,016	516,636	9.9	15.9	25.8

resource-poor farmers used to grow more OPVs than hybrids, since OPVs are cheaper and can be recycled for several years without substantial yield loss (personal communication with Tanseed Branch Managers in Mbeya, Iringa and Morogoro). The current production and sales of Quality Declared Seeds (QDS), which were recently started by some community-based organizations, cannot by any means satisfy the demand for OPVs at this time.

Sales of hybrids, on the other hand, were quite good in the first two years. However, they dropped slightly in the third year, due to farmers' low purchasing power and the poor weather conditions. The season was hit by poor weather from the beginning, which deterred farmers from buying seed, and it went on to become one of the driest seasons in decades.

Area planted in improved maize seed

Different sources have quoted or estimated the maize acreage in Tanzania differently: From 1.78 million hectare of maize in the whole country (Mayagilla, 1988), to over 1.8 million ha (Hassan et al., 2001; Pingali, 2001) to about 2 million hectares (Nkonya et al., 1998). Since the estimated area may have fluctuated over the years, we used an average national area of 2 million ha for our calculations. Based on an estimated seed rate of 15kg/ha, the area planted in improved maize can be calculated per category (Table 4).

The total area planted in improved seed clearly decreased by one third over the three years, most of the decrease occurring between the first and second year. The proportion of maize area planted in OPVs decreased from about 16 to 7%. whereas the area under hybrids decreased from 32% to 22%. The average area planted in OPVs in the three-year period was 10 and 16% for hybrids, so the area planted in OPVs was about 2/3 of the area grown in hybrids.

Based on the estimated total national area of 2.0 million ha- and an average seed rate of 15 kg/ha, the area in improved maize varieties can be estimated at 26% of the total maize area, of which 10% was in OPVs and 16% in hybrids. These percentages do not take into account the recycling of the varieties, which is treated subsequently.

Extension agents' interviews

Due to financial constraints, some of the questions were directed to the extension agents instead of the farmers. Because extension agents have close working relationships with the farmers they work with, they should have a good understanding of farmers' production constraints. Although their responses may not be exactly the same as those which would have been obtained from farmers, they do give a good general impression of how farmers handle maize production and marketing issues. Some of the extensionists have demonstration plots which provide them with first-hand information. The extension agents were asked to give their comments or responses to important issues, such as the recycling of maize seed by farmers, farmers' main production constraints, the reasons why farmers do not use improved seed, and the strategies which farmers use to obtain improved maize seed.

Recycling of improved maize seed

Seed recycling is defined as the practice of replanting seed harvested from farmers' fields (Morris et al., 1999: 59). A hybrid seed is a seed obtained from an F1 generation resulting from crossing two maize parents coming from two genetically different inbred lines. An OPV, on the other hand is a sub-division of a species that is different (distinguishable from other varieties), uniform (its identifying characteristics are well defined), and stable (its identifying characteristics are constant in time and space). Farmers in Tanzania often recycle their purchased seed. One study reported that most farmers recycled their maize seed: 77% in the Northern and 60% in the Southern Highlands, 89% in the Central zone, 100% in the Southern zone, and 65% in the Lake Zone(Moshi, 1997: 141). Extension agents were, therefore, asked to estimate how often or up to how many years they think their farmers recycle the hybrid and OPV seed they buy. Their responses differed: They estimated that hybrids are recycled from a period of one year (20% of respondents) to four or five years (one respondent each) (Table 5). So 87% of agents interviewed reported a recycling period of up to three years, with the most frequently reported period being two years (40%). While

Table 5. Average number of years for recycling hybrid maize seed in Tanzania as estimated by agricultural extension officers.

District or region	Number of years for recycling hybrids				
	1	2	3	4	5
Sengerema		X			
Mwanga					X
Muheza			X		
Same			X		
Morogoro Region				X	
Iringa Region			X		
Shinyanga	X				
Misungwi Mwanza	X				
Ukerewe Nansio			X		
Mbeya Region		X			
Geita		X			
Kilimanjaro Region	X				
Bukombe		X			
Meatu		X			
Arusha Region		X			
Total (number of respondents)	3	6	4	1	1
Percentage	20	40	27	7	7

few agents reported recycling hybrids longer than three years, cases were reported of farmers recycling hybrids to the point of forgeting their original names and starting to call them local varieties. Improved OPVs are estimated to be more frequently recycled by farmers than the hybrids. About 33% of the respondents said that farmers recycle their OPVs up to three years before looking for fresh seed (Table 6). Another 26% indicated that the farmers in their area recycle them up to two years. No respondent reported the recycling of OPV seed for less than two seasons, while the rest of the respondents (40%) reported recycling of OPVs for five years or more. If we consider recycled OPVs as improved seed for the first two years after purchase, the area grown in improved OPVs would increase from 10 to 30%. Recycled hybrids, on the other hand, should not be considered as improved varieties, so recycling does not change their 16% proportion of the area. Incorporating the two-year recycled improved OPVs would, however, increase the proportion of the total maize area in improved varieties from 26 to 46%.

Maize production constraints

Drought seems to be the most limiting constraint for maize production, mentioned by 67% of the respondents (Table 7). The next two constraints, mentioned by about half of the respondents, were low prices for the produce or lack of an assured market, and pests and diseases – both in the field and during storage. Other constraints were high inputs prices, so farmers are unable to purchase them, lack of the improved seed, and poor husbandry or lack of know-how. Finally, constraints mentioned only a few times were the non-use of fertilizers, leading to low soil fertility, and the lack of credit to purchase inputs. Drought has featured many times in farmers' assessments of maize varieties as one of the most important criteria farmers consider when selecting maize varieties (Lyimo et al., 2000, 2001).

Main reasons why farmers do not use improved maize seed

For a large majority of respondents (87%), the high price of improved maize seed is the most important factor why farmers do not use them (Table 8). The second most important factor was the susceptibility of the improved varieties to pests and diseases, mentioned by about two thirds of the respondents.

Other important reasons were lack of information or knowledge about the varieties, and their availability. Poor poundability and taste are considered important by farmers, because in good harvest years a good percentage of the farmers mill their maize and prepare local dishes which require maize varieties with hard endosperms or grains. Most farmers roast their green maize so taste becomes important. That hybrids should not be recycled was the least important factor, since farmers clearly recycle their seed anyway,including hybrids, as discussed previously.

Table 6. Average number of years for recycling Open Pollinated Varieties (OPVs) in Tanzania as estimated by agricultural extension agents.

District or region	Number of years for recycling					
	1	2	3	4	5	>5
Sengerema			X			
Mwanga					X	
Muheza						X
Same					X	
Morogoro Region					X	
Iringa Region						X
Shinyanga						X
Misungwi Mwanza		X				
Ukerewe Nansio		X				
Mbeya Region			X			
Geita			X			
Kilimanjaro Region		X				
Bukombe		X				
Meatu			X			
Arusha Region			X			
Total (number of respondents)	0	4	5	0	3	3
Percentage	0	27	33	0	20	20

Table 7. Main constraints for maize production in Tanzania as perceived by extension agents.

District or region	Drought	Low prices	Pests and diseases	Lack of inputs	Know how	Lack of credits	Lack of improved seed	Decreasing soil fertility
Sengerema	X		X	X	X			
Mwanga	X				X		X	X
Muheza	X	X	X		X			
Same	X		X				X	
Morogoro region		X	X				X	
Iringa region	X	X				X		X
Shinyanga	X		X					X
Misungwi Mwanza			X					X
Ukerewe Nansio								
Mbeya region	X	X		X	X	X		
Geita		X		X	X			
Kilimanjaro region	X	X		X		X	X	
Bukombe			X	X			X	
Meatu	X	X	X				X	
Arusha region	X	X	X	X				
Total (number of respondents)	10	8	8	6	5	3	6	4
Percentage of respondents	66	53	53	40	33	20	40	27

Farmers' strategies to obtain improved maize seed

More than two thirds of the extension officers interviewed reported that farmers obtained their improved seed through purchases from input dealers or stockists. About half of them reported that farmers recycled the seed they used in the previous season (Table 9). Other strategies to obtain improved seed were to request support from the government or from donor or relief agencies, and the formation of Savings and Credit Cooperative Societies (SACCOs), both mentioned by 40% of respondents. Finally, working as casual labor to earn money to

Table 8. Major reasons why farmers do not use improved maize seed.

District or region	High cost	Susceptible to pests and diseases	Poor communication, high investments, ignorance	Availability	Poor poundability and taste	Cannot be recycled
Sengerema	X	X	X			
Mwanga	X		X			
Muheza	X	X		X		
Same		X			X	
Morogoro region	X	X		X		
Iringa region	X	X	X			X
Shinyanga	X		X			
Misungwi Mwanza	X	X		X		
Ukerewe	X					
Mbeya region	X	X	X			
Geita			X	X		
Kilimanjaro region	X			X	X	X
Bukombe	X	X		X		
Meatu	X	X			X	
Arusha region	X	X	X			
Total (number of respondents)	13	10	7	6	3	2
Percentage	87	67	47	40	20	13

Table 9. Farmers' strategies to obtain improved maize seed.

District or region	Buy from stockists	Recycling their seed	Support from Govt. and donors	Formation of savings and credit societies	Conduct maize trials and extensionist	Casual labor
Sengerema						X
Mwanga			X			X
Muheza	X	X	X			
Same	X					
Morogoro Region	X	X		X		
Iringa Region						
Shinyanga						
Misungwi Mwanza	X	X			X	
Ukerewe	X	X				
Mbeya Region				X		X
Geita	X	X	X			
Kilimanjaro Region	X	X	X	X	X	
Bukombe	X	X			X	
Meatu	X					
Arusha Region	X	X		X		
Total (number of respondents)	10	8	4	4	3	3
Percentage of respondents	67	53	27	27	20	20

purchase seed, participating in research trials and demonstrations, and getting advice from the extension officers were also mentioned. Strategies such as selling livestock or crops, borrowing from other farmers, farm visits, use of contract farmers and establishing seed banks were not considered by the extension officers to be important farmers' strategies to obtain improved seed.

Recent developments in the tanzanian maize seed sector

Since the time of our survey, the seed sector in Tanzania has gone through substantial changes. The liberalization of the sector, which started in the 1990s, has led to many institutional changes in the 2000s, which resulted in a dramatic increase in the number of seed companies and released varieties, substantially widening farmers' choices in improved maize seed varieties, but this did not lead to a considerable increase in adoption rates.

Legislation and regulatory processes

The liberalization, initiated in the 1990s, led to the establishment of several institutions in the seed sector, creating an enabling environment for private sector participation, at least in the food and maize sectors. Donor-inspired attempts to liberalize export crop markets, on the other hand, have faced considerable opposition from the political-bureaucratic class (Cooksey, 2011).

Tanzania enacted a new Seeds Act in 2003, with subsequent regulation signed in 2007, which encouraged private sector seed production and distribution (World Bank, 2012). The act established TOSCI (Tanzania Official Seed Certification Institute), now the sole agency for seed certification, quality control and other regulatory tasks. The act supports the harmonization of the East and Central Africa seed policies based on the Organization for Economic Co-operation and Development (OECD) standards. Harmonization agreements were reached in 2002, and they have reduced the length of variety release period to two seasons and they allow information of trials in similar regions of other countries to be used in the application (Waithaka et al., 2011). Kenya and Uganda have acceded to the OECD, while Tanzania has applied for membership. The standardized certification procedure has greatly improved the working relationship between regulators and seed companies in the ECA region.

Other important recent legislation in Tanzania includes the Protection of New Plant Varieties (Plant Breeders Rights) Act of 2002 which established a plant variety protection (PVP) system based on the International Union for the Protection of New Varieties of Plants' (UPOV) 1991 convention, in line with Kenya and Ethiopia. However, in contrast to the other countries in the region, the act allows for a mechanism to promote on-farm seed production and the multiplication of seed, categorized as "Quality Declared Seed (QDS)" which is distinct from certified seed. This act also established the Agricultural Seed Agency (ASA), a government agency whose main mandate is to provide all foundation seed for varieties bred from public institutions, but it is also mandated to produce and market seed, creating a potential conflict of interest. In line with the liberalization, the Tanzania Seed Trade Association (TASTA) was established in 2002 and, by 2013, had grown to 28 members. TASTA is a member of the African Seed Trade Association, which was established in 2000 to promote trade in quality seed and technologies in Africa for the benefit of both members and farmers.

Maize seed companies and released varieties

The liberalization of the agricultural input sector dramatically increased the number of seed companies in Tanzania and the number of varieties they released. The Tanzania Seed Company used to have the monopoly on seed production and distribution, but it collapsed after many years of poor performance, and the government opened the market to the private sector. In 1993, Cargill became the first private company to release a maize hybrid in Tanzania, followed by Pioneer in 1994 and Pannar (from South Africa) in 1995. By 1996, there were one public and three private seed companies in Tanzania (Hassan et al., 2001) and by 2007, there were 14 seed companies (Langyintuo et al., 2010), including major players such as Monsanto in1999, Kenya Seed Company (KSC) in 2000, and Seed Co. (from Zimbabwe) in 2001. In 2002, after the collapse of the government-owned company Tanzania Seed Company, Tanseed International was founded. Smaller companies include FICA Seed (from Uganda) and Western Seed (from Kenya), and several local companies. In 2011, there were 52 registered private seed companies, although not all were active. Apart from Pannar, who produces seed in the country, international companies tend to import their seed.

During the 2010/2011 season, the private sector provided nearly 80% of the total commercial seed supply, mostly hybrids. The Seed Unit reported 13 companies with maize seed sales of 100 tons or more (Figure 1), but the sector is clearly dominated by international companies, in particular companies from other African countries. The two largest companies, Pannar Seed (28%) and Seed Co. (26%), capture more than half of the market. The first local company is Suba Agro (9%), followed by Kibo Seed (a subsidiary of KSC) and Monsanto, a multinational. Other local seed companies are Highland Seed (6%) and ByTrade (5%), followed by the government ASA and the Ugandan FICA Seeds (4%).

Improved maize varieties

Since the liberalization, there has been a large increase in maize varieties released, and the emphasis has shifted from the public to the private sector. As in most African countries, maize variety development in Tanzania was initiated by the public sector, who dominated the first decades. From 1976 to 1993, 11 varieties were released,

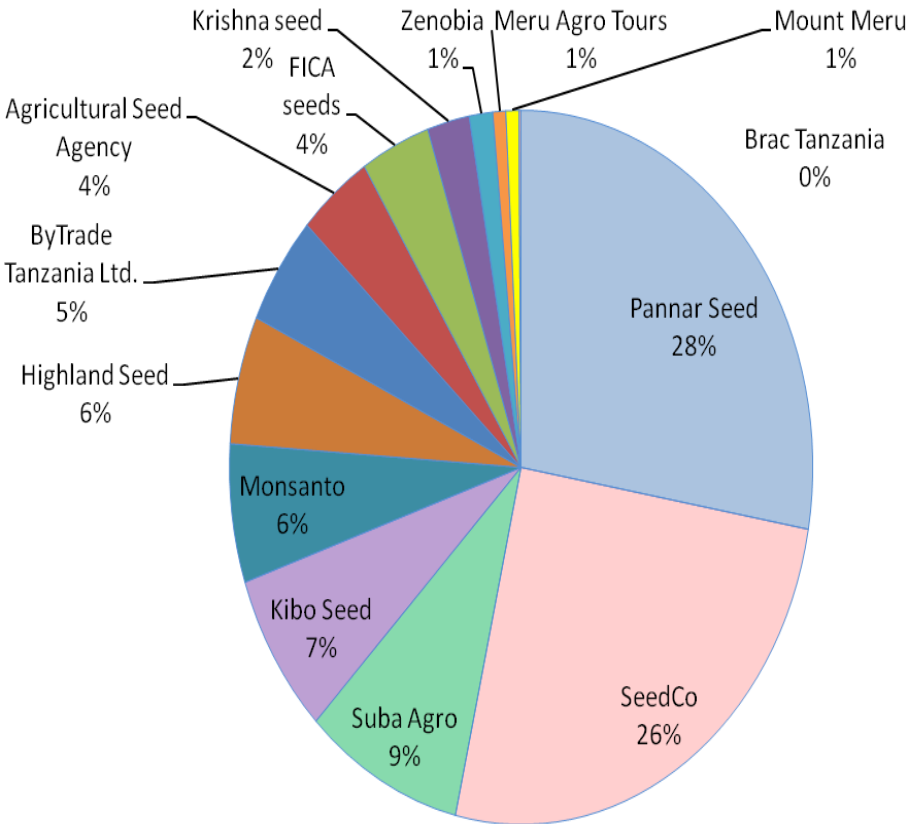

Figure 1. Maize seed companies in Tanzania with their market share in 2010/2011 (Total = 18,184 tons). Source: World Bank (2012).

all public (Figure 2). The private sector released its first variety in 1994, the start of the liberalization, and has dominated since, although the public sector has made a rebound since 2008. By 2010, 91 varieties had been released, 79% of which were hybrids. Two thirds of these releases were released by the private sector, mostly by regional companies (35) and multinationals (20). The first variety by local private seed companies was released in 2006, and by 2010 this group had released five varieties. While the public sector was dormant in the late 1990s, since 2000 it released another 15 varieties, seven of them after 2005. The private sector released almost uniquely hybrids (97%), with only four OPVs and three by national private companies (out of five releases).

Seed sales and adoption

While seed sales have increased dramatically over the last decade, the proportion of maize area in improved seed remains low, and the proportion of farmers adoption of IMVs is even lower. Seed sales have increased five times over the last ten years (Figure 3), from less than 5000 tons in 2003/2004 to more than 25,000 tons in 2010/2011, of which nearly 80%, mostly hybrid maize, was supplied from the private sector (World Bank, 2012). The increase in the availability of improved seed and the increase in seed sales improved the adoption of improved varieties, although it remains relatively low. In 1997, based on seed sales, 4% of the maize area was estimated to be planted in improved varieties (4% based on a key respondents' survey) (Hassan et al., 2001). The results of our survey showed an adoption rate of improved varieties of 26% of maize area in the late 1990s (Table 4).

Based on seed sales obtained from a survey conducted in 2006/07, adoption rates in 2007 were estimated at 18% (Table 10) (Langyintuo et al., 2008). This estimate did not include recycled seed, so likely the adoption rates had not changed much over the previous ten years. The survey also revealed the increasing importance of hybrid seed (Table 10) (Langyintuo et al., 2008). This was attributed to the large number of seed companies who sell seed of their own hybrids, mostly imported, and a few publicly released OPVs which are marketed by all registered companies. The improved seed need ranges from 40,000 tons estimated in the 2006/2007 season to 74,000 tons in 2009/10 (MAFSC 2009).

In a recent study to document the perceived level of adoption and diffusion of released maize varieties in Tanzania, the maize experts agreed that in 2009/2010 both

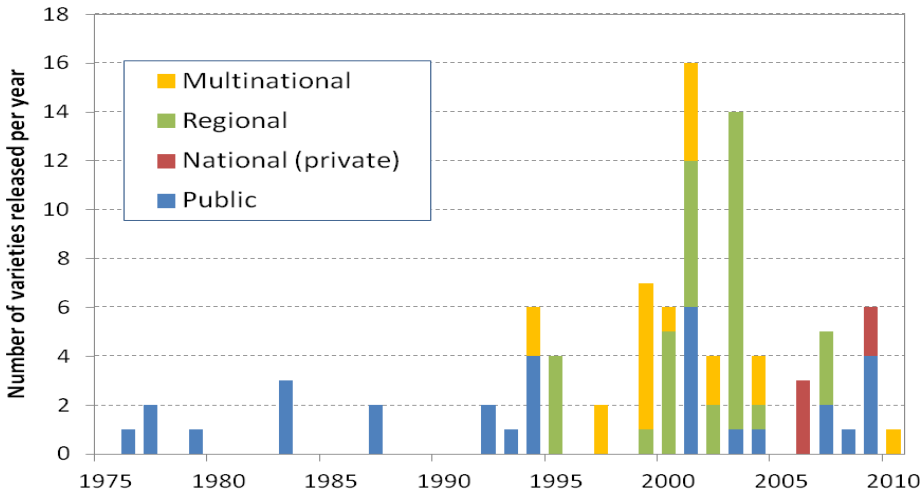

Figure 2. Number of maize seed varieties released per year in Tanzania, by type of seed company Source: De Groote et al. (2014).

Figure 3. Seed sales in Tanzania, by year and by sector (private or public). Source: World Bank (2012).

regional and multinational seed companies' hybrids occupied a total of about 18.3% of the total area under maize (Table 11). The experts considered both seed sales and recycled seed of the hybrids. In 2009/2010, maize was grown on about 3.7 million hectares throughout the seven zones of the country. The experts estimated that in 2009/10 the improved maize varieties occupied about 985,120 ha or 26.6% under improved maize varieties (Table 11).

The total area under maize grain production and the percentage of the area under improved seed for the two years 2005/2006, 2006/2007 and estimates for the 2009/2010 season, as received from the Ministry of Agriculture, Food Security and Cooperatives are presented in Table 11 (Zubeda et al., 2012). Apparently only 20.4 and 26.1% of the area under maize was occupied by fresh improved seed distributed in 2005/06 and 2006/07 seasons, respectively. Based on the area under maize production in 2009/2010 and the fact that farmers recycle maize varieties for at least two years, the maize experts estimated the area covered by improved seed as 27% of the total area under maize.

Similarly, based on seed sales in 2010/2011, 27% of the maize area is estimated to have been planted in improved seed (World Bank, 2012), and in the same years, the National Panel Survey (NPS) found that just 17% of rural households used improved seed (National Bureau of Statistics, 2012). Finally, a recent survey of smallholder maize farmers in 2010 in two areas of Tanzania found hybrid adoption rates of 48% in the north, but only 13% in the east, even though the average net yield gains are 50 to 60% (Kathage et al., 2012).

A review of the maize production statistics (FAOSTAT, 2013) show that maize production has doubled since the 1990s to about five million tons (Figure 4). However, the increase comes mostly from an area increase. Despite the increased seed sales, the average yield has dropped to less than 1.5 tons/ha.

Table 10. Area grown to improved maize varieties in Tanzania in 2009/2010 compared to 2006/2007 crop season.

Period	Area under improved maize varieties (ha)			% of total maize area based on 2mi ha in 2006/7 and 3.7mi ha in 2009/10			
	OPV's	Hybrids	Total	Improved OPV's	Hybrids	Total IMV	Adjusted Adoption
2006/07[z]	195,000	365,000	560,000	6.5	12	18.5	22
2009/10[b]	310,800	674320	985,120	8.4	18.2	26.6	

Sources: [z]Langyintuo et al. (2008); [b] Expert opinion estimates based on both seed sales and recycled seed.

Table 11. Area under maize, maize grain production and percent area under improved seed for the year 2005/06, 2006/07 and 2009/10.

Year	Area under maize in Tz (Has)	Production maize grain (Tonnes)	Area covered by improved seed	Percent area under improved seed
2005/2006[a]	2,570,000	3,373,000	523,850	20.4
2006/2007[a]	3,168,000	5,446,000	826,250	26.1
2009/2010[ab]	3,700,000	4,475,416	985,120	26.6

Source: [a] Ministry of Agriculture, Food Security and Cooperatives, [b] Maize experts;

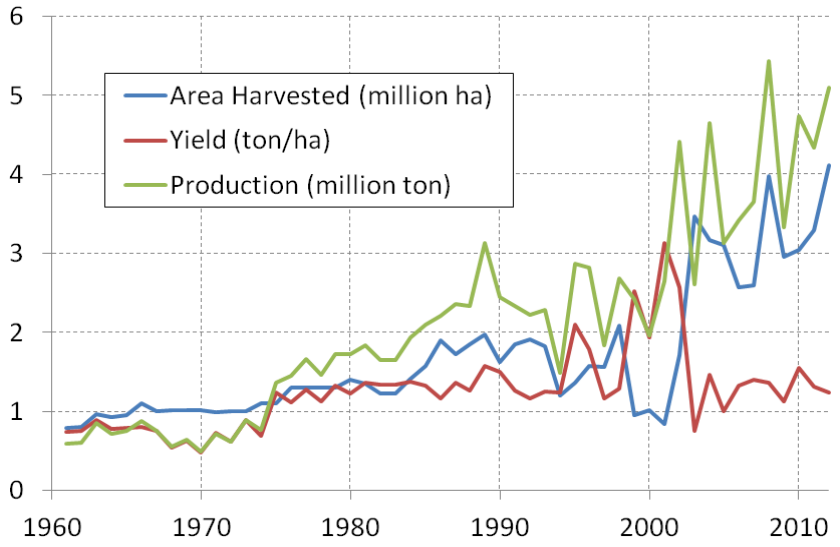

Figure 4. Trends in maize production in Tanzania. Source: FAOSTAT (www.faostat.fao.org).

Constraints

Several factors can be identified that contribute to the low adoption rate (World Bank, 2012). First, despite the liberalized environment, a number of policy-level hurdles remain in the seed industry. Only recently did a government directive lift a restriction prohibiting private companies from producing their own foundation seed from public varieties, and local seed companies have difficulties accessing foundation seed from public varieties in a timely manner. Despite the passage of the new Seeds Act, the certification and release of new seed varieties is still slow, taking up to three years. TASTA members indicate that seed regulation is still weak in Tanzania and that monitoring is inadequate; fake seed can be found in the market. The other problem faced by local companies interested in investing in seed production in Tanzania relates to the high taxes on imports of packaging materials.

Further, farmers still lack awareness about improved seed and their higher yields. Finally, certified seed is expensive: the seed-to-grain price ratio for hybrids is ten, the highest in East Africa, where the average is eight (Erenstein et al., 2011). To improve the adoption rate,

the government in 2009 introduced the National Agricultural Input Voucher Scheme (NAIVS) program, under which seed prices are subsidized by 50%. The NAIVS program trained agro dealers, which effectively increased the number of outlets selling seed in rural areas. The input subsidy program has been successful in reaching large numbers of farmers, but late payment by the government in the past year to the participating bank that channels funds to agro dealers, has affected the effectiveness of the program.

Conclusions

The use of fresh improved maize seed by farmers in Tanzania, based on sales or distribution by seed companies and other organizations, decreased over the study period , from 1997 to 2000. The use of hybrids has been on the increase since the mid-1990s due to the incoming private seed companies, and it remained similar over the study period, with an average of 4,770 tons per year. The use of OPVs, on the other hand, declined by one third over this period, from 4,689 to 2,114 tons. The area grown in fresh hybrids remained more or less the same in the three years and it was more or less similar to the one grown in OPVs in 1997/98. Based on the estimated total maize area of 2.0 million ha and a seed rate of 15 kg/ha, the average area planted in fresh improved maize seed over the three years was about 520,000 ha, about 26% of the total maize area. Most farmers recycle hybrids and OPVs up to two and three years respectively before buying fresh seed. OPVs were reported to be recycled for more than five years. If the recycling of OPVs for two years is taken into account, the adoption rate for improved varieties can even be placed at 46%.

The survey of extension officers revealed that drought, lack of markets and low prices of the produce, pests and diseases, and high input prices were the most important constraints to maize production. The high cost of improved seed and its poor availability and lack of knowledge regarding improved seed were the main reasons why farmers did not use improved seed. Key farmer strategies to obtain improved seed were: Purchasing from stockists, recycling their own seed, and the formation of SACCOs which could provide credit to buy seed.

Research and development efforts should therefore be directed to solving the farmers' key production constraints, in particular drought, lack of markets and low produce prices, pests and diseases. Knowledge of how to obtain and grow improved varieties (husbandry practices) is critical in adopting improved varieties.

More recent analysis of the secondary data shows a small increase in the adoption rate, up to 27% in 2010. We conclude that the liberalization of the seed sectors has encouraged many new seed companies to enter the market and release many new varieties. This development has only led to a relatively small increase in the adoption rate. The private sector has been slow to take over the seed distribution from the classic, extension-based distribution, although the recent increase in seed sales is promising.

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