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Evaluation of Maize (*Zea mays* L.) Variety Adaptation Performance at Omo Kuraz Sugar Development Project South Omo Zone, SNNPRs, Ethiopia

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Keywords

Genotypes, adaptation, and performance

Abbreviations;
ESC = Ethiopian Sugar Corporation,
gtp2= Growth transformation plan-2

Abstract

Five Maize genotypes were evaluated in RCBD with three replications at Omo-Kuraz Sugar development Project. Analysis of Variance was computed and genotypes included in the test differed highly and significantly at (p 0.01) probability level for two traits Plant height at maturity (PH(m)) and stalk count(SC), while, early maturity (EM), Flowering date (DF(Female)) for female, Male flowering date (DF(male)), Biomass (BMkg), hundred seeds weight (HSW), plot yield (PY), Yield in tones per hectare (YtHa) and harvest index (HI) differ significantly at (p 0.05). Genotype BH546 and BH547 with respective 53.6 and 44.1 quintals yield per hectare are found to be superior. Genotype BH546 with 53.6 qt/ha productivity scored the highest net income 9760 birr/ha than the others genotypes followed by BH547 6435 birr/ha from this study it can be suggested that Genotypes BH546 which scored the first superior grain yield per hectare mean value and better maturity class with higher economic advantage shall be recommended for commercial production at Omo-Kuraz Sugar Development Project.

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 good. Private and state commercial farms produce just 6% of food crops and 2% of the coffee grown (Atsbaha et al., 2008).

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(Adaptation and Promotion project document 2016). 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 dependant 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 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 150 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 (Adaptation and Promotion project document 2016).

Therefore, there is an opportunity to make use of uncultivated land for other agricultural production until the factory development projects 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 (Adaptation and Promotion project document 2016). In this regard, the Ethiopian Sugar Corporation 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 selected sugar estates. 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 (Feeding Africa 2015). The central role of maize as a staple food in Sub-Saharan Africa is comparable to that of rice or wheat in Asia, with consumption rates being the highest in eastern and southern Africa. An estimated 208 million people in Sub-Saharan Africa depend on maize as a source of food security and economic wellbeing. Maize occupies more than 33 million ha of Sub-Saharan Africa'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 (Feeding Africa 2015).

Therefore, this study was initiated with the objective to evaluate adaptation performance of Maize genotypes thereby to identify high yielding and heat tolerant genotypes adapted to Omo Kuraz 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.

Materials and Methods

Description of the study area

Kuraz Sugar Development Project is located between 5^o 8' 18" – 6^o 16' 59" latitude and 35^o 43' 37" – 36^o 13' 54" longitude and its elevation ranges from 370 – 500 m.a.s.l. It is located 918 km away from Addis Ababa in the south direction. It is found in South Omo Zone in the plain areas of the lower Omo basin of the Southern Nations Nationalities and Peoples Region. According to Kuraz metrology station, the annual rain fall of study area is 889.94mm and the average maximum and minimum air temperature of study area is 36^oc and 22.91^oc respectively. Soil types of the study area dominated by clay texture which may hold water for a long time.

The climate of the Zone is "Dega (0.5%) "Weyna Dega" (5.1%), " Kolla " (60%) and semi-Bereha (34.4%). The Omo valley has an estimated 350,000 ha of land suitable for irrigation with 150, 000 ha in Selamago Woreda alone. The project area receives modest rainfall annually and close to the Kefa Skeka Zone in the North West.

Experimental Materials and Design

Genotypes (BH547, Melkassa 2, MH140, BH546, and MH130) were used for Maize Adaptation Trial (mother trial) at Kuraz Sugar Development Projects. Some of the candidate varieties have been in production and have proved their potential in similar agro-ecologies. Pertaining to this fact, the trial were set to be organized as two independent but related activities to help achieve the specific objectives of evaluating varieties for their adaptation and demonstrating more promising ones on larger plots at the same time.

In the mother trial (Activity 1), the entire set of the candidate varieties of each crop were tested in RCBD design 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 one under each sugar estate conditions. The plot size for the mother trial was 10 m by 10 m. The trial was carried out using surface irrigation during the coolest season following recommended agricultural practices.

Crop performance data on days to 50% emergence, vigourisity, days to flower, days to silking, days to maturity, plant height, disease incidence, insect attack, ear length, plant height up to ear, Stand count at harvest, biomass weight ,100 seed weight , plot yield and grain yield(t/ha) were recorded.

Analysis of variance:

The data obtained for different traits was statistically analyzed using GenStat 15th Edition (32 bit) 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 (Cochran and Cox, 1957).

RCBD ANOVA was computed using the following model:

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

Where, Y_{ij} = the response of trait Y in the ith genotype and the jth replication
μ = the grand mean of trait Y
r_j = the effect of the jth replication
g_i = the effect of the ith genotype
ε_{ij} = experimental error effect

Results and Discussion

Variance analysis

The analysis of variance showed that genotypes included in the test differed highly and significantly at (p 0.01) probability level for two traits Plant height at maturity (PH(m)) and stalk count(SC), while, early maturity (EM), Flowering date (DF(Female)) for femal, Male flowering date (DF(male)), Biomass (BMkg), hundred seeds weight (HSW), plot yield (PY), grain yield in tones per hectare (GYtHa) and harvest index (HI) differ significantly at (p 0.05). Similar reports were reported by Salami et al., (2016) for Flowering date, Plant height and grain yield.

This indicates that the existence significant amount of phenotypic variability and all the genotypes differ each other with regard to the mentioned characters that opened a way to proceed for further improvement research. 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 (Galarreta & Alvarez, 2001; Lucchin et al., 2003; Ortiz et al., 2008). Dreisigacker *et al (*2005) also 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 bottleneck 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 (1953) and according to the formulae of Singh and Chaundary (1977).

The highest PCV and GCV was observed for biomass (58.07 and 51.94) followed by stalk count (43.42 and 40.22), Grain yield per plot (43.36 and 33.65), and Grain yield in tones per hectare (43.36 and 33.65) respectively (Table 2). Amsal et al., (1994) and Sharma et al (1995) reported similar high PCV and GCV value for biomass, stalk count and grain yield per hectare. The lowest PCV and GCV values were observed for Days of tassel ling /male flowering/ (6.69 and 5.09) and Days of earring /female flowering/(7.63 and 6.62). 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 (1973) 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 2. It ranged from 88.90 % (plant height at harvest) to 47.87 % (number of ear per plant). Heritability values are categorized as low (0-30%), moderate (30-60%) and high (60% and above) as stated by Robinson et al., (1949). All traits recorded high heritability value except number of ear per plant and says of teaseling which recorded moderate value.

Genetic advance as percent of mean classified as low (0 to 10%), moderate (10 to 20%) and high (20% and above) as stated by Johnson et al. (1955).Genetic advances as a percent of mean ranged from the lowest 7.09 (hundred seed weight) to the highest 95.71for biomass. Heritability estimates were considered in conjunction with genetic advance (Johnson *et al.*, 1955). Results for genetic advance as the percentage of the mean (GAM) at 5% selection intensity is presented in Table 2. Based on these considerations, High heritability coupled with high genetic advance as percent of mean recorded for plant height at maturity, stalk count at maturity biomass, grain yield per plot, and grain yield per hectare and harvest index.

Character Association

Association of characters: Estimates of phenotypic correlation coefficients between each pair of characters are presented in Table 3.

The mean value comparison:

The mean values for early maturity, plant height at maturity, number of ear per plant, stalk count, flowering date for female, biomass, hundred seed weight, plot yield in kg, grain yield per hectare in tones and harvest traits are presented in Table 4. The result indicated that the existence of wide variation among genotypes for studied traits.

The result revealed that BH546 score significantly higher Grain yield mean value per plot in kg (24.12) followed second by BH547 (19.83) and the third Melkassa-2 (16.91) with respective mean value for grain yield in kilograms per plot. While, Treatment BH546 score significantly higher superior Grain yield mean value per hectare in tones (5.36) than the other genotypes followed second by BH547 (4.41) and third Melkassa-2 (3.76) with respective mean value for grain yield in tones per hectare. As indicated in Table 3, BH547 (4.67) significantly late maturing genotype than other genotypes followed by BH546 (3) but the second genotype do not have significant variation with earlier maturing genotypes, while, two maize genotypes Melkassa-2 (1.67) and MH130 (1.67) mature earlier than BH547 and BH546 with statistically significant difference.

As the mean separation indicated in table (4) shown genotype BH546 and BH547 with respective value 53.6 and 44.1 quintals of yield per hectare are superior genotypes than other studied genotypes.

Economic Advantage of Maize Production

The economic analysis result shown that producing Maize in Omo-Kuraz Sugar development project could provide additional income to the project with net profit that ranges from 1785 birr to 5110 birr per one hectare. As indicated in the table genotype BH546 with 53.6 qt/ha productivity scored the highest net income 9760 birr/ha than the others genotypes followed by BH547 6435 birr/ha (Total Income minus total production cost). The result indicated in table (5) clearly indicated these two genotypes BH546 (5110 birr/ha) and BH547 (1785 birr/ha) were also profitable compared to the income that could be gained from national Maize Productivity average (39qt/ha).

Table 2. ANOVA variance components, broad sense heritability, genetic advance as percent of mean for ten characters of five studied Maize genotypes at Omo-Kuraz Sugar development Project

	Tret MS	**EMS**	**GM**	**σ2 e**	**σ2g**	**σ2ph**	**σg**	**σph**	**GCV**	**PCV**	**hb2**	**EGA**	**GA**
PHMme	0.33743*	0.01348	1.91	0.01348	0.11	0.12	0.33	0.349	17.18	18.22	88.90	63.83	33.37
NEPl	0.030667	0.008167	1.07	0.008167	0.01	0.02	0.09	0.125	8.07	11.66	47.87	12.34	11.50
SC	12795.2*	669.2	158.07	669.2	4042.00	4711.20	63.58	68.638	40.22	43.42	85.80	12131.03	76.75
DF(male)	27.73*	5.4333	53.60	5.4333	7.43	12.87	2.73	3.587	5.09	6.69	57.77	426.89	7.96
DF(Female)	46.4*	4.6	56.40	4.6	13.93	18.53	3.73	4.305	6.62	7.63	75.18	666.72	11.82
BMkg	2616.6*	201.2	54.63	201.2	805.13	1006.33	28.37	31.723	51.94	58.07	80.01	5228.34	95.71
HSW	9.9*	1.7	37.73	1.7	2.73	4.43	1.65	2.106	4.38	5.58	61.65	267.42	7.09
PY	116.38*	20.99	16.76	20.99	31.80	52.79	5.64	7.265	33.65	43.36	60.24	901.54	53.80
YtHa	5.747*	1.037	3.72	1.037	1.57	2.61	1.25	1.615	33.65	43.36	60.22	200.31	53.79
HI	0.016175*	0.002477	0.34	0.002477	0.00	0.01	0.07	0.084	19.87	24.67	64.83	11.21	32.95

Where: * indicates significant at 0.05, Genotypic mean square/ Treatment Mean Square = Tret MS, Error Mean Square= EMS, Grand Mean= GM, Environmental variance (σ2e) = Mse, Genotypic variance (σ2g) = (msg – mse) /r, Phenotypic Variance (σ2ph) = σ2g + σ2e, σg = genotypic standard deviation, "σp = phenotypic standard deviation, GCV = Genotypic Coefficient of Variation (GCV) = (σg/grand mean) x 100, PCV = Phenotypic Coefficient of Variation (PCV) = (σph/grand mean) x 100, Heritability, Genetic advance for selection intensity (k) at 5% (2.06) and Ggenetic advance as percent of population mean= GA

Table 3. Correlation among Fifteen Characters of Five Maize Genotypes at Kuraz Sugar Development Projects

	DE	SC	PHDAP cm	EM	Wild	PHMme	EL	NEP	SC	DF (Male)	DF (Female)	BMkg	HSW	PY	YtHa
SC	-0.526*														
PHDAPcm	0.088	0.166													
EM	0.096	0.072	-0.318												
Wild	0	-0.009	0.034	-0.747*											
PHMme	-0.067	0.448	0.221	0.456	-0.422										
EL	-0.066	-0.08	0.021	0.491	-0.47	0.273									
NEP	0.108	-0.47	0.281	-0.391	0.038	-0.556	-0.102								
SC	-0.301	0.551*	-0.01	0.56*	-0.549*	0.855*	0.235	-0.444							
DF(Male)	-0.041	0.293	-0.01	0.468	-0.366	0.797*	0.059	-0.395	0.751*						
DF(Female)	-0.009	0.439	0.049	0.648*	-0.52*	0.869*	0.308	-0.49	0.855*	0.895*					
BMkg	-0.067	0.466	0.221	0.549*	-0.535	0.839*	0.448	-0.353	0.885*	0.678*	0.891*				
HSW	0.061	-0.124	0.437	0.043	-0.065	0.341	0.365	-0.002	-0.029	0.299	0.264	0.117			
PY	-0.168	0.423	0.447	0.254	-0.384	0.835*	0.336	-0.224	0.799*	0.602*	0.725*	0.885*	0.182		
YtHa	-0.168	0.423	0.447	0.254	-0.384	0.835*	0.336	-0.224	0.799*	0.602*	0.725*	0.885*	0.182	1	
HI	-0.114	-0.26	0.148	-0.727*	0.566*	-0.686*	-0.407	0.399	-0.748*	-0.727*	-0.87*	-0.818*	-0.097	-0.502	-0.502
	0.686	0.35	0.598	0.002	0.028	0.005	0.132	0.14	0.001	0.002	0	0	0.731	0.057	0.057

Where: * indicates significant at 0.05 and **highly significant EM=early maturity, PHMme= plant height at maturity, NEP= number of ear per plant, SC= stalk count, DF(Female)= flowering date for female, BMkg=biomass, HSW=hundred seed weight, PY= plot yield in kg, YtHa= grain yield per hectare in tones and HI= harvest index.

Table 4. Mean Separation result for ten traits of Five Maize genotypes at Omo-Kuraz Sugar development Project

Tret Cod	Entries	N	EM Mean	PHMme Mean	NEP Mean	SC Mean	DF(Female) Mean	BMkg Mean	HSW Mean	PY Mean	YtHa Mean	HI Mean
Tret1	BH547	3	4.67a	2.19a	1b	229a	60a	81.91a	38.33ab	19.83ab	4.41ab	0.25b
Tret2	Melkassa-2	3	1.67b	1.87b	1.2a	158.33b	54.67b	44.93b	36.67b	16.91ab	3.76ab	0.38a
Tret3	MH140	3	2.67b	2.02ab	1b	127.67b	56.67ab	41.82b	40.67a	15.68b	3.48b	0.37a
Tret4	BH546	3	3ab	2.16a	1b	209.333a	60a	87.42a	36.33b	24.12a	5.36a	0.28b
Tret5	MH130	3	1.67b	1.377C	1.17AB	66c	50.67c	17.06b	36.67b	7.25c	1.61c	0.42a

Where: 1. EM=early maturity, PHMme= plant height at maturity, NEP= number of ear per plant, SC= stalk count, DF(Female)= flowering date for female, BMkg=biomass, HSW=hundred seed weight, PY= plot yield in kg, YtHa= grain yield per hectare in tones and HI= harvest index. 2. Means that do not share a letter are significantly different

Table 5. Economic Advantage of Maize Production

Genotypes	**Production cost per components (Birr per Hectare)**					**Production and income**		**Net Profit birr/ha(I-P)**	**Genotypes Economic advantage over the national average**	**Remark**
	Total Land Preparation	**Total Inputs**	**Total Crop Management**	**Other Cost**	**Production Cost Total(P)**	**Productivity Qt/ha**	**Income Birr/ Hectare (I)**			
BH546	3000	3000	2500	500	9000	53.6	18760	9760	5110	350 birr/Qt farm get selling price
BH547	3000	3000	2500	500	9000	44.1	15435	6435	1785	
Melkassa-2	3000	3000	2500	500	9000	37.6	13160	4160		
MH140	3000	3000	2500	500	9000	34.8	12180	3180		
MH130	3000	3000	2500	500	9000	16.1	5635	-3365		
Average National Productivity	3000	3000	2500	500	9000	39	13650	4650		

Based on the obtained data it is possible to project the net profit that could be generated by cultivating 1000 hectares of land by cultivating the superior genotype BH546

Total production = Productivity X 1000 hectares
= 53.6qt X 1000 = 53600 quintals

Total Income/hectare = 53.6qt X Unit product Sealing price

Net profit per hectare = Total Income/hectare - Total Production Cost/hectare

Net Profit = net profit per hectare X 1000 hectares
= 9760 X 1000 = 9,760,000 birr

The simple economic analysis result indicated here shown that by cultivating 1000 hectare of land at the project site with the selected superior Maize genotype could possibly generate 9,760,000 birr within five months, the income could also be doubled. We can simply understand the significant contribution of cultivating projected 1000 hectares of land with this variety mean that, producing 53,600 quintals could provide food for at least 13,400 people for (considering 4qt/year/person FAO Food production margin) at least 12, 700 people.

Conclusion and Recommendation

The analysis of variance showed that genotypes included in the test differed highly and significantly at (p 0.01) probability level for two traits Plant height at maturity (PH(m)) and stalk count(SC), while, early maturity (EM), Flowering date (DF(Female)) for female, Male flowering date (DF(male)), Biomass (BMkg), hundred seeds weight (HSW), plot yield (PY), grain yield in tones per hectare (GYtHa) and harvest index (HI) differ significantly at (p 0.05). This indicates that the existence significant amount of phenotypic variability and all the genotypes differed each other with regard to the mentioned characters that opened a way to proceed for further improvement research.

The mean comparison result revealed that BH546 given significantly higher grain yield mean value per plot in kg (24.12) followed second by BH547 (19.83) and the third Melkassa-2 (16.91) with respective mean value for grain yield in kilograms per plot. While, Treatment BH546 given significantly higher superior grain yield mean value per hectare in tones (5.36a) than the other genotypes followed second by BH547 (4.41) and third Melkassa-2 (3.76) with respective mean value for grain yield in tones per hectare. As indicated in Table 3, BH547 (4.67) significantly late maturing genotype than other genotypes followed by BH546 (3), while, two maize genotypes Melkassa-2 (1.67) and MH130 (1.67) mature earlier than BH547 and BH546 with statistically significant difference

As the mean separation indicated, genotype BH546 and BH547 with respective 53.6 and 44.1 quintals yield per hectare were found to be superior. Genotype BH546 with 53.6 qt/ha productivity scored the highest net income 9760 birr/ha than the others genotypes followed by BH547 6435 birr/ha.

Therefore, from this study it can be suggested that genotypes BH546 which scored the first superior grain yield per hectare mean value and better maturity class with higher economic advantage shall be recommended for commercial production at Omo-Kuraz Sugar Development Project. 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 fertilizer rate, planting time and season by considering to the specific Agro-climatic condition of the area.

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