Seed System of Finger Millet [*Eleusine coracana* (L.) Gaertn] in Yilmana-Densa and Mecha Districts, Northwestern Ethiopia

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Abstract

Background: Finger millet is one of the major crops grown in Amhara Regional State particularly in West Gojjam Administration Zone in maintaining food and nutrition security. However, farmers in the study area grow limited number of finger millet varieties due to inadequate efforts of variety development, seed production, distribution and marketing.
Objective: The survey was conducted to assess the existing finger millet seed system, variety development, seed production and to suggest options for effective finger millet seed system development.
Materials and Methods: The survey included 120 sample households from four farmers' associations of Yilmana-Densa and Mecha districts, West Gojam Zone, Northwestern Ethiopia. A structured questionnaire was employed to collect primary data through individual interviews and focus group discussions as well as secondary data from relevant organizations and analyzed using SPSS software Version 20.
Results: The farmers allocate relatively the highest share of their farmland to finger millet. Farmers used multiple seed sources, but gift from parents were found to be a predominant seed source at initial time. In both study areas, on-farm saved seeds accounted 83.6 to 88.1% and borrowed or purchased locally seeds accounted 11.9 to 16.4%. This showed the informal seed system accounted 100% of the seeds used, and the use of seed-fertilizer package did not get attention by extension organization. Few farmers' cultivars are grown in the study area due to inefficiency of informal seed system with poor promotion and poor seed quality.
Conclusion: Finger millet producing smallholder farmers have not access to seeds of improved varieties of the crop and informal seed system was inefficient. Therefore, it is suggested to strengthen both the formal and informal seed systems to enhance the yield of the crop.

Keywords: Formal seed system; Informal seed system; Seed production; Seed source

1. Introduction

Finger millet (*Eleusine coracana*) is the tropical and sub-tropical regions crop cultivated in dry areas with limited rainfall and can adapt to different agro-climatic conditions (Gull *et al*., 2014). It is extensively cultivated in semi-arid regions of Africa and India and is known to save the lives of poor farmers from starvation at times of extreme drought (Kotschi, 2006). One of the important features of millet is its ability to adjust itself to various agro-climatic conditions and serves as a food security crop because it is low input crop and grown mainly by subsistence farmers with high nutritional value and excellent storage qualities (Dida *et al*., 2007).

Finger millet is a source of dietary fiber, minerals, phenolics and vitamins that have nutritional and health benefits. These substances with nutritional values are found in the outer layer of the grain or the seed coat (Antony *et al.,* 1996). The availability of these nutrients can protect against the risk of cardiovascular diseases, type II diabetes, gastrointestinal cancers and a range of other disorders due to regular consumption of whole grain cereals and their products (McKeown, 2002). However, finger millet in Ethiopia does not have history of intensive research and the productivity of the crop is low due to shortage of improved varieties, absence of seed supplying seed companies, poor adoption of improved technologies and local practices dominated cultivation of crop, diseases and moisture stress (Degu Erenso *et al*., 2009).

Modern technology has been the major driving force for increasing agricultural productivity and promoting agriculture development. Generation and transfer of improved technologies are a critical prerequisite for

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agricultural development in Ethiopia (Dawit Alemu *et al.,* 2008). Enhancing the productivity finger millet requires to utilize improved technologies. In Ethiopia, finger millet is considered a minor crop and has received far less research and development recognition than other crops with regard to crop improvement, cultivation practices and utilization as the idea supported by Global Facilitation Unit for Underutilized Species (2014).

The largest producer of finger millet is Amhara Regional State, which has 53.5, 53.56% and 20.18 kg ha^{-1} share from national finger millet area, production, and productivity, respectively. West Gojam from Amhara Regional State has a substantially larger shares of 35.21%, 28.97% and 16.61 kg ha^{-1} area coverage, production and productivity, respectively (CSA, 2015). It is used as food and feed crop in West Gojam; however, the yield of the crop is low as compared to other cereal crops. This is due to the limited access to improved finger millet varieties and less attention given to agronomic packages in extension services as compared to other cereal crops (Wossen Tarekegne *et al.*, 2019). Dida and Devos (2006) also described that the yield of finger millet can reach up to 5 t ha^{-1}, if provided optimal growing condition, but usually, with low emphasis of the crop its productivity is much lower. Limited availability and access to improved seeds is regarded as one of the main obstacles to increasing agricultural productivity in Ethiopia (Ojiewo *et al.*, 2015). Improved seed, chemical fertilizers, and extension services to supply the available inputs are important to increase the productivity of crops (Araya Mebrhatu and Sung-Kyu, 2019). The sustained increase of crop production and productivity is dependent largely on the development of improved varieties and an efficient seed system for the timely supply of these seeds to farmers (Girma Abebe and Amanuel Alemu, 2017).

However, limited number of finger millet improved variety coupled with poor seed quality, unavailability of a given variety at the right place, time and required amount; which support with poor extension system observe in the northwest Ethiopia. These issues are new point to consider for finger millet and in the northwest Ethiopia also. In the other way the farmers' seed obtained and planted is saved, selected and exchanged among farmers themselves through informal seed system only. However, it is critical to preserving the germplasm and cultivar improvement, it delays the farmers to accessing modern technology for the crop improvement. This implies increasing its productivity by penetrating with application of improved technology to improve the livelihood of the farmers' is weak through formal seed system; and then all these challenges are hold true to reflect the existence of in efficient seed system of finger millet. Therefore, understanding seed system is crucial particularly for crops like finger millet. Thus, the objective of this study was to assess the existing finger millet seed system, finger millet varieties used for cultivation, and to suggest effective seed production and supply option in Yilmana-Densa and Mecha districts of West Gojam, northwestern Ethiopia.

2. Materials and Methods

2.1. Description of the Study Areas

The survey was conducted in two adjacent districts; Yilmana-Densa and Mecha of West Gojam Zone, Northwestern Ethiopia. The districts are major finger millet producing and located at about 30 km and 45 km in southwest and southeast of Bahir Dar City, respectively. Rainfall in the areas is bimodal; the short rainy season (*belg)* in March to April followed by more substantial rainfall between June and September *(kremt)*. During the study period, Mecha district received annual rainfall of 1454.5 mm, with maximum and minimum temperatures of 28.1 ^{o}C and 9.4 ^{o}C, respectively. Yilmana-Densa district also received an annual rainfall of 1164.1 mm and the maximum and minimum temperatures were 26.9 ^{o}C and 10.9 ^{o}C, respectively (WAMSC, 2013). The geographical descriptions of the experimental area are presented (Table 1).

Table 1. Geographical description.

Location	Elevation (m.a.s.l.)	Latitude	Longitude
Mecha	1960	11^{o}25'20" N	37^{o}10'20" E
Adet	2240	11^{o}16'19"N	37^{o}28'38"E

Note: *Geographical data were organized from Berhanu et al., 2014; and NSRC, 2006.*

2.2. Sampling Procedures and Participants

The study was based on the data that were obtained through a multi-stage sampling technique. Three stage-sampling techniques were used to select sites and to draw sample farmers. The administrative levels were selected from higher to lower level purposively. First, West Gojam Zone and two districts were selected on the basic of larger area coverage and production potential through purposive sampling techniques. Second, four farmers' associations were selected purposively based on their potential for finger millet production. Third, a total of one hundred twenty finger millet growing farmers were selected based on the list from sample farmers' associations with random sampling techniques. Sample size in each farmer's association was determined according to the proportion to farmers' population in each farmer's associations. In addition, four focus group discussions and individual interviews were conducted using 44-key informants (70.5% males and 29.5% females) who had in depth knowledge about the areas, the farms, crops and local conditions and problems in the farmers' associations. Selection of this group was done in consultation with development agents and a farmers' associations' leader who resided in the area and had knowledge of the farmers around. Key-informants consisted of male and female, as well as young and old farmers who were growing finger millet varieties. Additional information collected from relevant governmental organizations to back up information captured through individual interview and group discussion.

2.3. Data Collection

Interview schedule: a questionnaire was designed to gather information on: household characteristics, farmers' awareness and source of information of new agricultural technologies, farmers' perception and adoption and diffusion of finger millet varieties, number and types of finger millet varieties, important variety characteristics, seed source and seed selection criteria's. Primary data were collected through focus group discussion and individual interviews on household characteristics (household type, distribution of household by educational status, age, and family size), household resource base characteristics, farmers' adoption and seed source, farmers' agronomic practices and perceptions, contractual seed production practices, partners' involvement and coordination.

2.4. Data Analysis

The data were subjected to statistical analyses using SPSS (Version 21) computer package (IBM, 2012), and relationships were explored through frequencies and descriptive statistics.

3. Results

3.1. Household Socio-economic and Land allocation Characteristics

The result in Yilmana-Densa and Mecha Districts among the respondents was found to be 59 and 54 male-headed households; two and five were female-headed households, respectively. The ratio of male and female family members was close to 1:1 (Table 2). The average age of male household members in Yilmana-Densa and Mecha districts was 43.9 (Std = 10.5) and 45.04 (Std = 8.6) years, respectively. The corresponding value for female household members was 37.5 (Std = 3.5) and 46.4 (Std = 4.2) years, in the same order. The age of the respondents also ranged from 20 to 66 years at Yilmana-Densa and 28 to 67 years at Mecha districts.

Nearly half of the total family sizes of sample finger millet producing households in both districts were found to be in the age range below 15 years. The mean number of male and female family members below the age of 15 years in Yilmana-Densa was found to be 1.34 (Std = 1.05) and 1.12 (Std = 0.82), respectively. The corresponding values for Mecha district was 1.48 (Std = 1.18) and 1.56 (Std = 1.12) respectively. In contrast, the average number of male and female family members who were above 15 years old in Yilmana-Densa district were 1.75 (Std = 1.07) and 1.54 (Std = 0.87) while in Mecha district 1.76 (Std = 1.07) and 1.78 (Std = 0.74), respectively (Table 2). Both male and female family members in this age range were found to be actively involved in crop production. The contribution of family members even in this age group to farm work and cattle herding is not negligible.

Among the respondents, 36.1% and 52.5% were found to be illiterate in Yilmana-Densa and Mecha districts, respectively (Table 2). This indicated the presence of variation in education level between study areas and large number of farmers who cannot read and write. Education improves access to information and raises the capacity to understand agricultural instructions provided by extension workers. Hence, it is expected to determine the level of technology adoption. Some studies have found evidence that support this prediction (Rahman, 2008; Hassen Beshir *et al.*, 2012).

The area of farmland allocated for finger millet production as compared to other crops ranked first at Mecha and third at Yilmana-Densa Districts. The average finger millet production farmland sizes per household were 0.26 ± 0.098 ha and 0.54 ± 0.25 ha in Yilmana-Densa and Mecha districts, respectively. The average farmland sizes owned by the farmers were 1.2 ha in Yilmana-Densa and 1.24 ha in Mecha. Farmers who grew cereal crops ploughed their land using oxen only. Farmers, who do not have oxen, cultivated their land by hiring some from neighboring farmers who did have oxen or would rent out their farmland. The types of livestock found are cows, calves, heifers, bulls, sheep, goats, donkeys, horses, and mules. Sample farmers of Yilmana-Densa and Mecha districts owned on average 9 (Std 4.6) and 7.6 (Std 7.1) heads of livestock. The number of oxen owned were 1.9 (Std 0.7) and 1.93 (Std 1.03), respectively (Table 2).

Table 2. Household socio-economic and land allocation characteristics of respondent's farmers in 2013 main cropping season in Mecha and Yilmana-Densa districts.

Variable	Mecha district				Yilmana-Densa district			
	Number	Mean	%	SD	Number	Mean	%	SD
Number of respondents	59				61			
MHH head	54	45.04	91.5	8.6	59	43.9	96.7	10.5
FHH head	5	46.4	8.5	4.2	2	37.5	3.3	3.5
HH size males (>15 years)	104	1.76	26.8	1.07	107	1.75	30.5	1.07
HH size females (>15 years)	105	1.78	27.1	0.74	94	1.54	26.8	0.87
HH size males (< 15 years)	87	1.48	22.4	1.18	82	1.34	23.3	1.05
HH size females (<15 years)	92	1.56	23.7	1.12	68	1.12	19.4	0.82
Total family size	388	6.58	100	1.66	351	5.75	100	1.73
Respondents age range								
20 – 66	–	–			61		100	
28 – 67	59	100			–		–	
Education								
Read & write	2		3.4		3		5	
Grade 1–4	10		17		10		16.4	
Grade 5–8	1		1.7		1		1.6	
Above	1		1.7		1		1.6	
Illiterate	31		52.5		22		36.1	
Land holding (ha)								
< 1	15		25.5		19		31.1	
1 to 2	39		66		38		62.3	
> 2	5		8.5		4		6.6	
Average land holding (ha)		1.24		0.62		1.2		0.57
Average land area rent (ha)		0.49		0.5		0.57		0.54
Average Finger millet (ha)		0.54		0.25		0.26		0.098
Oxen ownership HH^{-1}		1.93		1.03		1.9		0.7
Cattle ownership HH^{-1}		7.6		7.1		9		4.6
Household oxen ownership								
0	5		8.5		1		1.6	
1	11		18.6		14		23	
2	32		54.2		36		59	
3	6		10.2		10		16.4	
4	4		6.8		–		–	
5	1		1.7		–		–	
Total	59		100		61		100	

Note: *MHH = Male household; FHH = Female household; HH = Household; and Std = Standard deviation.*

3.2. Farmers' Selection Criteria for Adopting Finger Millet Cultivars

Cultivars grown by the farmers during the time of study were, *Angedi, Abate necho, Abate tikur, Tikur dekie and Nech dekie*. Of all the criteria, most respondents selected cultivars based on seed yield, food quality, early maturity, marketability, thresh-ability and disease resistance.

Angedi is the most preferred cultivar by farmers for yield and grain color for making *injera*; medium for brew quality, marketability, lodging and disease resistance; but less preferred for biomass quality, to poor soil fertility (ability to grow on soil with low inherent fertility), thresh-ability and early maturity. *Abate necho* is preferred for food quality (*injera* making), marketability (seed color), seed yield, making a brew; and less for other criteria. However, more farmers preferred *Abate tikur* for food quality (*injera* and brew) and yield; medium required for biomass quality, marketability, disease and lodging resistance; but less preferred or thresh-ability and early maturity. The above three local cultivars were grown in both study areas. But at Mecha farmers additionally grew widely other local landraces namely *Tikur* and *Nech dekie* but small number of farmers in Yilmana-Densa District grew *Tikur dekie*. *Tikur dekie* was uniquely appreciated by farmers because of its high yield, good food and biomass quality, marketability, early maturity, thresh-ability and grow the on low soil fertility, disease resistance and lodging tolerance. However, the variety was noted to be low in biomass yield and less preferred for seed color. *Nech dekie* was not widely grown and popular, though it was rated as high in seed yield, seed color, marketability, early maturity and food quality (*injera* and bread), but it was found to be less preferred for brew making and disease resistance.

More than 80% of farmers in Yilmana-Densa district selected *Abate tikur*. In Mecha district, more than 78% of farmers selected *Tikur dekie*, *Tikur dekie,* and *Nech dekie*, which are early maturing and appropriate for late sowing, and they are replaced by *Abate tiku*r, *Angedi* and *Abate necho* when there were early onset and enough rainfall. The second selected crop is *Abate tikur* as compared to other cultivars in all selection criteria except marketability, for which *Abate necho* is preferred (Table 3).

Table 3. Selection criteria of farmers for finger millet cultivars in 2013 main cropping season in Yilmana-Densa and Mecha districts.

Selection criteria	*Angedi* %		*Abte tikur* %		*Abte ncho* %		*Tikur deki* %		*Nech deki* %	
	YD	Mecha	YD	Mecha	YD	Mecha	YD	Mecha	YD	Mecha
Seed yield	24.6	22.0	80.3	39	4.9	23.7	4.9	86.4	–	3.4
Ingera	27.9	37.3	91.8	67.8	6.6	40.7	4.9	89.8	–	5.1
Brew (local)	19.7	11.9	91.8	66.1	1.6	8.5	4.9	91.5	–	–
Bread	23.0	23.7	91.8	66.1	3.3	27.1	4.9	89.8	–	3.4
Marketability	11.5	20.3	39.3	28.8	6.6	39.0	4.9	50.8	–	5.1
Early maturity	3.3	–	19.6	3.4	–	1.7	3.3	89.8	–	1.7
Thresh ability	4.9	–	6.6	8.5	–	3.4	4.9	78.0	–	–
Disease resistance	11.5	3.4	29.5	23.7	–	8.5	4.9	59.3	–	1.7
Poor fertility tolerance	–	1.7	24.6	1.7	–	1.7	–	37.3	–	–
Lodging tolerance	19.7	5.1	26.2	11.9	–	6.8	4.9	45.8	–	–
Stover	–	–	14.8	5.1	–	–	–	15.3	–	–

Note: *YD = Yilmana-Densa.*

Until 2013, sixteen improved finger millet varieties were released by Agricultural Research Institutes in the country; among them, two varieties were released in Adet Agricultural Research Center.

Table 4. Description of finger millet varieties released in Adet Agricultural Research Center at survey period in 2013 main cropping season.

S/N	Variety	Year of release	Seed color	Maintainer center
1	Degu	2005	Black	ADARC/ARARI
2	Necho	2011	White	ADARC/ARARI

Note: *ADARC = Adet Agricultural Research Center; and ARARI = Amhara Region Agricultural Research Institute.*

3.3. Seed Sources, Purchasing and Exchange Seed of Finger Millet

The farm-saved varieties obtained by the sampled farmers during the initial time of sourcing the seed was largely found from parents, but later they used their own stock and later purchased certain amounts of seeds from other farmers in the market. Farmers' seed source of finger millet was initially obtained as a gift from parents and later dominated by own seed stock. The norms that have existed for long in the society has contributed to serve as a seed source because parents provide seed for their daughters/sons when they start life independently. Exchange for better seed is common to all farmers, but no one requests seed freely in the study areas as the requester could be regarded as lazy. The main advantage of farmers' uses of their own stock/saving seed were on availability and convenience, quality, save money to buy seed during sowing time, to maintain preferred varieties and increase confidence in abundance of seed at planting time.

Parents, neighbors, relatives and market were the sources of seed and purchase (farmers, traders); exchange (exchange of labor and other seed), gift and loan are the bases of seed flow. In the context of both study areas, the informal system was only important for the bulk of the seed supply. The seed used by smallholder farmers are shown at decreasing and increasing order at Yilmana-Densa and Mecha, respectively, from our data source (Table 5). Therefore, the informal seed system accounts for 100% of the seed used during the survey period. Finger millet seed flow happens both within and outside the village. Farmers use different seed sources for reasons of crop loss, unfavorable weather, to obtain other/new varieties. Except those few farmers who received seed from organizations for the demonstration purpose, there is no formal finger millet supply system in the study areas

(Table 5 and Table 6). The survey result on the major initial sources of seed illustrated that farmers obtained seed as a gift from parents (78.7%) and purchase from farmers (18%) in Yilmana-Densa and correspondingly in Mecha (81.4%) and (10.2%) gift from parents and purchase, respectively (Table 5). About 88.5% and 83.6% respondents of Yilmana-Densa district used own seed stock during 2012 and 2013, respectively, and 76.3% and 88.1% respondents of Mecha district used own seed stock in 2012 and 2013, respectively (Table 5).

Table 5. Initial finger millet seed source during the 2012–2013 cropping seasons for farmers' in Yilmana-Densa and Mecha districts.

Seed source	Yilmana-Densa						Mecha					
	IS		2012		2013		IS		2012		2013	
	N	%	N	%	N	%	N	%	N	%	N	%
Purchase from farmer	11	18	7	11.5	10	16.4	6	10.2	8	13.6	7	11.9
Gift from parents	48	78.7	0	0	0	0	48	81.4	0	0	0	0
Own stock	0	0	54	88.5	51	83.6	0	0	45	76.3	52	88.1
Others	2	3.3	0	0	0	0	5	8.4	6	10.1	0	0
Total	61		61		61		59		59		59	

Note: *IS = Initial source; and N = Number of farmers.*

Number of farmers involved for purchased and exchanged seeds of finger millet for reasons of absence of own stock seed, replace old seed and to obtain better quality seed at increasing order in both Yilmana-Densa and Mecha districts (Table 6). Only very small portion of farmers in both districts purchased seed due to absence of own stock seed. About 96.2% and 90.9% farmers, in Yilmana-Densa replace their seed in average after three years by purchasing and exchange, respectively. Similarly, about 74.3% and 80.2% numbers in Mecha District renewed their seed after three years in the same order. Large number of farmers, about 80.8% and 91.4% buy local cultivar with market distance located less than 11 km radius for Yilmana-Densa and Mecha Districts, respectively.

Table 6. Purchasing and exchange reason for local source seed by sample farmers in 2013 main cropping season in Yilmana-Densa and Mecha Districts.

Reason for purchasing	Yilmana-Densa		Mecha		Reasons for exchange	Yilmana-Densa		Mecha	
Finger millet seed	N	%	N	%	Finger millet seed	N	%	N	%
Replace old variety	9	17.3	8	22.9	Replace old variety	4	9.1	9	17.6
Better seed quality	39	75	24	68.5	Better seed quality	35	79.5	41	80.4
No own seed	4	7.7	3	8.6	No own seed	5	11.4	1	2
Frequency seed purchase					**Frequency of exchange of seed**				
Every year	0	0	4	11.4	Every year	0	0	3	6
Every other year	1	1.9	1	2.9	Every other year	0	0	1	2
Every 3/more year	50	96.2	26	74.3	Every3/more years	40	90.9	41	80.2
First time	1	1.9	4	11.4	First time	4	9.1	6	11.8
Distance to buy seed									
1 to 4 km	22	42.3	17	48.6					
5 to 10 km	20	38.5	15	42.8					
11 to 15 km	10	19.2	3	8.6					

Note: *Farmers may use two alternatives.*

3.4. Source of Information and Agronomic Practices for Finger Millet Production

Farmers used different sources of information, among them formal extension system has been considered as main source of information and followed by from other farmers' in both study areas. The most important institutional factor identified to obtain information on availability of agronomic packages was agricultural extension in Bureau of Agriculture. The data shown 100% of the respondents have access to information on availability of fertilizers and herbicides at both locations as compared to pesticide, storage and agronomy practices (Table 7).

Table 7. Farmers' sources of information for agronomic packages for local finger millet production (n = 120) in 2013 main cropping season in Yilmana-Densa and Mecha districts.

Sources of information	Fertilizer (%)		Herbicide (%)		Pesticide (%)		Storage (%)		Agronomy %)	
	YD	Mecha	YD	Mecha	YD	Mecha	YD	Mecha	YD	Mecha
BoA	78.1	80.3	77.8	81.2	40	76.6	0.0	3.1	3.3	5.0
Relatives/friends	4.2	1.4	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neighbors	0.0	5.6	0.0	7.2	0.0	0.0	0.0	2.0	0.0	6.9
Farmers'	16.5	9.9	13.8	8.7	0.0	7.8	0.0	0.0	0.0	5.0
Traders	1.2	0.0	4.2	0.0	0.0	0.0	3.3	0.0	0.0	0.0
Local leaders	0.0	2.8	0.0	2.9	0.0	2.0	0.0	0.0	0.0	0.0

Note: *BoA = Bureau of Agriculture; YD = Yilmana-Densa; and same farmers practiced more than one response.*

Land preparation is undertaken using oxen in the study areas. The land plough frequency, such as three, four and five times coincide at increasing order with the number farmers involved in both Yilmana-Densa and Mecha districts (Table 8). Most farmers plough their farmland five times for finger millet production. The seed rate utilized by farmers' can be grouped into three as 15, 25 to 50 and 51 to 75 kg ha^{-1}. About 75.4% and 100% of the respondents in Yilmana-Densa and Mecha districts, respectively, used seed rate above the recommendation (15 kg ha^{-1}). The majority (> 50%) of farmers used broadcasting of 25 to 50 kg ha^{-1} seed rate (Table 8).

Table 8. Agronomic practices used for finger millet production in 2013 main cropping season in Yilmana-Densa and Mecha districts.

Agronomic practice	Yilmana-Densa		Mecha		Fertilizer type and rate	Yilmana-Densa		Mecha	
	N	%	N	%		N	%	N	%
Time of plow					Artificial fertilizer use				
Three time	7	11.5	0	0	Yes	61	100	59	100
Four time	17	27.9	7	11.9	No	0	0	0	0
Five time	29	47.5	40	67.8	Compost				
Above five	8	13.1	12	20.3	Yes	4	6.6	3	5.1
Seed rate kg ha^{-1}					No	57	93.4	56	94.9
15	15	24.6	0	0	DAP kg ha^{-1}				
25–50	31	50.8	34	57.6	50	1	1.6	0	0
51–75	15	24.6	25	42.4	100	31	50.8	20	33.9
Row planting	0	0	0	0	150	1	1.6	8	13.6
Broadcast	61	100	59	100	200	28	45.9	31	52.5
Soil fertility status					Urea kg ha^{-1}				
Good	5	8.2	8	13.6	25	0	0	1	1.7
Medium	33	54.1	30	50.8	50	31	50.8	18	30.5
Poor	23	37.7	21	35.6	100	4	6.6	4	6.8
					Total	35	58.4	23	39.0

Note: *N = Number of farmers'.*

All of the farmers' in both districts applied DAP, but only 58.4% and 39.0% farmers in Yilmana-Densa and Mecha applied Urea, respectively. Only about 6.6% in Yilmana-Densa and 5.1% in Mecha districts applied compost. About 50.8% in Yilmana-Densa and 30.5% in Mecha Districts, farmers have used the recommended fertilizer rates of DAP 100 kg ha^{-1} and Urea 50 kg ha^{-1};

however, the remaining farmers used fertilizer above the recommended rates (Table 8).

3.5. Farmers' Contractual Seed Production

As per the key informants and focus group discussion, the Contractual Seed Production (CSP) on finger millet was not implemented. However, all interviewed farmers showed interest to participate in contractual seed production in finger millet except some due to shortage of land. In Mecha district particularly in the sampled peasant association there was no contractual seed production, but 64.4% of the sample farmers showed interest to participate in contractual seed production due to information obtained in the nearest peasant association. However, at Yilmana-Densa district, 98.4% of farmers showed interest to participate in contractual seed production since some farmers participate in *tef* seed production others observed the field during field visit. Farmers has shown an interest in contractual seed production to obtain improved input, higher yield, good quality seed, training and higher selling price (Table 9).

Table 9. Farmers' contractual seed production in 2013 main cropping season in Yilmana-Densa and Mecha Districts.

CSP	YD		Mecha		CSP	YD		Mecha	
	N	%	N	%		N	%	N	%
Farmers liked to	60	98.4	38	64.4	**Reasons for Participation**				
have CSP					Better input	47	77	26	44.1
Farmers do not	1	1.6	21	35.6	Higher yield	52	85.2	36	61
like to have CSP					Good quality seed	47	77	27	45.8
Total	61	100	59	100	Training	28	45.9	2	3.4
					Higher selling price	49	80.3	18	30.5
					Reasons for not Participation				
					Shortage of land	1	1.6	11	18.6
					Un exposure to see CSP	0	0	1	1.7
					Shortage of labor	0	0	3	5.1
					No suitable land	0	0	6	10.2

Note: *CSP = Contractual seed production; and YD = Yilmana-Densa.*

3.6. Partners Involvement and Linkage

Public institutions and individuals which have been involved in crop production extension service, technology generation and seed multiplication and supply are Amhara Region Bureau of Agriculture and Rural Development offices at different levels, Adet Agricultural Research Center, Ethiopian Seed Enterprise, Amhara Region Seed Enterprise, Amhara Region Seed Agency, and farmers'. The above institutions and farmers were involved at different level during focus group discussion and interviewee.

3.6.1. Agriculture offices and research center

Bureau of Agriculture and Rural Development has different departments that are responsible for production, quality control and marketing of seed produced by farmers. Bureau of Agriculture and Rural Development support farmers based on seed multiplication activity. However, except the major cereal crops, finger millet did not get attention by government in providing improved varieties, promotion work, even though the crop has been grown in wide agro-ecologies and has important role for food security in the region.

Development agents are providing technical support to the farmers based on present crop- packages. There are manuals prepared for cereal seed production, which contain guidelines from seed production to distribution. However, there was no finger millet package like other crops at hand of the development agents to guide improved production. Adet Agricultural Research Center is one of the research centers in the Amhara Region Agricultural Research Institute and working on in the improvement of cereal, pulse and horticultural crops. The center has developed a number of finger millet varieties through selection. However, these varieties did not reach to farmers mainly due to low effort of promotion and scale up work of the center and the extension institutions.

3.6.2. Seed enterprises and farmers

The formal sectors play minor roles in supplying finger millet seed. The parastatal Ethiopian Seed Enterprise only produces a limited amount of finger millet seed previously. The formal system is now ceased because of poor extension and promotion system in improvement, seed multiplication, distribution and marketing. The stakeholders have very weak linkage in doing their responsibilities.

Amhara Region Seed Enterprise was participated in multiplication of finger millet seed, in limited area of land, but because of low attention by extension organization to reach farmers; and sale it as grain for consumption. The formal sector is not functioning due to absence of coordination in stakeholders. Amhara Region Seed Agency has not multiplied finger millet seed and has not information on farmers' demand and availability of basic seeds. This formal sector needs promotion work that could be undertaken in an organized manner to access and ensure availability of improved varieties to increase productivity of finger millet.

During individual interview and focus group discussion, farmers in four peasant association have reported the importance of improved varieties and use certified seed of maize and *tef*. They have also mentioned the storage problem of maize compared to finger millet. Especially farmers in Mecha district reported the superiority of finger millet over other crops in terms of its tolerance to drought and risk minimizing capacity, long life in storage, use of its straw for animal feed and its medicinal value. They finally stated that **"**you people living in a town have interest on crops like *tef*, maize and wheat white crops, and do not give enough attention to crops which are very important to us (farmers) such as finger millet *"Dagusa yehele-anbesa"*.

4. Discussion

Sex, age, family size and education level were the factors, which influenced the status and intensity of seed system of finger millet. Male-headed households predominantly produced finger millet. The age of most household heads were within the age range considered as productive ages. The national average of 4.6 persons per household (EDHS, 2012; CSA, 2017) was also lower than the average family sizes of the study areas. All age groups of farmers (young and old) were generally involved in most of the farming activities. This indicated the presence of enough family labor that contributed to farm operations. The education level between study areas had variation and there are large numbers of farmers who cannot read and write. Education improves access to information and for the capacity to understand agricultural instructions provided by the extension workers. Hence, it is expected to determine the level of technology adoption to give emphasis to establish elder school by government. This result is consistent to findings of (Hassen Beshir *et al.*, 2012; Takahashi *et al.*, 2020).

Farmland allocated was large for finger millet from farmer land holding as compare to other crops, but they are found in low productivity. According to Oduori and Kanyeji (2007), Girma Abebe and Amanuel Alemu (2017) finger millet production and productivity increase when work should be done on the availability of improved seed, improved extension services, establish efficient system for the timely supply of these seeds. The amount of land owned by the farmers' had a positive effect on the extent of crop diversification. This implies that relative large farm size in an area may enable households to allot their land for multiple crops, thereby, minimize production costs and risks than small land holders. This result supports by the finding of (Wondimagegn Mesfin *et al.,* 2011; Rehima Mussema *et al*., 2013; Abebe Birara *et al*., 2019).

Farm animals are a source of draught power, means of transport, food and cash, in the study areas. Animal dung is used as organic fertilizer and fuel. Animals also serve as a measure of wealth in rural areas, but now a day grazing lands changed to cultivated land. Among farm animals, oxen are the main draught power sources in the study areas. Similarly, Solomon Asfaw *et al.* (2011), Hassen Beshir *et al.* (2012) and Melesse Birhanu (2018) indicated that livestock holding plays important role in the decision of farmers to use improved technology.

The supply of improved varieties of finger millet was not practiced in the study areas though improved technologies and efficient seed production and supply system is vital to bring change on the livelihood of smallholder farmers. No attempt was made in participated farmers in plant breeding in the process of variety improvements. Altaye Sisaye (2012) mentioned that researcher's contribution to technology development with involvement of farmers on finger millet is low. Hence, development of varieties without considering farmers' preferences of traits, are also considered the main reason for farmers to use and grow the landraces up to present time.

Most respondents' selection criteria for available cultivars were in agreement with varietal choice on finger millet (Wossen Tarekegne *et al*., 2019). Farmers replaced one cultivar with other cultivars, such as, *Tikur* and *Nech dekie* in Mecha district due to the perception of better return. In addition, farmers' preferences for different traits have decisive role on varietal composition and diversity. About 100% of finger millet production comes from only local cultivars, and also farmers themselves have domesticated, selected and grown till now the cultivars for their adaptation to heterogeneous soil type, rain fall period, time of planting and productivity. This is due to poor promotion of extension service and in efficient seed system. Temesgen Teressa (2019) also reported on unavailability of improved seeds at a required period and place with weak extension and seed system.

Finger millet was produced from farm-saved seeds of farmer's cultivars in the study areas. This is because that modern seed production and supply system in the country has focused mainly on few crops such as maize and wheat varieties (Abebe Atilaw and Lijalem Korbu, 2011; Dawit Tsegaye *et al*., 2017). In addition, Ojiewo *et al.* (2015) revealed that as one of the main obstacles in Ethiopia for increasing agricultural productivity is limited availability and access to quality seed. The demand assessment is also made without considering the environment, social acceptance and economic benefit of crops to smallholder farmers. As a result, farmers merely depend on farm-saved seeds of farmers' cultivars, which are genetically heterogeneous and low productivity. In agreement with this study finding, Firew Mekbib (2007) on sorghum in eastern Ethiopia and Melkam Anteneh and Firew Mekbib (2013) on tef in East Gojam, Amhara Regional state reported that farmers produced from farm-saved seeds of farmers cultivars. In contrary to our result, in Kenya about three-quarters of survey, farmers obtain quality seed for finger millet production from both private and public sectors supply whereas the remained finger millet producing farmers utilized their own saved seed of local varieties (ACET and KIRDI, 2014).

In the study areas, proximity to market center becomes easier to the farmers to take the products to market and to diversify the choice of farmers. This findings matches that of Sichoongwe *et al.* (2014) who also discovered that presence of output market access have impact of crop diversification, which is intended to give a wider choice in the production of a variety of crops in a given area. However, only very small portion of farmers in both districts purchased seed of local cultivar due to absence of own stock seed, which indicated lack of improved seed cultivars demanded in the market.

The recommended seeding rate of finger millet is 15 kg ha^{-1} as cited by (Molla Fentie, 2012), though, the farmers have been using more seed rates due to their perception using such high seed rates would help to cope up with environmental uncertainties such as germination problem, weed competition and pest damage at seedling stage. Thus, high seeding rates improve the chance of even crop establishment stand under farmer's conditions. Similar to the present study, Shinggu *et al.* (2009) reported that, millet suppressed weed when planted at spacing of 10 cm and 25 cm of between plants and rows, respectively, with 30 kg ha^{-1} seeding rates. These showed that farmers, researchers, and extension agents' mechanism of exchange of knowledge and information, feedback on agricultural innovations and activities of surveys and joint adaptive trials were found to be at minimal. Similarly, Altaye Sisaye (2012) reported that research and development in finger millet obtained less emphasis for generating and adoption of improved technologies.

Farmers have used the same to the recommended fertilizers application of DAP at rate of 100 kg ha^{-1} and 50 kg ha^{-1} of Urea as cited by (Molla Fentie, 2012) and also different fertilizer rates. This difference in rates of fertilizers application might be the absence of site-specific fertilizers rates recommendation for the crop, farmers' decision and financial resource. Likewise, in Ethiopia there have been attempts made by the government and non-government organizations to promote quality seed production and distribution through market channels, although until now they represent limited availability of and access to quality seed, and which, become as one of the main obstacles to increasing agricultural productivity (Ojiewo *et al.*, 2015). The contribution of these actors in finger millet production and seed system is very limited, even though the crop has been grown in wide agro-ecologies without season bound if moisture is available and has important role for nutrition, health benefit and food security in the region. Therefore, to improve the existing dysfunctional seed systems an integration of both informal and formal seed systems is vital for the productivity of finger millet.

5. Conclusion

The results of this study demonstrated that the numbers of farmers' cultivars grown in the study areas were low due to inefficiency of informal seed system coupled with poor promotion system. Farmers kept these cultivars for production due to their taste, tolerance to most biotic and abiotic stresses, adaptability and stability of yield. One key and significant observation was that no improved variety of finger millet was available during the assessment period of the informal seed system; but farmers demanded high yielding improved varieties, mainly with their preferred traits (early maturity, food quality, seed yield, disease resistance, marketability and biomass yield and quality). The results of the study also showed that millet is cultivated totally for home consumption as a subsistence crop, though it has potential to grow as a commercial crop. The use of heterogeneous farmers' cultivars without application of improved agronomic practices, extension services and efficient seed system could not allow farmers to produce enough to meet their seed demands. As a result, farmers are gradually shifting to grow high yield but non-traditional crops such as maize in the study areas. This indicates that the need of integrated work by component of seed system in variety development, seed multiplication, distribution and promotion.

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