Evaluation of midland maize (Zea mays l.) varieties in selected districts of southern Ethiopia

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Abstract: This study was aimed at selecting maize varieties that perform better in midland maize production areas. Seven improved midland maize varieties were tested in Basketo Special district (Motikesa and Sasa Kebeles) and Darashe district, southern Ethiopia. The experiment was done using a randomized complete block design with three replications. Seeds were sown on a plot size of 15 m² (3 m × 5 m) having four rows with a spacing of 75 cm between rows and 25 cm between plants. Combined analysis of variance was conducted after testing the uniformity of error variance. There were significant differences (p < 0.05) between varieties for grain yield and other studied traits over locations. Mean separation for grain yield over locations indicated that varieties BH 547 (6851 kg/ha) and BH-546 (6638 kg/ha) gave better grain yield as compared to others. These two varieties gave 41.6% and 39.7% yield advantages over the national (4000 kg/ha) maize average productivity, respectively. Generally, the result revealed that the existence of variation for the characters studied in midland maize varieties, and so, testing of the varieties has paramount importance before large-scale production.

1. Introduction

Maize (Zea mays L.) is one of the most important cereal crops in Ethiopia. It is an important field crop in terms of area coverage, production and utilization. It ranks second in area coverage and first in total production (Central Statistical Agency [CSA], 2018). It is grown for its food and feed values and one of the most important staples and cash crops and the main sources of calories (Wedajo et al., 2015).
In southern Ethiopia, maize is the first crop both in productivity and in production (CSA, 2018). It is the most extensively cultivated food crops and the main source of calories in western, southern and eastern parts of Ethiopia (Mosisa, Wonde, Berhanu, Legesse, & Alpha, 2001). Gamo, Gofa and Segen area people zones are among major maize producers in southern Ethiopia. The productivity of existing varieties is below potential. The low yield in this area is mainly not only lack of improved varieties but also attributed to improper use of technology packages. Testing of different released varieties in Ethiopia for their environmental reaction is crucial to avoid risks of various environmental factors (biological, physical and chemical). Hence, it is important to test maize varieties for their adaptation that were released for midland areas of Ethiopia to enhance production and productivity. Therefore, this study was initiated with the objective of selecting better performing maize variety/ies for yield in midland areas of southern Ethiopia.

2. Materials and methods
An experiment was conducted during 2018 cropping season comprising seven midland maize varieties in four testing locations of southern Ethiopia. The experiment was laid down in a randomized complete block design with three replications. The plot size of 222.5 m$^2$ (4.5 m × 5 m) having six rows with inter-row spacing of 75-cm and 25-cm spacing between plant was used. Fertilizers (NPS 100 kg/ha at planting and 100 kg/ha urea (1/3 kg/ha at planting and 2/3 kg/ha at knee stage)) were applied after weeding. Data were collected for plant height (taken at maturity) and ear height on the basis of five sample plants randomly taken from four central rows, and grain yield was taken from four central plot bases. Data were subjected to Genstat software for analysis of variance (ANOVA) for individual and combined locations. Mean separation was conducted by using the least significant difference.

3. Results and discussion
Combined ANOVA for locations, varieties and varieties by location interaction revealed significant difference ($p < 0.05$) for the parameters studied (Table 1). This indicated that the presence of significant variations among varieties and the varieties had inconsistent performance over the tested locations. Workie, Habbitamu, and Yigzaw (2013) in maize and Yayis, Agdew, and Yasin (2014) in field pea and Simion et al. (2018) in cowpea also reported the significant effect of locations, varieties, and locations by varieties on yield and some other yield-related traits.

Mean performance of varieties for grain yield for each location is presented in Table 3, 4, 5 and 6. The varieties had over locations mean grain yield of 6271 kg/ha (Table 2). The highest over locations mean grain yield obtained were BH547 (6851kg/ha) and BH546 (6638kg/ha). These varieties had an yield advantage of 41.6% and 39.7% for BH 547 and BH 546, respectively, over the national maize average productivity (4000 kg/ha$^{-1}$). Moreover, performances of varieties were not consistent across locations. Inconsistent performances of varieties for studied traits across locations were due to physical, chemical and biological factors (Tariku et al., 2018)

Among varieties, SBRH, BH660, BH547 and BH546 had better grain yield at Walayite location with a yield advantage of 50.1%, 50.0% and 48.6% and 47% over the national maize average productivity (4000 kg/ha, CSA 2018) (Table 3) in the given order.

| Table 1. Combined analysis of variance for yield and agronomic traits over four locations |
|------------------------------|--------|--------|--------|--------|
| Source of variation          | DF     | PH     | EH     | CL     |
|-------------------------------|--------|--------|--------|--------|
| Replications                  | 8      | 263.0  | 42.5   | 2.452  |
| Locations                     | 3      | 5206.6**| 3924.4**| 466.193**| 9,636,804**|
| Varieties                     | 6      | 2285.1**| 2034.5**| 32.941**| 1,533,045**|
| Locations × varieties         | 18     | 220.8* | 147.9**| 5.818* | 105,149**|
| Pooled error                  | 48     | 450.3  | 444.3  | 13.587 | 752,542   |

DF = degree of freedom, PH = plant height, EH = ear height, GY = grain yield and CL = cob length.
Among tested varieties at Motikesa, BH543, BH546, BH547 and BH661 yielded better in the given order with a yield advantage of 52.6%, 49.9% and 48.8% over the national (4000 kg/ha, Central Statistical Agency (CSA), 2018) maize average productivity (Table 4).

Table 2. Combined mean values for yield and agronomic traits over four locations

| Varieties | PH (cm) | EH (cm) | CL (cm) | GY (kg/ha) |
|-----------|---------|---------|---------|------------|
| BH543     | 213.9a  | 130.4b  | 27.87ab | 5967c      |
| BH546     | 215.7a  | 125.0bc | 27.62bc | 6638ab     |
| BH547     | 239.7b  | 126.9bc | 29.63a  | 6851a      |
| BH660     | 247.4b  | 145.4a  | 28.38ab | 6006c      |
| BH661     | 220.3c  | 154.0a  | 28.58ab | 6379b      |
| SPRH      | 218.5c  | 120.3c  | 25.75cd | 5994c      |
| SBRH      | 212.4c  | 120.1c  | 25.90d  | 6062c      |
| Grand mean| 224.0   | 131.7   | 27.5    | 6271       |
| LSD (0.05)| 12.16   | 9.95    | 1.97    | 265.41     |

PH = plant height, EH = ear height, GY = grain yield and CL = cob length.

Table 3. Mean values of yield and agronomic traits of midland maize varieties at Walayite, Darashe district, 2018

| Varieties | PH (cm) | EH (cm) | GY (kg/ha) |
|-----------|---------|---------|------------|
| BH543     | 202.7b  | 114.7b  | 6342b      |
| BH546     | 211.6ab | 106.1bc | 7776a      |
| BH547     | 202.7b  | 116.5b  | 7560a      |
| BH660     | 225.9a  | 130.4a  | 8024a      |
| BH661     | 223.9ab | 130.3a  | 6549b      |
| SPRH      | 202.7b  | 101.7c  | 6678b      |
| SBRH      | 208.3ab | 110.0bc | 8012a      |
| Grand mean| 211.1   | 115.7   | 7277.3     |
| LSD (0.05)| 22.0    | 115.7   | 752.9      |

PH = plant height, EH = ear height and GY = grain yield.

Table 4. Mean values of yield and agronomic traits of midland maize varieties at Motikessa, Basketo Special district, 2018

| Varieties | PH (cm) | EH (cm) | CL (cm) | GY (kg/ha) |
|-----------|---------|---------|---------|------------|
| BH543     | 222.6b  | 133.6bc | 31.40bc | 8444a      |
| BH546     | 228.0b  | 123.5c  | 35.07ab | 8448a      |
| BH547     | 212.6b  | 128.0c  | 36.87a  | 7956ab     |
| BH660     | 269.1a  | 174.7a  | 36.47a  | 6356d      |
| BH661     | 260.5a  | 153.0ab | 32.87abc| 7822ab     |
| SPRH      | 218.5b  | 114.3c  | 31.33bc | 7289bc     |
| SBRH      | 223.7b  | 121.7c  | 30.67c  | 6444cd     |
| Grand mean| 233.6   | 135.5   | 33.52   | 7650.8     |
| LSD (0.05)| 28.86   | 10.30   | 1.97    | 857.97     |

PH = plant height, EH = ear height, GY = grain yield and CL = cob length.
Among varieties tested at Sasa, BH661 had better grain yield with a yield advantage of 38.9% over the national maize average productivity (4000 kg/ha, Central Statistical Agency (CSA), 2018) (Table 5). Average yield performances of varieties were low mainly due to low moisture stress and incidence of fall armyworms during the experimental season.

Among varieties tested at Belta, all except BH660 showed better performance for yield with a yield advantage of up to 30.7% over the national maize average productivity (Central Statistical Agency (CSA), 2018). Average yield performances of varieties in this study area were low mainly due to low moisture stress and incidence of fall armyworms during the experimental season.

### 4. Conclusion and recommendation

Maize is an important field crop in terms of area coverage, production and utilization in the study area. The combined analysis of variance revealed a significant difference \((p < 0.05)\) for location, variety and variety by location interaction. The present study indicated the existence of variability among varieties studied in terms of their reaction with locations to yield and yield-related traits. The mean separation for grain yield over locations indicated that varieties BH 547 (6851 kg/ha) and BH-546 (6638 kg/ha) were superior varieties compared to others. Based on the average national maize productivity, these superior varieties had 41.6% and 39.7% yield advantages over the national maize average productivity. Therefore, to increase maize production in the study area, these two varieties are recommended and need to be demonstrated with their improved production packages in many farming fields with a larger plot size.

| Varieties | PH (cm) | GY (kg/ha) |
|-----------|---------|------------|
| BH543     | 197.7a  | 3335c      |
| BH546     | 193.0a  | 3556c      |
| BH547     | 237.7b  | 5111b      |
| BH660     | 237.7b  | 3333c      |
| BH661     | 206.3ab | 6556a      |
| SPRH      | 210.3ab | 3778c      |
| SBRH      | 199.3ab | 3778c      |
| Mean      | 211.7   | 4206.3     |
| LSD (0.05)| 43.03   | 978.40     |

PH = plant height, GY = grain yield.

| Varieties | PH (cm) | EH (cm) | CL (cm) | GY (kg/ha) |
|-----------|---------|---------|---------|------------|
| BH543     | 227.4b  | 143.1bc | 25.93ab | 5200a      |
| BH546     | 242.0b  | 135.7bc | 25.73ab | 4956a      |
| BH547     | 229.1b  | 145.1b  | 30.20 a | 5778a      |
| BH660     | 264.2a  | 182.2a  | 27.53ab | 3778b      |
| BH661     | 268.9a  | 175.7a  | 28.93a  | 5356a      |
| SPRH      | 231.9b  | 129.9bc | 22.73bc | 5400a      |
| SBRH      | 224.6b  | 124.3bc | 19.07c  | 4889ab     |
| Mean      | 241.2   | 148.0   | 25.73   | 5050.79    |
| CV (%)    | 4.3     | 7.4     | 11.3    | 14.5       |
| LSD (0.05)| 18.51   | 19.46   | 5.166   | 1303.35    |

PH = plant height, EH = ear height, GY = grain yield and CL = cob length.
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References
CSA (Central Statistical Authority). (2018). Agricultural Sample Survey. Area and production of crops. Central Statistical Authority, Statistical Bulletin 532,1 4–63. Addis Ababa.
Genstat Release 16th Edition (PC/Windows 7) Copyright. (2014). In C. A. Fatokun, S. A. Tarawali, B. B. Singh, P. M. Kormawa, & M. Tamo (Eds.). VSN International Ltd. germplasm.
Mosisa, W., Wonde, A., Berhanu, T., Legesse, W., & Alpha, D. (2001). Performance of CIMMYT maize germplasm under low nitrogen soil conditions in the mid altitude sub humid agro ecology of Ethiopia. Afr. J. Sci. Conf. Proc, 18, 15–18.
Tariku, S., Wassu, M., & Berhanu, A. (2018). Genotype by environment interaction and stability analysis of cowpea [Vigna unguiculata (L.)Walp] genotypes for yield in Ethiopia. Journal of Plant Breeding and Crop Science, 10(9), 249–257. doi:10.5897/JPBCS2013.0406
Wedaño, G., & Hussein, M. (2015, July). Study on adaptability and stability of drought tolerant maize varieties in drought prone areas of South Omo Zone, SNNPRS. International Journal of Research in Agriculture and Forestry, 2(17).
Workie, A., Habtam, Z., & Yigzaw, D. (2013). Genotype × environment interaction of maize (Zea mays L.) across North Western Ethiopia. Journal of Plant Breeding and Crop Science, 5(9), 171–181. doi:10.5897/JPBCS2013.0406
Yayis, R., Agdew, B., & Yasin, G. (2014). GGE and AMMI biplot analysis for field pea yield stability in SNNPR State, Ethiopia. International Journal of Sustainable Agricultural Research, 1(1), 28–38.