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Original Research Article

Evaluation of Promising Highland Maize Genotypes in Highland Districts of Western Shewa Zone, Ethiopia

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Abstract: The on-farm trials were conducted in three districts of west shewa zene, Oromia region, Ethiopia, to compare the performance of Promising hybrids under farmers field and promote one or two hybrids for possible release as commercial variety. Seven hybrids were evaluated using randomized complete block design (RCBD) in 2021 cropping season. The combined analysis of variance for three districts showed highly significant mean squares due to genotypes for all studied traits except ear position. Site*entry interaction showed significant mean variance only for grain yield (GY) indicating that, the performance of these genotypes were not consistent across sites for this trait. Hybrids SXH180174 and 3XH1900432 were the best performing genotypes for grain yield and some yield related traits. The single cross hybrid SXH180174 scored the highest grain yield (10.05 tons/ha) as compared to the checks and showed preferred plant and ear aspects. Accordingly this hybrid was recommended for variety verification trial stage for release as commercial hybrid in highland agro-ecology of the country.

Keywords: Grain yield, Hybrids, Improved varieties, Maize, On-farm.

INTRODUCTION

Maize (Zea mays L.) is cultivated globally as one of the most important cereal crops and ranks third next to wheat and rice. It is the second most popular staple crop in Ethiopia after tef (Eragrostis tef) and contributes the greatest share of production and consumption together with other major cereal crops, such as tef [*Eragrostis tef(Zucc.)*Trotter], wheat (*Triticum aestivum* L.) and sorghum [*Sorghum bicolor* (L.) *Moench*] (CSA, 2020). In 2020 cropping season, the total annual production and productivity in Ethiopia has reached 10.02 million tons and 4.24 t ha^{-1} respectively (FAOSTAT, 2021), which is the second highest national average yield reported in sub Saharan Africa (SSA), only after South Africa (Abate *et al.*, 2015).

Improved varieties developed by the national maize breeding program, in conjunction with introduced hybrids by multi-national seed companies, have significantly contributed to the rapid increase in maize production in the country (Ertiro *et al.*, 2017). The highland sub-humid agro-ecology is one of the diverse agro-ecology in which maize is broadly grown in Ethiopia. The highland maize breeding program coordinated from Ambo agricultural research center is contributing a lot to boost the production and productivity of maize in the highland areas of the country. However, maize productivity in this area is far below the potential due to several factors, including limited number of improved varieties, inadequate farmers' access to affordable quality seeds and mineral fertilizers, high incidence of pests and diseases, parasitic weeds and poor soil fertility (Twumasi-Afriyie *et al.*, 2002). To increase number of highly productive improved maize varieties, the process of developing new highland maize varieties has been progressing well at the main breeding station of Ambo Agricultural Research Center.

In the process of developing new maize varieties, evaluating promising genotypes under farmer's field before releasing to the commercial use is an important stage to increase adoption of the varieties by farmers and other users after release. Therefore, the present study was conducted to compare the performance of Promising hybrids under farmers field and promote one or two hybrids for possible release as commercial variety.

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MATERIALS AND METHOD

Description of Study Area

An experiment was conducted on farmer's field in 2021 cropping season at Liban Jewi, Toke Kutaye and Ejersa Lafo districts of west shewa zone. The districts were located at $8^0$58'N, $37^0$33'E, $9^0$00'N, $37^0$46'E, $9^0$00'N, $38^0$16'E latitude and longitude and at an altitude ranges from 2000 to 2560 masl (meters above sea level) respectively. The districts receives mean annual rainfall of 1040 mm, while they have a medium cool sub-humid climate with the mean minimum, mean maximum and average air temperatures of 8.9, 27.4 and 18.1^{o}C, respectively (Abera *et al*., 2021). The soil type is brown clay loam Ultisols for Liban Jewi (Abera *et al.*, 2020), and mostly vertisols for Ejersa Lafo and Toke kutaye districts (Tolesa *et al.*, 2021, Abera *et al.*, 2016).

Experimental materials

A total of seven entries composed of four promising crosses, selected from previous national variety trials depending on met-analysis and three standard checks (Jibat, Kolba and BH661) were investigated. The promising crosses were composed of three single crosses and one three way cross for evaluation. One of the standard checks (BH661) was released by Bako national maize research center for optimum rainfall areas of mid-altitude and transitional highlands, while Jibat and Kolba varieties were released by Ambo agricultural research center for transitional and true highland sub-humid agro-ecologies of the country. Lists of the promising crosses and checks are presented in Table 1.

Table-1: List of hybrids and check evaluated and their source

S/N	Genotype name	Type of hybrid	Entry type	source
1	SXH180063	Single cross	Test entry	EIAR-HMBP
2	SXH180165	Single cross	Test entry	EIAR-HMBP
3	SXH180174	Single cross	Test entry	EIAR-HMBP
4	3XH1900432	Three way cross	Test entry	EIAR-HMBP
5	JIBAT	Three way cross	Check entry	EIAR-HMBP
6	KOLBA	Three way cross	Check entry	EIAR-HMBP
7	BH661	Three way cross	Check entry	EIAR-BNMRC

*EIAR-HMBP = Ethiopian Institute of Agricultural Research -Highland Maize Breeding Program, EIAR-BNMRC = Ethiopian Institute of Agricultural Research- Bako national maize research center

Experimental design and field managements

The experimental design was randomized complete block design with two replicates. Each entry was planted in a two rows of 5.25 m long plot with spacing of 0.75 m between rows and 0.25 m between plants within a row. The experimental materials were hand planted with two seeds per hill, which were later thinned to one plant to get the recommended planting density for the testing fields, 53,333 plants per hectare. Planting was conducted on the onset of the main rainy season after an adequate soil moisture level was reached to ensure good germination and seedling development. Other agronomic practices were carried out as per the recommendation for the test areas.

DATA COLLECTION AND ANALYSIS

Data on grain yield and other important agronomic traits were collected on a plot and sampled plants bases. Data collected on plot basis include Grain yield (GY), Ear aspect (EA), Plant aspect (PA), Bad husk cover (HC), and Ear rot (ER), while Plant and ear height (cm) were collected from sampled plants per plot. Number of ears per plant (EPP) and Ear position (EPO) were obtained as a ratio of total number of ears divided by total number of plants per plot and ear height divided by plant height respectively. The collected data for each character were subjected to statistical analysis of variance using SAS 9.4 (SAS Institute, 2017). The HC and ER data were normalized using square root transformation before analysis (Gomez and Gomez, 1984). Significant means will be separated using the least significant difference at 5% probability level (LSD 0.05).

RESULT AND DISCUSSION

The combined analysis of variance for grain yield and other related traits are computed and presented in Table 2. The analysis of variance showed highly significant mean squares due to genotypes for all studied traits except EPO. This shows the presence of considerable genetic variation among the genotypes and the possibility to select high yielding and adaptable hybrids for the environments under question. In agreement to the current findings (Bassa and Goa, 2017) reported similar results for grain yield and other traits. Site*entry interaction showed significant mean variance only for grain yield (GY) indicating that, the performance of these genotypes were not consistent across sites for this trait. Similar results were reported by different authors for this trait (*Tulu et al.*, 2021, Keimeso *et al.*, 2020). On the other hand site*entry interaction showed non-significant mean square variance for PH, EPP, HC, ER, EA and PA indicating that, the genotypes showed consistent performance across sites for traits in this study. (Tesfaye *et al.*, 2019) and (Tulu *et al.*, 2021) also reported similar findings for PH and EPP in their study for different batches of highland maize genotypes.

Table-2: Mean squares from combined analysis of variance for yield and yield related traits over three districts in west shewa Ethiopia in 2021

Source of variation	Traits								
	DF	PH	EPO	EPP	HC	ER	EA	PA	GY
Loc	2	880.07*	0.02**	0.39**	8.41**	2.21	0.31	0.17	73.04**
Rep(loc)	3	672.5*	0.002	0.07	0.23	0.43	0.12	0.62	5.51**
Entry	6	1610.75**	0.005	0.09*	13.48**	6.16**	1.63**	1.3**	5.75**
Loc*Entry	12	154.65	0.001	0.03	1.57	1.09	0.25	0.19	1.91**
Error	18	210	0.003	0.03	0.82	0.74	0.29	0.23	0.45
CV (%)		6.69	12	12.64	30.99	57.37	10.74	9.97	8.04
Overall mean		216.5	0.47	1.25	11.17	3.37	4.98	4.81	8.34

DF = Degrees of freedom, EA=Ear aspect, EPO = Ear position, EPP = Ears per plant, ER = Ear rot, GY = Grain Yield, HC = Husk cover, PA = Plant aspect, PH = Plant height.

Mean Performances of Genotypes

Phenology and growth

The performances of hybrids (Four promising and three checks) are presented in Table 3. Plant height (PH) ranges from 201.25 (SXH180165) to 248cm (BH661) with grand mean of 216.5cm. The high yielder promising hybrid (SXH180174) scored 207.50cm which less than the grand mean. BH661 check which is popular variety in the transitional highlands of the country scored the highest PH 248.00cm. From the breeders point of view the maize genotype scoring tall PH are prone to stalk and root lodging, whereas genotypes with medium PH may be good to scape these problems. In agreement with this result, (Keimeso *et al.*, 2020) and (Keno *et al.*, 2017) also identified genotypes with short plant heights as good behavior.

Ear position (EPO) which is calculated as Plant height divided by ear height ranges from 0.44 (Kolba) to 0.52 (3XH1900432) with grand mean of 0.47. Almost all of the evaluated genotypes were scored less than 0.5 except 3XH1900432 which is good to escape stalk and root lodging.

Table-3: Mean grain yield and other traits of promising hybrids and standard checks evaluated across three districts of highland agro-ecologies in west shewa zone of Ethiopia.

Hybrids	Traits							
	PH (cm)	EPO (ratio)	EPP (#)	HC (%)	ER (%)	EA (scale 1-9)	PA (scale 1-9)	GY (ton/ha)
SXH180063	226.25	0.49	1.34	0.62	0.00	5.33	5.17	8.29
SXH180165	201.25	0.47	1.29	7.59	0.76	5.17	5.00	8.39
SXH180174	207.5	0.45	1.33	13.23	0.48	4.5	4.33	10.05
3XH1900432	203.75	0.52	1.04	1.62	0.52	4.33	4.17	9.03
JIBAT	210.00	0.47	1.17	19.56	9.59	5.83	5.5	6.92
KOLBA	218.75	0.44	1.04	9.38	11.17	5.00	4.83	7.26
BH661	248	0.46	1.4	26.22	1.11	4.67	4.67	9.79
LSD	17.58	0.07	0.19	7.4	4.58	0.65	0.58	1.83
Grand Mean	216.50	0.47	1.23	11.17	3.38	4.98	4.81	8.53
Minimum	201.25	0.44	1.04	0.62	0.00	4.33	4.17	6.92
Maximum	248.00	0.52	1.40	26.22	11.17	5.83	5.50	10.05

EA=Ear aspect, EPO = Ear position, EPP = Ears per plant, ER = Ear rot, GY = Grain Yield, HC = Husk cover, PA = Plant aspect, PH = Plant height and LSD = Least significant difference

Grain yield and related traits

The combined means from across sites' for grain yield (GY) and ears per plant (EPP) are given in Figure 1. Overall mean grain yield of the Hybrids was 8.53 t/ha with a range of 6.92 t/ha to 10.05 t/ha. SXH180174 (10.05 t/ha) followed by BH661 (9.79 t/ha) had higher grain yield, while Jibat (6.92 t/ha) showed lower grain yield. The higher yield obtained from promising hybrids (SXH180174 and 3XH1900432) under farmers field in this study indicated, recommending these hybrids for commercial use can contribute for the production and productivity this crop in the targeted agro-ecology of the country. In line with this result, (Wegary *et al.*, 2010, Tulu *et al.*, 2018, Tulu *et al.*, 2021) also identified genotypes that performed better than the checks used in their studies for grain yield**.**

The promising hybrids and checks bear on average more than 1.04 numbers of ears per plant (EPP) with grand mean of 1.23. The maximum number of EPP (1.4) was harvested from BH661 followed by SXH180174 (1.33) which is the top yielder hybrid whereas, the minimum number of EPP was obtained from 3XH1900432. In line with the present findings, Keimeso *et al.*, (2020) reported minimum and

maximum number of EPP 1.18 and 1.74 for the hybrids trial at the highland maize breeding program.

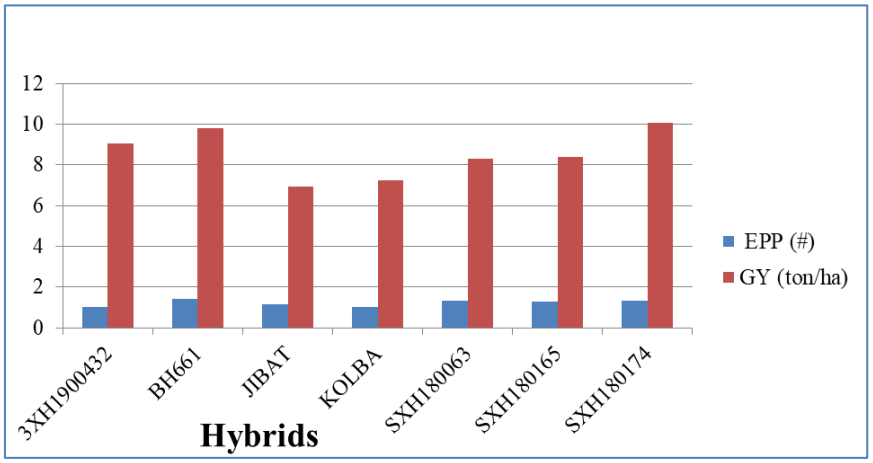

Fig-1: Means for grain yield and ears per plant of hybrids and standard checks evaluated across three districts

The hybrids ranged from 4.33 to 5.83 for their ear aspect (EA) with a mean of 4.98 (Table 3). The highest and lowest mean values for ear aspect were observed in hybrids Jibat and 3XH1900432. 3XH1900432 hybrid followed SXH180174 were preferred for this trait because of smaller value of EA which is desirable. The plant aspect (PA) also ranged from 4.17 to 5.5 with grand mean of 4.81. The lowest PA scale score was also obtained from 3XH1900432 hybrid followed SXH180174. In line with the current findings (Keno *et al.*, 2017) reported the score in scale (1 to 5) from 1.33 to 2.92 with grand mean of 2.06 for this trait in their study for different hybrids and suggested the genotypes with lower EA score are preferred for this trait.

The percentages for bad husk cover (HC) ranges from 0.62 to 26.22 % with grand mean of 11.17 %. The high yielders promising hybrids were scored considerably lower HC percentage as compared to checks BH661 (26.22%) and Jibat (19.56%). The mean percentages of ear rot (ER) damage among the hybrids ranged from 0.0 to 11.17% (Table 3). In general, both high yielder promising hybrids (SXH180174 and 3XH1900432) showed percentage score for ER less one, which means they could be taken as resistant to this disease under natural infestation. In line the current finding (Tulu *et al.*, 2018) reported lower percentage for ER in study.

CONCLUSION

The current study identified high yielder promising hybrids under farmers' field condition. The two high yielder promising hybrids (SXH180174 and 3XH1900432) which were significantly out yielded the check varieties (Jibat and Kolba) released for these agro-ecologies can be recommended for variety verification and released as commercial hybrid. The selected hybrids were also tested across different sites before they selected for on-farm evaluation and they can also be recommended for similar agro-ecologies in Ethiopia.

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