Adoption of Maize Technologies in East Africa – What Happened to Africa's Emerging Maize Revolution?

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Abstract

A study of the maize production trends in East Africa (Ethiopia Kenya, and Tanzania) shows that maize yields increased substantially (from 1 tons/ha in the early 1960s to 1.5 tons/h in the mid 1980s). This yield increase can be attributed partly to the increase in use of improved maize seed varieties and fertilizer, which many farmers have adopted over the years. This adoption process has, however, stalled in Kenya and Tanzania. Despite the liberalization of the seed and fertilizer sectors in these countries, sales have not increased. In Ethiopia, the maize sector is still largely under government control, and a strong extension with credit program increased the use of improved maize seed and fertilizer in the late 1990s. Maize production increased during the same period, which was also influenced by an increase in area. However, the maize price collapsed in 1997 and 2001, leading to a dramatic decrease in adoption in 2002.

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1. Introduction:

Sub-Saharan Africa (SSA) has experienced a deterioration of its food security status since the 1970s, when most countries were self-sufficient or even had an agricultural surplus, to the current situation where food shortages are frequent occurrence. SSA together with South Asia are the only two regions where child malnutrition is expected to increase over the next 20 years. Until recently, maize was seen as the crop most likely to take advantage of new technologies and contribute to food security. Based on experience of research and extension impact, maize farmers in east and southern Africa were expected to progressively adopt new varieties and crop management techniques and repeat the Green Revolution experience from Asia (Byerlee and Eicher, 1997). However, Africa's emerging maize revolution seems to have stalled. Africa's population is increasing rapidly, but agricultural production can barely keep up. Options of increasing crop areas are limited, and purchasing power of most of its population low, so yield increases are essential to ensure food security. Yield increases are expected from two types of technologies: new varieties and better soil fertility management. Unfortunately, while maize yields have increased from 1 tons/ha to 1.5 tons/ha from 1961 to 1985, there has been little or no progress since then (FAOSTAT data base, 2001).

CIMMYT, in collaboration with NARS, has been working in the region for many years. Breeders and agronomists have been developing new varieties and technologies, while economists were active in developing the Farming Systems Research approach (Collinson, 1987), conducted a series of adoption studies (Doss et al. 2002), studied the seed sector, and developed a maize data base for Kenya (Hassan, 1998). This paper synthesizes the adoption of maize technologies in the region, based on previous research and secondary data.

We first present an overview and analyses of the importance of maize in east and central Africa.. The next section examines each of the three most important maize producing countries namely Kenya , Tanzania and Uganda This is followed by an analysis of the factors that influence adoption. The paper ends with conclusions and a discussion on the way forward.

2. Maize in East Africa

2.1. Eastern and Central Africa

In the agricultural research community, SSA is usually divided into three regions: West Africa, Southern Africa, and East and Central Africa. Research in the last group is increasingly coordinated by ASARECA (Association of Agricultural Research for East and Central Africa), the umbrella organization of the National Agricultural Research Systems (NARSs). Currently, the organization has 10 member countries (Table 1). The region has a total population of 253 million and, as the statistics indicate, a large number of these are poor. GDP per capita averages US$ 767, and a third live below the poverty level of US$ 1/day. Only two countries, Uganda and Kenya, had positive GDP/capita growth rates over the last 30 years, and only Ethiopia and Uganda have shown positive growth rates over the last 10 years.

Table 1. Basic Statistics for ASARECA countries

Country	Population (million)	Adult literacy rate (%)	Underweight children < 5 yrs old (%)	Population under poverty ($1/day)	GDP /capita	GDP/capita growth (%)	
					US$	1975-99	1990-1999
Burundi	7	46.9	37		578	-0.5	-5
Congo, DR	50	60.3	55	34	801	-4.7	-8.1
Ethiopia	61	37.4	47	31.3	628	-0.3	2.4
Kenya	30	81.5	22	26.5	1,022	0.4	-0.3
Madagascar	15	65.7	40	63.4			
Rwanda	7	65.8	27	35.7	885	-1.4	-3
Sudan	29	56.9	34				
Tanzania	33	74.7	27	19.9	501		-0.1
Uganda	21	66.1	26		1,167	2.5	4
Total	253			32.1	767.5		

Source: UNDP (2002) NB We need data for ERITREA

The ASARECA countries produce 8.5 million tons of maize on 6.0 million ha, or 1.4 t/ha on average (Table 2). Three countries produce more than 2 million tons each: Kenya, Tanzania and Ethiopia, accounting for 86% of the total. Maize consumption per person is 103 kg/person in Kenya, and 85 kg/person in Tanzania, representing 36% and 44% respectively of the daily calories in the diet. In Ethiopia, average maize consumption is 45 kg/person (19% of the calories in the diet) reflecting the importance of other cereals such as teff and wheat in certain areas. In two other countries of the region maize is an import part of daily consumption: Rwanda (41.5 kg/person) and Uganda (38.6 kg/person). No statistics are available for Congo and Sudan.

Table 2. Population and Selected Maize Statistics by Country

Country	Population 1,999	Harvested area (000 ha)	Yield (t/ha)	Production (000 t)	maize imports (000 t)	maize consumption 1995-97 (kg/yr)	maize consumption % of calories
Burundi	6,565	115	1.18	135	n.a.	25.0	10.6
Congo, D. R.	50,335						
Ethiopia	61,095	1,606	1.70	2,724	24.7	44.7	19.0
Kenya	29,549	1,502	1.50	2,255	427	102.9	43.8
Madagascar	15,497	192	0.89	170	-4	12.3	5.2
Rwanda	7,235				163	41.5	17.7
Sudan	28,883	169	0.33	56			
Tanzania	32,793	1,785	1.32	2,362	34	85.0	36.2
Uganda	21,143	615	1.24	763	-64	38.6	16.4
Total	253,095	5,984	1.41	8,465			

2.2. Agroecological zones in East Africa

In East Africa, based on altitude three major agroecological zones can be distinguished: the lowlands (from the coast up to 600 meters), the mid-altitudes (600-1800 meters) and the highlands (above 1600 meters) (Figure 1). Maize breeders also make a distinction between mid-altitudes and transitional zone(towards the highlands) and each zone is split into dry and moist (see Hassan,1988 for Kenya and Mosisa et al.,2002 for Ethiopia). Population density (Figure 2) is clearly driven by geography. Areas of high density include the highlands, followed by the mid-altitudes, especially around Lake Victoria. The lowlands are usually dry and sparsely populated, except for the coastal strip.

Figure 1. Topography of East Africa

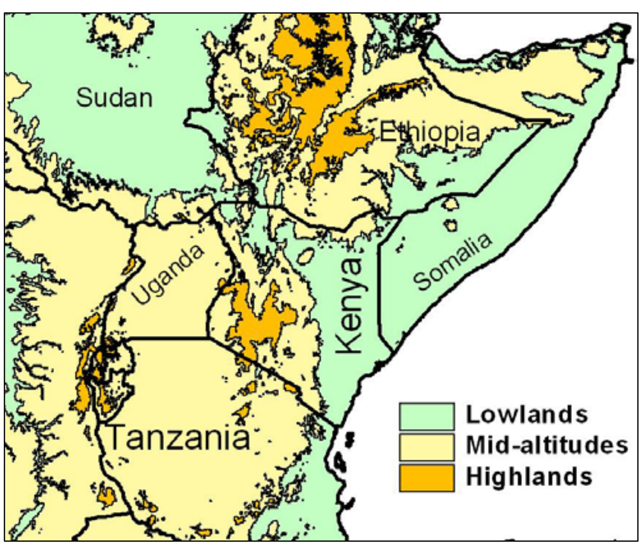
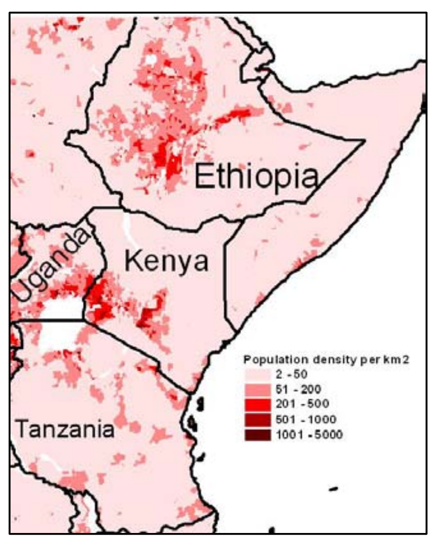


Figure 2. Population density



2.3. Policy environment in the three major maize producing countries

The three countries under study have very different political histories. Tanzania and Kenya were colonized by the British from the late 19th century until the early 1960s. After independence and elections, both countries quickly moved to one-party rule. Tanzania chose a distinct socialist development path, while Kenya favored a market economy. But despite this, Kenyan agriculture was heavily regulated, especially maize and export crops. In Kenya, multi-party elections were organized again in 1992, which coincided with a liberalization of the agricultural sector, under pressure from the donor community. Similarly in Tanzania, multi-party elections were held in 1995, and were followed by an ambitious liberalization program.

The political evolution in Ethiopia was very different. With the exception of five years of Italian rule (1936-41), the country was independent and the political system was feudal in nature until 1974. The system was overthrown by a marxist military coup in 1974, and the following decennia were characterized by heavy state control and internal turmoil. The regime was overthrown in 1991, and the country has experienced some stability since then. Years of strife and wars have led to poor infrastructure, and the country remains vulnerable to droughts and famines. Agricultural research, extension and seed production is still very much state dominated. Only few private companies are engaged in private seed production and distribution following market liberalization in 1992.

2.4. Evolution of maize production, area and yield

The three major maize producers in East Africa produce 7.34 million tons of maize on average, on 4.89 million ha, or a yield of 1.5 t/ha (Table 3). The yield is slightly higher in Ethiopia (1.7 t/ha), and slightly lower in Tanzania (1.3 t/ha). The trends are different. In Tanzania and Kenya both area and yield increased in the 70s and 80s, they did not change or even decreased for the 90s. As a result, the high production increases of the 70s and 80s turned to decreased in the 90s, especially in Kenya. In Ethiopia, on the other hand, production increases were modest in the 70s and 80s, but high in the 90s (12.3%/year).

Table 3. Growth rates in area, yield and production of maize in East Africa, 1966-77 to1988-89

	Maize statistics (1997-1999)			Growth rates (%/year								
	Area	Yield	Production	area			yield			production		
	(1000 ha)	(t/ha)	(1000 t)	'66-77	'78-87	'88-99	'66-77	'78-87	'88-99	'66-77	'78-87	'88-99
Ethiopia	1,606	1.7	2,724	-1.2	1.53	8.92	3.34	0.79	3.39	2.14	2.32	12.31
Kenya	1,502	1.5	2,255	3.25	-0.14	0.2	2.5	3.64	-1.45	5.75	3.5	-1.26
Tanzania	1,785	1.3	2,362	1.8	3.6	-0.6	5.83	0.74	0.1	7.63	4.34	-0.5
Total	4,893	1.5	7,341									

Source: Pingali 2001.

Figure 3 represents the evolution of area in the three countries. While the area stayed fairly constant in Kenya over the last two decades, it increased in Ethiopia and Tanzania.

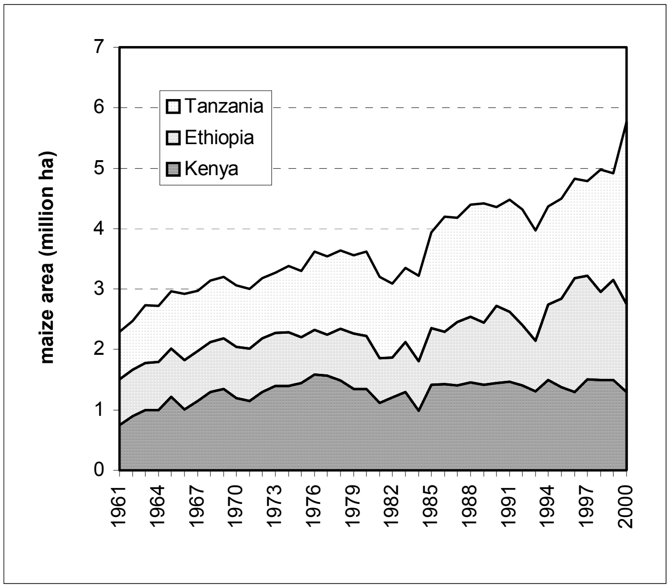
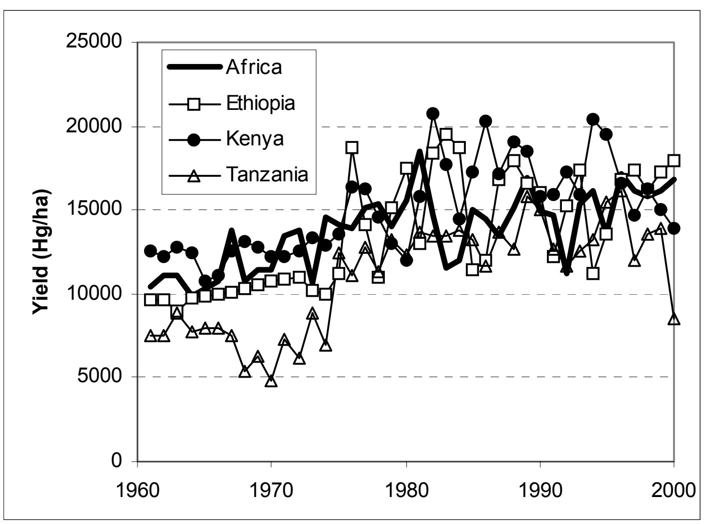


Figure 3. Evolution of maize area in East Africa

Figure 4 represents the evolution of maize yields for the whole of Africa and for the three major producers from East Africa. It reveals that the yields were erratic but on average increased during the 1960s and 1970s. From the mid 1980s till now, there is little or no increase.



Source: FAO data base

Figure 4. Evolution of maize yields in East Africa,1960 to 20

Combining area and yield we see a constant level of production for Kenya (Figure 5), a modest increase in Tanzania (driven by an area increase rather than yields) and a larger, but highly variable, increase in Ethiopia (from a combined increase in yield and area).

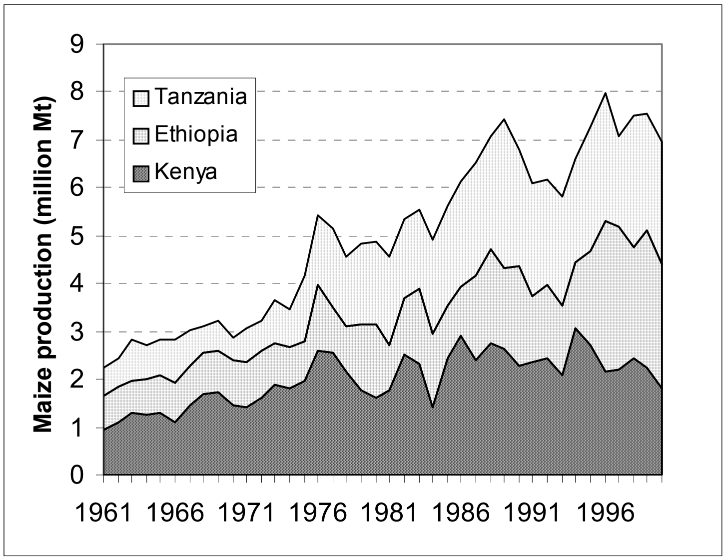


Figure 5. Evolution of maize production, 1961 to 1996

2. Kenya

3.1.Overview

Although maize arrived at the Kenyan coast in the sixteenth century, its progress was slow at first. In 1903, it covered an estimated 20% of Kenya's crop area, but by 1960 this area had risen to 44% (Hassan and Karanja, 1997), helped by the interest of the European settlers for this crop, grown on large-scale settler farms. A highly succesful maize breeding program was started in 1955, first in the high potential areas, and later in the other areas. Many popular hybrid varieties and OPVs were released in the 1960s and 1970s. The hybrid varieties for the highlands took off very fast (Gerhart, 1975), and they still form the base of the most popular varieties decennia later. The OPVs for the dry areas, in particular the Katumani variety, and to a lesser degree for the coast, were also very successful.

The Kenya maize success story gathered a lot of interest from economists. Gerhart (1975) described the initial success of the hybrids in Western Kenya. Karanja (1990) calculated a very high rate of return to the investment. Hassan (1998) organized a maize database, from a survey conducted in 1992. This survey covered the adoption of maize technologies such as improved varieties and fertilizer in Kenya. To understand the factors that determine these adoptions, CIMMYT launched a series of adoption studies in East Africa (Doss et al., 2002). Four of those studies took place in Kenya, covering two districts in Western Kenya (Salasya et al. 1998), one district in Central Kenya (Makhoka et al., 2001), one district in Eastern Kenya (Ouma et al., 2002), and two districts at the coast (Wekesa et al., 2002). Finally, the Insect Resistant Maize for Africa (IRMA) project is currently developing insect resistant varieties, and for its impact assessment the project started a baseline survey in 2002. This database will provide the latest assessment of maize technology adoption.

3.2.Adoption of improved maize varieties

Corbett (1998) adjusted the classification of maize production zones and defined six major agroecological zones for maize production in Kenya, presented in Figure 2. The major new development was splitting the transitional zone off the mid-altitude zone. Moving from east to west, there are the Lowland Tropics (LT) on the coast, followed by the Dry Mid altitudes and Dry Transitional zones around Machakos. These three zones are characterized by low yields (less than 1.5 t/ha); although they cover 29% of maize area in Kenya, they only produce 11% of the country's maize (Table 1). In Central and Western Kenya, we find the Highland Tropics (HT), bordered on the west and east by the Moist Transitional (MT) zone (transitional between midaltitudes and highlands). These zones have high yields (more than 2.5 t/ha) and produce 80% of the maize in Kenya on 30% of the area (see Table 4). Finally, around Lake Victoria, is the Moist Midaltitude (MM) zone, which produces moderate yields (1.44 t/ha), covers 22% of the area and produces 9% of maize in the country.

Table 4. Agroecological zones for maize production in Kenya

Agroecological zone	Elevation (meter)	Total				Area under improved varieties (IV)	Farmers adopting IV
		Area ha	Yield t/ha	Prodn. '000 ton	Prodn. %	%	%
Lowland Tropics	0-700	41	1.29	53	2	16	16
Dry Mid-altitude	700-1400	166	0.98	162	6	45	44
Dry-Transitional	1100-1700	66	1.15	76	3	12	21
Moist-transitional	1200-2000	466	2.65	1234	46	94	85
Highlands	1600-2900	316	2.88	909	34	95	86
Moist Mid-altitude	1110-1500	173	1.34	231	9	51	41
Total		1,244	2.15	2671	100	74%	

Source: Survey data , 1992 (Hassan et al., 1998c)

The results of the farmers' survey in 1992 indicate high adoption rates in the high potential areas (over 90% of the area and 85% of the farmers), less than 20% in the low potential areas (coast and dry transitional), and around 50% in the mid-altitudes. The country wide average is 73.6%.

Adoption studies conducted in Kenya in 1998 indicated a higher adoption rate at the coast (30%) (Wekesa et al. 2002), but a lower adoption rate in Embu (65%), a district in the moist-transitional zone (Ouma et al. 2002). A third study in two district in Western Kenya had a similar result as the 1992 survey for the moist-mid altitude (51%).

3.3.Seed sales

Apart from adoption surveys, production and sales of improved seed also give us a good indicator of adoption of new varieties. Seed sales increased steadily through the 80s and 90s (Figure 6), to reach a high of 22,800 tons in 1992. With a recommended seed use of 25 kg/ha, this would translate into an area of 874,000 ha, or 69.4% of the total maize area. This result is very similar with the one obtained through the survey, without taking recycling into account. Since then, however, seed sales have been decreasing. Although the Kenya Seed Company has not released data since 1992, the company agrees that seed sales have not increased since that period. Market demand is estimated at 16,000 tons per year, which would translate into 51% of maize area in improved varieties. Seed production in 1999 was estimated at around 20,000 tons, and sales at 16,000 Mt.

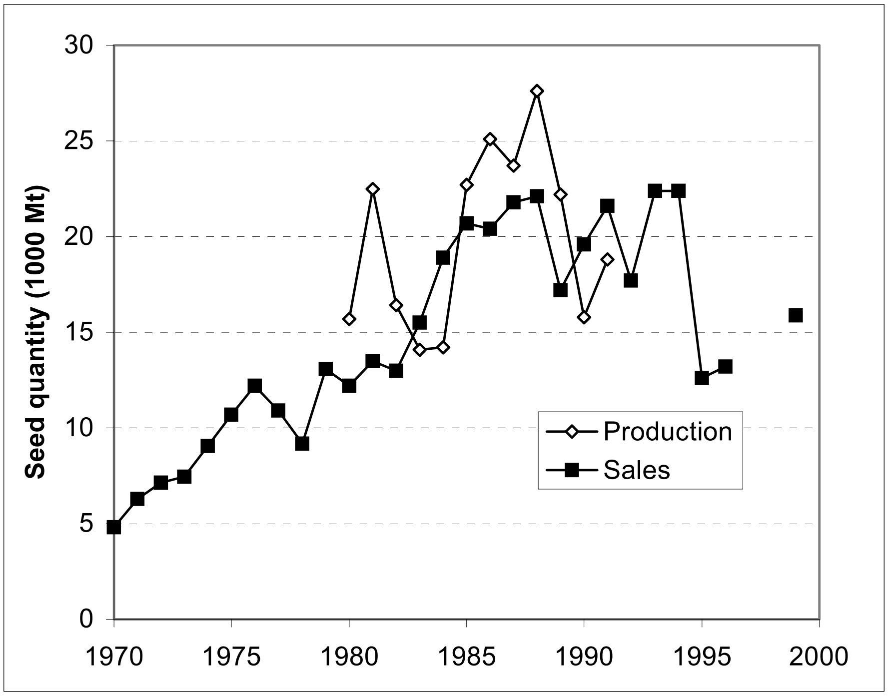


Figure 6. Seed sales and production by the Kenya Seed Company

3. Tanzania

3.1. Overview

In Tanzania, research and extension efforts in maize started in 1960, leading to the release of two popular OPVs. In the 1974, 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 mid 70s up to mid 90s about 15 improved maize varieties (hybrids and Open Pollinated Varieties) have been released by the NMRP. The foundation seeds of the improved varieties are produced by five State Foundation Seed Farms. This foundation seed is passed on to the state owned Tanzania Seed Company (TANSEED) to produce certified seeds for farmers. TANSEED had been the sole or main supplier of improved maize to farmers up to mid 90s when other private seed companies around the region were allowed to bring in their materials.

Some of the main private seed companies operating in the country are Delkab/Monsanto, , PANNAR, Kenya Seed Company, Pioneer/Bytrade and Seedco. The private companies are selling hybrids mainly. A number of stockists shops have also been opened up to sell the private companies seeds. Recently a number of non-governmental organisations (NGOs), churches, individual farmers, farmer groups and other organisations have started community based seed production in a number of regions in the country. These organisations are playing a significant role in the production of Quality Declared Seeds (QDS) of the improved varieties. All of them are producing OPVs.

3.2. Seed production and sales

A survey was conducted in 2001, covering all seed companies, and institutions selling or producing seed.

Table 5. Improved maize seeds sales in Tanzania in 1997/98 - 1999/2000 crop seasons

Period	Amount in metric tones						Grand Total
	Public sector		Private sector		Total		
	OPVs	Hybrids	OPVs	Hybrids	OPVs	Hybrids	
1997/98	1,182.70	748.7	3,506.00	4,058.10	4,688.70	4,806.80	9,495.50
1998/99	974.3	436.9	1,160.40	4,522.10	2,134.70	4,959.00	7,093.70
1999/2000	477.7	360.5	1,636.80	4,184.40	2,114.50	4,544.90	6,659.40
Mean					2,979.30	4,770.23	7,749.53

The use of fresh OPVs over the three years has declined drasticaly to less than half in the last two years compared to the first year. This was mainly caused by the decreased production from TANSEED over the years as this was the main or sole producer of seeds especially OPVs for the whole country. TANSEED is currently undergoing divestiture and hence producing very low amounts of seeds. Otherwise past experience shows that most resource poor farmers used to grow more OPVs than hybrids because they can be recycled for a greater period, and because their price is lower.The current production and sales of Quality Declared Seeds (QDS) recently started by some Community Based Organisations cannot by any means satisfy the demand for OPVs at the moment.

Sales of hybrids, however, was quite good in 1997-1999. It dropped slightly one year later, because of farmers' low purchasing power as well as very poor weather conditions which dettered farmers from buying the seeds. This season was hit by the most severe drought conditions in decades.

3.4.Acreage under improved seed

Since the majority of extensionists could not indicate the area under to improved maize, data were obtained from elsewhere. Based on a variety of sources (Annon.2000; Pingali, P. L. 2001) the estimated total area under maize is 1.8 to 2.0 million hectares. Field experience has shown that the majority of the farmers use a seeding rate of about 15 kg/ha, so the area under improved maize can be derived (Table 6).

Table 6: Area under improved maize seeds in Tanzania in 1997/98 - 1999/2000 crop seasons

	OPV's (ha)	Hybrids (ha)	Total (ha)	% based on 2 million.ha
1997/1998	312,580	320,453	633,033	31.7
1998/1999	142,313	330,600	472,913	23.6
1999/2000	140,967	302,993	443,960	22.2
Mean	198,620	318,015	516,635	25.8

Based on the estimated total national area of 2.0 million. ha under maize and using average seeding rate of 15kgs/ha ; acreage grown to improved maize in 1997/98 was about 32% of the total. It decreased in the last two years to about 22% - 24 %. Average acreage under improved fresh maize seeds over the three years was therefore about 26 %. These percentages do not take into account the recycling of the varieties, which is considered in the next section.

Alternatively, we can estimate the rate of adoption from the different farmer surveys that were undertaken in the late 1990s (see Table 7). Although these surveys usually represent the most important maize areas, and might therefore not be representative, they nevertheless provide some useful indicators. Clearly, the adoption rates are substantially higher than calculated from the seed sales. Apart from the mid-altitudes in the Central Region (adoption rate 3%), the adoption rates of improved maize seed range from 44% to 100%.

Table 7. Percentage of farmers adopting improved maize seed and fertilizer in different regions of Tanzania

Region	Zone	Adoption of improved seed (% of farmers)	Adoption of Fertilizer (% of farmers)
Central:	Lowlands	78	17
	Intermediate	3	77
	Highlands		17
Eastern:	Lowland	85	17
	Intermediate	95	8
Lake Zone:	Low rain	45	50
	Intermediate rain	62	48
	High rain	100	100
Northern:	Lowland	89	64
	Intermediate	92	44
Southern			3
Southern Highlands:	Intermediate	64	65
	Highlands	44	79
Western:	High	55	66
	Low	93	60
Mbeya District	Southern Highlands	79	40

Source: Various adoption studies—dates?
NB. I thought Mbeya was part of Southern Highlands?

4. Ethiopia

4.1. Background

Ethiopia's seed sector is mostly public and centralized, and dominated by the Ethiopian Seed Enterprise (ESE). The ESC was restructured and renamed as the Ethiopian Seed enterprise (ESE) in 1993. Prices were also deregulated and private sector was allowed to participate in the production of improved seeds. Pioneer Hi-Bred has been engaged in producing and selling hybrid seed of maize since 1993 (Adugna and Melaku, 2002). While originally the national seed company was catering mostly to large-scale state farms, it has been paying more attention to the small holder recently. Nevertheless, the market for improved seeds is still concentrated in the hands of ESE, supplying over 90% of commercial seed. Price deregulation and removal of subsidy from fertilizer has resulted in significant price rise. Thus Hybrid maize price rose 3.7 times in 1993 and 9.7 times in 2000 compared to the pre-reform price.

In 1993, Sasakawa 2000 launched a pilot project to bring hybrid maize seed and fertilizer to the smallholder (Takele Gebre, 2002). The method is based on large-scale demonstrations and availability of inputs as well as credit. Based on this experience, the national agricultural extension system launched a massive program in 1995 (Takele Gebre, 2002 –not in reference list). As a result of the diffusion of maize technology and partly due to favorable weather, maize yields and production rose dramatically in 1995/96 and 1996/7. Consequently, the price of maize fell dramatically down in 1996/97and in 2001 the price of maize fell equally dramatically down to a third of its' 1999-2000 price (from 116 and 114 Birr/100 kg in 1999 and 2000 respectively, down to 39 Birr/100 kg). In order to stabilize the market, the Ethiopian Grain Trade Enterprise [EGTE] attempted to intervene and stabilize its maize market through export market. It was able to export 48,000 ton of maize in 1997 (Girma, 2003). However, this situation created major setback for farmers to adopt maize technology including fertilizer.

4.2. Seed production and sales

The annual improved maize seed supplied by the ESE grew by 31% per year from 1992 to 2000 (Yonas and Mulugeta, 2002). Seed distribution increased tremendously from 1997 to 2000 (Figure 7). There is always a discrepancy between the supply and demand for improved maize seed as shown in the Table 8.

Table 8. Seed produced (Qt) and sold or distributed (1994/95-1996/97)

	produced		**Sold/distributed**	
	Composite	Hybrid	Composite	Hybrid
1994/95	41890	11368	19722	6601
1995/96	31191	9017	8295	9597
1996/97	9889	16924	5140	11540

Source: Ethiopian Seed Enterprise, 1997

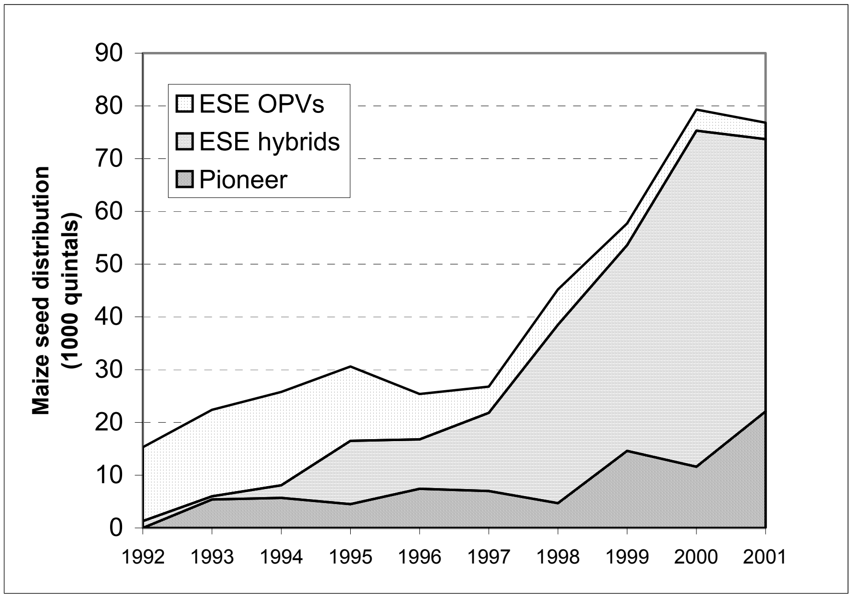


Figure 7. Maize seed distribution by ESE and Pioneer HI-Bred in Ethiopia, 1992 to 2001

Seed distribution by ESE was highest in 2000 (6,769 tons), and somewhat less in 2001 (5,466 tons), while Pioneer seed distribution increased from 0.54 tons to 2.21 tons. Ignoring recycling of seed, and with a 25 kg/ha seed rate, the area under improved seed can be estimated at 0.30 million ha, or 21% of the total area under maize.

5.3 Adoption of new varieties

As in the other countries, adoption levels of new maize varieties in Ethiopia were also measured through farmer surveys. Here, the adoption rates ranges from 6.7% to 45% in the areas studied in 1996. However, these levels have been increasing dramatically since 1992, when almost no small scale farmers were growing improved varieties of maize.

Table 8. Adoption of maize technologies in Ethiopia

	region	Maize Seed adopters (%)	Fertilizer adopters (%)
Central Highlands:	Ada - MHH	0	90-95
	Ada-FHH	0	
	Lume-MHH	13	
	Lume-FHH	11	
	Gimbichu-MHH	0	90
	Gimbuchu-FHH	0	
Sidama and North Omo Zone:	Lowland	22	58
	Intermediate	25	70
Western Oromia:	Chaliya	46	78
	Bako-Tibe	49	97
	Bila-Sayo	56	88
	Sibu Sire	39	79
	Northern Ethiopia		
Western Tigray	Tselemiti and Medbai- Zana	10	64
Eastern Gojam	Hulet Eju Anebise and Enebise Sar Midir	58	86
Wollo	Jamma	15	42

Source: Doss et al. 2002, Tiruneh et al. 2001, Mandefro et al, 2001, Abdissa et al, 2001, Gezahegn et al, 2004

A study conducted recently (Gezahegn et al, 2004) indicated that the spread of the technological inputs has been quite considerable. Taking into consideration the reference period 1987/88-2000/01, the adoption of the package of the technologies increased at an average of 35.4% per annum. Until the price collapse of the latter years beginning from 1997/98, the only year of negative rate of adoption was the crop year following the political transition of 1991/92. In the middle of the PADET years and SG-2000 before the steady decline from 1998/1999 onwards, the average increase in the rate of adoption was over 80% after which the average negative rate was about 30%.

The adoption of all the major fertilizer and seed inputs sharply increased from 1994/95, peaked in 1997/98 at national level, slightly declined in the following year, more pronouncedly in the next year and a near collapse in 2000/01 when the aggregate national new adoption rate fell down sharply. This pattern took similar picture for the different regions and different units of the technological packages. When the technological packages are taken individually, major price collapse in the rate of adoption at national level was pronounced by maize technology following major price collapse in 1996/7 and high rate of exit and dis-adoption was observed.

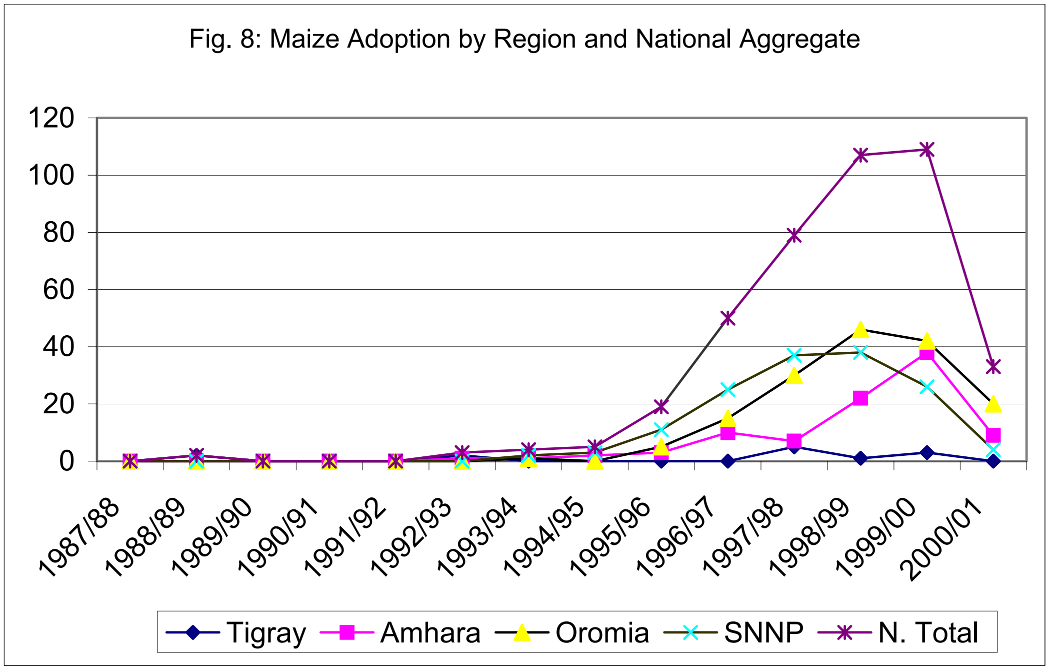


Fig. 8: Maize Adoption by Region and National Aggregate
120
100
80
60
40
20
0
1987/88
1988/89
1989/90
1990/91
1991/92
1992/93
1993/94
1994/95
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
Tigray
Amhara
Oromia
SNNP
N. Total

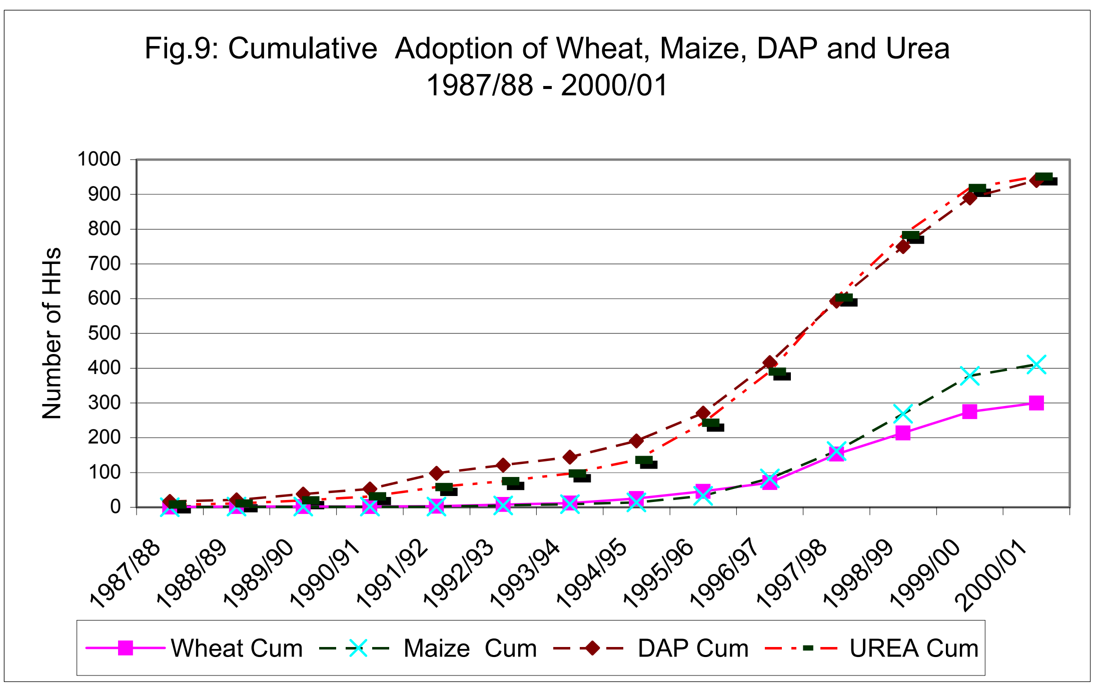


Fig.9: Cumulative Adoption of Wheat, Maize, DAP and Urea
1987/88 - 2000/01
Number of HHs
1000
900
800
700
600
500
400
300
200
100
0
1987/88
1988/89
1989/90
1990/91
1991/92
1992/93
1993/94
1994/95
1995/96
1996/97
1997/98
1998/99
1999/00
2000/01
Wheat Cum
Maize Cum
DAP Cum
UREA Cum

5. Factors influencing adoption of maize technologies

Doss et al. (2002) made an attempt to analyze the different adoption studies. Extension is clearly the variable that is most highly correlated with the use of improved technologies. There continues to be an important role for extension services to disseminate information on new varieties and how to manage them. It is not always clear, however, what the extension variable is actually capturing. It may be related to the provision of both inputs and information. The extent of extension services may also be picking up infrastructure issues: farmers in more accessible, less remote areas may receive more frequent extension visits. Market access was also found extremely important for maize adoption in Ethiopian context. Although often variables that are available are not ideal, they can be used but care needs to be exercised in interpreting them.(This sentence is not clear!!).[

To the extent that farmers do not adopt improved technologies because they are not profitable given the state of the technology and their circumstances, there are two directions that policies can take. The first is to increase productivity of improved varieties to increase output. The second is to reduce input costs for farmers. Subsidizing costs is not sustainable and it is crucial to think about how to reduce input costs by changes in infrastructure, transportation, credit availability, and markets.

It is difficult to determine which factors are behind farmers' decisions not to use new technologies. Farmers often report that input prices are too high, but this means that prices are too high given their knowledge and expected returns. Seeds and fertilizer may be unavailable in a particular region in part because they cannot profitably be sold and used in that area. Inputs may not be available if transportation costs for inputs and outputs are too high..

The availability of seeds and fertilizer varies from Kenya and Tanzania, where they are widely available locally through private shops, and to Ethiopia where seeds are less readily available for purchase. Promoting the role of private institutions, in the provisions of inputs might be advantages to improve quality and efficiency of delivery of inputs. Although the simple adoption numbers do not necessarily reflect patterns of adoption by country, and thus by availability of seed, it does seem to be the case that more farmers purchase seed in areas where seeds are available. Causality should not necessarily be inferred – it may be the case that the private sector is more willing to supply seeds in areas where farmers would choose to purchase them.

6. Conclusion

6.1. Empirical results

Farmers are, in most areas of East Africa, not resistant to using improved varieties of maize. There does not seem to be strong cultural views against using these improved varieties. Likewise, farmers appear to be willing to use fertilizer. We do observe, however, that the adoption process has basically stalled in Tanzania and Kenya, while in Ethiopia it is still largely driven by government intervention.

Much of the improved seed that is used, especially in Ethiopia and Tanzania is recycled and come from old varieties. Thus, not all of the benefits of hybrid seeds are being realized. A recent survey of literature on recycled maize seed use concludes that "while advanced-generation hybrids may not perform as well as crops grown from F1 seed, in many cases they significantly outperform the variety that the farmer was growing previously" (Morris et al. 1999). This suggests that farmers obtain some, but not all agronomic benefits from improved varieties. Using newly purchased seed would presumably increase output, but would also increase costs.

6.2. Methodology

The survey of maize farmers in Kenya is representative and gives a good picture of adoption of new maize technologies 10 years ago. The surveys in Tanzania cover most regions and can thus be fairly indicative of adoption there. The surveys in Ethiopia, however, do not necessarily represent the country as a whole. The surveyed areas were chosen because they were in the crop producing areas. The adoption rates are relatively high in many of these areas where the researchers expected to find these technologies in use. However, as it was evident from the national picture, the Ethiopian case is somewhat disappointing for adoption went down due to lack of market and price stabilization policy.

Adoption studies can be improved and made more useful by standardizing the definitions across studies (or providing information using more than one definition) and by using sampling techniques to allow the results to be generalized across wider areas. Despite their limitations, these studies indicate that even in the higher potential regions with relatively high levels of adoption, there is still considerable scope to improve the productivity of smallholder agriculture in surveyed areas.

6.3.Future research

The studies so far have presented us with figures on the evolution of adoption rates, and logistic regression provides an idea of some factors that might influence the adoption. Still, few insights are provided as to why farmers do or do not adopt new technologies. Even more important, it is not clear to what extent new technologies made a difference in poverty reduction and livelihoods. It would also be imperative to look into price policy (e.g grain stabilization) and institutions determining adoption of the maize technology.

To address those issues, we do need to take a more institutional and overall approach (with emphasis to each country peculiarities). In future research, we want to take a holistic approach, based on participatory rural appraisals with multi-disciplinary teams. In selected sites, farmers will be asked which technologies in recent history made a difference in their lives.

References

Abdissa G., G. Aboma, H. Verkuijl, and W. Mwangi. 2001. *Farmers' maize seed systems in Western Oromia, Ethiopia.* Mexico, D.F.: CIMMYT and Ethiopian Agricultural Research Organisation (EARO).

Adunga Negeri and Melaku Adisu. 2002. Hybrid Maize Seed Production and commercialization: the Experience of Pioneer Hi-Bred Seeds in Ethiopia. In: Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (eds.). 2002. Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, 12-16 November 2001. Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improment Centre (CIMMYT), pp. 166-169.

Bisanda, S., W. Mwangi, H. Verkuijl, A.J. Moshi, and P. Anadajayasekeram. 1998. *Adoption of maize production technologies in Southern Highlands of Tanzania.* Mexico, D.F.: CIMMYT, United Republic of Tanzania, and Southern African Centre for Cooperation in Agricultural Research (SACCAR).

Byerlee D. and C. K. Eicher. 1997. Africa's emerging maize revolution, pp. 81-94.

Collinson, M. P. 1987. Farming Systems Research: Procedures for Technology Development. Expl. Agric. 23: 365-386.

Corbett, J. D. 1998. Classifying maize Production zones in Kenya through Multivariate Cluster Analysis. In: Hassan R. M. (ed.). Maize Technology Development and Transfer. A GIS Application for Research Planning in Kenya. Oxon, UK: CAB International. pp. 15-25.

Doss, C., W. Mwangi, H. Verkuijl, and H. De Groote. 2002. *Adoption of maize and wheat technologies in East Africa: Synthesis of East African adoption studies.* CIMMYT Economics Working Paper 02-04. Mexico, D.F.: CIMMYT.

Gerhart, J. 1975. The diffusion of hybrid maize in western Kenya. Mexico, D. F. : CIMMYT, 1975. 57 pp.

Getahun Degu, W.Mwangi, H. Verkuijl, and Abdishekur Wondimu. 2000. *An assessment of the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Sidama and North Omo Zone, Ethiopia.* Mexico, D.F.: CIMMYT and Ethiopian Agricultural Research Organisation (EARO). (Repeated)

Gezahegn Ayele, Tenkir Bonger and Tadesse Kuma. 2004. Agricultural Extension, Adoption, Difusion and Impact Assessment in the four [Tigray, Amhara, Oromia and SNNPR] Regions of Ethiopia. A paper presented to the National workshop on Technology Adoption. Ghion Hotel, February 26, 2004. Addis ababa, Ethiopia

Girma Bekele. 2003. Grain Marketing and Food Security. In Gezahegn Ayele, Omamo, W and Gabre-Madhin E.(eds)The state of Food security and Agricultural Marketing in Ethiopia. IFPRI/EDRI pp.131-145

Hassan R. M. (ed.). 1998. Maize Technology Development and Transfer. A GIS Application for Research Planning in Kenya. Oxon, UK: CAB International. 230 p.

Hassan R. M., F. Murithi, and G. Kamau. 1998a. Determinants of Fertilizer Use and the Gap between Farmers' Maize Yields and Potential Yields in Kenya. In: Hassan R. M. (ed.). Maize Technology Development and Transfer. A GIS Application for Research Planning in Kenya. Oxon, UK: CAB International. pp. 137-162.

Hassan R. M., K. Njoroge, J. D. Corbett and K. Njoroge. 1998c. Combining Geo-referenced Survey Data with Agroclimatic Attributes to Characterize Maize Production systems in Kenya. In: Hassan R. M. (ed.). Maize Technology Development and Transfer. A GIS Application for Research Planning in Kenya. Oxon, UK: CAB International. pp. 43-68.

Hassan R. M., K. Njoroge, M. Njore, Robin Otsyula, and A. Laboso. 1998b. Adoption Patterns and Performance of Improved maize in Kenya. In: Hassan R. M. (ed.). Maize

Technology Development and Transfer. A GIS Application for Research Planning in Kenya. Oxon, UK: CAB International. pp. 107-136.

Hassan, Rashid M. and D. D. Karanja. 1997. Increasing Maize Production in Kenya: Technology, Institutions and Policy. In: D. Byerlee and C. K. Eicher. Africa's emerging maize revolution, pp. 81-94.

Kaliba, A.R.M., H. Verkuijl, W. Mwangi, A. Moshi, A. Chilangane, J.S. Kaswende, and P. Anadajayasekeram. 1998. *Adoption of maize production technologies in Eastern Tanzania*. Mexico, D.F.: CIMMYT, United Republic of Tanzania, and Southern African Centre for Cooperation in Agricultural Research (SACCAR)..

Kaliba, A.R.M., H. Verkuijl, W. Mwangi, A.J.T. Mwilawa, P. Anandajayasekeram, and A.J. Moshi. 1998. *Adoption of maize production technologies in Central Tanzania.* Mexico, D.F.: CIMMYT, United Republic of Tanzania, and Southern African Centre for Cooperation in Agricultural Research (SACCAR).

Kaliba, A.R.M., H. Verkuijl, W. Mwangi, D.A. Byamungu, P. Anadajayasekeram, and A.J. Moshi. 1998. *Adoption of maize production technologies in Western Tanzania.* Mexico, D.F.: CIMMYT, United Republic of Tanzania, and Southern African Centre for Cooperation in Agricultural Research (SACCAR).

Katinila, R., H. Verkuijl, W. Mwangi, P. Anadajayasekeram, and A.J. Moshi. 1998. *Adoption of maize production technologies in Southern Tanzania.* Mexico, D.F.: CIMMYT, United Republic of Tanzania, and Southern African Centre for Cooperation in Agricultural Research (SACCAR).

Lyimo, S.D And Z.O. Mduruma. 2002. Growing Improved Maize in Tanzania: Trends And Status In 1997 – 2000. Arusha (Tanzania): Selian Agriculture Research Institute. Mimeo.

Mafuru, J., R. Kileo, H. Verkuijl, W. Mwangi, P. Anandajayasekeram, A. J. Moshi. 1999. *Adoption of maize production technologies in Lake zone of Tanzania*. Mexico. D.F.: CIMMYT, United Republic of Tanzania, and Southern African Center for Cooperation in Agricultural Research (SACCAR).

Makokha, S., S. Kimani, W. Mwangi, H. Verkuijl, and F. Musembi. 2001. *Determinants of fertilizer and manure use in maize production in Kiambu District, Kenya*. Mexico, D.F.: CIMMYT and KARI.

Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (eds.). 2002. Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, 12-16 November 2001. Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improment Centre (CIMMYT).

Morris, M., J. Risopoulos, and D. Beck.1999. *Genetic change in farmer-recycled maize seed: A review of the evidence*. CIMMYT Economics Working Paper No. 99-07. Mexico, D.F.: CIMMYT.

Mosisa Worku, Hadji Tuna, Mandefro Nigussie and Abera Deressa. 2002. Maize production trends and research in Ethiopia. In: Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (eds.).Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, 12-16 November 2001. Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improment Centre (CIMMYT), pp. 10-14.

Muhammad L., K**.** Njoroge, C**.** Bett, W**.** Mwangi, H**.** Verkuil and H. De Groote. 2002. The Seed Industry for Dryland Crops in Eastern Kenya**.** Mexico, D.F.: CIMMYT and Kenya Agricultural Research Institute (KARI).

Nambiro E., H. De Groote and W. Oluoch K'osura. 2002. The Hybrid Maize Seed Industry in the Transnzoia District of Western Kenya. Paper presented at the 7th Eastern and Southern Africa Regional Maize Conference, Nairobi, Kenya, 11 - 15 February 2002.

Nkonya, E., P. Xavery, H. Akonaay, W. Mwangi, P. Anandajayasekeram, H. Verkuijl, D. Martella, and A.J. Moshi. 1998. Adoption of maize production technologies in Northern Tanzania. Mexico, D.F.: CIMMYT, United Republic of Tanzania, and Southern African Centre for Cooperation in Agricultural Research (SACCAR).

Ouma, J., F. Murithi, W. Mwangi, H. Verkuijl, M.Gethi, H. De Groote. 2002. *Adoption of seed and fertilizer technologies in Embu District, Kenya.* Mexico, D.F.: CIMMYT and KARI.

Pingali, P.L. (ed.). 2001. CIMMYT 1999-2000 World Maize Facts and Trends. Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector. Mexico, D.F.: CIMMYT

Salasya, B.D.S., W. Mwangi, H. Verkuijl, M.A. Odendo, and J.O. Odenya. 1998. *An assessment of adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Kakamega and Vihiga Districts.* Mexico, D.F.: CIMMYT and KARI.

Takele Gebre. 2002. Maize technology adoption in Ethiopia: Experiences from the Sasakawa-Global 2000 agriculture program. In: Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (eds.). Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, 12-16 November 2001. Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improment Centre (CIMMYT). Pp. 153-156.

Tesfaye Zegeye, Bedassa Tadesse and Shiferaw Tesfaye. 2002. Determinants of adoption of imporoved maize technoloiges in major maize growing regions of Ethiopia. In Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (eds.). Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, 12-16 November 2001. Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improment Centre (CIMMYT), pp. 125-136.

Tiruneh, A., T. Tesfaye, W. Mwangi, and H. Verkuijl. 2001. *Gender differentials in agricultural production and decision-making among smallholders in Ada, Lume, and Gimbichu Woredas of the Central Highlands of Ethiopia*. Mexico, D.F.: CIMMYT and Ethiopian Agricultural Research Organisation (EARO).

UNDP. 2002. Human Development Report 2002. New York: United Nations Development Program.

Wekesa E., W. Mwangi, H. Verkuijl, K. Danda, H. De Groote. 2002. *Adoption of maize production technologies in the Coastal Lowlands of Kenya.* Mexico, D.F.: CIMMYT and KARI.

Yonas Sahlu and Mulugeta Kahsay. 2002. Maize seed production and distribution in Ethiopia. In: Mandefro Nigussie, D. Tanner, and S. Twumasi-Afriyie (eds.). 2002. Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia, 12-16 November 2001. Addis Ababa, Ethiopia. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improment Centre (CIMMYT), pp. 160-165.

Annex. Average Rate of Use of Major Inputs [kilograms per hectare] by Crop, Region and Zone and Type of Plot [fertilized and unfertilized]

	Improved seeds kg/ha			Local seeds (Kg/ha)			Chem. Fertilizer (kg/ha)		Manure		
	Fer	Unf	Tot	Fer	Unf	Tot	Dap	Urea	Fer	Unf	Tot
Wheat											
Tigray	44 (10)	37 (36)	38 (46)	42 (68)	37 (30)	40 (98)	15 (62)	15 (61)	111 (34)	146 (10)	119 (44)
Amhara	104 (4)	51 (21)	60 (25)	40 (99)	48 (103)	44 (202)	37 (123)	35 (121)	605 (7)	6 (2)	472 (9)
Oromiya	5 (2)	46 (12)	40 (14)	33 (102)	49 (22)	36 (124)	52 (32)	47 (9)	73 (2)	101 (2)	87 (4)
SNNPR	60 (1)	59 (96)	59 (97)	18 (8)	43 (17)	35 (25)	29 (113)	21 (92)		134 (3)	134 (3)
Total	54 (17)	52(165)	53(182)	38 (277)	46 (172)	41 (449)	31 (330)	26(280)	189 (43)	122 (17)	170 (60)
Maize											
Tigray	9 (3)	9 (10)	9 (13)	12 (115)	9 (42)	11 (157)	16 (48)	19 (48)	269 (70)	294 (17)	274 (87)
Amhara		9 (56)	9 (56)	9 (22)	11 (57)	10 (79)	30 (95)	28 (103)	144 (4)	79 (10)	97 (14)
Oromiya	5 (10)	10 (85)	10 (95)	10 (151)	15 (16)	10 (167)	40 (96)	72 (78)	271 (24)	167 (3)	259 (27)
SNNPR	14 (5)	17 (45)	17 (50)	13 (101)	25 (48)	17 (149)	96 (82)	61 (39)	114 (8)	94 (5)	106 (13)
Total	8 (18)	11(196)	11(214)	11 (389)	15 (163)	12 (552)	48 (321)	44(260)	253 (106)	193 (35)	238 (141)
Teff											
Tigray	20 (5)	17 (10)	18 (15)	15 (138)	13 (61)	15 (199)	20 (72)	22 (72)	94 (23)	58 (6)	86 (29)
Amhara	177 (3)	18 (24)	35 (27)	14 (147)	34 (173)	25 (320)	57 (198)	34 (170)	221 (6)	2 (2)	166 (8)
Oromiya	64 (10)	26 (2)	57 (12)	44 (204)	46 (68)	44 (272)	52 (74)	28 (6)	51 (3)		51 (3)
SNNPR		9 (4)	9 (4)	7 (21)	25 (95)	22 (116)	42 (98)	41 (21)			
Total	70 (18)	17 (40)	34 (58)	26 (510)	31 (397)	28 (907)	47 (442)	31 (269)	114 (32)	44 (8)	100 (40)
Sorghum											
Tigray	13 (4)	1 (1)	11 (5)	19 (97)	15 (25)	18 (122)	24 (31)	21 (31)	187 (10)	200 (6)	192 (16)
Amhara	0 (1)	20 (1)	10 (2)	5 (78)	33 (2)	6 (80)	27 (3)	21 (2)	196 (7)		196 (7)
Oromiya	7 (5)	5 (1)	7 (6)	7 (180)	7 (7)	7 (187)	21 (5)	22 (2)	440 (23)	200 (1)	430 (24)
SNNPR	2 (3)		2 (3)	4 (89)	5 (1)	4 (90)			600 (1)		600 (1)
Total	7 (13)	9 (3)	8 (16)	9 (444)	14 (35)	9 (479)	23 (39)	21 (35)	340 (41)	200 (7)	320 (48)
Barley											
Tigray	48 (5)	28 (2)	42 (7)	47 (93)	36 (27)	44 (120)	13(2)	13 (27)	79 (39)	63 (4)	77 (43)
Amhara	313 (4)	33 (2)	220 (6)	32 (47)	48 (66)	41 (113)	19(62)	17 (53)	733 (3)	143 (4)	396 (7)
Oromiya	69 (3)		69 (3)	48(143)	100 (1)	48 (144)	30 (1)		140 (3)		140 (3)
SNNPR	1 (1)	40 (9)	36 (10)	6 (30)	34 (11)	14 (41)	12 (15)	10 (10)	2 (4)	100 (1)	21 (5)
Total	131(13)	37 (13)	84 (26)	41(313)	44(105)	42 (418)	17(106)	15 (90)	116 (49)	103 (9)	114 (58)

Source: National survey result, Gezahegn et al (2002/03)