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Performance Evaluation of Maize (*Zea mays L.*) Varieties for Grain Yield in Buno Bedele, South West Oromia, Ethiopia

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Abstract

The objective of this study was to identify and recommend adapted and high yielding hybrid maize varieties for the study area. To this end, five maize hybrids were evaluated using randomized complete block design with three replications to evaluate grain yield and yield related traits during2020/21-2022 cropping season at Dabo Hana, Dhaye-sub-site. Analyses of variances showed significant differences among the hybrid maize varieties for grain yield, days to flowering, plant height, ear height and number of cobs per plant. From the combined analysis of variances, BH547 variety gave higher yield (90.25 qt ha-1) followed by BH549 (72.82 qt ha-1). The correlation parameters/analysis indicated that almost most important traits are positively and significantly correlated with grain yield. Generally, the study indicated BH547 and BH549 varieties were promising varieties for Dabo Hana district and other similar ago-ecologies for further demonstration and scaling up.

Keywords: Adaptation; Highland; Hybrid; Yield

Introduction

Maize *(Zea mays L.)* is the most important grain crop in the world and is produced nationwide in various environments. Maize ranks first in the global grain production (https: //www.statista.com/statistics/263977/world-grain-production-by-type/accessed 30.11.2018). It is an important staple crop of the world-third most important after wheat and rice. Successful maize production depends on the correct application of production inputs that will sustain the environment as well as agricultural production (Boote et al., 1996; Eriksson et al., 2005; Bocianowski et al., 2016). These inputs include adapted cultivars, optimum plant population, soil tillage, fertilization, insect and disease control, harvesting (Pandey et al., 2000; Costa et al., 2002; Szulc and Bocianowski, 2011; Szulc et al., 2011, 2013, 2018; Bocianowski et al., 2019b). Maize is a versatile crop due to its multifarious uses as feeds, food and industrial raw material. The crop serves as a source of basic raw material for a number of industries viz., starch, protein, oil, alcoholic beverages, food, sweeteners, cosmetics and biofuels [1,2].

In Ethiopia cereals account for about 80% of the annual crop production and maize is the first in total production and yield per unit area and second after tef in area coverage among all the cereals. Currently, Ethiopia is the fourth largest maize producing country in Africa, and first in the East African region (FAO, 2017). It is also significant that Ethiopia produces non-genetically modified (GMO) white maize, the preferred type of maize in the neighboring markets. This strategy envisions export markets being a significant part of the demand sink for Ethiopian maize. Maize is the largest cereal commodity in terms of total production, acreage, and the number of farm holdings [3].

In Ethiopia, maize grows under a wide range of environmental conditions, between 500 to 2400 meters above sea level. Maize is Ethiopia's leading cereal in terms of production, with six million tons produced in 2012 by nine million farmers on two million hectares of land (CSA 200/21). Over half of all Ethiopian farmers grow maize, mostly for subsistence consumption, with 75% of all maize produced being consumed by the farming household. Currently, maize is the cheapest source of calorie intake in Ethiopia, providing 20.6% of per capita calorie intake nationally (Rashid, 2010).

Total area covered by maize during the 2006/07 growing season was 1.7 million ha and the national average yield was about 2.2 t ha^{-1} (CSA, 2020). 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. This resulted in the recommendation of several maize varieties for the maize growing regions of the country (Abdurahman, 2009).

Maize is an important crop for overall food security and also used for making local beverages. Additionally, the leaves and stover are used to feed animals and the stalks are used for construction and fuel. A small quantity of the grain produced is currently used in livestock and poultry feed, and this is expected to increase with the development of the livestock and poultry enterprises in the country. The green fodder from thinning and topping is an important source of animal feed and the dry fodder is used during the dry season. Moreover, the crop has potential uses for industrial purposes, serving as a starch, a sweetener for soft drinks, an input for ethanol fuel production and oil extraction (FAO, 2012) [4,5].

As compared to other cereals, maize can attain the highest potential yield per unit area. The average yield in developing countries is 2.5 t/ha. In Ethiopia the national average yield is about 4.2 t/ha (CSA, 2020). While significant gains have been made in maize production over the past decade, there remains large potential to increase productivity. From 2001 to 2011, maize production increased by 50%, due to increases in both per hectare yields (+25%) and area under cultivation (+20%). However, estimates indicate that the current maize yield could

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be doubled if farmers adopt higher quality inputs and proven agronomy best practices. At present, only 17% of maize farmers representing 30% of maize planted area make use of improved varieties of seed and only 30% of farmers use the recommended rates for fertilizer application (ATA, 2017) [7,8].

Maize is mainly grown in the four National Regional States of the country: Oromia, Amhara, SNNP and Tigray. Oromia and Amhara contribute to almost eighty percent of the maize produced in 2012 (CSA, 2015/2016). Maize is among the major food crops widely produced and consumed by smallholder farmers in Ethiopia in general and in south western Oromia in particular. Area under maize during 2016/17 main cropping season in Ethiopia was about 2.1 million ha, which makes maize to be first in area coverage out of cereals. During the same period, maize ranked first among cereals in terms of total production accounting for about 7.8 million tons. During the same period Buno Bedele Zone average productivity of maize was about 4.2tons in that order which is nearly equal to the national average of about 4.23 tones ha^{-1} (CSA, 2020). The low productivity of maize is attributed to many factors like declining of soil fertility, low rates of adoption of improved varieties, poor management practice, limited use of input, insufficient technology generation, poor seed quality, disease and pests (Muzari, 2012; Govind et al., 2015) [9,10].

The current average national maize productivity of Ethiopia is 42.37 quintals per ha. However, it is still low compared to that of the world average maize productivity (55.4 quintals per ha) in (CSA, 2020). Several studies have been conducted so far in relation to maize technologies and attempted to identify factors affecting in adoption of improved maize verities and effect of technology and its linkage with crop diversification and efficiency of maize farmers (Feleke and Zegeye, 2006; Jaleta et al., 2013; Kassa et al., 2013, Mekuria, 2013, Abdi et al., 2015 and Sisay, 2016). Thus, research in this area has identified lack of improved varieties in many maize producing areas, including the South West part of Oromia. Therefore, the current study was initiated with the objective of evaluating and recommending better adapted maize varieties for yield and yield components for the study areas and other similar agro-ecologies [11,12].

Materials and Methods

Description of the study area

Dabo Hana: Dabo Hana is one of the districts in Buno Bedele Zone, Oromia Regional State Southwest part of Ethiopia. The district is bordered on the south by Bedele, on the west by Dega and Mako, on the north by Chewaka and Leka dulecha, on south west by Chora, on the east and north east by Jima Arjo. The administrative center of this district is Dabo Hana. The district is located 521 km away from the capital city of the country and 38 km away from Bedele Town of Buno Bedele Zone. The district is located at an average elevation 1190-2323 masl and located at 8°30' 21" to 8°43' 29" N latitude and 36°5'27" to 36°26' 19"E longitude. It is generally characterized by warm climate with a mean annual maximum temperature of 28°C and minimum temperature of 11°C. The annual rainfall ranges from 900-2200mm. The soil of the area is characterized as Nitisol, Acrisol, Lithosol, Cambisol and Vertisol [13,14].

Experimental materials and design

Five maize varieties were collected from BARC and Corteva Science Ethiopia PLC and evaluated as experimental materials. These materials were randomly assigned to the experimental block and the experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The spacing between blocks and plots was 1m and 0.5m, respectively. The gross size of each plot was 12m2 (3m × 4m) having five rows with a row-to-row spacing of 80cm.The total area of the experimental field was 306m2 (17m × 18m). Planting was done by keeping the spacing of maize plants (25cm) with a seed rate of 25kg ha^{-1}. NPS fertilizer was applied at the rate of 150kg ha^{-1} at the time of planting; and Urea was also applied at vegetative stage at the rate of 200 kg ha^{-1} [15,16].

Data collected

Data were recorded on plot and single plant basis and taken from the central rows of the plot. Individual plant-based data were taken from five plants in each plot taken randomly from the central rows of the plot [17].

Data collected on plot basis

Days to male flowering (MF): The number of days from 50% of the plots showing emergence of seedlings up to the emergence of the tips of the panicles from the flag leaf sheath in 50% of the plot stands.

Days to maturity (DM): The number of days from 75% of the plots showing emergence of seedlings up to the

Grain yield (g/plot): The weight of grain for all the central row plants including tillers harvested at the level of the ground

Data collected on plant basis

Plant height (cm): Measured as the distance from the base of the stem of the main tiller to the tip of the panicle at maturity

Ear height (cm): The length from the earth to the first node where the ear is emerged

Data analyses

Genstat 18th edition software was used to analyze all the collected data. Mean separations was carried out using Least Significant Difference (LSD) at 5% probability level [18].

Results and Discussions

Combined ANOVA for the varieties were very highly significant ($P<0.001$) whereas year and year by varieties interaction revealed significant difference ($P <0.05$) for grain yield. This indicated the presence of significant variations among varieties and the varieties had inconsistent performance over years. Workie et al., 2013) in maize also reported the significant effect of years, varieties, and years by varieties on yield and some other yield-related traits (Table 1) [19].

The combined analysis of variance showed that except days to maturity and plant height all parameters were significantly ($P \leq 0.05$) affected due to main effect of variety and years. The highest mean grain yield obtained was from BH547 (90.25 qt ha^{-1}) followed by BH549 (72.82 qt ha^{-1}). These varieties had an average yield advantage

Table 1: Description of Maize varieties used in the experiment.

Variety Names	Altitude ranges (m.a.s.l)	Year of Release	Maintainer
BH 540	2200-2600	1995	BARC/OARI
BH 546	2400-2600	2013	BARC/OARI
BH 547	2200-2600	2013	BARC/OARI
BH 549	1500-1800	2017	BARC/OARI
Damote	2000-2800	2015	**CAEPLC**
BARC: Bako Agricultural Research Center, OARI: Oromia Agricultural Research Institute			

Table 2: Combined analysis of variance for maize grain yields over the two years (2020-2021/22).

Source of variation	Degree of freedom	Sum of square	Mean of square	Vr.	F.pr
Replications	2	633042	316521	0.22	
Treatments (Trt)	4	6.4E+07	15916142**	11.05	<.001
Year (Yr)	1	1.3E+07	12740083*	8.84	0.008
Trt*Yr	4	2.3E+07	5713341*	3.97	0.018
Residual	18	2.6E+07	1440700		
Total	29	1.3E+08			

Table 3: Combined mean grain yield and yield components of maize varieties for two years.

Varieties	MF (days)	FF (days)	DM (days)	PH (cm)	EH (cm)	GY (qt/ha)	Diseases (1-5)	
							LR	TLB
BH 540	61.83^{b}	65.33^{b}	148.3	224.8	103.9^{ab}	49.00^{c}	10 mr	15 mr
BH 546	64.50^{b}	67.83^{b}	140.7	229.8	99.4^{ab}	54.86^{bc}	15 mr	10 mr
BH 547	64.67^{b}	67.33^{b}	148.0	227.8	136.3^{a}	90.25^{a}	5 r	10 mr
BH 549	73.00^{a}	80.50^{a}	147.7	228.8	127.1^{ab}	72.82^{ab}	5 r	10 mr
Damote	72.33^{a}	79.50^{a}	146.3	233.4	98.8^{b}	62.32^{bc}	5 r	15 mr
GM	67.27	72.10	146.20	228.89	113.09	65.85		
LSD 5%	5.08	7.97	8.80	39.07	37.24	19.53		
CV%	6.30	9.30	5.00	14.30	27.60	24.80		
P-value	*	*	NS	NS	*	*		

MF: Male Flowering, FF: Female Flowering, DM: Days to Maturity, PH: Plant Height, EH: Ear Height, Dis (1-5 scale) GY: Grain Yield, GM: Grand Mean, LSD: Least Significant, CV: Coefficient of Variation, *significant, NS: Non-Significant.

Table 4: Morpho-phsiological correlations of yield and yield related traits of maize varieties.

Traits	MF	FF	PH	EH	MD	Ncob/p	GY
MF	1						
FF	0.97**	1					
PH	0.18	0.13	1				
EH	0.22	0.16	0.78**	1			
MD	0.76**	0.63**	0.59**	0.65**	1		
Ncob/p	0.34	0.25	0.76**	0.69**	-0.45*	1	
GY	0.24	0.13	0.91**	0.86**	0.71**	0.81**	1

NB: MF: Male Flowering date, FF: Female Flowering date, PH: Plant Height, EH: Ear Height, MD: Maturity Date, Ncob/p: Number of cobs per plant, GY: Grain Yield (qt ha^{-1})

of 38.24% and 30.85% f, respectively over the national maize average productivity (42.37qt ha^{-1}). However, the performance of varieties was not consistent over years perhaps due to physical, chemical and biological factors (Tariku et al., 2018). The lowest grain (49 qt ha^{-1}) yield was recorded from variety BH 540. Thus, BH547 and BH549 were selected and recommended for further production at Dabo Hana and similar agro-ecologies (Table 2) [20].

Character associations

Results of the correlation coefficient for the pairs of characters are presented. The result shows that the association between grain yield and four yield components (plant height, ear height, maturity date and number of cobs per plant) were positive and significantly correlated ($P \leq 0.05$). The correlation coefficient between plant height, ear height, maturity date and number of cobs per plant and grain yield were 0.91, 0.86, 0.71 and 0.81, respectively. These observations agree with the finding of Muhammed et al.(2002), who independently observed positive and significant correlation between grain yield and kernel rows ear-1, kernel row-1, ear height, and 100-kernel weight in maize (Tables 3 and 4) [21,22].

Conclusion and Recommendation

The experiment was carried out using five improved maize varieties in randomized complete block design (RCBD) with three replications during 2021 to 2022 main cropping seasons. According to the study results, all the studied growth parameters, yield components and grain yield were significantly affected by varieties. The analysis of variance showed significant variations among varieties (P 0.05) for male flowering (MF), female flowering (FF), Ear height (EH) and grain mean yield. The result indicated that variety BH-547 was superior in grain yield to others and gave 90.25 quintals per hectare followed by BH-549 with yield level of 72.82 quintals per hectare.

Therefore, from this study it can be concluded that varieties BH-547 and BH-549 which had higher grain yield with appreciable yield advantage over the national productivity are recommended for commercial production at Dabo Hana district and similar environments.

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