Seed system of tef [*Eragrostis tef* (Zucc.) Trotter] In East Gojjam Zone, Ethiopia

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This research was initiated to document Seed System on tef [Eragrostis tef (Zucc.)Trotter]; specifically, quantify the relative importance of formal and farmer tef seed system. A total of 100 sample households drawn from four PAs of the two districts were interviewed using structured interview schedule. Qualitative data were also collected using group discussion among selected tef growers and extension development agents who were working in the respective PAs. The use of appropriate technologies like fertilizer, improved seed, weeding and/or herbicide application with the recommended rate and time helped to increase productivity. Dissemination of improved varieties to farmers is limited. The informal seed system should prioritize improving seed quality by increasing awareness and skills of farmers, improving seed quality of early generations and market access. In conclusion, to enhance tef productivity in east Gojjam zone through supply of improved varieties and quality seed it is important to integrate formal and farmer (informal) seed system.

Key words: Farmer and formal seed system

INTRODUCTION

Ethiopian farmers grow tef for a number of merits, which is mainly attributed to the socioeconomic, cultural and agronomic benefits. The area under tef cultivation is over 2,481,333 hectares (ha) of land with annual production of 3,028,018.1ton (t) and yield of 12.2 tons per hectare (t/ha). During the 2008/2009 cropping season, tef occupied 28.29% of the cultivated land under cereals, while maize occupied 20.16%, sorghum 18.42%, barely 11.148%, finger millet 4.65%, rice 0.4% and oats 0.35%; this clearly shows the importance of tef in Ethiopia (CSA, 2009).

Nutritionally, tef has as much, or even more food value than the major grains: wheat, barley and maize. This is probably because tef is eaten as the whole grain. Tef grains contains 14-15 percent (%) proteins, 11-33 milligram (mg) iron, 100-150 mg calcium and rich with potassium and phosphorous. The absence of anemia in Ethiopia seems to be associated with the level of tef consumption as the grains contain high iron as reported by the US National Academy of Science (1996). Ecologically, tef is adapted to diverse agro-ecological regions of Ethiopia and grows well under stress environments better than other cereals known worldwide (Hailu and Peat, 1996).

Seed is generally considered to be the most affordable external input for farmers, and many of its benefits are assumed to be 'scale-neutral'. So investments in crop improvement potentially can reach a wide range of farmers, while many other inputs such as markets, credit supply, support institutions, policies, and access to appropriate seed also important for agricultural development (McGuire, 2005). The term seed system represents the entire complex organization, individual and institution associated with the development, multiplication, processing, storage, distribution and marketing of seed in any country. The seed system includes informal and the non-traditional (formal or commercial) systems. The formal seed sector was set up and organized with the principal goal of diffusing quality seed of improved varieties developed by formal breeding programs. The principal sources of materials for formal breeding programs are the *ex situ* collections of gene banks. The farmers' seed production essentially refers to growing a crop for food and save part of it as seed for own use (FAO, 1998).

Saving the best grains, roots or tubers from consumption, farmer's storage and planting developed over centuries into structured local seed systems. The objective of farmer seed systems is to produce sufficient quantities of seed for the preferred crops and varieties of optimum quality available for each farming unit every planting season (FAO, 1998). This seed system includes various aspects of seed such as production, multiplication and quality control.

Although there is a high demand for tef both in the local and export markets, tef production in Tef seed supply is mostly dominated by the informal seed sector. However, there is little information on informal seed sector, farmers indigenous knowledge in seed selection and maintenance, farmers seed sources, seed quality and seed management practices. Hence this study was undertaken with the following objective: to quantify or evaluate the relative importance of formal and farmer tef seed system

MATERIALS AND METHODS

Study area

The study was undertaken in Gozamin and Enarji Enawga district of Eastern Gojjam Zone (EGZ) of Amhara National Regional State (ANRS), Ethiopia (Figure 1). In the study area, during the 2008/2009 cropping season, tef occupied 48.5% of the cultivated land under cereals, while maize occupied 12.75%, sorghum 6.5%, barely 10.9%, and wheat occupied 20.6% (CSA, 2009). Gozzamin is near the capital of East Gojjam (Debre Markos) (3-5 km) while Enarji Enawga is 115km from Debre Markos. These two *weredas* were selected based on scale of *tef* production in the two study areas.

Gozamin district

The Gozamin district is located at $10^0$2' - $10^0$8' north latitude and $37^0$3' - $38^0$1' east longitudes at about 300 kilometer (km) northwest direction of Addis Ababa. The area receives a mean annual rainfall of 1327 mm with a mean maximum temperature of 22.4^{0}C and a mean minimum temperature of 10.6^{0}C. The Gozamin district has two Rural *Kebele* Administration Units

consisting of 40 peasant associations, 47,199 household farmers and a total human population of 256,974. Over 98% of the populations of Gozamin have been involved in agriculture. Listed in order of importance, tef, wheat, maize and barely were the dominant crops cultivated in the Gozamin district (GDAO, 2003).

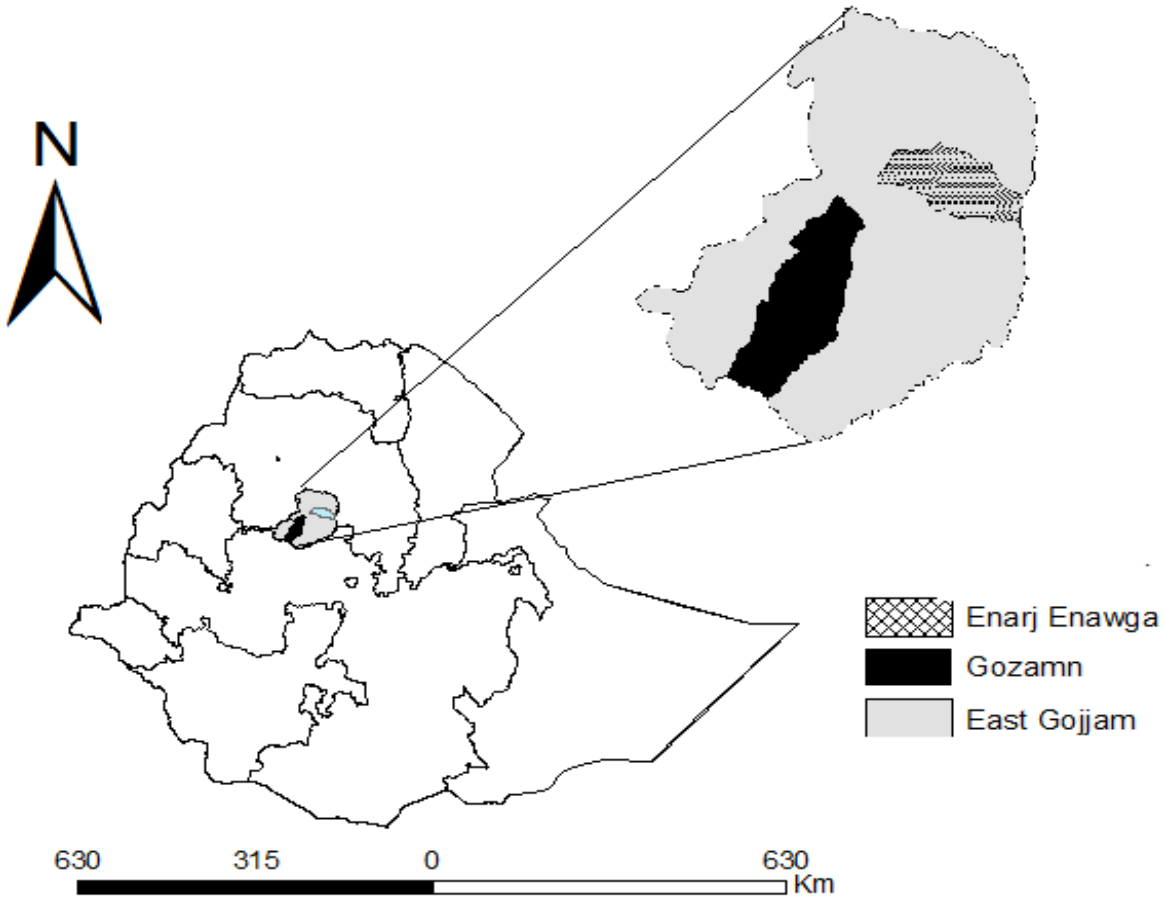

Figure 1. Location map of the study districts

Enarji Enawga district

The district covers a total land area of 76,095.25 ha with widely varying altitudinal ranges of 1100 to 3200 masl. Accordingly, 30% of the total land area lies in *Dega,* 50% *Weynadega* and 20% *Kolla*. The area receives a mean annual rainfall of 1228 mm with a mean maximum temperature of 25 ^{0}C and a mean minimum temperature of 7.5^{0}C. With regards to the land

features, 50% of the district is plain with gentle to flat slopes, 30% is mountainous with undulating to steep slopes and the remaining 20% constitute valley relief. The Enarji Enawga district rural *Kebele* administration units consisting of 27 peasant associations has 165,415 household farmers and a total human population of 185,124. Over 98% of the populations of Enarji Enawga were involved in agriculture Enarji Enawga District Agricultural office (EEDAO, 2009).

Sampling technique and method of data collection

Three stage sampling technique used. First, two *weredas* selected from East Gojjam zone. Second, in each *weredas* four peasant associations selected purposively. Third, farmers were randomly selected from each peasant association. Formal questionnaires developed and used to collect relevant information from the farmers with the help of trained enumerators. The data collection made in the year 2009/2010. A total of 50 farmers from Gozzamin and 50 from Enarji Enawga interviewed. Additional set of information was collected from relevant governmental organizations to back up questionnaire based statistics. Qualitative data were also collected using group discussion among selected tef growers and extension development agents who were working in the respective PAs.

RESULTS AND DISCUSSION

Farmer's characteristics and household resource bases in Gozzamin and Enarji Enawga District

The mean number of male and female family members above 15 years old who helped the farmer during crop production (economically active work force) was 1.48 (SD = 0.68), 1.44 (SD = 0.61), respectively, the mean number of male and female family member less than 15 years was 2.72 (SD = 2.38), 3.44 (SD = 2.26), respectively, in Gozzamin district. Male and female family member less than 15 years were contributing to farm labor was non-significant ($p > 0.05$). These findings were roughly similar for both districts. However, male family members greater than 15 years were highly significant different ($p < 0.01$) between the two districts. Farmers in both districts were sharing labour during plowing, harvesting, and threshing of the tef.

Furthermore, between the two districts the mean number of cattle and oxen were highly significant ($p < 0.01$) (Table 1).

The average age of household head from sample farmers (n=100) was about 44.8 years (SD = 12.09) with the range from 28 to over 70 in Gozzamin, 42.76 (SD = 7.5) with the range from 20 to over 55 in Enarji Enawga district. Only 15% were over 55 years of age. More than 50% of the farmers were above the average age indicating less involvement of younger generation in farming. The mean years of farming experience was about 16 years (SD = 6.45) in Gozzamin whereas, 15 years (SD = 5.33) in Enarji Enawga district. Farmers in the two districts were not statistically different in their ages and years of farming experience (Table 1).

Table 1. Family size and livestock number, farmers age, year of farming experience and amount of land allocated in 2009

	Gozzamin		Enarji Enawga		
Item	Mean	SD	Mean	SD	t-test
Male>15yrs	1.48	0.68	1.96	1.05	-2.66**
Female>15yrs	1.44	0.61	1.43	0.66	0.04^{ns}
Male<15yrs	2.72	2.38	2.22	1.29	1.27^{ns}
Female<15yrs	3.44	2.26	2.61	1.87	1.96^{ns}
Number of Cattle	12.1	4.62	5.82	3.39	7.75**
Number of Oxen	3.52	1.432	2.0	1.29	5.57**
Farmers Age	44.8	12.09	42.76	7.49	0.98^{ns}
Year of farming experience	15.9	6.45	14.86	5.33	1.07^{ns}
Amount of land allocated 2009					
Own land	2.34	0.74	1.62	0.65	5.18**
Hired land	0.53	0.32	0.75	1.33	-3.39**
Share cropped	0.83	0.67	1.5	0.68	-5.01**

SD = Standard deviation,* = Significant at ($P < 0.05$), ** = highly significant ($P < 0.01$) and ns = Non-significant ($P > 0.05$)

About 98% of farmers had holding rights over the land they cultivated whereas the rest were landless and worked being hired and shared crop land. Farmers (n=100) had previous experience

having hired (94% farmers) and shared cropped (90% farmers) from female headed households or old age or lazy farmers additional land for tef production. The two districts were highly significant different ($p < 0.01$) in their average size of own land, hired and sharecropped land holding (Table 1).

The household characteristics of the interviewed farmers were almost all male headed one wife but in Enarji Enawga district had only one female headed no husband. Almost all sampled farmers were married, except one (Enarji Enawga districts) who was divorcee (Table 2).

Table 2. House hold type characteristics, educational level of the respondent, position of the respondent and received credit for buying seeds (n=50)

	Gozzamin		Enarji Enawga	
House hold type characteristics'	n	%	n	%
Male headed	50	100	49	98
Female headed no husband	0	0	1	2
Educational level of the respondent				
Illiterate	32	64.0	36	72.0
Read and write	14	28.0	11	22.0
Elementary school	3	6.0	3	6.0
Junior secondary school	1	2.0	0	0.0
Position the respondent hold				
None	40	80.0	33	66.0
PA leadership member	4	8.0	11	22.0
Traditional leader	6	12.0	6	12.0
Received Credit				
Yes	6	12	13	26
No	44	88	37	74

Source: Own surveyed data, 2010.

The Education level of interviewed farmers varied: 64 and 72% were illiterate (none), 28 and 22% can read and write, 6 and 6% elementary, 2% and 0% were Junior secondary school, from

Gozzamin and Enarji Enawga districts, respectively (Table 2). Farmers with formal education (elementary to high school) constituted 14%, and these would not stay on farm because of employment opportunities in urban area. The social positions of 100 interviewed farmers were 73 of them without position, 15 PA leadership member and 12 farmers were traditional leadership member. Those farmers who have position were more likely to adopt new technology and expand to other farmers or relatives most of the time than those without positions.

Farmers (38%) in the sample area received credit from co-operative union, microfinance institute, as a loan from rich farmers rarely from both districts (Table 2). Farmers received credit most of the time for other purposes like construction of house, buy horses and oxen, not used to buy or purchase of tef seed.

Types of crop grown

The major crops grown includes tef, wheat, maize, and barely. Farmers of EGZ produce various type of crops like millets, oats, sorghum, faba bean, grass pea, nigerseed, chickpea, lentil, Lathyus (*guaya)*, common bean, lupin (*gibeto)*, rapseed, lineseed, sufflower, small amount of sesame dominantly for their own consumption. Crops were listed in Appendix Table 1 with production area in hectares and yield in tons. The productivity of tef was lower than other cereals, for example from the report of BoA of EGZ, 1.68 to 1.99 ton for tef; 2.85 to 4.7 ton for wheat; 1.88 to 2.6 ton for barely; 3.53 to 4.06 ton for maize productivity in the year 2005/2006 to 2009/2010 cropping seasons, respectively. The productivity per unit area of wheat was higher than maize, barely and tef. The area coverage of tef increased from time to time: for example, the total land coverage was 145,129 ha (2005/2006) to 162,394 ha (2009/2010) (Appendix Table 1).

Varieties grown

Farmer seed system

Almost all the interviewed farmers had grown tef in both districts. Other local varieties known and grown by most farmers were *Daboo (key), Sergenga* and *Magna (nech)* and are normally

obtained in their own village or travelled no more than 5 km in search of seed. Farmers' perception on the maturity and threshability of tef varieties was almost all medium. Panicle characteristics were more compacted for *Magna* tef than *Sergenga* while *Daboo* tef panicle loose as compared to the two varieties from both districts. *Daboo* tef was more susceptible for lodging, rust or pest (red tef worm) than *Sergenga* and *Magna* (Table 3).

Table 3. Farmers perception on the currently growing varieties and their characteristics

	Gozzamin						Enarji Enawga					
	Magna		*Sergenga*		*Daboo*		*Magna*		*Sergenga*		*Daboo*	
Maturity	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Early	2	4	4	8	19	36	21	42	16	32	21	42
Medium	28	56	44	88	31	62	27	54	29	58	26	56
Late	20	40	2	4	1	2	2	4	5	10	1	2
Panicle characteristics												
Compact	25	50	31	62	15	30	18	36	25	50	3	6
Medium	5	10	9	18	13	26	12	24	11	22	9	18
Loose	20	40	10	20	22	44	20	40	14	28	38	76
Threshablity												
Highly	2	4	5	10	8	16	16	32	13	26	12	24
Medium	38	76	43	86	41	82	29	68	34	68	38	76
Poorly	40	20	2	4	1	2	0	0	3	6	0	0
Disease or insect Resistance												
Resistance	40	80	47	94	39	78	46	92	45	90	35	70
Susceptible	10	20	3	6	11	22	4	8	5	10	15	30

Source: Own survey data, 2010.

From the discussion, *Magna* tef seed has pale white color and is the variety favored by all farmers but susceptible to rust and armyworm (*Spodotera exempta*) like other tef varieties. *Daboo (key)* tef variety, its selling price was lower, color deep brown, narrow adaptation and it

had low land coverage in every season production than other tef varieties from both districts. Most of the interviewed farmers did grow (86%) local *Daboo, Magna* and *Sergenga* tef varieties (Table 4). The seed system of farmers was dominantly dependent on the farmers' varieties. This is in agreement with the finding of Mekbib (2006a) on sorghum in eastern Ethiopia.

Daboo (*key*), *Sergenga* (*mix*) and *Magna* (*nech)* which were local varieties discovered to have more than one name depending upon the localities they were grown (e.g. instead of *Daboo* farmers said that *Bunegn* in low land area). These varieties were normally grown on different soil type. Main advantages of the farmers' varieties were the seed quality they had, the seed was readily available and it was cheaper than the improved tef varieties. According to Delouche (1982), at least 80% of the seed of the main food crops is produced by the farmers themselves, a figure that is confirmed in other reports and also in this study.

Formal seed system

Mostly, sixteen of the 100 interviewed farmers used improved varieties recently. In the Gozamin district nine of the 50 interviewed farmers used the currently available commercial varieties. The recommended improved tef variety was Dz-01-354 for farmers of the study area locally called as *Global* which had a long history to be grown in those areas. Generally 32% of the farmers used improved tef varieties (Table 4). A remarkable increase was observed year to year in both districts in the use of improved tef varieties. However, since the 2004, the speed and use of new varieties has been accelerated and constitute about 30% of grain traded (Rubyogo *et al*., 2007). However, access to improved tef seed was limited in the study area. These are probably due to the limited technologies in the research area and, in fact, lack of institute that takes the responsibility to multiply released tef varieties (Mesfin *et al*., 2004). Reasons for selection of improved varieties of tef from those interviewed farmers increasingly interested responding to their priority needs to increase productivity (i.e. lodging tolerance) with good marketability or white in color and good cooking/eating qualities (palatability).

Table 4. Farmers using improved tef varieties

	Gozzamin	Enarji-Enawga

Farmers using	n	%	n	%
Yes	9	18	7	14
No	41	82	43	86

Source: own survey data, 2010.

Extension agents said that, the ESE and Ethiopian Agricultural Research Organization (EARO) used to send limited amount of improved tef seed and distributed to small numbers of farmers with the help of district BoA. From key informant interview ESE is involved in tef seed production of improved varieties like Dz-01-387, Dz-01-974, Dz-cr-37, Dz-01-354 and Dz-01-196 at certified level with 3151 hectares of land produced 37,600 quintal in 2008/2009 year. BoA for demand for certified seed was higher than the seed demand forecasted by the ESE marketing division.

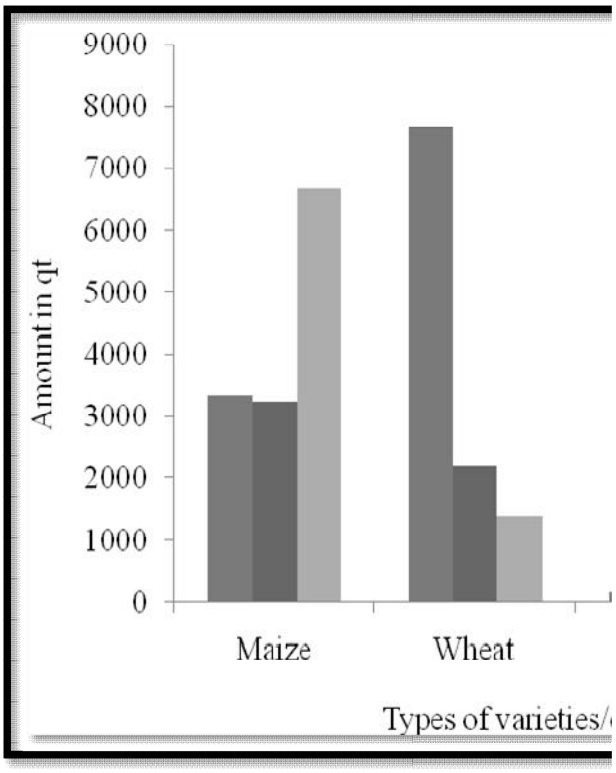

Figure 2. Crop varieties, certified seed supply and distribution (BoAs of EGZ, 2009/10)

BoAs have been aiming to make improved seed available for the small farming communities. As indicated in Figure (2), the supply or demand of certified wheat and maize seed were higher than

tef seed with three and four varieties respectively in the year 2009/2010. For example, the distribution of certified maize seed were 3247.9 qt (BH 660, BH 540, A 511 and BH 543) and certified wheat were 2187.5 (Har1685, Har604 and Durum wheat) for small scale farmers by EGZ Agricultural Office (Appendix Table 2).

Source of information for improved varieties with packages were radio, district BoAs office, other farmers, relatives and neighbours. Farmers of both districts were not aware of the storage structure from radio and extension agents (Table 5). Across the two districts, farmers depended on relatives for information on new varieties, followed by neighbours. Informal sources of information such as relatives, neighbours and other farmers appeared to be the major sources of information flow compared to the formal extension services.

Table 5. Sources of information about improved tef varieties

Source of information	Gozzamin						Enarji Enawga					
	Improved varieties		Fertilizer		Storage		Improved varieties		Fertilizer		Storage	
	n	%	n	%	n	%	n	%	n	%	n	%
Radio	11	22	31	62	0	0	2	4	15	30	0	0
DAs	8	16	15	30	0	0	11	22	9	18	0	0
Other farmers	8	16	0	0	11	22	2	4	4	8	11	22
Relatives	8	16	4	8	25	50	26	52	13	26	18	36
Neighbors	15	30	0	0	14	28	9	18	9	18	21	42

Source: Own survey data, 2010.

The other farmers who were seed sources had participated in extension agents on farm trials and farmers training. The linkage between organizations such as research, extensions and development was poor in both districts. Although none from Gozzamin and Enarji Enawga districts had access to information about improved tef varieties from the Amhara Regional Agricultural Research Institute (ARARI) as farmers are located far away from institute and no institute research activity is available in the two districts.

No seed was distributed by the formal sector except the seed made available by BoA through demonstration and popularization programs. These revealed that, the trained farmers (seed/grain producers) took the lead in passing that information to the field day participants (Rubyogo *et al*., 2007). Tripp and Pal (1998) also found that other farmers followed by shopkeepers were the major sources of information for hybrid pearl millet growers particularly within villages in Rajasthan, India.

Seed sources: initial and current

Gift (done only initially) followed by exchange had the highest seed standards because it was given from the seed saved for planting. Seed sources of farmers' in 2009 and 2010 cropping season were own saved seed, BoA and exchange with other crop seed (Table 6). So, farmers' seed source of tef was initially as a gift from parents, the later on own stock dominated which is in agreement with the finding of Mekbib (2006b) on sorghum in eastern Ethiopia.

Table 6. Initial sources of tef seed

	Gozzamin		Enarji Enawga	
Initial Seed Source	n	%	n	%
BoAs	1	2	8	16
Exchange with other crops seed	17	34	3	6
Purchase from farmers	2	4	8	16
Loan	5	10	5	10
Gift	25	50	26	52

Source: own survey data, 2010.

Although about 30% and 16% were noted to plant seed obtained from BoA, 10% and 20% farmers responded to have the culture of exchanging with other crop seeds like wheat, barley and maize receiving or purchasing tef seeds from their neighbours at the time of the survey from Enarji Enawga and Gozzamin districts, respectively. Farmers who used seed from neighbours suggested the importance of changing their seeds anyway because they assumed that yield decreased when the land and the seed/varieties adapt each other among local tef varieties.

Farmers indicated that in addition to getting seeds from neighbours they either used their own saved seed or buy commercial seed in the same /other years.

The regional agricultural extension program was going on in many parts of the surveyed areas where farmers were supplied with seeds of improved crop varities and other related inputs as packages. Recently distributed improved variety is Dz-Cr-387 (*Quncho*) for few farmers in 2010 cropping season. Even if, farmers in Enarji Enawga (40%) and Gozzamin (70%) knew about improved tef varieties, they did not have access. In addition to supply of the seeds of new varieties, those farmers were considerable source of skills and knowledge about the variety adaptation and management (Rubyogo *et al.,* 2007).

Table 7. Source of tef seed in 2009 and 2010 cropping season

Seed source	Enarji Enawga		Gozzamin	
2009	n	%	n	%
Own saved	37	74	41	82
Neighbors'	6	12	5	10
Others	7	14	4	8
2010				
Own saved	30	60	32	64
Neighbors'	5	10	10	20
Others	15	30	8	16

Source: Own survey data, 2010. Note: others include BoAs, Neighbors include tef seed exchange with farmers

Agronomic package, tef seed management and protection

The frequencies of the land plowed by oxen ranged from four to ten times depending on the cleanlines of the land. The majority of the farmers plowed seven (26%) and eight (42%) times when the land was weedy and it normally starts after harvesting in Gozzamin district (Table 8). The available experimental data generally indicated that the grain yield increases with an increase in number of plowing. However, the necessity of plowing more than three times was not

apparent at least in vertisol areas of the central highlands. Under farmers practices, tef fields are plowed between two and five times; in most cases more than three times (Fufa *et al*., 2001).

From Gozzamin (64%) and Enarji Enawga (58%) district of the sampled farmers weeded at seedling and vegetative stage, one at young stage and three times at vegetative to flowering. Farmers gave due attention to the management of tef production. However, all farmers practiced broadcasting but not row planting which made difficult to do inter-cultivating such as weeding and maintain appropriate plant population. Some of the recommended practices were not properly managed by sampled households. It was witnessed that no shift in their cropping pattern to replace the long time culture of tef production. Research results have also indicated that drilling in rows did not show significant grain yield advantage over the broadcasting method (Fufa *et al*., 2001).

Table 8. Farmers weeding and plowing frequency

	Gozzamin		Enarji-Enawga	
Weeding frequency	n	%	n	%
One times	15	30	20	40
Two times	32	64	29	58
Three times	3	6	1	2
Plowing time				
Four times	0	0	4	8
Five times	0	0	7	14
Six times	6	12	17	34
Seven times	13	26	13	26
Eight times	21	42	10	20
Nine times	7	14	0	0
Ten times	3	6	0	0

Source: own survey data, 2010.

Mostly adopted and widely used fertilizers are DAP and urea and the rate used varied among different farmers. The mean DAP usage was higher than that of urea in both districts. Seed rate

applied was higher in Gozzamin than Enarji Enawga districts and was significantly different ($p < 0.05$) (Table 9). Similar to present results the use of high dose of nitrogen fertilizer, for instance, is restricted considerably to increase yield in tef. Up to 100 kg per ha of DAP should be applied to tef grown on Nitosols. These recommendations corroborate the fact that urea is less effective on acidic soils (Tekalign *et al*., 2001).

All of the farmers apply fertilizer and compost with or without the recommended rate before and after sowing. From Gozzamin (90%) and Enarji Enawga (60%) farmers in the two districts had land of medium fertility, while few farmers in each districts had fertile as well as unfertile land. Most farmers in Enarji Enawga district had tef land with good and poor soil fertility than farmers in Gozzamin districts (Table 9).

Table 9. Seed, fertilizer rate and farmers perception of soil fertility

	Gozzamin		Enarji Enawga		
Rate kg per ha	Mean	SD	Mean	SD	t-test
Urea	27.3	19.80	32.9	28.4	-1.14^{ns}
DAP	89.0	15.28	100.0	48.7	-1.52^{ns}
Seed	36.9	8.26	33.2	7.6	2.33*
Perception on soil fertility	n	%	n	%	
Good	5	10	7	14	
Medium	45	90	30	60	
Poor	0	0	13	26	

Source: Own survey data, 2010. SD= Standard deviation.

During the group discussion, farmers pointed out that when moisture stress occurs cut-worms appear largely on tef fields. It affected Dz-01-354 more than the local one. Farmers control it culturally by mixing mud and cow dung. Herbicide non-users reported that they didn't use herbicide for the cost reason. Instead of using herbicide they burn crop residue on the field to suppress weed development use family labour. Similarly, the return from herbicide was not attractive even though it's effective in saving labour that would be used for other activities (Teklu *et al.,* 2001).

Seed production, harvesting and processing

No separate plot was allocated for tef seed production in both districts; it is normally produced with the grain. The reasons indicated by the farmers were no idea about separate production of the seed, scarcity of land and not easily managed during harvesting, threshing. Farmers who had no idea about separate plot production of the tef seed were 40% and 34%, not manageable during post harvest management 60% and 34%, scarcity of land 0% and 32% from Gozzamin and Enarji Enawga districts, respectively (Table 10).

Table 10. Farmers' reason for not producing tef seed separately, mechanism of tef seed sorting and knowing physiological maturity time

	Gozzamin		Enarji Enawga	
Reason for not producing tef seed separately	n	%	n	%
No idea about separate production of seed	20	40	17	34
Not manageable during post harvest process	30	60	17	34
Scarcity of land	0	0	16	32
Farmers mechanism of tef seed sorting				
Cleaning after storage before planting	21	42	23	46
After threshing, separate grain and seed	9	18	8	16
After storage, planting without cleaning	20	40	19	36
Mechanism of knowing physiological maturity				
Change in plant color from green to yellow	31	62	37	64
Change in plant color and plant drying	4	8	0	0
All	15	30	13	26

Source: own survey data, 2010.

Forty two and thirty six percent of the farmers store and clean tef seed before planting, 40% and 36% of them sow the tef seed without cleaning and 18% and 16% after threshing separate seed and grain before storage in Gozzamin and Enarji Enawga districts, respectively. Farmers separate seed from grain threshing up to storage when the rain damaged the harvested panicle (Table 10). Farmers normally produce tef seed with grain and quality of tef seed not easily controlled.

Mechanism of physiological maturity time detection of sampled farmers were when 62% and 64% change the color of the plant green to yellow, 8% and 0% change the plant color and when the plant parts dried, 30% and 26% farmers used plant color, plant drying, counting the time from sowing up to harvesting from Gozzamin and Enargi Enawga district, respectively (Table 10). Farmers who stayed for long period after physiological maturity tef panicle shatters by strong wind and unexpected rain which could reduce the yield and quality of seed. During focus group discussion, farmers pointed out that in tef there were not separate production practices of seed and grain. However, farmers differentiate seed from that of grain before sowing.

Contractual seed production

Farmers produce seed contractually in Gozzamin (14%) and Enarji Enawga (10%) districts. Moreover, farmers of Gozzamin (84%) and Enarji Enawga (42%) district had demand for Contractual Seed Production (CSP) for the reasons of getting good quality seed, yield/income and to get on time all the recommended inputs (Table 11). Although tef is a strategic crop and grown on 32% of the cultivated land, seed production of this crop was not attractive to large commercial farmers. As a result, small-scale farmers are now being encouraged by ESE to grow seed of this crop on contract with farmer (Kugbei and Fikru 1997).

In the course of discussion, participating farmers benefited by gaining inputs like tef seed from BoAs, sold the seed for other farmers locally for seed and consumption purpose. Wealth was not an issue in CSP as interested farmers produce by renting land (*kiray*). Moreover, farmers agree on contractual seed production on the next scaling up on tef seed and other crops. As per the key informant interview, the CSP was legally binding agreement between the cooperatives and the farmer to meet the commitments; the cooperatives must provide seed for initial sowing, provide close supervision and technical backup for the seed plots on the same area (*kuta getem*), and purchase the seed for cash at an agreed price at a specified time.

Table 11. Farmers practicing contractual seed production

	Gozzamin		Enarji Enawga	
Had contractual seed production	n	%	n	%

Yes	7	14	5	10
No	43	86	45	90
Type of crop				
Wheat	8	16	0	0
Maize	21	42	30	60
Tef	6	12	10	20
Barely	0	0	10	20
Like to have contractual seed production for non-participating farmers				
Yes	42	84	21	42
No	8	16	29	56

Source: Own survey data, 2010.

The farmers must produce high-quality seed, grow the seed in an area of the farm specified by the responsible technical staff, manage the crop, clean the seed after harvest and deliver it at a specified time. Contract prices were based on estimated yield and production cost. BoAs purchase with higher price than the local market but growers sold tef seed to other farmers for grain/seed purpose as they were not bought by cooperatives' or BoA as per the contract timely.

Seed storage and protection

Farmers of both Gozzamin and Enarji Enawga district, dominantly (88%) store seed/grain in Gotta for the following reason: (1) seed is not attacked by pests, (2) when seed is not affected by moisture, (3) for seed that needs to be stored for longer period of time. Those to be used immediately are commonly stored in plastic sacks (8%) and leather sacks (4%) (Table 12). All farmers had to save seed from one season to the next and have storage structure to maintain good quality seeds for the next cropping season. As report of table 16, hundred percent of the farmers of Gozzamin and 98% from Enarji Enawga districts put the seed/grain of tef in the storage. Farmers especially women's are responsible for storage and maintenance of seed.

The interviewed farmers said that storage pest were not a major problem in Gozzamin (54%) and Enarji Enawga (84%). About 60% from both districts of sampled farmers protect tef seed by

sunning. Chemical was used only 2% of the farmers from Gozzamin district when the tef is it attacked by rodents when tef is stored in the sacks (Table 12). In the course of discussion, farmers have revealed that there was no serious storage pest for tef, as result they do not have special protection measures. For protection from rodents' farmers was normally used a cat or rat-trap.

The amount of tef seed stored was significantly different among tef varieties from both districts. The amounts of *Magna* and *Sergenga* tef sold in the sampled area were not significantly different while the amount of *Daboo* tef sold was highly significant different ($p < 0.01$) between the two districts (Table 13).

Table 12. Farmers tef storage structure and protection

	Gozzamin		Enarji Enawga	
Put in to storage	n	%	n	%
Yes	50	100	49	98
No	0	0	1	2
The storage material of seed/grain				
Gota in the house	44	88	44	88
Sack in the house	4	8	4	8
Jute or leather sacks	2	4	2	4
Measures to be taken from storage pests				
Not affected the tef seed	27	54	42	84
Chemical	1	2	0	0
Sunning	22	44	8	16

Source: Own survey data, 2010.

Table 13. Varieties of tef seed stored (kg) and sold (kg) in 2009/2010

	Gozzamin		Enarji Enawga		
Tef seed stored (kg)	Mean	SD	Mean	SD	t-test
Magna	95	45.65	78.5	34.26	2.110**

Daboo	73	72.10	47.5	37.54	2.220**
Sergenga	78	32.89	81.0	80.10	-0.245*
Tef seed sold (kg)					
Magna	726.0	449.40	846	498.25	-1.265^{ns}
Daboo	306.0	177.75	422	170.58	-3.330**
Sergenga	69.7	37.200	82.5	51.57	-1.423^{ns}

Source: Own survey data, 2010. SD = Standard deviation,* = Significant at ($P < 0.01$), ** = highly significant ($P < 0.05$), ns = Non-Significant ($P > 0.05$).

Seed diversity, management and varietal selection criteria

The number of varieties grown also varied within the sampled farmers. Types of varieties usually grown were *Magna* (16%) and (2%); *Sergenga* and *Magna* (20%) and (36%); *Sergenga* and *Daboo* (14%) and (6%); *Daboo* and *Magna* (16%) and (6%); *Sergenga*, *Daboo* and *Magna* (24%) and (28%) from Gozzamin and Enarji Enawga districts, respectively. Some farmers practiced growing only one tef variety. Farmers producing *Magna* (76%), *Daboo* (60%), *Sergenga* (52%) from Gozzamin and *Magna* (52%), *Sergenga* (84%), *Daboo* (48%) from Enarji Enawga districts. Farmers growing more than one variety normally produced up to three varieties and these were common scenarios (Table 14).

Farmers reflected that simple variety selection to develop locally adapted varieties that are better fitted to the local environment. Farmers of the surveyed area noted change in the performance of the local cultivars. As to the number of varieties grown farmers rated 20% and 14% high, 74% and 70% medium finally 6% and 16% low in Gozzamin and Enarji Enawga districts, respectively (Table 15).

Table 14. Tef varieties usually grown

	Gozzamin		Enarji Enawga	
Type of varieties usually grown	n	%	n	%
Sergenga	2	4	7	14

Daboo	3	6	4	8
Magna	8	16	1	2
Sergenga and *Magna*	10	20	18	36
Sergenga and *Daboo*	7	14	3	6
Daboo and *Magna*	8	16	3	6
Sergenga, Daboo and *Magna*	12	24	14	28

Source: Own survey data, 2010**.**

Table 15. Change in performance of the local varieties, status of on-farm tef genetic resource and varietal/seed selection criteria

	Gozzamin		Enarji Enawga	
Change in performance	n	%	n	%
Yes	28	56	22	44
No	22	44	28	56
Number of varieties grown by farmers				
High	10	20	7	14
Medium	37	74	35	70
Low	3	6	8	16
Varietal/seed selection criteria				
Non-lodging	2	4	1	2
Pest resistance (disease, insect)	5	10	8	16
Seed color/marketability	24	48	16	32
Food quality or water-to-flour ratio	17	34	20	40
Straw yield or quality	2	4	5	10

Source: Own survey data, 2010.

In general, farmers on the sampled area were knowledgeable, skilled and confident on tef genetic resources management activities thereby favoring the conservation and improvement of these materials on-farm. From the discussion, farmers pointed out that, there is no change in number and type of varieties grown. The number of varieties grown by the farmers was rated from medium to high. Farmers of both districts indicated none of tef varieties were lost.

Farmers practiced varietal or seed selection criteria such as for lodging resistance 4% and 2%, pest resistance 10% and 16%, seed color or marketability 48% and 32%, food quality high water-to-flour ratio 34% and 40%, straw yield and quality 4% and 10% from Gozzamin and Enarji Enawga district, respectively (Table 15). As reported by the key informant, tef seed selection was not based on individual plant observation.

Seed security

Farmers were seeds secured from Gozzamin (92%), from Enarji Enawga (84%) districts, while the rest of them were not secured. The reasons of seed insecurity were selling all out, consumption and post harvest problem (Table 16). Similarly, very commonly in the community, the farmer who is seed secure and insecure is known and hence the insecure farmers go and request the secure ones to get seed. As the tradition of rural settlement in the region is based on their affinity (Mekbib, 2006a), seed flow is strongly facilitated.

Table 16. Seed security and reason for seed insecurity

	Gozzamin		Enarji Enawga	
Seed secured	n	%	n	%
Yes	46	92	42	84
No	4	8	8	16
Reason for seed insecurity				
Selling all-out	13	26	6	12
Consumption	12	24	6	12
Post harvest problem	25	50	38	76

Source: Own survey data, 2010.

SUMMARY AND CONCLUSION

The EGZ farmers have, for centuries, used their own seed of land races saved from previous crops, or seed obtained from neighbouring farmers, usually in exchange for grain or some other commodity or even in the form of credit to be paid back in kind or cash after harvest for the following reasons; it was accessible, cheap and timely available, varieties well adapted/known

and adaptive to the farmers conditions/needs. Farmers or producers at village level to produce seed cost-effectively and distribute this within the community.

The majority of (86%) the farmers in the study area are using local varieties of tef; namely, *Sergenga*, *Daboo* and *Manga*. The popular improved tef variety used by the farmers is Dz-01-354. The dominance of one variety of tef is both interesting and worrying. Dz-01-354 is very good variety with many desirable attributes and is widely accepted.

The cooperatives were the main and only source of improved tef seed, while most farmers saved their own seed of tef. There seems to be an effective extension service and farmers are aware of new varieties and modern technologies. The necessary inputs were generally available; the main constraint on the use of inputs such as seed, fertilizer and pesticide were not lack of knowledge, but lack of cash to buy them. The extension service was by far the most popular means of disseminating technical information about improved varieties of tef to farmers in this area. Other means such as the radio, the neighbor, or other farmers played an important part. Research, in particular, did not seem important for communicating information directly to the farmers.

The crop and dirt admixture is easily picked out by hand. No machine can select and clean as that of the manual operation. Seed cleaning focuses on winnowing and sieving. Traditional storage material (*gota*) is more difficult for molds and insects to get started on and also makes aeration more efficient. Linkages with institutions supplying extension services, complementary inputs, etc. are essential. It is important for formal organizations to provide support for strengthening the seed system which are often weak in these areas.

The efforts being made by the ministry of agriculture and other organization to develop local seed business using farmers' cooperatives needs to be strengthened and scaled up to enhance seed supply system. A major strength in having small-scale seed enterprises at village level was the effective link that could form integration between variety selection, seed multiplication, distribution and use, with all stages involving the participation of the smallholders themselves.

In general the role of formal seed system in the tef seed system is very low. The farmers' seed system dominated. The efforts being made by the BoA to supply improved tef variety did not commensurate with the demand. Hence, to circumvent the challenges and establish sustainable seed system in EGZ, integrating formal and farmer seed system at variety development, seed production, seed management, seed protection, seed processing and marketing is indispensable.

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APPENDIX

Appendix Table 1. Five years (1997/98-2001/02) annual production area and yield in east Gojjam zone agricultural rural development office

Crops	1997/98		1998/99		1999/2000		2000/2001		2001/2002	
	Area (ha)	Production (tons)	Area(ha)	Production (tons)	Area(ha)	Production (tons)	Area(ha)	Production (tons)	Area(ha)	Production (tons)
Tef	145,129	243,743.8	146,578	246,680.8	149,056	278,969.9	150,788	279,448.9	162,394	323,462
Wheat	91,604	260,830	100,254	311,348	98,396	322,273.7	109,710	373,429.2	129,655	611,767.8
Barely	41,266	77,942.1	34,846	71,603.5	33,305	75,600.1	46,113	10,192.2	53,433	136,549.3
Maize	38,949	137,727.1	52,034	236,328.4	55,535	269,698.8	58,978	287,675.5	41,563	168,802.2
Sorghum	23,868	50,465.5	25,428	65,872.3	25,567	68,830.4	24,264	66,768	18,423	43,162.5
Bean	21,942	28,997.1	22,546	39,413.6	21,426	42,315.7	30,161	58,502.8	30,125	63,095
Pea	11,904	10,827.4	13,926	19,645.7	13,286	19,792.5	13,513	20,280.7	13,993	23,560.9
Lentil	1,115	8,887	116	9,410	1,128	9,682.00	1,383	11,441	843	8,502
Chickpea	9,900	15,882	10,642	19,690.5	9,163	19,820.6	11,132	23,525.6	9,465	22,378.7
Vetch(*guaya*)	1,099.4	1,772.17	963.2	1,555.17	1.022.0	2.259.49	1.018.6	2,320.37	1,060.8	2,380.58
Hortic.crops	-	-	13,731	15,9615	16,493	18,2075.7	25,014	33,6715	13,015	16,85180
Oat	10,994	17,721.7	9,632	15,551.7	10,220	22,594.9	10,186	23,203.7	10,608	23,805.8
Lupin*(Gebeto)*	155	1,670	244	2,938	203	1,872.00	255	2,665	15	180

Source: East Gojjam Agricultural and Rural Development Office.

Appendix Table 2. Crop varieties and certified seed distribution by BoAs of EGZ, Ethiopia.

Crops	Varieties	Supply (qt) 2009/10	Distribution (qt) 2009/10	Supply (qt) 2010/11
Maize	BH660	2832	2806	4634
	BH540	420	412.8	1209
	A511	97	29.5	-
	BH543	-	-	832
	Total	3349	3247.9	6675
Wheat	1685	7241.5	2055.76	1400
	604	420	68	-
	Durum Wheat	-	63.74	-
	Total	7662	2187.5	1400
Barely	HB42	35	-	-
	Beca	50	-	-
	Shegi	-	-	126
	Hollker	89	4.87	125
	Total	174	4.87	251
Bean	S20	-	-	33
	Cs20Dk	-	-	400
Tef	Dz-01-354	80	45	400
	Dz-01-387	-	-	450
	Total	80	45	950
Pea	*Tegenech*	-	-	34

Source: East Gojjam Zone Agricultural and Rural development Office annual report.