Farmers' Maize Seed Systems In **Western Oromia, Ethiopia**

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Abstract: This study was initiated in western Shewa and eastern Wellega zones of Oromia Regional State to describe the seed system and assess the effectiveness of the seed testing and release mechanism; identify how farmers acquire and transfer maize seed; explore problems related to farmers' seed acquisition and transfer mechanisms; and document the use of released maize varieties and hybrids. The major maize growing areas of western Oromia were purposively classified into four strata: Bako-Tibe and Chaliya Woredas in western Shewa, and Bila-Sayo and Sibu-Sire Woredas in eastern Wellega. Five peasant associations (PAs) were selected from each stratum. From each PA, 11 farmers were randomly selected and interviewed using a structured questionnaire. The total sample size was 220 farmers. Descriptive statistics and tobit analysis were used to assess farmers' adoption of improved maize seed and their seed management practices and strategies. Total area under improved maize increased in the study area from 1992 to 1996 and total area under local varieties decreased. Since 1995, total production of improved maize has surpassed the total production of local varieties. During the 1996 cropping season, most farmers planted seed that had been saved from their previous harvest. The Ministry of Agriculture was the next most common seed source. In all woredas, BH-660 was the preferred maize cultivar for its high yield, seed size, and early maturity. The main problems constraining the use of improved maize seed were its high price, unavailability, and sometimes the distance traveled to acquire improved seed. All farmers in Bako-Tibe and Sibu-Sire and about 83% of farmers in Bako-Tibe and Bila-Sayo replaced their hybrids every year. The average time since farmers had purchased hybrid seed was 1.4 years in Chaliya, 2.3 in Bako-Tibe, 2.1 in Bila-Sayo, and 2 in Sibu-Sire. Most farmers selected seed during harvesting using good looking grain/cobs as the most important selection criterion. Seed quality was good, according to most farmers, and was mostly judged on the basis of grain filling and germination rate. Farmer education, extension services, off-farm income, and livestock units all significantly and positively influenced the area of land allocated to improved maize. A farmer's proximity to a formal seed source had a positive impact on the allocation of land to improved maize. Next to the extension system, farmer-to-farmer seed exchange remained the most important mechanism for disseminating improved maize technology. The government can strengthen this informal system through the provision of low-interest finance, technical assistance, and publicly bred parent material. The extension system should advise farmers on the characteristics and correct adaptation zones of newly released maize cultivars. Maize breeding programs need to give proportionate weights to yield and non-yield characteristics when selecting the best varieties.

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Acronyms and Abbreviations

AAU	Addis Ababa University
ACA	Awasa College of Agriculture
AISCO	Agricultural Inputs Supply Corporation
AUA	Alemaya University of Agriculture
BRC	Bako Research Center
BSI	Breeder seed increase
CCT	Christian Council of Tanzania
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CRI	Crops Research Institute
CTDA	Coffee and Tea Development Authority
DAP	Diammonium phosphate
DZARC	Debre Zeit Agricultural Research Center
EARO	Ethiopian Agricultural Research Organization
EMTP	Extension Management Training Plots
ESE	Ethiopian Seed Enterprise
GLDB	Grains and Legumes Development Board
GRCRI	Genetic Resource Conservation and Research Institute
GSID	Ghana Seed Inspection Division
IAR	Institute of Agricultural Research
ICU	Input Coordination Unit
IFAD	International Fund for Agricultural Development
masl	Meters above sea level
MOA	Ministry of Agriculture
NGO	Non-governmental organization
NSIA	National Seed Industry Agency
NVRC	National Variety Release Committee
NVT	National Variety Trial
OPV	Open-pollinated variety
PA	Peasant association
PNVT	Pre-national Variety Trial
PYT	Preliminary Yield Trial
RVT	Regional Varietal Trial
SC	Service Cooperative
TOSCA	Tanzania Official Seed Certification Agency
VVT	Variety Verification Trial

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Executive Summary

Despite the importance of improved seed for bettering the livelihoods of small-scale farmers, access to this invaluable technology in Ethiopia is still constrained by many factors including the underdeveloped seed industry. Independent studies have estimated a large annual demand for seed that is never met or, in the case of hybrid maize and sunflower, is met only through imports. Consequently, the government has increased its efforts to develop plant breeding research networks and a complementary seed production, multiplication, processing, storage, marketing, and distribution system. The private sector, including non-governmental organizations (NGOs), has been encouraged to participate in the development of the national seed industry.

This study was initiated in western Shewa and eastern Wellega zones of Oromia Regional State to: 1) describe the seed system in Ethiopia and assess the effectiveness of the seed testing and release mechanism; 2) identify how farmers acquire and transfer maize seed; 3) explore problems related to farmers' seed acquisition and transfer mechanisms; and 4) document the use of released maize cultivars.

Methods

The study used a multistage stratified sampling design. Based on informal assessment and secondary data, the major maize growing areas of western Oromia were purposively classified into four strata: Bako-Tibe and Chaliya Woredas in western Shewa, and Bila-Sayo and Sibu-Sire Woredas in eastern Wellega. Five peasant associations (PAs) were selected from each stratum. From each PA, 11 farmers were randomly selected and interviewed using a structured questionnaire. The total sample size was 220 farmers. Descriptive statistics and tobit analysis were used to establish relationships and draw inferences and conclusions about farmers' adoption of improved maize seed and their seed management practices and strategies.

The Seed Industry

The Ethiopian seed industry is composed of formal and informal sectors as well as public and private organizations. The formal sector includes federal and regional agricultural research establishments, universities, the National Seed Industry Agency (NSIA), the Ethiopian Seed Enterprise (ESE), and a few private companies. The informal sector encompasses millions of farmers who continue to practice seed selection and preservation, just as their ancestors did. Today, the bulk of the national seed demand is met through this informal system of local seed maintenance and exchange.

The maize seed industry comprises two sequential processes: 1) varietal development, testing, and release; and 2) seed multiplication, processing, certification, marketing, and distribution. At a minimum, seven years are required to release a variety. Release may be unnecessarily delayed because of stringent varietal release requirements.

Farmer Characteristics and Maize Production in the Study Area

The study area is located in western Oromia. In the mid-altitude zone, maize is the dominant crop for smallholders. The average age of farmers was between 40 and 48 years, while the average holding was between 12 to 15 timmad (1 timmad = 0.25 ha). There were more literate farmers in Bako-Tibe (65%) compared to Chaliya (55%), Bila-Sayo (50%), and Sibu-Sire (58%). In all woredas, farmers had access to off-farm income; however, there were differences in the amount generated. Cows and oxen were the dominant livestock.

The total area under improved maize increased in the four woredas between 1992 and 1996, while the total area under local varieties decreased. Also, since 1995, the total production of improved maize has surpassed the total production of local varieties.

Seed Issues

Farmers in western Oromia grew 16 maize cultivars. The popular varieties in 1992 were Shashemene, Burrie, and Kenya. In 1996, the popularity of these improved OPVs decreased due to the introduction of improved maize hybrids particularly BH-660.

During the 1996 cropping season, most farmers planted seed that had been saved from their previous harvest. The Ministry of Agriculture (MOA) was the next most common seed source. The price of hybrid maize seed from the MOA was about 600 Birr/100 kg compared to 50-80 Birr/100 kg for local maize seed purchased in the local market (Birr 7 = US$ 1). In all woredas, BH-660 was preferred for its high yield, seed size, and early maturity. Extension and other farmers were important sources of improved maize information. Farmers mostly used their own financial resources to purchase improved maize seed. The main problems indicated by farmers as constraining the use of improved maize seed were its high price and unavailability. In some cases, the distance traveled to acquire improved seed was another constraint.

The NSIA estimated that the quantity of improved maize seed used in 1996 was 35,120 t, while ESE distributed about 1,670 t of improved maize seed. This implies that about 5% of the improved seed was purchased, while the remaining 95% was recycled improved seed.

All farmers in Bako-Tibe and Sibu-Sire and about 83% of farmers in Bako-Tibe and Bila-Sayo replaced their hybrids every year. The average time (years) since farmers had purchased hybrid seed was 1.4 in Chaliya, 2.3 in Bako-Tibe, 2.1 in Bila-Sayo, and 2 in Sibu-Sire. From farmers' responses it was estimated that, on average, a hybrid needs to be replaced after about 1.7 years in Chaliya, 1.2 years in Bako-Tibe, and 1 year in both Bila-Sayo and Sibu-Sire.

Most farmers selected seed during harvesting using good looking grain/cobs as the most important selection criterion. Seed quality was good, according to most farmers, and was mostly judged on the basis of grain filling and germination rate.

Factors Influencing the Allocation of Land to Improved Maize

Farmer education, extension services, off-farm income, and livestock units all significantly and positively influenced the area of land allocated to improved maize. A farmer's proximity to a formal seed source had a positive impact on the allocation of land to improved maize.

Recommendations

- Next to the extension system, farmer-to-farmer seed exchange remains the most important mechanism for disseminating improved maize technology. The government can strengthen this informal system through the provision of low-interest finance, technical assistance, and publicly bred parent material.
- The extension system should advise farmers on the characteristics and correct adaptation zones of newly released maize cultivars. Maize breeding programs need to give proportionate weights to yield and non-yield characteristics when selecting the best varieties.

Farmers' Maize Seed Systems in Western Oromia, Ethiopia

Abdissa Gemeda, Girma Aboma, Hugo Verkuijl, and Wilfred Mwangi

1.0 Introduction

1.1 The Potential of Improved Seed and the Importance of the Seed Industry

The effectiveness of research results emanating from experiment stations is conditioned by the strength and efficiency of support services such as extension, credit, and input supply, including the supply of improved seed. The role of improved seed, particularly of wheat and rice, in alleviating poverty has been widely debated (Dasgupta 1977; Singh 1990; DZARC 1995). Ellis (1993) outlined the social and economic impact of improved varieties in countries where they have been widely grown, and it is commonly observed that the dissemination of improved seed and complementary inputs has removed the shadow of famine from the lives of millions of poor farm families. Because improved seed embodies a plant's genetic potential, it determines the upper limits on yield and even the productivity of other inputs (Jaffee and Srivastava 1994).

Despite the importance of improved seed for bettering the welfare of small-scale farmers, access to this invaluable technology can be constrained by many factors, including an underdeveloped seed industry. A seed industry essentially consists of all enterprises that produce or distribute seed (Pray and Ramaswami 1991). At a minimum, the industry has four components: 1) plant breeding research, 2) seed production and multiplication, 3) processing and storage, and 4) marketing and distribution. The industry's overall performance depends on the efficiency of each component, and each component possesses different economic and technical characteristics that determine the roles that public and private organizations play within the industry. These characteristics include economies of scale, externalities, excludability, and problems of information or quality.

The development of new varieties and hybrids can be profitable for specialized research and development firms. However, owing to 1) the high fixed costs of entering the industry, 2) the externalities associated with plant breeding, and 3) the difficulty of excluding non-paying farmers or firms from benefiting from new seed varieties, the amount and direction of private sector investment in these activities may be insufficient or inappropriate. The significance of these difficulties will vary, depending on whether the seed is of hybrid or self-pollinating plants. Because the desirable properties of hybrids are attenuated if hybrid seed is grown over successive generations, farmers must buy new seed to achieve undiminished yields. The originator of a new hybrid can therefore easily exclude competing seed firms and farmers from the benefits of the new hybrid if they have not paid for access. In contrast, breeders of new self-pollinated varieties may capture few of the benefits because others (including farmers) can easily duplicate the variety without paying for it.

The dissemination of improved seed to small-scale farmers can also be constrained by the varietal release committee. Some regulatory frameworks are neither sufficiently responsive to the needs of small-scale farmers nor adequately adapted to changing institutional environments (ODI 1995). Furthermore, significant biases in the way that varieties are developed and released mean that small-scale farmers are less likely to benefit from the product. Similarly, seed multiplication and distribution regulations often hinder farmers' access to seed and varieties that would be useful to them. A report by the Overseas Development Institute (ODI) (1995) stated that no solution will be perfect, but regulatory frameworks that take account of farmers' conditions and preferences, and that allow their participation, are likely to be steps in the right direction.

The skills required to multiply seed of a new variety or hybrid and the technical and commercial risks associated with this activity are considerably lower than those associated with research to develop a new variety or hybrid. For this reason, there are fewer economic and technical barriers to private sector involvement in seed multiplication than research. Even so, excludability may be a serious problem in some instances because harvested grain of self- and open-pollinated crops resembles commercial seed. The private sector can profitably perform most seed distribution functions; public sector distribution of seed can be justified only in the early stages of seed industry development, when private channels are weak.

Another important mechanism responsible for the majority of seed diffusion in various farming systems is informal farmer-to-farmer seed exchange. This operates mainly at individual community levels, although lines of supply may extend over a relatively wide geographical area. These channels are more accessible and affordable sources of seed for farmers. An accurate understanding of the role of improved seed in small-scale farming systems and of the mechanisms by which seed reaches small farmers is therefore critical to fostering agricultural development (ODI 1990a).

1.2 The Local Seed Industry

Maize was introduced in Ethiopia in the 16th or 17th century. Despite the existence of some local cultivars, the genetic diversity of those cultivars was insufficient for establishing suitable source populations. Since its establishment in the 1950s, the national maize research program has been introducing germplasm from exotic sources. Beginning in 1967, Ethiopia has systematically participated in the East Africa Cooperative Maize Trial, which has resulted in the evaluation of several promising varieties. The hybrids from Kenya and Zimbabwe had a 30% yield advantage over tested varieties, however, so the state farms were encouraged to import Kenyan hybrids. In the beginning of the 1980s, a vigorous national maize breeding program was started and located at Bako

Research Center (BRC)**.** Since 1988, this program has developed a number of outstanding hybrids: BH-140, BH-660, and BH-540 (Benti Tolessa et al. 1996).

Improved seed goes through elaborate procedures such as on-farm verification, on-farm demonstration, and pilot production stages before being approved for release by the National Variety Release Committee (NVRC). The role of releasing improved varieties is now performed by the National Seed Industry Agency (NSIA), which acts as the overall watchdog for the seed industry. A dynamic informal seed sector exists alongside the formal sector, where farmers exchange seed. The role of both sectors in the supply of seed to farmers will be outlined in this paper.

The Ethiopian Seed Enterprise (ESE) dominates the production/multiplication, processing, and distribution of seed of new major crop varieties in Ethiopia in general, and in particular in western Oromia. The ESE manager at the Nekemte Branch reported that before 1990, ESE imported parental lines from Kenya (H625) and Zimbabwe (CG4141) and produced seed by making contractual agreements either with private investors, the Institute of Agricultural Research (IAR, now renamed Ethiopian Agricultural Research Organization, EARO), or state farms. The Agricultural Inputs Supply Corporation (AISCO) distributed seed, as well as other major inputs such as fertilizer.

After the economic reform in 1991, policies changed and the importation of parental lines was discontinued. Since 1991, ESE has obtained breeder and/or basic seed from the IAR (EARO), regional research centers, Alemaya University of Agriculture (AUA), and Awasa College of Agriculture (ACA). It also makes contractual agreements with private investors, EARO, seed farms, and state farms for the production/multiplication of improved maize seed.

1.3 Objectives of the Study

The formal seed sector alone is not sufficient to meet farmers' seed needs, and hence cannot produce a sustainable increase in production and productivity to realize national objectives of food self-sufficiency and food security. Thus it is expected that the informal seed sector has an important role to play. Specifically, this study was designed to:

- Describe the seed system in Ethiopia and assess the effectiveness of the seed testing and release mechanism.
- Identify how farmers acquire and transfer seed of maize cultivars.
- Explore problems related to farmers' seed acquisition and transfer mechanisms.
- Document the use of released maize cultivars.

1.4 The Study Area

Eastern Wellega and western Shewa zones are among 12 zones in Oromia (Figures 1 and 2). These zones have different agro-ecologies, but the study focused on the mid-altitude zone, where maize is the dominant crop for smallholders. Here, the elevation ranges from 1,500 meters above sea level (masl) to over 2,000 masl. Soils are mainly reddish brown clay dominated by nitosols. The survey area is located at 9°6′ N and 37°09′ E, with an average annual rainfall of 1,320 mm at Bako. The temperature ranges from 14.1°C to 28.3°C and the average relative humidity is 67.2%.

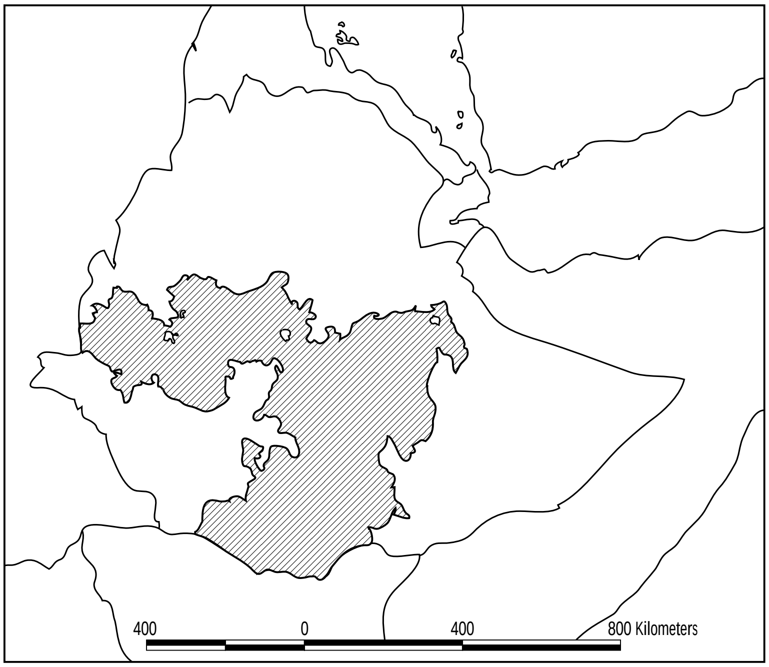

Figure 1. Oromia, Ethiopia.

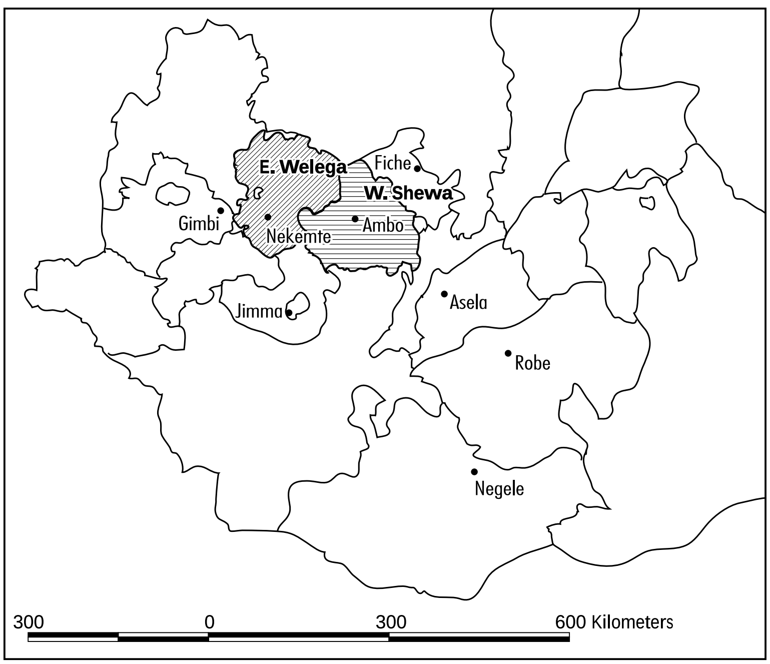

Figure 2. The study area, western Oromia, Ethiopia.

The total population in the two zones is about two million people. The major crops grown include maize, sorghum, pepper, noug, finger millet, teff, wheat, barley, field peas, faba beans, sweet potatoes, *anchote*, and *gomencher*. The main types of livestock kept include cattle, sheep, goats, equines, and chickens. The farming system is mixed crop-livestock.

The principal production constraints that have been identified in other studies are: 1) shortage of draft power; 2) labor shortage during the peak season; 3) low soil fertility; 4) low income; 5) shortage of feed during the dry season; 6) crop pests and diseases; 7) animal diseases and parasites; and 8) low genetic potential of local crop varieties and cattle breeds.

2.0 Methodology

2.1 Sampling Method

A multi-stage purposive sampling procedure was used to select farmers in eastern Wellega and western Shewa. The major maize growing areas were selected based on an informal survey and secondary data sources. In eastern Wellega, Bila-Sayo and Sibu-Sire Woredas were selected and Bako-Tibe and Chaliya Woredas were selected in western Shewa (Figure 3. Proximity to BRC was a second stratifying parameter: Bila-Sayo and Bako-Tibe Woredas are much closer to the BRC than Chaliya and Sibu-Sire. It was hypothesized that farmers nearer to BRC benefited more from improved maize cultivars. Five peasant associations (PAs) were randomly selected from each woreda, from which 11 smallholder farmers per PA were randomly selected and interviewed using a structured questionnaire. The total sample size was 220 farmers.

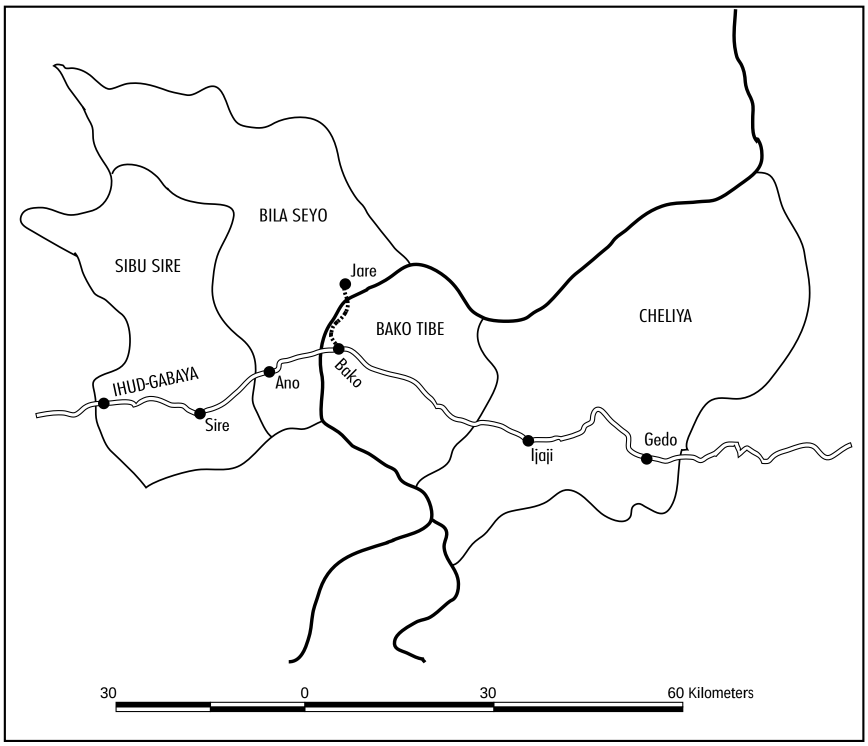

Figure 3. Woredas in Western Oromia, Ethiopia.

2.2 Analytical Model

Factors influencing the adoption of new agricultural technologies can be divided into three major categories: 1) farm and farmers' associated attributes; 2) attributes associated with the technology (Adesina and Zinnah 1992; Misra et al. 1993); and 3) the farming objective (CIMMYT 1988). Factors in the first category include the farmer's education level, age, and family and farm size. The second category varies with the type of technology, e.g., the characteristics a farmer prefers in improved maize. The third category assesses how different strategies used by the farmer, such as commercial versus subsistence farming, influence the adoption of technologies.

In this study, a tobit model was used to test the factors affecting the allocation of land to improved maize. The model, which tested the factors affecting the incidence and intensity of adoption (McDonald and Moffitt 1980; Maddala 1983) was specified as follows:

$$
\begin{aligned}
Y_t &= X_t\beta + U_t &\quad \text{if } X_t\beta + U_t > 0 \\
&= 0 &\quad \text{if } X_t\beta + U_t \leq 0 \\
& &\quad t = 1,2,\ldots, N
\end{aligned}
$$

where:

Y_t = the expected amount of land allocated to improved maize at a given stimulus level, X_t;
N = number of observations;
X_t = vector of independent variables;
β = vector of unknown coefficients; and
U_t = independently distributed error term assumed to be normal with zero mean and constant variance σ^2.

X_t is the index reflecting the combined effect of the independent (X) variables that inhibit or promote adoption. The index level X_t can be specified as:

$$X_t = \beta_0 + \beta_1 X_1 + \ldots + \beta_{13} X_{13} + \varepsilon_i$$

where:

b_0 = constant;
X_1 = FSIZE (farm size, timmad);
X_2 = EXP (experience of the household head, yr);
X_3 = EDUC (education level of household head, dummy variable);
X_4 = LSTOCK (livestock units; index in which livestock numbers are aggregated using the following weighting factors: oxen and cow = 1.0, goat = 0.08, sheep = 0.08, poultry = 0.02);
X_5 = EXT (farmer received extension visit, number);
X_6 = HSIZE (family labor, number of adults in the household);
X_7 = FDAY (farmer attended a field day, dummy variable);
X_8 = YOFI (amount of off-farm income, Birr);
X_9 = HLAB (use of hired labor, dummy variable);
X_{10} = HYLD (farmer's preference for high yield, dummy variable);
X_{11} = LODG (farmer's preference for lodging resistance, dummy variable);
X_{12} = IMPURE (farmer's preference for pure seed, dummy variable);
X_{13} = CONDITIO (farmers condition their seed, dummy variable); and
ε_i = error term.

Formation of the model was influenced by a number of working hypotheses. It was hypothesized that a farmer's decision to adopt or reject a new technology at any time is influenced by the combined (simultaneous) effects of a number of factors related to the farmer's objectives and constraints (CIMMYT 1993). The following variables were hypothesized to influence the allocation of land to improved maize, either hybrids or improved open-pollinated varieties (OPVs).

Farm size: Farm size (X_1) is an indicator of wealth and perhaps a proxy for social status and influence within a community. It is expected to be positively associated with the decision to adopt improved maize technology. Farm size can also encourage farmers to intensify their production, in which case a larger farm size is expected to be negatively related to the adoption of improved maize technology.

Experience: A farmer's experience (X_2) can either generate or erode confidence. With more experience, a farmer can become more or less averse to the risk implied by adopting a new technology. This variable can thus have a positive or negative effect on a farmer's decision to adopt an improved maize technology.

Education: Exposure to education (X_3) should increase a farmer's ability to obtain, process, and use information relevant to the adoption of improved maize technology. Education is thus thought to increase the probability that a farmer will adopt an improved maize technology.

Livestock: Ownership of livestock (X_4) is hypothesized to be positively related to the adoption of improved maize technologies.

Extension: Agricultural extension services provided by the MOA are the major source of agricultural information in the study area. It is hypothesized that contact with extension workers (X_5) will increase a farmer's likelihood of adopting improved maize technologies.

Household size: Large households will be able to provide the labor that might be required by the improved maize technologies. Thus, household size (X_6) would be expected to increase the probability of adopting improved maize technologies.

Field days: Attending a field day (X_7) will increase a farmer's awareness of new technologies and hence increase the probability of adopting improved maize.

Off-farm income: Access to off-farm income (X_8) enables farmers to purchase inputs and is expected to have a positive influence on the adoption of improved maize.

Hired labor: Hired labor (X_9) helps farmers to overcome labor constraints, especially with respect to the number of hand weedings required for improved maize. Thus, hired labor is expected to have a positive influence on the adoption of maize technologies.

Varietal characteristics: A number of varietal characteristics are expected to positively influence the allocation of land to improved maize. It is expected that farmers prefer varieties that are high yielding (X_{10}) and resistant to lodging (X_{11}). Also, adopters are expected to want pure (X_{12}) and well-conditioned (X_{13}) seed.

3.0 Seed Supply

3.1 Seed Industry Structure

Douglas (1980) showed that seed supply systems in most countries pass through four evolutionary stages characterized by increasing technological and organizational complexity:

1. Farmers save their own seed from crop to crop by selecting the most productive plants. They also exchange seed with a few farmers.
2. A specialized government agricultural department emerges under pressure from farmers and conducts plant breeding research and varietal development. A few farmers specialize in multiplying and distributing seed released by the government research stations.
3. Private seed companies enter the seed industry and invest in plant breeding research and development, seed growing, processing, and marketing.
4. Plant breeding and seed production and marketing become highly organized and technologically intensive. Both public and private organizations engage in seed production, marketing, and international trade.

The Ethiopian seed industry is currently at the second stage of development. Improved varieties are developed by the national agricultural research system and development programs or introduced from outside. Public institutions are responsible for producing and distributing seed to farmers, although some private companies are now entering the seed industry and have started research on hybrid seed production, marketing, and distribution.

The NSIA was established in 1993 to strengthen the seed industry in Ethiopia. Its objective is to increase the flow of seed to farmers. The supply of seed is constrained by inefficiency of public seed enterprises, poor seed promotion, poor transportation, and inappropriate agricultural and pricing policies. Moreover, because high-yielding varieties perform well with fertilizers, the limited availability of fertilizers constrains the demand for improved seed. As a result, most seed in the peasant sector is still produced by farmers (Hailu Gebremariam 1992).

The Ethiopian seed industry is thus characterized by formal and informal sectors. For the industry to evolve into the third stage of its life cycle, linking of the formal and informal systems and promotion of private sector provision of seed will be important. The advantages of linking the two systems are that farmers can maintain seed quality, the informal system can widely distribute seed, and the informal system is more effective in selecting and diffusing appropriate varieties (Thiele 1999).

The formal sector includes research institutions, MOA, development projects, and public and private seed enterprises. The participants in the informal sector are farmers, non-governmental organizations (NGOs), and relief agencies.

The seed distribution channels in the study area changed in 1991 due to political and economic reforms as depicted in Figure 4.

Figure 4. Seed distribution and marketing channels in the study area.
Source: Respective district agricultural development offices, 1997, pers. comm.

3.1.1 The formal sector. Most seed for cropping is obtained from the previous harvest. Nevertheless, farmers periodically obtain seed from beyond the farm gate, and their sources include other farmers, commercial seed dealers, NGOs, national research institutes, or other public agencies. Seed may be brought into the farm to cover deficits following harvest failures; introduce new varieties; and provide seed of better quality, either physiologically and/or genetically.

Many organizations have developed strategies to stimulate the flow of improved seed to farmers (Wiggins and Cromwell 1995). During the 1960s and 1970s, many countries received funding from donors to set up national seed production and distribution programs, with public agencies carrying out most of the activities. For example, the FAO Seed Development and Improvement Program supported 60 countries during 1972-84; the World Bank supported 13 national seed projects and 100 other seed-related projects during 1975-85; and USAID provided long-term support to public bodies concerned with seed in 57 countries during 1958-87 (Wiggins and Cromwell 1995). The support from the formal sector, however, has been disappointing. The public agencies often lacked sufficient resources, or their staff lacked incentives or were poorly managed. Consequently, they produced less seed than expected and frequently at a higher cost than the private sector. Also, the seed suppliers had difficulty in supplying seed to farmers in marginal areas (Wiggins and Cromwell 1995).

In Ethiopia, varietal development is handled by EARO, Alemaya University of Agriculture (AUA), Addis Ababa University (AAU), and regional and state agricultural research centers. Virtually all plant breeding has been done by public institutions, although Pioneer Hi-Bred International has been involved in some varietal development.

Before a variety or hybrid can be recommended for release, it must be evaluated in farmers' fields for disease resistance, productivity, stability, and quality. After on-farm verification and evaluation, NVRC officially releases the varieties. This procedure is sometimes violated. For instance, in 1991, Pioneer tried to produce 144 ha of hybrid maize seed and 60 ha of sunflower using imported seed that had not been officially tested, verified, and released. The company harvested only 71.1 t of maize seed and the sunflower did not even set seed.

In 1979, ESE was incorporated to produce, process, and market seed. Initially, ESE only supplied improved varieties to state farms and producer cooperatives that were the foundation of the socialist economy. Now it is governed by an interministerial seed board and has been given autonomous status to function as a profit-making enterprise. This organization was the only seed enterprise in Ethiopia until December 1990, when it entered into partnership with Pioneer Hi-Bred International (Hailu Gebremariam 1992). [1]

The national maize program at BRC and AUA supplies ESE with improved and basic seed that ESE multiplies at two of its basic seed farms. ESE also produces seed under contractual arrangements with state farms and private producers. The organization maintains five processing plants, from which it also distributes seed. These plants are located in Awassa, Assela, Koffela, Nekemte, and Bahir Dar. From 1980 to 1991, ESE produced and distributed an average of 23,065 t of seed per year

[1] The joint venture was discontinued in December 1995 as part of the reform to liberalize the economy.

(Table 1). Since 1994, ESE has increased its seed supply because the government embarked on a major effort to promote improved seed through its extension management training plots (EMTPs). During 1995–98, about 15% of ESE's seed was distributed to state farms, 55% to EMTPs, and about 30% to others. In 1998, 67.5% of the distributed seed was wheat, 31% was maize, 1% was barley, and 0.5% was of other crops.

The type and amount of maize seed produced by the ESE-Nekemte Branch is shown in Table 2. The table shows an increase in production of the recommended maize hybrids BH-660, BH-550, and BH-140. The production of Beletech and CG-4141 was discontinued in 1994 because they did not perform as well as the recommended hybrids.

The ESE processes seed that is produced through contractual agreements made with private enterprises, EARO, regional research centers, and state farms. The contractual agreement is signed between ESE and the contractor and entails the following obligations: all production costs are borne by the seed producer; the inspection cost and cost of the jute bags is borne by ESE; and ESE pays for the raw seed.

The ESE sells its seed to farmers and interested organizations, such as MOA, Sasakawa-Global 2000 (SG-2000), state farms, and different administrative regions. In 1996, the price of improved maize seed at the ESE-Nekemte Branch was Birr 547/100 kg (Birr 7 = US$ 1). The ESE head office in Addis Ababa sets the price of seed, which is based on the cost of raw seed, processing, transportation, in-bred line, and overhead. Also, a 5% profit margin is added to the price of seed. The ESE has acknowledged that it was not meeting the demand for maize seed and reported a shortage of inbred lines supplied by EARO.

Table 1. Seed distribution (000 t) by the Ethiopian Seed Enterprise, 1980-98

Year	Wheat	Barley	Maize	Teff	Sorghum	Total
1980	19.08	0.26	1.16	0.02	0.20	20.72
1981	18.85	0.74	2.35	0.13	0.17	22.24
1982	16.43	0.29	1.42	0.27	0.15	18.56
1983	16.57	0.87	2.50	0.22	0.05	20.21
1984	12.25	1.65	1.30	0.13	0.26	15.58
1985	21.77	1.72	12.58	0.77	0.07	36.92
1986	25.54	1.83	11.78	0.56	1.12	40.83
1987	19.91	2.16	8.28	0.53	1.44	32.32
1988	18.81	4.12	4.51	0.57	2.15	30.17
1989	9.19	1.39	3.16	0.22	0.94	14.89
1990	8.81	0.71	3.87	0.74	0.61	14.74
1991	7.1	1.24	1.14	0.03	0.10	9.61
1992	6.96	1.23	1.53	1.89	0.19	11.8
1993	11.09	0.31	2.38	1.42	2.06	17.26
1994	12.06	0.17	3.61	2.42	0.29	18.55
1995	10.13	0.15	2.63	0.04	0.58	13.53
1996	12.37	0.27	1.89	0.36	0.16	15.05
1997	8.18	0.37	1.67	0.28	0.007	10.6
1998	11.08	0.14	4.25	0.05	0.01	15.53
Total	266.18	19.62	72.01	10.65	10.56	379.02

Source: Hailu Gebremariam (1992); ESE (1999).

The seed required for the peasant sector is collected from the processing plants by AISCO and distributed to farmers through the service cooperatives (SCs) and PAs. There has always been some discrepancy between the amount of seed ordered and purchased by AISCO. For example, between 1985/86 and 1990/91, AISCO annually ordered 24,688 t of seed from ESE and

Table 2. Maize seed produced by the Ethiopian Seed Enterprise, Nekemte Branch, 1992-96

	Quantity produced per year (100 kg)				
Variety	1992	1993	1994	1995	1996
BH-660	50	1,593	3,194	3,756	12,045
BH-140	470	2,577	450	3,906	6,038
BH-540	-	-	100	100	400
Abobako	200	-	-	-	-
Beletech	2,000	205	445	-	-
Kuleni	-	-	113	-	-
CG-4141	3,528	1,875	375	-	-

purchased only about 21%, which left ESE with a large residual seed stock every year. Furthermore, AISCO distributed only part (60%) of what it had purchased. This discrepancy in production and distribution of seed to peasant farmers is caused by problems in demand assessment, the seed distribution mechanism, seed quality, and the seed price and credit system (Hailu Gebremariam 1992).

At present ESE distributes seed directly to SCs through district agricultural development offices. The ESE seed prices should be lower than those of AISCO because the costs of ESE services are less. Formerly AISCO charged Birr 20/100 kg above the price it paid to ESE for its services (Hailu Gebremariam 1992). There is no independent national seed quality control and certification scheme, although ESE has its own internal quality control facilities. As a result, none of the commercial seed distributed by ESE is certified, and farmers and development workers have sometimes disputed the purity and quality (Hailu Beyene 1993). The major constraint for multiplication of hybrid maize seed is an increase in susceptibility to gray leaf spot. The OPVs A511 and Katumani are not well maintained.

In general, commercial farmers take advantage of the formal seed sector. They are located mostly in high potential areas with a relatively well-established market infrastructure. These farmers follow different strategies for seed acquisition depending on their participation in the ongoing package program and their capacity to follow package recommendations. Farmers who host EMTPs have access to credit for the acquisition of package components, namely, seed and fertilizer. Extension, education, and technical support are given in accordance with the cropping calendar. The down payment for inputs is determined by MOA staff at the woreda level and depends on the ability of each host farmer to pay. It ranges from 5% to 50% of the cost of inputs supplied, and the balance is settled at the time of harvesting.

Some farmers who participate in the package extension program host EMTPs for a few years (1-2 years). After they stop hosting, they become *graduate farmers*. Another group of farmers learns the practices either from graduates or package host-farmers and are called *copy farmers*. The two groups of farmers usually buy seed that has been distributed to EMTP host-farmers on a cash basis. Although they have access to credit, they rarely make use of it due to a lack of information, unavailability, and/or the complicated bureaucratic procedures required to access credit.

The Oromia Agricultural Development Bureau determines the amount of credit disbursed to farmers. A farmer's elegibility is assessed by the Input Coordination Unit (ICU) at the zonal and woreda level. This unit is responsible for disbursing and collecting credit from farmers. The committee starts its assessment of farmers' credit needs between November and February. The farmers are advised about credit availability as well as the consequences of defaulting on payment.

As noted, BRC plays an important role in developing improved maize and in producing basic and certified seed that is sold to ESE. This research center has produced an average of 883 qt of BH-660 on 56 ha and 441 qt of BH-540 on 45 ha annually. In 1996, the price of hybrid maize seed at BRC was Birr 225/qt.

3.1.2 The informal sector. The most common form of seed exchange in African countries is from farmer to farmer. This system has a number of advantages for farmers over formal seed exchange. It uses indigenous structures for information flow and exchange of goods, and its informal nature makes it less rigid than the formal sector. Furthermore, it operates at the community level between households within a small number of communities, so farmers have easy access to seed and often know the farmer from whom they obtain the seed. Availability is further enhanced by the wide variety of exchange mechanisms that are used to transfer seed between individuals and households, such as cash, exchanges in kind, barter, or transfers based on social obligations (Table 3). This is especially important for households that have limited resources to purchase seed. A further benefit of this exchange system is that farmers are able to acquire seed in the quantities they want (Cromwell 1996).

Ethiopian farmers have been practicing seed selection and preservation for centuries and, as we have noted, the bulk of the national seed requirement is still met through this informal system. Of the total annual seed requirement (about 0.42 million tons), 15% is produced by the formal sector as improved seed stock, whereas 85% is produced by the informal farmer-to-farmer exchange system as local varieties (Table 4). Most farmers in western Shewa (68.4%) and eastern Wellega (41.5%) bartered maize seed for grain at a rate of 1 kg of seed for 1 kg of grain. About 5% of farmers in western Shewa and 21% in eastern Wellega purchased their local maize seed at a rate of Birr 90/100 kg (Table 3).

Non-governmental organizations are involved in the supply of seed for a variety of reasons. Most NGOs concentrate on providing source seed, other inputs, and technical assistance aimed at strengthening local community-driven multiplication of improved hybrids, OPVs, and enhanced local varieties. They distribute seed that is developed and multiplied by the formal research system and contract farmers. A drawback of this system is that seed quality varies due to lack of regulation. In some cases when NGOs wanted to ensure that seed quality was adequate, agencies inspected the growing seed crops and certified the seed. The links with government programs consisted of information exchange, contract services for the provision of source seed, seed testing, and field inspections. The NGOs had little contact with the private sector.

The average seed price set by NGOs was roughly US$ 0.85/kg higher than the price of seed produced by the formal sector. The higher costs of small-scale seed production by NGOs resulted from considerable overhead costs, and the NGOs themselves recovered only 25-50% of their seed production costs from seed sales. Equity issues were rarely addressed, and most of the participants were better-off farmers who were considered to be more effective at multiplying seed (Wiggins and Cromwell 1995).

Table 3. Farmers' seed acquisition and exchange rate in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega		
Means of acquiring seed	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers	Exchange rate
Purchased	3	5.3	11	20.8	Birr 0.9: 1 kg
Bartered with grain	39	68.4	22	41.5	1 kg : 1 kg
Bartered with labor	-	-	1	1.9	-
Obtained free of charge	14	24.6	18	34.9	-

Table 4. Area planted to improved and local varieties of major food crops in Ethiopia, 1996/97

Crop	Harvested area ('000 ha)	Area under improved varieties ('000 ha)	Quantity of improved seed used ('000 qt)	Percent area planted to local materials	Percent area planted to improved materials
Teff	2396.9	92.7	27.8	96.1	3.9
Bread wheat	855.1	770.0	1155.0	10.0	90.0
Durum wheat	571.1	22.8	22.8	96.0	4.0
Barley	1370.1	23.0	25.3	83.2	16.8
Maize (OPVs, hybrids)	1951.1	1170.7	351.2	40.0	60.0
Sorghum	1750.1	420.0	42.0	76.0	24.0
Finger millet	442.0	0.0	0.0	100.0	0.0
Oats	71.3	71.3	71.3	0.0	100.0
Total cereals	9407.7	2570.5	1695.4	72.7	27.3
Faba beans	510.4	5.1	10.2	99.0	1.0
Field peas	245.0	1.2	1.8	99.5	0.5
Chick peas	229.2	0.5	0.4	97.6	2.4
Lentils	81.8	0.0	0.0	100.0	0.0
Grass peas	165.4	0.0	0.0	100.0	0.0
Haricot beans	174.8	131.4	196.6	25.0	75.0
Total pulses	1406.6	138.2	209.0	90.2	9.8
Noug (niger seed)	250.5	0.2	0.02	99.0	1.0
Linseed	148.2	0.16	0.04	98.0	2.0
Rapeseed	21.4	0.83	0.01	85.0	15.0
Sesame	18.5	0.0	0.05	100.0	0.0
Groundnuts	17.4	0.63	0.0	80.0	20.0
Fenugreek	17.3	0.0	0.0	100.0	0.0
Sunflowers	5.2	0.0	0.0	90.4	9.6
Total oilseeds	478.5	1.82	0.12	99.6	0.4
Total	11292.8	2710.5	1904.5	76.0	24.0

Source: National Seed Industry Agency, 1998, unpublished data.

Another role of NGOs is to distribute relief seed after emergencies such as war or drought (Tripp 1997). In Ethiopia, distribution of relief seed is often dispersed and badly coordinated. Initially, NGOs were assumed to be responsible for acquiring and providing early generation seed to service cooperatives at cost, including transport. The distribution of free seed by NGOs and relief agencies has actually had several negative effects by creating dependency on free services, disrupting the informal farmer-to-farmer seed exchange system, and weakening sustainable development in the seed subsector (Hailu Gebremariam 1992). Nevertheless, NGOs have tended to work well with small-scale, resource-poor farmers, who are mostly located in remote and inaccessible areas.

3.2 Mechanisms of Maize Seed Development and Supply

3.2.1 Varietal development, testing, and release. Maize research in Ethiopia has greatly depended on introduced germplasm, which may be used as parental stock for further research or included in the Regional Varietal Trial (RVT). Materials in the RVT are evaluated further (mainly for yield, disease resistance, and other desirable traits) in the Preliminary Yield Trial (PYT) and the Pre-national Variety Trial (PNVT) for two years. Promising genotypes are included in the National Variety Trial (NVT) for further evaluation for two to three years at five to seven locations in major maize growing environments. The best materials from NVT and RVT are included in the Variety Verification Trial (VVT), which is conducted on research stations as well as on farmers' fields under recommended and farmers' management levels for one to two years. The objectives of the VVT are to obtain farmers' pre- and post-harvest assessment of varieties, evaluate the performance of the varieties in a real production system, and assist in the decision of the variety release committee.

The variety release committee is composed of professionals from different research and seed user organizations, e.g., EARO, NSIA, ESE, and MOA. The committee considers mostly biological factors in deciding to release a variety, and there is no guarantee that farmers' preferences and priorities are fully represented. In general, seven years are required to release a variety. Sometimes release may be unnecessarily delayed because of the stringent variety release requirements. After a variety is released, it is included in Breeder Seed Increase (BSI). Breeder seed is then provided to BRC to generate basic/foundation seed, and then to ESE for further multiplication on large plots.

3.2.2 Seed imports. Aside from producing seed to meet local demand, ESE is also responsible for importing seed. Between 1986 and 1991, ESE imported nearly 3,000 t of seed (Table 5), mostly hybrid maize from Kenya and hybrid sunflower from Argentina. After establishing a joint venture with

Table 5. Seed imports by the Ethiopian Seed Enterprise, 1986-91

Year	Crop	Country	Quantity (t)	Price (US$/t)
1986	Hybrid maize	Kenya	3.8	750.0
	Malt barley	Kenya	0.5	900.0
1987	Hybrid maize	Kenya	980.0	996.0
	Hybrid maize	Zimbabwe	120.0	834.7
	Malt barley	Spain	150.0	626.0
	Sunflower	Argentina	11.0	3,513.2
1988	Hybrid maize	Kenya	580.0	869.7
	Maize, basic	Kenya	30.0	899.8
	Sorghum	Kenya	10.0	869.7
	Maize, basic	France	2.0	22,434.1
	Sunflower	Zimbabwe	33.0	3,821.3
	Sunflower	Argentina	30.0	3,821.3
	Sunflower, basic	Argentina	0.15	84,000.0
	Pepper	Argentina	0.1	43,500.0
1989	Maize, basic	Zimbabwe	2.5	17,076.4
	Sunflower	Argentina	47.5	4,471.2
1990	Sunflower	Argentina	11.5	3,022.4
	Maize, basic	Malawi	0.3	21,866.7
	Cotton	Israel	0.6	10,225.0
1991	Hybrid maize	Kenya	900.0	1,000.0
1992	Hybrid maize	Zimbabwe	2.0	18,000.0
1993	Hybrid maize	Zimbabwe	2.4	18,000.0
1994	Hybrid maize	Zimbabwe	2.1	18,000.0
1995	Hybrid maize	Zimbabwe	2.5	19,000.0
1996	Hybrid maize	Zimbabwe	2.0	20,000.0
1997	Hybrid maize	Malawi	2.0	20,000.0
1998	Hybrid maize	Zimbabwe	2.8	19,000.0
Total			2,973.2	

Source: Hailu Gebremariam (1992); ESE (1999); unpublished data.

Pioneer Hi-Bred International in 1990, ESE imported more seed. Increasing seed imports may have a negative impact on national efforts to develop adapted, high-yielding varieties and hybrids, on creating a sustainable seed supply that would foster self-sufficiency, and on the conservation and sustainable use of indigenous germplasm (Hailu Gebremariam 1992). On the other hand, increased imports reflect ESE's inability to meet domestic seed demand.

3.2.3 Seed distribution and marketing. The institutions involved in seed distribution and marketing are ESE, AISCO, Development Bank of Ethiopia, Commercial Bank of Ethiopia, SCs, and private organizations.

Commercial seed production and processing are handled by ESE. AISCO distributes seed through SCs, which receive loans from the Development Bank and Commercial Bank to purchase seed. Although it is envisaged that the private sector will play an important role in the seed industry in the future, the contribution of private firms in supplying seed of the major food grains is still small (Hailu Gebremariam 1992). Private companies, such as Ethiopia Amalgamated Ltd., Ambassel, and Dinsho Trading Enterprises, have recently entered the seed industry, buying seed from ESE and distributing it to a limited number of farmers on commission.

The promotion of improved seed by ESE has been limited. It also seems that sometimes ESE is not aware of which varieties farmers want. Better marketing could play an important role in the diffusion of new varieties. For example, a greater effort could be made to advise farmers on the benefits of improved varieties and to differentiate between grain and improved seed.

3.2.4 Local seed supply. A typical farmer-managed seed production process consists of the following steps. Farmers rogue their growing crops by hand to remove diseased and off-type plants. Selection is usually carried out based on characteristics including high yield, low input (including labor) requirement, resistance to pests and diseases, particular processing, cooking and taste qualities, storability, and good yield of non-grain biomass (leaves and stalks). It is important to note that subsistence farmers select for yield stability, which is associated with diversity within and between crops and cultivars (Almekinders et al. 1994).

The crops are harvested by hand, which avoids mechanical damage to the seed and contamination with weed seeds and other inert material. After harvest, crops are often threshed and cleaned by hand to minimize damage and contamination, and then they are usually dried in the sun to reduce moisture content. Seed is often stored separately from grain. It is commonly hung overhead in a smoky place, such as the kitchen, to minimize insect damage and reduce moisture content. Also, seed can be conditioned by adding local insecticides and/or fungicides (eucalyptus leaves, sand, ash, neem) before being placed in special containers and stored above the fireplace (Cromwell 1996).

Various organizations have been involved in strengthening local commercial seed production, by building on the existing farmer-to-farmer seed exchange. As one would expect, an important component of this activity is *plant breeding and variety selection*. Farmers' participation in variety testing can be linked to seed provision. In Colombia, farmer groups were formed to collaborate with research and extension in participatory technology development for identifying new varieties (Tripp 1997). Several of these groups received considerable training and assistance for small-scale seed production and were able to sell seed of these varieties in local shops and markets. Similar efforts were carried out in Zambia (Tripp 1997).

The public sector (the national agricultural research system) will continue to play an important role in producing source seed of modern varieties for small-scale seed producers, who in turn have to be able to pay for the full cost of developing the source seed. One of the dilemmas of contract seed multiplication is that only farmers with sufficient resources at their disposal can participate.

Another important issue is that an official agency needs to be involved with seed quality and control, and small-scale seed producers need to pay the full cost of seed certification. One element of quality control is seed conditioning and storage, which implies that small-scale producers need access to specialized equipment and facilities. In some cases, small-scale seed producers have rented state-owned processing facilities. There is a need for the construction of storage structures.

Finally, a marketing and distribution strategy needs to be developed to assist farmers in selling their products (Rohrbach et al. 1997). One of the major weaknesses of the organizations that have set up small-scale seed provision is that not all of them had the time and resources to develop the necessary technical capabilities for organizing seed production and distribution. Also, they did not always test the adaptability of the varieties to the local environment. They often worked with the better-off farmers and created new structures instead of building on existing structures (Tripp 1997).[2]

3.3 Policies and Institutions

3.3.1 Seed legislation. In 1997, Ethiopia enacted seed legislation to devise seed transaction mechanisms, ensure that farmers had access to quality seed, protect and promote the country's seed resources, and guard the interests of seed users/farmers, originators, and traders.

Many countries explicitly restrict the types of institutions allowed to operate in the seed sector. Sometimes implicit restrictions exist as well; for example, NGOs have often been discouraged from participating in the seed sector, aside from providing emergency aid, although they could play an important role in strengthening the small-scale seed sector.

In Ethiopia, formal and informal institutions can be involved in seed multiplication, as long as they fulfill the criteria set by NSIA. The formal institutions involved are Pioneer-Hybrid Seeds, Ethiopia P.C. Ltd., and ESE. In the informal sector, there is a program initiated by the NSIA with financial assistance from the World Bank and the International Fund for Agricultural Development (IFAD). This is a five-year seed system development project, which includes farmer-based seed production and marketing schemes in seven regional states. The Swedish government supports another program, which is aimed at promoting seed multiplication and marketing by farmers in Amhara.

2 For a discussion of experiences with alternative seed supply practices in Ghana and Tanzania, see Tripp (1997) and Mdruma (1998).

3.3.2 Variety registration. The NVRC, under the auspices of NSIA, is responsible for variety registration and comprises members from EARO, NSIA, ESE, AUA, Genetic Resource Conservation and Research Institute (GRCRI), MOA, Coffee and Tea Development Authority (CTDA), Awassa College of Agriculture, and others when deemed necessary.

The team leader of NVRC and other concerned researchers consult with appropriate scientists and extension and on-farm research personnel to prepare a proposal for promising varieties. The variety should be tested for yield, disease resistance, and other important characteristics for a minimum of two to three years in regional or national variety trials at three to five locations. Promising varieties are promoted to farm verification trials. The breeder applies to the NVRC for his/her variety to be evaluated for release during the same season. The candidate varieties are planted with established local or improved cultivars in plots of at least 100 m^2 at two to three sites. During the anticipated year of release, the varieties are verified both on-station and on-farm by the NVRC.

The NVRC appoints a subcommittee composed of its own members and other relevant specialists to report on varietal performance after examining performance data submitted by the breeder and field performance evaluation. The reports cover the performance evaluation, field performance evaluation, general comments, and recommendations. A maximum of three varieties per crop are proposed for release. The proposal for variety release should be submitted to the committee chairman by 30 May of each year and decisions reached by the committee are reported at the NVRC in April the following year. A new variety should be assigned a short and a permanent designation by the breeder/team leader after it has been approved for release. The breeder or institution responsible for developing a variety is also expected to maintain and supply an appropriate quantity of the breeder and pre-basic seed for replenishing and restoring commercial seed of the variety to the desired genetic purity.

The strengths of the current varietal release procedures are the clear regulations and guidelines for variety evaluation and release. The weaknesses, according to NSIA, are that breeders are not strictly following the guidelines and do not use the latest released varieties as a standard check. Furthermore, the evaluations do not take place at the appropriate stage of plant growth. Finally, there is no independent variety testing and release institute.

3.3.3 Seed certification. Seed certification is a new activity carried out by NSIA. The main objective of this procedure is to test the eligibility of the variety for multiplication and to check the compliance with the established seed and field standards. As yet there is no quality control procedure.

3.3.4 Seed price policy. The long-term viability of small-scale seed provision relies on government intervention in price setting, with the result that official seed prices do not reflect the full cost of production. Another aspect of government intervention is the tying of agricultural subsidies and credit programs to the use of publicly bred improved seed, which can artificially promote its use but restrict the viability of small-scale seed provision (Tripp 1997).

3.3.5 Plant breeders' rights. At the time this paper was written, there are no policies concerning plant breeders' rights in the country.

4.0 Demographic and Socioeconomic Characteristics

Socioeconomic and demographic characteristics of sample farmers in western Shewa and eastern Wellega are shown in Table 6. The mean age of farmers in Chaliya Woreda was about 48 years compared to 40 years for Bako-Tibe, 43 years for Bila-Sayo, and 44 years for Sibu-Sire. The level of farming experience was highest in Chaliya (27 years) and lowest in Bako-Tibe (21 years). About 99% of households were headed by men. Mean family size was about 8 persons in Sibu-Sire compared to about 7 persons in each of the other three woredas. The number of adults above 17 years of age was, on average, about 3 persons in all woredas. The number of adults between 14 and 17 years of age was about 1, on average, for all woredas, while the number of children below 14 years of age was about 3.

The number of family members working off-farm was very low in all woredas. The annual average off-farm income was Birr 131 in Sibu-Sire compared to Birr 81 in Bako-Tibe, Birr 53 in Chaliya, and Birr 31 in Bila-Sayo. Off-farm income in Sibu-Sire was higher because more farmers were engaged in income-generating activities such as carpentry, wood-carving, and trading. Most farmers used their off-farm income to purchase fertilizer or farm implements. The percentage of farmers hiring labor was highest in Bila-Sayo (55.9%) compared to 42.9% in Sibu-Sire, 36.8% in Bako-Tibe, and 33.3% in Chaliya.

Table 7 shows the education level of farmers in the study area. About 50% of farmers in Bila-Sayo were illiterate compared to 46% in Chaliya, 42% in Sibu-Sire, and 36% in Bako-Tibe. More farmers in Sibu-Sire (18%) attended a literacy campaign compared to 11% in Bako-Tibe, 9% in Bila-Sayo, and 6% in Chilayo. More farmers in Bako-Tibe (54%) finished primary or secondary education compared to 49% in Chaliya, 41% in Bila-Sayo, and 40% in Sibu-Sire.

The average farm size was about 15 timmad (1 timmad = 0.25 ha) in Sibu-Sire compared to 14 timmad in Bila-Sayo, and 13 timmad in both Chaliya and Bako-Tibe. In the four woredas, farmers cultivated about 75% of their farms, and the area used for grazing was about 2 timmad (Table 8).

Table 6. Demographic and socioeconomic characteristics of sample farmers in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Characteristics	**Chaliya**	**Bako-Tibe**	**Bila-Sayo**	**Sibu-Sire**
Age of household head (yr)	47.6	39.9	42.6	43.9
Farming experience (yr)	27.2	21.2	23.5	24.5
Family size (no.)	7.4	7.3	7.1	7.9
Number of adults (>17 yr)	3.0	3.1	3.3	3.5
Number of adults (14-17 yr)	1.2	0.9	1.1	1.4
Number of children (<14 yr)	2.9	2.9	2.9	2.8
Number of off-farm workers	0.3	0.1	0.2	0.2
Annual off-farm income (Birr)	52.8	80.5	31.3	130.5
Farmers hiring labor (%)	33.3	36.8	55.9	42.9

Most farmers in the four woredas cultivated their own land (Table 9). In Bako-Tibe, about 24% of farmers rented land, while less than 10% of farmers in each of the other woredas rented land. In Sibu-Sire, about 42% of farmers sharecropped their land compared to 36% in Chaliya, 34% in Bako-Tibe, and 18% in Bila-Sayo. Inputs contributed by the landowner and the sharecropper are shown in Table 10.

The average number of oxen owned was about 3 in all woredas (Table 11). The average number of cows owned was highest in Bila-Sayo. The average number of poultry owned was 5 in both Bila-Sayo and Sibu-Sire and 3 in both Chaliya and Bako-Tibe. The number of goats and sheep owned was low in all woredas.

Table 7. Education level of sample farmers in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Education	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
None	45.5	35.5	50.0	41.6
Literacy campaign	6.1	10.5	8.8	18.2
Elementary	36.4	35.5	32.4	31.2
Secondary	12.1	18.4	8.8	9.1

Table 8. Land use in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Land use area (timmad)	Chaliya	Bako-Tibe	Bila-Sayo	Sibu-Sire
Total farm size	12.6	12.7	14.1	15.4
Cultivated	9.4	9.3	10.7	11.6
Grazing	2.6	1.8	2.3	2.4
Fallow	0.1	0.5	0.7	1.2
Other	0.5	0.5	0.4	0.2

Table 9. Land tenure in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Tenure type	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Farmer's land	93.9	88.2	91.2	84.4
Family/farmer's land	0.0	11.8	0.0	2.6
Family land	0.0	7.9	5.9	6.5
Sharecropped land	36.4	34.2	17.6	41.6
Rented land	9.1	23.7	2.9	5.2

Table 10. Details of sharecropping arrangements, western Oromia, Ethiopia, 1996

Inputs contributed by landowner	
Land	30%
Fertilizer	15%
Seed	20%
Labor	20%
Oxen	15%
Inputs contributed by sharecropper	
Fertilizer	25%
Seed	25%
Labor	30%
Oxen	20%
Percentage of sharecroppers sharing harvest equally with landowner	
Chaliya	75%
Bako-Tibe	88%
Bila-Sayo	83%
Sibu-Sire	88%

Table 11. Livestock ownership by sample farmers in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Livestock	Chaliya	Bako-Tibe	Bila-Sayo	Sibu-Sire
Poultry	3.5	2.9	5.4	4.9
Goats	0.2	0.5	0.0	0.9
Sheep	0.1	0.1	0.3	0.7
Cows	4.4	5.8	7.1	5.4
Oxen	2.6	2.6	3.2	2.8

5.0 Maize Cultivars Grown and Farmers' Seed Sources

5.1 Cultivars Grown

Table 12 shows some agronomic traits of maize cultivars that were released in western Oromia. Smallholders grew local maize as well as improved maize developed and popularized by BRC, such as BH-660, BH-140, BH-540, Beletech, and Kuleni. Altogether, sample farmers from the four woredas grew about 16 cultivars (Table 13). A shift towards newly released maize hybrids, particularly BH-660, has been observed in all woredas.

The preferred maize cultivars are shown in Table 14. Reasons for farmers' preferences—which ranged from a cultivar's performance in the field to its end uses for home consumption—are listed in Table 15.

5.2 Seed Sources, Prices, and Rates

In 1996/97, most farmers planted maize seed saved from their previous harvest (Table 16). About 59% of farmers in Chaliya, Bila-Sayo, and Sibu-Sire planted their own seed compared to 49% in Bako-Tibe. The next most common source of seed in 1996/97 was MOA for Bila-Sayo (33.9%), Sibu-Sire (25.5%), Bako-Tibe (24.8%), and Chaliya (23.1%). Additional seed sources included other farmers, local markets, or sharecroppers. Over 90% of the seed obtained from MOA was hybrid, while most of the maize seed exchanged with other farmers was of local varieties. The price of maize seed purchased from MOA was about Birr 6/kg in Chaliya and Bila-Sayo, and about Birr 5/kg in Bako-Tibe and Sibu-Sire.

Table 12. Agronomic traits of maize cultivars released in western Oromia

Variety	Type	Plant height (cm)	Yield (t/ha)	Maturity (days)	Year of release
BH-660	Hybrid	290	9.2	165	1993
BH-140	Hybrid	250	8.3	140	1988
BH-540	Hybrid	240	8.4	145	1995
Phb-3253	Hybrid	200	7.5	140	1996
Phb-3435	Hybrid	200	NR	140	1996
Beletech	Improved OPV	272	7.3	150	1990
Kuleni	Improved OPV	262	6.5	150	1995
Gutto	Improved OPV	170	4.0	126	1988
Kenya	Improved OPV	320	6.0	165	1978
Israel	Improved OPV	330	4.0	175	1978
Jimma-Bako	Improved OPV	330	7.4	165	1970s
Abo-Bako	Improved OPV	250	6.0	150	1986
Bc	Improved OPV	330	6.6	165	1975
Shashemene	Improved OPV	330	4.0	175	-
Burrie	Local	330	4.0	175	-
Araba	Local	330	4.0	175	-
Jiru	Local	330	4.0	175	-
Orome	Local	160	2.0	125	-
Dima	Local	330	4.0	175	-

Note: NR = Not released but grown by farmers (see Table 13).

Table 13. Maize cultivars grown by farmers in western Oromia, Ethiopia, 1992 and 1996

	Western Shewa				Eastern Wellega			
	Chaliya (%)		Bako-Tibe (%)		Bila-Sayo (%)		Sibu-Sire (%)	
Variety	1992	1996	1992	1996	1992	1996	1992	1996
BH-660	0.0	26.3	0.0	23.2	0.0	27.1	0.0	26.5
BH-140	0.0	7.9	1.4	13.1	0.0	2.1	0.0	2.0
Phb-3253	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
Phb-3435	0.0	0.0	0.0	0.0	0.0	4.2	0.0	1.0
Beletech	0.0	2.6	1.4	2.0	0.0	4.2	0.0	0.0
Kuleni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shashemene	56.3	36.8	45.2	26.3	9.1	10.4	11.6	10.2
Burrie	15.6	13.2	9.6	5.1	42.4	25.0	40.6	25.5
Kenya	0.0	0.0	20.5	11.1	18.2	8.3	33.3	25.5
Orome	3.1	2.6	1.4	2.0	6.1	2.1	5.8	4.1
Guto	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Israel	0.0	0.0	0.0	0.0	3.0	2.1	1.4	1.0
Jiru	12.5	5.3	13.7	6.1	12.1	8.3	5.8	4.1
Arabe	12.5	2.6	4.1	2.0	0.0	0.0	0.0	0.0
Diimaa	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0
Other	0.0	2.6	1.4	7.1	9.1	4.2	1.4	0.0

Note: BH-660, BH-140, Phb-3253, and Phb-3435 are hybrids, and the others are OPVs (see Table 12).

Table 14. Preferred maize cultivars in western Oromia, 1996

	Western Shewa		Eastern Wellega	
Variety	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
BH-660	48.1	42.6	45.2	35.8
Shashemene	18.5	16.2	3.2	10.4
BH-140	7.4	11.8	6.5	1.5
Burrie	11.2	2.9	12.9	20.9
Kenya	0.0	8.8	16.1	20.9
Jiru	3.7	5.9	6.5	6.5
Beletech	3.7	4.4	3.2	0.0
Phb3435	0.0	0.0	6.5	1.5
Orome	3.7	0.0	0.0	4.5
Araba	3.7	2.9	0.0	0.0
Other	0.0	4.4	0.0	0.0

Table 15. Reasons for farmers' preference for most popular maize cultivars, western Oromia, Ethiopia, 1996

Region, variety, and reason for preference	Percent of farmers
Western Shewa: Chaliya	
BH-660	48.1
High yield	36.7
Seed size	16.7
Early maturity	10.0
Lodging resistance	10.0
Taste in injera	10.0
Shashemene	18.5
Taste in injera	33.3
Seed size	25.0
High yield	16.7
Western Shewa: Bako-Tibe	
BH-660	42.6
High yield	32.8
Lodging resistance	15.6
Early maturity	9.4
Shashemene	16.2
Taste in injera	29.4
High yield	17.6
Seed size	11.8

Table 15. Cont'd.

Table 15. Cont'd.

Region, variety, and reason for preference	Percent of farmers
Eastern Wellega: Bila-Sayo	
BH-660	45.2
High yield	25.0
Taste in injera	15.9
Lodging resistance	11.4
Seed size	9.1
Kenya	16.1
Disease resistance	30.8
Early maturity	15.4
Taste in injera	15.4
Sweetness in beer	15.4
Eastern Wellega: Sibu-Sire	
BH-660	35.8
High yield	32.4
Lodging resistance	18.9
Early maturity	10.8
Seed color	9.5
Kenya	20.9
Taste in injera	22.7
Early maturity	15.9
Seed size	13.6
Taste in bread	11.4
Burrie	20.9
Disease resistance	20.0
Taste in injera	17.1
Seed size	14.3
Sweetness in beer	11.4

Table 16. Farmers' sources of maize seed in western Oromia, Ethiopia, 1996/97

Seed source	Western Shewa		Eastern Wellega	
	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Own	59.0	48.6	58.9	59.1
Other farmers	10.2	20.1	5.4	10.0
Local market	2.6	3.7	1.8	1.8
MOA	23.1	24.8	33.9	25.5
Sharecropper	2.6	0.9	0.0	1.8
Other	2.6	1.8	0.0	1.8

Significantly more farmers in Bako-Tibe (69.3%) supplied maize seed to other farmers compared to Bila-Sayo (44.1%), Sibu-Sire (44%), and Chaliya (36.4%) (χ^2= 15.0;p<0.01). In Chaliya, farmers provided seed free of charge (46.2%) or bartered for seed with grain (46.2%). Similarly, in Sibu-Sire farmers bartered maize seed for grain (40.7%) or provided maize seed free of charge (38.9%). In Bako-Tibe, farmers bartered maize seed for grain (68.2%), while in Bila-Sayo farmers bartered maize seed (41.2%) or sold maize seed to other farmers (29.4%). All farmers bartered 1 kg of maize seed for 1 kg of maize grain.

Farmers' opinions of the advantages and disadvantages of obtaining seed from other farmers and the Ministry of Agriculture (the second two most important seed sources after "own seed") are listed in Table 17.

Farmers in the four woredas used their own resources to purchase improved maize seed. Distance traveled to purchase maize seed differed considerably across woredas (Table 18). About 75% and 64% of farmers in Chaliya and Bako-Tibe, respectively, traveled less than 5 km, while 73% and 62% of farmers in Bila-Sayo and Sibu-Sire, respectively, traveled more than 5 km.

About 58% of farmers in Chaliya had problems obtaining improved maize seed compared to 36% in Bako-Tibe and 38% in Bila-Sayo and Sibu-Sire. The main problems were high seed price and unavailability. The price of maize seed from the MOA was Birr 610/100 kg in Chaliya compared to Birr 580/100 kg in Bila-Sayo and Birr 530/100 kg in Bako-Tibe and Sibu-Sire, whereas seed bought from other farmers or the local market was about Birr 50-80/100 kg. This price differs because MOA sold improved hybrids and OPVs, whereas the local market and farmers sold local varieties.

In Bako-Tibe, about 44% of farmers reported the unavailability of seed to be an important problem compared to 33% in Chaliya, 25% in Bila-Sayo, and 16% in Sibu-Sire. Time of availability was also an important constraint on the use of improved seed. About 53% and 52% of farmers in Bako-Tibe and Bila-Sayo, respectively, did not get their seed at the right time compared to 27% for Chaliya and 12% for Sibu-Sire.

Table 17. Advantages and disadvantages of acquiring seed from other farmers and the Ministry of Agriculture, western Oromia, Ethiopia, 1996

Region and seed acquisition strategy	Percent of farmers
Western Shewa: Chaliya	
Advantages of acquiring seed from other farmers	
Fair price	30.4
Right quantity available	17.4
Quality	17.4
Timely availability	8.7
Disadvantages of acquiring seed from other farmers	
Poor quality	35.0
No credit to purchase	25.0
Advantages of acquiring seed from MOA	
Quality	34.8
Right quantity available	26.1
Disadvantages of acquiring seed from MOA	
High price	35.0
Western Shewa: Bako-Tibe	
Advantages of acquiring seed from other farmers	
Right quantity available	34.9
Timely availability	18.6
Accessible seed source	16.3
Quality	15.1
Disadvantages of acquiring seed from other farmers	
Poor quality	29.0
No credit to purchase	25.0
Advantages of acquiring seed from MOA	
Right quantity available	34.5
Quality	27.3
Disadvantages of acquiring seed from MOA	
High price	40.7
Right quantity *not* available	14.8
Eastern Wellega: Bila-Sayo	
Advantages of acquiring seed from other farmers	
Timely availability	30.8
Right quantity available	30.8
Credit to purchase	26.9
Disadvantages of acquiring seed from other farmers	
Poor quality	45.0
No credit to purchase	20.0
Advantages of acquiring seed from MOA	
Quality	43.8
Credit to purchase	25.0
Right quantity available	21.9
Disadvantages of acquiring seed from MOA	
High price	51.6
Untimely seed delivery	16.1
Eastern Wellega: Sibu-Sire	
Advantages of acquiring seed from other farmers	
Credit to purchase	26.2
Good price	21.4
Timely availability	21.4
Disadvantages of acquiring seed from other farmers	
Poor quality	50.0
No credit to purchase	20.0
Advantages of acquiring seed from MOA	
Quality	38.1
Credit to purchase	25.4
Right quantity available	25.4
Disadvantages of acquiring seed from MOA	
High price	75.0

Table 18. Distance traveled by farmers to purchase seed in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Distance	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Same village	37.5	29.8	4.5	17.2
<5 km	37.5	34.0	22.7	20.7
5-10 km	12.5	23.4	31.8	20.7
>10 km	12.5	12.8	40.9	41.4

Table 19. Farmers' sources of improved maize seed information in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Distance	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Extension	68.4	56.7	78.3	87.5
Radio	5.3	5.0	0.0	3.1
Other farmers	26.3	31.7	8.7	6.3
Other	0.0	6.7	13.0	3.1

Most farmers reported that they were able to buy the required quantity of seed.

The seed rate for improved maize in 1996 was about 6 kg/timmad in Chaliya, about 5.5 kg/timmad in Bako-Tibe and Bila-Sayo, and 5 kg/timmad in Sibu-Sire. In 1996, the seed rate for local varieties was about 6.5 kg/timmad for farmers in Chaliya and Sibu-Sire, 6.3 kg/timmad in Bila-Sayo, and about 5.3 kg/timmad in Bako-Tibe.

5.3 Farmers' Sources of Information on Improved Maize Seed

In Bila-Sayo (78.3%) and Sibu-Sire (87.5%), extension was the most important source of information on improved maize seed (Table 19). Extension and other farmers were the most important sources of information for 68.4% and 26.3% of farmers in Chaliya, respectively, and 56.7% and 31.7% of farmers in Bako-Tibe, respectively.

6.0 Maize Production Practices

6.1 Increased Use of Improved Maize Seed

As mentioned previously, the maize cultivars that farmers grew changed dramatically between 1992 and 1996 (Table 20). In 1992, of all farmers sampled, only 4% in Bako-Tibe grew improved maize cultivars. In 1996, about 56% of farmers in Bila-Sayo grew improved maize hybrids or OPVs, compared to 49% in Bako-Tibe, 46% in Chaliya, and 38% in Sibu-Sire. Higher yield was the main reason that farmers adopted improved cultivars. A second important reason for adopting improved cultivars was that they matured earlier than the cultivars previously grown, according to 20% of farmers in Sibu-Sire, 6% in Chaliya, 14% in Bako-Tibe, and 15% in Bila-Sayo.

Table 20. Use of local / improved maize cultivars in western Oromia, Ethiopia, 1992 and 1996

	Western Shewa		Eastern Wellega	
Cultivar	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
1992				
Improved hybrids / OPVs	0.0	4.1	0.0	0.0
Local maize	100.0	95.9	100.0	100.0
1996				
Improved hybrids / OPVs	45.5	49.4	55.9	37.7
Local maize	54.5	50.6	44.1	62.3

Between 1992 and 1996, the total area under improved maize increased in the four woredas, while the total area under local maize decreased (Figures 5 and 6). The growth in improved maize area is also reflected in production. In 1995, the total production of improved cultivars surpassed the total production of local varieties in the study area (Figures 7 and 8). In 1996, the average production of improved cultivars was about four times that of local varieties in Chaliya, Bila-Sayo, and Sibu-Sire, and about three times that of local varieties in Bako-Tibe (Table 21). Improved maize area and production are highest in Bako-Tibe, which may be due to the popularizing of hybrids and improved OPVs by BRC and extension services.

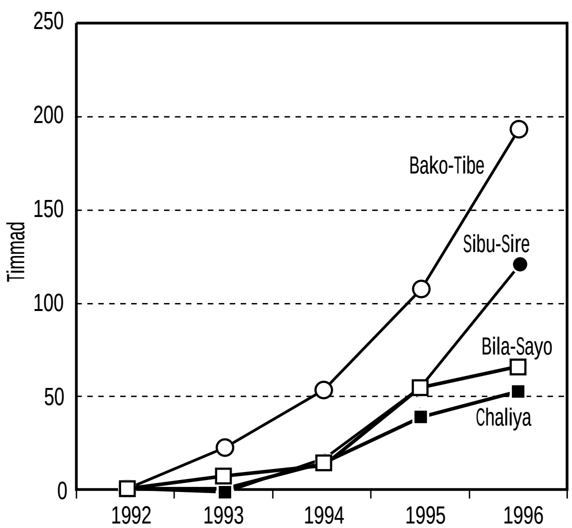

Figure 5. Total area (timmad) under improved maize production by woreda in western Oromia, Ethiopia,1992-96.

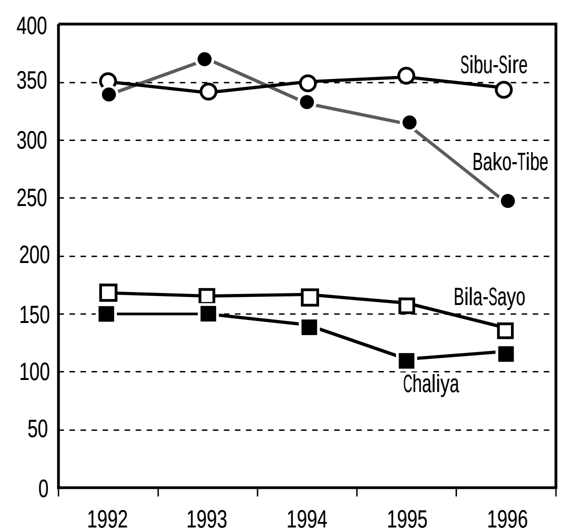

Figure 6. Total area (timmad) under local maize production by woreda in western Oromia, Ethiopia, 1992-96.

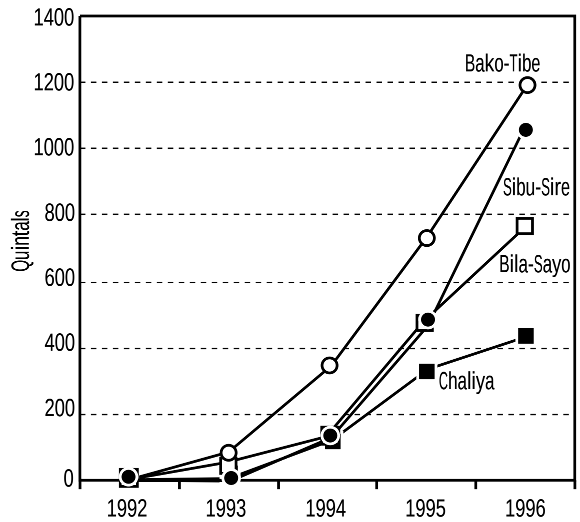

Figure 7. Total production (quintals) of improved maize varieties by woreda in western Oromia, Ethiopia, 1992-96.

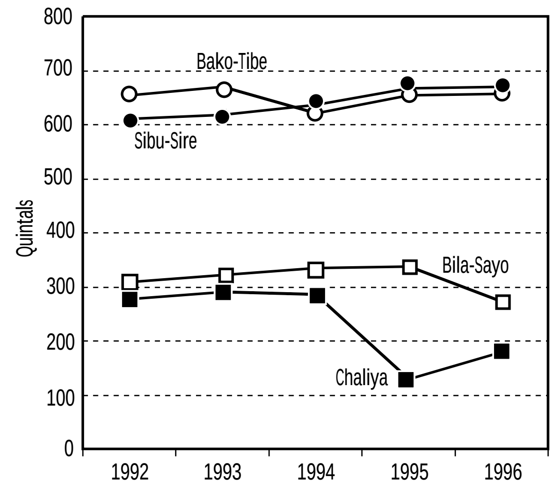

Figure 8. Total production (quintals) of local maize varieties by woreda in western Oromia, Ethiopia, 1992-96.

Table 21. Average production of local and improved maize in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
	Chaliya	Bako-Tibe	Bila-Sayo	Sibu-Sire
Improved maize (qt)	35.7	33.2	40.1	38.2
Local maize (qt)	8.5	13.4	10.5	10.3

Table 22. Fertilizer use for maize production in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Use of fertilizer for				
Maize production	78.1	97.4	88.2	78.9
Improved maize	51.9	54.3	53.3	61.2
Local maize	71.9	82.4	60.7	80.3
Improved and local maize	45.8	45.7	46.4	29.6
Reason for not using fertilizer				
Lack of awareness	0.0	50.0	0.0	12.8
High price	66.7	50.0	40.0	62.5
Unavailability	11.1	0.0	40.0	0.0
Late delivery	22.2	0.0	0.0	6.3
Other	0.0	0.0	0.0	18.8

6.2 Fertilizer and Pesticides

The use of fertilizer for maize production by farmers in western Oromia is shown in Table 22. Most farmers in all four woredas used fertilizer. More farmers applied fertilizer to local maize than to improved maize. The recommended fertilizer rate is 100 kg/ha of DAP and 200 kg/ha of urea. Farmers in Bila-Sayo applied about 94 kg/ha of DAP compared to 87 kg/ha in Sibu-Sire, 85 kg/ha in Bako-Tibe, and 83 kg/ha in Chaliya. In Sibu-Sire, farmers applied 176 kg/ha of urea compared to 172 kg/ha in Bako-Tibe, 160 kg/ha in Bila-Sayo, and only 97 kg/ha in Chaliya. The main constraint on fertilizer use was its high price. About 18% of farmers in Chaliya used pesticides compared to 13% in Bako-Tibe, 12% in Bila-Sayo, and 10% in Sibu-Sire.

6.3 Farmers' Access to Information for Maize Production

Farmers' access to information related to maize production is shown in Table 23. About 38% of farmers in Bila-Sayo attended a farmer field day or demonstration trial compared to 33% in Chaliya, 31% in Sibu-Sire, and 28% in Bako-Tibe. In Bila-Sayo, 12% of farmers attended a farmers' training course compared to less than 10% of the farmers in the other woredas.

Table 23. Farmers' access to information on maize production in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Source of information	**Chaliya (%)**	**Bako-Tibe (%)**	**Bila-Sayo (%)**	**Sibu-Sire (%)**
Attended field day	33.3	27.6	38.2	31.2
Attended training course	9.1	8.0	11.8	5.3
Received extension visit	30.3	30.7	52.9	40.3
Owned a radio	15.2	18.4	17.6	23.4

Twenty-three percent of farmers in Sibu-Sire owned a radio compared to 18% in both Bako-Tibe and Bila-Sayo and 15% in Chaliya. Most farmers who owned a radio in Chaliya (75%) listened to agricultural education programs compared to 41% in Sibu-Sire, 38% in Bako-Tibe, and 30% in Bila-Sayo.

An extension agent visited 53% of farmers in Bila-Sayo, 31% in Bako-Tibe, 30% in Chaliya, and 40% in Sibu-Sire. The farmers were visited during plowing, planting, weeding, and harvesting. The average number of extension visits during the cropping season was 2.4 for Bila-Sayo, 1.6 for Sibu-Sire, 1.2 for Chaliya, and 0.9 for Bako-Tibe.

7.0 Farmers' Management of Cultivars and Seed

7.1 Varietal Replacement

A farmer's decision to change an adopted cultivar is termed "varietal replacement," whereas the decision to obtain fresh stock of a variety that they already grow is termed "seed renewal." There are various methods to measure the rate at which farmers replace cultivars. In this study, we have used the weighted average age (WA) because it is simple and unambiguous (Brennan and Byerlee 1991). This measure is based on the average age of varieties grown by farmers in a given year (measured in years since release), weighted by the area planted to each variety in that year. This measure, WA_t, is computed for a given year, *t*, as follows:

where:

P_{it} = the proportion of area sown to variety *i* in year *t*, and
R_{it} = the number of years (at time *t*) since the release of variety *i*.

In western Oromia in 1996, the weighted average age of maize cultivars was about 16 years. To put this figure somewhat into perspective, it is helpful to know that in Kenya, the weighted average age of maize cultivars was 10 years and that large-scale farmers had a smaller WA (9 years) than small-scale farmers (11 years) (Hassan et al. 1998).[3]

[3] Similarly Bishaw et al. (1994) found that 21% of wheat farmers saved seed for 6-10 years and 14% saved seed for 11-15 years. In Pakistan, the useful life of a wheat variety (before its disease resistance breaks down) averaged five to six years (Heisey 1990) .

The comparatively slow turnover of cultivars in western Oromia reflects a poorly developed seed industry and ineffective extension services and explains why farmer-to-farmer seed exchange is common in the study area and Ethiopia in general. In Kenya, the small weighted age of cultivars reflected a relatively superior seed supply system, transportation network, and extension service. Large-scale farmers had relatively better access to information, extension services, and credit, and a greater capacity to bear risk compared to small-scale farmers. Brennan and Byerlee (1991) have contended that the optimal seed retention period depends on the yield gain of the variety, yield losses from old varieties, and the risk involved in changing from one variety to another.

The replacement of improved maize seed by farmers in the study area is shown in Table 24. More farmers in Bila-Sayo (67.9%) and Sibu-Sire (66%) purchased improved maize seed every year compared to farmers in Chaliya (48%) and Bako-Tibe (37.1%). All farmers in Bako-Tibe and Sibu-Sire and about 83% in Bako-Tibe and Bila-Sayo replaced hybrids every year. The average number of years since farmers purchased a hybrid was 1.4 in Chaliya, 2.3 in Bako-Tibe, 2.1 in Bila-Sayo, and 2 in Sibu-Sire. From farmers' responses, it was estimated that on average a hybrid needs to be replaced after about 1.7 years in Chaliya, 1.2 years in Bako-Tibe, and 1 year in Bila-Sayo and Sibu-Sire.

Table 24. Replacement of improved maize seed by farmers in western Oromia, 1996

	Western Shewa		Eastern Wellega	
Source of information	**Chaliya (%)**	**Bako-Tibe (%)**	**Bila-Sayo (%)**	**Sibu-Sire (%)**
Improved maize seed purchased every year (%)	48.0	37.1	67.9	66.0
Type of cultivar replaced				
Hybrid	83.3	100.0	83.3	100.0
OPV	16.7	0.0	16.7	0.0
Hybrids purchased (yrs ago)	1.4	2.3	2.1	2.0
Frequency of hybrid replacement (yr)	1.7	1.2	1.0	1.0

7.2 Farmers' Maize Seed Management

About 97% of farmers in Chaliya selected seed from their harvest compared to 94% in both Bila-Sayo and Sibu-Sire and 91% in Bako-Tibe. Eighty percent of farmers in Chaliya reported that selecting good grain or cobs at harvest was the most important seed selection criterion compared to 83% in Bako-Tibe, 55% in Bila-Sayo, and 71% in Sibu-Sire (Table 25). A study by Almekinders et al. (1994) also reported that the selection of large seeds from healthy plants was an important selection criterion for farmers. Less than 6% of farmers in the four woredas had separate fields for seed production. Most farmers stored their seed separately, hanging the cobs high above the fire. About 42% of farmers in Sibu-Sire treated stored maize seed with chemicals compared to about 50% of farmers in the other woredas.

Ninety-four percent of farmers in both Bila-Sayo and Sibu-Sire shelled their seed before planting compared to 88% and 84% in Chaliya and Bako-Tibe, respectively. About 38% of farmers in Bila-Sayo conditioned their seed before planting compared to 33% in Sibu-Sire, 22% in Bako-Tibe, and 15% in Chaliya. In Bila-Sayo and Sibu-Sire, about 60% of farmers used chemicals to condition their seed compared to 53% in Bako-Tibe and 40% in Chaliya.

Table 25. Maize seed management by farmers in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Select seed	97.0	90.7	94.1	93.5
Selection criterion				
Good plants in field	2.5	0.0	5.3	2.2
Good ears at harvest	52.5	38.4	34.2	44.9
Good ears from *gotera* (i.e., local storage structure)	2.5	3.5	5.3	7.9
Good grain at harvest	27.5	44.2	21.1	25.8
Good grain from gotera	0.0	4.7	7.9	3.4
Weevil-free seed from gotera	15.0	9.3	26.3	15.7
Store seed separately	97.0	86.8	94.1	92.2
Method of storage				
Above fire in cobs	87.5	94.8	100.0	95.5
In tree with husk	9.4	5.2	0.0	4.5
Underground	3.1	0.0	0.0	0.0
Seed treatment	41.6	50.0	50.0	51.5
Shell seed separately	88.0	84.0	94.0	94.0
Condition seed before planting	15.0	22.0	38.0	33.0

7.3 Quality of Seed and Strategies for Improving Quality

About 83% of farmers in Bako-Tibe reported they had good quality seed compared to 78% in Bila-Sayo, 68% in Sibu-Sire, and 61% in Chaliya. The characteristics of good seed are shown in Table 26. Good grain filling was the most important criterion for farmers in Chaliya (27.8%), Bako-Tibe (33.3%), Bila-Sayo (36.4%), and Sibu-Sire (38.0%). A second important criterion was germination rate for 25% of farmers in Sibu-Sire, 22% in both Chaliya and Bila-Sayo, and 21% in Bako-Tibe.

When seed quality was poor, farmers used a number of strategies to find superior seed. Thirty-three percent of farmers in Bila-Sayo made sure to obtain seed from a reliable source compared to 21% in Chaliya, 20% in Sibu-Sire, and 15% in Bako-Tibe. The remaining farmers shifted to another cultivar. About 63% of farmers in Bila-Sayo reported that selecting seed at harvest was an important method for improving seed quality compared to 45% in Bako-Tibe, 40% in Sibu-Sire, and 38% in Chaliya. Post-harvest treatment of seed with chemicals was another important method for farmers to ensure good seed for planting.

Table 26. Characteristics of good seed, according to farmers in western Oromia, Ethiopia, 1996

	Western Shewa		Eastern Wellega	
Characteristcs	Chaliya (%)	Bako-Tibe (%)	Bila-Sayo (%)	Sibu-Sire (%)
Good grain filling	27.8	33.3	36.4	38.0
No impurities	11.1	12.7	10.9	8.3
Adapted to local conditions	19.4	13.5	14.5	12.0
Disease free	11.1	11.1	14.5	14.8
High germination rate	22.2	20.6	21.8	25.0
Other	8.3	8.7	1.8	1.9

8.0 Tobit Analysis of Land Allocation to Improved Maize

Feder et al. (1985) defined adoption as the degree of use of a new technology in a long-run equilibrium when a farmer has all of the information about the new technology and its potential. Adoption at the farm level reflects the farmer's decision to incorporate a new technology into the production process. On the other hand, aggregate adoption is the process of spread or diffusion of a new technology within a region. Therefore, a distinction exists between adoption at the individual farm level and aggregate adoption within a targeted region. If an innovation is modified periodically, the adoption level may not reach equilibrium. This situation requires the use of econometric procedures that can capture both the rate and the process of adoption. The rate of adoption is defined as the proportion of farmers who have adopted a new technology over time. The incidence of adoption is the percentage of farmers using a technology at a specific point in time (e.g., the percentage of farmers using fertilizer). The intensity of adoption is defined as the aggregate level of adoption of a given technology (e.g., the number of hectares planted with improved seed).

The tobit model results on the mean proportion of land allocated to hybrid maize are presented in Table 27. The tobit model was used because the proportion of land allocated to improved maize is a continuous variable but truncated between zero and one. The use of ordinary least squares will result in biased estimates (McDonald and Moffitt 1980). In the table, $\delta EY/\delta X_i$ shows the marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable,

Table 27. Tobit model estimates for land allocation to improved maize hybrids

Parameter	Coefficient	Wald statistic	$\delta EY/\delta X_i$	$\delta EY^*/\delta X_i$	$\delta F(z)/\delta X_i$
Constant	-1.4502	4.69***	-0.697225	-0.610479	-1.052637
Farmer's experience	-0.0012364	0.16	-0.000594	-0.000520	-0.000897
Education (dummy)	0.43737	2.12**	0.210278	0.184116	0.317468
Extension (no.)	0.1611	4.03***	0.077453	0.067817	0.116935
Field day (dummy)	0.38603	1.97**	0.185595	0.162504	0.280202
Farm size (timmad)	-0.017662	1.40	-0.008492	-0.007435	-0.01282
Family size (no.)	0.015859	0.66	0.007625	0.006676	0.011511
Hired labor (dummy)	-0.20916	1.03	-0.100559	-0.088048	-0.15182
Livestock (no.)	0.017007	1.18	0.008177	0.007159	0.012345
Off-farm income (Birr)	0.00065	2.36**	0.000313	0.000274	0.000472
High yield	1.2053	6.16***	0.579482	0.507385	0.874874
Resistance to lodging	0.31996	1.63*	0.153830	0.134691	0.232245
Impurity	0.34796	1.63*	0.167292	0.146478	0.252569
Seed conditioning	0.068675	0.35	0.033017	0.028909	0.049848
Sigma			0.53647		
Number of samples			219		
Number of positive observations			90		
Proportion of positive observations (%)			41.1		
z-score			-0.22		
$f(z)$			0.3894		
Log of likelihood function			-121.33		
Wald chi-square (δ_i=0)			123.1***		

Note: * = significant at p<0.1; ** = significant at p<0.05; *** = significant at p>0.01.

$\delta EY^*/\delta X_i$ shows changes in the intensity of adoption with respect to a unit change of an independent variable among adopters, and $\delta F(z)/\delta X_i$ is the probability of change among nonadopters (the probability of adopting improved maize) with a unit change in the independent variable X_i (Roncek 1992). The Wald chi-square statistic was significant at $p<0.01$.

Farmers' education level, the number of extension visits, field days, the amount of off-farm income, and some technology characteristics (high yield, resistance to lodging, and seed purity) significantly influenced the mean proportion of land allocated to improved maize. The marginal effect of education on the area under improved maize was 0.21, and education increased the probability of adoption among nonadopters by 31.7%. Literate farmers are more disposed to understand new ideas and concepts provided by extension workers and other informants. This underlines the importance of human capital development in increasing the area under improved maize.

The marginal effect of extension on improved maize area was 0.07, and extension increased the probability of adoption among nonadopters by 11.7%. Extension workers are an important support service for delivering information on improved maize technologies to farmers, and they also provide necessary inputs.

The marginal effect of attending a field day on improved maize area was 0.19, and increased the probability of adoption among nonadopters by 28%.

The marginal effect of off-farm income on improved maize area was 0.0003, and the probability of adoption among nonadopters increased by 0.04%. Off-farm income enables farmers to make the required down payment to access credit in kind (seed and fertilizer) at the agricultural development offices.

Three technology characteristics significantly influenced the area allocated to improved maize: high yield, resistance to lodging, and seed purity. The marginal effect of farmers' preference for higher yields on improved maize area was 0.58, and the probability of adoption among nonadopters increased by 87.5%. Farmers clearly recognized the yield benefits of hybrids versus local varieties. The marginal effect of farmers' preference for lodging-resistant varieties on improved maize area was 0.15, and the probability of adoption among nonadopters increased by 23.2%. The marginal effect of farmers' preference for pure seed on improved maize area was 0.17, and the probability of adoption among nonadopters increased by 5%.

The tobit model results of the area allocated to improved OPVs are presented in Table 28. The Wald chi-square statistic was significant at $p<0.01$. The number of extension visits significantly influenced the probability of adoption of improved OPVs. The marginal effect of extension on the area allocated to OPVs was -0.08, and extension decreased the probability of adoption among nonadopters by 6.9%. Extension workers in the woredas encourage farmers to grow improved hybrids instead of OPVs.

Table 28. Tobit model estimates for land allocation to improved OPVs

Parameter	Coefficient	Wald statistic	$\delta EY / \delta X_i$	$\delta EY^* / \delta X_i$	$\delta F(z) / \delta X_i$
Constant	0.40443	1.51	0.202626	0.139572	0.166453
Farmer's experience	-0.007632	1.16	-0.003824	-0.002634	-0.003141
Education (dummy)	-0.068113	0.39	-0.034126	-0.023506	-0.028034
Extension (no.)	-0.16655	3.21***	-0.083444	-0.057478	-0.068548
Field day (dummy)	-0.36538	1.88	-0.183062	-0.126095	-0.150382
Farm size (timmad)	0.0099028	0.90	0.004961	0.003418	0.0040757
Family size (no.)	0.026089	1.06	0.013071	0.009004	0.010738
Hired labor (dummy)	0.093014	0.52	0.046601	0.032099	0.038282
Livestock (no.)	-0.021576	1.46	-0.010809	-0.007446	-0.00888
Off-farm income (Birr)	0.0000494	0.17	2.4752E-05	1.7048E-05	2.0332E-05
High yield	0.11484	0.63	0.057537	0.03963	0.047266
Resistance to lodging	-0.33869	1.59	-0.169689	-0.116884	-0.139396
Impurity	-0.25998	1.11	-0.130254	-0.089721	-0.107001
Seed conditioning	0.19806	1.03	0.099231	0.068352	0.081517
Sigma			0.79239		
Number of samples			219		
Number of positive observations			101		
Proportion of positive observations (%)			46.1		
z-score			-0.1		
f(z)			0.397		
Log of likelihood function			-195.44		
Wald chi-square (β_i=0)			31.74***		

Note: * = significant at p>0.1; ** = significant at p<0.05; *** = significant at p>0.01.

9.0 Conclusions and Implications

The farming communities surveyed in four districts of western Shewa and eastearn Wellega zones of Oromia are among the most important maize growers in the country. Farmers in the study area have increasingly planted hybrids and improved OPVs rather than local varieties since the economic reform of 1991, which gave more emphasis to agricultural development and the role of small-scale farmers. To achieve this, the government has strengthened the extension service to better serve small-scale farmers, and this has led to the increased use of improved maize, especially hybrids.

The NSIA estimated the quantity of improved maize seed used in 1996 was 35,120 t, while ESE distributed about 1,670 t of improved maize seed. This implies that about 5% of the improved seed was purchased, while the remaining 95% was recycled.

This study has shown that most farmers rely on extension for information on improved maize technologies. Farmer-to-farmer seed exchange remains the most important mechanism for the diffusion of improved maize seed and should therefore be strengthened by the government through the provision of low-interest finance, technical assistance, and publicly bred parent materials. Another important factor in the adoption of improved maize seed was seed purity. Maize breeding programs should give equal attention to yield and non-yield characteristics when selecting their best varieties, and the extension system should advise farmers on the characteristics and correct adoption zones of newly released maize cultivars.

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