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Research Article
Evaluation of Drought Tolerant Maize Varieties (*Zea mays* L.) For Low Land of Guji Zone, Southern Oromia, Ethiopia

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Abstract
Background and Objective: Maize is one of the most cultivated and used as a staple food crop in Ethiopia and its production is constrained by many challenges such as the lack of improved maize variety is highly limited in different parts of Ethiopia due to the inaccessibility of different production factors. The lowlands of Guji Zone is one such area where the technologies are not been widely addressed and adopted so far. Hence, this study was conducted by Bore agricultural research centre to select and recommend adaptable high yielding and early maturing maize varieties for low land agro-ecologies of the Guji Zone. **Materials and Methods:** The experiment was done at lowland parts of three districts Adola, Wadera and Liben. Seven released maize varieties with one local check were used. RCBD experimental design with three replications was used on a plot size of 3×3.75 m. All phonological and yield data were collected subjected to analysis using GenStat (18th edition) software. Combined data analysis was used to test the performance of the varieties across the testing locations. **Results:** The result of the study shows that all varieties revealed a significant difference for the selected characters across the locations. Based on the obtained result, two maize varieties (Melkassa 07 and 03) were early maturing and gave higher yields. **Conclusion:** Therefore, these varieties are recommended for demonstration and popularization in the study area and similar agro-ecology of the zone. But the further study should be carried out including several recently released maize varieties for improved maize production.

Key words: Adapted, analysis, effect, improved, maize, variety, significant

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals broadly adapted worldwide[1,2]. Among cereal crops, maize is the most important used for human diet and major grain crop in the world in terms of total production in the large parts of the world[3,4]. Maize was introduced in Ethiopia more than three centuries ago Abate *et al*.[5] and is grown mainly for human consumption. It is largely produced in Western, Central, Southern and Eastern parts of Ethiopia. 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.

Maize cultivars that are used in the low land regions of Ethiopia are well adapted but low yielding open-pollinated varieties developed by local farmers. However, Maize is one of the most important cereal crops in Ethiopia, ranking second in area coverage and first in total production. About 40% of the total maize growing area is also located in low-moisture stress areas, where it contributes less than 20% to the total annual production. Availability of the limited number of drought-tolerant maize varieties that reached few smallholders is the main factor for instability and low production in low-moisture stress areas of the country[6].

Maize is one of the most important cereal crops in the Southern Oromia region in general and the lowlands of the Guji Zone. Its productivity (26.55 qt ha^{-1}) is very low when compared to potential maize areas (42.37qt ha^{-1})[7]. Most of the low land farmers of the Guji Zone mainly earn their livelihood from livestock, they practice crop production as well. Maize is the major crop cultivated in the zone. However, information is lacking on the performance and variability of drought-tolerant maize variety. The low yield in this area is mainly attributed to recurrent drought, low levels of fertilizer use and low adoption of improved varieties. Hence, it is paramount important to introduce improved drought-tolerant maize varieties to the target area for improved maize production and productivity. Thus, this study was proposed to select the best performing drought-tolerant maize varieties to the target area.

MATERIALS AND METHODS

Study area: The experiment was conducted at three districts locations namely, Wadera, Adola and Liben on farmer fields during the 2018 and 2019 main cropping season. These three districts were selected purposively based on agroecology and the potential of the crops. Hence, this study was conducted by Bore agricultural research centre with the objectives of selecting and recommending high yielding, adaptable, disease resistant/tolerant and drought-tolerant maize varieties for low land areas of the Guji Zone. Those three districts are characterized by three agro-climatic zones, namely Dega (high land), Weina dega (midland) and Kola(low land) with different coverage. Based on this condition two time cropping season was commonly practised i.e., Arfasa (main cropping season) which start from March-April, especially for maize, haricot bean, wheat and barley.

Experimental materials and design: A randomized complete block design with three replications was used to conduct the experiments per site. The seeds were planted in rows with two seeds per hill at a rate of 25 kg ha^{-1} in a plot consisting of six rows each of 3.75 m long and 3 m wide and seedlings was thinned into one plant per hill for 4 weeks after emergence to obtain 144 plants per plot. The inter-row spacing was 0.75 m, while the intra row spacing was 0.25 m, giving a population density of 53,333 plants per hectare. Fertilizers were applied at the rate of 100/100 kg ha^{-1} NPS/Urea. Urea was applied in split (the half at planting and the other half at knee height). First weed control was carried out after 3 weeks of planting and next weeding as needed.

Data collected: The middle four rows were used for data collection and harvest at maturity. Individual plant-based data as well as plot base data, was collected on seven traits of maize varieties. Data were collected on an individual plant basis from five randomly selected plants such as plant height (cm), ear length (cm), ears per plant, tassel length (cm) and cob weight (gm) while data on a plot basis included grain yield (qt ha^{-1})

RESULTS AND DISCUSSION

Phenological and growth parameters: The analysis of mean squares variance revealed that the main effect of variety was a significant ($p<0.05$) effect on growth parameters maize as described in Table 1. The mean squares of growth parameters maize showed a significant difference between varieties as mentioned in Table 1.

Days to tasseling: The highest prolonged duration to tassel (77.83 days) was observed in the local check as it was not statistically different from the Gambela composite variety. However, the minimum duration (71.5 days) to tasseling was recorded at variety Melkassa 07 in Table 2. This might be due to genetic variations among different maize varieties. In line with this result, Abduselam *et al*.[8], who reported significant

Table 1: Mean squares of ANOVA for growth parameters of maize (DTT, DS, DM, PH, E/P, EL) at lowland of Guji in the 2017-2018 main cropping season

Source of variations	Mean squares						
	DF	DTT	DS	DM	PH (cm)	E/P	EL (cm)
Rep	2	0.0007	23.62	73.5	327	0.05	0.80
Variety	7	0.003*	154.21*	200.71*	7593**	0.15^{NS}	7.43*
Error	62	0.0006	1.87	26.91	1483	0.09	2.10
CV (%)	-	19.1	1.7	3.2	20.6	27.1	9.70

DTT: Days to tassel, DS: Days to silk, DM: Days to mature, pH: Plant height, E/P: Ear/plant, EL: Ear length and *Significant level at p<0.05

Table 2: Combined mean of DTT, DS, DM, PH, E/P, EL of maize at lowland of Guji in 2017-2018 main cropping season

Varieties	DTT	DS	DM	PH (cm)	E/P	EL (cm)
Melkassa 02	73.83^{cd}	78.5^{c}	160.7^{bc}	192.6^{bc}	1.141	15.21^{bc}
Melkassa 01	73.83^{cd}	77.83^{c}	158.5^{bc}	151.2^{d}	1.033	13.83^{d}
Melkassa 03	72.83^{d}	77.5^{c}	158.3^{bc}	173.9^{bcd}	1.085	15.36^{ab}
Melkassa 07	71.5^{e}	76.17^{d}	155.8^{c}	162.5^{cd}	1.259	14.47^{bcd}
Gibe 02	74.17^{c}	80.83^{b}	160.3^{bc}	176.6^{bcd}	0.993	15.08^{bcd}
Gibe 03	75.5^{b}	81.17^{b}	167^{a}	199.6^{b}	1.022	16.67^{a}
Local	77.83^{a}	89.5^{a}	170^{a}	246.6^{a}	0.896	14.78^{bcd}
Gambela comp.	76.83^{a}	80.5^{b}	160.8^{b}	190^{bc}	1.263	13.92^{cd}
Mean	74.54	80.25	161.44	186.0	1.09	14.92
CV (%)	1.4	1.7	3.2	20.6	27.1	9.7
LSD (5%)	1.014	1.26	4.88	36.28	ns	1.36

DTT: Days to tassel, DS: Days to silk, DM: Days to mature, PH: Plant height, E/P: Ear/plant and EL: Ear length, Different letters in a column with Mean values are significant at p<0.05 and LSD: Least significant difference

differences among maize varieties. A similar result, Hussain *et al.*[9] reported a differential pattern of maize varieties for days to tassel. Other researchers also reported genetic variations among different cultivars of maize[10,11].

Days to silking: The analysis of variance revealed that the main effect of variety was significant (p<0.05) on days to silking of maize as described in Table 1. The highest prolonged duration to silking (89.5 days) was observed in the local check while the minimum duration to silking (76.17 days) was recorded at variety Melkassa 07 as cited in Table 2. This might be due to genetic variations among different maize varieties. In line with this result, Abduselam *et al.*[8] reported significant difference days to silking among maize varieties.

Days to maturity: The analysis of variance revealed that the main effect of variety was highly significantly (p<0.05) affect days to maturity. The highest prolonged duration to mature (170 days) was observed in the local check as it was not statistically different from the Gibe 02 variety while the minimum duration to maturity (155.8 days) was recorded at variety Melkassa 07 in Table 2. This variation might be due to differences in experimental location. These results agreed with Kinfe *et al.*[11] also reported different days to maturity for different maize varieties might be depending on environmental conditions.

Plant height: The analysis of variance revealed that the main effect of variety was significantly (p<0.01) affecting plant height of maize while the main effect of location and the two-factor interactions of variety×location did not influence days to maturity. The highest plant height was observed in the variety local (246.6 cm) as while the minimum plant height (151.2 cm) was recorded at variety Melkassa 01 as described in Table 2. This might be due to the reason that genetic variation among maize varieties. Similarly, Kinfe *et al.*[11] reported different plant heights for different maize varieties, Abduselam *et al.*[8] also reported different plant heights for different maize varieties.

Yield and yield component parameters: The analysis of mean squares variance revealed that the main effect of variety was a significant (p<0.05) effect on yield and yield components of maize as described in Table 3. The mean squares of growth parameters (CW, DTM, DTS, DTTH, EL, GY, NEPP, PH, TKW, NRPP, NSPC, PH and TKW) showed a significant difference between varieties as combined in Table 3.

Ear length: The analysis of variance revealed that the main effect of variety significantly (p<0.05) affects the ear length of maize. The longest ear length (16.67cm) was recorded from Gibe 03 whereas the shortest ear (13.83 cm) was obtained from Melkassa 01 as listed in Table 4.

Table 3: Mean squares of ANOVA for yield and yield components of maize at lowland of Guji in the 2017-2018 main cropping season

Source of variations	Mean squares						
	DF	CW	R/C	S/R	S/C	TKW (g)	GY (kg ha^{-1})
Rep	2	0.0007	0.38	27.74	2344	1103	760365
Variety	7	0.003**	3.28^{ns}	32.52*	13504**	10032**	3356367**
Error	62	0.0006	1.56	8.12	1886	1202	714182
CV (%)		19.1	9.7	10.3	11.1	14.3	21.2

df: Degree of freedom, Cw: Cob weight, R/C: Row/cob, S/R: Seed/row, S/C: Seed/cob, TKW: Thousand kernels weight, GY: Grain yield *Significant level at p<0.05, **Significant level at p<0.01, NS: Non-significant and (CW, DTM, DTS, DTTH, EL, GY, NEPP, PH, TKW, NRPP, NSPC, PH and TKW)

Table 4: Combined mean of CW, DTM, DTS, DTTH, EL, GY, NEPP, PH, TKW, NRPP, NSPC, PH and TKW of maize at lowland of Guji in 2017-2018 main cropping season

Varieties	CW	R/C	S/R	S/C	TKW (g)	GY (kg ha^{-1})
Melkassa 02	0.1307^{abc}	14.14	28.81^{ab}	411^{abc}	273.8^{ab}	4262^{ab}
Melkassa 01	0.0915^{d}	13.56	24.19^{c}	329.4^{f}	274.5^{a}	3430^{cd}
Melkassa 03	0.1297^{bc}	13.83	27.92^{ab}	432.9^{ab}	239.5^{c}	4593^{a}
Melkassa 07	0.1516^{ab}	13.54	26.12^{bc}	354.7^{ef}	231^{c}	4663^{a}
Gibe 02	0.1437^{abc}	13.82	29.63^{a}	397^{bcd}	223.1^{c}	4225^{abc}
Gibe 03	0.1541^{a}	13	29.75^{a}	441.8^{a}	277.5^{a}	4102^{abc}
Local	0.1283^{bc}	12.94	26.56^{bc}	366^{def}	241.7^{bc}	2870^{d}
Gambela comp.	0.1271^{c}	14.81	27.94^{ab}	390.3^{cde}	178.8^{d}	3700^{bc}
Mean	0.13	13.71	27.62	390.38	242.7	3980.62
CV (%)	19.1	9.7	10.3	11.1	14.3	21.2
LSD (5%)	0.024	Ns	2.686	40.927	32.67	796.35

Cw: Cob weight, R/C: Row/cob, S/R: Seed/row, S/C: Seed/cob, TKW: Thousand kernels weight, GY: grain yield, different letters in a column with mean values are significant at p<0.05 and LSD: Least significant difference

Cob weight: The analysis of variance revealed that the main effect of variety was significantly (p<0.01) affect cob weight of maize. The highest cob weight was (0.1516 kg) observed in the variety Melkassa 07 which was statistically not different from Gibe 03 while the minimum cob weight (0.92 kg) was recorded at variety Melkassa 01 as can be seen in Table 4. This may be due to genetic and environmental variability among maize varieties.

Number of ears per plant: The analysis of variance revealed that the main effect of variety and location is not significantly (p<0.05) effect on the number of ears per plant of maize as well as the two-factor interactions as described in Table 4. This finding is in line with Kandil *et al.*[12], who reported no significant difference among maize varieties.

Number of rows per cob: The analysis of variance revealed that the main effect of variety as well as interaction, did not significantly (p<0.05) affect the number of rows per cob of maize as described in Table 4.

Number of seeds per cob: The analysis of variance revealed that the main effect of variety was highly significant (p<0.01) on the number of seeds per cob of maize. The highest number of seeds per cob (441.8) was observed in the variety Gibe 03 while the minimum number of seeds per cob (329.4) can be seen in Table 4. This might be due to genetic variability among maize varieties. The result agreed with Inamullah *et al.*[13] reported different seeds per cob for hybrid maize varieties.

Grain yield: The analysis of variance revealed that the effect of variety was significantly (p<0.01) affect grain yield of maize. The highest grain yield (4663 kg ha^{-1}) was obtained in the variety Melkassa 07 which was not statistically different from Melkassa 03 variety while the minimum (2870 kg ha^{-1}) grain yield was recorded at variety local check as listed in Table 4. This might be due to genetic variability among maize varieties. Similar to this result, Kinfe *et al.*[11] reported the effects of variety on the yield of maize. The result was agreed with Taye *et al.*[14] and Abduselam *et al.*[8], who reported evaluating and identified high yielding maize varieties among different varieties tested.

Thousand kernel weight: The analysis of variance revealed that the effect of variety was highly significantly (<0.01) in affecting the thousand kernel weights of maize. The highest thousand kernel weight (277.5 g) was observed in the variety Gibe 03 while the minimum thousand kernel weight (223.1 g) was recorded at variety Gibe 02 as described in Table 4. The differences in the thousand kernels' weight of the maize varieties could be attributed to genetic differences. This result is like Taye *et al.*[14] and Kinfe *et al.*[11], who evaluated and reported different thousand kernels weight of maize varieties among different tested varieties.

Significant differences between varieties were observed for grain yield and yield components. Based on the combined mean performance almost all varieties were shown above mean performance of the local check-in the studied locations. From this experiment, based on the combined mean performance two varieties (Melkassa 07 and 03) were shown above mean performance of the local check in the studied locations. Therefore, these varieties are recommended for demonstration and popularization in the study area and similar agro-ecology of the zone. But the further study should be carried out including several recently released maize varieties for improved maize production and to put the recommendation on a strong.

CONCLUSION

Maize is one of the important cereal crops globally and in Sub-Saharan Africa including Ethiopia. The production and productivity of maize are affected by both abiotic and biotic constraints. Among the biotic factors drought tolerance rank first reducing grain yield and quality. Therefore, a field experiment was conducted at three districts locations namely, Wadera, Adola and Liben on farmer fields during the 2018 and 2019 main cropping season to select the best performing drought-tolerant maize varieties to the target area. Based on the combined mean performance almost all varieties were showed the above mean performance of the local check-in the studied locations (Table 4). Based on this experiment, based on the combined mean performance two varieties (Melkassa 07 and Melkassa 03) were shown above mean performance of the local checks in the studied locations.

SIGNIFICANCE STATEMENT

Maize is the major crop cultivated in the zone. However, there is limited information on the performance and variability of drought-tolerant maize variety. The low yield in this area is mainly attributed to recurrent drought and low adoption of improved varieties. Hence, it is paramount important to introduce improved drought-tolerant maize varieties to the target area for improved maize production and productivity across the areas. Therefore, this experiment was conducted to recommend the most drought-tolerant variety. Two varieties are recommended for demonstration and popularization in the study area and similar agro-ecology of the zone.

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