Performance and Participatory Variety Evaluation of Finger Millet [*Eleusine coracana* (L.) Gaertn] Varieties in West Gojam Zone, Northwest Ethiopia

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Abstract: Ten released and elite finger millet varieties were evaluated during 2013 in West Gojam Zone, Northwest Ethiopia under rain fed conditions through involvement of farmers in participatory variety selection. The study was carried out with the specific objectives to: (1) identify farmers' selection criteria/parameters for finger millet genetic improvement; and (2) select high yielding varieties through participatory variety selection approach. The research was conducted at Adet and Koga Agricultural Research sites in Yilmana-Densa and Mecha Districts (*Woredas*), respectively. The data were collected from agronomic and Farmers' Research and Extension Group members with involvement of fifteen (Koga) and seventeen (Adet) farmers of both sexes (male and female) in pair-wise and direct matrix ranking; on varieties, including Necho, Degu, Mecha, Acc.229380, Padet, Tadesse, Debatsi, Gute, Wama and Barieda. All collected agronomy and farmer selected criteria were analyzed. Combined mean values indicated that, Wama (2067 kgha^{-1}) followed by Gute (1967 kgha^{-1}) and Barieda (1717 kgha^{-1}) were found to be high yielding finger millet varieties, and Debatsie (1367 kgha^{-1}) was identified as the least seed yielding variety. According to farmers' evaluation criteria, over all higher rank was scored by the varieties Barieda and Degu followed by Wama and Gute varieties, in that order, with reference to ease of threshing, early maturity, high biomass yield and quality. The researcher and farmers together identified and suggested Barieda, Degu, Wama and Gute finger millet varieties for production in different ranks. Among the traits preferred by farmers seed color was given priority at Mecha as well as tillering capacity per mat and number of fingers per panicle at Adet. Early maturation was scored 146.5 and 146.8 days on wama and barieda, respectively. High tillering capacity (6.3) and (5.37) for barieda and degu shown in that order; as well as, low disease susceptibility depicted on barieda, degu and gute. The farmers also prefer white seed color for sale and injera making, and also the black seed color for local beer, arki and bread making. Therefore the results indicated, farmers are interested in a wider range of traits or combinations of traits than breeders expected.

Keywords: Combined mean values; Eleusine coracana, finger millet; pair-wise and direct matrix ranking; participatory evaluation; selection criteria; variety; yield.

1. Introduction

In Ethiopia finger millet [*Eleusine coracana* (L.) Gaertn] is one of the most important indigenous cereal crop grown largely by small holder farmers. Finger millet has been mainly grown in Amhara, Benishangul-Gumuz, Oromia, Southern Nations, Nationalities and People's Region of Ethiopia, and Tigray (Figure 1). Finger millet covers about 453,909.38 ha of land with production of 915,314.518 tons (CSA, 2015). It had 3.62 and 3.39% share as compared to the national cereal crops area and production, respectively. Amhara Region is the largest finger millet producer, which has 53.5 and 53.56% share from national finger millet area and production, respectively. West Gojam Zone from Amhara Region has substantially a large share in area coverage with 35.21% and production 28.97% (CSA, 2015). West Gojam Zone from Amhara Region has substantially a large share in area coverage with 35.21% and production 28.97% (CSA, 2015).

In this regard, finger millet in West Gojam Zone, particularly Mecha District (*Woreda*) finger millet-growing area has equal importance as food and feed crop. In spite of the fact that the crop yield in the above zone is low as compared to other cereals (CSA, 2015), its stiff straw is used for animal feed. This is because finger millet has received less priority in research and in the agricultural development extension service. Similarly, several researchers reported that finger millet received less emphasis from research and development for generating improved new varieties, crop management practice and enhancement of adoption of improved technologies (Andualem, 2008; Degu *et al.*, 2009; Molla, 2010; Altaye, 2012; Tafere and Melak, 2013).

According to Mecha District Agriculture Development Office Extension workers, (personal communication, August 10, 2013), ascribed the limitation to lack of improved finger millet varieties and other agronomic package in extension services as compared to other cereal crops. Even if there are a number of released improved varieties, farmers in the study areas do not have information about the existing improved varieties. Likewise, Salasya *et al.* (2009) and Osiru *et al.* (2010)

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ISSN 1993-8195 (Online), ISSN 1992-0407(Print)

pointed out that if the selection and development of the varieties is performed in the absence of major stakeholders and their selection criteria, the resulting technologies would have poor and low adoption and diffusion. A similar problem was also observed in potato improved varieties for high yielding and resistance to late blight (Abebe *et al.,* 2013; Gebremedhin, 2013; Semagn *et al*., 2015).

Participatory variety selection addresses problems of farmers that were not touched by the formal breeding system; for instance, evaluation of released and pre-released varieties that enhance varietal diversity in farm cropping system (Sangay and Mahesh, 2010). Likewise, Thapa *et al. (*2009) and Tiwari *et al.* (2009) illustrated participatory variety selection as a desirable method to resolve problems in introduction and adoption of released varieties, in evaluation and selection for preferences of farmers for their target environments.

Therefore, it is important to identify high yielding and good quality finger millet varieties by participating farmers of Yilmana-Densa and Mecha Districts. Thus, this study was carried out with the specific objectives to (1) identify farmers' selection criteria for finger millet genetic improvement; and (2) select high performing varieties through participatory variety selection approach.

2. Materials and Methods

2.1. Description of Experimental Sites

Adet and Koga were the testing sites found in Yilmana-Densa and Mecha Districts in West Gojam Zone of northwest Ethiopia. Their geographical and edaphic (Table 1) characteristics are indicated in tabular form below.

Table1. Description of experimental sites in the two districts of West Gojam in 2013 cropping season.

Parameters		Mecha (Koga)	Yilmana-Densa (Adet)
Edaphic factors	Soil pH	5.09-5.30	5.38-5.48
	Class	Clay	Clay
	Soil type	Nitisol	Fluvisol
	% OM	2.34-4.44	2.67-2.86
	% total N	0.18-0.24	0.17-0.47
	Available P (ppm)	3.54-8.70	2.64-2.67
Geographical positioning	Altitude	1960	2240
	Latitude	11°25'20"	11°16'16"
	Longitude	37°10'20"	37°28'38"
Weather conditions	Maximum	28.1	26.9
	Minimum	9.4	10.9
	Rainfall (mm)/annum	1454.5	1164.1

Source: WAMSC, 2013; NSRC, 2006; Berhanu, 2014*; NSRC, 2006**; O.M- Organic matter; ppm - parts per million.

2.2. Treatments, Experimental Design and Agronomic Management

Ten finger millet varieties and elite genotype Necho, Degu, Mecha, Acc.229380, Padet, Tadesse, Debatsi, Gute, Wama and Barieda were used for this study. The seed of each variety was obtained from Adet, Melkasa, Pawe Bako Agricultural Research Centers, Amhara Region Agricultural Research Institute (ARARI), Oromia Agricultural Research Institute (ORARI) and Ethiopian Institute of Agricultural Research (EIAR). Some of the major characteristics of the varieties are indicated below (Table 2).

Table 2. Description of tested finger millet varieties included in the varietal evaluation study in two districts of West Gojam Zone in 2013 main cropping season.

No.	Variety	Year of Release	Origin	Seed Color	Maintainer
1	Necho	2011	Local	White	ADARC/ARARI
2	Degu	2005	Local	Black	ADARC/ARARI
3	Mecha	2014	Local	Red Brown	ADARC/ARARI
4	Acc 229380	-	Local	Brown	ADARC/ARARI
5	Padet	1998/99	Introduced	Brown	MARC/EIAR
6	Tadesse	1998/99	Introduced	Brown	MARC/EIAR
7	Debatsi	2010	Local	Brown	PARC/EIAR
8	Gute	2009	Local	Brown	BARC/OARI
9	Wama	2007	Introduced	Brown	BARC/OARI
10	Barieda	2009	Local	Brown	BARC/OARI

Note: ADARC-Adet Agricultural Research Center; ARARI -Amhara Region Agricultural Research Institute: MARC-Melkasa Agricultural Research Center; EIAR-Ethiopian Institute of Agricultural Research; PARC-Pawe Agricultural Research Center; BARC-Bako Agricultural Research Center; OARI-Oromia Agricultural Research Institute

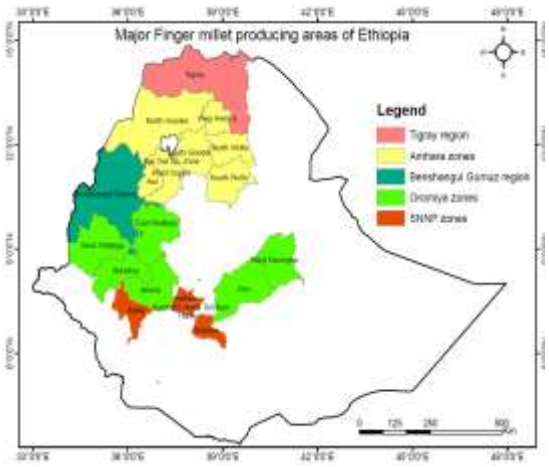

Figure 1. Map of Ethiopia indicating the study areas for the field experiment in 2013 and major finger millet-producing regions of Ethiopia.

Each experimental plot had an area of 10 m^2 with five rows of 2 m length spaced at 0.40 m between rows and 0.15 m between plants as well with seed rate of 15 $kgha^{-1}$. The ten finger millet varieties were laid down in a randomized complete block design (RCBD) with three replications. Fertilizer rates of 100/50 $kgha^{-1}$ for DAP and UREA were applied in rows, respectively. Sowing was done on July 3 and July 11, 2013 at Adet and Koga experimental sites, respectively. At the same time the guard rows were planted at both end side of experimental area. The total required amount of phosphorous applied at basal, but from the total nitrogen applied half was used at planting and the remaining was top dressed at tillering stage. Hand hoeing and weeding was made one and two times, respectively over the growing season to put the experimental plots free of weeds. There was no major insect pest incidence in the season and hence plants were not sprayed with any agro-pesticide. Other agronomic management practices were done as per their recommendation. Depending on the maturity period of each variety, harvesting was done, from mid up to last week of December, 2013. Threshing was done after the harvest was exposed to sun drying.

2.3. Agronomic Data Collected

The phenological, seed yield and yield components and blast susceptibility and lodging percentage of the crop are recorded as follows.

Days to Flowering (DTF): This parameter was recorded as number of days from sowing to stage when ears emerged from 50% of the tillers per plot.

Days to Physiological Maturity (DPM): It was recorded as number of days from sowing to stage when 50% of the tillers per plot had matured ears (detected by yellowing of leaves).

Plant Height (PH) (cm): It was recorded by measuring the height of plants from ground level to the tip of inflorescence (ear), at dough stage.

Number of Tillers per Plant (NOT): The number of tillers per plant was number of basal tillers that bear mature ears and recorded from five randomly taken plants of each plot at harvest.

Number of Ears per Plant (NOE): The number of ears per plant was recorded as the total number of ears produced from all tillers and recorded from five randomly taken plants of each plot at harvest.

Number of Fingers per Ear (NOF): The number of fingers per ear was recorded from five randomly taken plants at harvest.

Finger Length (FL) (cm): The finger length was recorded from the base of the ear to the tip of the finger at each five randomly taken plants of main tillers, at dough stage.

Biomass Yield/plot (BMY) (kg): The biomass yield was recorded from weight of the aboveground parts (stem + leaves + seed) by sensitive balance at harvest after sun drying.

Seed Yield (SYD) (kg ha^{-1}): Seed yield was determined by harvesting all plants from the five rows of each plot, since there was no space between plots to remove the border effect. Seeds were weighed by sensitive balance and approximately adjusted to 10% moisture content by drying in the sun.

Thousand Seed Weight (TSW) (g): Thousand seeds were counted manually from a bulk of threshed seeds of each plot, their moisture were adjusted and weighed in the same way as seed yield data.

Harvest Index/plot (HI) (%): Harvest index was estimated from the proportion of seed weight to the above-ground biomass weight at harvesting dry weight (stem + leaves + seed) at harvest×100.

Head Blast: It was recorded and scored on a 1-9 scale, where: 1 = No lesion (resistant/no susceptibility); 3 = low susceptibility, 5 = medium susceptibility, 7= high susceptibility.

Lodging Susceptibility: This parameter was recorded at the stage of maturity as 1 = very low or no lodging, 3 = low lodging, 5 = intermediate and 7 = high lodging susceptibility according to the finger millet descriptors (IBPGR, 1985).

2.4. Farmers' Participatory Variety Selection

The selected research areas for finger millet research through participatory variety selection (PVS) are found within the research mandate area of Adet Agricultural Research Center (AARC). During 2004, Adet Agricultural Research Center formally adopted client-

oriented research for enhancing the technology generation and transfer processes through establishment and working with Farmers Research and Extension Group (FREG). The farmers' Research and Extension Group members were selected by dwellers of the *Peasant Association* and the established size of Farmers' Research and Extension Group ranged from 15 to 45 farmers based primarily on their finger millet indigenous knowledge, capable for technology transfer and willingness to participate in the research. The Farmers' Research and Extension Group members of fifteen (Koga) and seventeen (Adet) farmers of both sexes (male and female) participated from each district in the evaluation and selection of improved finger millet varieties. To undertake participatory variety selection, farmers identified the selection criteria with respective weight on the basis of their interest. Then the varieties were ranked accordingly. Decision was made among Farmers Research and Extension Group members through group discussion on the appropriate growth stage for evaluation. The farmers then observed and evaluated the varieties based on their overall performance at physiological maturity stage.

The Farmers' Research and Extension Group members were regrouped by mixing literate and illiterate members to facilitate for writing the criteria and varieties in order. Discussions were made in each group and ranked the criteria using pair-wise ranking matrix and obtained the relative weight of each character by considering their interest. Lelo *et al.* (1995) stated that selection criteria identified by farmers were ranked depending on the number of repetition of each selection criterion chosen by the respective Group. After identifying the weight, randomly taken one block of the experimental site, farmers obtained clarification how to evaluate ten varieties of finger millet based on the fitness of specific agreed selection criteria.

Scores were given to each variety based on the selection criteria (1 = very good, 2 = good, 3 = average, 4 = poor and 5 = very poor) and ranked each of them. To select the best variety fitted to farmers' interest, multiple weights were given to each criterion by the rank of the varieties. According to de Boef and Thijssen (2006) scoring and ranking were done based on agreement of farmers involved during discussion on the criteria and variety selection.

2.5. Data Analysis

Analysis of variance (ANOVA) was done for all the traits following procedures of Gomez and Gomez (1984) using statistical analysis system (SAS, 2002). Combined data analysis was done on the measured parameters in the two districts, since the error variances were homogenous. The mean separation was done with Duncan's Multiple Range Test (DMRT) method. Data collected through participation of Farmers' Research and Extension Group members were analyzed using pair-wise ranking and direct matrix procedure. The criteria were fixed in the first row while the varieties in the first column of the table; and ranking was done in groups.

3. Results and Discussion

3.1. Performance of Tested Finger Millet Varieties in Two Locations

The analysis of variance (ANOVA) revealed significant ($P \leq 0.01$) difference among the varieties for phenological and agronomic traits, and indicated the presence of sufficient variability, which could be attributed to the genetic potential of the varieties used among the evaluated varieties and for the traits under consideration (Table 3). This result is in agreement with similar findings of sorghum (Yalemtesfa *et al.*, 2014; Mihret, 2015).

Results of combined analysis for days to flowering ranged from 96.5 to 110.3 days. Except Debatsie, other tested finger millet varieties flowered earlier, but the least range was recorded for Acc.229380 (Table 3). Days to physiological maturity ranged from146.5 to 158.3 days. The finger millet varieties Wama and Barieda matured earlier than the rest varieties and recorded 146.5 and 146.8 days, respectively, but Debatsie matured later (158.3 days) (Table 3). The physiological maturity for the varieties Wama and Degu agreed with that of the observation by Molla (2012).

The finger millet Degu was the tallest (mean height 73.67 cm) variety, while Debatsie was the shortest (with mean height of 56.1 cm) variety in the group (Table 3). As far as finger length is concerned, Degu had the longest (mean of 11.67 cm), followed by Necho (11.2 cm) and Barieda (9.5 cm); however, the varieties Tadesse and Padet (6.07 cm) and Debatsie (5.5 cm) had the shortest lengths (Table 3). High number of fingers (8.2 fingers per panicle) was recorded for the variety Necho, followed by the variety Degu (7.23) and Debatsie (7.17), whereas less numbers of 4.6 and 5.0 were recorded for the varieties Wama and Mecha, respectively, than the rest varieties. High mean numbers of tillers of 6.3, 5.37 and 4.5 were recorded for the varieties Barieda, Degu and Necho, in that order. Correspondingly, less numbers of fingers of 3.5 and 3.53 were recorded for the Acc. 229380 and for both varieties Tadesse and Gute. High number of ears was recorded for the variety Degu (7.63), followed by Barieda (6.7) and Necho (5.7); but less numbers of 4.0 and 4.03 were recorded for the Acc.229380 and Tadesse, respectively. Previously Molla (2012) reported similar results with the current findings with reference to plant height, finger length and number of fingers tested under various environments. The varieties evaluated in the present study had a wide adaptation across the various agro-ecologies of the study areas. The differences in plant heights, finger lengths, numbers of fingers, numbers of tillers and numbers of ears among the finger millet varieties might be due to inherent characters of the varieties and the variability in the rainfall distribution in the study areas. Finger length per plant, number of fingers per plant, number of tillers

per plant and number of ears per plant are important features of the crop in determining the yield potential, particularly for varieties having thin straws (stems); however, this result contradicts with the tested finger millet performance that illustrated maximum yield with stiff stalks (i.e. Wama and Gute varieties). Wama and Gute varieties showed higher seed weight and wider finger width with large number of seeds per finger. The present research results are consistent with the investigation by Molla (2012).

Table 3. Combined mean values for different traits of tested finger millet varieties in two districts of West Gojam Zone in 2013 main cropping season.

No.	Varieties	Days to flowering	Days to maturity	Plant height	Finger length	Number offinger	Number of tiller	Number of ear
1	Necho	99.00b	150.80b	70.85abc	11.20a	8.20a	4.60bc	5.70bc
2	Degu	100.50b	149.00bc	73.67a	11.67a	7.23b	5.37ab	7.63a
3	Mecha	99.30b	148.80bc	65.50bc	8.03c	5.00cd	4.37bc	5.10cd
4	Ac.229380	96.50b	147.30bc	64.70c	7.50c	5.50cd	3.50c	4.00d
5	Padet	99.20b	148.30bc	68.70abc	6.07d	5.07cd	3.60c	4.10d
6	Tadesse	98.70b	148.50bc	69.47abc	6.07d	5.63c	3.53c	4.03d
7	Debatsi	110.30a	158.30a	56.10d	5.50d	7.17b	3.73c	4.10d
8	Gute	99.30b	148.20bc	73.17a	7.62c	5.07cd	3.53c	4.10d
9	Wama	99.00b	146.50c	71.63ab	7.97c	4.60d	3.67c	4.20d
10	Barieda	101.30b	146.80c	67.10abc	9.50b	5.27cd	6.30a	6.70ab
	Mean	100.32	149.27	68.52	8.11	5.88	4.22	4.97
	SE (±)	0.54	0.74	0.95	0.124	0.11	0.1	0.14
	CV (%)	1.32	1.22	3.42	3.75	4.62	5.91	6.99

The analysis of variance (ANOVA) revealed highly significant ($p \leq 0.01$) difference between locations for phenological and agronomic traits between locations (Table 4). A result of combined analysis for flowering was early (97.8 days) at Mecha, while it was late (102.83 days) at Adet (Table 4). Short duration (147.67 days) was required for physiological maturity at Mecha. On the contrary, plants required long duration (150.87 days) to mature at Adet (Table 4). Differences among varieties for phenological traits could be due to the inherent genetic ability of the varieties, altitude and climate differences. Hence, the longest duration (days) to physiological maturity was suitable to areas having long production season, but the early maturing ones are suited to short crop production season.

Table 4. Combined mean values for phenological and agronomic traits of finger millet tested varieties across locations in West Gojam Zone in 2013 main cropping season.

No.	Location	Days to 50% flowering	Days to physiologic al maturity	Plant height (cm)	Finger length (cm)	Number of fingers	Number of tillers per mat	Number of ears per panicle
1	Adet	102.83a	150.87a	64.85b	8.28a	6.42a	4.71a	5.90a
2	Mecha	97.80b	147.67b	71.34a	7.95b	5.33b	3.727b	4.04b
	Mean	100.3	149.27	68.1	8.11	5.88	4.22	4.97
	SE(±)	0.24	0.33	0.43	0.06	0.05	0.05	0.06
	CV (%)	1.32	1.22	3.42	3.75	4.62	5.91	6.99

3.2. Combined Analysis of Yield and Yield Components of tested Finger Millet varieties

The analysis of variance (ANOVA) revealed significant ($P \leq 0.01$) difference in yield and yield components among the tested finger millet varieties except for biomass yield. The mean seed yield of the varieties ranged from 1,367 to 2,067 kg ha^{-1} for Debatsie and Wama, respectively. The high yielding varieties were Wama (2,067 kg ha^{-1}), Gute (1,967 kg ha^{-1}) and Barieda (1,717 kg ha^{-1}). On the contrary, Debatsie (1,367 kg ha^{-1}), Acc.229380 (1,383 kg ha^{-1}) and Necho (1,417 kg ha^{-1}) were low yielding varieties (Table 5). Highly significant seed yield variations among varieties could be due to inherent genetic characters of the varieties, different and uneven rainfall distribution and variation in altitudes.

High value (3.33 g) of thousand seed weight was recorded for the varieties Wama and Mecha, which had large seed sizes. But, Barieda, Degu and Necho had the respective low values of 2, 2.13 and 2.18 g thousand seed weight (Table 5). In agreement with the present finding previously several researchers reported similar results in their investigations and stated the presence of significant difference among varieties in seed yield of

finger millet (Andualem, 2008; Chrispus, 2008; Molla, 2012). The variety Wama had the highest performance in seed yield and biomass yield both in this and previous study of Molla (2012). The variation for seed yield and thousand seed weight among varieties might be due to the inherent genetic difference of the tested finger millet varieties.

Combined mean values of seed yields and harvest indices of Debatsie, Padet and Tadesse were less than that of the other tested finger millet varieties even though they had better performance in biomass. The varieties Wama, Gute and Barieda showed consistent performance in seed yield, biomass yield and harvest indices in both tested areas, which, in turn, contributed to their selection preferences by farmers and plant breeders. The breeders showed that the higher yielding varieties were found to have both higher biomass and harvest indices than the low yielder varieties. Therefore, Wama, Gute and Barieda had genetic differences in more than one preferred character, namely seed yield, harvest index and biomass yield, could use as parent material in breeding program to improve finger millet.

The analysis of variance (ANOVA) revealed highly significant ($p \leq 0.01$) difference in yield and yield components between locations except for thousand seed weight and harvest index (Table 6), indicating the presence of sufficient genotypic differences in finger millet for the traits under consideration. The variability among the evaluated traits could be attributed to the genetic potential of the varieties used, which is in concurrence with the results of sorghum (Yalemtesfa *et al.*, 2014; Mihret, 2015). About 1693 kg ha^{-1} seed yield was obtained at Adet as compared to 1473 kg ha^{-1} at Mecha (Table 6). Generally, the performance of tested finger millet varieties was recorded higher at Adet than at Mecha. This might be because of occurrence of favorable weather conditions throughout the growing season of the crop at Adet.

Table 5. Combined mean values for yield and yield components of tested finger millet varieties in two districts of West Gojam Zone in 2013 main cropping season.

No.	Varieties	Seed yield (kg ha^{-1})	1000 seed weight (g)	Biomass yield(kg ha^{-1})	Harvest index (%)
1	Necho	1417c	2.18e	7300b-d	19.69a-c
2	Degu	1483bc	2.13e	7900a-d	19.03b-d
3	Mecha	1450c	3.33a	6800cd	22.03ab
4	Ac.229380	1383c	2.77cd	6600d	21.12ab
5	Padet	1483bc	2.95bc	9550a	15.63cd
6	Tadesse	1500bc	3.03bc	9167ab	16.57cd
7	Debatsi	1367c	2.53d	9100ab	15.18d
8	Gute	1967a	3.17ab	8800a-c	22.88ab
9	Wama	2067a	3.33a	9067ab	23.83a
10	Barieda	1717b	2.00e	7783a-d	22.71ab
	Mean	1583	2.74	8.21	19.87
	SE (±)	0.0396	0.09	0.41	1.2
	CV (%)	6.125	7.55	12.3	14.84

3.3. Lodging Susceptibility and Reaction of the Tested Finger Millet Varieties to Disease

Lodging susceptibility among varieties of finger millet and across the two locations observed was none except the variety Degu with low lodging susceptibility (Table 7). Equal to the other parameters, disease resistant varieties are more advantageous for finger millet improvement. Among tested finger millet varieties, susceptibility difference for head blast disease was expressed at both research locations. This might have occurred due to genetic variation in the finger millet varieties and dissimilarity in weather conditions and altitudes of the research areas. The environmental conditions, such as low minimum up to high maximum temperatures and high rainfall and low altitude were recorded at Mecha. In connection to this, head blast disease was more severe in Mecha than in Adet. Similarly, Patro and Madhuri (2014) expressed that the increase in temperature high rainfall and high relative humidity would increase infection on susceptible finger millet varieties by head blast disease.

The values of reaction of tested finger millet varieties to head blast disease at Adet and Mecha are tabulated (Table 7). The occurrence of the disease varied among varieties and across locations. The severity of head blast was relatively much higher on Necho, Degu, Mecha, Padet, Gute and Wama in Mecha than in Adet district. But, Barieda and Debatsie showed resistant reaction, while Tadesse and Acc.229380 exhibited moderately susceptible reaction to head blast. According to Lule *et al.* (2013), an average of 42% finger millet grain yield was lost due to blast disease in Ethiopia. Similarly, finger millet yield loss was estimated at 41.8% (Gashaw *et al.*, 2014).

Table 6. Combined mean values for yield and yield components of the varieties across locations in West Gojam Zone in 2013 main cropping season.

No.	Location (District)	Seed yield (kg ha^{-1})	1000 seed weight (g)	Biomass yield(kg ha^{-1})	Harvest index (%)
1	Adet	1693a	2.79a	9056a	19.08b
2	Mecha	1473b	2.69b	7356b	20.65a
	Mean	1583	2.74	8207	19.87
	SE(±)	0.02	0.04	0.18	0.54
	CV (%)	6.13	7.55	12.3	14.84

Table 7. Mean values of tested finger millet varieties for disease reaction and lodging susceptibility at two locations in West Gojam Zone in 2013 main cropping season.

		Head blast		Lodging	
No.	Varieties	Mecha	Adet	Mecha	Adet
1	Necho	3	1	1	1
2	Degu	2	1	1	1.33
3	Mecha	3	1	1	1
4	Acc.229380	5	1	1	1
5	Padet	4	1	1	1
6	Tadesse	5	2	1	1
7	Debatsie	1	1	1	1
8	Gute	3	1	1	1
9	Wama	4	2	1	1
10	Barieda	1	1	1	1

Head blast: 3= low susceptibility, 5= medium susceptibility, 7= high susceptibility.
Lodging: 1= very low or no lodging, 3= low lodging, 5= intermediate and 7= high lodging susceptibility.

3.4. Farmers' Evaluation Results of Tested Finger Millet Varieties

The evaluation result of Farmers' Research and Extension Group members' selection criteria are described here under Table 8 and Table 9. The selection criteria that farmers depended on for evaluation were seed yield, yield components, seed color and disease resistance; which are similar to selection criteria identified for bean (Asrat and Fitsum, 2008; Mekonen *et al.*, 2012) and sorghum (Yalemtesfa *et al.,* 2014). At the time of criteria selection, women and men farmers were grouped separately; and women farmers chose seed yield and seed color (especially at Adet) traits, while men focused on seed yield and other yield related characters. The interest of selection depends on the demand to generate income in local market and home consumption in women's and needs for food and feed for animals in men.

Focus Group Discussion (FGD) was under taken together in the Farmers' Research and Extension Group members prior to individual group's variety selection to depict the performance of variety according to the selection criteria in each experimental plot (Figure 2).

Figure 2. FREG members holding focus group discussion (FGD) for identification of stage of evaluation, and setting selection criteria for evaluation of performance of finger millet varieties in two districts of West Gojam Zone in 2013 main cropping season

Table 8. Pair-wise ranking matrix of FREG selection criteria at Mecha site, (n=15), West Gojam Zone in 2013 main cropping season.

No.	Criteria	Early maturity	Biomass quality	Seed Yield	Disease resistance	Biomass yield	Seed color	Total	Rank
1	Early maturity	X	Early maturity	Seed yield	Disease resistance	Early maturity	Seed color	2	4
2	Biomass quality		X	Seed yield	Disease resistance	Biomass yield	Seed color	0	6
3	Seed yield			X	Seed yield	Seed yield	Seed yield	5	1
4	Disease resistance				X	Disease resistance	Disease resistance	4	2
5	Biomass yield					X	Seed color	1	5
6	Seed color						X	3	3

Note: Number of participants=15 (male=12, female=3)

Table 9. Pair-wise ranking matrix of FREG selection criteria at Adet site, (n= 17) West Gojam Zone in 2013 main cropping season.

No.	Criteria	Early maturity	Biomass quality	Seed yield	Disease resistance	Tiller capacity	Number of finger	Total	Rank
1	Early maturity	X	Early maturity	Seed yield	Disease resistance	Tiller capacity	Early mature	2	4
2	Biomass quality		X	Seed yield	Disease resistance	Tiller capacity	Number of finger	0	6
3	Seed yield			X	Seed yield	Seed yield	Seed yield	5	1
4	Disease resistance				X	Disease resistance	Disease resistance	4	2
5	Tiller capacity					X	Tiller capacity	3	3
6	Number of finger						X	1	5

Note: Number of participants=17 (male= 15, female= 2)

Farmers' Research and Extension Group members found in both sites were evaluated general performance of varieties based on the selection criteria (Table 10 and Table 11).

Table 10. Focus group discussion and evaluation of merits and drawbacks given for each finger millet variety at Mecha, West Gojam Zone, during 2013 cropping season.

No.	Variety	Merits	Drawbacks
1	Necho	Long finger length, good grain filling, preferred for injera	Uniformity problem, susceptible to blast disease
2	Degu	Long finger length, high tiller, ease of threshing, high biomass yield and quality, tall height	Uniformity problem
3	Mecha	Long finger length, tall height, good grain filling, average biomass quality	Low uniformity
4	Acc.229380	Average finger length, good biomass yield and quality	Non effective tiller, low uniformity, susceptible to disease
5	Padet	_	Short finger length, low tillering capacity, poor biomass quality
6	Debatsi	_	Late maturing, short height, short finger length, non effective tiller
7	Gute	Tall height, long finger length, good grain filling, high biomass yield, average biomass quality	Low tillering capacity
8	Wama	Good grain filling, wide finger width, average biomass quality	Short finger length, low tillering capacity
9	Barieda	Good performance, tall height, long finger length, high tillering capacity, have uniformity, ease of treshing, high biomass yield and quality	_
10	Tadesse	_	Short finger length, low tillering capacity, low uniformity, low biomass quality

Each group of FREG members' ranked each variety based on the agreed selection criteria and the total points each scored and the ranks of finger millet varieties were depicted (Table 12 and 13). The degree of concurrence between the results of focus group discussion (Table 10 and 11), and the information gathered during participatory variety selection in individual group evaluation were high (Table 12 and 13). The process of ranking revealed that there were differences among finger millet varieties. High scores were given to five of the finger millet varieties, including Barieda, Degu, Gute, Wama and Acc. 229380 at Mecha (Table 12). Similarly, the finger millet varieties Barieda, Degu, Necho, Wama and Gute scored one up to five, in that order, at Adet (Table 13).

Table 11. Focus group discussion and evaluation of merits and drawbacks given for each variety at Adet, West Gojam Zone, during 2013 cropping season.

No.	Variety	Merits	Drawbacks
1	Necho	Tall height, long finger length, have branched tillers, medium biomass yield and quality	Low uniformity, low basal tillering capacity
2	Degu	High basal tillering capacity, ease of threshing, high biomass yield and quality	Low finger thickness, low branched tillers
3	Mecha	_	Short finger length, low tillering capacity,
4	Acc.229380	_	Short finger length, low tillering capacity, low number of finger,
5	Padet	Wide finger width, good grain filling	Low number of fingers, low biomass yield and quality
6	Debatsi	More number of finger, good grain filling	Short height, low biomass quality
7	Gute	Long finger length, good grain filling, medium biomass yield and quality	Low number of fingers
8	Wama	Good grain filling, high tillering capacity, medium biomass quality, high biomass yield	_
9	Barieda	Long finger length, more number of finger, high uniformity, high tillering capacity, ease of trashing high biomass yield and quality	_
10	Tadesse	Good grain filling	Low tillering capacity, low biomass quality

Table 1. Direct matrix ranking finger millet varieties for the selected traits by FREG at Mecha West Gojam Zone, in 2013 cropping season.

No.	Selection Criteria	Relative weight	Finger millet varieties									
			Necho	Degu	Mecha	A2293 80	Padet	Debat si	Gute	Wama	Baried a	Tadess e
1	Early Maturity	4	(4.7) 18.8	(3) 12	(3) 12	(3.3) 13.2	(2.7) 10.8	(4.3) 17.2	(2) 8	(1.7) 6.8	(1) 4	(3.7) 14.8
2	biomass quality	6	(4.7) 28.2	(1) 6	(4) 24	(2.3) 13.8	(3.3) 19.8	(5) 30	(2) 12	(2.7) 16.2	(1) 6	(4) 24
3	Seed Yield	1	(4.7) 4.7	(2.7) 2.7	(2.7) 2.7	(3.7) 3.7	(3) 3	(5) 5	(1) 1	(2) 2	(1) 1	(4.3) 4.3
4	Disease Resistance	2	(1.7) 3.4	(1) 2	(1.3) 2.6	(1.7) 3.4	(1.3) 2.6	(1.7) 3.4	(1.3) 2.6	(1.3) 2.6	(1) 2	(1.7) 3.4
5	Biomass Yield	5	(4.3) 21.5	(1) 5	(2.3) 11.5	(3) 15	(4.3) 21.5	(3) 15	(3.3) 16.5	(3.3) 16.5	(1) 5	(4) 20
6	Seed color	3	(1) 3	(2) 6	(3) 9	(3) 9	(3) 9	(4) 12	(3) 9	(3) 9	(4) 12	(3) 9
	Total Rank	21	79.6 9	33.7 2	61.8 6	58.1 5	66.7 7	82.6 10	49.1 3	53.1 4	30 1	75.5 8

Note: Numbers in parenthesis are mean scores given by farmers to each variety with respect to each character (5=very poor, 4=poor, 3=average, 2=good, 1=very good); Numbers in bold case are the product of relative weight of the selection criterion and the score of a variety given by farmers. Ranks are in ascending order from one to ten.

3.5. Identified Finger Millet Varieties for Yilmana-Densa (Adet) and Mecha Districts'

Tested finger millet varieties suitable to both study areas were identified based on their seed yield potential and farmers' preferences. The overall selection results are presented in the following sections. Varietal yield performance and farmers' variety evaluation ranks are presented illustrated and tabulated, respectively (Figure 3, Table 14). The traits utilized as selection criteria for the tested finger millet varieties are in harmony with previous finger millet research findings (Molla, 2012) and most of the selection criteria at physiological maturity used were similar to sorghum varietal selection criteria (Yalemtesfa *et al*., 2014). Accordingly, the present study on finger millet selection criteria and ranks were presented by farmers listed on the bases of their order of preferences. Hence, farmers' interest of traits and their order of importance could be explained through participatory research beyond the expectation of plant breeders (Ceccarelli and Grando, 2006; Fekadu, 2013). Generally, participatory variety selection was effective and reliable for identifying appropriate varieties through partnership with resource- poor farmers (Tafere *et al*., 2012).

Table 13 Direct matrix ranking of finger millet varieties for the selected traits by FREG of Adet West Gojam Zone, in 2013 cropping season.

			Finger millet varieties									
No.	Selection Criteria	Relative weight	Necho	Degu	Mecha	A.229380	Padet	Debatsi	Gute	Wama	Barida	Tadesse
1	Early	4	(2.7)	(1)	(4)	(3.7)	(2.7)	(5)	(4.3)	(2.3)	(1)	(3.3)
	Maturity		10.8	4	16	14.8	10.8	20	17.2	9.2	4	13.2
2	Biomass	6	(2)	(1)	(2.7)	(3.7)	(3.7)	(5)	(1.7)	(2)	(1)	(4.7)
	Quality		12	6	16.2	22.2	22.2	30	10.2	12	6	28.2
3	Seed yield	1	(2)	(2)	(3.7)	(2.7)	(2.7)	(5)	(1.7)	(1)	(1)	(3)
			2	2	3.7	2.7	2.7	5	1.7	1	1	3
4	Disease	2	(1)	(1.3)	(1.7)	(1.7)	(1.3)	(1.3)	(1.7)	(1.3)	(2)	(2.3)
	Resistance		2	2.6	3.4	3.4	2.6	2.6	3.4	2.6	4	4.6
5	Tiller	3	(2)	(1)	(3)	(3)	(3.7)	(5)	(3.3)	(2.7)	(1)	(3.7)
	capacity		6	3	9	9	11.1	15	9.9	8.1	3	11.1
6	Number	5	(1)	(2.7)	(3)	(3.3)	(3.7)	(5)	(3.7)	(2.3)	(2)	(2.7)
	of finger		5	13.5	15	16.5	18.5	25	18.5	11.5	10	13.5
	Total		37.8	31.1	63.3	68.6	67.9	97.6	60.9	44.4	28	73.6
	Rank		3	2	6	8	7	10	5	4	1	9

Note: Numbers in parenthesis are mean scores given by farmers to each variety with respect to each character (5=very poor, 4=poor, 3=average, 2=good, 1=very good); Numbers in bold case are the product of relative weight of the selection criterion and the score of a variety given by farmers. Ranks are in ascending order from one to ten.

The result of seed yield performance of ten finger millet varieties in both research areas, namely Mecha and Adet (Figure 3) revealed that Wama, Gute and Barieda produced higher (mean 1583 kg ha^{-1}) seed yield than the means for the rest tested finger millet varieties. Similarly, Wama, Gute and Barieda, except all the tested varieties, produced above the average (1661 kg ha^{-1}) seed yield of finger millet in West Gojam Zone (CSA, 2015).

Table 2. Farmers' preference ranking of tested finger millet varieties at two locations (Mecha and Adet) in West Gojam Zone in 2013 main cropping season.

No.	Finger millet varieties	Mecha	Adet	Overall ranking
1	Necho	9	3	6
2	Degu	2	2	2
3	Mecha	6	6	6
4	Acc.229380	5	8	7
5	Padet	7	7	7
6	Tadesse	8	9	9
7	Debatsie	10	10	10
8	Gute	3	5	3
9	Wama	4	4	3
10	Barieda	1	1	1

The overall ranks of the tested finger millet varieties (Table 14) were evaluated by Farmers Research and Extension Group members of the Farmers' Associations in Adet and Koga research sites in West Gojam Zone. Farmers' preference ranking indicated that Barieda, Degu, Wama and Gute ranked one up to four, respectively, in that order. The identified finger millet varieties based on yield potential and farmers' preferences are the same, but, their harmony differs only because of selected varieties prioritization order. This occurred due to the need for multiple traits found in one variety, like straw palatability, early maturity and seed color.

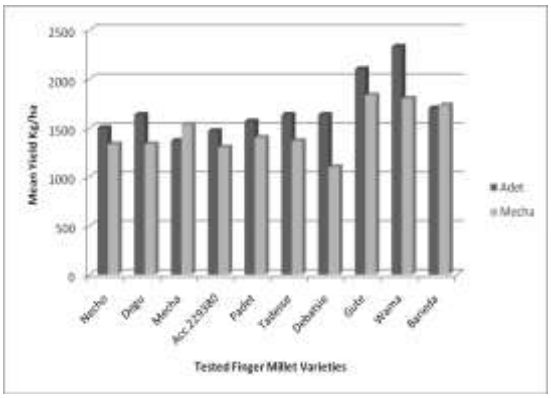

Figure 3. Seed yield performance of finger millet varieties in two location of West Gojam Zone in 2013 main cropping season.

4. Conclusion

The results of the study showed that the tested finger millet varieties had a wide agro-ecological adaptation. The identified varieties by the farmers based on yield potential and other agronomic parameters in both study areas' were the same, but, their concurrence differed only in priotization order of varieties. This is because the Farmers' Research and Extension Groups' interaction in participatory variety selection indicated differences by farmers in their choice of finger millet varieties based on

their preferred traits and evaluating the performance of better varieties. These showed that, the developed participatory finger millet variety selection criteria could identify suitable varieties with necessity of more than one criteria preferred by farmers, and, this farmers' evaluation helps to introduction, adoption and dissemination of selected improved varieties and different farmers in different communities select different varieties therefore the biodiversity over the total area is maintained or even increased in the tested areas along with local landraces grown by farmers. In this regard, the underlying rationale and empirical evidence presented in the text argue strongly for success of this approach. Therefore the research should give priority for a wider range of traits or combinations of traits as farmers' interest.

5. Acknowledgements

This paper is part of PhD research work done at Haramaya University. The authors thank the Ministry of Education and Debre Markos University for their financial support. Furthermore, we are grateful to Amhara Agricultural Research Institute (ARARI) and Adet Agricultural Research Center (AARC), particularly finger millet research team for access to the internet, material and place of study.

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