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Study on Adaptability and Stability of Drought Tolerant Maize Varieties in Drought Prone Areas of South Omo Zone, SNNPRS

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ABSTRACT

Six improved drought tolerant maize varieties were tested at three drought prone woredas of South Zone. Randomized complete block design with three replications was used. Seeds were sown on a plot size of 4.5 m x 6 m (27 m2) in rows of six per plot at a spacing of 75 cm between rows and 25 cm between plants. Drought tolerant varieties of two types namely hybrids (MH-130 & MHQ-138) and open pollinated varieties (Melkassa-4, Melkass-6Q, Melkass-7 and Melkass-2) was used. ANOVA revealed significant differences ($p<0.05$ and 0.01) between varieties for grain yield at all three locations and two characters studied (plant height & ear length) and non significant between varieties for ear height and tassel length. Significant differences between varieties were observed for grain yield at all three testing locations. Dasnch gave highest yield followed by Shanko while Alduba gave lowest yield. Three varieties (MH-130, MHQ-138, and Melkassa-4) were showed above mean performance in the studied locations. Only variety MH-130(45.89q/ha) out yielded the standard check and it showed stable performance in the studied areas. The GGE biplot distinguish the locations in two, alduba and Shanko in one mega environment while lobet alone. Separate recommendation should be mandatory. So variety MH-130 was more adapted to alduba and shanko and was more productive, it would be highly recommended under rain fed conditions at alduba and Shanko as well as similar growing vicinity. Until another studies carried out pastorals around lobet and similar areas those produce maize through irrigation, it is advisable them to use variety Melkassa-2.

Keywords: Drought tolerant, Adaptation, Hybrid maize variety, Hamer, Dasnch

INTRODUCTION

Maize (*Zea mays* L) 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 was the main factor for instability and low production in low-moisture stress areas of the country (Worku,M.,..etal, 2012).

Maize is one of the most important cereal crops in Southern region in general and South Omo Zone in particular. In south Omo zone maize rank 1st in area coverage (19896.48hectar) and total production (485780.71 quintal). Its productivity (24.42quintal/hectare) very low when compare potential maize areas (33.qt/ha) (CSA, 2013).The low yield in this area, is mainly attributed to recurrent drought, low levels of fertilizer use, and low adoption of improved varieties.

Hot to warm semi-arid lowlands (SA1&SA2) of south omo zone which is almost habited agro pastoral community, any one of the open pollinated varieties from Melkassa Agricultural Research Center, except Melkasa1, can be used for production based on rainfall conditions in the study area. Currently settlement of pastoral community is on and Irrigation scheme constriction is and use is ongoing. Hence; it is paramount important to introduce improved drought tolerant maize varieties to the target area for improved maize production and productivity. Therefore, this study is aimed at and initiated with the objective of selecting the best performing drought tolerant maize varieties to the target area.

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MATERIALS AND METHODS

Description of Study Area

The experiment was conducted at three selected woredas of South Omo namely; BenaTesmay, Hamer and Dasnch woreda during 2013 & 2014 cropping seasons. These locations are found within altitudinal ranges of 369 to 1343 m.a.s.l. Geographically, Alduba is found at E 036^{0}02.720 Longitude and N 050 25' 00" Latitude and at an altitude of 1343 meters above sea level, whereas Dasnch/Lobet/ is found at E 360 36' 30.8" Longitude and N 04^{0}47.22' Latitude and at an altitude of 369 meters above sea level.

Table1. *Description of the experimental locations and their overall agro-climatic conditions*

Location	Altitude(m)	Mean annual rainfall(mm)	Mean annul temperature(^{0}c)	Position/Coordinate
BenTesmay/Alduba/	1343	**NA**	**NA**	050 25' 00"N, 360 36'0.8"E
Hamer/Shanko/	NA	NA	**NA**	NA
Dasnch/Lobet/	369	350	35	04^{0}47.22'N,036^{0}02.720E

NA= data not available, Source: Woreda office Agriculture & direct GPS reading

Experimental Design, Treatments and Trial Management

A randomized complete block design with three replications was used. Maize varieties were sown on a plot size of 4.5 m x 6 m (27 m2) in rows of six per plot at a spacing of 75 cm wide and plant spacing of 25 cm. Recently released drought tolerant hybrid varieties (MH-130 & MHQ-138) and open pollinated varieties (Melkassa-4, Melkass-6Q, Melkass-7 and Melkass-2) were tasted. Melkassa-2 was used as standard check. All agronomic practices recommended for maize production were applied equally for each plot.

At Dasnch the trial was conducted with furrow irrigation. Open ridge was made manually and irrigated before to retain moisture that imbibes seeds after planting. After three days of first irrigation varieties were sown and after four days later the plots were irrigated. Up to knee height stage of growth irrigation was applied in seven day interval. At flowering stage irrigation was waited for 10 days/induced drought/ to see the response of varieties for drought. Leaf rolling and leaf senescence data was recorded.

Data Collection and Analysis

Plot base and individual plant base data were collected as follow:- Plot base data such as disease and insect pest score/1-9sale/, stand count at harvest to adjust yield, and grain yield (dry weight of grain harvested from central row after drying at 12% moisture content /using moisture tester/). Individual plant base data, such as ears per plant, Anthesis-Silking interval (ASI), leaf senescence, Leaf rolling, Ear height(cm), Plant height(cm), Ear length(cm), Tassel length(cm), and farmers assessment were collected and recorded respectively.

All the data were collected when the crop reached to physiological maturity. These data were subjected to analysis of variance using the GLM procedure of SAS software version 9.2 (SAS, 2008). Effects were considered significant in all statistical calculations if the P-values were < 0.05. The data were combined over location after carrying out Analysis Of Variance (ANOVA) for each location separately, and homogeneity tested (the ratio of larger mean square to smaller mean squares) as suggested by Gomez and Gomez (1984). Means were separated using Duncan's multiple range (Duncan) test.

Genotype and Genotype by Environment Interaction biplot analysis (GGE): Genotype and Genotype by Environment Interaction biplot analysis was conducted using GenStat Release 15.1 computer software.

RESULT AND DISCUSSION

The analysis of variance for grain yield is given in Table 2. Analysis of variance showed significant differences for grain yield among the varieties. The significance of varieties difference indicates the presence of variability for grain yield among the tested entries. This result is in agreement with the previous findings reported by Tekle Yoseph, etail, 2014. On the other hand, it was reported that there was no significant difference observed among the maize genotypes for grain yield (Olakojo and Iken (2001).

Table2. *The mean squares for different sources of variation and the corresponding CV (%) for grain yield studied at Alduba, Shanko kelma and Lobet site, in 2013-14*

Trait/characteristics	Varieties (5)	Replication (2)	Error (18)	CV (%)	Mean	R^2
GY(alduba)	37.68**	3.79NS	4.35	6.31	33.08	0.81
GY(Hamer)	135.80*	63.47Ns	41.19	15.72	40.81	0.64
GY(Dasnch)	64.94*	10.82Ns	21.84	10.61	44.02	0.61

**, NS significant and non-significant at probability level of 0.05, GY= grain yield (qt/ha)*

The mean grain yield (qt/ha) ranged from 30.75 at alduba for melkassa-7 to 49.66 at lobet for melkassa-2. Lobet site gave highest grain yield (44.36 kg/ha) followed Shanko site (41.20 kg/ha) but alduba site gave lowest yield (34.27kg/ha). Since at Dasnch the trial was conducted with irrigation, may resulted with high mean performance. Based on mean grain yield variety MH-130 gave highest yield at Alduba and Shanko while the standard check (Melkassa-2) gave highest yield at lobet Kebele (Table 3), where as MHQ-138 gave high yield at Alduba and Lobet and Melkass-4 gave high yield at Shanko. The lowest yield 34.86qt/ha across sites, was noted for variety Melkassa-7. Similar resulted was obtained by Hussain *et al. (2011),* who reported significant differences among maize cultivars for grain yield. The standard checkv(melkassa-2) gave highest yield(50qt/ha) at alduba during 2010(Tekle Yoseph, etail, 2014), but it gave low yield(32.22qt/ha-)at alduba in 2013; this may due fluctuation of rainfall in precipitation; in quantity and distribution within and across seasons in the study area. Because at lobet with supplementary irrigation it gave high grain (49.66qt/ha) even the environment was quiet different (Table 1.).

Table3. *Mean grain yield (qt/ha) of verities over locations during 2013-14*

No.	Varieties	Alduba(BenTesmay)	Shanko(Hamer)	Lobet(Dasnch)	Variety Mean
1	Melkassa-2	32.22b	**39.88b**	**49.66a**	**40.58b**
2	Melkassa-4	33.71**b**	44.12ab	41.31bc	**39.71bc**
3	Melkassa-6Q	31.23b	42.40b	43.87abc	39.17bc
4	Melkassa-7	30.75b	37.41bc	36.42c	34.86
5	MH130	**41.30a**	**48.50a**	**47.87ab**	**45.89a**
6	MHQ138	**36.44ab**	37.33bc	**47.03ab**	**39.95bc**
Site mean		34.27	41.86	44.36	39.94
CV (%)		10.75	17.26	10.26	13.06
Critical Range		(6.70, 7.37)	(13.89, 15.21)	(8.28, 9.11)	(5.02, 5.65)

a=highest, b=medium, c=poor, d=poorest, e=bad mean grain yield, varieties having same letters are same in mean performance.

Pastorals and extension agents visited the trial at physiological maturity. The selection criteria of the pastoral were stay greenness, earliness, tip bareness/ear closeness/, ear size, stalk thickness, stand Vigoursity and low susceptibility of variety to termite. Accordingly, pastorals at alduba during field day selected the four best varieties, MH-130, MH-138Q and Melkassa-2 which were ranked 1st and 2nd, 3rd respectively. At Hamer the best three selected varieties were MH-130, Melkassa-4 and Melkassa-6Q which were ranked 1st, 2nd and 3rd respectively. The GGE biplot also confirm the pastoral selection variety MH-130 as shown on figure1 below.

COMBINED ANALYSIS OF VARIANCE

The Combined analysis of variance showed that the effect of locations and genotypes for grain was significant ($p \leq 0.01$) (Table 4).The significant effect of locations is due to their variation in rainfall amount and seasonal distribution, temperature and soil type (Table 1). Therefore locations played a significant role in influencing the expression of these traits, especially grain yield, plant height and ear length. The genotype by environment was not significant, indicates that genotypes were not significantly interacted with location i.e. possibility of selecting stable and adapted variety based on high mean performance across locations.

Table4. *Combined analysis of variance for yield and other traits for 4 varieties of tested at three locations.*

Source of variation	DF	GY	PH	EH	EL	TL
Env (E)	3	479.22**	2573.87*	7.56^NS^	558.53*	5.60^NS^
Genotype(G)	2	112.55**	338.41^NS^	96.98^NS^	8.47^NS^	11.44^NS^
G*E	5	39.62^NS^	698.48^NS^	206.02^NS^	21.52^Ns^	25.32^NS^
Rep (E)	10	23.31^NS^	443.81^NS^	335.23^NS^	16.55^NS^	40.19^NS^
Error	12	27.25	386.54	124.23	7.94	14.60
Mean	30	39.94	139.16	70.47	22.80	35.63
CV (%)		13.09	14.12	15.81	12.35	10.72
R-square		0.71	0.55	0.53	0.82	0.54

**, NS significant and non-significant at probability level of 0.05 respectively, GY= grain yield (qt/ha), DF=degree of freedom, PH=plant height, EH=Ear height, EL=ear length, TL= tassel length*

The polygon view of the GGE biplot (Figure 1) indicates the best genotype(s) in each environment and groups of environments (Hunt, 2002). The locations within one sector are the ones where the certain genotype had the best yield and can be considered as mega-environments for that genotype. In this study locations can be distinguished in to two mega environments, i.e., locations Alduba(1) and Shank(2) become one mega environment while Lobe(3) alone different from the two location. This is may due that two locations were under rain fed condition while lobet was under irrigation. So separate recommendations should be mandatory. Except variety MH-138Q,MH-130 and Melkassa-2 , the rest of varieties were below mean performance. The variety MH-130(5) was more productive because it has long PC1 and it was more adapted to location alduba (1)and Shank(2), therefore , it is recommendable in the two locations. Melkassa-2(1) was the highest yielding variety at lobet it recommendable this location.

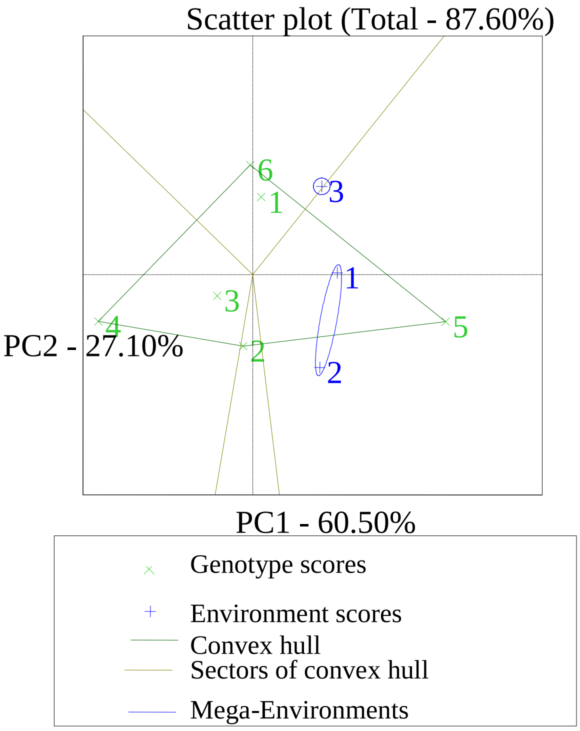

Figure1. *GGE biplot of 6 maize varieties for grain yield across three locations*

SUMMERY AND CONCLUSION

Maize is one of the most important field crops in terms of area coverage, production, and economic importance in Ethiopia. It grows from sea level to over 2,600 masl, from moisture deficit semi-arid lowlands, mid-altitude and highlands to moisture surplus areas in the humid lowlands, mid-altitudes and highlands. Maize improvement in Ethiopia started half a century ago. During the late1960s and early 1970s, several promising hybrids and composite varieties of East African origin were introduced and evaluated at different locations. These resulted in the recommendation of several maize varieties for the maize growing regions of the country.

To advance improvement of crop productivity in different localities, continual identification of the best and suitable crop technologies appeared to be essential. This can be achieved, through adaptability tests and generation of new technologies. Accordingly, this study was initiated to identify and select best adapted relatively high yielding maize varieties for drought prone areas of South Omo especially agro-pastoral areas of the zone.

Six released low land maize varieties were tasted at three sites in randomized complete block design with three replications during 2013-14 cropping season. Drought tolerant hybrid varieties (MH-130 & MHQ-138) and open pollinated varieties (Melkassa-4, Melkass-6Q and Melkass-7) were sown on a plot size of 4.5 m x 6 m (27 m2) in rows of six per plot at a spacing of 75 cm between rows and 25 cm between plants.

Significant differences between varieties were observed for grain yield at all three testing sites. From the three testing site, lobet gave highest yield followed by shanko while alduba gave lowest yield. Three varieties (MH-130, MHQ-138, and Melkassa-4) were showed above mean performance in the studied locations. Only variety MH-130(45.89q/ha) out yielded the standard check. Variety MH-130 would be highly recommended alduba and shanko and similar growing vicinity, while at lobet non new varieties performed better than Melkassa-2, it should be used by pastoral.

Variety MH-130 showed high yield performance in the study areas, as seen above on the Figure(1), the locations are categorized in two, it is recommendable under rain fed conditions even though further study should be carried out including a number of recently released maize varieties for improved maize production and also to put the recommendation on a strong basis.

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