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Participatory Evaluation of Adaptability and Morpho-agronomic Performance of Released and on Pipeline High Land Maize Technologies

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ABSTRACT

Adaptability and agronomic performance test across environments are important in plant breeding. The current study was conducted with the objective to generate information on adaptability and morpho-agronomic performance of maize genotypes through participatory breeding. The experiment were conducted using released and on pipeline maize genotypes with one local check in six different environments (Shanaka, Agarfa, Shallo, Hissu, Gassera and Sinana) in 2005 and 2006 main season. From the two years pooled mean grain yield performance, BH-660 (8.3 ton ha^{-1}) and BH-670 (7.6 ton ha^{-1}) gave, relatively the highest yield, ranked 1st and 2nd, respectively in both years while Kuleni gave the lowest yield and ranked least in both years. The analysis of variance of mean grain yield (ton ha^{-1}) of seven varieties and one local check tested in six environments showed that 39.0, 40.2 and 20.8% of the total sum of squares were attributed to environment, genotype and genotype X environment interaction effects, respectively. From the AMMI analysis results, the lowest Principal Components Analysis-1 (PCA1) scores were observed in genotype G4 (0.03), followed by G1 (0.10) and G2 (0.12) but in case of Interaction Principal Components Analysis-2 (IPCA2) the lowest score showed by G6 (0.13), followed by G5 (0.17) and G8 (0.31). In general, the study showed the importance of participatory plant breeding, genotype adaptation test across environment and the effects of environments.

Key words: Maize, additive main effect and multiplication interaction, environment, genotypes, interaction, adaptability

INTRODUCTION

Improved varieties released elsewhere, testing for adaptation in the new similar agro ecologies are important to make use of varieties nation wise where improved technologies are highly demanding. Farmers hosting the new improved varieties in their regions which introduced form elsewhere should involve in evaluating and selecting based on their own views and criteria which involve morphological, economic and agro ecological suitability. Participatory Plant Breeding (PPB) exploits the potential gains of breeding for specific adaptation through decentralized selection (Ceccarelli and Grando, 2007).

Breeders and farmers should work together for the better evaluation of adaptability and agronomic performance and promotion of varieties introduced or genotypes in yield trial in different environment of the same agro ecologies in order that to sustain food security of the region. In investigating genotypes for adaptability, variation across environment cause phenotypic and genotypic rank differences which create an opportunity for better selection of traits of interest. By exposing a number of genotypes to a set of contrasting environments, it is possible to identify genotypes with a high average yield and low GEI (Ceccarelli, 1989). Participatory plant breeding evaluation involves adaption to both the physical environment (climate, soil, abiotic/bioitics stresses) and the socioeconomic environment (economic status, user concerns, consumer preferences and market which suggests the need for more decentralized breeding approaches (Hordon, 1995).

In participatory plant breeding, testing genotypes across a number of environments for performance and adaptability require scientific interpretation using different statistical analysis and indigenous knowledge of farmers based on their own criteria of selection during field experiment. Among statistical analysis methods, AMMI Stability Value (ASV) of Purchase (1997), Ecovalence (W_i) of Wricke (1964) which is the contribution of each genotype to GEI effect and Francis and Kannenberg (1978) coefficient of variability (CV_i) and mean of grain yield performance per location and across location frequently employed during adaptation test. Farmers can also interpret the performance of genotypes by visual observation of morphological and some agronomic traits based on their own criteria: earliness, no of ear per plant, good straw yield, plant height, disease resistance, color and stand per plot.

Maize (*Zea mays*) is the most popular and important crop in Ethiopia. According to CSA (2011) report of Ethiopia, Maize covered 2.15 million hectares and ranked second after Tef (*Eragrostis tef*). South Eastern Ethiopia, in Bale high lands small scale farmers produce maize on different locations: Dodola, Shanaka, Agarfa, Shallo, Hissu, Gassera and Sinana largely both around their homestead and on farm. Currently maize production coverage through introduction of released technologies increased and farmers demanding information on maize production system and breeding where there is insufficient information. Therefore, the present study was conducted to generate information on adaptability and morpho-agronomic performance of maize through participatory maize breeding.

MATERIALS AND METHODS

Experimental material and location: The experiment were conducted using seven released and pipe line maize varieties with one local check in six different environments in 2005 and 2006 main season. The test materials for adaption were introduced form Bako Agricultural Research Center (BARC) of highland maize research (Table 1).

Design of experiment and agronomic practices: Experimental layout was a randomized complete block design with four replications. Planting were done on plot size of 16.2 m^2 with

Table 1: Genotype code, name and sources of experimental material

Genotype code	Genotype/variety name	Source
G1	BH-660	BARC
G2	KULENI	BARC
G3	BH-670	BARC
G4	AMBO 1 Syn-3	BARC
G5	F548XKULENI	BARC
G6	AMBO 3Syn-5	BARC
G7	AMBO 3Syn-1	BARC
G8	Local check	BARC

BARC: Bakko agricultural research center spacing of 30 cm between plant, 75 cm between rows and 1.5 m between replications. Seed rate of 25 kg ha^{-1} and fertilizer rate of 92 kg ha^{-1} urea in split application (at planting time and at knee height) and 100 kg ha^{-1} DAP at planting time were used for the experiment. All other management aspects were applied uniformly.

Data collection and statistical analysis: Both statistical analysis and visual interpretation were employed during participatory adapted and performed maize variety selection. Highly significant differences ($p<0.01$) were observed for genotypes, environment and Genotype X Environment Interaction (GEI). GEI was partitioned into four Interaction Principal Component Analysis (IPCA) and the four IPCAs (1,2,3,4) scores showed highly significant ($p<0.01$) differences. The statistical analysis was done by SAS and AMMI stability analysis by IRRI STAT. Qualitative data were taken from farmers' selection criteria and ranking varieties based on the criteria employed by farmers was done.

RESULTS AND DISCUSSION

Exploiting farmer's indigenous knowledge side by side with scientific plant breeding is very important due to the final target end users are farmers themselves. Based on farmers selection criteria results BH-660, BH-670 and local check ranked 1st, 2nd and 3rd, respectively (Fig. 1). During evaluation and selection of test materials farmers used criteria such as number of seed per comb, ear length, lodging resistance, number of ears per plant, seed color, straw biomass, insect pest resistance and stand per plot.

Mean grain yield results per location and across location and ranks of seven genotypes and one local check tested in 2005-2006 are presented in Table 2. The result showed relatively highest grain yield observed on BH-660 (6.0 ton ha^{-1}) followed by BH-670 (5.1 ton ha^{-1}) and AMBO 3Syn-1 (4.3 ton ha^{-1}) while the lowest grain yield were observed on KULENI (2.7 ton ha^{-1}) in 2005 growing season. In 2006, the highest grain yield observed on BH-660(8.3 ton ha^{-1}) followed by BH-670 (7.6 ton ha^{-1}) and F548XKULENI (6.2 ton ha^{-1}), respectively. From the two years pooled mean grain yield performance, BH-660 (8.3 ton ha^{-1}) and BH-670(7.6 ton ha^{-1}) gave relatively the highest yield, ranked 1st and 2nd, respectively in both year while KULENI gave the lowest yield and ranked least in both year (Table 2). From observed results, the two released varieties (BH-660 and BH-670) are the most adapted and best performed varieties whereas KULENI is the least adapted variety. Relatively the highest coefficient of variation was observed on KULENI (41.5%)

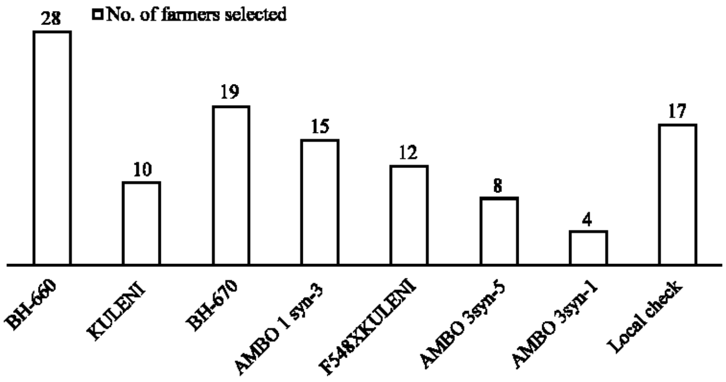

Fig. 1: Evaluation results of high land maize genotypes and on pipeline from farmers perspectives

Table 2: Seven genotype and one local check per location and over location mean yield (ton ha^{-1}) and their ranks

	Test location (2005)					Test location (2006)						
Genotype	Shallo	Agarfa	Gassera	Mean over loc.	Rank	Sinana	Hisu	Shanaka	Mean over loc.	Rank	Mean over year	Rank
BH-660	7.8	7.0	3.20	6.0	1	9.2	6.5	9.2	8.3	1	7.2	1
KULENI	2.2	3.9	2.08	2.7	8	1.3	3.6	4.4	3.1	8	2.9	8
BH-670	4.06	7.8	3.42	5.1	2	6.8	7.7	8.2	7.6	2	6.4	2
AMBO 1 Syn-3	3.39	4.7	2.50	3.5	7	6.6	5.3	5.0	5.6	5	4.6	7
F548XKULENI	5.24	3.7	2.88	3.9	5	6.4	5.7	6.6	6.2	3	5.1	3
AMBO 3Syn-5	3.76	5.0	2.76	3.8	6	5.6	5.3	6.1	5.7	4	4.8	5
AMBO 3Syn-1	6.00	4.3	2.60	4.3	3	5.7	4.2	6.3	5.4	7	4.9	4
Local check	4.80	4.3	2.95	4.0	4	5.9	4.6	5.8	5.5	6	4.7	6

Table 3: Pooled analysis of variance and interaction principal components in AMMI for mean grain yield (ton ha^{-1}) of maize genotypes tested in 2005-2006 main growing season

Source	DF	Sum of squares	Mean squares	F-value	% of total
Environments	5	64.712173	12.942434	15.270**	39.0
Genotypes	7	66.768570	9.538367	19.360**	40.2
Genotype X Environment	35	34.630447	0.989441	2.480**	20.8
Total	47	166.111191			
Analysis of variance for the AMMI model of mean grain yield					
AMMI component 1	11	19.245700	1.749600	2.729**	76.5
AMMI component 2	9	9.401100	1.044500	2.619*	15.6
AMMI component 3	7	4.519400	0.645600	3.528*	4.3
AMMI component 4	5	1.412400	0.282400	16.361**	2.5
GXE residual	3	0.051700	-	-	-
Total	47	166.111000	-	-	-

**: Highly significant difference, *: Significant difference

which shows high environmental influence and the lowest coefficient of variation was observed on local check (23%) which shows less effect of environmental influence which may be due to prolonged cultivation as farmer's variety in the area.

Highly significant differences were detected ($p<0.01$) for genotypes, environment and genotype X environment (Table 3). Similar results were reported by different researchers (Maarouf, 2009), (Das *et al.*, 2010; Tiawari *et al.*, 2011; Jalata, 2011). The analysis of variance of grain yield (ton ha^{-1}) of the seven varieties and one local check tested in six environments showed that 39.0%, 40.2% and 20.8% of the total sum of squares were explained by environment, genotype and genotype X environment interaction effects respectively. The highest % of sum of squares explained by genotype was found contrary to the result obtained by Letta (2009) and Sadeghi *et al.* (2011) that reported genotypic effect explained was less than environmental effect.

The genotype x environment interaction (GEI) were partitioned into four Interaction Principal Component Analysis (IPCA). The four IPCAs scores showed highly significant ($p<0.01$) differences and explaining 76.5, 15.6, 4.3 and 2.5% of the total variation of GEI (Table 3). The two principal component together captured 92.1% from the total variation and the rest interaction effect were captured by the remaining PCAs. Farshadfar *et al.* (2011) also reported that highly significant results were observed in the four PCAs.

Genotype interaction principal component scores provide indicators for stability/adaptability on range of environments (Purchase, 1997). From the AMMI analysis results, the lowest PCA1 scores

Table 4: Mean yield, IPCAs and various yield-stability analyses and ranks in seven genotypes and one local check tested in 2005-06 main growing season

Geno.	Mean	Rank	PCA1	PCA2	ASV	Rank	W^2i	Rank	CV (%)	Rank
G1	7.2	1	-0.10	0.47	0.51	1	3.18	7	31.2	5
G2	2.9	8	0.12	-1.00	1.03	5	3.22	8	41.5	8
G3	6.4	2	1.00	0.95	2.25	8	1.05	6	32.7	7
G4	4.6	7	0.03	0.60	0.60	2	0.02	2	31.7	6
G5	5.1	3	-0.51	-0.17	1.06	6	0.01	1	29.6	4
G 6	4.8	5	0.31	0.13	0.65	3	0.03	3	26.1	2
G 7	4.9	4	-0.70	-0.67	1.59	7	0.09	4	29.3	3
G 8	4.7	6	-0.30	-0.31	0.68	4	0.32	5	23.0	1

were observed in genotype G4 (0.03), followed by G1 (0.10) and G2 (0.12) but in case of IPCA2 the lowest score showed by G6 (0.13), followed by G5 (0.17) and G8 (0.31) (Table 4). Based on AMMI stability value (ASV), G1 (0.51) followed by G4 (0.60) and G6 (0.65) showed the lowest score and the most stable genotypes. Genotype 5(0.01), followed G4 (0.02) and G6 (0.03) showed the lowest ecovalances and considered to be relatively the most stable genotype. The smallest CV observed on local check 23.0% whereas the largest CV observed on KULENI (41.5%) which indicated that KULENI is the most affected genotype by environmental influence.

CONCLUSION

In both farmers' selection criteria and breeder evaluation using different statistical analysis method, BH-660 and BH-670 found to be the most preferred and adapted varieties which showed the highest mean grain yield and ranked 1st and 2nd. KULENI was the variety showed the least in mean grain yield and the highest coefficient of variation which evidenced the most affected variety by environmental effect. Generally, the importance of participatory evaluation of varieties for adaptability with stakeholders (farmers) was clearly observed in this study which has significant role in utilization of research technologies.

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