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Evaluating Hybrid Maize Genotypes for Grain Yield and Yield Related Traits in north western Tigray, Ethiopia

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ABSTRACT

In Ethiopia, there are several maize production constraints, among which shortage of high yielder and stable improved maize varieties is the major one. The objective of this study was to evaluate the mean performance of maize hybrids for grain yield and other agronomic traits in six maize hybrids. The study was conducted at Laelay adiabo and Medebay zana locations for two years, during 2014 and 2015 main cropping season. Seven improved maize hybrids were used. The genotype was planted in rows with 4 m along five rows per plot, 80cm between rows and 40cm between plants. The individual location analysis of variance for yield and yield related traits were revealed that variances were highly significant for most of the studied characters, there is genetic variability among the genotypes which are important for further breeding due to their different genetic potential and agronomic performances. Combined mean squares for the maize hybrids were significant (P< 0.01) for 100 seed weight and grain yield per hectar and there is significant (P<0.05) for days to anthesis and silking date. More over, hybrids BH-546(7140 kg), BH-661(6622 kg) and MH-140(6734 kg) produced the highest grain yield as compared the standard check of BH-543(5883.58kg). It can be concluded that these superior hybrids can be demonstrated and popularized as well as important for inclusion in further breeding program, since they may contribute favorable alleles in the synthesis of new varieties and great contribution in food security of the target areas.

INTRODUCTION

Maize (*Zea mays L*., 2n=20) is an important cereal crop belonging to the tribe *Maydeae*, of the grass family, *Poaceae*, Genus *Zea*, Species *mays* (Piperno and Flannery, 2001). Even its origin is still controversial, but the most common opinion is towards Mexico as its center of origin. Globally, maize is ranked thirdly in terms of acreage after wheat and rice (FAO, 2011). Total world area of maize production in 2012 was 176 million ha, while that of wheat was 216 million ha and rice was 184 million ha (FAOSTAT, 2012). But in terms of production and productivity, the report of FAOSTAT (2008) indicated that in 2008 maize was the world's leading cereal crop with annual total production of 695 million ton and with productivity of 4.8 ton ha^{-1}. Based on the report from the Food and Agricultural Organization of the United Nations (FAO, 2008), maize breeders were and still are very successful in improving maize grain yield and its productivity so as to increase; globally maize productivity increased from 1.9 tons ha^{-1} in 1960 to 5 tons ha^{-1} in 2008. According to FAO statistics (2008), the usage distribution of maize grain in 2008 consumption was 21% for human food, 72% for animal feed and 7% for industry.

Considering its importance in terms of wide adaptation, total production and productivity, maize has been selected as one of the high priority crops to feed the increasing population of Ethiopia. Past research efforts in Ethiopia resulted in the development and release of open-pollinated and hybrid varieties for different agro-ecologies of the country (Mosisa and Habtamu, 2009). However, the national average yield, 3.43 tons ha-1(CSA, 2015) is still far below the world average 5.5 tons ha-1. The yield of maize is less in Ethiopia (3430 kg ha-1) when compared to other countries like Germany (8828 kg ha-1), Italy (8899 kg ha-1), Canada (9988 kg ha-1), Argentina (6603 kg ha-1) and China (6016.2 kg ha-1) (FAOSTAT, 2013).

Despite such circumstances, the potent al maize productivity in the low- and mid-altitude sub-humid areas is not yet exploited and is unable to play a role in ensuring food security for the country. The estimated average yields of maize in the mid- and low-altitude areas are about 2.5 t ha-1 and 2.0 t ha -1, respectively (CSA, 2010). This is far below the world average (5.1 t ha-1) (FAO, 2008). One of the major constraints affecting maize product on and productivity in these agro-ecologies is inadequacy of broadly adapted, high yielding, disease and insect resistant varieties. In addition, the weather conditions varying between seasons and locations within these agro-ecologies is another limitation. Such factors associated with the low level of crop management practices, the increasingly dwindling soil fertility situation, incidence of erratic diseases and insect pests, and escalation of climatic changes are growing concerns for maize product on in Ethiopia. Hence, the current study was aimed to evaluate the adaptability of maize hybrids in north western Tigray with the following objectives.

Objective of the study

- ✓ To examine the adaptability and performance of the hybrid maize Varieties
- ✓ To identify high yielding, disease and insect pest resistant (tolerant) of hybrid maize Varieties

MATERIAL AND METHODS

The experiment was conducted at districts of Laelay adiabo and Medebay zana in 2014/15 and 2015/16 cropping season. Six improved hybrid maize varieties (BH-546, BH-661, BHQPy-545, MH-130, MH-140, MHQ-138) with one standard check (BH-543) and one local Check (local red maize) as a treatment were arranged in a randomized complete block design (RCBD) with three replications. The following yield and yield related traits such as days to Anthesis, silking, ,physiological maturity , Plant height and Ear height, Number of ears/plant, cob length,100 seed weight(g),grain and biomass yield, disease and insect pest reaction (1-5) were collected and analyzed using gene stat soft ware and means were compared using Duncan multiple range test (DMRT) at 0.05 level of probability. All plots were fertilized uniformly at the rate of 100 kg/ha Urea and 100 kg/ha DAP. All DAP and half of urea at planting and the remaining half urea at silking were applied. The experimental plot had an area of 4m x 4m (16 m^2) separated by a distance of 1m between plots within a block and 2m between blocks within the experiment. A spacing of 80 cm b/n rows and 40 cm b/n plants was maintained. A seed rate of 25 kg/ha was used. Any other important agronomic practices were applied equally to all the entries at their proper time of application.

RESULT AND DISCUSSION

Grain Yield and Some Yield Related Traits

The analysis of variance for yield and yield related traits for location Laelay adiabo and Medebay zana are given in Table 1 and 2 respectively. Analysis of variance showed significant differences for plant height, ear height, hundred seed weigh, grain and biomass yield among the varieties in both locations (Table 1 and 2). The significance difference among varieties indicates the presence of variability for grain yield among the tested entries. This result is in agreement with the previous findings reported by Tekle Yoseph, *et al*, 2014. On the other hand, it was reported that there was no significant difference observed among the maize genotypes for grain yield and other major traits (Wodajo G.*et al*, 2015). Base on Based on mean grain yield variety BH-546 gave highest yield at Laelay adiabo and Medebay zana districts as compared with both local checks (red maize) and standard check of BH-543 while MH-130 at Laelay adiabo and MHQ-138 at Medebay zana district scored low yield.

Maturity is an important attribute of a given genotype, which directly or indirectly affects economic yield. Maturity itself is existed by several components such as days to 50 per cent tasseling, silking and brown husk maturity etc. Normally in maize, it has been reported that the female inflorescence in ear formation is very sensitive is less affected by such situations (Giesbercht, 1960). Hence, among genotypes there was existed significantly difference ($P \leq 0.05$) in maturity character at location of Medebay zana district (Table 2). According to Lu *et al*. (2010) earliness in maize used mostly in screening genotypes for tolerance to stresses especially for drought resistance. Mean while it is directly correlated with seed setting percentage.

All genotypes were differed highly significantly for plant height which was ranged from 203.1 cm (MH-130) to 265.0 cm (BH-546) at Laelay adiabo and 182.5cm (MH-130) to 295.5cm (BH-661) at Medebay zana location. Among the genotypes, two varieties showed greater plant height than the standard check (BH-543) in both location and this indicated that most of the hybrids have desirable traits for lodging and can be used for further breeding. Present result also get sufficient validation from the findings of Daniel Tadesse (2012) and Nazir H. (2010), they indicated most of the hybrids had shorter plant height as compared the local and standard checks.

For grain yield (GY) trait, significant differences were revealed among the genotypes used in this study. Based on the combined anova result genotypes BH-546, BH-661 and MH-140 showed higher grain yield, 7140.21, 6622.60, 6734.56 kg respectively as relatives with the standard check of BH-543(5883.58 kg), while MH-130 produced lower grain yield in both locations. Regarding 100-grain weight (g) of the eight genotypes (Table 3) were significantly different. Maximum value for 100-grain weight was shown by Local red maize (127.0g), while the minimum value was recorded in genotype BHQPy-545 (78.7g).

Table1. *Yield and Yield related performance of hybrid maize varieties in Laelay adiabo, 2015*

SN	Genotype	50% AD	50%SD	90% MD	PHt(cm)	EHt(cm)	CL(cm)	Ears/ plant	100s wt(g)	Gy(kg ha-1)	BY(kg ha-1)
1	BH-543(SC)	76.7	80.3	132.7	248.2	132.5	23.6	1.67	35.9	8526.4	24371
2	BH-546	78.0	81.6	130.7	265.3	135.5	23.9	1.2	37.5	8720.8	24115
3	BH-661	79.0	80.3	135.3	267.3	146.3	22.3	1.3	39.1	8522.2	25261
4	BHQPy-545	77.0	78.6	125.3	225.1	104.9	18.9	1.67	33.4	7523.6	20149
5	Local-red maize	78.0	80.3	125.7	227.7	104.5	20.1	1.3	34.1	7118.1	19110
6	MH-130	71.3	76	131.0	203.1	84.7	20.2	1.4	35.1	3966.7	12717
7	MH-140	78.0	83.3	133.7	229.8	106.1	20.7	1.6	37.6	7527.8	20889
8	MHQ-138	79.3	80.6	120	211.2	99.4	18.8	1.7	25.7	6738.9	21278
SEM		3.27	80.6	3.37	13.19	10.91	0.63	0.15	2.5	524.3	1815.6
LSD		9.9	6.6	10.22	40	33.10	1.9	0.47	7.7	1590.5	5506.9
CV		7.3	4.7	4.5	9.7	16.5	5.2	18.4	12.6	12.4	15.0
F-test		Ns	Ns	Ns	*	*	**	Ns	*	**	**

Key: *AD: days to anthesis, SD: days to silking, MD: Days to maturity, PHt: plant height (cm), EHt: Ear height (cm),CL: Cob length(cm),GY: grain yield per ha, BY: Biomass yield per ha, SC: Standard check variety, SEM : standard error of means, LSD : least significant difference, CV: coefficient of variation*

Table2. *Yield and Yield related performance of hybrid maize varieties in Medebay Zana, 2015*

SN	Treat name	50% AD	50% SD	90% MD	PHt(cm)	EHt(cm)	CL(cm)	Ears/ plant	100s wt(g)	Gy(kg/ ha	BY(kg/ha)
1	BH-543(SC)	92.3	97	154.3	236.7	129.5	21.1	1.2	32.2	7255.8	22020
2	BH-546	91	96.7	153	265.0	149.1	20.8	1.2	25.4	7949.8	25304
3	BH-661	97	101	154.6	295.5	177.7	21.2	1.0	36.1	6421.5	26402
4	BHQPy-545	88.6	92.3	145.6	234.1	116.7	20.5	2.0	21.4	3865.2	10255
5	Local-red maize	80.6	84.3	144.6	253.3	129.9	22.1	1.0	36.2	6249.5	20488
6	MH-130	82.3	94.7	144.6	182.5	82.9	8.9	1.5	32.7	5581.3	15011
7	MH-140	86.0	91.3	152	259.7	116.9	20.9	1.2	38.5	6651.8	20823
8	MHQ-138	89	92.0	150	216.3	109.7	18.3	1.1	20.7	3841.4	14007
SEM		1.2	3.5	2.3	8.9	8.9	1.04	0.1	2.3	638.4	1324
LSD		3.5	10.7	6.8	27.0	27.2	3.2	0.3	6.8	1936.4	4018
CV		2.3	6.5	2.6	6.4	12.3	8.8	15.4	12.9	18.5	11.9
F-test		**	NS	*	**	**	NS	**	**	**	**

Key: *AD: days to anthesis, SD: days to silking, MD: Days to maturity, PHt: plant height(cm), EHt: Ear height(cm),CL: Cob length(cm),GY: grain yield per ha, BY: Biomass yield per ha, SC: Standard check variety, SEM : standard error of means, LSD : least significant difference, CV: coefficient of variation*

Combined Analysis of Variance of Yield and Yield Related Traits

The Combined analysis of variance showed that the effect of environments and genotypes for grain was significant ($p \leq 0.01$) (Table 3).The significant effect of environment is due to their variation in rainfall amount and seasonal distribution, temperature and soil type (Table 1).Therefore locations played a significant role in influencing the expression of these traits, especially grain yield, 100 seed weight, plant height and ear height. The genotype by environment was significant for silking date, grain and biomass yield while the genotype by environment was not significant for days to maturity, plant and ear height, indicates that genotypes were not significantly interacted with location i.e. possibility of selecting stable and adapted variety based on high mean performance across locations. An ideal maize hybrid should have a high mean yield combined with a low degree of fluctuation under different environments (Annic-chiarico, 2002). One of the most important goals of maize breeders has been to enhance the stability of performance of maize when exposed to stresses (Campos *et al*., 2006).

Table3. *Combined Mean Performance of Maize Hybrids of 2014/15 and 2015/16 Cropping Season Laelay adiabo and Medebay zana, 2015*

SN	Genotype	50%AD	50%SD	90%MD	PHt(cm)	EHt(cm)	100_wt_g	GY_kg_ha
1	BH-543(SC)	86.44 cd	91.56 de	142.11 b	220.3 cd	116.3 bc	94.0 cde	5883.58 bc
2	BH-546	86.78 cd	91.56 cde	142.56 b	238.5 ab	125.2 b	94.5 cde	7140.21 a
3	BH-661	90.00 d	93.67 e	145.11 b	255.2 a	146.4 a	111.0 abc	6622.60 ab
4	BHQPy-545	85.00 bc	88.56 bcd	137.22 a	208.2 de	97.7 d	78.7 e	4493.79 d
5	Local-red maize	77.22 a	81.67 a	134.67 a	208.8 de	101.2 d	127.0 a	5446.59 cd
6	MH-130	77.44 a	84.89 ab	138.11 a	177.7 f	77.9 e	101.9 bcd	4878.32 d
7	MH-140	81.67 b	87.56 bcd	143.22 b	227.7 bc	103.4 cd	116.7 ab	6734.56 ab
8	MHQ-138	84.33 bc	87.0 bc	135.22 a	199.4 e	94.0 d	87.6 de	4876.78 cd
Mean		83.61	88.31	139.78	217.0	107.8	101.4	5759.55
CV	Geno* Env't	4.5	5.0	2.9	8.4	13.5	17.7	17.2
LSD(0.05	Geno* Env't	6.21	7.20	6.7	29.97	23.93	29.42	1631.475
F-test	Geno	**	**	**	**	**	**	**
	Env't	**	**	**	**	**	**	**
	Geno * Env't	*	*	ns	ns	ns	**	**

Key: *AD: days to anthesis, SD: days to silking, MD: Days to maturity, PHt: plant height(cm), EHt: Ear height(cm),CL: Cob length(cm),GY: grain yield per ha, BY: Biomass yield per ha, SC: Standard check variety, SEM : standard error of means, LSD : least significant difference, CV: coefficient of variation*

SUMMARY AND CONCLUSION

Maize improvement in Ethiopia started half a century ago. During the late1960s and early 1970s, several promising hybrids and composite varieties of East African origin were introduced and evaluated at different locations. These resulted in the recommendation of several maize varieties for the maize growing regions of the country. To advance improvement of maize productivity in different localities, continual identification of the best and suitable crop technologies appeared to be essential. This can be achieved, through adaptability tests and generation of new technologies. Accordingly, this study was initiated to identify and select best adapted relatively high yielding maize varieties for mid and low altitudes of North Western Tigray.

Six released mid and low land maize varieties with one standard and local check were tasted at two sites for two years in randomized complete block design with three replications during 2014/15-2015/16 cropping season. The genotypes were sown on a plot size of 4 m x 4m (16 m2) in rows of five per plot at a spacing of 80cm between rows and 40 cm between plants.

Significant differences between varieties were observed for grain yield at both testing sites. From the two testing site, Laelay adiabo gave highest yield. Generally from this study genotype by environment interaction of the mid and low altitude maize hybrids evaluated was found to be significant for grain yield and yield related traits, indicated the presence of large genetic variability for the respective traits, good progress can be made in selecting for grain yield under the different environments. Although, variability among genotypes was highly significant within and among the testing locations; locations were found to contribute greatly to the variations in hybrids' performance. This indicates that, unpredictable environmental conditions are one of the major players in selecting superior and widely adapted maize varieties. Based on the combined mean performance three varieties (BH-546, BH-661, and MH-140) were showed above mean performance of the standard check of BH-543 in the studied locations and those variety would be highly recommended to demonstrated and popularized in both location and similar growing areas. Even though further study should be carried out including a number of recently released maize varieties for improved maize production and also to put the recommendation on a strong basis and further justification by use of the multi-trait selection method to identify and recommend the best six candidates for direct production.

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