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Association of Traits and Adaptability of Hybrid Maize (*Zea mays* L.) Varieties in Western Part of Ethiopia

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ABSTRACT

In Ethiopia, maize is one of the most important and major strategic food crop among cereal. Hybrid maize varieties plays important role as the average yield of the country increased through time. The objectives of the study are to determine the correlation between grain yield and other agronomic parameters and to identify high yielding adapted hybrid maize varieties. Nineteen released hybrid maize varieties were evaluated at Kamash and Assosa area of western Ethiopia during the 2016 main season. Quantitative traits including phenology, disease, yield and yield component traits were evaluated using randomized complete block design with three replications. Analysis of variance revealed highly significant difference (p≤ 0.01) among genotypes for most of tested traits for both locations. These indicated presence of sufficient amount of variability among genotypes for the tested traits. Hybrid maize varieties Limu, Shone and BH546 showed the highest grain yield and significantly different from the standard check BH543 at Kamash location. At Assosa maize hybrids Viz. Abarya, Shone, BH546 and BH547 revealed highest yield performance. Therefore, demonstration and popularization of these varieties could boost maize yield in the area. Positive significant correlation of grain yield were observed with days to maturity and fresh ear weight at Kamash location and with plant height, ear height and fresh ear weight at Assosa location. Negative significant correlation of yield with gray leaf spot and Turcicum leaf blight disease were observed under both locations. Selection for higher fresh ear weight, late maturity, longer plant and ear height simultaneously could result yield improvement in maize.

INTRODUCTION

Maize (*Zea mays* L.) is the most widely grown cereal in the world, and the third most important cereal crop after wheat and rice. It serves as a primary staple food in most developing countries and provides ~60% of all human calories alongside with rice and wheat (Cassman et al., 2003; Khalil et al., 2011). In Africa maize is staple food and source of income for small holder farmers and the need will be doubled in 2050 worldwide especially in developing countries including Ethiopia (FAO, 2017). Therefore, to feed the ever increasing human population especially in developing countries more maize grain production is demanded.

In Ethiopia, maize is one of the most important and major strategic food crop among cereal, ranking second after teff in area coverage and first in production and productivity with national average yield of 3.73 t/ha (CSA, 2017; FAO 2017). Ethiopia has wide agro ecologies suitable for maize production from which Benshangul Gumuz region is one of the highest potential maize production area (Gemechu *et al*., 2016). In Benshangul Gumuz region maize is the second most cultivated crops and the first in production with average yield of about 3.84 t/ha (CSA, 2017). Even though, the region have the highest potential maize growing environment average yield is far from the world average 5.75 t/ha (FAO, 2017). And it needs to be increased by using appropriate maize variety for the area. From the day maize research started in Ethiopia in 1950 several OPVs and hybrid maize varieties have been released. However, after 1995, as commercial maize production shifts to hybrid seeds, the average yield increased significantly and creates more job opportunity to the people (Worku et al., 2012).

Yield is complex trait governed by many genes and influenced directly as well as indirectly by its various components. Hence, it's important to quantify the observed and true association through simple phenotypic and genotypic correlation coefficients. For all crop breeders understanding the association between yield and other contributing phenotypic trait is important for joint selection of two or more traits for yield improvement (Sonnad 2005; Wolie and Dessalegn 2011). Generally, yield improvement through selection of two or more traits simultaneously and identifying the most adapted and high yielder hybrid maize varieties for commercial utilization could help to boost maize productivity in the study area. Hence, the objectives of the study were to determine the correlation between grain yield and other agronomic parameters and to identify high yielding adapted hybrid maize varieties

MATERIALS AND METHODS

Experimental Material, Design and Management

The experiment was conducted on two locations Assosa (10°2ˈ24.2"N, 34°34ˈ19.2" E, 1553 m altitude) and Kamash ($09^0$31'21.0"N, 35^0 53'09.4E", 1217 m altitude) in Benshangul Gumuz region of western Ethiopia in 2016 main cropping season. Nineteen released hybrid maize varieties were evaluated using randomized complete block design in three replications. Hybrid maize varieties MH130, MH138, AMH760Q, Gibat, Wenchi, BH140, BH540, BHQP542, BHQPY545, BH546, BH547, BH660, BH661, BH670 and BH543 (standard check) are released by Ethiopian institute of Agricultural Research (Bako National Maize, Melkasa and Ambo Agricultural research centers) Whereas, Limu and Shone released by Pioneer Hi-Bred Seeds Ethiopia, and the rest Abarya and SCDUA43 released by Seed co company. Each genotype was planted by using a plot size of two rows with a 5.1m length and 0.75m x 0.15m inter and intra row spacing, respectively. Two border rows were used in each direction to reduce the border effect. Each variety was planted two seeds per hill and recommended planting density were achieved through thinning after two weeks of emergence. The experimental field preparation, seed rate and other agronomic activities were done following recommended agronomic practice for the area. Inorganic fertilizer UREA (180 kg/ha) and DAP (100 kg/ha) were used as a source of N and P as per the recommended rate and time for the area.

Data Collection and Analysis

Data were collected on plant and plot basis for ten quantitative traits. Plant height (cm), ear height (cm) and number of ears per plant were taken from five randomly selected plants. Whereas the rest on plot basis. Phonological data like days to anthesis (DA), days to silking (DS) and days to maturity (DM) were collected as the number of days from sowing to 50% of the plot reaches. Disease data like gray leaf spot (GLS) and Turcicum leaf blight (TLB) were collected on 1-5 scale as described by Badu-Apraku et al. (2012). Ear weight was recorded from total plot and converted to kilogram per hectare. Grain yield was calculated using formula adopted by MacRobert et al. (2014).

$$\text{Grain yield (kg/ha)} = \frac{\text{Fresh ear weight} * (100 - \text{MC}) * 0.8 * 10{,}000}{(100 - 12.5) * 7.65}$$

Where, MC = harvest time moisture content in grains (%), 0.8 = standard shelling co-efficient, 12.5 = standard moisture content, and 7.65 = area harvested (m^2)

Data were subjected to analysis of variance (ANOVA) procedure using a general linear model (GLM). Phenotypic and genotypic correlation analysis between grain yield and other traits was done using the formula adopted by Singh and Chaudhary (1985). The correlation value was tested for their significance using t-

test as described by Sharma, (1998). Data analysis was carried out using SAS software version 9.2 (SAS, 2009).

RESULTS AND DISCUSSION

F-test indicates the homogeneity of error variance violates the assumption of ANOVA for all tested traits, therefore analysis were done separately for each locations. Analysis of variance revealed highly significant difference ($p \leq 0.01$) among genotypes for most of tested traits at both Kamash and Assosa locations (Table 1 and 2, respectively). These indicated presence of sufficient amount of variability among genotypes for the tested traits. The days to maturity ranged from 111-152 and 140-169 days after sowing with mean value of 140 and 159 for Kamash and Assosa location, respectively. Genotypes showed relatively shorter phenology at kamash and it may be due to its lower altitude. Similarly, Xue-jun et al. (2013) reported the positive association of altitude with growing period on maize. Phenological traits showed highly significant difference among genotypes in which MH130 and BH670 showed the shortest and the longest days to maturity, respectively at kamash. Whereas, BH661 and BH670 recorded the longest days to maturity while SCDUA43 found to be early maturing in Assosa condition. The mean value for plant and ear height were 262 cm and 139 cm for Kamash whereas 256 cm and 146 cm for Assosa, respectively. Under both locations, varieties MH130 and BH661 recorded the lowest and the highest plant and ear height, respectively. The highest fresh ear weight were recorded from Limu, Shone and BH546 varieties while the lowest value were from MH138, MH130, BHQPY545 and Jibat varieties at Kamash location. At Assosa Shone, BH546, Abarya and BH547 recorded highest fresh ear weight while MH130 was the least. Similarly, several authors observed significant genotypic difference in maize for phonological and agronomic traits (Yusuf, 2010; Reddy et al., 2012; Musvosvi and Wali 2017; Debela et al., 2017).

Several biotic and abiotic stresses resulted in considerable yield loss in maize. Among these turcicum leaf blight and gray leaf spot are the most economically important maize diseases in western Ethiopia (Wende et al., 2013). Accordingly, hybrid maize varieties evaluated for both disease reactions and showed highly significant difference among genotypes. Resistance and susceptible phenotype for gray leaf spot disease reaction observed from BH546 and MH130 at Kamash, and from Limu and SCDUA43 at Assosa, respectively. At kamash condition, low disease severity was observed from AMH760Q for tircicum leaf blight. Comparable result was reported by Debela et al. (2017).

Highly significant differences ($p \leq 0.01$) were observed in grain yield under both locations with the mean values of 7856 kg/ha and 6831 kg/ha at Kamash and Assosa, respectively. This result is in conformity with the findings of Reddy et al. (2012) and Kinfe et al. (2015) in maize. Hybrid maize varieties Limu, Shone and BH546 showed the highest grain yield and significantly different from the standard check BH543 at Kamash location. At Assosa maize hybrids showed non-significant yield difference from the check. Although, best agronomic performance and greater than 13% yield advantage over the check were recorded from varieties Abarya, Shone, BH546 and BH547. Therefore, demonstration and creating awareness about these high yielding and adaptable maize varieties to maize growers could boost maize production in the area. Least grain yield and other agronomic performance were observed from MH130, BHQPY545 and Jibat varieties under both locations while MH138 at Kamash. Hence, cultivating these released hybrid maize varieties were not recommended for the study area.

The relationship between yield and agronomic traits is important to the plant breeders to find out the traits correlated with yield and also how they are associated among themselves. The results of genotypic and phenotypic correlation for the tested traits were presented in Table 3 and 4 for Kamash and Assosa locations, respectively. At Kamash field condition, correlation analysis revealed highly significant ($p \leq 0.01$) positive genotypic and phenotypic correlation of grain yield with fresh ear weight. Grain yield showed highly significant ($p \leq 0.01$) genotypic and phenotypic negative correlation with gray leaf spot. Also grain yield showed significant ($p \leq 0.05$) positive correlation with days to maturity and negative correlation with Turcicum leaf blight at phenotypic level. This implies that selection high values for the positively correlated traits could result simultaneous improvement of yield and vice versa. Fresh ear weight showed significant negative correlation with gray leaf spot and Turcicum leaf blight at phenotypic level while with gray leaf spot at genotypic level. Days to maturity showed highly significant ($p \leq 0.01$) genotypic and phenotypic correlation with days to anthesis, days to silking, plant height and ear height. Similarly, correlations among phonological traits were reported by Reddy et al. (2012) in maize.

At Assosa field condition, grain yield showed significant positive genotypic correlation with plant height and fresh ear weight. Phenotypic correlation of grain yield were significant and positive for plant height, ear height and fresh ear weight while significant and negative with grey leaf spot and Turcicum leaf blight disease reaction. The strong correlation between fresh ear weight, ear height and plant height with grain yield suggested that improvement of grain yield in maize hybrids through indirect selection of these traits could be possible. Similar results were reported by Reddy et al. (2012) and Ndebeh et al. (2017) for correlation of grain yield with plant height and ear height. Significant genotypic correlations of fresh ear weight were positive for days to maturity and plant height and negative for gray leaf spot. Fresh ear weight revealed significant phenotypic correlations with days to maturity, plant height and ear height positively. Significant negative genotypic correlation was observed between ears per plant and plant height. Days to maturity showed significant positive genotypic and phenotypic correlation

with days to anthesis, days to silking, plant height and ear height. Similarly, significant positive correlation were reported for fresh ear weight and yield, days to anthesis with days to silking and days to maturity, ear height with plant height and days to silking (Patil et al., 2016; Reddy et al., 2012; Sadaiah et al., 2013).

Table 1. Analysis of variance and mean performance of hybrid maize varieties for yield and other traits at Kamash.

No	Variety	DA	DS	DM	PH	EH	GLS	Blight	EPP	EW	GYLD
1	Shone	71.7	75.0	147.0	278.3	124.7	2.0	2.0	1.1	14598.4	10338.7
2	BH140	72.7	78.0	145.0	252.7	140.3	2.3	3.0	1.0	10711.6	7758.7
3	BH540	69.7	73.3	144.3	262.3	130.7	3.3	2.7	1.1	10070.1	7442.2
4	BH543	67.7	78.3	147.3	270.7	151.3	2.3	2.0	0.9	10263.6	7395.1
5	BH546	71.7	76.7	145.7	257.3	140.7	1.7	2.3	0.9	12803.7	9108.5
6	BH547	73.0	77.7	147.3	248.3	142.0	2.0	2.7	0.9	12195.2	8872.8
7	BH660	73.7	82.0	151.3	301.3	186.0	3.3	2.3	1.0	11119.7	7973.5
8	BH661	73.0	83.7	148.7	314.0	186.0	2.0	2.3	1.0	10750.5	7683.7
9	BH670	75.0	81.7	152.0	304.3	180.3	2.7	2.3	0.9	10225.7	7386.2
10	BHQP542	71.7	74.0	144.0	268.3	122.3	2.0	2.7	1.3	11349.0	8465.7
11	BHQPY545	74.0	77.3	143.7	251.3	123.3	3.0	3.3	1.3	8602.8	6201.3
12	MH130	60.3	66.3	110.7	213.7	95.0	4.0	3.3	0.9	8035.1	6050.5
13	MH138	72.0	73.7	114.0	245.7	109.7	2.3	2.3	0.9	7969.2	5903.7
14	Limu	71.7	75.0	146.7	267.0	124.3	2.0	2.0	1.2	14647.3	10751.0
15	SC DUA43	64.7	69.3	113.7	250.3	105.0	3.0	2.3	1.1	11463.7	8573.3
16	Abarya	69.0	73.0	146.0	253.7	130.3	3.0	2.7	1.0	10261.7	7798.7
17	AMH760Q	72.3	77.0	150.0	247.0	156.0	3.0	1.7	1.0	10182.6	7260.2
18	Gibat	68.0	71.7	145.0	266.0	130.0	3.7	2.3	1.0	8971.8	6699.7
19	Wenchi	68.3	74.3	115.0	230.3	108.7	3.3	3.3	1.1	10655.7	7595.0
	Mean	70.5	75.7	139.9	262.2	136.1	2.7	2.5	1.0	10783.0	7855.7
	CV	2.1	3.2	2.7	3.6	7.0	21.1	20.5	15.6	12.4	11.9
	LSD (0.05)	2.4	4.0	6.2	15.8	15.8	0.9	0.9	0.3	2219.1	1553.9
	F-test	**	**	**	**	**	**	**	*	**	**

Key: DA: Days to anthesis, DS: Days to silking, DM: Days to maturity, PH: Plant height (cm), EH: Ear height (cm), GLS: Gray leaf spot, TLB: Tircicum leaf blight, EPP: Ears per plant, EW: Fresh ear weight (kg/ha), GYLD: Grain Yield (KG/ha), CV: Coefficient of Variation, LSD: Least Significant Difference.

Table 2. Analysis of variance and mean performance of hybrid maize varieties for yield and other traits at Assosa.

No	Variety	DA	DS	DM	PH	EH	GLS	TLB	EPP	EW	GYLD
1	Shone	79.3	83.3	160.0	266.0	140.7	2.0	2.0	1.0	12132.6	8354.7
2	BH140	84.7	88.7	162.0	249.3	143.3	2.3	3.0	1.1	8074.9	5713.8
3	BH540	85.0	86.7	161.7	236.0	128.3	2.7	2.3	1.0	8170.6	5764.4
4	BH543	80.7	83.3	161.0	264.3	158.3	2.0	3.0	1.1	10270.8	7134.6
5	BH546	82.7	86.0	163.3	257.7	142.0	2.0	2.3	1.1	12014.9	8072.5
6	BH547	83.7	86.3	161.7	242.0	145.3	2.0	2.7	1.0	11424.3	8062.2
7	BH660	86.3	87.3	167.3	307.3	201.0	2.3	2.3	1.1	10347.9	7161.7
8	BH661	87.3	90.0	169.0	274.7	163.0	2.0	2.3	1.1	10153.6	6791.4
9	BH670	86.3	88.7	169.0	293.3	186.0	2.0	2.0	1.1	11004.2	7597.8
10	BHQP542	82.3	84.7	155.3	268.0	144.0	2.0	3.7	1.2	9042.1	6534.3
11	BHQPY545	84.7	87.7	159.7	222.3	118.7	2.0	2.0	1.8	8225.0	5679.3
12	MH130	71.3	73.3	148.3	213.3	103.7	2.7	3.7	1.3	7680.4	5691.6
13	MH138	77.7	80.0	149.3	233.7	113.7	2.3	3.3	1.4	8879.6	6504.6
14	Limu	82.0	84.3	161.3	252.3	133.7	1.3	2.3	1.2	10903.8	7575.8
15	SC DUA43	72.0	73.7	140.3	251.7	120.7	3.7	2.7	1.3	8586.8	6361.9
16	Abarya	78.3	81.3	161.7	249.3	138.0	2.0	2.3	1.2	11755.7	8460.2
17	AMH760Q	81.0	85.3	167.3	279.0	176.0	2.0	2.7	1.3	9844.9	6676.2
18	Gibat	79.0	82.0	163.3	257.0	154.7	1.7	2.0	1.2	8130.8	5653.2
19	Wenchi	76.3	78.3	145.3	240.0	136.0	2.7	3.0	1.1	8278.9	5997.8
	Mean	81.1	83.7	159.3	255.7	144.6	2.2	2.6	1.2	9732.7	6830.9
	CV	3.4	3.3	2.2	6.1	9.7	21.0	19.9	10.9	15.4	15.1
	LSD (0.05)	4.5	4.5	5.7	26.0	23.2	0.8	0.9	0.2	2485.4	1709.9
	F-test	**	**	**	**	**	**	**	**	**	**

Key: DA: Days to anthesis, DS: Days to silking, DM: Days to maturity, PH: Plant height (cm), EH: Ear height (cm), GLS: Gray leaf spot, TLB: Tircicum leaf blight, EPP: Ears per plant, EW: Fresh ear weight (kg/ha), GYLD: Grain Yield (KG/ha), CV: Coefficient of Variation, LSD: Least Significant Difference.

Table 3 Genotypic (above diagonal) and phenotypic (below diagonal) correlations of ten quantitative traits at Kamash.

Traits	DA	DS	DM	PH	EH	GLS	Blight	EPP	EBM	GYLD
DA		0.81**	0.68**	0.59**	0.63**	-0.55*	-0.26	0.03	0.27	0.22
DS	0.78**		0.68**	0.76**	0.90**	-0.45	-0.28	-0.23	0.20	0.13
DM	0.61**	0.60**		0.66**	0.74**	-0.38	-0.44	-0.08	0.38	0.35
PH	0.49**	0.56**	0.59**		0.82**	-0.35	-0.49*	-0.08	0.30	0.27
EH	0.51**	0.72**	0.65**	0.79**		-0.23	-0.42	-0.39	0.12	0.06
GLS	-0.40**	-0.33**	-0.30*	-0.29*	-0.20		0.40	0.02	-0.63**	-0.60**
Blight	-0.24	-0.15	-0.33*	-0.36**	-0.27*	0.25*		0.26	-0.43	-0.42
EPP	-0.03	-0.15	-0.03	-0.07	-0.22	-0.01	0.17		0.14	0.17
EBM	0.15	0.11	0.31*	0.24	0.13	-0.40**	-0.29*	0.29		0.99**
GYLD	0.09	0.03	0.29*	0.23	0.09	-0.38**	-0.28*	0.29	0.99**	

Key: DA: Days to anthesis, DS: Days to silking, DM: Days to maturity, PH: Plant height, EH: Ear height, GLS: Gray leaf spot, TLB: Tircicum leaf blight, EPP: Ears per plant, EW: Fresh ear weight, GYLD: Grain Yield.

Table 4 Genotypic (above diagonal) and phenotypic (below diagonal) correlations of ten quantitative traits at Assosa.

Traits	DA	DS	DM	PH	EH	GLS	TLB	EPP	EBM	GYLD
DA		0.95**	0.77**	0.53*	0.65**	-0.50*	-0.42	-0.28	0.34	0.22
DS	0.89**		0.77**	0.41	0.57*	-0.57*	-0.46	-0.12	0.34	0.22
DM	0.65**	0.63**		0.56*	0.70**	-0.68**	-0.50*	-0.24	0.44*	0.32
PH	0.08	0.02	0.34*		0.89**	-0.20	-0.32	-0.47*	0.54*	0.46*
EH	0.28*	0.25	0.51**	0.84**		-0.33	-0.41	-0.43	0.43	0.34
GLS	-0.27*	-0.33*	-0.37**	-0.22	-0.27*		0.32	0.04	-0.47*	-0.39
TLB	-0.22	-0.28*	-0.34**	-0.31*	-0.31*	0.40**		0.01	-0.43	-0.33
EPP	-0.31*	-0.24	-0.22	-0.08	-0.22	-0.11	-0.14		-0.41	-0.42
EBM	-0.01	-0.01	0.27*	0.58**	0.50**	-0.40**	-0.39**	-0.04		0.98**
GYLD	-0.11	-0.11	0.17	0.56**	0.45**	-0.35**	-0.33*	-0.01	0.99**	

Key: DA: Days to anthesis, DS: Days to silking, DM: Days to maturity, PH: Plant height, EH: Ear height, GLS: Gray leaf spot, TLB: Tircicum leaf blight, EPP: Ears per plant, EW: Fresh ear weight, GYLD: Grain Yield.

CONCLUSION

In Ethiopia, maize is one of the most important and major strategic food crop among cereal. Significant yield increments on yield have been observed as commercial maize production shifts to hybrid seeds. To keep the change in the yield advances selection should be made for yield and important yield components simultaneously. Moreover, newly released maize hybrids should be testified for their adaptability and yield performances there by selection should be made for further popularization of the variety.

Analysis of variance revealed sufficient amount of variability among genotypes for the tested traits. Hybrid maize varieties Limu, Shone and BH546 are showed significant yield advantage over the check at Kamash areas. At Assosa maize hybrids Viz. Abarya, Shone, BH546 and BH547 revealed highest yield performance. Therefore, demonstration and popularization of these varieties in the respective areas could boost maize yield. Correlation analysis depicts negative significant correlation of grain yield with gray leaf spot and Turcicum leaf blight diseases. Positive significant correlation of grain yield were observed with days to maturity and fresh ear weight at Kamash location and with plant height, ear height and fresh ear weight at Assosa location. These positive and significant associations between these traits suggested that they can be selected simultaneously for yield improvement in maize breeding program. However, since the study conducted for a year only, it is important to repeat the experiment to confirm the result of the present study.

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REFERENCES

Abera, W., Hussein, S., Derera, J., Worku, M. and Laing, M.D., 2013. Preferences and constraints of maize farmers in the development and adoption of improved varieties in the mid-altitude, sub-humid agro-ecology of western Ethiopia. *Afr. J. Agric. Res., 8*(14), pp.1245-1254.

Badu-Apraku, B. and Oyekunle, M. 2012. Genetic Analysis of Grain Yield and other Traits of Extra-Early Yellow Maize Inbreeds and Hybrid Performance Under Contrasting Environments. *Field Crops Res.,* 129, 99–110.

Cassman, K.G., Dobermann, A., Walters, D.T. and Yang, H., 2003. Meeting cereal demand while protecting natural resources and improving environmental quality. *Annu. Rev. Envir. Res.*, *28*(1), pp.315-358.

Central Statically Agency. 2017. Crop Area and Production of Major Crops Report, Private Peasant Holdings, and Main season Volume I. Addis Ababa, Ethiopia.

Debela, M., Dejene, M. and Abera, W., 2017. Management of Turcicum leaf blight [Exserohilum turcicum (Pass.) Leonard Suggs] of maize (Zea mays L.) through integration of host resistance and fungicide at Bako, Western Ethiopia. *Afr. J. Plant Sci.* 11(1), pp.6-22.

FAO STAT. 2017. Food and Agricultural Organization Statistical Data base: Production and Trade.

http://www.fao.org/faostat/en/#data/QC. Accessed on September 5, 2018.

Gemechu Nedi, Sentayehu Alamerew and Leta Tulu. 2016. Review on Quality Protein Maize Breeding for Ethiopia. *J. of Bio., Agric. and Health care,* 6(15): 84-85.

Khalil AI, Ur- Rahman H, Ur-Rehman N, Arif M, Khalil IH, Iqbal M, Hidayatullah, Afridi K, Sajjad M, Ishaq M (2011). Evaluation of maize hybrids for grain yield stability in North-West of Pakistan. *Sarhad J. Agric*. 27(2):213.

Kinfe H,Tsehaye Y, Redda A, Welegebriel R, Yalew D, et al. (2017) Evaluating Adaptability and Yield Performance of Open Pollinated Maize Varieties in North Western Tigray. *Adv. Crop Sci. Tech*. 5: 316.

MacRobert, J. F., Setimela, P. S., Gethi, J., & Worku, M. (2014). Maize Hybrid Seed Production Manual. Mexico,D.F.:CIMMYT.

Musvosvi, C. and Wali, M.C., 2017. Genotype by Trait Associations among Drought Tolerant Maize Inbred Lines. *J. of Agric. Sci*, *9*(12), p.21.

Ndebeh, J., Akromah, R., Vah, E.G., Kolleh, D.S. and Baysah, N.S., 2017. Correlation analysis for grain yield and other agronomic parameters for 90 single crosses hybrid maize evaluated in three agrological zones in Ghana. *Afr. J. Agric. Res*, *12*(51), pp.3529-3536.

Patil, S.M., Kumar, K., Jakhar, D.S., Rai, A., Borle, U.M. and Singh, P. 2016. Studies on Variability, Heritability, Genetic Advance and Correlation in Maize (Zea *mays* L.). *Inter. J. of Agric., Env. and Biotec*, 9(6): 1103-1108.

Reddy, V.R., Jabeen, F., Sudarshan, M.R. and Rao, A.S., 2012. Studies on genetic variability, heritability, correlation and path analysis in maize (*Zea mays* L.) over locations. *Int. J. Appl. Biol. Pharm. Technol.*, *4*(1), pp.196-199.

SAS, S., 2009. STAT User's Guide, Version 9.2. Cary, NC, USA: SAS Institute.

Sharma, J.R., 1998. Statistical and Biometrical Techniques in Plant Breeding. New Age International (P) Limited Publishers, New Delhi.432p.

Singh, R.K. and Chaudhary, B.D., 1985. Line x Tester analysis. Biometrical Methods in Quantitative Genetic Analysis*,* Ed, *3*, pp.215-223.

Sonnad SK. 2005. Stability analysis in white ragi (*Eleusine coracana G*aertn.) genotypes. PhD Thesis, University of Agricultural Sciences, Dharwad, India.

Wolie A, Dessalegn T. 2011. Correlation and path coefficient analyses of some yield related traits in finger millet (*Eleusine coracana* (L.) Gaertn.) germplasm in northwest Ethiopia. *Afr. J. Agric. Res.,* 6:5099-5105.

Worku, M., Twumasi-Afriyie, S., Wolde, L., Tadesse, B., Demisie G., Bogale, G., Wegary, D. and Prasanna, B.M. (Eds.) 2012. Meeting the Challenges of Global Climate Change and Food Security through Innovative Maize Research. *Proceedings of the Third National Maize Workshop of Ethiopia.* Addis Ababa, Ethiopia.

Xue-jun, C., Guang-cai, C., Qun, S., Dong-bin, W., Jing, C., Ya-xiong, Y.U., Jie, L. and Wei, L., 2013. Altitude effects on maize growth period and quality traits. *Acta Ecologica Sinica*, *33*(4), pp.233-236.

Yusuf, M., 2010. Genetic variability and correlation in single cross hybrids of quality protein maize (Zea mays L.). *Afr. J. Food, Agric., Nutr. Dev.*, *10*(2).

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