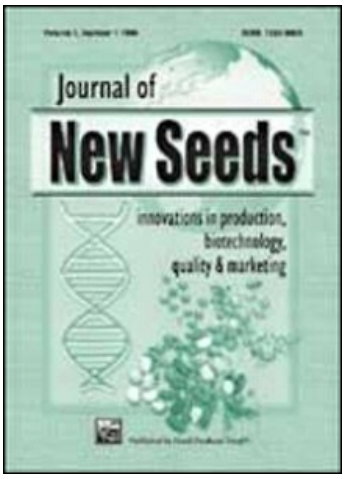

Journal of New Seeds
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t792306908

Farmers' Seed System of Sorghum (Sorghum bicolor (L.) Moench) in the Center of Diversity

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Online Publication Date: 04 April 2007

To cite this Article Mekbib, Firew(2007)'Farmers' Seed System of Sorghum (Sorghum bicolor (L.) Moench) in the Center of Diversity',Journal of New Seeds,8:3,63 — 86
To link to this Article: DOI: 10.1300/J153v08n03_05
URL: http://dx.doi.org/10.1300/J153v08n03_05

Farmers' Seed System of Sorghum (*Sorghum bicolor* (L.) Moench) in the Center of Diversity: I. Seed Sources, Distribution, and Networking

Firew Mekbib

ABSTRACT. Farmers' seed system is defined as a system in which seed selection, seed production, seed storage, seed management and seed diffusion are integrated with crop production. Formal seed system is the one that is run by formal private and public seed companies. Farmers indicated that when they started sorghum farming the seed of farmers' varieties (FVs) they obtained was normally a gift from the parents and relatives. Thereafter own stock was the predominant seed source. However,

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The author thanks the farmers of eastern Ethiopia for their participation and sharing their ideas and knowledge on the different aspects of seed system. He is grateful for the research and field assistants that assisted the interview with farmers; field and laboratory work. Thanks go also to various NGOs and GOs who have helped and assisted the various aspects of the fieldwork. The various support provided by Alemaya University for the research work in Ethiopia is appreciated. The comments provided by various colleagues in reviewing the draft manuscripts were valuable.

This research was supported by Consultative Group for International Agricultural Research (CGIAR), Participatory Research and Gender Analysis (PRGA), Small Grant Program, and Norwegian government. Due thanks goes to both for funding the project.

Journal of New Seeds, Vol. 8(3) 2006
Available online at http://jns.haworthpress.com

doi:10.1300/J153v08n03_05

for the improved varieties (IVs) purchasing was the common initial source. The current seed source is predominantly own stock. The farmers' seed system was dominantly dependent on the FVs. Consequently, the demand for IVs is very low. The weather conditions partly affect the seed-sourcing pattern. In a bad cropping season, farmers were forced to use seed sources other than own stock; namely, purchase, gift, exchange and loan. Genetic diversity dictated the pattern of seed sources. High on-farm genetic diversity leads to more on-farm and less off-farm seed sourcing (more own stock than non-own stock). The most widely used non-cash based seed channels were gift and exchange. The role of formal seed system in seed supply is very limited. Over the last 20 years, the total amount of seed produced by Ethiopian Seed Enterprise (ESE) amounted to 16,740 tons, which is almost equivalent to two years' sorghum seed requirement. The low amount of seed produced and sold by the ESE is due to the low demand by farmers for IVs and lack of appropriate varieties for the intermediate and highland areas. Farmers' seed system has been found resilient, accommodative, adaptive and flexible. It has been always responsible for on-farm conservation, maintenance and selection of farmers' varieties. doi:10.1300/J153v08n03_05

KEYWORDS. Seed system, seed source, seed diffusion, seed network, Ethiopia, *Sorghum bicolor*

INTRODUCTION

Ethiopia with a land size of 1,223,660 km^2 and a population of 65.8 million, has 85% of the population dependent on agriculture. Ethiopia has favourable environment for the production of various crops and livestock. The agricultural sector accounts for nearly 52.3% of the GDP and provides employment for more than 86% of the population. It also accounts for 80% of the export revenue and satisfies 70% of raw material demand of the country's industries (World Bank, 2002). Of the total land, only 15.3% provides the main food crops of cereals, pulses, oil seeds, vegetables and root crops. The major food crops namely, *tef (Eragrostis tef)*, maize (*Zea mays*), wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), and barley (*Horedum vulgare*) account for 73.5% of the total crop production (CSA, 2005).

Sorghum is the fifth most important cereal and is cultivated worldwide on 43,727,353 ha with a total production of 58,884,425 Mt (FAO, 2005). It is one of the most important and strategic crops in the semi-arid tropics of the world–380 million people, which represents, 38% those who live in poverty, 45% of those who are hungry, and 70% of the world's malnourished children. Developing countries account for roughly 90% of the world's sorghum area and 70% of the total output. The major sorghum producing countries of the world are the USA, India, Nigeria, China, Mexico and Sudan (FAO, 2005).

In order to produce sorghum, seed is an indispensable input and must be supplied in order to produce the crops continuously. Seed is farmers' most precious resource and concerns about the viability of traditional agricultural systems center on the diversity and stability of seed supply (Tripp, 2001). The seed system is a function of seed source, network, distribution and availability. Van Amstel et al. (1996) define seed system as the total physical, organizational, and institutional components, their actions and interactions that determine the seed supply and use, in quantitative and qualitative terms.

The seed system in Ethiopia, like most developing countries, is a function of both formal and farmer seed system. The farmer seed system (FARSS), a term used in this paper, is defined as a system in which seed selection, production, storage, management and diffusion or exchange are integrated with crop production. Alternative terms used are farmer-managed system (Bal and Douglas, 1992), informal seed system (Cromwell, Friis-Hansen, and Turner, 1992), traditional seed system (Linnemann and de Bruijn, 1987) or local seed system (Cromwell, Friis-Hansen, and Turner, 1992).

The components of FARSS are farmers and agro-ecological, socioeconomic and cultural environments. The formal seed system (FORSS) has not played a significant role in supplying seed to the majority of the farmers (Mekbib and David, 1999). The Ethiopia Seed Enterprise (ESE), state seed monopoly until 1990, supplies seeds of only a few crops, particularly hybrid varieties of maize, which have a good demand and fetch higher prices. Very recent attempts made by the Ethiopian National Seed Industry Agency (ENSIA), on promotion of private seed agencies, for example, Ethiopian Pioneer Hi-breed Seed, Inc. (a joint venture), have focused on supplying crop seeds that are commercially important. In Ethiopia, the dominant seed supply system for the majority of the crops is FARSS. For some indigenous crops, such as *Enset, Tef, Anchote* and so on, the whole seed system is handled by FARSS.

In the case of sorghum, FORSS plays a limited role in seed selection, supply, maintenance, storage and protection (Mekbib and Farley, 2000). However, the relative importance of FARSS has not been investigated in-depth (Almekinders, Louwars, and de Bruijn, 1994; Tripp, 2001) with a few exceptions (Berg, 1994; Sperling, Scheidegger, and Buruchara, 1996; Mekbib and David, 1999). A study on bean (*P. vulgaris*) seed system in eastern Ethiopia has shown that farmers do select, produce, store, protect, distribute, and maintain seeds and it is inferred that FARSS has to complement FORSS, and it should be an integral part of the national seed system (Mekbib and David, 1999). The genetic base of bean is very narrow and farmers have to rely on formal institutes for genetic enrichment of the FARSS. However the seed system scenario of crops in which the center of diversity is Ethiopia is expected to be different *de facto*. No study has been made on crops such as sorghum, coffee, tef and so on, where Ethiopia is a center of origin and diversity. In this study the research focus is on sorghum, for which Ethiopia is the center of origin and diversity for the crop.

The objectives of this study were:

1. To identify the major seed sources and networks,
2. To identify the dominant farmers' varieties grown and their distribution,
3. To assess the efficiency of farmers' seed systems versus formal seed systems,
4. To assess factors impacting seed sourcing.

MATERIALS AND METHODS

Study Sites Selection

Eastern Ethiopia (Figure 1) was selected for the following reasons:

1. Sorghum is the major food crop in the region.
2. The seed system is the function of FORSS and FARSS, and hence suitable to assess the relative importance of both.
3. FARSS in crops with high diversity such as sorghum has never been studied in Ethiopia. The region being one of the micro-centers of diversity (Mekbib, 2006b) is suitable to make such study.
4. As the FARSS is dependent on farmers' varieties it would be convenient to assess the farmer varieties diffusion and distribution.

5. In view of these reasons, the established Indigenous Technical Knowledge (ITK) on FARSS can be easily assessed.
6. No comprehensive study on sorghum seed system has been made in Ethiopia since this will be the first case study.

Survey Methods

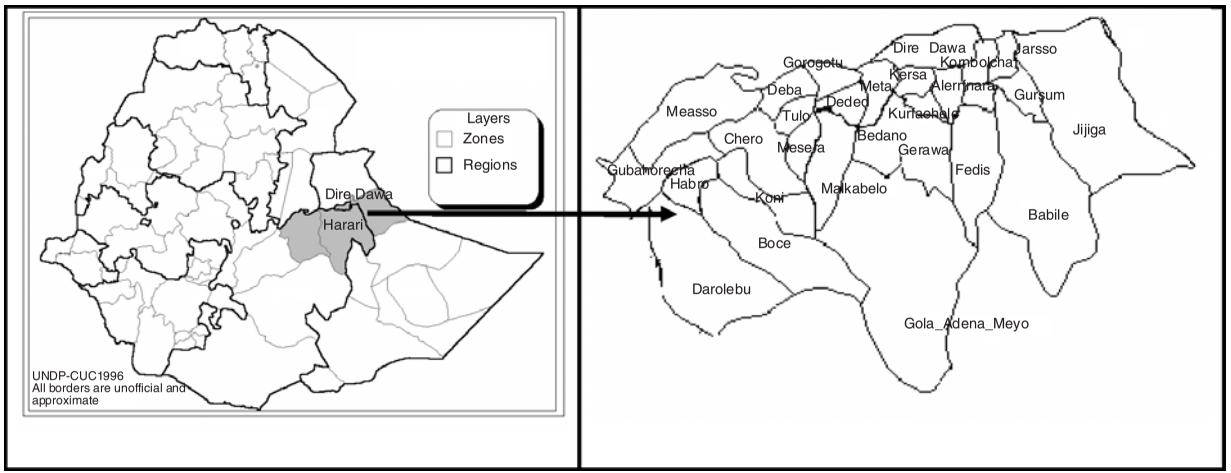
Different survey methods were employed for undertaking the study:

- *Focused group (gender and wealth based)*. First, community based Participatory Rural Appraisals (PRAs) were made in 12 Farmers Associations (FAs) of highland, intermediate and lowland areas and then participants were seconded by the community based on wealth and gender, to know who does what in the seed system and assess the general indigenous technical knowledge (ITK) of the farmers. More than 360 farmers in groups were interviewed. The selected weredas for this study were: Girawa and Hirna from the highland; Alemaya and Hirna from the Intermediate; and Babile and Dire Dawa from Lowland. The criteria employed for wealth as developed by the community were land size, livestock size, size of *Khat* (*Chata edulis Forsk*) land, access to irrigation, having farm shops, having tractor or pickups, grinding mill and so on. The criteria varied from one community to another. With regard to gender, either male or female, only one member of the house was included in the group.
- *Direct on-farm participant monitoring and observation* of seed sources, distribution and networking were done with 120 farmers across the selected weredas in the three sorghum crop ecologies.
- *Key informant interview* was conducted to assess the general seed sources, distribution and flow of varieties interview were conducted of elderly people up to five per FA, Ministry of Agriculture crop production experts, eastern and western Hararghe Disaster Preparedness and Prevention Zonal Offices, NGOs in each site and the Ethiopian Seed Enterprise and National Seed Industry Agency.
- *Semi-structured interview* was done with 250 farmers to quantify the seed system scenario across the weredas in the region.

Agro-Climatic Classification of Surveyed Weredas

A classification of weredas into agro-climates is based on where the major portion where the wereda lies. Though most of the weredas did

FIGURE 1. Map of the study sites. Names indicate weredas.



have the three ecologies, depending on the major ecological area coverage, a simple classification is given in Table 1. The traditional agro-climatic criteria to group the weredas into different agro-ecologies are indicated in Table 2.

Data Analysis

Descriptive statistics such as mean, minimum, maximum and percentage was determined. SPSS Ver. 10 statistical software was used for the analysis.

RESULTS AND DISCUSSION

Seed Sources

Dynamics in Seed Source System: Initial and Current Sources

Many factors were found to influence farmers' seed sources in the farming system: economic (as related to wealth), social (ethnic, cultural,

TABLE 1. A simplified classification of weredas into agro-climatic regimes based on the dominant ecological region.

Ecology	Weredas
Highland	Deder, Gorogutu, Gobakoricha, Jarso, Kersa, Kombolcha, Kuni, Melkabello, Kurfachelle
Intermediate	Alemaya, Bedeno, Habro, Fedis, Boke, Chirro, Darolabu, Hirna, Messela, Gursum, Hirna
Lowland	Babile, Meiso, Dire Dawa, Goloda, Jijiga, Girawa

TABLE 2. Characteristics of agro-climatic regimes.

Ecology	Climate	Altitude (Meters above sea level)	Average Annual Temperature (°C)	Average Annual Rainfall (mm)
Lowland	Warm semiarid	<1700	20-27.5	200-800
Intermediate	Cool and subhumid	>1700-2100	17.5-20	800-1200
Highland	Cool and humid	>2100	11.5-17.5	1200-2200

and traditional), biological (varietal characteristics, multiple uses, etc.), and ecological (adaptive characteristics, weather factors, etc.). Some of these factors were intentional and others were accidental. In most cases farmers did take into account these four factors indicated determining seed sources.

Farmers indicated that when they started sorghum farming the seed of FVs they obtained was normally given as gift. Seed is seen as a resource of farming communities and as the symbol of their integrity and self-sufficiency which agrees with the idea of Tripp (2001). Thereafter own stock was the predominant seed source. In addition, this was manifested very well in sorghum, where farmers seed source is initially from parents as a gift, then later on own stock predominated (Figure 2).

However, for the IVs, even when over 90% of the farmers did not grow IVs (Figure 3), purchasing was the common initial source, and in the year 2000 they used their farm-saved seeds. Farmers purchased the improved seeds to use them as early maturing varieties, when the first planting of FVs failed.

Seed sources of farmers, other than own stock, were dominantly from local seed sources. This is because local seed sources, other than the farmers' own stock, have the advantage that the variety or mixture is usually known to be adapted to the agro-ecological and socio-economic conditions of a given area. Besides, seeds produced at local level are readily

FIGURE 2. Seed sources: initial and at 2000 for farmer varieties.

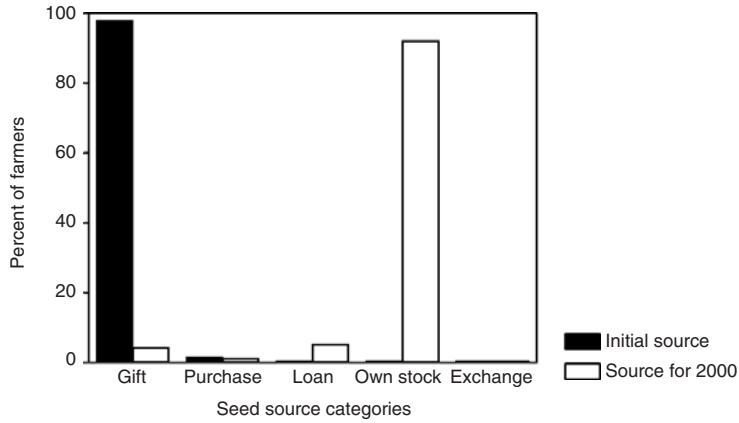
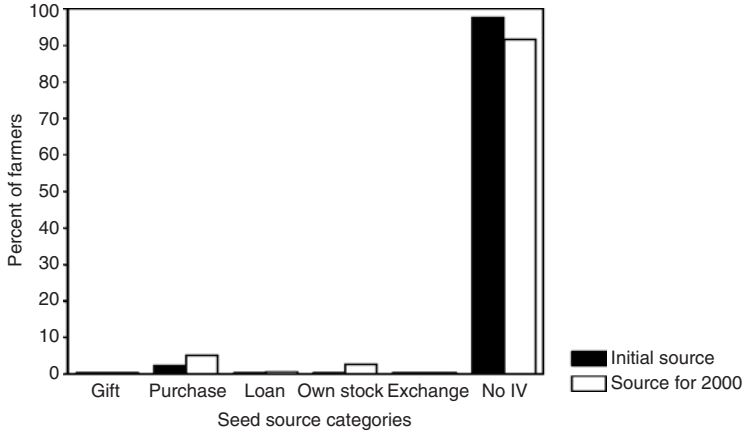


FIGURE 3. Seed sources: initial and at 2000 for improved varieties (IV) and proportion of farmers who are not growing IV.



available. Seed prices of FARSS and FORSS were comparative. The local seed cost around planting time was 2 birr/kg but that of FORSS level was 1.96 birr/kg in 1999 (Source: Ethiopian Seed Enterprise (ESE)). Individuals and households supplying seed in the FARSS often do not charge lower prices despite the fact that they do not face the additional transport, processing and packaging, seed certification and information gathering costs of the FORSS. The availability and accessibility of appropriate varieties in the FARSS is highly valued by the farmer.

There were no big differences between sorghum seed and grain prices in comparison to other crops like maize. The five-year seed and grain price of sorghum in ETB (Ethiopian Birr) per 100 kg were: 1995 (165, 219), 1996 (119, 223), 1997(119, 223), 1998 (184, 186), and 1999 (155, 196). Even if there is no official policy to subsidize seeds, by virtue of being multiplied by public seed enterprise there is an implicit subsidy that substantiated the lower seed price. However, this does not signify that grain is a substitute for seed.

Type of Varieties Grown in FARSS Dictates Type of Seed Sourcing

The types of varieties, either FVs or IVs, grown by farmers have an explicit impact on the seed demand.

Formal research organizations, Ethiopian Agricultural Research Organization (EARO) and Alemaya University (AU), are responsible for development, testing and release of improved sorghum varieties. The release of varieties is normally approved by NVRC (National Variety Release Committee), an ad-hoc committee under ENSIA (Ethiopian National Seed Industry Agency). From 1979 to 2000, >16 sorghum varieties were released. Of those, only 3 to 4 were multiplied by Ethiopian Seed Enterprise. However, the proportion of farmers growing IVs was appreciably low (Figure 3).

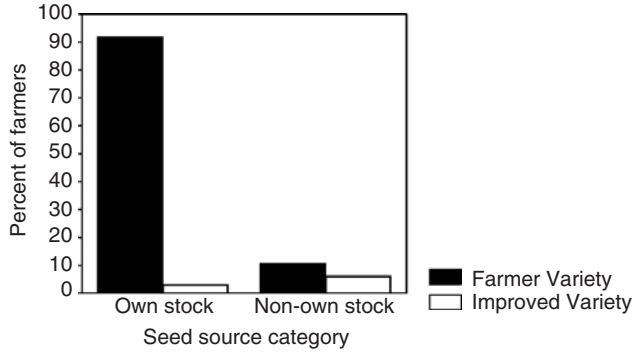
In view of this, the seed system of farmers was dominantly dependent on the FVs. The details of the type of varieties developed and grown by farmers are elsewhere (Mekbib, 2006a). As a result of this, the demand for IVs is very low. Getting seeds from non-own stock is a good indicator of seed demand at the household level. This can be seen from the low proportion of farmers obtaining varieties from non-own stock seed sources for both FVs and IVs (Figure 4).

Hence, in eastern Ethiopia, for years to come, locally adapted FVs need to be coupled with appropriate inputs and management practices to increase and sustain agricultural efficiency, productivity and profitability.

Seed Sourcing Is Affected by Weather Conditions

The seed sourcing, that is, either from FORSS and FARSS is affected by the weather conditions of the year (bad and good years) and comes

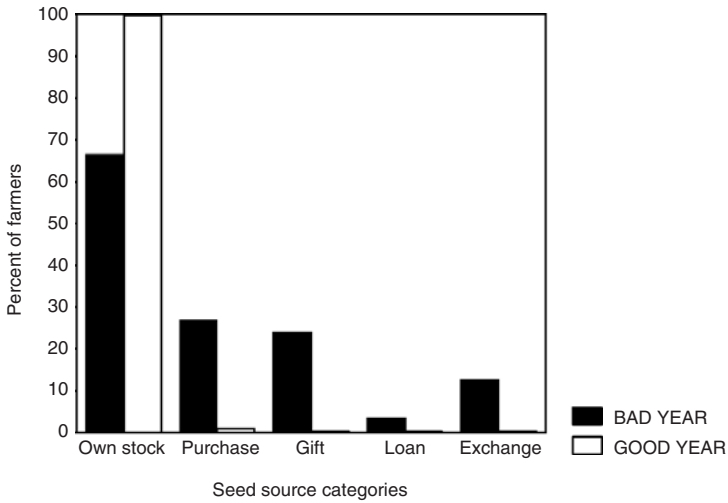
FIGURE 4. Effect of type of varieties grown on the seed sourcing.



primarily through non-commercial exchanges. The weather conditions partly affect the seed-sourcing pattern. In bad cropping seasons, farmers were forced to use seed sources other than own stock; namely, purchase, gift, exchange and loan (Figure 5). In spite of bad cropping seasons, majority of the farmers (65%) were still seed-self-sufficient. The best sources of seed for farmers in bad years, other than own stock, were the other farmers in the area. However, the local market was not a preferred seed source, as seed there sold in grain form was admixtures and of poor planting value. For this reason, 91.3% of the farmers rated the local market as the worst seed source. This largely explains why only 9.2% of the farmers sold seed. Of those farmers that sold sorghum varieties, the majority sold more than one variety.

The preferred seed source was thus non-cash-based seed networking (Figure 6). Exchange and gift together were the preferred seed sources for men (70%) as well as for women (50%) farmers. Hence, FORSS should capitalize on these established diffusion systems in order to disseminate FVs and IVs. For seed, the price charged was likely to be higher than for grain because of the fact that maximum care was given to panicle selection, threshing, cleaning and storage.

FIGURE 5. Pattern of seed source in good and bad year for farmers varieties.



Unique Feature of FARSS Seed Channels: Non-Cash-Based Seed Channels

Farmers are more inclined to use non-cash-based channels than cash-based ones as the former ones are more established than the latter.

In the FORSS, the only seed sourcing system is cash-based. However, in the FARSS, most of the farmers use the non-cash-based system for initial and current sources (Figure 7). Actually this is one of the major deterrents for farmers to buy seed from the FORSS; farmers are required to have cash at hand except in some cases where seeds are given as a loan or sold with a certain percentage of down payment. In view of this, most of the NGOs working in the region (CARE, HCS, Lutheran Federation, CISP) give seeds as loan to be re-paid in kind.

With regard to the diffusion, cash purchases and transactions that are used in the FORSS are commonly made in times of crop failures of FVs for purchasing early-maturing IVs. Non-cash based seed source alternatives in the FARSS provide access to seed to a wide range of socio-economic groups.

The most widely used non-cash-based seed channels were gift and exchange. Gift as dominant non-cash-based seed diffusion system is *de facto* and established seed source *ab initio* sorghum farming. Seed given as a gift or exchange, as indicated by the farmers, had the highest seed standard for planting because it was given from the seed saved for planting. Farmers indicated that the reason for giving seed as a gift was to help themselves; it is rooted in the culture to share seed (Table 3).

FIGURE 6. Preferred seed sources, other than own stock, for men and women.

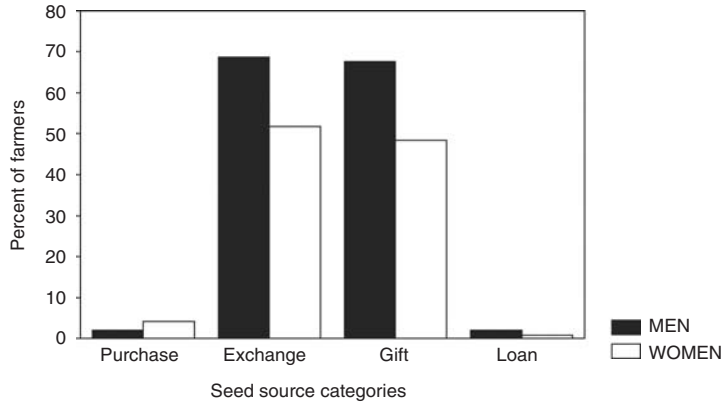


FIGURE 7. Proportion of cash and non-cash based channels in the FARSS for FVs and IVs.

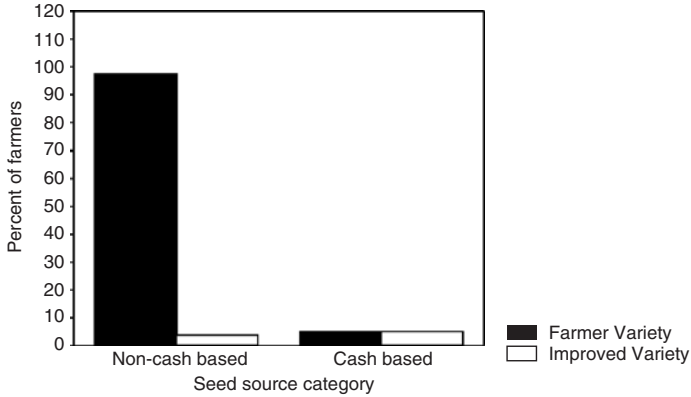


TABLE 3. Reasons for giving seeds as a gift.

Reasons	Percent of farmers (N = 250)
Help each other	93.3
Culture to share seed	96.0
Receiver is not secure	29.6
Receiver does not have a good quality seed	51.0
Expecting the receiver will pay back	6.9

Of the farmers receiving seed as a gift, < 2% received it every year, 7% received it every other year and 71% received it every third year. The number of varieties given out also varied. Closer to 76% gave one variety, whereas 24% indicated that they gave more than one variety, two varieties were the common scenario. In the gift system there were categories of people that were not to be given seed as a gift. Non-givers (13.3%), non-neighbors (11.3%), socially unacceptable farmers (13.3%), lazy farmers (51%) and rich farmers (30.2%) were included in this category of farmers.

Seed exchange was used very often to exchange sorghum with other crop seeds. Though not frequent, they exchanged also sorghum seed for labor, *tef*, wheat, maize, and barley. Approximately 50% of the farmers receive sorghum seed through such exchanges. However, initial seed exchanges were often between neighbors or more closely related family members or ethnic groups; so seed movement was limited in scope at the

beginning but through time the effective seed distribution scope will normally widened.

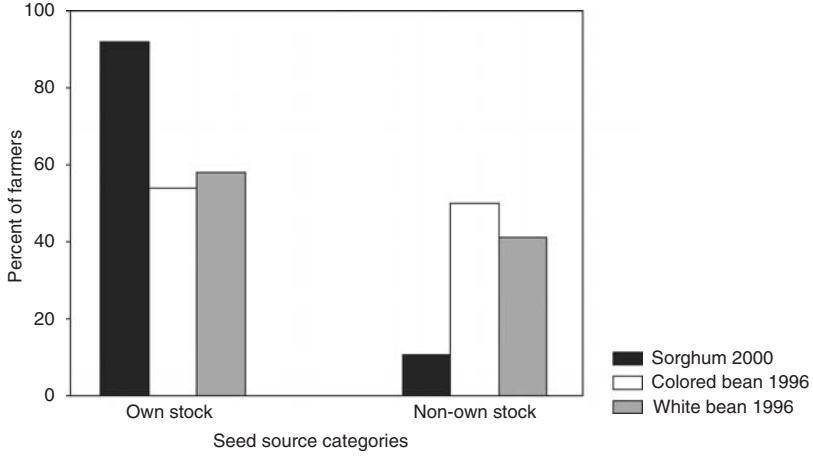
Purchasing seeds was rare. The most frequent seed purchasers do so every other year (4%). The major group of farmers, 78.4%, had never purchased seed since they started sorghum production. With the average number of years of sorghum farming experience in this study (21 years), it was evident that cash-based seed channels were not popular. The few farmers that bought seeds focused on a few varieties namely, *Fendisha, Gebabe, Masugi, Muyra* and *Wegere*. The dominant source for seed purchasing was local market, local traders and other farmers.

Level of Genetic Diversity Dictates Types of Seed Sourcing

Genetic diversity dictated the pattern of seed sources. High on-farm genetic diversity leads to more on-farm and less off-farm seed sourcing (more own stock than non-own stock).

This is shown by comparative seed sourcing pattern for sorghum with high on-farm genetic diversity and bean with low on-farm genetic diversity. In the case of sorghum, own stock was dominantly high as compared with bean (Mekbib and David, 1999) though for different years (Figure 8). Bean (*P. vulgaris* L.) was introduced to Ethiopia by Portuguese in the Sixteenth Century. It is one of the most important cash crops and protein sources for farmers in many lowland and mid-altitude regions of Ethiopia

FIGURE 8. Variation in seed sourcing between sorghum and beans.



(Mekbib, 1997, 2002, 2003). Both colored and white beans are produced; the latter ones are commonly produced for export. The comparative data for beans were taken from bean seed system study made in 1996 in the same area. Though, it is not easy to make comparison for the years 1996 and 2000 for two different crops, at least it signals that on-farm genetic diversity had an impact on seed sourcing pattern.

For sorghum, on the contrary, the heterogeneity of farming systems and high number of varieties per farm (Mekbib, 2006b) in centers of diversity limited the diffusion of modern varieties and maintained production space for FVs. The higher the genetic diversity, the higher is the proportion of farmers using own stock as seed sources.

In eastern Ethiopia, farmers have developed/selected varieties that are well adapted, preferred and high yielding. The *opportunity cost* for IVs to surpass the varietal mixture is commonly very low. The dominant seed source system for the sorghum varieties was own stock while for beans own-stock and non-own stock had a comparative share. Seed source for sorghum had fewer and effective choices than for bean where farmers had more initial multiple seed sources and a low level of non-commercial exchanges (Mekbib and David, 1999).

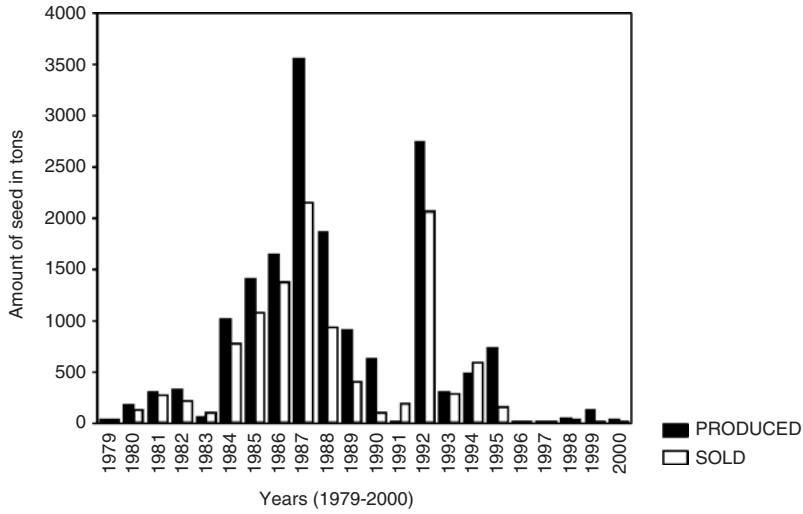
Importance of Formal Seed Supply System (FORSS) in Seed Sourcing and Distribution

The Role of Sorghum FORSS Is Very Limited and Is Restricted to the Lowland Varieties

Ethiopian Seed Enterprise was, until 1990, responsible for the sale of seeds to farmers, state farms, Agriculture Input Supply Corporation (AISCO) and NGOs involved in relief and rehabilitation programs. Up to 1990 the share of ESE's annual sales to state farms, NGOs, and AISCO was 50, 26 and 24%, respectively. However, in 1994 this share changed dramatically with state farms receiving only 5%, NGOs (65%), emergency relief through MoA (29.7%) and direct sales to farmers (0.3%). Over the last five years (1996 to 2000), the Regional Agricultural Bureau (RAB) has also become involved in distribution of improved seed to the peasant sector through a new agricultural extension program. The share again has changed with RABs receiving 56, 47 and 70% in 1997, 1998, and 1999, respectively.

ESE across 22 years. The total amount of sorghum seed produced and sold from 1979 to 2000 amounted to 16,740 tons and 10,902 ton, respectively (Figure 9). This is closer to 3% share of the total amount of seed

FIGURE 9. The amount of sorghum seed produced and sold by ESE over two decades.



produced and sold by ESE. In the year 2002, the area coverage of sorghum was 1,132,037 ha with an output of 154,621 tons and with a mean yield of 1.4 ton/ha (CSA, 2002). Estimated yearly seed demand was 8,490 tons of seed. However, over the last 20 years, the total amount produced has been 16,740 tons that would be almost equivalent to two years sorghum seed requirement. The low amount of seed produced and sold by ESE was due to the low demand by farmers for IVs and lack of appropriate varieties for the intermediate and highland areas. The bulk of the varieties produced were lowland varieties, namely, *Birimash*, *IS 9302*, *Seredo* and *76T$_1$#23* which in Ethiopia have a narrow genetic base (Gebrekidan, 1981). In view of this, farmers relied on their own varieties and seed system for sorghum seed and grain production.

In contrast, the seed supply role of ESE for non-indigenous crops like maize and wheat is very high. Moreover, ESE had a problem of carry-over stock, while the majority of the farmers were unable to obtain improved seed. This was evident in sorghum in almost all years, where the amount produced has never been sold out. The problem was attributed to poor seed marketing (promotion and marketing outlets) and/or the inability of the ESE to meet the farmers' need (varietal choice, product quality). An attempt by ESE to use private dealers was not successful. On

the contrary, the physical capacity of ESE for seed production, processing and storage was considerable.

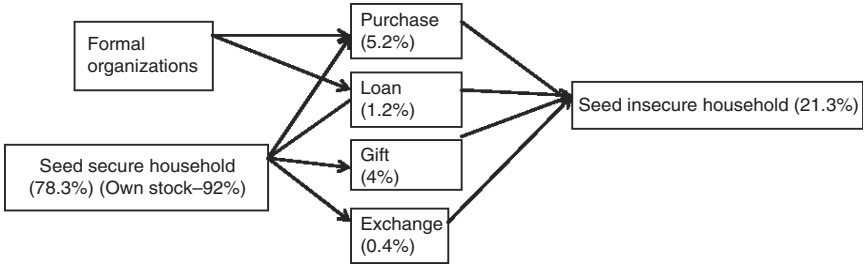
In conclusion, most of the farmers relied on the FARSS not only because their villages were scattered and poorly accessible where FORSS is dysfunctional in this type of infrastructure (which is an attributed cause for importance of FARSS in poorly accessible areas), but also it is an established system that caters for all varieties seed demand at the local level. Even in highly advanced agricultural systems found in most countries of the North, where infrastructure is well developed, farmer-saved seed contributes >30% of all seed for self-pollinated crops (Ghijsen, 1996; Jaffee and Srivastava, 1994).

The Capacity of FARSS for Seed Diffusion and Conservation of FVs

FARSS Distributes Seeds Widely Over the Region, and Has Resulted in Both Locally and Widely Adapted Varieties

As opposed to the idea of Green (1987), the range of diffusion and distribution of FVs is found to be very wide, but time-consuming (Brush, 1999). The varietal diffusion network in the region was very efficient, disseminating hundreds of varieties across areas that were inaccessible by FORSS (Figure 10). This has resulted in ecotype differentiation (Mekbib, 2006a) and presumably locally adapted types. The flow can be among farmers within farmers association (FAs), between FAs, within or among weredas or with in region or sometimes across the region. The most common seed flow was with in the community. The flow among weredas

FIGURE 10. Seed sources and distribution network for 2000 for FVs in eastern Ethiopia.



normally took a long period of time sometimes even up to a decade. Actually this has made some of the folk species *Fendisha*, *Muyra*, *Gebabe*, *Wegere*, the most important ones (Mekbib, 2006b) all over the region. Folk species is farmers' taxonomic unit of classification of sorghum. Farmers use botanical, technological, use and agro-ecological criteria in their taxonomic system. A folk species has folk varieties, and a folk variety has sub-varieties (Mekbib, 2006a). These FVs can be found over a range of 300 km. Seed flowed from seed secure into deficit areas. Hence, the flow direction might change sometimes due to fluctuation of factors; areas which were seed deficit becomes seed secure areas. These networks were present as there are seed secure and deficit areas and demand for FVs. Seed has to flow from seed secure into seed deficit areas. Some of the varieties were distributed throughout the region while others were limited to zones and others to weredas and FAs. Retrospective and historical analysis showed that seed mainly flowed from intermediate altitude into both lowland and highlands.

FARSS Has Been Accountable for On-Farm Maintenance and Conservation of FVs

Traditionally seed production, varietal conservation and grain production are normally different facets of a sorghum seed system. In view of the fact that farmers have been using FARSS, a considerable number of FVs *de facto* have been conserved on-farm (Table 4). Some of the varieties as reported by the farmers have a life span of 100 years. For instance, variety names such as *Fendisha, Muyra, and Wegere* have been cited as FVs from the 18th century (Source: Harer Arabic Historical Archives).

An important parameter identified in the FARSS was that the turnover of varieties was slow or sometimes absent vis-à-vis IVs, in agreement

TABLE 4. The duration of varieties maintained on farm in the FARSS.

Years	Rank	Variety	% growers
≥40 years	First variety	*Fendisha*	40.0
	Second variety	*Muyra*	39.0
	Third variety	*Cherchero/Daslee*	6.7
<40 and ≥20 years	First variety	*Fendisha*	27.6
	Second variety	*Muyra*	27.3
	Third variety	*Cherchero*	9.4

with Brush (1991). On the contrary, if the varietal turnover were high, it would have precluded significant local adaptation of varieties. However, in the lowland where there was adoption of IVs, farmers simply incorporate the new varieties into the existing system; they had never replaced their varieties with improved ones: *varietal addition, not substitution was the commonest process*.

Taking 20 years as an average period for "reduced varietal importance" or "the variety gets tired" turnover, the relative significance of the three varieties across the last four decades was almost similar (Table 4). This signaled the role the FARSS played in conserving varieties on-farm. This finding is in disagreement with that of Dennis (1987) who found out that in rice variety turnover was 1.7 varieties per farm and farmers replaced them on average every three years and this was almost comparable to the rate of turnover of wheat in modern agricultural systems (Brennan and Byerlee, 1991). However, it is important to note that *Fendisha* had many ecotypic forms with specific and diverse production and ecological niches. The names like, *Fendisha, Muyra,* and *Wegere* are folk species from folk taxonomic point of view (Mekbib, 2006b) that have many varied forms.

Versatility, Resilience and Complex Nature of FARSS

FARSS Is More Efficient in Provision of Appropriate Varieties than FORSS

Farmers grew a number of varieties locally. Attempts had been made very recently, to infuse new IVs into FARSS, but most of the IVs were not in tune with farmers' needs and preferences. The low level of adoption of IVs was 12% and this was limited to the lowland areas. The major reasons for adopting the varieties in this environment were early maturity and drought tolerance/escape. The low level of adoption was due to low multipurpose and food values of the IVs. In contrast, there was high level of "adoption" of FVs by farmers. This was because FARSS had been selecting, producing, and disseminating seeds that were adapted, preferred and had multiple uses. This was also supported by the high number of fewer farmers growing FVs and few numbers growing IVs (Figure 3). In addition, seeds received from formal seed sources constituted only 2% for FVs and 6% for IVs.

The FARSS are resilient to environmental changes, which at times are catastrophic, and agricultural advances are evidenced by the observation

that they still contributed an estimated 90% of all seed used for food production in developing countries (Almekinders, Louwars, and de Bruijn, 1994). One reason for efficiency of FARSS is the cyclic or horizontal nature of the organizational system against linear or vertical nature of FORSS. The FARSS maintains a wide range of varieties or landraces in response to diverse ecosystems and local markets.

As the farming system is commonly resilient and dynamic, FARSS has been resilient and dynamic, as opposed to the rigid nature of FORSS. Hence, the FARSS corresponded with farmers' goals and preferences, fit to the natural conditions and its ecological viability has made it a very efficient seed system.

FARSS Includes Farmers with Different Wealth (Socio-Economic Classes) Ranks

FARSS caters to farmers having various socio-economic characteristics. Taking wealth as one of the criteria, the FARSS encompasses farmers of various socio-economic classes. The common indicator for wealth was land. Wealthier farmers had larger pieces of land size, amount of seed planted, yield harvested, and amount of seed stored as they are directly associated with wealth. These factors were significantly different among the wealth classes, Leading To Differential Wealth Ranks.

Varietal Mixtures Based on Farm Seed Production Strategies Have Been a Routine and Dynamic Seed Production System to Meet the Heterogeneous Biophysical and Socio-Economic Environments

Though the FORSS seed production believed in DUS (Distinctiveness, Uniformity and Stability) of varieties, the FARSS of eastern Ethiopia rarely considers DUS, as the dominant seed production system was varietal mixture based, where a number of varieties were grown together on-farm. About 62.3% of farmers had grown varietal mixtures while the rest of the farmers grew "uniform" varieties in relative terms. In fields of farmers who indicated that they did not grow varietal mixtures, it was not uncommon to encounter many varieties in the field though the dominant one was one variety. There was no statistically significant difference among different wealth and ecology for growing varietal mixture. Varietal mixture was a common production technique exercised in the farming system regardless of wealth and ecology.

Flexible Package Size (Seed Amounts) Is Prevalent in FARSS Whereas FORSS Is Less Flexible to Meet the Different Socio-Economic Groups

The package size used in the ESE was 5 kg per bag. Commonly used seed-bag sizes start with a size small enough to cover half a hectare. This applied only to the farmers who had one hectare of land. Packages of less than 5 kg were not available. However, in the FARSS, mean and range of "package size" varied to cater to the different wealth groups of farmers (Table 5). Exchange was normally made with equivalent proportion for other sorghum varieties and maize, the mean amount was not indicated, however.

Farmers' Varieties as Technology Carriers in the FARSS

Seeds have the greatest socio-economic benefit to human welfare of any known biological device and provide the greatest good at minimal cost; they stand between survival and starvation. Seeds concentrate really useful technology into the most transportable, the most storable, the most nutritional, the most tradable, the cheapest and the most functional format possible (Scowcroft and Scowcroft, 1998; Srivastava and Jaffee, 1993). This was true not only for IVs but also for FVs. In view of this, farmers-cum-natural selections had resulted in the development of varieties that were endowed with various useful traits (Table 6). None of the varieties embodied all the necessary traits. This resulted in cultivation of growing of varietal mixtures in order to use the diverse useful traits endowed in different varieties. Of course, this was one of the reasons that farmers still hung on to their own varieties.

In summary, sorghum farmers in Ethiopia used predominantly farmer seed systems (FARSS) as a means of seed sources and diffusion for the following reasons: (1) it was very accessible, cheap and timely available; (2) it had flexible 'package' size; (3) varieties in the system were well

TABLE 5. Mean amount in kg of seeds diffused in different FARSS channels.

Seed source	Mean	Minimum	Maximum	SD
Purchase	13.4	2	60	13.40
Loan	33.6	1	130	33.60
Gift	9.96	1	124	6.96

TABLE 6. Useful traits carried by some of FVs in the FARSS.

Varieties	Important traits carried by the variety
Fendisha	Drought resistant for the highland, good seed quality, leaf disease resistance, better seed storability, better *Injera* storability, good mixer with *tef*, better multipurpose value (feed, fuel wood and construction)
Chefere	Cold tolerance, bird resistance, good seed quality, better storability, leaf disease resistance, multipurpose value
Muyra	Good medicinal value, good seed quality, better multipurpose value (feed, fuel wood and construction), excellent '*Nifro*' (boiled grain)
Wegere	Early maturing variety for highland and good mixer with *tef* to produce *Injera*, good '*Nifro*' (boiled grain)
Bullo	Drought resistance, early maturity, lodging resistant, good seed quality
Ammajicta	Drought resistance, lodging resistance, good seed quality
Merturasse	Cold tolerance, mold tolerant, good *Injera*, stalk borer resistance, bird resistance, leaf disease resistance
Fitibile	Bird resistance, top fiber quality, stalk borer resistance, high postharvest storability, leaf disease resistance, mold tolerant, bird resistance

adapted and known as they were developed by the farmers; (4) it had diverse diffusion mechanism including non-cash-based diffusion, as farmer might not have cash to buy seeds; and (5) there were no rigidities in operation and is very much flexible, resilient and adaptive to the farmer conditions/needs.

REFERENCES

Almekinders, C., N.P. Louwars, & G.H. de Bruijn, 1994. Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica* 78: 207-216.

Bal, S.S., & J.E. Douglas, 1992. *Designing successful farmer-managed seed systems.* Winrock International Institute for Agricultural Development. Development Studies Paper Series. Winrock, Arlington, USA.

Berg, T., 1994. *Local seed systems mass selection. How simple? Plant Breeder/Scientist*. Noragric, Agricultural University of Norway, Box 5002 Aas, Norway.

Brennan, J.P., & D. Byerlee, 1991. The rate of crop varietal replacement on farms: Measures and empirical results from wheat. *Plant Varieties and Seeds* 4:99-106.

Brush, S., 1999. Genetic erosion of crop productions in the centre of diversity: A revision. In: *FAO proceedings of technical meeting on the methodology of the FAO world information and Early Warning System in PGR*. Research Institute of Crop Production, Prague, Czech Republic, 21-23, June 1991. FAO

Cromwell, E., E. Friis-Hansen, & M. Turner, 1992. *The seed sector in developing countries: A framework for performance analysis*. ODI, London.

CSA, 2002. *The preliminary result of area, production, and yield of temporary crops. Part I*. Addis Ababa, Ethiopia.

Dennis, J.V., 1987. *Farmer management of rice variety diversity in northern Thailand*. Ph.D. Dissertation, Cornell University, USA.

FAO, 2005. *FAOSTAT. Crop Acerage Database*. FAO, Rome, Italy.

Gebrekidan, B., 1981. Salient features of the sorghum breeding strategies used in Ethiopia. *Ethiopia Journal of Agricultural Sciences* 3(2): 97-104.

Ghijsen, H., 1996. The development of varietal testing and breeder's rights in the Netherlands. Pages 223-226. In: *Integrating seed systems for annual food crops* (van Amstel, H., Bottema, J., Sidik, M. and van Santen, C. (eds), CPGRT Center, Bogor, Indonesia.

Green, T., 1987. *Farmer-to-farmer seed exchange in the eastern hills of Nepal: The case of "Pokhrei masino rice."* Pakhribas Agricultural Centre working paper 05/87, p. 36.

Jaffee, S., & J. Srivastava, 1992. *Seed system development: The appropriate roles of the private and public sectors*. World Bank Discussion Papers 167. The World Bank, Washington, DC.

Linnemann, A.R., & G.H. de Bruijn, 1987. Traditional seed supply for food crops. *ILEIA Newsletter* 3(2):10-11.

Mekbib, F., 1997. Farmer participatory variety selection in beans. *Experimental Agriculture* 33:399-408.

Mekbib, F., & S. David, 1999. *Informal bean seed systems in eastern Ethiopia*. Alemaya University, Research Report Series No. 1. Alemaya University, Ethiopia.

Mekbib, F., & C. Farley, 2000. *Participatory research for improved agro-ecosystems Management eastern Ethiopia, Alemaya wereda*. Alemaya University, Research Report Series, No. 2. Alemaya University, Ethiopia.

Mekbib, F., 2002. Simultaneous selection for yield and stability. *Journal of Agricultural Sciences* (*Cambridge University*) 138:249-253.

Mekbib, F., 2003. Yield stability in common bean (*Phaseolus vulgaris* L.) genotypes. *Euphytica* 130:147-153.

Mekbib, F., 2006a. Farmer and formal breeding of sorghum (*Sorghum bicolor* L. (Moench)): Implications for integrated plant breeding. *Euphytica* (In Press).

Mekbib, F., 2006b. Infra-specific folk taxonomy of sorghum (*Sorghum bicolor* L. (Moench)) in eastern Ethiopia: Folk nomenclature, classification and criteria. *Economic Botany* (In press).

Scowcroft, W.R., & C.E.P. Scowcroft, 1998. *Developing a strategy for sustainable seed supply Systems in sub-Saharan Africa: Policies, stakeholders and coordination*. FAO.

Sperling, L., U. Scheidegger, & R. Buruchara, 1996. Designing seed systems with small farmers: Principles derived from bean research in the great lakes region of Africa. Agricultural research and extension network paper. No. 60. ODI, London.

Srivastava, J., & S. Jaffee, 1993. *Best practices for moving seed technology. New Approaches to doing business*. World Bank Technical Paper No. 213. p. 36.

Tripp, R., F. Miti, S. Mukumbuta, D.J. Walker, & M. Zulu, 1998. *Farmers' seed management in Zambia–A study of sorghum, cowpea, and groundnut seed in Southern and Western provinces*. NRI Research Report. Natural Resources Institute, Chatham, Maritime, UK.

Tripp, R. 2001. *Seed provision and agricultural development*. Overseas Development Institute, UK.

Van Amstel, H., J.W.T. Bottema, M. Sidak, & C.E. van Santen (eds.), 1996. *Integrating seed systems for annual food crops. In*: *Proceedings of a workshop, 24-27 Oct. 1995, Malang, Indonesia*. CGPRT Center, Bogor, Indonesia.

World Bank. 2002. Ethiopia, Country Profile.

doi:10.1300/J153v08n03_05