Farmers' Seed Sources and Management of Bread Wheat in **Wolmera Woreda, Ethiopia**

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CIMMYT MR
International Maize and Wheat Improvement Center

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Abstract: Because seed supply and cost strongly influence farmers' ability to increase wheat production, researchers undertook a survey to document how Ethiopian farmers in Wolmera *woreda* acquire, manage, and transfer wheat seed. Wolmera *woreda* was selected for this study because it is typical of the central highlands, one of the most important wheat-growing areas of Ethiopia. A sample of 80 farmers, selected using a multistage sampling procedure, were surveyed using a structured questionnaire. A logit model was used to assess factors affecting adoption of improved wheat varieties. The analysis revealed several means of improving the dissemination of new wheat varieties. The slow rate of varietal replacement in the study area reflects problems with the seed industry and extension services. Radio was the main source of information about improved wheat varieties, and extension agents should use this medium in addition to demonstration and popularization programs, which also influenced the adoption of improved seed. Extension agents should focus on informing younger farmers about how to manage improved seed, given that farming experience was negatively associated with the use of improved wheat. The dissemination of improved varieties through farmer-to-farmer seed exchange indicated that there was demand for improved varieties, but the participation of the formal sector in distributing improved wheat seed is limited. Current changes in the seed industry, such as permission for private firms to participate, the creation of the National Seed Industry Agency, and strengthening of the national extension service, should improve this situation considerably. A clear seed policy would encourage private firms in the production and distribution of improved seed. Farmers themselves could participate in seed production and distribution. Policies and institutional and legal frameworks should be developed to link the formal and informal seed sectors so they can work in a complementary fashion.

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ACRONYMS AND ABBREVIATIONS

AADE	Arsi Agricultural Development Enterprise
AAU	Addis Ababa University
AID Bank	Agricultural and Industrial Development Bank
AISCO	Agricultural Input Supply Corporation
AMC	Agricultural Marketing Corporation
ARDU	Arsi Rural Development Unit
AUA	Alemaya University of Agriculture
DZARC	Debre Zeit Agricultural Research Center
DAP	Diammonium phosphate
ESE	Ethiopian Seed Enterprise
HRC	Holetta Research Center
IAR	Institute of Agricultural Research
MOA	Ministry of Agriculture
MSFD	Ministry of State Farms Development
NGOs	Non-governmental organizations
NVRC	National Variety Release Committee
PGRC	Plant Genetic Resource Center
SCs	Service Cooperatives
WA	Weighted average

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EXECUTIVE SUMMARY

Wheat is one of the major cereals grown by subsistence farmers in Ethiopia, usually under rainfed conditions. Wheat area increased from 600,000 to 760,000 ha between 1979/80 and 1994/95, but the national average yield is less than 1.5 t/ha. For more than 20 years, research has been conducted to improve the productivity of bread wheat, and the improved varieties and agronomic practices (including fertilizer recommendations) emerging from this research have been demonstrated to farmers and extension agents. Since 1976/77, farmers in Wolmera woreda (a woreda is an administrative division) have used improved wheat varieties, but the persisting gap between farmers' actual yields and potential yields led researchers in 1992 to conduct a study to quantify the extent of adoption of improved wheats and identify problems associated with adoption. The study revealed that two major reasons that farmers did not adopt new wheat technologies were their unavailability and the high cost of seed. Only a limited number of institutions are involved in local seed supply, and their performance is particularly weak in relation to serving small-scale farmers.

Because seed supply and cost strongly influence farmers' ability to increase wheat production, the present study was undertaken to gather more detailed information about these important issues. The study sought to identify how farmers acquire, manage, and transfer seed; to explore problems related to farmers' seed acquisition and transfer mechanisms; to document the status of previously released bread wheat varieties; and to describe the seed system in Ethiopia.

Wolmera woreda was selected for this study because of its proximity to Holetta Research Center (HRC). Located along the Addis Ababa-Ambo road, 30-50 km west of Addis Ababa, the HRC is at an altitude of 2,400 masl, and annual rainfall is 1,085 mm. The mean minimum and maximum temperatures are 5.8°C and 22°C. The soils are predominantly Nitosols with minor pockets of Vertisols.

Wolmera is typical of the central highlands, which is one of the most important wheat-growing areas of Ethiopia. Major crops in the farming system include wheat, teff, barley, and faba bean. All farmers own cattle, which are kept mainly for draft power and sold during crop failures to meet immediate cash needs. Wheat is the second most important crop in terms of area and is a staple food as well as a source of cash. More than 85% of the farmers in the area grow wheat mainly for food, on 25-35% of the cultivated land. Only surplus production above the family need is occasionally sold. Although wheat is grown by 94% of sample farmers, the average yield was less than 1.0 t/ha, lower than the national average. All farmers use improved varieties although recently released varieties are not available in the area.

A multistage sampling procedure was used to draw a sample of farmers. Five peasant associations (PAs) within a radius of 20 km from HRC were identified. Two PAs (Wolmera Goro and Robe Gebeya) where HRC had conducted several wheat demonstrations and popularization campaigns were purposively selected for this study. A total of 80 farmers (40 from each PA) were selected randomly from the list of PAs with the help of the development agent. Under the supervision of researchers, trained enumerators interviewed farmers using a structured questionnaire. Farmers' adoption of improved wheat varieties, their seed sources, and their seed management practices were compared for the two PAs. A logit model was used for adoption of improved wheat varieties because it is computationally easier to estimate. The model was estimated using the maximum likelihood method.

The average family size for the total sample was seven persons. The mean number of male family members who help the farmer in crop production was 1.7, while the number of females was 1.9. Of the total sample of 80 households, 74 were male-headed households and 6 were female-headed households. Almost all sample farmers were married, except two who were divorced. Among sample farmers only 22% were illiterate. Of the remainder, 43% were literate and 35% had some formal education. The average age of sample farmers was about 51 years and the mean number of years dedicated to farming was 29.

The seed industry component of the study looked at both the formal and informal seed sectors. The formal sector includes research institutions, agricultural ministries, development projects, public and private seed enterprises. Farmers, non-governmental organizations (NGOs), and relief agencies constitute the informal sector. The development of new varieties is handled by the research institutions. Before a variety is recommended for release, its disease resistance, productivity, stability, and quality are tested in farmers' fields. After farmers' assessment and proper evaluation, varieties are officially released by the National Variety Release Committee. The Ethiopian Seed Enterprise (ESE) buys breeder's seed from the Institute of Agricultural Research (IAR), Alemaya University of Agriculture (AUA), and Addis Ababa University (AAU) and multiplies basic seed on its own farms. The ESE also contracts with state farms, the Ministry of Agriculture (MOA), and private producers to produce seed. The ESE has five processing plants to clean and distribute seed. Finally, the ESE provides seed wholesale to the Agricultural Input Supply Corporation (AISCO), Ministry of State Farms Development, and NGOs. Seed and other inputs are supplied to the peasant sector by AISCO, which uses the development agents of MOA and Service Cooperatives (SCs) to obtain seed orders and distribute seed and other inputs. The SCs are made up of two or more PAs. The Cooperatives buy seed and fertilizer on credit and purchase other inputs with cash from AISCO and distribute them to farmers. The SCs obtain credit for inputs from the Agricultural and Industrial Development Bank (AID Bank).

About 78% of farmers in Wolmera Goro and 68% in Robe Gebeya were aware of improved bread wheat varieties. Their sources of information were radio (37% and 52% for Wolmera Goro and Robe Gebeya, respectively), other farmers who participated in on-farm trials and demonstrations (35% and 32%), and MOA extension agents (20% and 15%). The improved bread wheat varieties known and grown by most farmers were ET-13, Dashen, and Enkoy. ET-13, HAR-1709, and HAR-1685 are the recommended varieties for the area. Dashen, which has white grain and is the variety most favored by farmers in lower altitude zones, is no longer recommended because of susceptibility to stripe rust. Although Enkoy is a widely adapted variety, it is not liked by farmers because of its color, and it has recently been affected by stem rust. However, farmers still grew both varieties because the recommended ones were not available. Farmers in Wolmera Goro first obtained seed through neighboring farmers (35%), HRC (27.5%), and MOA (17.5%). In Robe Gebeya farmers first obtained seed from other farmers (65%) and MOA (15%). Farmers' sources of seed of these varieties in the 1995 crop season were their last harvest (75% and 58% for Wolmera Goro and Robe Gebeya, respectively), neighboring farmers (8% and 28%), and HRC/MOA (12% and 12%). Farmers who recycled seed from their previous harvest had originally received the seed from demonstration and popularization programs between 1988 and 1995. Only one farmer planted the new variety HAR-1709 in 1995, and he obtained the seed from HRC. He had learned about the variety from the MOA development agent, although he lives near the HRC.

A few farmers (4%) maintained separate fields for seed production and selected the seed production field before planting. These fields were selected for seed production because they were relatively more fertile and less weedy. Farmers applied more fertilizer to seed production fields and weeded them on time. Farmers who did not have separate fields for seed production selected seed during threshing (68%), harvesting (11%), and at planting (11%). Most farmers (80%) kept their seed separately from grain, either in sacks or in local storage structures. The majority of farmers (94%) clean their seed before planting, and the majority (80%) also agreed that seed should be replaced every two to four years before it is attacked by diseases.

This study has several implications for improving the dissemination of new wheat varieties. Because radio was the main source of information about improved wheat varieties, extension agents could use this medium in addition to the demonstration and popularization programs to teach farmers about the improved seed and related technologies. One factor that influenced the adoption of improved seed was receiving an extension visit, which calls for a strong extension program in the major wheat-growing areas.

The most important source of seed was farmers themselves. The dissemination of improved varieties through farmer-to-farmer seed exchange indicated that there was demand for improved varieties, but the participation of the formal sector in distributing improved wheat seed is very limited (in the study area, it was negligible). Seed suppliers should be encouraged to disseminate improved seed to small farmers. There should be a clear seed policy to encourage private firms in the production and distribution of improved seed. Farmers themselves could participate in seed production and distribution and benefit considerably, since there would be minimal bureaucracy. Younger farmers could particularly take advantage of such a system, because they are more aware of the advantages of improved seed.

Farmers had different views on the number of years a new variety yields well before it must be replaced, but they generally agreed that seed needs to be replaced every four years. This implies that breeders have to maintain seed quality and distribute new stock every four years to seed suppliers. The weighted average age of varieties grown in farmers' fields was found to be 13 years for the study area. This slow rate of varietal replacement reflects the poor development of the seed industry and the ineffectiveness of the extension services. Current changes in the seed industry, such as permission for private firms to participate, the creation of the National Seed Industry Agency, and strengthening of the national extension service, should improve this situation considerably. But the seed sector would become even more effective if policies and institutional and legal frameworks were developed to link the formal and informal sectors so they could work in a complementary fashion.

1.0 INTRODUCTION

1.1 Background of the Study

Wheat is one of the major cereals grown in Ethiopia, mainly by subsistence farmers under rainfed conditions. Smallholders cultivate 82% of the wheat area and account for 76% of wheat production (Adugna Haile et al. 1991). Wheat area increased from 600,000 to 760,000 ha between 1979/80 and 1994/95 (CSA 1989; CSA 1995), but the national average yield remains less than 1.5 t/ha (Hailu Beyene and Chilot Yirga 1992).

Research to improve the productivity of bread wheat has been conducted for more than 20 years at Holetta Research Center (HRC), located in Wolmera woreda, 30-50 km west of Addis Ababa. Based on the results of research conducted at this experiment station, several recommendations on varieties and agronomic practices (including fertilizer types/rates and herbicide) have been made to farmers. Most of these technologies have been demonstrated to extension agents and a selected group of contact farmers or have been part of popularization campaigns. Except for herbicide in some rare cases, all demonstrations were handled by government organizations. For the demonstrations, farmers received all inputs (seed and fertilizer) free of charge from researchers; farmers in turn provided the land and the necessary labor for the demonstration plot. Farmers participating in popularization programs received technical advice from researchers but paid for all the inputs themselves.

Farmers in Wolmera woreda began using improved varieties in 1976/77, when the Department of Agricultural Economics initiated programs to demonstrate wheat and barley technologies available from HRC to the neighboring community (Mulugetta Mekuria et al. 1992). To quantify the extent to which these wheat technologies had been adopted, and to identify constraints to adoption, a study was conducted in 1992. Farmers' two most important reasons for not adopting wheat technologies were the lack of seed or its high cost (Hailu Beyene and Chilot Yirga 1992).

The role of improved varieties, particularly of wheat and rice, in alleviating poverty has been widely debated (see, for example, Dasgupta 1977; Singn 1990). Generally it has been concluded that the generation and dissemination of improved varieties with their complementary inputs have relieved millions of poor farmers from the threat of famine. According to one conservative estimate from Ethiopia, the incremental production arising from use of certified seed in Arsi region was estimated to be in the range of 2-5 qt/ha (Linden and Wellving 1985). However, a continuous, reliable supply of certified seed is lacking in Ethiopia, and farmers reportedly use recycled seed that has a low germination rate and is contaminated by many weed seeds (Ayele Badebo and Lindeman 1987; Linden and Wellving 1985; MOA/SEAD 1986). Moreover, rapid evolution of rust pathogens means that wheat varieties need to be replaced more frequently and regularly in Ethiopia's wheat-growing areas than in other parts of the world.[1] These circumstances highlight the need for strong frameworks to govern the testing, release, and distribution of new seed.

[1] The decision by farmers to change varieties already adopted is termed "variety replacement," whereas the decision to obtain fresh seed stocks of the same variety is termed "seed renewal."

1.2 Objectives of the Study

Given the limited adoption of newer improved wheat varieties in the study area and the problems perceived with seed production and distribution, the objectives of this study were:

- To describe the seed system in Ethiopia.
- To identify farmers' seed acquisition, management, and transfer mechanisms.
- To explore problems related to farmers' seed acquisition and transfer mechanisms.
- To document the status of previously released bread wheat varieties.

1.3 The Study Area

Because of its proximity to HRC, Wolmera woreda was selected for this study. The woreda is primarily dominated by Oromo Christians. The area is located along a good tarmac road (the Addis Ababa-Ambo road), providing access to weekly markets at Holetta (capital of Wolmera) and Menagesha. The elevation of HRC is 2,400 masl, and the area receives 1,085 mm annual average rainfall (1969-94). More than 70% of the rain falls from June to September. The mean minimum and maximum temperatures are 5.8°C and 22°C, respectively (Hailu Gebremariam 1992). Soils are predominantly red-brown Nitosols with minor pockets of Vertisols (Hailu Beyene and Chilot Yirga 1992).

The major crops in the farming system are wheat, teff, barley, and faba bean. Most farmers had two plots for wheat, teff, and barley and only one plot for pulses. All farmers own cattle, which are kept mainly for draft power (land preparation and threshing) and sold during crop failures to meet immediate cash needs.

Wolmera woreda represents the central highlands, one of the most important wheat-growing areas of Ethiopia (Figure 1). Wheat is the second most important crop in terms of area and is a staple food as well as a source of cash. In this area, more than 85% of farmers grow wheat mainly for food, and the crop occupies 25-35% of the cultivated land (Hailu Beyene and Chilot Yirga 1992). Only surplus production above the family's need is occasionally sold. Although wheat is grown by 94% of sample farmers, the average yield was less than 1.0 t/ha, which is significantly below the national average of 1.5 t/ha (Hailu Beyene 1993).

One wheat crop is grown per year, usually from April to December. Land preparation commences at the onset of the rains, which can vary from January to April. Farmers mainly wait for the rains because they soften the soil, which otherwise is too hard to be broken by the local wooden plows with their metal blades. The number of plowings ranges from two to four. Farmers plant in June. Wheat seed is broadcast with fertilizer on a flat seedbed and covered using the ox-drawn plow.

All farmers use improved varieties, although recently released varieties are not available in the area. The most commonly used fertilizer is diammonium phosphate (DAP), 18-46-0. About 80% of the sample farmers use fertilizer at the rate of 40 kg/ha. Peasant farmers' use of fertilizer depends on its availability and fertility of the soil. The quantity of fertilizer supplied to farmers is generally less than what they demand.

The use of hand weeding and post-emergence herbicide (2,4-D) are common in wheat production. However, wheat is weeded later than recommended because of overlapping of activities. Most farmers (55%) perform one hand weeding. When herbicide is available, many farmers use it to control broadleaf weeds, and about 57% of farmers apply herbicide to their wheat. The rate ranges from 0.3 to 0.4 l/ha depending on the weed infestation, whereas the recommended rate is 1.0 l/ha (Hailu Beyene and Chilot Yirga 1992).

Wheat is harvested from November to December, depending on sowing date and variety. Harvesting is manually done with a sickle, and harvested sheaves are piled in the field until threshing. Threshing is done using oxen to trample on the wheat on a small threshing ground (a hard surface of sun-dried dung and soil).

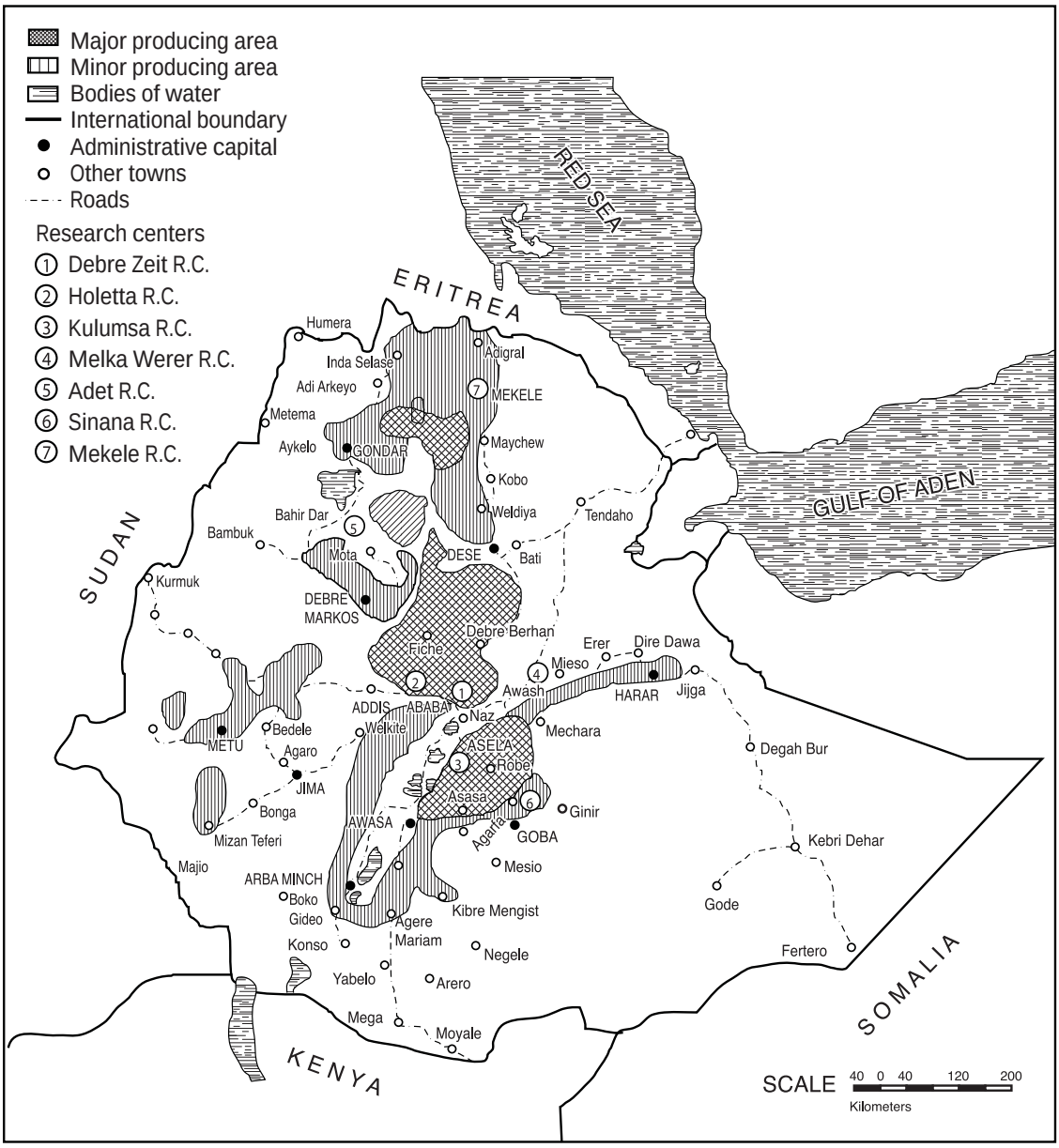

Figure 1. Major and minor wheat production areas in Ethiopia.
Source: Land Use Planning and Regulatory Department, MOA.

2.0 METHODOLOGY

2.1 Sampling Method and Survey Procedure

A multistage sampling procedure was used to draw a sample of farmers for the survey. Five peasant associations (PAs) within a 20 km radius of HRC were identified. Two PAs, Wolmera Goro and Robe Gebeya, where the research center had conducted several demonstrations and popularization campaigns, were purposively selected for this study. Wolmera Goro is near HRC (5-10 km) and Robe Gebeya is more distant (15-20 km). A total of 80 farmers, 40 from each PA, were selected randomly from the PA lists with the help of the development agent. An equal sample was selected from each PA, since they each have approximately the same number of members (254 in Wolmera Goro and 250 in Robe Gebeya).

A structured questionnaire developed for a similar study by agricultural economists at Kulumsa Research Center was adapted for this study. Pre-testing was not done because it had been undertaken by the Kulumsa research group. Farmers were interviewed by trained enumerators supervised by researchers. Farmers' adoption of improved wheat varieties, sources of seed, and seed management were compared for the two PAs.

2.2 Analytical Model

The two most common functional forms used in adoption studies are the logit and the probit models. The advantage of these models is that the probabilities are bounded between 0 and 1. Moreover, they compel the disturbance terms to be homoscedastic because the forms of probability functions depend on the distribution of the difference between the error term associated with one particular choice and another. Usually a choice has to be made between logit and probit models, although the statistical similarities between the logit and probit models make such a choice difficult (Amemiya 1981). The choice of model may be evaluated a posteriori on statistical grounds, although even here, in practice, there will usually not be strong reasons to choose one model over the other. We selected the logit model because it is computationally easier to estimate.

Following Pindyck and Rubinfeld (1981), the model is written as:

$$[1] \quad \text{Ln}\,[P/(1-P)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + e,$$

where:

X_1 = 1 if the farmer is in Wolmera Goro, 0 otherwise.
X_2 = farmer's farming experience in years.
X_3 = 1 if farmer is literate, 0 otherwise.
X_4 = 1 if farmer attended field days or demonstration trials, 0 otherwise.
X_5 = 1 if farmer had extension contact, 0 otherwise.
X_6 = farm size (ha) per household.
X_7 = 1 if farmer served as a contact farmer, 0 otherwise.

X_8 = 1 if farmer attended farming course, 0 otherwise.
X_9 = 1 if farmer owned radio, 0 otherwise.
X_{10} = Family size (number of persons).
e = error term.

The dependent variable is the natural log of the probability of awareness of the new wheat variety (P), divided by the probability of unawareness (1-P). The model was estimated using the maximum likelihood procedure of the Statistical Package for the Social Sciences (version 6.1).

Formation of the model was influenced by a number of working hypotheses. Several variables were hypothesized to influence the adoption of new wheat varieties in the study area.

Proximity to HRC (less than 10 km) (X_1): It is hypothesized that those farmers who are nearer to HRC will receive information on new wheat varieties, whereas farmers who are farther away will not. Nearness to the research center should increase the probability that farmers adopt new wheat varieties.

Farming experience (X_2): In the study area, new agricultural technologies are often tested by the HRC as part of the Center's outreach program. Thus farmers are frequently exposed to improved crop varieties. Consequently, experience in farming is likely to increase the farmer's adoption of new wheat varieties.

Farmer's education level (X_3): Formal schooling enhances the farmer's ability to perceive, interpret, and respond to new events in the context of risk. Hence education is likely to increase the probability of adoption of new wheat varieties.

Farmer attended field day or demonstration trial (X_4): Attending field days or demonstration trials gives the farmer access to information, which increases the likelihood that the farmer will adopt new wheat varieties.

Extension contact (X_5): Contact with extension gives the farmer access to information and increases the likelihood that the farmer adopts new wheat varieties.

Farm size (ha) per household (X_6): Population pressure in the study area is causing a land shortage, and the scope for increasing land productivity will rely on increased cropping intensity. This in turn will require farmers to allocate their limited land to newer and better yielding wheat varieties. Hence, cultivated land per person is hypothesized to increase a farmer's adoption of new wheat varieties.

Serving as contact farmer (X_7): Serving as a contact farmer gives a farmer access to information and should increase the likelihood of adopting new wheat varieties.

Farmer attended farming course (X_8): Attending a farming course exposes the farmer to new agricultural technologies. Hence, it is hypothesized that such a course would increase adoption of new wheat varieties.

Farmer owns radio (X_9): Ownership of a radio gives the farmer access to information, especially if he/she listens to agricultural programs. Ownership of a radio is hypothesized to positively increase adoption of new wheat varieties.

Family size (X_{10}): Larger households will be able to provide the labor that might be required by improved wheat technologies. Thus a larger family size would be expected to increase the probability of adopting new wheat varieties.

Before proceeding to discuss the results of the survey and the logit model, some background information on the structure and functions of the seed sector in Ethiopia is needed. In the next section, then, we will review the history and performance of the wheat seed industry.

3.0 THE SEED INDUSTRY IN ETHIOPIA

3.1 Seed Industry Structure

Douglas (1980), in his life cycle model of seed industry development, showed that seed supply systems in most countries pass through four evolutionary stages characterized by increasing technological and organizational complexity:

1. During the first stage, farmers save their own seed from crop to crop by selecting the most productive plants and exchange seed with a few farmers.
2. In the second stage, 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. During the third stage, private seed companies enter the seed industry and invest in plant breeding research and development and seed growing, processing, and marketing.
4. In the fourth stage, 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 in the second stage of seed industry development. Improved varieties are developed by national research systems 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 seed supply is constrained by the 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 demand for improved seed. As a result, in the peasant sector most seed is still produced by farmers themselves (Hailu Gebremariam 1992).

The Ethiopian seed industry is characterized by formal and informal sectors. The formal sector includes research institutions, agricultural ministries, development projects, and public and private seed enterprises. The participants in the informal sector are farmers, non-governmental organizations (NGOs), and relief agencies.

3.1.1 The formal sector

Varietal development is handled by the Institute of Agricultural Research (IAR), Alemeya University of Agriculture (AUA), Addis Ababa University (AAU), and regional state agricultural research establishments. Hence plant breeding has been done mainly by public institutions (Pioneer Hi-Bred International has also done some varietal development).

Before a variety 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, varieties are officially released by the National Variety Releasing Committee (NVRC). But this procedure is sometimes violated. For instance, in 1991, Pioneer tried to produce 144 ha of hybrid maize and 60 ha of sunflower using imported seed that had not been tested. The company harvested only 71.1 t of maize seed whereas the sunflower did not even set seed.

The Ministry of Agriculture (MOA), particularly Arsi Rural Development Unit (ARDU) and the Ministry of State Farm Development (MSFD), have undertaken a limited amount of seed production and distribution since the late 1960s. The MSFD produced seed to meet its own requirements, whereas ARDU produced different kinds of seed for peasant farmers in Arsi.

The Ethiopian Seed Enterprise (ESE) was incorporated in 1979 to produce, process, and market seed. Initially, the ESE supplied improved varieties only for state farms and producers' co-operatives that were the foundation of the socialist economy. Now the ESE 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).[2]

The ESE is supplied with breeder and basic seed by IAR, and AUA and multiplies this seed at two of its basic seed farms. The 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. From 1980 to 1991, on average, ESE produced and distributed 23,065 t of seed per year (Table 1). Although there are no supporting data, it is believed that ESE should presently distribute more than this amount of seed, given the high demand for improved varieties and the strong, government-supported extension program.

Table 1. Seed distribution (000 t) by Ethiopian Seed Enterprise (1980-91)

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	7.10	1.24	1.14	0.03	0.10	9.61
Total	194.31	16.98	54.05	4.19	7.26	276.79

Source: Hailu Gebremariam (1992).

The seed required for the peasant sector is collected by the Agricultural Input Supply Corporation (AISCO) of MOA from the processing plants and distributed to farmers through the Service Co-operatives (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 24,687.9 t of seed from ESE and purchased only about 21%. This left ESE with a large residual seed stock every year. Furthermore, AISCO actually distributed only

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

part (60%) of what it had purchased. This discrepancy in production and distribution of seed to peasant farmers is caused by related 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 MOA offices. The ESE seed prices should be lower than those of AISCO because ESE services are less. AISCO used to charge 20 Birr[3] per 100 kg over 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 the purity and quality of seed supplied by ESE has sometimes been disputed by farmers and development workers (Hailu Beyene 1993).

In general, the formal sector's contribution to seed supply has been very low, but it is improving. Seed distribution by IAR-Debre Zeit Agricultural Research Center (DZARC) through on-farm testing, demonstration, and popularization, and through the Plant Genetic Resource Center (PGRC) and community level landrace conservation initiatives is minimal. However, these efforts have contributed to the distribution of improved varieties through farmer-to-farmer seed exchange, although the distribution of the research centers is limited to their immediate vicinity.

3.1.2 The informal sector

Ethiopian farmers have been practicing seed selection and preservation for centuries. Even today the bulk of the national seed requirement is met through this informal system of local seed maintenance and exchange. Of the total annual seed requirement of about 0.42 million t, 15% is produced by the formal sector as improved seed stock, whereas local varieties from the informal farmer-to-farmer exchange system constitute 85% of the total seed requirement (Table 2).

The role played by NGOs and relief agencies in the seed industry is difficult to assess. Their activities are dispersed and uncoordinated, because their operations are mainly based on providing emergency relief and on replacing seed lost as a result of natural disasters or civil disorders. Initially NGOs were assumed to be responsible for acquiring and providing early generation seed to SCs at cost, including transport. In fact, the distribution of free seed by NGOs and relief agencies had several negative effects, 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 tend to work well with small-scale, resource-poor farmers, who are mostly located in remote and inaccessible areas. Others have observed that very few improved wheat varieties released or recommended by the research system have reached farmers, mainly because of the poor seed dissemination mechanism (Adugna Haile et al. 1991).

3.1.3 Potential seed users

In the Wolmera study area, potential seed users can be categorized into three groups: small-scale farmers, state farms, and the contract farmers who have emerged since the economic reform of 1991. The sources of seed for each of these groups of farmers differ slightly (Figure 2); for instance, state farms depend mostly on formal seed channels.

[3] 7 birr = US$ 1.

Table 2. Annual harvested area, estimated area planted with improved varieties/hybrids, quantity of improved seed used, and share of area planted to landraces/local varieties and improved varieties of major food crops, Ethiopia

Crop	Harvested area (000 ha)	Area under improved varieties (000 ha)	Quantity of improved seed used ('000 qt)	Percent area planted with local materials	Percent area planted with improved materials
Teff	1389.2	27.8	8.3	98.0	2.0
Bread wheat	380.5	304.4	456.6	20.0	80.0
Durum wheat	396.0	15.8	19.7	96.0	4.0
Barley	987.2	39.5	43.4	96.0	4.0
Maize (OPVs, hybrids)	1037.8	363.2	109.0	65.0	35.0
Sorghum	887.0	149.0	14.9	83.2	16.8
Finger millet	213.6	0.0	0.0	100.0	0.0
Emmer	37.4	0.0	0.0	100.0	0.0
Cereals	**5317.7**	**899.7**	**651.9**	**83.1**	**16.9**
Faba bean	284.7	2.8	5.6	99.0	1.0
Field pea	131.0	0.0	0.0	100.0	0.0
Chickpea	126.2	0.0	0.0	100.0	0.0
Lentil	50.4	0.5	0.3	99.0	1.0
Grass pea	52.0	0.0	0.0	100.0	0.0
H. bean	45.1	33.8	20.3	25.0	75.0
Soybean	2.4	1.9	1.7	20.0	80.0
Pulses	**691.8**	**39.0**	**27.9**	**94.4**	**5.6**
Noug (Niger seed)	157.8	1.6	0.2	99.0	1.0
Linseed	87.8	1.8	0.4	98.0	2.0
Rapeseed	57.2	8.6	1.0	85.0	15.0
Sesame	7.7	0.0	0.0	100.0	0.0
Groundnut	5.2	1.0	0.8	80.0	20.0
Fenugreek	10.2	0.0	0.0	100.0	0.0
Sunflower	53.4	5.1	0.5	90.4	9.6
Oilseeds	**379.3**	**18.1**	**2.9**	**95.2**	**4.8**
Total	**6388.8**	**956.8**	**682.7**	**85.0**	**15.0**

Source: Hailu Gebremariam (1992).

3.2 Mechanisms of Wheat Seed Development and Supply

The bread wheat seed industry comprises several processes, beginning with varietal development, testing, and release and proceeding to processing, distribution, and marketing.

3.2.1 Varietal development, testing, and release

Bread wheat research in Ethiopia depends mainly on introduced germplasm, because the stock of local bread wheats is too limited in number and variability to constitute a viable, economic breeding program. Introduced materials may be used as parents for further breeding research or included in the Advanced Observation Nursery (AON). Materials evaluated in the AON are further evaluated for two years, mainly for yield disease resistance and other desirable traits, in the Preliminary Yield Trial (PYT) and the Pre-National Variety Trial (PNVT). Promising genotypes are then included in National Variety Trial (NVT) for evaluation for two to three years.

At this stage, some of the promising lines in the NVT may be included in the Cooperative Variety Adaptation Trial (CVAT) and tested for three more years at more than 20 locations in major wheat-growing environments of the country. The best materials from the NVT and CVAT are included in the Variety Verification Trial (VVT), which is conducted both on-station and on-farm under recommended

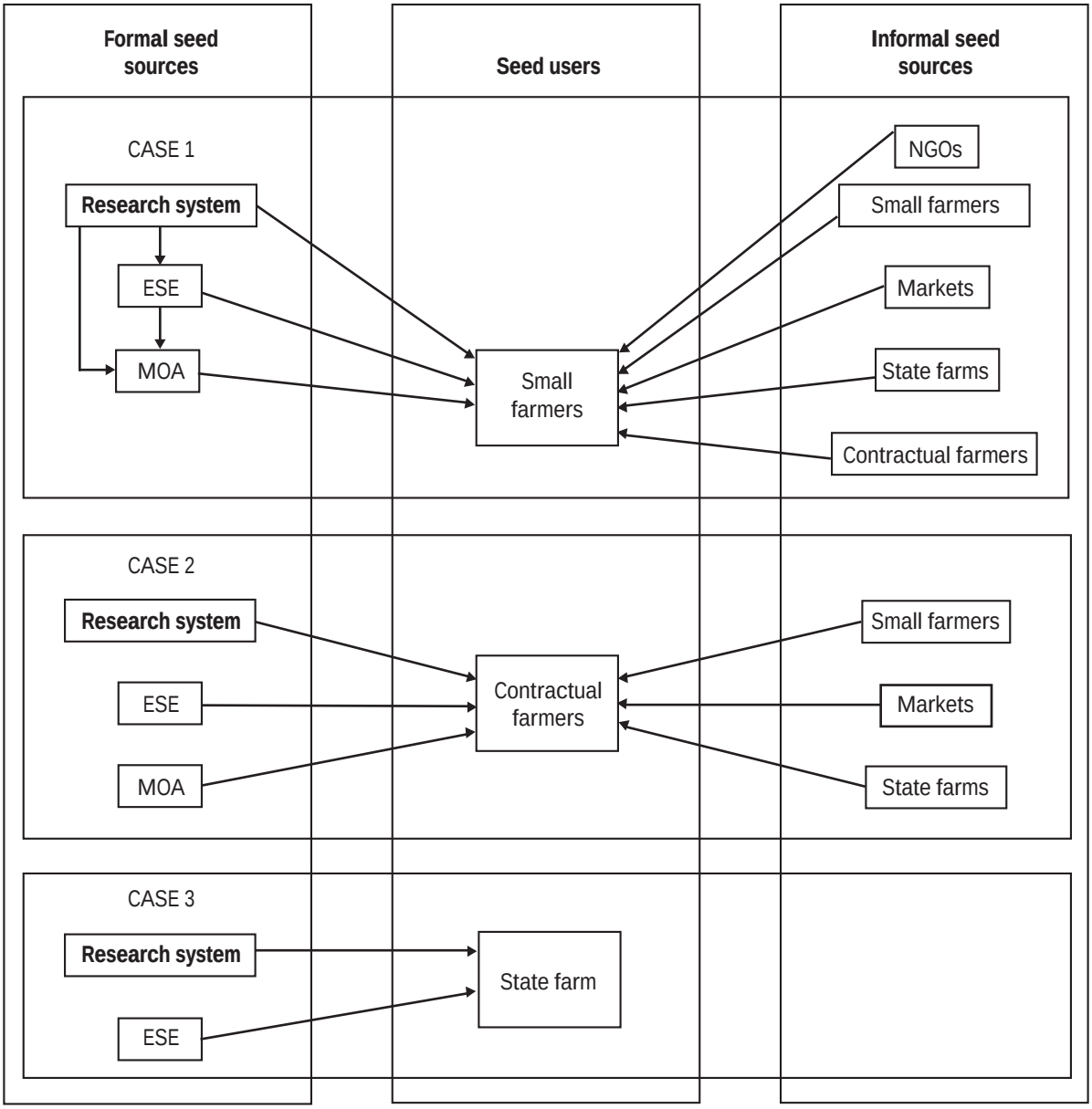

Figure 2. Mechanisms of seed supply in Wolmera woreda, Ethiopia.
Note: ESE = Ethiopian Seed Enterprise; MOA = Ministry of Agriculture; NGOs = non-governmental organizations.

and farmers' levels of management for one to two years. The objectives of the VVT are to obtain farmers' pre- and postharvest assessment of varieties, to evaluate the performance of the varieties in a real production system, and to assist in the decision of the variety release committee. The committee is composed of professionals from different research and seed user organizations (e.g., IAR, MOA, ESE). 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 the variety may be unnecessarily delayed because of the stringent variety release mechanism.

After a variety is released, it is included in Breeder Seed Increase (BSI). Breeder seed is then provided 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 2,957.4 t of seed (Table 3). Most of this seed was hybrid maize from Kenya and hybrid sunflower from Argentina. Since ESE became the partner of Pioneer Hi-Bred International in a joint venture established in 1990, the ESE tends to import more seed. If this trend continues, it 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, AID Bank, Commercial Bank of Ethiopia, the SCs, and private organizations.

Commercial seed production and processing are handled by ESE. AISCO distributes seed through SCs, which receive loans from AID Bank and the Commercial Bank of Ethiopia to purchase the 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 unaware of which seed farmers want, because it has produced and distributed seed that farmers did not request. A better marketing effort could play an important role in the diffusion of new varieties. For example, a greater effort could be made to convince farmers to use improved varieties and differentiate between grain and improved seed.

Table 3. Seed imports by Ethiopian Seed Enterprise (1986-91)

Year	Crop	Country	Quantity (t)	Price (US$/t)
1986	Hybrid maize	Kenya	3.8	750.00
	Malt barley	Kenya	0.5	900.00
1987	Hybrid maize	Kenya	980.0	996.00
	Hybrid maize	Zimbabwe	120.0	834.70
	Malt barley	Spain	150.0	626.00
	Sunflower	Argentina	11.0	3,513.20
1988	Hybrid maize	Kenya	580.0	869.70
	Maize, basic	Kenya	30.0	899.80
	Sorghum	Kenya	10.0	869.70
	Maize, basic	France	2.03	22,434.10
	Sunflower	Zimbabwe	33.0	3,821.30
	Sunflower	Argentina	30.0	3,821.30
	Sunflower, basic	Argentina	0.15	84,000.00
	Pepper	Argentina	0.1	43,500.00
1989	Maize, basic	Zimbabwe	2.5	17,076.40
	Sunflower	Argentina	47.5	4,471.20
1990	Sunflower	Argentina	11.5	3,022.40
	Maize, basic	Malawi	0.3	21,866.70
	Cotton	Israel	0.6	10,225.00
1991	Hybrid maize	Kenya	900.0	1,000.00
Total			2,957.4	

Source: Hailu Gebremariam (1992).

4.0 SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF SAMPLE FARMERS

The average family size in the sample was seven persons (SD = 2.5). The mean number of male family members who helped the farmer in crop production was 1.7 (SD = 0.82), and the number of female family members was 1.9 (SD = 1.17). These findings were roughly similar for both PAs (Table 4).

Of the 80 households that formed the sample, 74 were male-headed and 6 were female-headed (4 widows, 2 divorcees). Wolmera Goro had 36 male-headed households compared to 38 in Robe Gebeya. Of the 6 female-headed households, 4 (3 widows, 1 divorcee) were in Wolmera Goro, and 2 (1 widow, 1 divorcee) were in Robe Gebeya. Almost all sample farmers were married, except two (one each in the two PAs) who were divorcees. Among sample farmers, only 22% were illiterate. Of the remainder, 43% were literate and 35% had formal education (Table 5). Farmers in the two PAs were not statistically different in their levels of education. The average age of sample farmers was about 51 years (SD = 15.78). The mean years of farming was about 29 years (SD = 16.32). Farmers in the two PAs were not statistically different in their ages and years of farming (Table 5). Only 6% (4% in Wolmera Goro and 2% in Robe Gebeya) of farmers had off-farm work.

Table 4. Mean family size and number of family members who assist the farmer, Wolmera woreda, Ethiopia

Item	Wolmera Goro (N=40) (Mean)	Robe Gebeya (N=40) (Mean)
Family size	7.5	7.0
Male family members	1.7	1.7
Female family members	1.9	2.0

Table 5. Age of farmer, years of farming, and level of education, Wolmera woreda, Ethiopia

	Wolmera Goro		Robe Gebeya		
Item	Mean	Standard deviation	Mean	Standard deviation	t-statistic
Age	52	15.13	51	16.57	0.35 (NS)
Years of farming	30	15.67	29	17.14	0.94 (NS)
Level of education	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers	
Illiterate	9	22.5	9	22.5	
Literate	17	42.5	17	42.5	
Elementary (1-6)	9	22.5	7	17.5	
Junior (7-8)	2	5.0	3	7.5	
High school (9-12)	3	7.5	4	10.0	

Note: NS = not significant; + = standard deviations.

The majority of farmers in the two PAs had land of medium fertility, while equal numbers of farmers in each PA had fertile as well as unfertile land. More farmers in Robe Gebeya had fertile and infertile land than farmers in Wolmera Goro. For land of medium fertility, the reverse was true. For the three types of land, farmers in Robe Gebeya had more land area than farmers in Wolmera Goro. However, the difference was significant at the 5% level for land of medium fertility only (Table 6).

The two PAs were statistically different in their average size of land holding, cultivated land, pasture land, and land rent in cash (Table 7). More than 80% of farmers had pasture land and only 16% of farmers reported that they had fallowed their land. About 38% of farmers rented in land (16% in cash and 22% in kind), and only one farmer rented out land in kind.

Table 6. Farmers' perceptions of soil fertility, Wolmera woreda, Ethiopia

	Wolmera Goro			Robe Gebeya			
Fertility level	Number of farmers	Area (ha)	Standard deviation	Number of farmers	Area (ha)	Standard deviation	t-statistic
Fertile	18	0.47	0.27	24	0.62	0.32	1.54 NS
Medium fertile	36	0.81	0.56	31	1.19	0.77	2.28 **
Infertile	18	0.59	0.34	24	0.72	0.51	0.99 NS

Note: NS = not significant; ** = significant at 5% level.

Table 7. Sample farmers' land holdings in Wolmera woreda, Ethiopia (ha)

	Wolmera Goro		Robe Gebeya		
	Mean	Standard deviation	Mean	Standard deviation	t-statistic
Farm size	1.70	0.87	2.61	1.45	3.40***
Cultivated land	1.17	0.54	1.68	0.88	3.09***
Pasture land	0.58	0.39	0.82	0.73	1.81*
Fallow land	0.38	0.18	0.68	0.39	1.06 (NS)
Land rented in (for cash)	0.32	0.06	0.70	0.28	3.76***
Land rented in (in kind)	0.40	0.18	0.58	0.26	1.71 (NS)

Note: NS = not significant; * = significant at 10% level; *** = significant at 1% level.

5.0 FARMERS' SOURCES OF SEED AND SEED MANAGEMENT PRACTICES

5.1 Varieties

5.1.1 Major crops grown in the study area

The major crops grown in the two PAs are wheat, teff, barley, and faba beans. A mixture of faba beans and field peas is more common than sole planting of each. On average, crop area in the two PAs is statistically different, except for the mixture of faba beans and field peas (Table 8).

Sample farmers in the two PAs plant mainly local varieties of their crops, except for wheat. All farmers know about improved varieties of all crops, however, except field peas. More farmers in Wolmera Goro grow improved wheat varieties than farmers in Robe Gebeya (Table 9).

5.1.2 Farmers' knowledge of bread wheat varieties and seed sources

About 78% of farmers in Wolmera Goro and 68% in Robe Gebeya knew about improved wheat varieties. Their sources of information for improved varieties were the radio, the district MOA office, other farmers, and HRC (Table 10). The "other farmers" who were seed sources had participated in HRC on-farm trials and farmer training. Across the two PAs, most farmers depended on radio for information on new varieties, followed by other farmers. A few farmers obtained information about

Table 8. Mean area (ha) planted to major crops by sample farmers in Wolmera woreda, Ethiopia

	Wolmera Goro		Robe Gebeya		
	Mean	Standard deviation	Mean	Standard deviation	t-statistic
Wheat	0.38	0.20	0.50	0.24	2.66***
Barley	0.38	0.20	0.60	0.60	2.19**
Teff	0.42	0.22	0.60	0.37	2.36**
Faba beans	0.25	0.10	0.32	0.14	1.99*
Faba beans + field peas	0.30	0.12	0.35	0.19	0.85 (NS)

Note: NS = not significant; * = significant at 10% level; ** = significant at 5% level; *** = significant at 1% level.

Table 9. Distribution of sample farmers growing local and improved varieties of major crops, Wolmera woreda, Ethiopia

	Local varieties				Improved varieties			
	Wolmera Goro		Robe Gebeya		Wolmera Goro		Robe Gebeya	
	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers
Wheat	11	12	14	13	31	70	27	75
Barley	28	31	34	32	7	16	4	11
Teff	36	40	33	31	1	1	1	3
Faba beans	7	8	13	12	4	9	4	11
Faba beans + field peas	8	9	11	0	1	2	0	0

improved wheat varieties directly from MOA and HRC, depending on their proximity to these two institutions, and these farmers passed the information to other farmers. That is why the percentage of farmers who received information from other farmers is greater than the percentage of farmers receiving information from the two institutions. Although a few farmers from Wolmera Goro had access to information about improved wheat varieties from the HRC, none from Robe Gebeya did, because they are located far away from HRC (Table 10).

The recommended bread wheat varieties for the study area include ET-13, HAR-1709, and HAR-1685. The varieties known and grown by most farmers were Dashen, ET-13, Enkoy, and Bondae (Table 11). Only 25% of farmers in Robe Gebeya knew ET-13 compared to 75% in Wolmera Goro. Dashen, which has white grain and is the variety most favored by farmers in lower altitude zones, is no longer recommended because of susceptibility to stripe rust. Farmers dislike Enkoy because of its color, even though the variety is widely adapted, but Enkoy has recently been affected by stem rust. Farmers still grew Dashen and Enkoy, however, because the recommended varieties were not available. The other varieties grown by farmers (Bondae, Genet-71, and Gofer) were considered local varieties for this study, because the ESE had stopped growing them and they were produced only by farmers. Only one farmer planted the new variety HAR-1709 in the 1995 crop season, and he was planting it for the first time. The farmer learned about the seed from the MOA development agent and obtained the seed from IAR. He lived near HRC and traveled only 6 km to obtain the seed.

Table 10. Sample farmers' sources of information about improved bread wheat varieties, Wolmera woreda, Ethiopia

	Wolmera Goro		Robe Gebeya	
Source of information	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers
Ministry of Agriculture, extension	8	20.0	6	15.0
Other farmers	14	35.0	13	32.5
Radio	15	37.5	21	52.5
Holetta Research Center	3	7.5	0	0.0

Table 11. Bread wheat varieties known and grown by sample farmers, Wolmera woreda, Ethiopia

	Wolmera Goro		Robe Gebeya	
Variety	Farmers knowing variety (%)	Farmers growing variety (%)	Farmers knowing variety (%)	Farmers growing variety (%)
Dashen	58	32	85	30
Enkoy	62	15	52	35
ET-13	75	52	25	15
Bondae	25	5	53	15
Genet -71	2	2	48	18
HAR-1709	2	2	0	0
Gofer	0	0	8	8

Unlike that farmer, most farmers (85%) in the two PAs got seed of improved varieties from informal sources. No seed was distributed by the formal sector except for the seed made available by HRC and MOA through demonstration and popularization programs. Farmers' main initial sources of seed of improved wheat varieties in Wolmera Goro were other farmers who participated in HRC on-farm trials (35%), HRC (27.5%), and MOA (17.5%). In Robe Gebeya, main initial sources of seed were other farmers who participated in HRC on-farm trials (65%) and MOA (15%) (Table 12). Farmers' seed sources for the 1995 crop season are shown in Table 13. In Wolmera Goro, the main source of seed was seed retained from the previous harvest (75%). In Robe Gebeya, the main seed sources were seed retained from the previous harvest (58%) and other farmers (28%) (Table 13). Another study in Ethiopia also found that many farmers (95.3%) obtained seed from their own sources (Bishaw et al. 1994). This is similar to the diffusion of Green Revolution varieties of wheat and rice in Asia, which was largely facilitated by farmer-to-farmer seed movement (Heisey 1990).

5.2 Wheat Area Planted, 1993-95

Varieties grown and the area planted to each are presented in Table 14 (next page). The areas allocated to these varieties by farmers in the two PAs were not statistically different in the 1993 crop season. However, there was a statistical difference at the 5% level for Dashen and Bondae area in 1994 and at the 1% level for ET-13 area in 1995. In the 1995 crop season, 81% of farmers said that they were still planting these varieties while 10% were not planting them because of declining yields.

Most farmers who used their own seed had originally obtained seed from demonstrations and popularization programs between 1988 and 1993. All farmers who sold improved varieties to other farmers or exchanged varieties with other farmers had more wheat land than the buyers. Buyers paid Birr 163/100 kg with a range of Birr 90–227/100 kg. Money for purchasing the improved varieties was obtained by selling crops (46%), vegetables (15%), or borrowing from friends and relatives (15%).

Table 12. Sample farmers' initial sources of seed for new wheat varieties, Wolmera woreda, Ethiopia

	Wolmera Goro		Robe Gebeya	
Source of seed	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers
IAR	11	27.5	4	10.0
MOA	7	17.5	6	15.0
Other farmers	14	35.0	26	65.0
Local market	5	12.5	4	10.0
Producer Cooperatives	3	7.5	–	–

Table 13. Sample farmers' sources of seed for the 1995 crop season, Wolmera woreda, Ethiopia

	Wolmera Goro		Robe Gebeya	
Source of seed	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers
Own harvest	30	75	23	58
Other farmers	3	8	11	28
HRC/MOA	5	12	5	12
Local market	2	5	1	2

5.3 Farmers' Seed Management

5.3.1 Seed acquisition and recycling

Once farmers get improved varieties of wheat, they recycle the seed every year. Farmers had different views on the number of years a new variety will yield well before it needs to be replaced. The majority of farmers recycled seed for two to four years (Table 15).

The weighted average (WA) age of varieties was used to estimate the rate of varietal replacement, based on the average age of varieties grown by farmers in a given year since release, weighted by the area planted to each variety in that year (Brennan and Byerlee 1991). Following Brennan and Byerlee (1991), this measure, WA_t, is computed for a given year, t_1 as follows:

$$WA_t = \sum_i P_{it} R_{it} ,$$

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

Table 16 shows the weighted average age of wheat varieties grown by farmers in the two PAs in 1995. The WA of 13 years indicates slow varietal turnover, which reflects a poorly developed seed

Table 14. Mean planted area (ha) by variety for each Peasant Association, Wolmera woreda, Ethiopia, 1993-95

Variety	Area planted (ha)					
	1993		1994		1995	
	Wolmera Goro	Robe Gebeya	Wolmera Goro	Robe Gebeya	Wolmera Goro	Robe Gebeya
Dashen	0.30 (0.12)	0.29 (0.14)	0.25 (0.10)	0.43 (0.17)	0.26 (0.14)	0.35 (0.13)
Enkoy	0.36 (0.13)	0.48 (0.14)	0.34 (0.21)	0.40 (0.16)	0.28 (0.25)	0.46 (0.20)
ET-13	0.31 (0.11)	0.46 (0.26)	0.29 (0.11)	0.38 (0.14)	0.26 (0.09)	0.46 (0.17)
Bondae	0.42 (0.15)	0.48 (0.20)	0.25 (0.00)	0.51 (0.16)	0.50 (0.35)	0.39 (0.13)

Note: Figures in parentheses are standard deviations.

Table 15. Number of years a new variety gives good yield, reported by sample farmers, Wolmera woreda, Ethiopia, 1996

Number of years	Wolmera Goro		Robe Gebeya	
	Number of farmers	Percent of Farners	Number of farmers	Percent of farmers
One	1	2	0	0
Two	11	28	8	20
Three	16	40	20	50
Four	6	16	4	10
Five	2	6	0	0

Table 16. Weighted average age of wheat varieties grown in Wolmera woreda, Ethiopia, 1995

Varieties	Year of release	Mean area (ha) in 1995	Age (yr)
ET-13	1981	0.11 (14)	3.58
Dashen	1984	0.09 (11)	2.30
Enkoy	1974	0.10 (21)	4.88
Genet -71	1977	0.06 (18)	2.51
Gofer	NA	NA	
Bondae	NA	NA	
Total		0.43	13.27

Note: Figures in parentheses are years since release of the variety.

industry and ineffective extension services, and explains why farmer-to-farmer seed exchange is the common practice in the study area and Ethiopia in general. Others have shown that 21% of wheat farmers recycled seed for 6-10 years, whereas 14% recycled seed for 11-15 years (Bishaw et al. 1994). According to Brennan and Byerlee (1991), the optimal seed retention period will depend on the yield gain of the new variety compared to the current variety, the yield loss of old varieties, and the risk involved in changing the variety.

5.3.2 Seed production, selection, and storage

Only four farmers maintained separate fields for seed production. These fields were selected before planting; relatively more fertile and less weedy fields were chosen. Farmers applied more fertilizer to seed production fields and weeded them on time. Farmers who did not have separate fields for seed production selected seed after threshing (68%), during harvesting (11%), and during planting (11%).

About 80% of farmers kept stored seed separately from grain, either in sacks (84%) or in local storage structures (16%). In addition, 94% of farmers cleaned their seed before planting and 6% cleaned it during winnowing.

5.3.3 Farmers' information strategies

As noted previously, most farmers who planted improved varieties learned about them through radio, other farmers who participated in demonstration programs, development agents, and HRC. About 54% of the farmers in the study area had radios, and 70% of these said they listened to agricultural programs. Eighty percent of the listeners said that they were satisfied with the content of the program. More farmers (62%) in Wolmera Goro had radios; 40% listened to agricultural programs, and 75% of listeners were satisfied with the content of the program.

5.3.4 Farmers' participation

About 46% of the farmers had attended field days. Of these farmers, 11% had served as contact farmers and 12% had participated in farmer training. In the 1995 crop season, 36% of the farmers were visited by development agents during land preparation, weeding, and threshing. The number of visits varied from two to three. Eleven percent of the farmers had a leadership role (2% as vice chairmen, 2% as cadres, and 2% as militias) in the PAs. In addition, 14% of the farmers had lived outside the PA for a period of 13 years (the range was 0.3-26.0 years).

6.0 FACTORS INFLUENCING ADOPTION OF NEW WHEAT VARIETIES

Chilot et al. (1996) demonstrated that adoption of improved wheat seed in Wolmera is positively and significantly influenced by the performance (increased net benefit per hectare) of the improved variety over traditional varieties, the wealth of the farmer, a farmer's contacts with an extension agent, and the timely availability of fertilizer. The distance between a farmer's home and the office of the extension agent and availability of herbicide on time negatively influenced the adoption of improved seed. The effects of other factors, such as cultivated area, literacy, livestock ownership, and the farmer's years of experience, were not significant. In this study the major reasons for growing the new variety (ET-13) were its higher yield compared to previously released varieties (Genet-71, Enkoy, Dashen) and its disease resistance. Farmers still grew Dashen for its high yield and good market price, although its use without fungicide is no longer recommended. Farmers' principal problems in obtaining new seed was its unavailability and high cost.

The logit model was used to determine which factors affected adoption of improved wheat seed. The model predicted at least 74% of the cases correctly. The variables for participation in a training course, serving as a contact farmer, and hosting a demonstration trial were dropped because of multicollinearity with receiving an extension visit. As expected, location of the PA is significantly associated with the adoption of improved varieties. Farmers in the PA near HRC had more information about new varieties than farmers in the distant PA. A visit by an extension agent was positively and significantly associated with adoption of improved varieties (Table 17).

The predicted probabilities of growing improved wheat for changes in extension visit were estimated for the two PAs. The probability of growing improved varieties increased for farmers who received an extension visit. On the other hand, reducing the distance to HRC increased the adoption of improved wheat varieties. The probability of growing improved wheat varieties increased from 36% to 80% when farmers received an extension visit and lived near HRC, and it increased from 6% to 32% for farmers living far from HRC (Table 18).

Table 17. Logit analysis of factors influencing the adoption of improved bread wheat varieties in Wolmera woreda, Ethiopia

Explanatory variable	Parameter estimates (β)	Wald-statistic	Variable mean
Intercept	–3.7527***	7.20	–
Years of farming	–0.0128	0.31	29.44
Extension visit	1.9741***	8.90	–
Education	–0.1226	0.18	–
Own a radio	–0.1609	0.05	–
Family size (no.)	0.1876	2.14	7.24
Farm size (ha)	0.0146	0.04	2.16
PA (Wolmera Goro)	2.1704***	8.32	–
Model Chi-square		26.4***	
Degrees of freedom		7	
Cases predicted correctly (%)		73.8	
Sample size (N)		80	

Note: *** = significant at the 1% level.

Table 18. Predicted probabilities of adoption of improved wheat varieties for farmers who have received an extension visit in Wolmera woreda, Ethiopia

	Changes in probabilities (%) for adoption of improved varieties	
Factor	Wolmera Goro	Robe Gebeya
Extension visit		
No	36.1	6.1
Yes	80.3	31.7

7.0 SUMMARY AND IMPLICATIONS

As we have seen, all sample farmers had learned about improved bread wheat varieties from several sources, including radio, neighboring farmers who participated in on-farm trials and demonstrations, and MOA extension agents. The improved bread wheat varieties known and still grown by most farmers were ET-13, Dashen, and Enkoy. Farmers had originally obtained seed of these varieties from neighboring farmers, HRC, and MOA (often through demonstration and popularization programs from 1988 to 1995). The area planted to these varieties from 1993 to 1995 remained more or less the same, although a growing number of farmers were planting ET-13 because the yield of the other varieties was declining and because ET-13 had been promoted among them. Only one farmer planted the new variety HAR-1709 in 1995; he received the seed from HRC but learned about the variety from the MOA development agent.

Farmers' most important source of seed was their own fields. A few farmers had selected separate fields for seed production based on their relatively higher fertility and lower weed populations. These fields received more fertilizer and more timely weeding. Most farmers, however, selected seed at harvesting, threshing, and/or planting. Farmers stored seed separately from grain either in sacks or in local stores, and the majority of farmers cleaned seed before planting.

Farmers generally agreed that seed should be replaced every two to four years before it becomes vulnerable to disease, which implies that breeders must maintain seed quality and distribute new seed stocks every four years to seed suppliers. However, the weighted average age of varieties in farmers' fields was 13 years, indicating slow varietal turnover, a poorly developed seed industry, and ineffective extension.

This situation may be improved considerably as a result of changes taking place in the seed industry, such as the entry of private firms, the creation of the National Seed Industry Agency, and the strengthening of the national extension service. These changes would be even more effective if policies and an institutional and legal framework could be developed to link the formal and informal seed sectors so that they could function in a complementary way.

Because radio was found to be so important for disseminating information about improved wheat varieties, extension agents should use this medium as well as demonstration and popularization programs to tell farmers about improved seed and related technologies.

Extension visits had a positive influence on the adoption of improved seed, which underlines the important role that a strong extension program can play in the major wheat-growing areas.

Extension cannot do the job alone, however. The dissemination of improved varieties through farmer-to-farmer seed exchange indicates that there is considerable demand for improved varieties by Ethiopia's farmers. In the study area the participation of the formal seed sector in seed distribution was negligible, however, and most of the demand for seed, in the study area as in Ethiopia as a whole, was met by farmers themselves. Seed suppliers should be encouraged to disseminate improved seed to small-scale farmers, and there should be a clear seed policy to encourage private firms to produce and distribute improved seed. Farmers themselves could participate in seed production and distribution and benefit greatly, because there would be minimal bureaucracy. Younger farmers could particularly take advantage of such a system, because they are already more knowledgeable about the advantages of improved seed.

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