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On Farm Evaluation of Improved Maize (Zea Mays L) Varieties for Yield and Adaptation in Highland of Alicho, Silti and Analemo Districts of Southern Ethiopia

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Abstract: *The trials were conducted on farm in three districts of Silte and Hadiya Zones, south region, Ethiopia, to evaluate the adaptation and yield performance of improved maize varieties in 2013/2014 of Belg season. Data on plant height, Number of ear plant^{-1}, number of cob plot^{-1} ,ear height(cm) and grain yield were recorded. Six released varieties namely Hora, Kuleni, Jibat, Wenchi, BH661 and BH-660 (standard check) were planted on (5.1m*4.5m) plots at spacing of 75cm*30cm. The trials were laid in RCBD with three replications. Statistical analysis showed that there were significant differences among varieties for grain yield and some of traits. The varieties BH-661 and Wenchi out yielded other varieties and had average yields of 119.42qt ha^{-1} and 101.01 qt ha $^{-1}$ across three districts, respectively. The combined statistical analysis revealed BH-661 and Wenchi outshine other varieties which were as the most preferred varieties'. It is therefore recommended that BH-661 and Wenchi which had higher yields be promoted for cultivation in selected districts of south Ethiopia.*

Keywords: *adaptation, maize, on farm, improved varieties, agro ecology*

1. INTRODUCTION

Maize is one of the most important cereals broadly adapted worldwide (Christian et al., 2012). It is largely produced in Western, Central, Southern and Eastern parts of Ethiopia. In 2014/2015, cropping season 2,114,876.10 hectares of land was covered with maize with an estimated production not less than 72,349,551.02 quintals (CSA, 2014/2015). In Ethiopia maize is produced for food, especially, in major maize producing regions mainly for low-income groups, it is also used as staple food. Maize is consumed as "Injera," Porridge, Bread and "Nefro." It is also consumed roasted or boiled as vegetables at green stage. In addition to the above, it is used to prepare "Tella" and "Arekie." The leaf and stalk are used for animal feed and dried stalk & cob are used for fuel. It is also used as industrial raw material for oil & glucose production (MARD, 2014).

In Ethiopia, it is grown in the lowlands, the mid-altitudes and the highland regions. It is an important field crop in terms of area coverage, production and utilization for food and feed purposes. However, maize varieties mostly grown in the highlands at an altitude ranging from 1,700 to 2,400 masl of Ethiopia are local cultivars with poor agronomic practices (Beyene et al., 2005). In Ethiopia, its total annual production and productivity exceeds all other cereals (23.24% of 13.7 Million tons), and second after tef (*Eragrostis tef*) in area coverage (16.12% of the 8.7 000 000 ha), maize is one of the most important crops grown in Ethiopia (Mosisa et al., 2007). It is the most extensively cultivated food crops and main source of calorie in western, southern and eastern part of Ethiopian (Dagne et al., 2008). With the introduction of the hybrid seeds and the high yielding open pollinated varieties, and the increasing local demand, the importance of the crop may increase even further (Mosisa et al., 2007).

Maize is currently grown across 13 agro-ecological zones, which together cover about 90 percent of the country. Moreover, it is an increasingly popular crop in Ethiopia: The area covered by improved maize varieties grew from five percent of total area under maize cultivation in 1997 to 20 percent in 2006 (CSA, 2006). Maize cultivation is also a largely smallholder phenomenon in Ethiopia. The small-scale farmers that comprise some 80 percent of Ethiopia's population are both the primary producers and consumers of maize in Ethiopia. In support of the growing popularity of maize, a number of research centres and institutions have emerged in Ethiopia over the last several years (Dawit and Spielman, 2006).

Grain yield is the combined outcome of genetic potential and environment interaction. Variability in genetic potential among varieties is a major component of variable yield. Average maize yield in Ethiopia as well as in Southern region is low on account of insect pest damage, lack of high yielding cultivars and poor crop management practices. Another problem expressed by the farmers is lack of appropriate seed varieties at planting time. Available seed varieties are usually not well adapted to the local conditions and this leads to very low yields.

Olakajo and Iken (2001) reported that maize varieties produce significantly different yields at different locations. Olaoye (2009) emphasized the need to evaluate maize varieties in various agro-ecological zones for their adaptation, yield potential and disease reactions so as to identify suitable varieties for cultivation on farmers' fields. Although the production of highland maize was and is still relatively concentrated in the areas of Ambo and some highlands of Oromiya regions of Ethiopia. There is a need to maintain and evaluate the improved maize varieties in different agro-ecological zones of the country for rapid popularization to farmers in the southern region, Ethiopia. It is, therefore, imperative to understand the relationship among yield testing locations for better adaptation of germplasm to different production environments (Trethowan *et al.,* 2001). Keeping this in view, the present study was conducted to compare the performance of commercial varieties for their adaptability and to recommend a suitable one for the local maize growers of Southern Ethiopia.

2. Materials and Methods

2.1. Description of Study Area

An experiment was conducted at Lemlem3, Wolaya 6 and Dulanicho kebele of Alicho , siliti and Analemo woreda on farmers field respectively. The silitie zone kebeles; Lemlem3 and Wolaya 6 are in the range of 20.5% Dega & 79.5% Woina dega; the temperature ranges from 12-25.5c^{o} and the annual rainfall extends from 650mm up to 1818mm & the altitude reaches to 3273 meter (Ligbatto Ahmed, 2011).

The Hadiya zone kebele ;Dulanicho, is in the range of 12.9% Qola low altitude, 68.1% woina dega or moderately undulating land and 19% is dega or high altitude areas. The altitude in the zone ranges from 840m up to 2970m .The soil is supposed to be Nitosols and Chromic Luvisols, which are clay in nature (Anony, 2012).

2.2. Design Used and Treatment Details

The design used was randomized complete block (RCB) design having three replications. The RCBD was with the block size 33.1m x 15.5m. The plot size was 5.1m x 4.5m.There was six rows plot^{-1}. The number of plants row^{-1} was 17(seventeen). Plant spacing was 75cm and 30cm between row and plant, respectively. The Space between plots and blocks were 0.5m and 1m, respectively. The seed rate was 25 kgha^{-1}.The fertilizer rate was 150 kgha^{-1} DAP at planting and application of 200 kgha^{-1} of Urea in 2 splits that is 1/2 at knee height and 1/2 at flowering. The experiment consisted of six improved maize varieties considering BH660 as standard check to the highland (1800-2400masl) area of the selected farms. The treatments were Hybrids:-Wenchi (AMH-850), Jibat (AMH-851), BH660, BH661, and OPVS (Open Pollinated Varieties):-Hora and Kuleni maize varieties.

2.3. Data Collection and Analysis

Data collected were Plant height (cm), Ear height (cm), total number of ears plant^{-1}, number of ear per plot and grain yield (kgha^{-1}). The collected data for each character will be subjected to statistical analysis of variance using SAS (SAS Institute, 2008). Significant means will be separated using the least significant difference at 5% probability level (LSD 0.05).

3. Results and Discussion

The highland varieties evaluated in three locations; include wolaya 6, lemlem3 and Dulancho kebele of silti, Alicho and Analemo woreda respectively. Two farmers per a kebele were selected and varieties were sown in 6 farmers' farm land. Three of these farmers intercropped maize with legumes and Green pepper. Therefore, data were only collected from three farmers' trial land who managed their trial farm properly. The agronomic and grain yield of the maize varieties across locations were assessed (Table 1). The data available indicated that there some significant differences among the varieties in all the parameters analysed except in the number of ear per plot which showed no significant differences among the varieties. The variety BH-661 had highest number of ear per plant, while the lowest mean value of 1.11 was recorded for Kuleni. The variety BH-660 had the highest ear height (24.88 cm) and plant height (280.07cm), while BH-661 recorded the highest number of ear per plant (1.4) and number of ear per plot (84.44), respectively. Variety BH-661 produced highest grain yield of 119.4 qt ha-1. The lowest yield of 64.06 qt ha-1 was noted in maize variety Hora. The influence of across districts on growth and yield showed that maize varieties had significantly different ($P<0.05$) in grain yield and some agronomic characters. Statistical analysis in the study showed significant differences for grain yield among the genotypes. Similar results were reported by Ahmed *et al.* (2000) and Souza *et al.* (2002) who evaluated and identified high yielding maize varieties among different genotypes tested. McCutcheon *et al.* (2001) and Akbar *et al*. (2009) also reported significant differences among maize cultivars for grain yield. This also agrees with the findings of Hussain etal (2011) who reported that variations in growth and yield of maize due to climatic factors. Also, the differences in grain yield and other morphological characters observed among the cultivars across location is in consonance with the earlier findings of Workie etal.(2013) who reported that morphological characters such as plant height, ear placement, days to maturity are dependent on the genetic constituent of the varieties.

At Dulanicho (Analemo) district, Jibat recorded the highest number of ear per plant (1.20) and number of ears per plot (81.7), although it was not significantly different from others. The present result revealed that height of plant was highly significantly affected due to various maize varieties (Table 2). The tallest plants were observed in BH-660 (257.33 cm) followed by BH-661 with height of 243.87 cm. Similar results were reported by Daniel etal (2014) among maize cultivars for plant height. BH-660 had the highest plant height while the least was noted in maize variety Hora. Among the tested varieties, BH-660 had maximum ear height (23 cm) followed by varieties BH-661 with the ear height of 22.8 cm, while the cultivar Hora had the lowest ear height (19.7cm).This finding is in line with Daniel etal (2014). The highest mean values of grain yield of 93.5 qt ha^{-1} was recorded by BH-660 and closely followed by BH-661(89.3 qt ha^{-1}), while Hora had the least grain yield (Table 2).

At Wolaya 6 (silti) district, the highest number of ears per plant (1.27) and number of ears per plot (91.67) were recorded by Jibat and Hora respectively, while Kuleni recorded the least for number of ears per plant (1.0) and number of ears per plot (68.33) respectively. The variety BH-660 had the highest ear height (27.27 cm), followed by Jibat (25.3 cm) and lastly by Hora (22.53cm). Both the highest mean values of 317.9 cm and 102.11 qt ha-1 for plant height and grain yield respectively were recorded for maize variety BH-661 (Table 2).

Figure1. *Highland maize trial at siliti district ,maturing stage (H/Musafa Usiman's farm)*

At **Lemlem 3 (Alicho)** district, the highest number of ears per plant (2.0) and number of ears per plot (89.33) were recorded by BH-661, while Hora recorded the least for number of ears per plant (1.27) and number of ears per plot (57.33), respectively. The variety BH-661 had the highest plant height

(276.9cm), closely followed by BH-660 (266.06cm) and lastly by Hora (182.5cm). The highest mean values of 24.7cm and 166.9 qt ha-1 for ear height and grain yield respectively were recorded for Kuleni and BH-661, respectively (Table 2). The grain yield, number of ear per plant and plant height of maize trial also indicated in Fig.2

Figure2. *GY/HA, NEPP, EH, and PH of highland maize trial of Alicho site (Lemlem 3 kebele)**,** 2013 G.C*

At harvest, the influence of location/district on yield showed that the mean maize seed yields of 82.33 qt ha^{-1}, 80.35 qt ha^{-1} and 102.18 qt ha^{-1} for Wolaya 6, Dulanicho and Lemlem3 kebeles, respectively confirmed that variations in climatic factors in three districts have been partly responsible for the difference in yield of maize varieties. This result is also in agreement with the earlier report of (Hussain etal 2011 and Workie etal..2013) on maize which observed that the total output of the crop (yield), is dependent on the planting material genetic potential.

The mean data of individual districts indicated that maize varieties differ significantly in plant height (cm), ear height (cm), number of ear per plot and grain yield (qt ha-1) and harvest index. But the varieties did not differ significantly in number of ear per plant at Analemo district (Table 2). For all measured plant traits except few environments were significantly different. The significant effect of environment indicated that the testing environment were statistically different in yield potential i.e the mean yield of genotype differed from environment to environment. The superior mean grain yield (119.42qt ha-1) over the districts was recorded by the variety BH-661 followed by Wenchi (101.013 qt ha-1) (Table 2). Among the locations maximum mean seed yield was produced at Alicho (102.18 qt ha-1) followed by Silti (82.33 qt ha-1) and Analemo (80.35 qt ha-1) (Table 2). The environmental indices were found to be positive for ear height, number of ear per plot and plant height under silti agro climatic condition. At Analemo, almost all yields contributing traits except number of ears per plot were found negative. Under Alicho conditions almost all the yield related traits viz., number of ears per plant; ear height and grain yield possessed positive value for environmental index for each location which suggested that Alicho was the most favourable location for the expression of almost all the characters under study (Table 2). Therefore, results of the present study confirmed that Alicho district was found to be a favourable environment for the majority of maize varieties of this study.

Table1. *Grain Yield and some agronomic characteristics of improved maize varieties during Belg season of 2013/2014*

No	Maize varieties	NEPP	EH (cm)	NEPPO	PH (cm)	GY(qt/ha)
1	Jibat	1.35556ab	23.6778ab	75.556ab	240.111bc	77.061c
2	Hora	1.13333ab	21.4222c	75.444ab	209.511d	64.066c
3	Wenchi	1.20000c	23.6778ab	79.333ab	222.200cd	101.013 b
4	BH661	1.40000a	23.1222bc	84.444a	279.556a	119.422a
5	BH660	1.22222c	24.8889a	77.222ab	280.067a	98.925b
6	Kuleni	1.11111c	23.4111ab	71.333b	247.400b	69.240c
-	LSD(0.05)	0.1435	1.7342	8.1844	18.69	13.753
-	CV(%)	12.05067	7.708959	11.00875	7.876796	16.18078

Means with similar alphabets are not significantly different at $P < 0.05$ using DMRT. Note: NEPP =Number of ear per plant, EH =Ear height, NEPPO =Number of ear per plot, PH = Plant height & GY=Grain yield

Table2. *Grain Yield and some agronomic traits of six maize varieties at Dulanicho (Analemo), Wolaya 6 (Silti) and Lemlem 3 (Alicho) districts during Belg season of 2013/2014*

No	Maize varieties Wolaya 6 kebele	NEPP	EH (cm)	NEPPO	PH (cm)	GY(qt/ha)	V/indices
1	Jibat	1.26667a	25.300ab	87.000a	265.00b	69.503b	-12.83
2	Hora	1.06667ab	22.533b	91.667a	233.07b	67.790b	-14.54
3	Wenchi	1.06667ab	25.267ab	89.667a	246.00b	94.703 a	12.37
4	BH661	1.20000ab	23.200ab	84.333ab	317.87a	102.107a	19.77
5	BH660	1.06667ab	27.267a	72.000c	316.80 a	87.223 ab	4.89
6	Kuleni	1.00000b	25.267ab	68.333c	275.13ab	72.673 b	-9.66
-	LSD(0.05)	0.2065	4.131	13.691	45.39	19.685	-
--	CV(%)	10.21763	9.154421	9.158838	9.050825	13.14185	-
----	Location Mean	1.11	24.81	82.17	2.76	**82.33**	**-**
Environmental indices		-0.13	1.44	4.94	0.29	-5.95	-
No	Dulanicho kebele						
1	Jibat	1.20000a	22.033ab	81.667a	229.47ab	68.760bc	-11.59
2	Hora	1.06667 a	19.667b	77.333a	212.93 b	62.459c	-17.89
3	Wenchi	1.000a	22.067ab	83.667a	223.53ab	98.265a	17.92
4	BH661	1.000a	22.800a	79.667a	243.87ab	89.300ab	13.16
5	BH660	1.000a	23.000a	77.333a	257.33a	93.508a	13.16
6	Kuleni	1.000a	20.267ab	69.667a	241.73ab	69.800bc	-10.55
-	LSD(0.05)	0.158	3.0423	14.674	35.44	21.57	-11.59
-	CV(%)	8.322386	7.728172	10.31127	8.296028	14.75521	-
-	Location Mean	1.04	21.64	78.22	2.35	**80.35**	**-**
Environmental indices		-0.19	-1.73	1.00	-0.12	-7.94	-
No	Lemlem 3 kebele						
1	Jibat	1.6000ab	23.700ab	58.000c	225.867b	92.92bc	-9.26
2	Hora	1.2667b	22.067b	57.333c	182.533 c	61.95c	-40.23
3	Wenchi	1.5333b	23.700ab	64.667bc	197.067c	110.07b	7.89
4	BH661	2.0000a	23.367ab	89.333a	276.933a	166.86a	64.68
5	BH660	1.6000ab	24.400ab	82.333ab	266.067a	116.04b	13.86
6	Kuleni	1.3333b	24.700a	76.000ab	225.333b	65.25c	-36.93
-	LSD(0.05)	.3911	.2766	17.74	20.65	34.26	-
-	CV(%)	13.82101	5.641907	13.68317	4.957826	18.42904	-
-	Location mean	1.56	23.66	71.28	2.29	**102.18**	**-**
Environmental indices		0.32	0.29	-5.94	-0.18	13.89	-
Overall mean of three districts		1.24	23.37	77.22	2.46	88.29	-

Means with similar alphabets are not significantly different at $P < 0.05$ using DMRT. Note: NEPP =Number of ear per plant, EH =Ear height, NEPPO =Number of ear per plot, PH = Plant height V/indices=varietal indices & GY=Grain yield

4. Conclusion

From this study, it showed that BH-661 and Wenchi varieties had the highest yields over the standard check (BH-660) and others varieties evaluated. Therefore, maize varieties BH-661 and Wenchi are recommended for production in Silti, Analemo and Alicho districts and similar agro ecologies of south Ethiopia.

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