Performance of elite Finger millet (*Eleusine coracana*) genotypes in West Amhara

Andualem Wolie
Adet Agricultural Research Center, P.O.Box 08, Bahir Dar, Ethiopia

Abstract

Sixteen genotypes together with the standard and local checks were grown at Adet, Merawi and Finoteselam in 2005, 2006, 2007 and 2008 cropping seasons with objective of selecting the better yielding and widely adaptable varieties. The combined analysis results showed that there was highly significant differences ($p<0.001$) between genotypes in plant height, finger length, hectoliter weight, grain yield, and lodging as well as a significant Genotype x Environment Interaction. Two genotypes namely Acc# 203572 and Acc# 203539 out yielded the checks in most environments with an average grain yield of 2461.5 kg/ha and 2394.6 kg/ha, respectively. AMMI yield stability analysis indicated that Acc# 203539 showed wider adaptation and better yield potential while Acc# 203572 showed less stability and higher grain yield. As a result the national variety releasing committee has decided to release Acc# 203572 for the regional in 2011 due to the preference of the farmers during the evaluation.

Key words: AMMI, G x E, PCA.

Introduction

Finger millet (*Eleusine coracana*) is mainly grown as a grain cereal in the semi-arid tropics and subtropics of the world under the rain fed conditions. It is a staple food crop in the majority of drought prone areas in the world and often considered as a component of food security strategies. By virtue of its hardy nature, it can give reliable yield under circumstances where other crops give negligible yield (National Research Council, 1996).

In Ethiopia, it is an indigenous crop grown by subsistence farmers. Sole cropping is the common practice in rotation with other annual crops, preferably legumes. The crop is produced in Tigray, Amhara, Oromia, Benishangul-Gumuz, Southern Nations and Nationalities and Peoples (SNNP), and Gambela regional states. The Amhara region alone accounts for more than half of the total area and production of finger millet in the country (CSA, 2011). It is produced in all administrative zones of the Amhara region except North

Shewa. The total production area allotted for finger millet production in the region is 196114.7 ha with a production of 6.09% of total cereal yield and with an average yield of 13.54 q/ha. North Gondar, West Gojam, and Awi zones are the largest in area allocation while North Wolo, Awi and South Gondar zones rank highest in average yield (CSA, 2011).

Despite its importance and significance, finger millet production practices, the challenges farmers are facing, opportunities of finger millet production; marketing, and utilization issues were not systematically assessed and documented. Moreover, the regional average yield of the crop is low under farmers' management (National Research Council, 1996). This owing to low productivity of the local variety, which is characterized by high vegetative growth, high lodging, low threshability and infestation with head blast (Alelign Kefyalew and Regassa Ensermu, 1992). Therefore, it was essential to develop varieties, which are widely adapted, high yielding and better performing in major agronomic parameters.

Targeting variety selection onto its growing environments is the prime interest of any plant breeding program. To realize this breeding programs usually undertake a rigorous genotypes performance evaluation across locations and years mostly at the final stage of variety development process. In such type of multi-environment trials, the occurrence of genotype x environment interaction is inevitable (Ceccarelli *et al*., 2006). To this effect Adet agricultural research center has been taking a number of variety development activities on finger millet as a regional research center with the objectives: a) to select high yielding disease resistant and/or tolerant finger millet genotypes, b) to select adaptable and stable finger millet genotypes for release.

Materials and methods

Sixteen finger millet lines including the local and standard checks (Degu and Tadesse) were tested using RCBD with three replications at Adet, Merawi and Finoteselam (all on red soil) locations in the main cropping season for four consecutive years (2005-2008) at Adet, three years (2005-2007) at Merawi and two years (2005 & 2008) at Finoteselam i.e., a total of 9 environments. The three experimental locations are believed to have different agro ecological environments in the Western Amhara Region. Adet is located in midto highland agroecology, Merawi represents the mid to lowland agroecology whereas Finoteselam is typical midaltitude agroecology. The experimental sites have also different amount of annual rainfall amount and distribution. The experiment had plots of three rows with five meters length with inter-row and inter-replication spacing of 0.75 m and 1.5 m, respectively. A fertilizer rate of 50/100 kg ha^{-1} of DAP/Urea was applied with the application time of all DAP at planting while Urea was applied at tillering or after first weeding. Weeding was done three times in the cropping season starting from 30-35 days after planting and depending on the weed infestation.

All the necessary data i.e., days to heading, days to maturity, plant height (cm), finger length (cm), number of ear per plant, number of fingers per ear, number of tillers per plant, hectolitre weight (kg/hl), thousand grain weight (kg/ha), lodging (%), stand (%) at harvest, blast severity (%), grain yields (g/plot)) were recorded. as The data on grain yield and other agronomic parameters was analyzed using Cropstat V.6.1 (2007) and the AMMI stability analysis was done using GenStat V.12.1(2011). AMMI stability value was calculated to observe the stability of genotypes.

Results and discussion

Most of the agronomic parameters showed significant differences in all cropping seasons at the different sites except plant height which was non significant across environments (Tables 1 and 2). The mean performances grain yield and other agronomic traits of genotypes are presented in Table 3. The standard checks Tadesse and Degu were out yielded by 6 genotypes and the local check by all except Tadesse. Genotypes Acc# 203572 and Acc# 203539 had a yield advantage of 17.6% and 14.4% over the better check (Tadesse), respectively (Table 3).

Table 1. ANOVA for grain yield of each environment for genotypes.

Location	Year	Source of Variation	df	SS	MS	F	F-Prob
Adet	2005	Replication	2	2086836	1043418	7.12	0.003
		Genotype	15	4304127	286942	1.96	0.057
		Residual	30	4397315	146577		
		Total	47	10788278			
	2006	Replication	2	789343	394671	2.69	0.084
		Genotype	15	8142926	542862	3.71	0.001
		Residual	30	4395574	146519		
		Total	47	13327843			
	2007	Replication	2	1315268	657634	6.16	0.006
		Genotype	15	9410122	627341	5.87	<.001
		Residual	30	3203756	106792		
		Total	47	13929146			
	2008	Replication	2	2915706	1457853	5.05	0.013
		Genotype	15	5509037	367269	1.27	0.028
		Residual	30	8661307	288710		
		Total	47	17086049			
Merawi	2005	Replication	2	732220	366110	2.97	0.066
		Genotype	15	3696434	246429	2.00	0.052
		Residual	30	3694638	123155		
		Total	47	8123292			
	2006	Replication	2	2057024	1028512	5.24	0.011
		Genotype	15	1697262	113151	0.58	0.870
		Residual	30	5893030	196434		
		Total	47	9647317			
	2007	Replication	2	10760	5380	0.09	0.913
		Genotype	15	831785	55452	0.94	0.031
		Residual	30	1763203	58773		
		Total	47	2605747			
Finoteselam	2005	Replication	2	814964	407482	1.14	0.334
		Genotype	15	5123600	341573	0.95	0.023
		Residual	30	10759886	358663		
		Total	47	16698451			
	2008	Replication	2	1318767	659383	8.14	0.002
		Genotype	15	3021676	201445	2.49	0.016
		Residual	30	2430466	81016		
		Total	47	6770909			

Table 2. Mean squares for traits ANOVA across environments.

Source of Variation	DF	Yield	DH	DM	PH	TPP	EPP	FPE	FL	HLW
Environment	8	42425929***	2374.687***	8018.379***	3240.15	880.289***	2581.871***	4.5196***	66.52***	351.405***
Replication (Environment)	18	668938***	6.839	8.818	169.93	15.200***	27.374***	1.0138	12.35	7.008
Genotype	15	570776***	382.076***	291.546***	1071.33	29.524***	146.942***	42.4169***	88.70***	88.392***
Environment x Genotype	120	276461***	28.635***	28.690***	94.52	7.669***	20.080***	0.9780***	14.34	9.378***
Residual	270	167404	4.469	5.845	43.91	3.731	7.913	0.5743	14.52	5.502
Total	431									

Table 3: Grain yield and other agronomic traits performances of 16 finger millet genotypes across locations, 2005-2008.

Genotype	DH	DM	PH (cm)	TPP	EPP	FPE	FL (cm)	HLW (kg/hl)	GY (kg/ha)	Yield adv. (%)	Lodging (%)	Stand at harvest (%)	Blast severity (%)
Acc# 229463	103	164	96.8	9.3	11.7	8.3	10.1	81.5	2071.4		10.8	81.3	9.3
Acc # 229465	104	164	99.7	8.7	11.4	8.4	9.6	82.8	1986.7		12.4	85.4	8.7
Acc # 203572	97	156	90.0	7.9	11.3	7.8	10.9	82.5	2461.5	17.6	8.4	80.6	8.9
Acc # 203587	100	163	97.6	8.0	10.7	8.0	10.6	82.9	1962.0		11.7	80.4	9.4
Acc # 229407	104	160	89.8	7.5	9.5	5.0	8.1	79.0	2092.8		4.5	79.7	8.5
Acc # 229415	104	162	91.2	6.8	8.3	5.2	10.8	79.7	2217.5		3.0	79.5	8.7
Acc # 229440	94	155	91.5	8.6	10.3	5.0	7.5	81.7	2105.7		7.8	73.9	9.1
Acc # 229458	104	162	93.4	7.1	9.7	5.3	8.5	79.7	2108.5		3.0	79.1	8.9
Acc # 229461	105	163	88.8	7.5	8.6	5.0	8.0	79.2	2118.4		3.0	79.5	8.9
Acc # 229468	101	162	96.4	6.6	7.5	5.7	7.9	77.9	2086.3		3.0	76.3	9.3
Acc # 229469	102	161	95.4	7.0	8.3	6.0	7.0	79.7	2113.1		3.0	78.0	8.9
Acc # 203410	102	161	93.9	7.4	8.7	6.9	7.2	79.4	2226.9		4.5	76.2	9.1
Acc # 203539	97	156	72.8	8.7	12.0	6.7	5.1	80.1	2394.6	14.4	3.0	77.1	9.1
Tadesse(St.chk)	103	161	85.7	7.1	8.3	5.4	6.1	79.6	1924.4		3.0	78.9	9.3
Degu (St.check)	99	158	92.5	9.4	15.3	6.5	9.9	83.6	2093.0		12.6	81.5	8.7
Local check	97	159	92.7	9.0	14.2	6.5	10.0	83.5	1986.4		44.3	82.5	28.7
Mean	101.0	160.4	91.8	7.91	10.36	6.36	8.58	80.80	2121.8		6.75	79.37	8.97
SE	1.47	2.55	2.25	0.91	1.45	0.19	0.71	0.67	195.62		3.83	2.94	1.14
CV (%)	2.2	1.5	8.1	25.2	27.9	12.2	41.8	2.9	21.0		-	-	-
LSD (5%)	4.08	7.09	6.26	2.54	4.03	0.52	1.98	1.86	543.74		10.67	8.18	3.28

DH = Days to heading, DH = Days to maturity, PH = Plant height, TPP = Number of tillers per plant, EPP = Number of ears per plant, FPE = Number of fingers per ear, FL = Finger length, HLW = Hectoliter weight, GY = Grain yield.

Across environment analysis for grain yield (Table 4) showed that environment, genotypes and genotype x environment interaction were significant ($p<0.001$) which led to undertake additive main effect and multiplicative interaction (AMMI) stability analysis. The ANOVA for AMMI model also revealed that the two interaction principal component axis (IPCA1 and IPCA2) contributed 61.22% of the variations among the genotypes (Table 5).

Table 4. Analysis of variance for grain yield across environments.

Source of Variation	DF	SS	MS	F. ratio	F pr.
Environment	8	339407428.	42425929.	253.43	<.001
Rep (Environment)	18	12040887.	668938.	4.00	<.001
Genotype	15	8561644.	570776.	3.41	<.001
Environment x Genotype	120	33175325.	276461.	1.65	<.001
Residual	270	45199174.	167404.		
Total	431	438384459.			

Grand Mean = 2122 kgha^{-1}.

Table 5. The ANOVA table for AMMI model

Source	df	SS	MS	F	F_ prob.	Variation %
Treatments	143	381144397	2665345	15.92	0.00000	
Genotypes	15	8561644	570776	3.41	0.00003	
Environments	8	339407428	42425929	63.42	0.00000	
Blocks	18	12040887	668938	4.00	0.00000	
Interactions	120	33175325	276461	1.65	0.00042	
IPCA1	22	12388587	563118	3.36	0.00000	33.52%
IPCA2	20	8970672	448534	2.68	0.00019	27.70%
Residuals	78	11816066	151488	0.90	0.69500	
Error	270	45199174	167404	*	*	
Total	431	438384459	1017133	*	*	

NB: the block source of variation refers to blocks within environments

The AMMI stability value (ASV) of the genotype means was also calculated i.e., the smaller ASV value is the better stability of a given genotype. Accordingly, Acc# 203539 was the most stable with 2nd rank in grain yield (2395 kg ha^{-1}) while Acc# 203572 was less stable although was the highest grain yielding genotype (2461 $kgha^{-}1$) (Table 6).

Table 6: AMMI stability analysis for the Genotype means and scores.

Genotype	Description	Genotype Mean	IPCAg[1]	IPCAg[2]	AMMI stability value
G1	Acc# 229463	2071	-10.30600	-12.04884	18.64789
G2	Acc # 229465	1987	-8.43578	0.85818	11.68146
G3	Acc # 203572	2461	-12.75059	-24.35743	30.05579
G4	Acc # 203587	1962	-20.52394	4.55711	28.70777
G5	Acc # 229407	2093	4.65962	-0.59991	6.46288
G6	Acc # 229415	2217	9.11015	11.05436	16.74771
G7	Acc # 229440	2106	1.77062	7.69945	8.07841
G8	Acc # 229458	2109	5.51950	9.48876	12.17123
G9	Acc # 229461	2118	9.57367	12.63447	18.28752
G10	Acc # 229468	2086	17.88230	-17.66475	30.36310
G11	Acc # 229469	2113	9.94581	1.00414	13.77192
G12	Acc # 203410	2227	9.63671	-6.54567	14.83102
G13	Acc # 203539	2395	3.85059	2.18226	5.74806
G14	Tadese (St.chk)	1924	7.34443	-0.01671	10.14274
G15	Degu (St. check)	2093	-6.98171	-1.47161	9.75347
G16	Local check	1986	-20.29538	13.22618	30.99205

AMMI Stability Values close to zero = Stable genotype

A biplot was generated using genotypic and environmental scores of the first and second IPCA scores. Figure 1 shows the biplot of genotypes and environments against IPCA 1 while Figure 2 shows the biplot against IPCA 2 and figure 3 displayed the interaction against IPCA 1 and IPCA 2.

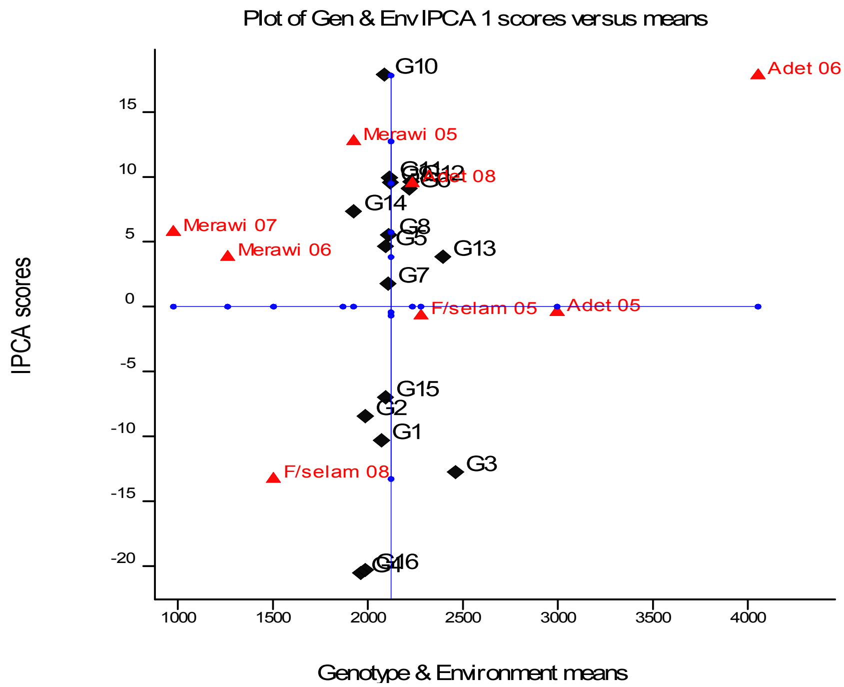

Figure 1. Biplot of 16 genotypes and 9 environments for grain yield using genotypic and environmental scores against IPCA1. Grand mean = 2122 kgha^{-1}.

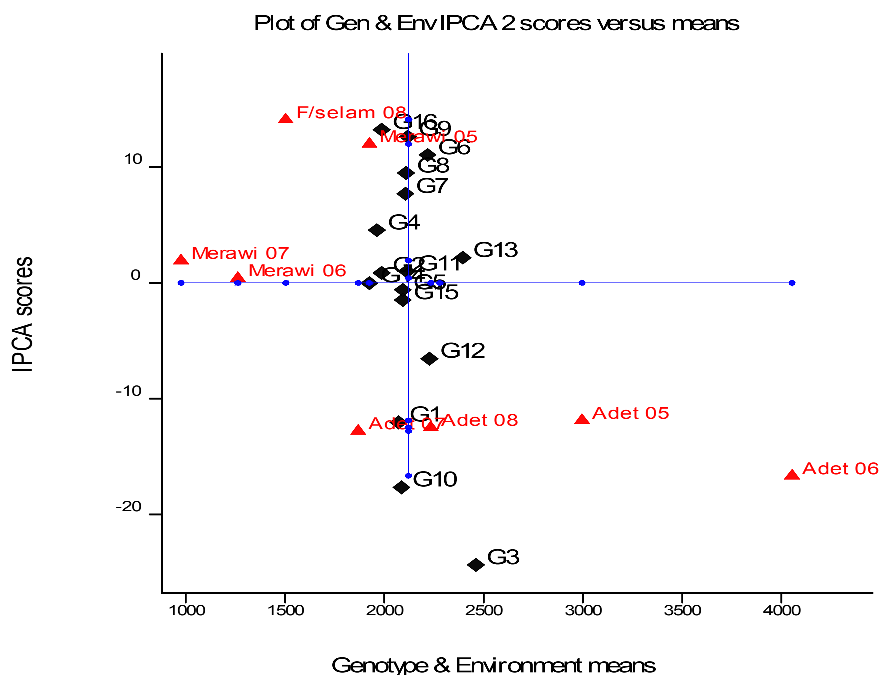

Figure 2. Biplot of 16 genotypes and 9 environments for grain yield using genotypic and environmental scores against IPCA2. Grand mean = 2122 kgha^{-1}.

Genotype G13 (Acc# 203539) was more stable with above average grain yield performance and better than most genotypes in all environments. Genotype G7 (Acc# 229440) was also most stable but with below average grain yield performance (Figure 1). Figure 2 and 3 of biplot also showed that G13 (Acc# 203539) and G3 (Acc# 203572) were the higher yielding genotypes with G13 (Acc# 203539) more stable than G3 (Acc# 203572).

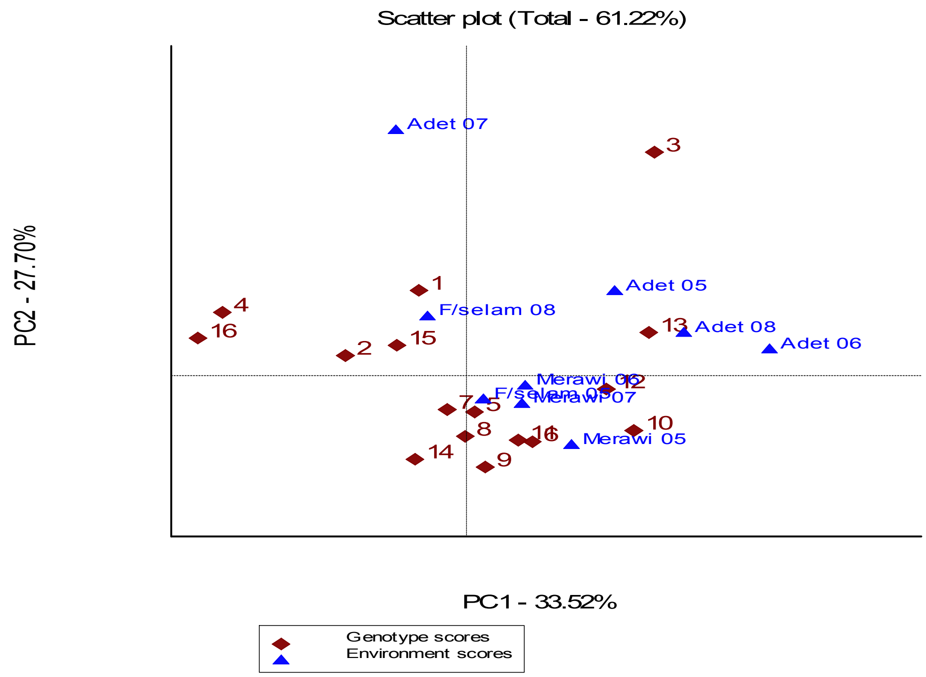

Figure 3. Biplot of 16 genotypes and 9 environments for grain yield of IPCA1 against IPCA2. Grand mean = 2122 kgha^{-1}.

Conclusion and recommendation

Acc# 203572 and Acc# 203539 out yielded all genotypes including the across locations and years. The genotype Acc#203539 was the highly stable and better yielding than Acc# 203572 which was highest yielder but better stable genotype. Hence, Acc# 203572 is going to be released by the national variety release committee regionally for wider production considering farmers' preference of overall morphology (expected biomass yield, straw palatability to cattle, finger number and length) and seed colour (whiteness). The farmers preferred the genotype with high yielding, loose panicle or ear, long fingers, high tillering capacity, high expected biomass and much number of fingers which were lacking in the highest stable genotype Acc#203539 while Acc# 203572 was fulfilling these characters.

Acknowledgement

I acknowledge Adet Agricultural research center for providing facilities and McKnight Foundation for providing fund for the study.

References

Alelign Kefyalew, and Regassa Ensermu, 1992, Bahir Dar Mixed Farming Zone Diagnostic Survey Report .Research Report, No 18 IAR, Addis Ababa.

Ceccarelli S, Grando S and Booth RH. 2006. Crop improvement in difficult environments: International breeding programs and resource-poor farmers, ICARDA, Allepo, Syria.

Cropstat Version 6.1. 2007. Crop Research Informatics Laboratory; International Rice Research Institute.

CSA, 2011. The federal democratic republic of Ethiopia central statistical agency, Agricultural Sample Survey, 2007/2008. Report on area and production of crops. Statistical Bulletin 417, Volume I, Addis Ababa. June, 2008 128p.

National Research Council, 1996. Finger millet. In: Lost crops of Africa: volume I: grains, *National Academy of Sciences*. pp. 39-57.