Performance Evaluation and Adaptation of Improved Maize (Zea Mays L) Varities for 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

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 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).

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. Olayoje (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.

MATERIALS AND METHODS

Description of study area
An experiment was conducted at Lemlem3, Wolaya 6 and Dulancho kebele of Alicho, siliti and Analemo woreda on farmers field respectively. The silite zone kebele; Lemlem3 and Wolaya 6 are in the range of 20.5% Dega & 79.5% Woina dega; the temperature ranges from 12-25°C and the annual rainfall extends from 650mm up to 1818mm & the altitude reaches to 3273 meter (Ligbatto Ahmed, 2011).

The Hadiya zone kebele ;Dulanichio, 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 Nitols and Chromic Luvisols, which are clay in nature (Anony, 2012).

Design 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. 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 kg ha\(^{-1}\). The fertilizer rate was 150 kg ha\(^{-1}\) DAP at planting and application of 200 kg ha\(^{-1}\) 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 (1800-2400msl) 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.

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 (kg ha\(^{-1}\)). 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).

RESULTS AND DISCUSSION

The highland varieties evaluated in three locations; include wolaya 6, lemlem3 and Dulancho kebele of siliti, 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\(^{-1}\) and 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 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 et al (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 et al.(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 Dulancho (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 et al (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 et al (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 (22.53 cm). 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).

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 (276.9 cm), closely followed by BH-660 (266.06 cm) and lastly by Hora (182.5 cm). The highest mean values of 24.7 cm 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

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 Lemlem 3 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 et al. 2011 and Workie et al..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 (119.42 qt 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.

Table 1: Grain Yield and some agronomic characteristics of improved maize varieties during Belg season of 2013/2014

<table>
<thead>
<tr>
<th>No</th>
<th>Maize varieties</th>
<th>NEPP</th>
<th>EH (cm)</th>
<th>NEPPO</th>
<th>PH (cm)</th>
<th>GY (qt/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jibat</td>
<td>1.35556ab</td>
<td>23.6778ab</td>
<td>75.556ab</td>
<td>240.111bc</td>
<td>77.061c</td>
</tr>
<tr>
<td>2</td>
<td>Hora</td>
<td>1.13333ab</td>
<td>21.4222c</td>
<td>75.444ab</td>
<td>209.511d</td>
<td>64.066c</td>
</tr>
<tr>
<td>3</td>
<td>Wenchi</td>
<td>1.20000ec</td>
<td>23.6778ab</td>
<td>79.333ab</td>
<td>222.200cd</td>
<td>101.013b</td>
</tr>
<tr>
<td>4</td>
<td>BH661</td>
<td>1.40000a</td>
<td>23.1222bc</td>
<td>84.444a</td>
<td>279.556a</td>
<td>119.422a</td>
</tr>
<tr>
<td>5</td>
<td>BH660</td>
<td>1.22222c</td>
<td>24.8889a</td>
<td>77.222ab</td>
<td>280.067a</td>
<td>98.925b</td>
</tr>
<tr>
<td>6</td>
<td>Kuleni</td>
<td>1.11111c</td>
<td>23.4111ab</td>
<td>71.333b</td>
<td>247.400b</td>
<td>69.240c</td>
</tr>
</tbody>
</table>

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

Table 2: 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

<table>
<thead>
<tr>
<th>No</th>
<th>Maize varieties</th>
<th>NEPP</th>
<th>EH (cm)</th>
<th>NEPPO</th>
<th>PH (cm)</th>
<th>GY (qt/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jibat</td>
<td>1.26667a</td>
<td>25.300ab</td>
<td>87.000a</td>
<td>265.00b</td>
<td>69.503b</td>
</tr>
<tr>
<td>2</td>
<td>Hora</td>
<td>1.06667ab</td>
<td>22.533b</td>
<td>91.667a</td>
<td>233.07b</td>
<td>67.790b</td>
</tr>
<tr>
<td>3</td>
<td>Wenchi</td>
<td>1.06667ab</td>
<td>25.267ab</td>
<td>89.667a</td>
<td>246.00b</td>
<td>94.703a</td>
</tr>
<tr>
<td>4</td>
<td>BH661</td>
<td>1.20000ab</td>
<td>23.200ab</td>
<td>84.333ab</td>
<td>317.87a</td>
<td>102.107a</td>
</tr>
<tr>
<td>5</td>
<td>BH660</td>
<td>1.06667ab</td>
<td>27.267a</td>
<td>72.000c</td>
<td>316.80a</td>
<td>87.223ab</td>
</tr>
<tr>
<td>6</td>
<td>Kuleni</td>
<td>1.00000b</td>
<td>25.267ab</td>
<td>68.333c</td>
<td>275.13ab</td>
<td>72.673b</td>
</tr>
</tbody>
</table>

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

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.
Acknowledgements
We are grateful to farmers of the study zones who made this variety evaluation study possible. The Bureau of Agriculture staffs at zone and district levels, development agents, and the Worabe Research centre are greatly acknowledged for facilitation of the work. Thanks also go to the South Agricultural Research Institute for funding this research.

References