Adoption of High Yielding Maize Technologies in Major Maize Growing Regions of Ethiopia

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Research Report No. 41

Ethiopian Agricultural Research Organization

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Contents

Acronyms

ACA:	Awasa College of Agriculture
ARC:	Awasa Research Center
AUA:	Alemaya University of Agriculture
BOA:	Bureau of Agriculture
BOPED:	Bureau of Planning and Economic Development
CADU:	Chilalo Agricultural Development Unit
CDE	Center for Development and Environment
CIMMYT:	International Center for Maize and Wheat Research
CSA:	Central Statistical Authority
EARO:	Ethiopian Agricultural Research Organization
EPID:	Extension Project Implementation Department
ESE:	Ethiopian Seed Enterprise
IAR:	Institute of Agricultural Research
IMV:	Improved maize
MEDAC:	Ministry of Economic Development and Cooperation
MOA:	Ministry of Agriculture
MPP1:	Minimum Package Program One
MPP2:	Minimum Package Program Two
MRS:	Maize Research Strategy
NSIA	National Seed Industry Agency
PADET:	Participatory Agricultural Demonstration and Training
PAS:	Peasant Associations
SG-2000:	Sakakawa Global-2000
SNNPR:	South Nations, Nationalities and Peoples Region
SPSS:	Statistical Packages for Social Sciences
T and V:	Training and Visit
TLU:	Tropical Livestock Unit
WADU:	Wolayita Agricultural Development Unit

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SUMMARY

The overall objective of this study is to investigate and document adoption levels and to specifically determine the factors that affect the adoption process of improved maize varieties and draw implications for research, extension and policy.

The mean age of adopters and non-adopters of improved maize was more or less 42 years and had similar years of experience in operating and handling their own farm. Out of the Adopters of improved maize varieties, 35 were illiterate, 23 had primary school education, 21 participated in a literacy campaign, and 6 and 9 reached junior and senior high school, respectively. The average household size of adopters was 7.30 persons, consisting of 3.53 children less than 14 years, 2.03 adult males, 1.91 adult females, and 1.16 aged dependents.

The average farm size of adopters of improved maize varieties was significantly larger (2.03 ha) than non-adopters (1.42 ha) ($t = -6.62$, $p<0.01$). Total cultivated area and the area allocated to maize production in 1998 by adopters was 1.74 and 0.9 hectares respectively.

Mean livestock herd size of adopters of improved maize technology was 1.94 oxen, 2.24 cows, 1.99 calves, 1.84 heifers, 1.59 bulls. On the other hand, 31 of adopters of improved maize own one ox, 37 own two oxen, 6 own 3 and 4 oxen. The t-test revealed that there is a significant difference ($p<0.001$) in the number of oxen owned by farmers who have adopted improved maize varieties and those who have not.

It was found that 93 of both adopters and non-adopters of improved maize obtained credit from extension, i.e., the Bureau of Agriculture, at all levels. A systematic association between adoption of improved maize and access to credit, indicating that farmers with access to credit have a higher probability of adopting improved maize varieties than those households with no access to credit ($\chi^2 = 747.306; p<0.001$).

Maximum likelihood estimates of the parameters and the respective influences of each exogenous variable on the probability of improved maize adoption are calculated. With highly significant ($p<0.001$) model chi-square statistic (χ^2) 788.178 value (with 16 degrees of freedom) and a 748.356 log likelihood ratio, the model achieved 90 & correct prediction. Figures for correctly predicted adopters and non-adopters of high yielding improved varieties were 95.1 and 73.3, respectively. Among the factors considered in the model, use of chemical fertilizer, attending formal training, distance to the nearest market center, access to credit, tropical livestock unit access to extension information and family size were found to significantly influence adoption of improved maize.

A logit maximum likelihood estimates of the parameters and the influences of each exogenous variable on the probability of chemical fertilizer adoption were analyzed. With highly significant ($p<0.001$) model chi-square statistic (χ^2) 426.638 value (with 16 degrees of freedom) and a 1093.051 log likelihood ratio, the model achieved 83.5 & correct prediction. Figures for correctly predicted adopters and non-adopters of improved varieties were 92.7 and 52.3, respectively. Among the factors considered in the model, use of improved maize, farm experience, distance to the nearest market center, access to credit, level of education, tropical livestock unit, family size, and use of community labor were found to significantly affect adoption of chemical fertilizer.

BACKGROUND AND RATIONALE

Ethiopia, with an area of 1.115 million hectare is the ninth largest country in Africa. It has a diverse physical feature ranging from about 200 meters below sea level at the Denakil Depression to over 4500 meter above sea level in the Semien Mountain. The country has 18 major and 49 sub agro-ecological zones. Environmental degradation, resulting in soil erosion and fast depletion of rich topsoil, has been the major problem confronting agricultural development.

Agriculture is the largest sector of the Ethiopian economy. It employs 85% of the labor force and accounts for 50% of the gross domestic product (GDP). The sector accounts for 90 % of total foreign exchange earnings with coffee contributing to about 60 % of total value of national export (or 70 % of the total value of agricultural export) and roughly 2 % of the world coffee market. Hides and skins account for 20 % of total value of agricultural exports, followed by pulses, *chat* and animal products in that order of importance (MEDAC 1999). Agriculture is an important source for supplying about 70% of the raw material for food processing, beverage and textile industries. However, this sector is still predominantly small-scale. The country's seven million smallholder farmers produce more than 90% of agricultural products and 98% of coffee (MEDAC 1999). Out of the total land area of 1.115 million hectares, about 60% is regarded to be potentially suitable for agriculture, but less than 10% of the potential, which is estimated at about 7 million hectares has been cultivated in any one-crop season. About 95% of the cultivated land is under smallholder farming, and the rest under state and commercial farms. Despite considerable land degradation, because of high erosion rate, Ethiopia is endowed with vast land potential for agricultural development. Agricultural production is predominantly rainfed depending on two (long and short) rainy seasons, and is characterized by fragmented plots of land due to soil degradation and population pressure.

Maize is an important cereal crop in Ethiopia as source of both food and cash. In terms of area coverage on a national basis, it stands second next to tef (*Eragrostis tef*). Of all food crops covered under the extension program, maize received the highest attention owing to its wider cultivation and significance in its share of food crops. This can be seen from the fact that at mean annual growth rate of 1.62 %, the total area of land under maize cultivation has increased significantly from 75,500 ha in 1961 to about 1.5 million ha in 1998. It constitutes 12.84 % of the total area under cereal crops in 1961 and 22.96 % in 1998. This depicts not only how important maize has remained in the cereal production of the country's agriculture but also the shift of many farmers towards cultivation of maize. Production wise, at present with annual production of more than 2.3 million metric tones, maize comprises nearly 30 % of the total cereal production in the country. The increases in maize production level and its share in the total cereal output have been at 3.27 and 1.92 %, respectively. Growth in productivity of maize farms has also been achieved. This stand at 1.62 % per annum over the years considered. Although environmental factors are conducive for maize production and the improvements in yield level from 9.6 q/ha in 1961 to 16.17 q/ha (in 1998), the growth in productivity of maize farms has not been that impressive. Compared to many other African countries that produce more than 25 q/ha on average, productivity of maize farms in Ethiopia is still too small. As a result, the Ethiopian government has ever since long been giving due emphasis to the promotion of the crop in terms of generating and transferring improved technologies. Over the last fourteen years, the then Institute of agricultural

Research and the present Ethiopian Agricultural Research Organization (EARO), Alemaya University and Awassa College of Agriculture have developed about 14 composite and hybrid maize varieties along with their respective agronomic and protection recommendations. Tapping the potential and increasing the yield level of these technologies depend mainly on the supply of complementary institutional and productivity augmenting factors like improved seeds, fertilizers, credit and extension services.

The effort of the Ministry of Agriculture and the different Bureaus of Agriculture in giving more emphasis to maize under its new extension package program emanated from the desire to utilize the existing high potential and to help contribute towards the achievement of increased productivity and production of food crops. Although the present attempt to introduce potentially high yielding improved maize seeds is not the first of its kind, the scale and organization of institutional arrangements and emphasis has not been as strong as this one. It is believed that institutional factors such as the agricultural extension program, credit facilities and related arrangements made by the ministry of agriculture and the bureaus of agriculture of the different regions have helped fostering the use of improved maize and promoting its adoption among small-scale subsistent farmers in the country. To this date however, the extent to which these factors and other related variables helped farmers adopt maize technology packages and the rate and pattern of its diffusion and adoption has not been well documented at larger scale. Aregay (1980) for Chilalo area and Yohannes et.al (1990) for Tegulet and Bulga area have indicated some demand setting factors. Hailu and Mohammed (1986) also carried out adoption studies. The major emphasizes of these studies have been either wheat crop or adoption of fertilizers. They were also limited to pocket areas, which received relatively more emphasis.

From literature, we see that different agricultural technologies were developed and transferred into the farming community in different parts of the world. However, only a small proportion of the farmers adopted few of these technologies. Epoug (1996) indicated that only 10 % of farmers in Africa have adopted new technologies. It is hypothesized that the reason for little or no adoption of new technologies could be technical, socio-economic or institutional. It is, therefore, relevant to identify the specific factors affecting the adoption of improved maize technologies and determine the current rate of adoption of improved maize technologies transferred so far in the country. This will then help to suggest possible areas of intervention for improving the efficiency of the agricultural research and extension process.

- The study covered the following major maize growing belts of the country:
- The Oromiya Regional State (in the southwestern belt);
- The Amhara Regional State (in the northwestern belt); and
- The Southern Nations and Nationalities Region (in the Southern maize belt).

These maize growing belts have their peculiarities. The funds for the study were obtained from the United States Agency for International Development (USAID).

Objectives of the Study

The overall objective of the study was to investigate and document adoption levels and to specifically determine the factors that affect adoption of improved maize and draw implications for research, extension and policy.

The specific objectives were to:

- investigate the rate of adoption of improved maize and chemical fertilizer;
- examine the characteristics of adopting and non-adopting farmers;
- identify demographic, socio-economic and institutional factors that affect the adoption of improved maize technologies; and
- draw implications for research, extension and policy.

DESCRIPTION OF THE STUDY AREA

The study was conducted in three major maize growing regions of the country. *Oromiya* National Regional State; *Amhara* National Regional, State and Southern Nations, Nationalities and Peoples' Regional State (Map 1).

Southern Nations, Nationalities and Peoples' Regional State

Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) is one of the nine regions of Ethiopia located in the southern and southwestern parts of the country. It borders Kenya in the south, Sudan in the southwest, Gambella in the southwest and Oromiya in the north and east. It lies roughly at 4° 27'-8° 30' latitude north and 34° 21'-39° 11' longitude east. It has an area of about 113539 km², which accounts for 10 % of the total area of the country. It is divided into nine administrative zones with 72 *woredas* (districts) and five special districts based on ethnicity and language identities.

Bureau of Planning and Economic Development (BOPED) (1998) indicated that the altitude of the region ranges from 376 m at Lake Rudolf to 4207 m at mount *Guge* in North *Omo*. The Region has a wide-ranging ecological variability. It comprises semi-arid (*Kola*) below 1500 m, mid-altitude (*Woinadega*) 1500-2500 m, high altitude (*Dega*) 2500-3500 m, and temperate cool (*wirch*) above 3500 m. *Kola* accounts for the highest proportion (49.8 %) followed by Woinadega , which is 36.8% of the Region.

Major crops grown in the region include maize, sorghum, wheat, barely, *tef*, millet oats, pulses, oil crops, *enset* and root crops. The area and production of maize account for 34% and 51%, respectively. The farmland put under cultivation of cereal account for the highest proportion followed by pulses.

The population of the Region is about 11 million (CSA, 1997). About 80% live in the highlands, which cover about 40% of the Region, while 20% of the population lives in the arid and semi-arid zones covering about 60%. The study was undertaken in three major maize growing administrative zones and five major maize growing districts of SNNPRS (Map 2).

Amhara National Regional State

The Amhara National Regional State (ANRS) is located in northwestern Ethiopia. The Region is situated between 8° 45'and 13° 45' latitude north and 35° 46'and 40° 25' longitude east and has an area of 1707552 km². ANRS covers about 15% of the country's land and is bordered by Tigray in the north, Afar in the east, Oromiya in the south, Benshagul Gumuz in the northwest and Sudan in the northwest. The Region is divided into 11 Zones and 105 Woredas, (BOPED, 1999). It has approximately 4.6 million ha of arable land of which 93% is under cultivation. The population of the Region is estimated at 15 million. Of these, 90% live in rural areas, while 10% live in towns. Population under 25 years of age is estimated to account for more than 65% of the population. The population density of ANRS is about 87 persons/km². Its highland accounts for a large part of the population and the remaining live in the lowlands.

The topography of the region varies from lowland plain to undulating hills with flat-topped plateau and mountain areas. The highlands which is about 65% of the total land lies at an altitude of above 1500 m have mid temperature and high rainfall. The annual mean temperature for most part of the Region is between 15°C and 21°C. High temperature (27°C) is observed at some valleys and arid marginal lands. The highest rainfall occurs between mid June and early September. The southern and central parts of the Region receive high rainfall compared to northwestern and northeastern parts. The mid and highland comprises the largest part of the southern, central, northern and eastern parts. These areas are mountainous, and many big rivers commence from them. Chains of mountains and plateau also characterize the highland. The lowlands are characterized by high temperature, low rainfall, and cover the western and eastern parts of the Region (BOA, 1999).

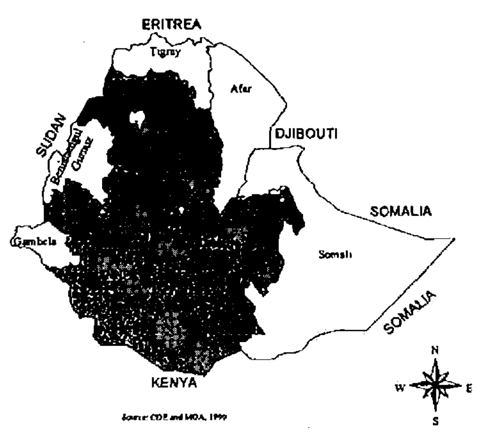
About 90% of the populations of ANRS are dependant on crop and livestock for living. The smallholder peasants living in rural areas make up the majority of the population. Cropping is predominantly rainfed, and is dominated by subsistence agriculture with crop and livestock farming being the principal practice. Because of population pressure and poor land husbandry practices, the level of land degradation and environmental depletion is getting worse over time. The region has a fertile farmland, and water resources, which are suitable for crop production and livestock husbandry. The high potential areas are the western midlands and the densely populated fertile surplus producing areas of Gojam and Gonder (UNECA, 1996). These high potential areas are also known to be major maize production areas. Farmers produce a combination of cereals, pulses and oil seeds. Out of the total areas of ANRS, 27.3% is under cultivation, 30% left for grazing and browsing, 2.1 % forestland, 12.6% covered by bush, shrubs, and 18.9% currently not used for any kind of production. The remaining 9.1% represent settlement sites, swampy areas, lakes, etc. The study was conducted in three Zones and five woredas (Map 2).

Oromiya National Regional State

Oromiya national Regional State is located between 3° 40' and 10° 35' latitude north and 34° 05' and 43° 11' longitude east. It is bordered in the north by Afar, Amhara and Benshangul Gumuz, in the east Somalia Regional State, in the south by Kenya, in the west Sudan and Benshangul Gumuz and in the south with SNNPRS and Gambella. It has a total area of about 113 539 sq.km, which accounts for 10 % of the total area of the country. It is divided into nine administrative zones with 72 districts and five special districts based on ethnicity and language identities (BOPED, 1997).

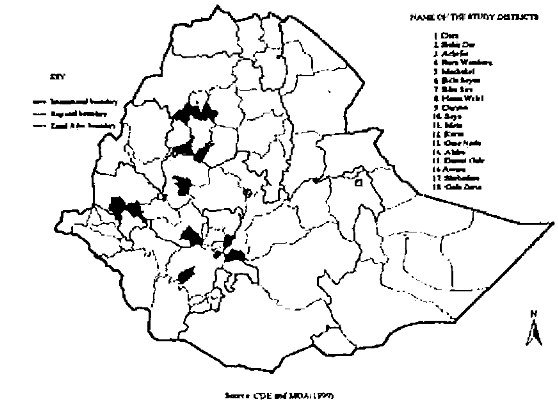
The total population of the region is estimated at 20,012,952 out of which 2,202,870 (11%) are urban and 17,810,082, (89%) are rural population. Out of the total population 47.7% are between the ages of 1-14; (2.8%) are above 65 years of age; and the economically active population is 49.5%. The population increases at a rate of 3% per year. Over 80% of the population live in areas with average altitude of 1800-2500 m and depend on agriculture for their livelihood. Regarding population density, Oromiya can be clustered into three categories. The Borena and Bale areas have the lowest density of 20 persons per km². The population densities of Arsi, North Shewa, West Shewa, East Welega, West Welega, Ilibabor and Jima Zones are 110 persons per km². Harerge has a medium population density of 60 persons per km² (BOPED, 1997).

Map1: Study Regions



Oromiya Regional State has favorable climate for agricultural activities and is endowed with natural resources. Agriculture provides employment for 90% of the labor force and accounts nearly to 64% of the region's GDP. Agriculture provides food for the large and expanding population of the region and the country at large. In general, about 84 % of the area under cultivation is under cereals, 11% under pulses and 5% under oil crops. Out of The total production of about 47 495.53 quintals of cereals, pulses, and oil crops contribute to 90%, 8% and 2% respectively. Tef and maize account for 17.6% and 31% of the total production of cereals, respectively.

Map 2: Study Weredas



Most zones of the region have unimodal rainfall, and some zones like Hararge and the neighboring areas have bimodal rain, (the Belg rain (February-April) and the Meher rain (June-September). The western part of the region receives up to 2600 millimeters of rainfall. The middle part, which is about 70% of the land area, receives between 680 - 1700 mm. The lowest amount of rainfall is received in eastern and southern boarder where the yearly amount is about 200 mm. The total land area of the region is 32 million hectares of which 20% is under cultivation and

24% is left for grazing respectively. There is a zonal variation where Borena and Bale account for 40% of the total regional land area and 70% of its grazing land. The Region has:

- 108028 km^2 cultivated land;
- 26460 km^2 forests;
- 91892 km^2 woodland;
- 129464 km^2 bushes and shrubs; and
- 1203 km^2 is marshy.

Farmers are mainly engaged in mixed farming crop and livestock production. The major crops grown are cereals, (maize, sorghum, wheat, barley, oats, and millet) pulses, (faba bean, field peas, chickpea, lentil, and soybean) oil crops, (rapeseed, noug, sesame, and groundnuts) horticultural crops, (fruits, spices, and tubers), fiber crops (cotton), and stimulants (coffee, tea, and chat).

Out of the twelve Zones of the Region, 4 major maize growing zones were selected and included in the study. These were: East Welega, West Welega, Jima and Ilubabor. From each Zone, two major maize growing weredas were selected and included in the study (Map 2).

MAIZE PRODUCTION, TECHNOLOGY DEVELOPMENT AND DESIMINAION

Production

Maize was introduced to Ethiopia in the 16th or 17th Century (Kebede, et al, 1993). It has a wide adaptation in Ethiopia. The bulk of maize comes from Oromiya, Amhara and SNNPRS (EARO, 1999). Maize grows under a variety of cultural practices including both short and long seasons rainfed cultivation. Maize in Ethiopia is produced mainly for consumption. Some amount is processed for human consumption and livestock feed. The green leaves and stalks are used for cattle feed, fuel and construction.

Of all food crops grown in Ethiopia, maize received the highest attention for its wider cultivation and significance in its share of food crops. As a result, maize production has a mean annual growth rate of 1.62 %, the total area of land under maize cultivation has increased significantly from 75,500 ha in 1961 to about 1.5 million ha in 1998. It constituted 12.84 % of the total area under cereal crops in 1961 and 22.96 % in 1998 (Table 1). This depicts not only how important maize has remained in the cereal production of the country's agriculture but also the shift of many farmers towards cultivation of maize. At present with annual production of more than 2.3 million metric tones, maize comprises nearly 30 % of the total cereal production in the country.

According to Kebede, et al (1993), the major constraints limiting maize production in Ethiopia are identified as:

- shortage or excess rainfall;
- pests such as stock borers;
- diseases such as rust, blight, streak virus and downy mildew;
- weeds such as striga (*Sriga hermonthica, S. aspera, S.asiatica*), orobanche; and
- continuous use of land without proper soil and water conservation.

The other major problem encountered in the last seven years was the price of maize has fallen below the recorded level:
low purchasing power of consumers,

- sales of maize to pay back loans;
- substitution of maize as a cash crop;
- need for cash forces farmers to sell more;
- traders lack finance and are risk averse; and
- change in the pattern of production from other cash crops to maize.

Table 1. Trends in area, production, and productivity of maize farms in Ethiopia (1961-1998)

Year	Area (000 ha)	Production (000 MT)	Yield (q/ha)	% To total cereal area	% To total cereal production
1961	75.5	727.000	9.63	12.84	17.30
1970	8471.1	909.000	10.73	12.87	17.93
1980	870.79	1,524.000	17.14	17.14	23.80
1990	1,277.79	2,055.640	25.77	25.77	33.49
1998	1,449.33	2,344.300	22.96	22.96	29.51
Average Annual Growth Rates (1961-98)	1.63	3.27	1.62	2.01	1.92

The growth rates are significant at P<0.001.

Technology Development

Research on maize was initiated at Jima College of Agriculture in 1952 and the Alemaya College of Agriculture (now Alemaya University) in 1953. These two teaching institutions were .the planners of research in Ethiopia and simple experiments were carried out on maize and other crops. In 1966, Bako Research Center of IAR was established in the western part of the country based on an agreement reached between the Ethiopian government and the Federal Republic of Germany. In addition, the Awasa Research Center was established with aid from the French Government in 1967. During this time various maize germplasm were introduced to the country. The research on maize focused on screening varieties, cultural practices such as seed rate, time of planting, spacing, fertilizer type, etc.

Starting form 1986 onwards, maize research has been nationally coordinated from Bako Research Center. Maize research was carried out based on a team approach composed of researchers with specialization in breeding, agronomy, pathology, entomology, weed science, soil science, agricultural economics, research and extension. The major objective of the maize research program of the then IAR and the present EARO is to develop high yielding varieties along with their improved management and protection technologies for different agro-ecologies. During the last 40 years different open-pollinated and hybrid maize were developed for different agro-ecologies of the country (Table 2). Agronomic and crop protection recommendations are presented in Tables 3 and 4.

Table 2: Maize varieties developed by research and their areas of adaptation.

Varieties	Altitude (m)	Rainfall (mm)	Days to maturity	Year released	Experimental yield (q)	On farm (q)
Open-pollinated varieties						
A-511**	500-1800	800-1200	150	1970	50-60	30-40
UCB*	1700-2000	1000-2000	163	1975	50-70	40-45
Alemaya* Composite	1600-2200	1000-1200	163	1975	50-70	40-45
Katumani	1550	600-1000	105		60-70	40-45
ACV-3	1550	600-1000	110	1996	35-50	25-30
ACV-6	1550	600-1000	110	1996	35-50	25-30
Abo-Bako*	500-1000	1000-1200	150	1986	50-70	35-45
Kuleni*	1700-2200	1000-1200	150	1995	60-70	40-45
Gutto*	1000-1700	800-1200	130	1988	30-50	25-30
Hybrids						
BH-140*	1000-1800	1000-1200	140	1988	80-90	50-60
BH-660*	1600-2200	1000-1500	165	1993	90-120	60-80
BH-540*	1600-2000	1000-1200	145	1995	80-100	50-65
BH-530*	1000-1300	1000-1500	137	1997	80-90	50-60
Beletech*	1500-2000	800-1200	160	1990	50-70	40-45

Source: Maize Research Commodity, EARO, 1998 * = *under production*

Table 3. Agronomic Recommendations for maize

Practices	Recommendation
Land preparation	2-3 times plowing with maresha
Planting depth	5-7 centimeters, planted in rows
Spacing	80 cm X 50 cm, two plants/hill for full season varieties
Fertilizer rate	100 (46 N/P2O5) kg/ha for open pollinated varieties
Weed management	Hand weeding: Twice hand weeding at 25-30 Days and 55-60 days supplemented with slashing
•	Herbicides: Premagram- 2kg/ha Note: Herbicide use should not be obviate the need for supplementary hand weeding
Precursor crop	Noug followed by haricot bean
Crops suitable for inter-cropping and relay cropping	Haricot bean, sweet potato as well as forage legumes

Source: Maize research commodity, EARO, 1998

Review of Extension Systems

Impacts from research investments could be assessed through changes in farm productivity. This envisages the use of research-generated technologies. Strong and efficient national agricultural extension services that stimulate the adoption of recommended farming techniques and ideas are prerequisite for the successful technology diffusion. Agricultural extension in Ethiopia began in the early 1950s with the establishment of the Alemaya College of Agriculture. In about a decade in the early 1960s the extension function of the college was transferred to the Ministry of Agriculture, which more or less followed the conventional approach to implement the extension service. When peasant agriculture gained more attention during the third five-year development plan (1968-73), comprehensive agricultural projects like Chilalo Agricultural Development Unit (CADU) and Wolaita Agricultural

Development Unit (WADU) were initiated (Tenasi, 1985). Besides agricultural extension these projects included development of infrastructure services such as roads and water, and were thought to serve as models to be expanded to other areas later.

Table 4. Protection Recommendations for Maize

Pests and diseases	Recommendations
Stalk borer	Early planting after on-set of rain
	Horizontal placement of the maize stalk in the sun for 4-6 weeks in the field
Storage pests	Drying of the grain to the optimum moisture level (? %)
	Use of insecticides such as Primiphosmethyl dust
Diseases	Use of resistant/tolerant varieties
	Management practices
	Proper tillage
	- Crop rotation
	- Timely weeding
	- Plant at the optimum sowing date
	- Optimum planting density
	- Balanced fertilization
	Crop sanitation
	- Removal of crop residues
	- Removal of subtle
	- Removal of alternate hosts
	- Seed dressing with chemicals
	Management of vectors that would transmit viral diseases like streak virus
	Use fungicides to control foliar diseases when justifiable

Source: Maize Research Commodity, EARO, 1998.

The comprehensive approach of extension gradually phased out because the running cost had been expensive to duplicate them to other areas. Nevertheless, the program left a consistently positive effect and major gains in extension knowledge in the project areas. The high financial demand of the comprehensive packages led to the initiation of the minimum package projects in the 1970s under the Extension and Project Implementation Department (EPID). The minimum package extension approach comprised limited extension components like inputs, credit and extension advice. It had wider area coverage though limited to ten km of either side of all weather roads. This project continued to operate in two phases Minimum Package Program1 (MPP1) and Minimum Package Program2 and (MPP2) when the training and visit system was introduced in 1985.

Despite various extension efforts, the performance of agriculture in the country has not been improving. The major problem in technology diffusion was to make the technologies available to farmers. Farmers had no easy access to improved varieties, fertilizers, and crop protection technologies. Improved seeds were not produced in sufficient quantities. There are also constraints from the farmers' side. Only few farmers would have the cash resource to purchase agricultural inputs. Credit for input purchase exists, but involves administratively cumbersome procedures, which most often repelled farmers.

The Sasakawa Global (SG-2000) project that was initiated in 1993 has proved that technologies generated by the national agricultural systems, if properly utilized, could at least double and even triple yields of major cereals grown in the country. The SG-2000 technology transfer program had simply filled in the major gaps that existed during the various extension systems of the past. These, among others, included access to improved varieties and other inputs and made them available through the provision of credit. Intensive practical training of extension staff from central down to development agent level and the improvement of mobility of extension workers through provision of vehicles, motorcycles and bicycles have greatly facilitated the success of the program. The other strength of the program was the big effort it made to bring stronger linkages between research extension and input distributors, which were a key issue for a successful agricultural technology transfer.

The experience of the SG-2000 project and the Training and Visit (T and V) system has greatly contributed to the formulation of an extension system known as the Participatory Demonstration and Training Extension System. (PADETES) It is a synthesis of the SG-2000 approach. It uses large demonstration plots; usually one-fourth to half of a hectare to demonstrate improved farming practices. Training is given both to the extension staff and to farmers. The regular visits to demonstration plots provide many opportunities to discuss with farmers about problems encountered in the process. Though the program is only 5 years old, there is already an indication that the country is on the right path if the present inertia could be maintained or strengthened even more. In the strategy, the most important packages of recommendations include:

- improved seed varieties;
- seedbed preparation;
- optimum seeding rate;
- methods of fertilizer application;
- fertilizer type and rate; and
- use of pesticides.

The recommended production packages for maize calls for tilling soil, forming furrows, applying half the fertilizer and then sow the seed in row. Farmers acquire improved variety and treat it with pesticide to limit damage from pest. At the second weeding, application of second dose of fertilizer near the base of the plants and then passes down the row with a plow burring the side dressed fertilizer into the soil and simultaneously destroying weeds.

Seed Production

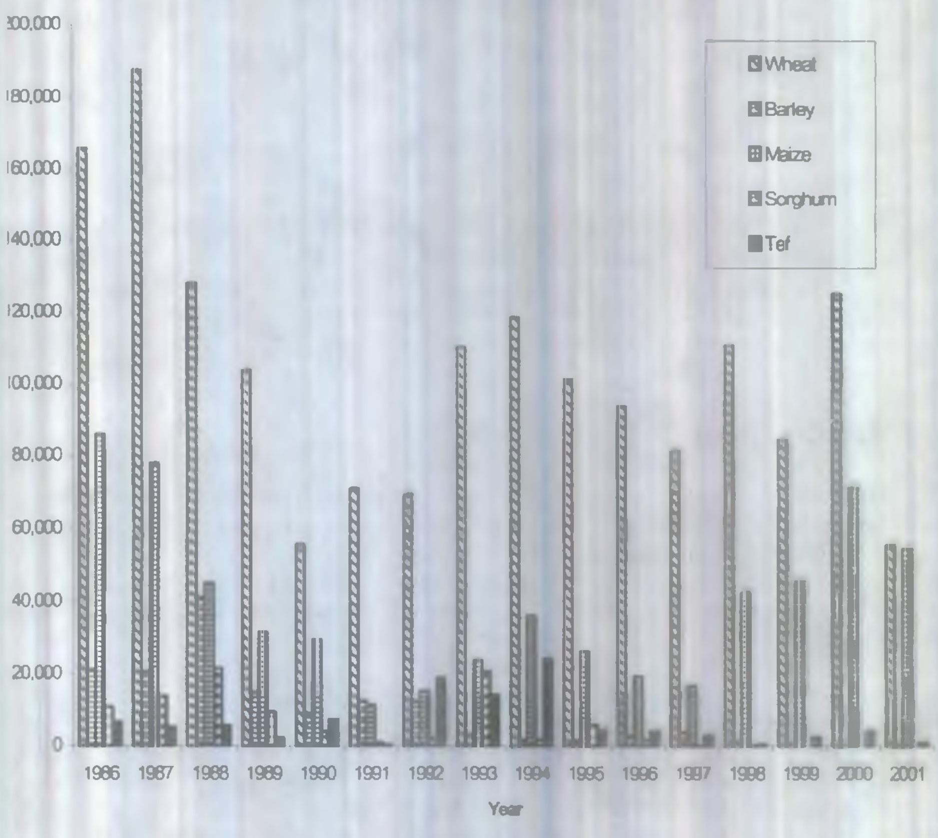
EARO, AUA and Awasa College of Agriculture (ACA) are responsible for breeding of improved varieties of different crops including maize and are involved in the production of breeder seeds supplied to the Ethiopian Seed Enterprise (ESE) for the production of pre-basic seed. After testing the variety at national or regional levels, the superior varieties are submitted to the National Variety Release Committee for release and registration.

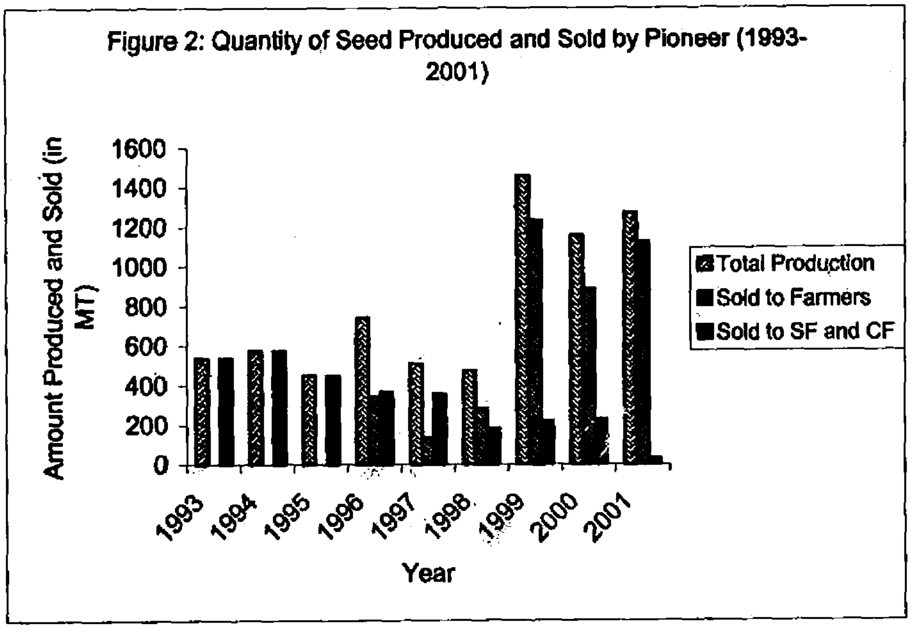
Maize seeds are produced on state farms and farms of the ESE located in Sidama, Welega and Gojam. These areas are ecologically suitable for maize seed production. Large quantities of composites and hybrid maize seeds were sold in Ethiopia over a period of 15 years (1986-2000) (Fig. 1). The quantity of hybrid maize seed produced has increased from 4799 in 1995/96 to 38237 q in 1998/99 and it is further expected to increase significantly in the near future, as maize hybrids possibly possess considerably higher yield potential than composites

Composite and hybrid maize seeds are processed and graded at the processing plants of the ESE at Asela, Awasa, Birr Valley, Nekemt and Koffele. Seeds of maize are treated and packed into 4, 7 12.5 and 25 kg bags according to the needs of its client and sold to farmers through the Ministry of Agriculture and the Bureaus of Agriculture of the different regions (ESE, 1999).

Pioneer Hi Bred Seeds Ethiopia PLC was registered in Ethiopia for the first time in December 4, 1990, as a joint venture with the Ethiopian Seed Enterprise (which is the country's sole seed organization) for five-year contractual agreement. The objective of the company is to produce, procure, distribute and sell hybrid seeds in domestic markets of Ethiopia on a commercial basis. The Company since its inception has dedicated itself in increasing the productivity of maize production by delivering hybrid seeds to farmers in general and to small-scale farmers in particular. The different types of seeds produced and distributed since the inception of the company are Phb 3242, Phb 3407, Phb3435, Phb3253, Phb30F19 and Phb30H83. At present Phb3242, Phb3407, Phb 3435, and Phb 30F19 are discontinued. The two varieties that are in production are Phb 3235 and Phb 30H83.

Figure 1. Certified and commercial seed sale (q)





Source: Pioneer Hibred Seed Company.

METHODOLOGY

Sampling Procedure

It has already been mentioned that the study was conducted in three major maize growing regions of Ethiopia namely, Amhara, Oromiya and SNNPRS. The study zones were selected based on maize production area, number of growers, and potential for maize production, accessibility and representativness of the farming system. They were selected in collaboration with the relevant extension experts of the SNNPR, Amhara and Oromiya Regional Bureau of Agriculture. The selected Zones were: South Gonder, West Gojam and East Gojam from Amhara Regional State; East Welega, West Welega, Jima and Illubabor from Oromiya and Kembata, Alaba and Timbaro, Sidama, and North Omo from SNNPRS; and once the Zones were selected, the same procedure and selection criteria were used to select the study districts. The relevant extension experts at the zonal agricultural department were involved in the selection of the weredas. The selection of sample farmers involved a two-stage sampling procedure. Sample peasant associations (PAs) were selected randomly using random sampling procedure. In the course of selection of the sample, PA precaution was taken not to select inaccessible and non-maize growing PA of the districts. Following the selection of the peasant associations, the sample farmers were then selected from sampling frame obtained from the development centers and/or peasant association offices of the respective PAs using random sampling procedure.

Data Collection

Data were collected from primary and secondary sources. The secondary source of information were published and unpublished works on agricultural production in the study area. The secondary information was collected from regional, zonal and weredas offices of agriculture, planning and knowledgeable individuals. Primary data were collected from sampled farmers using structured questionnaire. Before starting the actual data collection, the questionnaire was pre-tested to modify some of the questions, which were either irrelevant to the existing situation or were out of context. Experienced enumerators were hired to administer the questionnaire. The enumerators were given training on the content of the questionnaire, methods of data collection and on how to approach farmers. The data collection was done between November 1998 and May 1999.

Analytical Procedure

Adoption studies often attempt to analyze and understand the observed adoption pattern (CIMMYT, 1993). The examination of farmers' opinions and observations and statistical comparison of adoption measures with characteristics of the farmers' decision regarding a new technology are often quite complex. Following the completion of the data collection, the data was coded and entered into SPSS version 10.1 computer program for analysis. The different analytical techniques applied were t-tests, Chi square test, correlation analysis and logistic regression model. Frequency and mean were computed for different variables. The t-test was run to see the existence of statistically significant difference in continuous variables of farm characteristics of farmers who have adopted improved maize and those who have not done so. The chi-square test was run to see if there is any systematic association between adoption and some farm characteristics. Out of the two (logistic and probit) related multi factorial analysis techniques (Amemiya, 1981; Feder et al, 1985) that are particularly used for adoption studies a logistic adoption model was fit to determine the factors affecting the adoption of improved maize and chemical fertilizer use. The model was used to estimate the probability of adoption of improved maize that takes either of the two values of Y=1 for adoption and Y = 0 for non-adoption of improved maize and chemical fertilizer. The functional form of the model is presented as follows:

$$\Pr ob(Y = 1) = \frac{e^{(\beta' X)}}{1 + e^{(\beta' X)}}$$

Where B'X is defined as:

$$\beta' X = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_i X_i + \gamma_i$$

Where β_0 is the constant. β_i, = i =1,2,...n are the coefficients of the exogenous variables to be estimated. X_i is a vector of explanatory variables; γ_i is the error term with zero mean and constant variance. Farmer's decision to adopt or reject new technologies is influenced by the combined effects of factors related to farmer's objectives and constraints such as farmers' socio-economic circumstances (age, and formal education etc); farmers' resource endowments as measured by (size of family labor, farm size and oxen ownership); and institutional support systems available to farmers (credit, extension and availability of inputs) (CIMMYT, 1993).

The following variables were hypothesized to influence the adoption of improved maize and inorganic fertilizer:

Level of education

Level of education was assumed to increase farmers' ability to obtain, process, and use information relevant to the adoption of improved maize and fertilizer. Education Is therefore expected to increase the probability of adoption of improved maize.

Experience of farmers

Experience of farmer can generate or erode confidence, that is, with more experience; farmer can become risk averse to adopt improved maize so this variable can have either positive or negative effect on farmers' decision.

Household size

Household size was expected to increase the probability of adopting improved maize and chemical fertilizer. Large households could provide the labor that might be required by improved maize.

Use of hired labor

Use of hired labor was hypothesized to be positively related to the adoption of improved maize.

Access to credit

Access to credit can relax the financial constraints of farmers, and in some cases, access to credit is tied to a particular technology package. It was expected in this study that access to credit would increase the probability of adopting improved maize and fertilizer.

Agricultural extension service

It was hypothesized that contact with extension agents (development agents) will increase farmers' likelihood of adopting improved maize and fertilizer technologies.

Tropical livestock unit (TLU)

It was hypothesized that number of livestock owned by farmers is positively related to the adoption of improved maize and chemical fertilizer. Tropical livestock unit is an index where livestock numbers are aggregated using the following weighing factors: cows, heifers and bulls =0.8, goat=0.4, and sheep=0.4.

Distance to nearest development center

The further an extension office from farmers' homes, it is less likely that farmers will have access to information, thus it is inversely related to adoption.

Attending field day, visiting demonstration plot, and attending formal Agricultural training

Farmers who have attended field days, visited demonstration fields and attended formal agricultural training courses are expected to have a positive attitude to improved maize and use of chemical fertilizer. Hence, it is hypothesized that participation in the above-mentioned activities is expected to expose farmers to new technologies and is anticipated to positively affect the adoption of improved maize and chemical fertilizer.

Farmland

Increasing the production and productivity of maize depends on increased cropping intensity of improved maize and chemical fertilizer. Therefore, it is hypothesized that farmland is inversely related to adoption of improved maize and chemical fertilizer.

Adequacy of draft power

Adequacy of draft power was expected to enable farmers to cultivate more land on time. Hence, it was hypothesized that the probability of adoption of improved maize will be positively related to adequacy of draft power.

Distance to market center

Distance to market center was hypothesized to be negatively related to the probability of adoption of improved maize in that households near by market centers tend to use improved maize, for they can have easy access to dispose of their production.

Use of chemical fertilizer

Improved maize technologies are alleged to perform better with chemical fertilizer. Hence, Use of chemical fertilizer was expected to be positively related to the adoption of improved maize and fertilizer

DEMOGRAPHIC, SOCIO-ECONOMIC AND INSTITUTIONAL CHARACTERISTICS OF MAIZE FARMERS IN ETHIOPIA

Demographic Characteristics

Mean age of adopters and noon-adopters of improved maize was about 42 years old and adopters and non-adopters had similar years of experience in operating and handling their own farm. More adopters (65%) were more educated than non-adopters (41%)) (χ^2=35.4; p<0.01) (table 5). Out of the adopters of improved maize; 35% were illiterate, 23% had primary school education, 21% participated in a literacy campaign, and 6% and 9% reached junior and senior high school, respectively.

Table 5. Demographic characteristics of maize farmers in the study area

Characteristics	Adopters		Non-adopters		t-statistic
	Mean	SD	Mean	SD	
Age of head of household	42.33	13.32	42.00	13.40	0.464 NS
Level of education	2.46	3.26	1.53	2.59	4.892***
Farm Experience (own farm)	20.3	12.55	20.21	13.2	0.85 NS
Family size	7.30	3.10	6.30	2.70	5.546***
Children under 14 years	3.31	1.90	2.85	1.82	3.848**
Adult male, 15-60 years	1.98	1.27	1.74	1.19	3.150***
Adult female, 15-60years	1.86	1.22	1.56	1.08	4.115***
Dependent male and female 61 years and above	0.16	0.43	0.13	0.38	1.016 NS
Level of education	N	%	N	%	χ^2Statistics
- Illiterate	391	35.0	175	52.0	35.422 ***
- Primary school	253	23.0	61	19.0	
- Junior secondary	64	6.0	9	3.0	
- Secondary school	96	9.0	15	4.0	
- Lit racy campaign	237	21.0	66	20.0	
- Priest / Curran read and write	67	6.0	12	4.0	
Religion	N	%	N	%	
- Orthodox	590	53.0	127	38.0	45.483***
- Muslim	287	26.0	126	37.0	
- Protestant	187	17.0	68	20.0	
- Catholic	56	5.0	9	3.0	
-Have no religion	4	0.4	9	3.0	

*** = *Significant at P< 0.01, NS=Not Significant at all levels*

The average household size of adopters was 7.29 persons, consisting of 3.31 childre less than 14 years, 1.98 adult males, 1.86 adult females, and 0.16 aged dependents (Table 5). As expected, children less than 14 years of age dominate the family composition as in other parts of the country. The statistical analysis showed significant difference (t = 5.546; p<0.001) in family size of adopters versus non-adopters of improved maize.

Socio-economic Characteristics

Farmland

The average farm size of adopters of improved maize was significantly larger (2.04 ha) than non-adopters (1.42 ha) (t - 6.753; p<0.01) (Table 6). Total cultivated area and the area allocated to maize production in 1998 by adopters was 1.69 and 0.91 hectares respectively and is significantly different (t -5828; p<001) and (t - 5.019; p<001') when compared with the cultivated (1.27 ha) and maize area of (0.51 ha) of non-adopters.

Table 6. Size of land holding (hectare) of maize farmers in Ethiopia

	Adopters			Non-adopters			
Characteristic	N	Mean	SD	N	Mean	SD	t statistic
Total farm size (ha)	1104	2.04	1.54	339	1.42	1.23	6.753***
Cultivated land (ha)	1101	1.69	1.20	342	1.27	1.13	5.828***
Area of maize (ha)	1120	0.91	0.87	349	0.66	0.51	5.019***

* *Significance at P<0.01*

Labor

The use of hired seasonal and permanent labor is low for both adopters and non-adopters of improved maize. Adopters and non-adopters reported that they face a labor shortage during farm operations. To overcome this problem, 81.4% of adopters and 77.3% of non-adopters use community and hired labor, respectively, for maize production. Hiring seasonal labor and the participation of community labor in farm operation is significant for adopters and non-adopters at (χ^2 - 22.68, p-<0.01) and (χ^2 -2.74, p<0.1) respectively (Table 7). The most important community labor arrangements are locally called *Debo*" and "*Wonfel*" (locally developed systems of labor exchange). Plowing, planting, weeding and harvesting are the major farm operations for which seasonal labor is used while; community labor is used for all operations mentioned above except plowing. Very few household heads and their families' members are engaged in off farm activities and most farmers are not using the income they receive from off farm to purchase farm inputs or promote maize production.

Table 7. Socio-economic characteristics of maize farmers in the study area.

Characteristics	Adopters		Non-adopters		χ^2-Statistic
	N	%	N	(%)	
Have off-farm jobs					
- Yes	106	9.5	19	5.6	4.966**
- NO	1014	90.5	320	94.4	
Does any one in the family have off-farm jobs					
- Yes	25	2.5	14	5.1	4.998**
- No	973	97.5	258	94.9	
Use off-farm income to purchase farm inputs					
- Yes	91	22.4	17	15.6	2.989 NS
- No	314	77.1	92	84.4	
Hire seasonal labor					
- Yes	324	29.5	55	16.4	22.686***
- NO	776	70.5	281	83.6	
Use community labor for farm operations					
- Yes	891	81.4	262	77.3	2.740*
- No	204	18.6	77	22.7	
Have adequate draft power					
Yes	585	53.2	114	34.5	35.283***
No	515	46.8	216	85.5	
Operation for which seasonal labor is employed					
Plowing	54	17.9	4	8.2	5.294 NS
Planting	25	8.3	.3	6.1	
Weeding	165	54.6	27	55.1	
Harvesting	58	19.2	15	30.6	
Operations for which community labor is used					
Planting	163	22.7	54	28.1	3.547 NS
Weeding	243	33.1	57	29.7	
Harvesting	278	37.8	69	35.9	
Threshing and Winnowing	49	6.7	12	6.3	
Type of community labor used					
Debo	497	53.5	162	60.9	10.042*
Wonfel	4.5	44.7	102	38.3	
Hire permanent labor for farm operation					
Yes	140	12.7	16	4.8	16.439***
No	966	87.3	318	95.2	

****Significant at P<0.001; **Significant at P<0.05; *Significant at P<0.10; NS=Not Significant*

Livestock

Mean herd size of adopters of improved maize technology was 1.64 oxen, 1.67 cows, 1.32 calves, 0.78 heifers, 0.51 bulls. In terms of ownership, only 14% of the households have beehives, 57% have chickens, 3% has mules, 4% have horses, and 23% have donkeys. On the other hand, 31% of adopters of improved maize own one ox, 37% own two oxen, 6% own 3 and 4 oxen. The t-test revealed that there is a significant difference (t=7.537 <0.01) in the number of oxen owned by farmers who have adopted improved maize and those who have not (Table 8). Mules and horses, which are wealth indicators in some areas of Ethiopia, are not abundant in the study area; non-adopters apparently own fewer horses than adopters.

Table 8. Livestock owned by adopters and non-adopters.

Livestock types	Adopters			Non-adopters			T-Statistic
	N	Mean	SD	N	Mean	SD	
Livestock size in tropical livestock units	1128	4.97	4.03	354	3.35	3.09	6.916***
Oxen	1128	1.64	1.15	354	1.13	0.99	7.537***
Cows	1128	1.67	1.74	354	1.18	1.30	4.889***
Calves	1128	1.32	1.57	354	.87	1.07	5.008***
Heifers	1128	0.78	1.24	354	0.45	0.93	4.484***
Bulls	1128	0.51	0.93	354	0.28	0.63	4.205***
Sheep	1128	0.54	1.15	354	0.29	0.80	3.711***
Goats	1128	0.24	1.07	354	0.31	1.41	-1.087NS

**** = Significant at 1%; NS= Not significant at less than 10%.*

The number of livestock units owned by a farmer was hypothesized to affect the adoption of improved technologies, since tropical livestock unit (TLU) represent a ready source of cash for purchase of farm inputs. The study uncovered that there is a significant difference between adopters and non-adopters with regard to most livestock types.

Institutional Characteristics

Access to extension

Access to information or extension messages was one of the institutional characteristics hypothesized to influence farmer's decision to adopt a new technology. One can gain access to information about new technologies through various means such as attending field days, visiting demonstration fields, participating in formal training, listening to agricultural programs on radio, through contacts with extension or development agents, and through various forms of communication with neighbors, relatives and community leaders. Of these, the main source of information for maize production is the extension service of Bureaus of agriculture (BOA) at the regional, zonal and district levels.

About 32 % of adopters and 14 % of non-adopters had attended field days or demonstrations trials while only 18 % of adopters reported attending a formal training course on improved maize production practices. The chi-square analysis revealed that there is a significant difference in participation in demonstration trials (χ=41.255, (p=<0.01)) and attendance of formal training (χ=27.037, (p=<0.01) between adopters and non-adopters of improved maize (Table 9). As far as contacts made by extension agents with farmers were concerned, 78% of adopters and 28% of non-adopters were visited individually during the survey year. About 32% of adopters and 14 of non-adopters owned a radio.

Significant difference was observed between adopters and non-adopters in distance to a development center from the residence. The average time taken to reach the nearest development center and market centers was about 30 and about 61 for adopters and 35 and 52 minutes for non-adopters respectively.

Table 9. Institutional characteristics of maize farmers in the study area

Characteristics	Adopters		Non-adopters		χ^2-statistic
	N	%	N	%	
Ever attended a field day or Demonstration trial on maize					
Yes	362	32.3	49	14.4	41.255***
No	759	67.7	291	85.6	
Ever attended a formal training course in maize					
Yes	207	18.5	23	6.8	27.038***
No	912	81.5	317	93.2	
Visited by extension agent in 1998					
Yes	744	77.9	75	26.8	253.299***
No	211	22.1	20.5	73.2	
Have a radio					
Yes	328	32.3	41	13.5	41.270***
No	686	67.7	263	86.5	
Listen to any agricultural Education program on radio					
Yes	295	69.1	38	45.2	17.587***
No	132	31.0	46	54.8	
Coverage of radio program satisfactory					
Yes	294	71.9	41	51.3	13.203***
No	115	28.1	39	48.7	
Reasons for not listening to a radio program					
Broadcasting time is unsuitable	28	25.9	2	6.1	11798*
Language Barrier	19	17.6	11	33.3	
Not aware of agricultural program	31	28.7	14	42.4	
Number of visits made by extension agents before plowing					
One time	314	68.3	23	56.1	14.251**
Two times	92	20.0	10	24.4	
Three times	40	8.7	3	7.3	
Four times	10	2.2	5	12.2	
Five times	3	0.7	-	-	
Six times	1	0.2	-	-	
Number of visits at slack season					2.378 NS
One time	297	80.9	52	85.2	
Two times	39	10.6			
Three times	13	3.5	1	1.6	
Four times	9	2.5	1	1.6	
Number of visits during weeding					
One time	440	69.2	31	66.0	28.525***
Two times	139	21.9	10	21.3	
Three times	41	6.4	2	4.3	
Number of visits at planting					
One time	595	82.4	38	71.7	30.945***
Two times	100	13.9	8	15.1	
Three times	17	2.4	1	1.9	
Four times	8	1.1	4	7.5	
Number of visits at harvest time					
One time	338	82.6	27	75.0	15.542**
Two times	52	12.7	6	16.7	
Three times	12	2.9	-	-	

Table 9: Continued

Characteristics	Adopters		Non-adopters		χ^2-statistic
	N	%	N	%	
Are you a member of any organization					
Yes	1043	94.6	301	90.7	6.882*
No	59	5.4	31	9.3	
To which organization do you belong					
Peasant Association	851	98.5	26.5	98.1	0.955 NS
Youth association	8	0.90	4	1.50	
Service cooperatives	4	0.50	1	0.40	
Position of farmers in the organization					
Leader	5.9	6.30	2	0.70	19.449**
Executive member	68	7.20	20	7.4	
Ordinary member	760	80.7	236	87.4	
Services obtained from organizations					
Seed	244	40.5	5	3.90	92.749***
Credit	80	13.3	13	10.2	
Labor	26	4.3	10	7.9	
Seed and fertilizer	9	1.5	0.3	2.4	
No benefit	158	26.2	72	56.7	

** Significant at P<0.1; ** Significant at P<0.05; *** Significant at P<0.01;*
NS = Not significant.

Credit availability

It was found that 93% of adopters and 72 % of non-adopters of improved maize get credit. There was a systematic association (χ^2 = 747.306; p<0.001) between adoption of improved maize and access to credit (Table 10), indicating that farmers with access to credit have a higher probability of adopting improved maize than households with no access to credit. The main purpose for which both categories of farmers take credit was to purchase improved varieties and chemical fertilizer. The major source of credit was the Ministry of Agriculture and Regional Bureaus of Agriculture as indicated by 92 % of both adopters and non-adopters.

The main purpose for taking credit from the informal sector was for home consumption. The most important credit problems cited in the study area were unfavorable loan repayment terms, unavailability of loans from either formal or informal sources and high interest rates. The types of improved maize purchased using credit were BH660, A511, BH140, CG4141, PHB3253, and BH540 in their order of importance.

Table 10. Credit availability in the study area

Credit Characteristic	Adopters		Non Adopters		χ^2 statistic
	N	%	N	%	
Do you get credit for maize production					
Yes	1049	93.2	72	21.4	747.306***
No	76	7	264	78.6	
Purpose of taking credit					
To purchase improved seed	998	97.1	12	17.0	575.436***
To purchase fertilizer	29	2.8	58	82.9	
Do you have credit problems					
Yes	330	31.0	109	46.6	22.293***
No	751	70.0	125	.53.4	
Nature of credit problems					
MOA loan is not available	95	29.6	28	28.0	39.020***
Bank loan is not available	14	4.40	2	2.0	
Repayment term are not favorable	123	38..0	17	17.0	
Interest rates are too high	60	19.0	25	25.0	
Loan from informal sources is not available	4	1.2	6	6..0	
Used credit this production season (1998)					
Yes	971	91.2	97	33.4	454.955***
No	94	8.8	1.93	66.6	
Source of credit					
MOA	750	92.6	88	92.6	20.878**
Banks	8	1.0	2	2.1	
Local money lenders	3	0.3	-	-	
Service cooperatives	10	1.0	3	4.1	
AISCO	20	2.1	3	4.1	
Type of maize varieties purchased using credit					
BH660	585	65.0	1	11.0	24.733**
BH140	74	8.0	2	22.0	
CG4141	46	5.0	-	-	
PHB 3253	43	5.0	3	33.0	
A511	103	11.0	2	22.0	
BH540	13	1.0	-	-	

** Significant at P<0.1; ** Significant at P<0.05; *** Significant at P<0.01; NS = Not significant.*

MAIZE MANAGEMENT PRACTICES

Land Preparation and Planting

Farmers in the study area prepare land for maize production using both oxen and hoe. Farmers in short of draft power make one or a combination of different arrangements such as renting, borrowing, and *mekenajo* (two farmers owning one ox each join them together and use them turn by turn). The majority of farmers (67% of adopters of improved maize and 50% of non-adopters) use their own pair of oxen followed by *mekenajo* (15 % of adopters and 16% of non-adopters). The frequency of plowing ranges from one to four. The plowing months are usually from December to April (Table 11).

Table 11. Maize management practices

Characteristic	Adopters		Non-adopters		χ^2Statistic
	N	%	N	%	
First plowing					
December	207	18.6	86	25.8	20.656***
January	139	12.5	61	18.3	
February	301	27.0	67	20.1	
March	426	38.2	106	31.8	
April	42	3.8	13	3.9	
Second plowing					
January	255	23.0	110	34.1	30.740***
February	161	14.5	63	19.5	
March	530	47.7	126	39	
April	165	14.9	24	7.4	
Third plowing					
February	236	29.9	93	41.2	23.259**
March	255	32.4	86	38.1	
April	293	37.7	47	20.8	
Week of first plowing					
First	121	24.9	28	21.7	4.370 NS
Second	132	27.2	28	21.7	
Third	93	19.1	26	20.2	
Fourth	138	28.4	47	36.4	
Weeks of second plowing					
First	208	18.9	66	20.5	3.163 NS
Second	399	36.2	127	39.4	
Third	249	22.6	71	22.0	
Method of land preparation					
-Using own pair of oxen	722	66.9	161	50.2	47.061***
-Using hoe and oxen	113	10.4	54	16.8	
Mekenajo	165	15.2	52	16.2	
Borrow oxen	39	3.6	23	7.2	
Rent oxen	15	1.4	7	2.2	
Month of planting					
March	249	22.4	136	40.8	55.717***
April	393	35.4	118	35.4	
May	469	42.2	79	23.7	
Method of planting					
-Broadcasting	37	3.3	175	52.9	505.121
-Row planting	939	83.8	127	38.4	
-Both	144	12.9	29	8.8	

Table11: Continued

Characteristic	Adopters		Non-adopters		χ^2Statistic
	N	%	N	%	
Number of seeds planted per hole					
-One	470	44.3	98	69.5	31793***
-Two	586	55.3	43	30.5	
Use green manure in maize fields					
-Yes	31	2.8	19	6.0	7.298*
-No					
Use farm yard manure in maize fields					
-Yes	760	68.3	224	66.9	0.238 NS
-No	353	31.7	111	33.1	
Practice crop rotation					
-Yes	733	66.3	166	66.9	29.675***
-No	372	33.7	167	50.2	

**** = Significant at 1%; ** = Significant at 5%; * = Significant at 10%; and NS = Non-significant at less than 10%.*

About 84% of adopters reported to use row method while 53% of non-adopters reported to use broadcasting method of planting (χ^2=505.121; p<0.01). The adoption rate of row method of planting has increased dramatically from 0.3% in 1960 to 24.5 % in 1998. The average spacing used by adopters between plants was about 43.5 cm; while that practiced by non-adopters was 36.4 cm. A significant difference was found in this variable between adopters and non-adopters (t=2.125;p<0.05). The average spacing between rows practiced by adopters was about 70.3 cm; while that of non-adopters was 56.7 cm. The source of information for practicing row maize planting was mainly the extension agents as reported by 94% of adopters and 58.6% of non-adopters followed by neighboring farmers. Farmers indicated that row planting has a number of advantages like easiness to plant and apply chemical fertilizer, as well as convenience for weeding and cultivating (Table 12). The number of seeds planted per hole ranged from one to two. Both adopters (55 %) and non-adopters (30.5 %) used two seeds per hole.

Table 12. Methods of maize planting

Characteristics	Adopters		Non Adopters		χ^2 statistic
	N	%	N	%	
Method of planting					
Broadcasting	37	3.3	175	52.9	505.121***
Row planting	939	83.8	127	38.4	
Both	144	12.9	29	8.8	
Source of information about row planting					
Extension agents	1033	94.0	89	58.6	214.505***
Neighbors	48	4.4	45	29.6	
Relatives	4	0.4	9	1.0	
Reasons for row planting					16.417NS
Easy to plant	253	24.0	44	30.8	
Easy to apply fertilizer	388	36.8	57	39.9	
Easy to weed	269	25.5	19	13.3	
Easy to cultivate	82	7.8	15	10.5	

	Adopters			**Non adopters**			t-statistics
	N	Mean	SD	N	Mean	SD	
Spacing between plant	907	43.5	34.1	106	36.4	13.6	2.125**
Spacing between row	928	70.3	34.3	114	56.7	21.9	4.145***

*Significant at P<0.05; *** Significant at P<0.91; NS = Not significant.*

Management of Weeds, Pests, and Diseases

In the study area, there are a number of important weeds in maize fields. About 98 % of adopters and 97% of non-adopters reported to practice hand weeding. The frequency of hand weeding ranges from one to three. It was found that, 48 % of adopters and 51 % of non-adopters weed their maize field twice. This goes in comply with the research recommendation of frequency of hand weeding. First weeding is done from four to six weeks after planting with the majority of adopters (90.7 %) and non-adopters (94.9 %) weeding four weeks after planting. The time when second weeding is done also ranges from four to six weeks after first weeding with 74 % of adopters and 73 % of non-adopters weeding four weeks after the first weeding. In addition, 12.7% of adopters and 11.4 % of non-adopters. undertake the second weeding five weeks after first weeding (Table 13).

About 37% of adopters and 14% of non-adopters reported that they know the research recommendation on dates and frequency of weeding. The chi-square analysis showed that adopters appear to know better the date and frequency of recommendation than non-adopters (χ^2=59.221;P<0.01). The sources of information about weeding practices were extension agents for adopters while relatives and neighbors are the source of information for non-adopters. Almost all adopters and 29% of non-adopters reported that they practice cultivation for weed management. Farmers cultivate their maize field at different times. However, 46% adopters and 41% of non-adopters do their field cultivation before first weeding. In the study area, no farmer is currently using herbicides to control weeds found in maize fields.

It was learnt that both invertebrate and vertebrate pests affecting maize production in the study area. The invertebrate pests are insect pests such as stalk borer, cutworm and armyworm while the vertebrate one is a rodent. 41% of adopters and 36% of non-adopters reported that the damage caused by stalk borer on maize is severe (Table 14). 36% of adopters and 35% of non-adopters reported the severity of stalk bore is minor. The statistical analysis showed that severity of stalk borer appears to be systematically associated between adopters and non-adopters of improved maize (χ^2=5.401; p<0.10).

The damage by cutworm is reported as very sever and sever by 64% of adopters and 58% of non-adopters respectively. Significantly, more adopters reported the severity of cutworm than non-adopters (χ^2=7.664*; p<0.10). Both adopters and non-adopters ranked cutworm as the second important pest next to stalk borer.

Table 13. Weed control methods

Characteristic	Adopters		Non-adopters		χ^2Statistic
	N	%	N	%	
Practice weed control methods					
-Yes	1098	98.3	323	96.7	4.005 NS
-No	18	1.6	11	3.3	
Frequency of weeding					
-Once	100	9.0	25	7.5	18.891***
-Twice	525	47.5	203	50.6	
-Three	481	43.5	105	31.5	
Number of weeks after planting to start first weeding.					
-Four	1009	90.7	315	94.9	10.168***
-five	50	4.5	8	2.4	
-six	54	4.9	8	2.4	
Number of weeks required to start second weeding after first weeding					
- Four	766	74.2	223	72.9	1438 NS
- five	131	12.7	35	11.4	
- six	136	13.2	48	15.7	
Practice cultivation Tillage					
Yes	1094	98.8	290	29.0	74.266***
No	13	1.2	36	11.0	
Time of cultivation					
-Before first weeding	506	45.9	128	41.4	15.681***
-After first weeding	367	33.3	138	44.7	
-After second weeding	229	20.8	43	13.9	
Know the recommended dates and frequency of weeding					
-Yes	404	36.8	48	14.4	59.221***
-No	694	63.2	285	85.6	

**** = Significant at 1%; ** = Significant at 5%; * = Significant at 10%; and NS = Non-significant at less than 10%.*

Among the varieties used local maize varieties are the most susceptible to pests followed by A511. With regard to its control, only 35 % of adopters and 25% of non-adopters reported to practice pest control Table 15. Traditional and chemical methods in their order of importance are used to control pests of maize. The reasons for not using chemicals in large quantities are unavailability and high prices. In addition to the above-mentioned pests, there are also wild lives affecting maize production in the study area. These are porcupine, birds, foxes and pigs. The major control methods exercised by farmers to overcome problems of wild life are guarding, scaring, digging trapping holes, killing, constructing and erecting statues, and fumigating porcupine holes. Farmers had limited knowledge about plant diseases and were unable to give adequate information. They would rather mistake maize disease for insect pests.

Table 14. Severity and rank of pests affecting maize production

Characteristic	Adopters		Non-adopters		χ^2 statistics
	N	%	N	%	
Severity of damage of stalk borer					
-Very sever	194	22.1	79	28.7	5.401*
-Sever	364	41.4	100	36.4	
-Minor	321	36.5	96	34.9	
Rank of stalk borer					
First	189	30.4	34		
Second					
Third					
Severity of damage of cut worm					
-Very sever	170	26.6	32	17.0	7.664*
-Severe	240	37.6	78	41.5	
-Minor	228	35.7	78	41.5	
Rank of cut worm					
-First	189	30.4	34	18.9	15.113*
-Second	163	26.2	50	27.8	
-Third	96	15.5	35	19.4	
Severity of damage of rodents					
-Very sever	95	18.6	33	17.6	1.612 NS
Severe	211	41.4	78	41.7	
-Minor	200	39.2	76	40.6	
Rank of rodents					
-First	78	15.5	33	17.6	23.675**
-Second	127	25.2	58	31.0	
-Third	198	39.3	50	26.7	
Severity of damage of wild animals					
-Very sever	309	41.8	98	45.4	1.631 NS
-Sever	243	32.9	64	29.6	
-Minor	185	25.0	54	25	
Rank of wild animals					
-First	299	41.5	98	44.3	6.159 NS
-Second	222	30.8	70	31.7	
-Third	150	20.8	37	16.7	
Severity of damage of weevils					
-Very sever	192	67.1	56	60.9	1.393
Sever	81	28.3	30	32.6	
Minor	13	4.5	6	6.5	

**** = Significant at 1%; ** = Significant at 5%; * = Significant at 10%; and NS = Non-significant at less than 10%; NA = Not applicable.*

Table 15. Pest management practices of maize farmers

Characteristics	Adopters		Non-adopters		χ^2 statistics
	N	%	N	%	
Maize varieties susceptible to pest attack					
BH-140	21	2.7	1	0.5	229.800***
CG-4141	11	1.4	-	-	
PHB3253	21	2.7	1	0.5	
A511	80	10.2	1	0.5	
Local varieties	154	19.7	132	66.7	
Practice any pest control method					
Yes	367	34.9	80	24.9	11.120**
No	685	65.1	241	75.1	
Reasons for not using chemicals against pests					
Chemical are not available	423	71.9	107	59.8	
Chemical are expensive	74	12.6	28	15.6	
Chemical are unavailable and expensive	8	1.4	1	0.6	
Use crop rotation and fallowing	5	0.9	3	1.7	
Not aware	54	9.2	35	19.6	
Source of information regarding pest control					0.446 NS
Extension agents	103	76.3	6	85.7	
Relatives	1	7	-	-	
Not aware	27	20.0	1	14.3	

**** = Significant at 1%; ** = Significant at 5%; * = Significant at 10%; and NS = Non-significant at less than 10%; NA = Not applicable.*

Organic Fertility Management

The organic fertility management practices include the use of green manure, farmyard manure, crop residue, fallowing and crop rotation. The use of green manure is not common. Only 3% of adopters and 6 % of non-adopters of improved maize reported to practice green manure respectively. There was a significant difference in practicing green manure between adopters and non-adopters of improved maize (χ^2=11148; $p<0.01$). This was probably because adopters of improved maize use chemical fertilizers; while non-adopters who may not afford to buy chemical fertilizer resort to use cheap sources of nutrients that were locally available. About 68% of adopters and 67% of non-adopters of improved maize reported to use it for soil fertility management particularly at the backyard. In addition, to using it for purposes of soil fertility management, about 63% of adopters and 52% of non-adopters reported that they would use farmyard manure for other purposes such as firewood, construction of houses and storage (Table 11).

Post-harvest Management and Utilization

Maize is harvested mostly from September to January with both adopters and non-adopters (42% of each) harvesting in November followed by December, October, January and September. The majority of farmers usually harvest their maize during the first and second week of the respective months. Farmers practice different methods of maize grain storage (Table 16). These are putting in traditional storage (*gottera*) after shelling, putting in sacks/bags after shelling, putting in traditional storage with out shelling and putting in sacks with out shelling. Of these, the most important methods practiced by the majority of both adopters and non-adopters are putting in storage after shelling and putting in storage with out shelling.

About 59% of adopters and 31% of non-adopters reported to practice seed treatnent with chemicals. Significantly, more adopters knew about seed treatment with chemicals than non-adopters (χ^2=85.855***). This is probably because adopters of improved maize have access to information on chemicals. The major reasons for not treating maize varieties with chemicals are unavailability of chemicals as indicated by 33% of adopters and 19% of non adopters, no need for treating maize seeds, lack of cash, and lack of awareness.

Farmers use different criteria to select maize seeds. The criteria considered in the course of selection of maize seed were:

- size of cobs;
- maturity of grain;
- straightness of seed rows;
- seed color, seed size; and
- tolerance to pests like termite and birds.

The selection is done both at homestead and in the field. Only 25% of adopters and 15% of non-adopters do the selection in the field. 82% of adopters and 67% of non-adopters indicated that the selection of maize seed is done immediately after harvest.

Maize seed is stored in different ways such as:

- shelling and keeping in traditional storage (*gottera*);
- shelling and keeping in air tight containers;
- keeping in crips with out shelling;
- unshelling and keeping in traditional storage; and
- hanging over the stove .

About 42% of adopters and 60% of non-adopters store maize seed in crips with out shelling followed by shelling and putting in traditional storage as reported by 40% of adopters and 22% of non-adopters.

Significantly, more adopters (91%) reported that improved seeds are readily available than non-adopters (20%) (χ^2=95.52; $p<0.01$). About 79% of adopters and 9% of non-adopters of improved maize reported to buy maize seeds regularly (χ^2=123.654; $p<0.01$). This was because since adopters of improved maize were using mostly hybrid seeds, they have to buy regularly; while non-adopters who were using their own local varieties may not buy the seeds regularly. Almost all farmers reported that they buy improved seed every year. Farmers identified unaffordable price, unawareness about availability of seed, land and oxen shortage as the major reasons for not purchasing improved seed regularly.

About 88 % of farmers reported that improved varieties used so far have had no drawbacks. About 13 % of adopters and 7 % of non-adopters reported to use maize products for income generation in the form of food and beverage (χ^2= 3.253; $p<0.1$). This is probably because since improved maize are high yielding, adopters may have an extra amount of maize to sell while non-adopters who may not be able to get adequate maize output and may use it mainly for home consumption.

Table 16. Post harvest maize management and products utilization

Characteristics	Adopters		Non-adopters		χ^2 Statistics
	N	%	N	%	
Month of harvesting					
September	46	4.1	48	14.2	74.417***
October	154	13.8	70	20.7	
November	469	42	141	41.7	
December	345	30.9	67	19.8	
January	47	4.2	7	2.1	
Method of maize grain storage					
-Shell it and put in storage	539	51.4	112	37.3	62.450***
-Shell and store in bags	47	4.5	13	14.0	
-Unshell and put ion bags	110	10.5	42	14.0	
-Unshell and store in *gottera* (store)	268	25.6	69	33.7	
-Temporary store	59	5.6	43	14.3	
Treat maize seeds with chemical					
-Yes	665	59.5	104	30.8	85.855***
-No	453	40.5	234	69.2	
Reason for not treating maize width chemicals					
-No need	111	30.7	71	39.0	26.596**
-No money to buy chemicals	88	24.3	56	30.8	
-Chemicals are unavailable	120	33.1	34	18.7	
-Not a common practice	7	1.9	3	1.6	
Source of information on maize grain treatment					
Extension	583	86.0	64	66.0	34.378***
Friends	39	5.8	19	19.6	
Relatives	23	3.4	7	7.2	
Merchants	16	2.4	4	4.1	
Is improved seed readily available					
-Yes	652	78.8	34	20.7	216.902***
-No	175	21.2	130	79.3	
Time of seed selection					
Immediately after harvest	738	85.3	254	79.4	10.839**
When planting is approaching	105	12.1	60	18.8	
During harvesting	19	2.2	4	1.3	
Where do you make seed selection					
At home	455	51.6	208	63.2	13.600**
In market places	9	1.0	4	1.2	
In the field	418	47.4	117	35.6	
Who makes seed selection					
Husband	908	99.1	325	97.	3.911NS
Wife	4	0.4	3	0.9	
Children	2	0.2	3	0.9	
Purchase seeds regularly					
-Yes	765	76.3	19	8.3	373.748***
-No	238	23.7	211	91.7	
How often do you purchase improved maize					
-Every year	694	91.6	19	8.3	27.166***
-Every two years	36	4.7	3	15.8	
-Every three years	11	1.5	3	15.8	
Maize seeds selection criteria					
- Big cobs	831	95.2	294	91.3	14.857NS

**** = Significant at 1%; ** = Significant at 5%; * = Significant at 10%; and NS = Non-significant at less than 10%;*

RATE OF ADOPTION OF IMPROVED MAIZE AND CHEMICAL FERTILIZER

The logistic curve, which captures the historical trend of adoption over time, was constructed using data on the proportion of farmers adopting improved maize and chemical fertilizer over a given period. The basic assumption in constructing each logistic curve was that adoption increases slowly at first and then increases rapidly to approach a maximum level (CIMMYT, 1993). Mathematically, the logistic curve can be expressed by the following formula:

$$Y_t = K/(1 + e^{a+bt})$$

where:

Yt = the cumulative %age of adopters by time t;
K = the upper bound of adoption (%age);
b = a constant related to the rate of adoption; and
a = a constant term related to the time when adoption begins.

Rate of Adoption of Improved maize

The rate of adoption of improved maize increased from less than 1% in 1970 to 40% in 1998 (Fig 3). A significant increase in the adoption rate is observed over the last seven years after the national extension package program was started. In 1994/95 the SG-2000 and Participatory Agricultural Demonstration, Extension, and Training Systems (PADETS) of the government established on farm demonstration and production management sites, which included the provision of improved maize (seeds) and fertilizer on credit to promote the use of important crops including improved maize. Furthermore, new improved maize that was on the shelf of research centers were promoted rigorously to farmers using the initiatives of SG-2000. The preferred improved maize (in descending order of importance) was BH660 as indicated by 62% of adopters and 22.7% of non-adopters, BH140, CG 4141 and PHB 3253. About 98% of the farmers included in the study knew about availability of improved maize. The major actors in the dissemination of information on improved maize were extension agents (54%) and neighbors (20%). Other sources of information included relatives, researchers, traders, and producer and service cooperatives in decreasing order of importance.

The most important initial source of seed of improved maize was the Wereda Department of Agriculture. The reasons cited for adopting improved maize were many, but the most frequent reason was that improved maize yield better with fertilizer (89 %) (Table 17). Asked whether farmers would like to increase or decrease their farm size under improved maize 91.3 % of adopters reported that they would like to increase the size of farm of improved maize.

Table 17. Characteristics associated with acquisition and management of improved maize

Characteristics	Adopters		Non-adopters		χ^2 Statistics
	N	%	N	%	
Ever planted improved maize					
-Yes					
-No					
Improved maize grown first					
-BH-140	114	10.8	2	20.0	124.194***
-CG-4141	55	5.2	55	5.1	
-PHB-3253	50	4.7	50	4.7	
-BH660	551	52.0	3	30.0	
BH540	10	0.9	1	10.0	
A511	170	16.0	1	10.0	
UCB	4	.4	4	.4	
Guto	4	0.4	4	0.4	
Reasons for starting to grow improved maize					
-Gives more yield	871	88.9	7	77.8	9.744 NS
-Yield + Early maturity	15	1.5	15	1.5	
Improved maize most preferred					
-BH-140	88	9.3	3	13.6	42.221***
-CG-4141	49	5.5	3	13.6	
-PHB-3253	52	5.5	3	13.6	
BH660	588	62.0	5	22.7	
Beletech	15	1.6	1	4.5	
Reasons for preferring improved maize					
-Yields better with fertilizer	886	92.6	17	100	
-Early maturity	20	2.1	-	-	
-lodging resistant	18	1.9	-	-	
Future plans concerning farm size under improved maize					
-Increase	846	91.3	81	8.7	0.684 NS
-Decrease	78	89.7	9	10.3	
-No change	186	93.7	49	7.0	
Reasons for increasing or not changing farm area under improved seeds					
-It gives high yields	647	93.7	49	7.0	32.838**
-Land shortage	68	95.8	3	4.8	
Lack of oxen	14	93.3	1	67	
Future plans concerning farm size under local varieties					
-Increase	87	68.5	40	31.5	23.240***
-Decrease	682	82.9	141	17.1	
-No change	251	73.0	93	27.0	
Reasons for not changing land size under local variety					
-Low yields	555	87.8	77	12.2	131.938***
-Land scarcity	51	66.2	26	33.8	
To get higher yield	16	2.0	9	4.50	
Resistance to weevil	18	72.0	7	28.0	

**** = Significant at 1%; ** = Significant at 5%; NS = Not significant.*

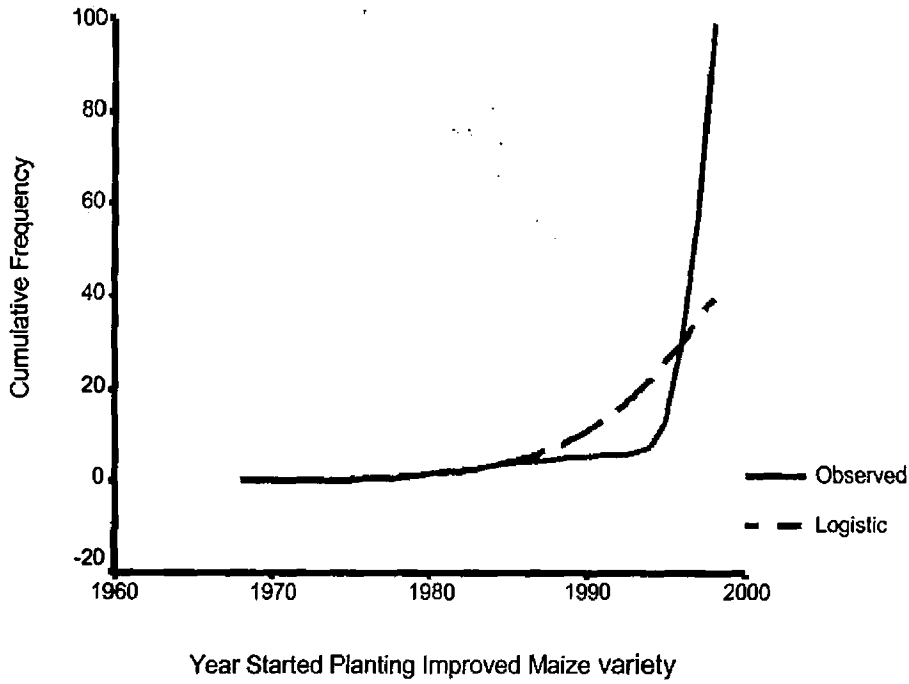


Fig 3. Adoption of improved maize in the study area

Rate of Adoption of Chemical Fertilizer

In 1998, more than 90 % of farmers used chemical fertilizer. The history of use of chemical fertilizer in the study area dated back to 1973. The rate of adoption of chemical fertilizer increased very slowly between 1970 and 1985 (Fig. 4). Higher increase in the adoption rate was observed over the last eight years. This seems due to the launching of the national extension package program, which promoted the use of inputs in particular, chemical fertilizer on a credit basis.

Over 93% of adopters of improved maize also used chemical fertilizer on their farms. The major crops to which chemical fertilizer was applied for the first time were tef, maize and barley. During the survey year (1998 cropping season), 69.8% of adopters of improved maize and 27% of non-adopters applied chemical fertilizer on maize. Diaminophosphate (DAP) was the principal fertilizer used by both adopters and non-adopters. The analysis of the relationship between adoption of improved maize and use of chemical fertilizer showed that the two factors are systematically related ($\chi 2 = 56.087$; $p<0.01$) (Table 18).

The major source of chemical fertilizer as reported by 40% of both adopters and non-adopters were the Bureau of Agriculture at all levels. Only a few respondents mentioned private traders as the source of chemical fertilizer. There is a significant difference between adopters (87%) and non- adopters (63%) of improved maize in receiving fertilize on time ($\chi 2$ - 20.242; $p<0.05$).

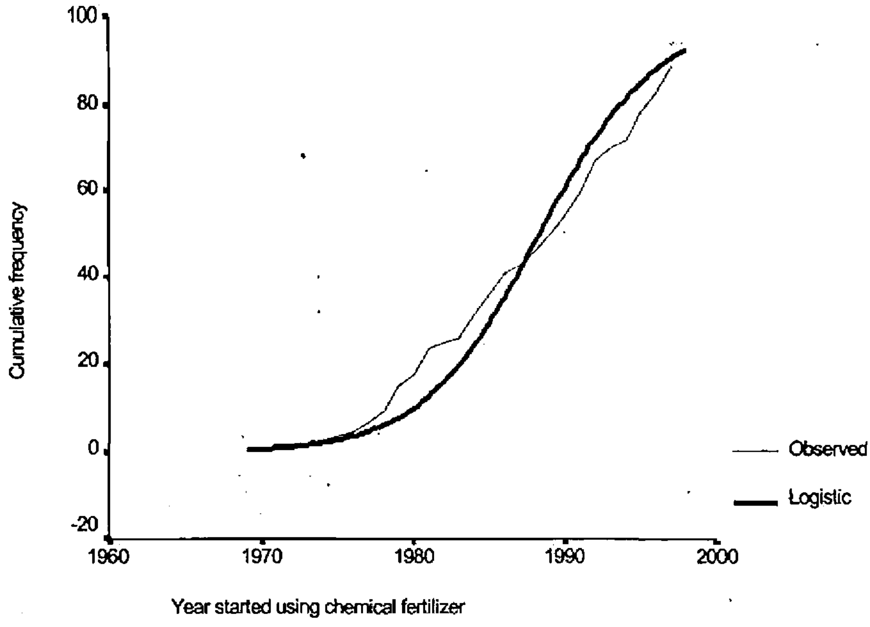


Fig 4. Adoption of chemical fertilizer in the study area

Table 18. Characteristics of chemical fertilizer application and use

Characteristic	Adopters		Non-adopters		χ^2Statistic
	N	%	N	%	
Does your soil require chemical fertilizer					
-Yes	1083	96.4	248	75.2	148.070***
-No	41	3.6	82	24.8	
Ever applied chemical fertilizer on maize					
-Yes	997	89.6	133	48.0	251.975***
-No	116	10.4	144	52	
Type of crop on which fertilizer was applied first					
-Tef	234	22.0	78	38.4	56.087***
-Maize	523	49.1	58	28.6	
Others (pepper, finger millet, barely, etc)	148	13.9	32	15.8	
Maize	13	1.2	3	1.5	
Tef and maize	87	8.2	15	7.4	
Application methods of fertilizer					
-Broadcast	42	4.0	43	32.8	156.687***
-Basal application	708	67.7	58	44.3	
-Row	248	23.7	27	20.6	
Get chemical fertilizer on time					
-Yes	837	75.4	141	60.5	22.018***
-No	272	19.5	151	39.5	
Applied chemical fertilizer in 1998					
-Yes	1071	96.0	157	56.5	230.905***
-No	45	4.0	121	43.5	
Types of fertilizer used					
-DAP	71	6.7	91	59.1	330.268***
UREA	4	0.4	3	1.9	
-DAP + urea	992	93	60	39.0	
Source of fertilizer					
Extension	932	92.2	82	89.0	195.965***
SG2000	3	0.3	-	-	
Traders	12	1.2	32	25	
Ambassel	54	5.3	11	8.6	
Service Cooperatives	5	0.5	1	0.8	

*** = *Significant at 1%*

DETERMINANTS OF ADOPTING IMPROVED MAIZE

In order to know to what extent the variables included in the model set decisive roles on farmers' adoption decision, a more rigorous analysis was carried out by fitting the logistic qualitative response function. A number of factors were postulated to influence the adoption decision of improved maize technologies. With highly significant ($p<0.001$) model chi-square statistic (χ^2) 797.102 value (with 14 degrees of freedom) and a 739.432 log likelihood ratio, the model achieved 90% correct prediction. Figures for correctly predicted adopters and non-adopters of improved varieties were 95% and 75%, respectively. Among the factors considered in the model, seven factors were found to have a significant and positive influence on the adoption decision of improved maize. These are use of chemical fertilizer, access to credit, attendance of formal training on maize production and other agricultural techniques, access to extension information, distance to the nearest market center, family size, and tropical livestock unit (Table 19).

Increase in the intensity of extension services which is significant at $p<0.01$ level and diversity of information increases the likelihood of adoption of improved maize technology package. The probability that farmers who have access to extension information would adopt improved maize increased by a factor of 3.67. This agrees with the finding of Chilot (1996) that extension contact has a positive and significant influence on the proportion of land allocated to improved maize in Tanzania, and adoption of improved wheat varieties in Addis Alem areas of Ethiopia, respectively.

The significant influence of these variables as a priori expected, therefore, support the hypothesis that the intensity of extension services is key to adoption decision. Increased agricultural extension activities are expected to speed up the time of adoption by lowering farmer's average cost of information (Fedder and Slade, 1984). Under the present Ethiopian Agricultural extension practices, the connotation of increased extension contacts in enabling the likelihood of maize technology adoption lies on the need of intensification of the existing extension services at grass root levels. Realizing this goals call for the availability of more extension agents. The agricultural extension departments of the Ministry and the different regional bureaus of agriculture therefore should think to build their manpower and keep the momentum achieved to reach the farming community at large.

Attendance of short-term agricultural training is positively related to the adoption of improved maize and is significant at $p<0.05$. Attendance of formal training course increased the probability of adoption of improved maize by a factor of 2.9. The significant coefficients of diversity of information sources indicate the possibility of using different complementary programs that help farmers be accustomed with the performance of new technologies.

To fully realize the benefit of improved maize, farmers need to purchase fertilizer in addition to seed and it is not likely that many will meet the cost involved from their meager resources. Credit, therefore, assists to removes or lessens the liquidity constraints of maize farmers and thereby enhances the rate of adoption of improved maize. The analysis further supported strongly the positive role of making available formal credit services in fostering adoption of improved maize. The positive and significant coefficient ($p<0.01$) proves how credit facilitates improved maize adoption decisions. The probability of adopting improved maize increased by a factor of about 24.6 among farmers who have access to credit showing that farmers who had received credit are more likely to adopt improved maize than those farmers who didn't use. Getahun, et al (1999) also confirmed that credit has a statistically significant impact on farmers' choice to adopt improved maize.

The positive and significant coefficient ($p<0.05$) of distance to market centers in the present study despises the usual argument that farmers who have more access to market centers are more likely to adopt improved technology. The more distant the farmers are located from market centers; the study reveals that, the higher the likelihood of adoption of improved maize.

As a priori expected the coefficients of the variables related with socio-economic factors reveal that the probability of adoption of improved maize in the country is an increasing function of the resource endowment base, especially the total livestock unit they own. The total livestock unit, which is used as proxy to wealth, has an influence on the adoption of improved maize. Such an outcome is consistent with the view that, farmers with better resource position will take the risk of trying new technologies and thereby maximize their advantage under conditions of high uncertainties and imperfect knowledge. This has been explained by the existence of fixed transaction costs associated with the new technology, which other things being equal can be better met by farmers of large resource position (Hassan1988). Furthermore, most farmers in Ethiopia practice mixed farming, i.e., they raise both livestock and grow crops. Besides providing them with traction power, the livestock they maintain serve as a source of additional income and food. Given this potential livestock contributes to sustainable household food supply and thereby encourage promising environment for adoption of new technology. With increasing number of livestock units maintained by the household, the study revealed that adoption of maize technology as a priori expected was higher.

Several empirical studies carried out elsewhere support the view that education, by expanding the person's capacity to think thoroughly and innovatively, enhances decision-making efficiency and thereby the industrious capabilities required to make innovative decisions. The out come of educating farmers indicates the importance of increased human capital values in triggering and fostering wider technology dissemination and adoption even in extremely poor agrarian economies like Ethiopia. In this study, the level of education of farmers did not have a significant impact on the adoption decision of improved maize. This is probably because information about improved maize was already available to most farmers through both the new extension package and regular extension program. This result agrees with the finding of Chilot, et al (1996), that the level of education of farmers has no impact on the adoption decision of improved wheat varieties in Addis Alem Areas of Ethiopia.

Table 19. Parameter estimates of a logistic model of factors affecting adoption of improved maize

Explanatory variables	Parameter estimate (β)	Partial effects of the variables on the likelihood of adoption Exp(β)
Use of hired labor	0.2049	1.2274
Use chemical fertilizer for maize	1.5478***	1.2390
Access to credit	3.2222***	24.5858
Attend field day or visit demonstration plot	0.1373	1.1472
Attend formal training on improved maize production	0.705**	2.023
Access to extension information	1.3128***	3.7167
Distance to development center (Minutes)	-0.0022	0.9978
Distance to market center (Minutes)	0.0066**	1.0067
Level of education	0.0175	1.0176
Farming experience (years)	-0.522**	0.9491
Family size	0.0980**	1.1030
Total farm size (ha)	0.0135	1.0135
Tropical livestock units	0.1003**	1.1055
Use of community labor	-0.0991	1.1900
Constant	-2.5155**	
Model χ^2	797.102***	
Log likelihood	739.432	
Overall cases correctly predicted	90%	
Correctly predicted adopters	95%	
Correctly predicted Non-adopters	75%	
Sample size	1414	

** = Significant at 10%; ** = Significant at 5%; and *** = Significant at 1%.*

Decision to adopt improved maize could also depend on the use of complementary inputs. As indicated in the table 12 the use of chemical fertilizer has significantly influenced the adoption of improved maize at 1% probability level. The probability that farmers who use chemical fertilizer adopt improved maize increased by a factor of 1.2, indicating that farmers using chemical fertilizer are more likely to adopt improved maize than those farmers who are not using chemical fertilizer. Farmers who applied chemical fertilizers on their maize fields were found to have significantly higher likelihood of adopting improved maize. This was because (a) for farmers who have realized the advantage of yield increasing complementary inputs, the adoption of related improved maize packages becomes simple and enhanced, and (b) in most cases once the exclusive ability of farmers is improved, it paves the way for further growth and development.

The regression coefficients and the model were used to calculate predicted probabilities of maize technology adoption for change in the significant explanatory variables. Probabilities were calculated keeping the continuous variables constant at their mean levels and the dummy variables at zero. The predicted probabilities show the likely effects of changes in the significant variables. The changes in the probability of adopting improved maize as a result of changes in the farmer getting access to credit, extension information, using chemical fertilizer, attending formal training, possessing livestock units above average, distance to market center and family size are significant and positive.

The probability of adopting improved maize among farmers with the average values of tropical livestock units and family size and other continues variables included in the model are about 9%. With access to credit, the probability that a farmer would adopt improved maize increased to 69%. Similarly, with access to extension information, attending formal training on maize production, use of complimentary inputs such as chemical fertilizer increases the probability of adopting improved maize by 26%, 16%, 30% respectively (Table 20).

Table 20. Impact of significant factors on the predicted probabilities of improved maize

Factors	Change in probabilities (%)
Use chemical fertilizer for maize	
No	9
Yes	30
Access to credit	
No	9
Yes	69
Attend formal training on improved maize production	
No	9
Yes	16
Access to extension information	
No	9
Yes	25
Family size	
Average (7.0)	9
Nine	10
Eleven	12
Tropical livestock units	
Average (4.6)	9
Six	10
Eight	12
Twelve	17

Determinants of Adopting Chemical fertilizer

Several factors were postulated to influence the adoption decision of improved maize and chemical fertilizer. With highly significant ($p<0.001$) model chi-square statistic (χ^2) 437.934 value (with 16 degrees of freedom) and a 1081.755 log likelihood ratio, the model achieved 84 % correct prediction. Figures for correctly predicted adopters and non-adopters of improved varieties were 93% and 54%, respectively. Among the factors considered in the model, six were found to have a significant and positive effect on the adoption decision of chemical fertilizer. These are access to credit, level of education, farm experience, total farm size, use of improved maize, use of community labor (Table 21).

Farm size and tropical livestock unit are indicative of wealth and income, which in turn are highly related to the possibility of acquiring more and better agricultural inputs (Brush, Taylor and Bellon, 1990), Belknap and Saupe 1998). In this study it is expected that the larger the farm the greater the probability of adopting chemical fertilizer. Farm size was found to have a significant and positive influence on the adoption decision of chemical fertilizer. This result is consistent with those found by Getahun et al (1999).

It is stipulated that chemical fertilizer or other technologies that increases the seasonal demand for labor may be less attractive to households with limited family labor (Hassan, 1998). Accordingly it is found that family size have negative and insignificant effect on the adoption of chemical fertilizer. However, Mulugeta (1994), in his study of the adoption of chemical fertilizer use in wheat in the South Eastern highlands of Ethiopia, has shown that family size could have both positive and significant effect (5% level).

The theoretical justification for considering agricultural extension in adoption studies is due to its effect on the acquisition of information. Increased agricultural extension activities are expected to speed up the time of adoption by lowering farmer's average cost of information (Fader and Slade, 1984). Contrary to the usual perception of the extension services, in this study, extension service has a positive but insignificant impact on the adoption decision of chemical fertilizer. The result might have been associated to the relative widespread of adoption of fertilizer by farm household in the study area, which could be associated to previous work. It may also be, probably because information about chemical fertilizer was already available to most farmers through both the new extension package and regular extension program. However, Kaliba, et al (1998) has indicated that an increase in the intensity of extension service increased the probability of fertilizer use in central Tanzania.

Credit availability and use can relax the financial constraints of farmers and therefore, enhance the purchase of inputs. The result of the study revealed that credit availability has significant ($p<0.01$) and positive impact on chemical fertilizer adoption. The probability of adopting chemical fertilizer increased by a factor of 4.5.

Table 21. Parameter estimates of a logistic model for factors affecting adoption of chemical fertilizer among sample farmers in Ethiopia

Explanatory variables	Parameter estimate (β)	Partial effects of the variables on the likelihood of adoption Exp (β)
Use of hired labor	0.3689	1.4462
Tropical livestock unit	0.0481	0.9530
Access to credit	1.4878***	4.4878
Attend field day or visit demonstration plot	-0.3785*	0.6849
Attend formal training on improved maize production	02234	1.2503
Access to extension information	0.1129	0.8932
Distance to development center (Minutes)	0.0000	1.0000
Distance to market center (Minutes)	-0.0040*	0.9960
Level of education	0.0933**	1.0978
Farming experience (years)	0.0618**	1.0638
Family size	-0.430	0.9579
Total farm size (ha)	0.1963**	1.2169
Use improved maize	1.5189***	4.5671
Use community labor	0.4830**	1.6210
Constant	-8778***	
Model χ^2	437.934***	
Overall cases correctly predicted	84%	
Correctly predicted adopters	93%	
Correctly predicted Non-adopters	54%	
-2 log likelihood ratio	1081.755	
Sample size	1414	

= Significant at 10%; ** = Significant at 5%, and *** = Significant at 1%*

Education level of farmers usually relates to greater rates of adoption of new technologies. The variable that has been used in this study to reflect educational level was the year of schooling of sample farmers. Participation in formal training is positively related to the adoption of chemical fertilizer The study revealed that educational level which is positive and significant at p<05 have increased the probability of adoption of chemical fertilizer by a factor of 1.1. Mulugeta (1994) also confirmed that education has a positive effect on the probability of adoption of chemical fertilizer.

Use of improved variety also influenced the decision of farmers to use chemical fertilizer positively and significantly at (1%) level.

Distance to market center, which represents the distance in minutes from the farm to the nearest market center where the farmer acquires, inputs and sell farm product significantly (10% level) and negatively influence the adoption of chemical fertilizer. This inverse relation to market centers and chemical fertilizer adoption indicates that farmers located further from market centers will have a smaller probability of adopting chemical fertilizer.

The regressions and the model were used to calculate predicted probabilities of chemical fertilizer adoption for change in the significant explanatory variables. Probabilities were calculated keeping the continuous variables constant at their mean values and the dummy variables at zero. The predicted probabilities show the likely effects of changes in the significant variables. The changes in the probability of adopting chemical fertilizer as a result of changes in the farmer getting access to credit, having level of education and farming experience above average, community labor, and using improved maize was significant

The probability that a farmer with average level of schooling and farming experience and other continues variables included in the model would adopt chemical fertilizer is 27%. However, if a farmer happens to get access to credit for purchasing chemical fertilizer, use of complementary inputs such as improved maize, use of community labor, the probability of adopting a chemical fertilizer would increase to 41, 41and 20% respectively. When the average level of education increases to 10 years the probability of adoption of chemical fertilizer increases by 24% (Table 22).

Table 22 Impact of significant factors on the predicted probabilities of chemical fertilizer

Factors	Change in probabilities (%)
Access to credit	
No	13
Yes	41
Use improved maize	
No	13
Yes	41
Use of community labor	
No	13
Yes	20
Level of education	
Average (2.24)	13
Four	15
Six	18
Ten	24
Twelve	
Farm size	
Average (1.9 hectares)	13
Four	
Six	26
Eight	34
Farming experience	
Average (27 Years)	13
Thirty Years	15
Forty Years	26
Forty Five Years	32

CONCLUSION AND IMPLICATIONS

The study shade light on some technical and socioeconomic factors that should be considered in maintaining the momentum generated and further enhancing the adoption of improved maize in major maize belts of Ethiopia. Policy and research implications were thus indicated as follows.

It was found that adopters of improved maize are more resource endowed. That is, they operate on average larger farm sizes, have more arable land and maintain more herd sizes as compared to the non-adopters. Many of them also feel that their draught animal power is adequate for their farm operation. As a result, with increases in economic access the likelihood of adoption of improved maize was found significantly higher. Designing policies and institutional arrangements that would improve farmers' resource positions especially livestock and land could help promote wider adoption of improved maize that will result in larger productivity gains. The problems of addressing relatively resource poor small-scale farmers should thus be a point of concern. Concerned institutions of the government should pay special attention to establish a system that resolve the problems facing these farmers so as to bring them into the front lines so that they also benefit from the gains of using improved maize and other technologies. This could be for example the formation of farmers' groups' or cooperatives.

It was observed that factors related to institutional services play key roles in enhancing improved maize technology adoption. Sustaining the momentum gained in the adoption of improved maize seeds and horizontal expansions of the same to other crops therefore depends on further intensification of extension services and establishing diversified information sources with clear, concise and varied information contents. Under the current agricultural extension practices in Ethiopia, this implies the need for further strengthening the existing extension services and increasing the number of development agents at grass root levels.

The study also revealed that physical inaccessibility to development centers and primary product markets poses significant and negative influence on the likelihood of improved maize technology package, particularly fertilizer adoption. This indicates either emphasis has been given to farmers located close to development centers (where offices of the extension agents or their residences are located) or farmers located at distant places have been given less opportunity to avail the new technology. However, the need for increased productivity gains and production level requires bringing more number of farmers under the program. The implication is that rethinking of the strategy through which many of the relatively remote rural villages could be given equitable access to the extension services needs to be the concern of policy makers within the state department of agriculture. This also would help minimize the common second-generation problems resulting from differentials in economic positions and physical accessibility in the end. To increase the interaction between farmers and development agents and to promote technology transfer more development agents must be recruited. The program should provide more transport facilities to development agents to increase their capacity to travel within their mandate area. In addition, frequent training must be organized for development agents and supervisors about existing and newly developed improved technologies and new methods of agricultural practices. This could help develop the confidence of the agents to transmit appropriate and useful information to farmers

Farmers who applied chemical fertilizers on their crop fields were found to have significantly higher likelihood of adopting improved maize. Exposure and practices of farmers in using complementary inputs like fertilizers make detrimental contribution to keeping their innovative abilities and thus their attitudes to changes. An efficient input marketing system will thus play an important role in upgrading the adoption of maize technology in the area. To establish such an efficient input market system the policy support of the government is very crucial. We infer that with increase in the number of farmers who use high yielding variety maize seeds over time, the demand for improved maize seed will rise. However, at present improved seeds are provided mainly by the parastatal ESE and very few other private seed companies. Encouraging the private sector for further participation in seed production and supply should therefore be a point in view. This will also provide a supplemental contribution to EARO, which is required to speed up the development and release of both hybrid and open pollinated maize varieties. Taking into account the prevalence of significant variations across regions, inevitably, the state policy makers should realize that enhanced productivity gains and increased production levels through adoption of improved technologies at large depends on their ability to provide these key factors in a more integrated manner.

The analysis made with regard to credit indicated that farmers who have access to credit tend to adopt improved maize and chemical fertilizer than those farmers who don't have access to credit. Constraints on rural credit appear to be a key factor limiting use of purchased inputs and investment. The most important credit problems in the study area were identified as unavailability of loan from formal and informal sources, high interest rates, high down payment and unfavorable loan repayment terms. Credit is essential to enable small farmers to purchase production inputs like improved maize, fertilizer, pesticides, etc. In the country as a whole the cost of fertilizer and other inputs are getting higher beyond the purchasing ability of farmers. This necessitates the strengthening of the rural credit system that is being implemented by the government in order to alleviate the cash constraints of farmers and thereby facilitate adoption.

It had been observed in this study that maize production in the country is being dominated by few hybrid maize varieties developed by the maize research program of EARO and the Pioneer Seed Company. The distribution of composite maize varieties is very limited and farmers have no alternatives varieties from which to choose. If farmers grow only the best varieties of maize particularly with respect to yield potential and if these varieties represent a narrowing of genetic diversity; farmers in the region and the nation at large could become increasingly vulnerable to the vagaries of diseases and pest outbreaks. Therefore, the national maize research program should foster its research activities by establishing a research system that conserves and promotes maize genetic diversity and by giving equal importance to the development of both hybrids and composites.

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