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Performance Evaluation of Drought Tolerant Hybrid Maize (Zea mays) Varieties in East Hararghe Zone, Ethiopia

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Abstract: Maize is one of a major crop in Ethiopia in production, consumption and income generation for both resource constrained men and women. The experiment was conducted moisture deficit areas of East Hararghe namely Fadis and Erer in 2019/20 and 2020/21 cropping seasons. The study was done with the objectives of to evaluate the performance of hybrid maize varieties for their adaptability, stability, high yielder and to recommend variety/ies for the study areas and similar agro-ecologies. The experiment was conducted with randomly complete block design with four replications. The analysis of variance revealed the significance variation of hybrid maize varieties for the traits evaluated. The variety Damote (182.9 cm) had the tallest in plant height which is not significant different from varieties, MH-140 and MH-138 with a mean value of 172.1, 169.8 cm respectively. MH-140 variety had the highest grain yield (72.78 Qtha-1), while Melkasa-4 had the lowest grain yield (32.45 Qtha-1). Thus, it can be concluded that hybrid maize varieties MH-140 and MH-138 resulted in best results in terms of yield and yielding component across the study areas. Therefore, for sustainable maize production in the study area these varieties had been recommended and need to be demonstrated with available local varieties to users along with their improved production packages.

Keywords: Grain Yield, Hybrid Maize, Variety Evaluation

1. Introduction

Maize (Zea mays L.) is a popular cereal grain that is widely cultivated around the world [1]. It is native to the Americas and has been stable food crop and source of animal feed in Africa, America and Asia [2]. Maize is largely produced in Western, Central, southern and Eastern part of Ethiopia. It is the third most important cereal after wheat, rice globally and the most widely distributed [3]. Maize has a significant role in Southern Africa, where it provides more than 30% of the region's total protein and calories [9]. Although maize is important in SSA, yields are still modest [10].

Ethiopia is one of the largest maize producers in Africa and the crop plays a crucial role in the economy and food security of the nation [4]. It ranks second after tef in area coverage 18.6% (2,367,797.39 ha) and first in total production 30.08% (94,927,708.34 quintals) [5]. Maize is grown in almost all regions of Ethiopia, with major production areas including Oromia, Amhara, SNNPR (Southern Nations, Nationalities, and Peoples' Region), and Tigray.

The consumption of maize in Ethiopia is also significant, with maize being a staple food for a large portion of the population. It is used for various traditional dishes like injera (a type of fermented flatbread), porridge, ‘’Tella’’, Arekie’’and other prepared foods. Additionally, maize is processed into flour for baking, animal feed, and as an ingredient in industrial products [6].

Maize is currently grown across thirteen agro ecological zones, which together cover about 90 percent of the country [5]. The majority of Ethiopia's population, which consists of small-scale farmers, is both a major producer and consumer of maize. From 2.34 million tons in 1998 to 9.5 million tons in 2019, Ethiopia's maize production has increased significantly, expanding at an average yearly rate of 30.08

percent. While maize production in Ethiopia has seen significant growth in recent years, challenges such as climate change, declining of soil fertility, poor agronomic practice, limited use of input, pests, diseases and weeds continue to impact productivity. However, the government and other stakeholders remain committed to increasing maize production and improving the livelihoods of farmers in the country. Ethiopia has seen a major increase in demand for hybrid maize cultivation in recent years. Improved traits of hybrid maize types include increased production potential, disease resistance, and resistance to environmental stresses.

Although maize was produced, it is still primarily confined in a few highland locations of Ethiopia's Oromia region. Several regional and federal research organizations across the country have published some improved hybrid maize types, but farmers are still concerned with a small number of local maize varieties. Therefore, the objective of this study was to identify the adaptability and performance of the hybrid maize varieties for the low moisture stress condition of the study areas.

2. Materials and Methods

The experiment was conducted at Fadis on-station (Boko) and Erer farmers field in 2019 and 2020/21 cropping seasons. The Fadis research station have an altitude of 1700 m. a. s. l and temperature range of 25-30 Co and annual rain fall of 400-800 mm. Three recently released lowland hybrid maize varieties (MH-140, MH-138 and Damote) including two standard check varieties (Melkasa-2 and Melkasa-4) were used and planted at Fadis research station and Qilee on-farm. Randomized Complete Block Design (RCBD) with four replications was applied during the experimentation. A plot size of 4 m x 3 m with plant spacing of 75cm and 25 cm between row and plant respectively was used. The distance between plots and replications were 0.5 m and 1 m apart respectively. Two seeds per hill were sown, which were thinned to one plant per hill after three weeks with the rate of 25 kg ha^{-1}. Fertilizer in the form of UREA and NPS was applied at the rate of 100 and 100 kg ha^{-1}, respectively. NPS was used all once during planting while UREA was applied at knee height (during 8-10 leaf). All other important agronomic practices and management was applied equally to all the entries at their proper time as required.

Data Collection and Analysis

The important data collected from plant and plot base were days to anthesis, days to silking, days to physiological maturity, plant height, grain yield and hundred seed weight. The recorded data were subjected to statistical analysis of variance (ANOVA) using Genstat 18th edition. Significant difference between and among treatment means were assessed using the least significant difference (LSD) at 5% level of probability.

3. Results and Discussion

The analysis of variance (ANOVA) showed significant differences among the genotypes ($P \leq 0.05$) for all the traits measured. However, mean squares for replication were not significant for all the traits measured (Table 1). Analyses of variance (ANOVA) revealed that very highly significant difference ($P<0.001$) on days to 50% anthesis, days to 50% silking and days to physiological maturity (Table 1) and also showed highly significant ($P<0.001$) on number of cobs per plant, plant height, grain yield and hundred seed weight whereas significant variation ($P<0.05$) on cob length (Table 2).

Table 1. *Analysis of variance for growth and Phenological traits of hybrid maize tested Fadis and Erer in 2019/20 and 2020/21.*

Source of Variation	Replication (3/)	Variety (4)	Error (32)	Mean	CV%	LSD (P<0.05)
DTT	20.95	154.642**	6.504	77.85	2.8	2.086
DTS	44.4	84.7**	219.6	93.3	2.6	12.14
DTM	47.6	93.86**	13.68	12.14	15.9	3.03

*-Significant at 5%, ***- Significant at 1%.; DTT= Days to 50 % Tasseling; DTS= Days to 50% silking; DTM= Days to physiological maturity

Table 2. *Mean square of yield and yield related traits for the hybrid maize varieties evaluated during 2019/20 and 2020/21 main cropping season.*

S. V	Replication (3)	Variety (4)	Error (32)	Mean	CV (%)	LSD (5%)
CL (cm)	0.558	3.579*	1.775	18.01	7.4	1.357
CPP	0.09089	0.46856**	0.06851	1.7	15.6	0.27
PH (cm)	347.5	4026**	271.6	162.6	10.1	13.5
Gyld (Kg ha^{-1})	3637693	27459865**	1651301	5581.8	24.4	1052.71
HSW (g)	2.6	58.667**	1.017	33	3.1	6.151

*-Significant at 5%, **- Significant at 1%.; CL= Cob length; CPP= Cob per plant; PH = plant height, Gyld= grain yield (Kg ha^{-1}); HSW = Hundred seed weight.

3.1. Mean Performance of Growth and Phenological Parameters of Maize Varieties

Days to tasseling, silking and Maturity are one of the variety selection criteria, in particular in areas where droughts are the major problems. The analyses of variance for the phenological data were presented in Table 3. The analysis stated highly significant differences ($P\leq 0.001$) for days to 50% tasseling, days to 50% silking, days to physiological maturity ($P< 0.001$). The overall average days to 50% tasselng was 77.86 days with a range of 73.33 days for the standard check (Melkasa-4) to 83.08 days for the variety Damote and days to 50% silking ranged from 90.08 days (Melkasa-4) to 97.33 days (Damote) with the mean values of 93.33 days (Table 3). The earliest variety in days to

physiological maturity was recorded from standard check Melkasa-4 (134.3 days) followed by Melkasa-2 (136.9 days) and MH138 (138.2 days) in which no significance difference was observed whereas the latest days to physiological maturity was recorded by variety Damote followed by MH-140 with the mean values of 141.7 days and 139.8 days respectively. The varieties have different genetic background, which might be the reason for the variation in tasseling, silking and maturity duration among the tested varieties. These results are in line with the findings of [7, 8].

Table 3. *Mean values of growth and phonological parameters of hybrid maize varieties tested at Qilee on farm and Fadis research station in 2019/20 and 2020/21 cropping season.*

Variety	DTT	DTS	DTM
Damote	83.08d	97.33c	141.7d
Melkasa-2	76.08b	92.25b	136.9b
Melkasa-4	73.33a	90.08a	134.3a
MH-138	78.58c	92.92b	138.2bc
MH-140	78.17c	93.92b	139.8cd
Mean	77.85	93.3	138.2
CV (%)	2.8	2.6	2.1
LSD (P< 0.05)	2.343	2.016	2.416

DTT= Days to 50% Tasseling, DTS= Days to 50% Silking, DTM= Days to physiological maturity. Means with the same letter within the same column are not significantly different.

3.2. Mean Performance of Yield and Yield Related Parameters of Hybrid Maize Varieties

The overall mean plant height (PH) recorded was 162.6 cm. Greater variation in plant height ranging from 151.4 to 182.9 cm was observed (Table 4). The maximum height was measured in variety Damote which was the tallest (182.9 cm) among the five maize varieties and produced more than 31.5 cm long and remained significantly taller than all the hybrid maize varieties tested. The tallest in plant height was recorded by variety Damote with height of 182.9 cm followed by MH-138 and MH-140 with a mean height of 172.1 cm and 169.8 cm respectively. The standard checks; Melkasa-2 and Melkasa-4 varieties had recorded the lowest mean plant height 151.4 cm and 136.9 cm, respectively (Table 4). The genetic variation of the varieties and their interactions with the environment may be the cause of the variation in plant height among the variations. According to Hussain *et al.* [8], the genotype of maize cultivars differed significantly in terms of plant height. Revilla *et al.* [11] also noted that interactions between genotype and environment resulted in various maize variety patterns for plant height.

The mean grain yield value of the tested maize varieties ranged from 3245 $Kgha^{-1}$ to 7278 $Kgha^{-1}$. The highest grain yield was obtained from hybrid maize varieties MH-140 with a value of 7278 $Kgha^{-1}$. In addition, two hybrid maize varieties (MH138 and Damote) gave high yields (Table 2). However, the lowest grain yield was obtained from OPV maize varieties (standard checks) Melkasa-2 and Melkasa-4 with a mean values of 5125 gha^{-1} and 3245 $Kgha^{-1}$, respectively. The genetic diversity of these types and how they react to the agro ecology of the experimental location may be the cause of the difference in grain yield. According to Daniel [12], considerable variations in grain production between several genotypes were found. The results were consistent with a study by Demelash and Yasin [13], which revealed considerable variations in grain yield between genotypes. The CSA [14] report that maize varieties have a potential of 9000–12000 kg ha1 in the research field and 6000–8000 kg ha1 in the farmer's field concurs with this conclusion. Souza et al. [15] also reported a similar outcome after evaluating and identifying high-yielding maize varieties among the many genotypes examined. The yield of grains varied significantly between maize varieties, according to [16].

Table 4. *Mean values of yield and yield related parameters of hybrid maize varieties tested at Qilee on farm and Fadis research station in 2019/20 and 2020/21 cropping season.*

Variety	CL-cm	CPP	PH-cm	Gyld-kg ha^{-1}	HSW-g
Damote	18.29 ab	1.515 bc	182.9a	6086b	36.75ab
Melkasa-2	17.59 b	1.75 ab	151.4b	5125b	33ab
Melkasa-4	18.05 ab	1.354 c	136.9c	3245c	33ab
MH-138	17.2 b	1.844 a	172.1a	6174ab	30.75b
MH-140	18.95 b	1.942 a	169.8a	7278a	38a
Mean	18.01	1.7	162.6	5581.8	34.3
CV (%)	7.4	15.6	10	24.4	11.6
LSD (P< 0.05)	1.357	0.27	13.4	1119.55	6.151

CL=Cob length, CPP= Cob per plant, PH = plant height, Gyld = grain yield, HSW = Hundred seed weight. Means with the same letter within the same column are not significantly different.

4. Conclusion and Recommendation

Based on the final data on hybrid maize evaluation in East Hararghe, it can be concluded that hybrid maize varieties have had a significant positive impact to increase agricultural production and productivity in the areas where there is low practice of using improved technologies such as improved crop varieties. According to the result of analysis of variance, all of the agronomic traits evaluated were revealed significant statistical variation. Hybrid maize varieties MH-140 and MH-138 gave the highest grain yield of all the tested varieties respectively, while standard checks Melkasa-4 and $Melkasa^{-2}$ varieties showed the smallest grain yield respectively. Thus, it can be concluded that hybrid maize varieties MH-140 and MH-138 resulted in best results in terms of yield and yielding component across the study area. Therefore, for sustainable maize production in the study area

these varieties had been recommended and need to be demonstrated tousers along with their improved production packages. Moreover, farmer training programs should be implemented to educate farmers on proper management practices for hybrid maize cultivation. This includes guidance on fertilization, irrigation, pest and disease control, and post-harvest handling, which can help farmers maximize their yields and ensure the quality of maize grains. In conclusion, the adoption of hybrid maize varieties in Eastern Hararghe has proven to be beneficial. By addressing the challenges mentioned and implementing the recommended measures, hybrid maize production can be further promoted, leading to increased food production, improved farmer incomes, and overall agricultural development in the country.

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