

Maize (*Zea mays* L.) Variety Adaptation Performance Evaluation at Tendahoo Sugar Factory Afar Regional State Ethiopia

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Abstract

Six Maize genotypes were planted in RCBD with three replication each in 10 meter by 10 meter plot by furrow irrigation to evaluate adaptation performance of Maize genotypes and identify high yielding and heat tolerant genotypes adapted to Tendaho sugar estate in order to enhance the net national crop production in general and product diversification in sugar estates in particular in the near future. The analysis of variance showed that genotypes included in the test differed highly and significantly at ($p=0.05$) probability level for all traits and maize grain yield mean value comparison or mean separation result indicated that the genotype BH-546 is superior compared to others with 58.5 quintals grain yield per hectare followed by MH-4 and BH-540 genotypes with 50.3 and 43 quintals grain yield per hectare value. Based on the productivity standard the superior genotype BH-546 scored 95% and 17%, respectively yield advantage over the national (30 qt/ha) and global (50 qt/ha) maize average productivity.

Keywords: Variance; Genotype; Kuraz

Introduction

Agriculture is the backbone of the Ethiopian economy. On average, crop production makes up 60% of the sector's outputs, whereas livestock accounts for 27% and other areas contribute 13% of the total agricultural. The sector is dominated by small-scale farmers who practice rain-fed mixed farming by employing traditional technology, adopting a low input and low output production system. Small-scale farmers produce 94% of the food crops and 98% of the coffee, the latter being Ethiopia's leading export goods. Private and state commercial farms produce just 6% of food crops and 2% of the coffee grown [1].

Like most developing countries, Ethiopia relies much on agriculture to drive economic growth. Despite considerable and dynamic efforts made towards increasing agricultural production, the country has yet to go a long way to secure self-sufficiency in strategic food crops. Consequently, the country is obliged to import large quantities of wheat and other grains even in normal year. The grain deficit worsens in drought years such as in 2015 [2]. During this year, the country imported an account of 3.2 million metric tons of wheat to close the deficit. On the contrary, a number of reports have shown that Ethiopia has good agricultural potential that would allow it to produce surplus quantities of agricultural commodities let alone meeting its food security strategy dependent merely on rain-fed agriculture through harnessing its fertile and irrigable land in the lowland areas. However, to date much of the irrigable low lands are not yet utilized for various reasons.

Ethiopian Sugar Corporation (ESC) has a vision to make the sugar industry among the top ten competitive sugar industries in the world in the year 2024. The sugar sector has already started transformation in this regard. Among newly established sugar estates Kuraz, Beles and Tendaho have bigger farm land size that ranges between 50 and 175 thousands of hectares (ESC gtp2). To date, the newly established sugar factories have not reached at a stage of utilized all their allocated land resource as initially planned [2].

Therefore, there is an opportunity to make use of uncultivated land for other agricultural production until the factory become fully operational. Global experiences showed that most sugar producing countries such as India, Thailand, Australia, South Africa and Brazil are running their sugar industries with complementary crops and

livestock's enterprises. In India, vegetable and pulse crops are produced as rotational and diversification crops at sugar cane farms. Similarly in South Africa, sugar estates are also linked with beef production [2]. In this regard, the Ethiopian Sugar Corporation (ESC) has established a wing tasked with crop, horticulture and livestock production to enhance product diversification.

However, most of the intended areas have not been touched by research process in developing improved crop varieties. Thus, it seems crucial to undertake a quick adaptation trial at each location so as to venture on large scale mechanized cereal and forage crop production in Tendaho Sugar Factory. To achieve this, there is a need to undertake adaptation trial of Maize in the selected sugar estates in order to identify suitable crop varieties.

Maize is a major staple food crop grown in diverse agro-ecological zones and farming systems, and consumed by people with varying food preferences and socio-economic backgrounds in Sub-Saharan Africa (SSA) [3]. The central role of maize as a staple food in SSA is comparable to that of rice or wheat in Asia, with consumption rates being the highest in eastern and southern Africa (ESA). An estimated 208 million people in SSA depend on maize as a source of food security and economic wellbeing. Maize occupies more than 33 million ha of SSA's estimated 200 million ha of cultivated land. Considering the low average maize grain yields that are still pervasive in farmers' fields, meeting the projected increase demand for maize grain in Africa presents a challenge [3].

Therefore, the objective of this experiment were to evaluate adaptation performance of Maize genotypes thereby to identify high

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yielding and heat tolerant genotypes adapted to Tendaho sugar estate in order to enhance the net national crop production in general and product diversification in sugar estates in particular in the near future.

Material and Methods

Description of the study area

Tendaho Sugarcane Estate is found in Afar Regional State North Eastern part of Ethiopia, that is located at 41°3'E longitude and 11°50' N latitude, receiving annual rainfall of about 200 mm with mean minimum and maximum temperature of 22.91°C and 37.72°C, respectively. The altitude of area is 374 m above sea level.

Temperature

53 years Average Temperature from 1953 to 2016 of Tendaho was taken into consideration (Table 1).

Materials

Following are the materials used (Table 2).

Methods

Six candidate genotypes were tested in RCBD with three replications following appropriate statistical procedures. This activity targets to evaluate adaptation ability and yield potential of the candidate varieties and identify the best performing under Tendaho conditions. The plot size for the trial was 10 m by 10 m. The trial was carried out using surface irrigation from November 2016 to April 2017 following recommended agronomic practices. Crop performance data on days to flower, days to maturity, plant height, disease incidence, insect attack, Stand count at harvest, 100 seed weight and grain yield were recorded.

Analysis of variance

The data obtained for different traits was statistically analyzed using GenStat 15th Software. Analysis of Variance for RCBD design was done for the characters such as Date of planting, Stand count at emergency, Stand count at harvest, Date of heading, Date of flowering, Date of maturity, Plant height in cm at maturity, harvest index and thousand seed weight.

Mean comparisons among treatment means were conducted by Least Significance Difference (LSD) methods at 5% levels of significance.

The RCBD design analysis of variance was used to derive variance components as structured as stated model [4].

RCBD ANOVA was computed using the following model:

$$Y_{ij} = \mu + r_j + g_i + \epsilon_{ij}$$

Where,

Y_{ij} = The response of trait Y in the i th genotype and the j th replication

μ = The grand mean of trait Y

r_j = The effect of the j th replication

g_i = The effect of the i th genotype

ϵ_{ij} = Experimental error effect.

Result and Discussion

Variance analysis

The analysis of variance showed that genotypes included in the test differed highly and significantly at (p 0.05) probability level for all traits grain Yield qt/ha (AdGYHqt), Days of Heading (DH), Days of Maturity (DM), Plot Grain yield in kg (GYPkg), Plant Hieght in cm (PH), Stand Count at Harvest (SCH) and Thousand Seed Weight in gm (TSWg) as indicated in Table 3. Similar reports were reported by Salami et al. [5] for Days of Heading/Flowering date, Plant height and grain yield. This indicates the existence of significant amount of phenotypic variability and all the genotypes are different to each other with regard to the mentioned characters. This result also points to that the existence of wider variations among the studied genotypes for the studied characters so as simple selection could be possible based on those characters. Phenotypic markers have been of great value in studies of maize landraces [6-8]. Dreisigacker et al. [9] reported the genetic variability of maize has been affected by various factors throughout their evolutionary history. Out crossing and fitness-relevant mutations generate intra-population diversity, whereas direct natural or human selection and bottle neck effects lead to an increase in inter population diversity.

Estimation of phenotypic and genotypic variances

The phenotypic and genotypic variances of each trait were estimated from the RCBD analysis of variance. The expected mean squares under the assumption of random effects model was computed from linear combinations of the mean squares and the phenotypic and genotypic coefficient of variations were computed as suggested by Burton and Devane [10] and according to the formulae of Singh and Chaundary [11].

The highest PCV were observed for plot grain yield in kg (28.0) followed by grain yield per hectare (21.2) coupled with medium GCV value 18.1 and 18.4, respectively; while medium PCV and GCV were recorded for thousand seed weight. Low PCV and GCV were observed for Days of Heading, Days of Maturity, plant height and stand count at maturity (Table 3). Amsal et al. [12] and Sharma et al. [13] reported similar high PCV and GCV value for grain yield per

Months	JAN	Feb	March	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Average
Temperature in °c	23	24.4	26	28.1	30.8	31.9	31.5	30.5	30.7	27.2	24.7	23.3	27.7

Table 1: 53 years Average Temperature from 1953 to 2016 of Tendaho.

Crop	Genotypes
<u>Maize</u>	BH-540
	BH-546
	MHQ-138
	BH-140
	MH-4
	BH-547

Table 2: Genotypes used for Maize Adaptation Trial at Tendaho.

Characters	MS	σ^2_e	σ^2_g	σ^2_{ph}	σ_g	σ_{ph}	GCV	PCV	hb2	EGA	GA	LSD	CV
AdGYHqt	222.41*	21.7	66.9	88.6	8.2	9.4	18.4	21.2	75.5	1463.8	33.0	8.48	10.5
DH	18.6222*	0.9	5.9	6.8	2.4	2.6	3.8	4.0	87.4	468.6	7.2	1.683	1.4
DM	9.5556*	1.0	2.9	3.8	1.7	2.0	1.8	2.0	74.3	300.0	3.1	1.809	1
GYPkg	220.09*	69.5	50.2	119.7	7.1	10.9	18.1	28.0	41.9	945.0	24.2	15.17	21.3
PH	1349.9*	121.9	409.3	531.2	20.2	23.0	8.6	9.8	77.1	3658.5	15.6	20.09	4.7
SCH	3392.2*	723.3	889.6	1612.9	29.8	40.2	6.5	8.7	55.2	4563.2	9.9	48.93	5.8
TSWg	2704.1*	347.5	785.5	1133.0	28.0	33.7	10.3	12.4	69.3	4807.4	17.6	33.91	6.8

*Indicates significant at 0.05 probability level.

Genotypic mean square/Treatment Mean Square=MS; Environmental variance (σ^2_e)=Mse; Genotypic variance (σ^2_g)=(msg-mse)/r; Phenotypic Variance (σ^2_{ph})= $\sigma^2_g + \sigma^2_e$; σ_g =genotypic standard deviation; σ_{ph} =phenotypic standard deviation; GCV=Genotypic Coefficient of Variation (GCV)=(σ_g /grand mean) \times 100; PCV=Phenotypic Coefficient of Variation (PCV)=(σ_{ph} /grand mean) \times 100; Heritability, Genetic advance for selection intensity (k) at 5% (2.06) and Genetic advance as % of population mean=GA.

Table 3: ANOVA of seven characters of six studied Maize genotypes and Variance components, broad sense heritability, genetic advance as % of mean for seven characters of six studied Maize genotypes at Tendaho.

Genotype	Grain Yield qt/ha	Yield advantage over national average	Yield Advantage in %	Yield advantage over Global average	Yield Advantage in %
BH-546	58.5a	28.5	95	8.5	17
MH-4	50.3ab	20.3	67.7	0.3	0.6
BH-540	43b	13	43.3	-ve	
MHQ-138	41.3bc	11.3	37.7	-ve	
BH-140	37bcd	7	23.3	-ve	
BH-547	36cde	6	20	-ve	
LSD	8.48	28.5	95		
CV	10.5	20.3	67.7		

Table 4: Grain yield Mean Comparison.

hectare. The genotypic variance was found to be relatively lower than its corresponding phenotypic variance for all character indicating that environment influence very high. As stated by Shivasubramanian and Menon [14] the PCV and GCV values are ranked as low, medium and high with 0 to 10%, 10 to 20% and >20%, respectively.

Heritability and genetic advance

In the present study, broad sense heritability was computed for the characters and is presented in Table 3. It ranged from 87.4% (Days of Heading) to 41.9% (plot grain yield). Heritability values are categorized as low (0-30%), moderate (30-60%) and high (60% and above) as stated by Robinson et al. [15]. All traits recorded high heritability except plot grain yield (41.9%) and stand count at harvest (55.2%) which recorded moderate value. As indicated in Table 3 high genetic advance as % of mean was recorded for grain yield per hectare (33%) and plot grain yield (24.2%); moderate value were recorded for thousand grain yield (17.6%) and plant height (15.6%); while low value were recorded for days of flowering, days of heading and stand count at maturity. Genetic advance as % of mean classified as low (0 to 10%), moderate (10 to 20%) and high (20% and above) as stated by Johnson et al. [16]. Heritability estimates were considered in conjunction with genetic advance [17].

The mean value comparison

The maize grain yield mean value comparison presented in Table 4 indicated that the genotype BH-546 is superior compared to others with 58.5 quintals grain yield per hectare followed by Melkasa-4 and BH-540 genotypes with 50.3 and 43 quintals grain yield per hectare value. Based on the productivity standard reported by feed Africa (2013) the superior genotype BH-546 scored 95% and 17% respective yield advantage over the national (30 qt/ha) and global (50 qt/ha) productivity [18].

Profit analysis of maize production

The economic analysis result shown that producing Maize could

Description	Unit Measurement	Quantity/ amount	Remark
Production (quintals/hectare)	Qt	50.3	600 birr/ quintal were considered as Grain selling price
Production cost per hectare	Birr	21535.424	
Total Income per hectare (production* grain selling price)	Birr	30180	
Gross Net Profit before tax per hectare	Birr	8644.58	
Production cost per quintal	Birr	428.14	
Net Profit from a quintal	Birr	171.86	

Qt: Volume equal to a quarter gallon; Birr: The basic monetary unit of Ethiopia, equal to 100 cents.

Table 5: Profit analysis of Maize.

provide additional income to the Factory with net profit per quintal 171.86 birr. With the current finding 53 quintal per hectare the net profit will be 8644.58 birr by considering the current Maize selling price (Table 5). We can project the current finding to calculate the net profit before tax by producing 1000 hectares in Tendaho, with this simple analysis the profit could be 8,644,580 birr.

Conclusion and Recommendation

The analysis of variance showed that genotypes included in the test differed highly and significantly at (p 0.05) probability level for all traits and maize grain yield mean value comparison or mean separation result indicated that the genotype BH-546 is superior compared to others with 58.5 quintals grain yield per hectare followed by MH-4 and BH-540 genotypes with 50.3 and 43 quintals grain yield per hectare value. Based on the productivity standard the superior genotype BH-546 scored 95% and 17% respective yield advantage over the national (30 qt/ha) and global (50 qt/ha) maize average productivity.

Therefore, from this study it can be concluded that Genotypes BH-546 which scored the first superior grain yield per hectare mean value and excellent yield advantage over the national and global maize productivity shall be recommended for commercial production at Tendaho Sugar factory and similar environments and soil types.

From this work It is also noted that, further research works should have to be done in developing varieties for irrigation, crop irrigation agronomy research like determination of fertilized, planting time and season by considering to the specific Agro-climatic condition of the area.

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