International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG(USA) Volume 6, Issue 4 - 2019

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.04.019

Evaluation of Sorghum Variety (*Sorghum bicolar* (L.), *Moench*) Adaptation Performance at Omo - Kuraz Sugar Development Project South Omo Zone, SNNPRs, Ethiopia

Zinaw Dilnesaw*[1], Mohamd Ebrahim[1], Belete Getnet[1], Yohanisse Mequaninnet[1], Hadush Hagos[1], Abiy Getaneh[1], Fikadu Fanjana[1], Abiwa Adane[1] and Tadesse Negi[1]

[1]Ethiopia Sugar Corporation Research and development Main Center
*Corresponding author: *zinawzi@gmail.com*

Abstract

Ethiopia is one of the centers of origin and domestication of sorghum and has an immense genetic diversity in the country diversified forms of the crop and its wild relatives represent possible sources of germplasm for crop improvement, Source of Novel genes and High lysine sorghum are characteristics of Ethiopian Sorghum. Six Sorghum genotypes were evaluated in RCBD with three replications at Omo Kuraz Sugar development Project in surface irrigation. Analysis of variance showed that genotypes included in the test differed highly and significantly at (p 0.01) probability level with respect to Plant height (PH(cm)) and Head length (EL(cm)). Treatment ESH 1 scored significantly higher mean value (5.0763) for GY(t/ha) than the other genotypes followed by Teshale (4.43037) and the third Dekaba (3.70519) with respective mean value for grain yield in tones per hectare. Genotype ESH 1 with 50.8 qt/ha productivity scored the highest net income 6240 birr/ha than the others genotypes followed by Teshale 4230 birr/ha profit. Therefore, genotypes ESH 1 and Teshale which scored the first and second superior grain yield per hectare mean value and higher economic advantage shall be recommended for commercial production at Omo-Kuraz Sugar Development Project.

Keywords: Genootypes, Adaptation, Performance

Introduction

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 (Adaptation and Promotion project document, 2016).

Sugarcane is rapidly becoming one of the most important industrial crops in the world, Owing its suitability to the low land areas and associated benefit of sugar production, the Government of Ethiopia has targeted to place Ethiopia among the top 10 sugar producing nations in the world by the year 2023. 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 the under-utilized land for other agricultural production until the factories 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. 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 utilized for 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 Sorghum in the selected sugar estates in order to identify high yield performance crop varieties.

Sorghum has its origin in Ethiopia and from here it spread to other parts of Africa, India, Asia, Australia and the US (Tawanda, 2004; ICRISAT, 2005). Ethiopia is one of the centers of origin and domestication of sorghum and has an immense genetic diversity in the country diversified forms of the crop and its wild relatives represent possible sources of germplasm for crop improvement. Source of Novel genes and high lysine sorghum (Singh & Axtel, 1973) are characteristics of Ethiopian Sorghum.

Sorghum is indigenous to Ethiopia contributes about 20-22% of total cereal production which is very important crop in the lowland arid and semi-arid areas which is dominant crop in areas where soil fertility degradation and drought stress are key constraints. Sorghum grows in 12 of the 18 major agro-ecological zones and stands 3rd next to teff and maize in area coverage while in moisture stress lowland areas of the country, it is the first both in area and production and second in total production next to maize (Feed Africa, 2015). It covers 16% of the total area allocated to grains and 20% of the area covered by cereals (CSA, 2013). Currently Sorghum covers 1.83 million ha area and 4.34 million quintals production with national average grain productivity 24 q/ha, and 5.7 million smallholder farmers grow sorghum (CSA, 2013). It is cultivated in all regional states of Ethiopia in altitude ranges of 400m to 2500m potential to produce a yield of 30-60Qt/ha using improved varieties and production practices (CSA, 2013). One of the major traditional food crops of Ethiopia and the second most important crop for Injera making quality next to teff.
Therefore, this study was initiated with the objective to evaluate adaptation performance of sorghum genotypes thereby to identify high yielding and heat tolerant Sorghum varieties 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.

Omo valley is situated largely in the South Omo Zone that consists of eight Woredas inhabited by 16 tribes. 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.

Omo-Kuraz Sugar Development Project is located 900 km from Addis Ababa at an altitude ranging from 370-500 m.a.s.l in Selamago Wereda of South Omo Zone. The project area receives modest rainfall annually and close to the Kefa Skeka Zone in the North West.

Materials and Methods

Sorghum genotypes (Melkam, Dekeba, Teshale, ESH1, ESH3 and ESH4) were used for variety adaptation trial with 0.4kg required seed amount. Some of the candidate varieties have been in production and have proved their potential in similar agro-ecologies. Pertaining to this fact, the trial is 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 for the respective crops and locations.

Crop performance data on days to 50% emergence, days to flower, tiller count, days to maturity, plant height, panicle length, tassel/heading length, stalk count at harvest, disease incidence, insect attack, vigourisity, stay greenness, thousand seed weight, grain weight were taken, and also grain yield and harvest index were calculated.

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 computed for the characters such as days to 50% emergence, days to flower, tiller count, days to maturity, plant height (PH(cm)), peduncle length (PL), tassel/ear/heading length, stalk count at harvest, vigourisity, stay greenness, thousand seed weight, grain weight, grain yield(GYtHA) and harvest index.

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 by 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 with respect to Plant height (PH(cm)) and Head length (EL(cm)) characters.(Table 1). Moreover, studied genotypes differ significantly at (p 0.05) for Number of tiller (NT), Stand count (SC) and Grain Yield per hectare (GY(t/ha)) and varieties showed wider variability for Disease Response (DiS), Vigourisity (VG), Stay greenness (SG) and Early maturity (EM) (annex). This indicates that there was significant amount of phenotypic variability and all the genotypes differ each other with regard to the studied characters that opened a way to proceed for further improvement through simple selection.

Similarly, Geleta and Labuschagne (2005) found the existence of morphological variation among sorghum accessions collected from eastern parts of Ethiopia using 10 morphological traits. Teshome et al. (1997) evaluated 117 sorghum accessions from the North Shewa and South Welo regions of Ethiopia based on 14 morphological traits and reported extensive variation of the accessions. Grenier et al. (2004) observed the morphological diversity among sorghum accessions as well as a high level of diversity within each region and was distributed with geographical origin using 2017 Sudanese sorghum landraces. Barro-Kondombo et al. (2010) also found a high level of morphological and genetic variability in sorghum varieties from Burkina Faso. Morphological traits provide a simple way of measuring genetic diversity while studying genotype performance under normal growing conditions, but are influenced by environmental factors (Tuinstra et al., 1996; Beuningen and Busch, 1997; Abdi et al., 2002; Fufa et al., 2005). These result 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.

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 GCV and PCV was observed for number of tiller per plant (64.85 and 97.98) followed by Plant height (39.51 and 39.87), while plot grain yield (31.21), biomass yield (32.70), and grain yield per hectare (31.21) resulted high PCV as indicated in (Table 2). The lowest GCV and PCV values were observed for stalk count (22.66 and 29.83). The genotypic variance was found to be relatively lower than its corresponding phenotypic variance for all character indicating that environment plays significant role on expression of traits. 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

Heritability values are categorized as low (0-30%), moderate (30-60%) and high (60% and above) as stated by Robinson et al., (1949).In the present study, broad sense heritability was computed for the studied ten characters and presented in Table 2. It ranged from 16.93 % (harvest index) to 98.20% (Plant height). Plant height and Ear length scored high heritability; moderate heritability were recorded for number of tiller per plant, stand count, thousand seed weight, grain yield per plot and grain yield per hectare while biomass yield and harvest index recorded low heritability.

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). Low genetic advance were recorded for harvest index while; moderate value were recorded for thousand seed weight and biomass yield while high genetic advance as the percentage of the mean (GAM) at 5% selection intensity were recorded for plant height, number of tiller per plant, stand count, grain yield per plot and grain yield per hectare (table 2).

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 Grain Yield per hectare (GY(t/ha)), Biomass (BM), Plant height (PH(cm)), Earliness, Stand Count, Response to pest (Pest), Ear length (EL(cm)) and grain yield per plot (GW) characters are presented in Table 4. The result indicated that the existence of wide variation among genotypes for studied traits.

The result revealed that Treatment ESH 1 score significantly higher mean value Grain yield per plot (22.8433) followed by Teshale (19.9367) and the third Dekaba (16.6733C) with respective mean value for grain yield in kilograms per plot. While, Treatment ESH 1 score significantly higher mean value (5.0763) for GY(t/ha) than the other genotypes followed by Teshale (4.43037) and the third Dekaba (3.70519) with respective mean value for grain yield in tones per hectare.

As indicated in Table 4, Teshale with 109.77A Biomass mean value scored first followed by Dekaba (94.828) and ESH 1(94.82), The mean value for early maturity indicate that genotype ESH3 is earlier than others followed by ESH 1 and Teshale, While, ESH4 scored significantly higher Disease and insect pest susceptibility followed by treatment ESH3 and Dekaba but treatment ESH 1 and Teshale showed lowest pest susceptibility indicating that these two genotypes are better tolerant than the studied genotypes.

Table 1. ANOVA, variance components, broad sense heritability, genetic advance as percent of mean for nine characters of six studied Sorghum genotypes at Omo-Kuraz Sugar development Project

Traits	Tret MS	EMS	GM	σ2 e	σ2g	σ2ph	σg	σph	GCV	PCV	hb2	EGA	GA
PH(cm)	1.09*	0.00663	1.52	0.00663	0.36	0.37	0.60	0.606	39.51	39.87	98.20	122.68	80.65
EL(cm)	0.011*	0.000496	0.33	0.000496	0.00	0.00	0.06	0.063	17.52	18.74	87.38	11.28	33.73
NT	0.71*	0.2126	0.63	0.2126	0.17	0.38	0.41	0.615	64.85	97.98	43.81	55.51	88.43
SC	9293.7*	1825.3	220.22	1825.3	2489.47	4314.77	49.89	65.687	22.66	29.83	57.70	7807.19	35.45
TSW(gm)	34.46	10.96	34.72	10.96	7.83	18.79	2.80	4.335	8.06	12.49	41.68	372.23	10.72
GW	56.25*	12.19	16.61	12.19	14.69	26.88	3.83	5.184	23.07	31.21	54.64	583.58	35.13
BM	1113.8	606	85.14	606	169.27	775.27	13.01	27.844	15.28	32.70	21.83	1252.31	14.71
GY(t/ha)	2.778*	0.6019	3.69	0.6019	0.73	1.33	0.85	1.152	23.07	31.21	54.65	129.70	35.14
HI	0.0035	0.002173	0.21	0.002173	0.00	0.00	0.02	0.051	10.08	24.51	16.93	1.78	8.55

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 2. Correlation among Fifteen Characters of Six Sorghum Genotypes at Kuraz Sugar Development Projects

	DE	PH	DiS	VG	SG	EM	PH(cm)	EL(cm)	NT	SC	TSW(gm)	GW	BM	GY(t/ha)
PL	-0.402													
DiS	0.161	-0.396												
VG	0.377	-0.242	0.769*											
SG	-0.142	-0.051	0.617*	0.227										
EM	-0.142	-0.108	0.399	-0.076	0.886*									
PH(cm)	-0.209	0.656*	-0.529*	-0.171	-0.158	-0.361								
EL(cm)	0.255	-0.448	0.447	0.333	-0.242	-0.148	-0.744*							
NT	0.125	-0.172	0.461	0.309	0.035	0.046	-0.45	0.771*						
SC	-0.219	0.51*	-0.552*	-0.53*	0.052	0.033	0.69*	-0.728*	-0.52*					
TSW(gm)	-0.327	0.437	0.166	0.293	0.21	-0.111	0.537*	-0.221	0.21	0.274				
GW	-0.337	0.539*	-0.628*	-0.696*	-0.194	-0.043	0.442	-0.302	-0.095	0.792*	0.188			
BM	-0.312	0.581*	-0.451	-0.338	-0.173	-0.191	0.5*	-0.379	-0.325	0.649*	0.27	0.597*		
GY(t/ha)	-0.337	0.539*	-0.628*	-0.696*	-0.194	-0.043	0.442	-0.302	-0.095	0.792*	0.188	1	0.597*	
HI	0.066	-0.24	0.132	-0.04	-0.017	0.076	-0.257	0.391	0.533	-0.252	-0.013	0.081	-0.712*	0.081

Where; DE= days to 50% emergence, PL= peduncle length, DiS= disease response,VG= vigourisity, SG= stay green, EM= early maturity,EL=ear length, NT= number of tiller, SC= stalk count, TSW= thousand seed weight, GW= grain weight, BM= biological mass(kg), GY= grain yield (t/ha), HI= harvesting index

Table 3. Mean Comparison for Eight studied characters of six Genotypes

Cod	Entries	GY(t/ha)	BM	PH	Earliness	Stand Count	Pest	EL(cm)	GW
Tret1	ESH 1	5.0763A	94.82AB	1.528B	2E	238AB	1F	0.364333AB	22.8433A
Tret2	ESH3	2.34148C	73.834AB	1.34333C	1F	151C	4B	0.397333A	10.5367C
Tret3	Teshale	4.43037AB	109.77A	2.68467A	3D	305A	2E	0.236667D	19.9367AB
Tret4	ESH4	3.16889BC	54.652B	0.92933D	6A	173BC	5A	0.383A	14.26BC
Tret5	Dekaba	3.70519ABC	94.828AB	1.296C	5B	248AB	3C	0.300667C	16.6733A
Tret6	Melkam	3.42593BC	82.929AB	1.346C	4C	206.333BC	2D	0.325BC	15.4167BC
LSD		1.411	44.78	8.94	**	77.7	**	0.04053	6.351
CV		21.0	28.9	15.3	**	19.4	**	6.7	21.0

Table 4. Economic Advantage of Sorghum production studied in Omo Kuraz Sugar Development Projects

Genotypes	Estimated Production cost per components (Birr per Hectare)					Production and income		Estimated Profit birr/qt(I-P)	Remark
	Total Land Preparation	Total Inputs	Total Crop Management	Other Costs	Production Cost Total(P)	Productivity Qt/ha	Income birr/ha (I)		
ESH 1	3000	3000	2500	500	9000	50.8	15240	6240	350 birr/Qt farm get selling price
Teshale	3000	3000	2500	500	9000	44.1	13230	4230	
Dekaba	3000	3000	2500	500	9000	37.06	11118	2118	
Melkam	3000	3000	2500	500	9000	34.3	10290	1290	
ESH4	3000	3000	2500	500	9000	31.7	9510	510	
ESH3	3000	3000	2500	500	9000	23.41	7023	-1977	
Average National Productivity	3000	3000	2500	500	9000	24	7200	-1800	

Economic Advantage of Sorghum Production

The economic analysis result shown that producing Sorghum in Omo-Kuraz Sugar development project could provide additional income to the project with net profit that ranges from 510 to 6240 birr per one hectare. As indicated in the table 5 genotype **ESH 1** with 50.8 qt/ha productivity scored the highest net income 6240 birr/ha than the others genotypes followed by Teshale 4230 birr/ha (Total Income minus total production cost).

Based on the obtained result it is possible to project the net profit that could be generated by scaling up the result by cultivating 1000 hectares of land with the superior genotype **ESH 1**

Total production = Productivity X 1000 hectares
= 50.8 qt X 1000 = 50,800 quintals

Total Income/hectare = 50.8 qt X Unit product Sealing price

Net profit per hectare = Total Income/hectare - Total

Production Cost/hectare

Total Net Profit = net profit per hectare X 1000 hectares
= 6240 X 1000 = 6,240,000 birr

The simple economic analysis result indicated here shown that by cultivating 1000 hectare of land at the project site with the selected superior genotype could possibly generate 6,240,000 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 genotype means, producing 50,800 quintals this could provide food for (considering 4qt/year/person FAO Food production margin) at least 12, 700 people.

Conclusion and Recommendation

The analysis of variance showed the presence of highly significant ($p<0.01$) differences among the tested genotypes for most of the characters, indicating the existence of variability among the tested genotypes for these characters. Since yield is a function of different traits, a genotype with a better adaptation potential expressed in superior grain yield values. Genotype ESH 1 scored significantly highest grain yield in tones per hectare mean value 5.1 followed by Teshale and Dekaba with 4.4 and 3.7 tones of grain per hectare respectively.

Genotype **ESH 1** with 50.8 qt/ha productivity scored the highest net income 6240 birr/ha than the others genotypes followed by Teshale 4230 birr/ha profit.

Therefore, from this study it can be suggested that genotypes ESH 1 and Teshale which scored the first and second superior grain yield per hectare mean value and 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.

Acknowledgments

I would like to thank Sugar Corporation, Ethiopian Agricultural Research Council Secretariat, Ethiopian Institute of Agricultural Research, South Nationalities and Peoples Region Institute of Agricultural Research, Omo-Kuraz-1 Sugar Development Project, Jinka Agricultural Research Center, Kuraz Research and Development Center staff members for their follow up and commitment for joint implementation of “cereal and forage crop adaptation research project in new sugar development projects”.

References

Abdi, A.; Bekele, E.; Asfaw, Z.; Teshome, A. 2002. Patterns of morphological variation of sorghum [*Sorghum bicolor* (L.) Moench] landraces in qualitative characters in North Showa and South Welo, Ethiopia. Hereditas 137: 161-172.

Adaptation and Promotion of Selected Cereal and Forage Crops in Newly Established Sugar Estates Ethiopian Agricultural Research Council Secretariat, July 2016, Addis Ababa, Ethiopia

Barro-Kondombo, C.; Sagnard, F.; Chantereau, J.; Deu, M.; Brocke, K.V.; Durand, P.; Goze, E.; Zongo, J.D. 2010. Genetic structure among sorghum landraces as revealed by morphological variation and microsatellite markers in three agro climatic regions of Burkina Faso. Theoretical and Applied Genetics 120: 1511-1523.

Beuningen, L.T. van; Busch, R.H. 1997. Genetic diversity among North American spring wheat cultivars: III. Cluster analysis based on quantitative morphological traits. Crop Science 37: 981-988.

Central Statistical Agency (CSA), 20013. Report on area and production forecast for major crops (for private peasant holdings, Meher season). Statistical bulletin, Addis Ababa, Ethiopia.

Cochran, W.G. and M. Cox, 1957. Experimental Designs. John Wiley and Sons, Inc., New York, pp: 611.

CSA (2015): Annual Statistical Report 2015: Smallholder Agriculture, Crop Production. Central Statistical Authority, Addis Ababa

Fufa, H.; Baenziger, P.S.; Beecher, B.S.; Dweikat, I.; Graybosch, R.A.; Eskridge, K.M. 2005. Comparison of phenotypic and molecular marker-based classifications of hard red winter wheat cultivars. Euphytica 145: 133-146.

Geleta, N.; Labuschagne, M.T. 2005. Qualitative traits variation in sorghum (*Sorghum bicolor* (L.) Moench) germplasm from eastern highlands of Ethiopia. Biodiversity and Conservation 14: 3055-3064.

Grenier, C.; Bramel, P.J.; Dahlberg, J.A.; El-Ahmadi, A.; Mahmoud, M.; Peterson, G.C.; Rosenow, D.T.; Ejeta, G. 2004. Sorghums of the Sudan: analysis of regional diversity and distribution. Genetic Resources and Crop Evolution 51: 489-500.

Johnson HW, Robinson HF, Comstock RE (1955). Estimates of genetic and environmental variability in soybeans. Agronomy Journal 47: 314-318.

Robinson HF, Comstock RE, Harvey VH (1949). Estimates of heritability and degree of dominance in corn. Agron. J., 41: 353-359.

Shivasubramanian S, Menon M (1973). Heterosis and inbreeding depression in rice. Madras Agric. J., 60: 1139

Singh, R.K. and B.D. Chaudhary, 1973. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi-Ludhiana, India, pp: 318.

Tawanda, Z. (2004) DNA-Based Methods in Sorghum Diversity Studies and Improvement. Plant Biotechnology Center, Ohio State University.

Teshome, A.; Baum, B.R.; Fahrig, L.; Torrance, J.K.; Arnason, T.J.; Lambert, J.D. 1997. Sorghum [*Sorghum bicolor* (L.) Moench] landrace variation and classification in North Showa and South Welo, Ethiopia. Euphytica 97: 255-263.

Access this Article in Online	
	Website: www.ijarbs.com
Quick Response Code	Subject: Agricultural Sciences
DOI:10.22192/ijarbs.2019.06.04.019	

How to cite this article:
Zinaw Dilnesaw, Mohamd Ebrahim, Belete Getnet, Yohanisse Mequaninnet, Hadush Hagos, Abiy Getaneh, Fikadu Fanjana, Abiwa Adane and Tadesse Negi. (2019). Evaluation of Sorghum Variety (*Sorghum bicolar (L.) , Moench*) Adaptation Performance at Omo- Kuraz Sugar Development Project South Omo Zone, SNNPRs, Ethiopia. Int. J. Adv. Res. Biol. Sci. 6(4): 149-156.
DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.04.019