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Evaluation of Rice (*Oryza sativa* L.) Variety Adaptation Performance at Omo Kuraz Sugar Development Project Salamago District South Omo Zone, SNNPR state, Ethiopia.

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Abstract

Five candidate varieties of Rice 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 Omo Kuraz conditions. The plot size was 10 m by 10 m. The trial was carried out using surface irrigation following others recommended agronomic practices. The analysis of variance shown that genotypes included in the test differed significantly at ($p<0.05$) probability level with respect to days of flowering, panicle length, plant height at maturity, thousand seed weight, biomass and harvest index. Highest yield were recorded for Nerica- 12 with 34.8qt/ha followed by Hibir with 32.7qt/ha grain yield value and recorded 5.9 qt/ha and 3.8 qt/ha more yield over the national productivity average. The obtained grain yield value indicate producing these two genotypes could earn 20% and 13.1 % more yield over the national productivity average respectively.

Keywords: variance, genotype, Kuraz

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).

The government of Ethiopia has established new sugar factories is undergoing, Among newly established sugar estates Kuraz, Beles and Tendaho have bigger farm land size that ranges between 50 and 150 thousands of hectares (ESC). 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 (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 the national research system yet. As a result food crop varieties with specific adaptability to these areas not yet developed. 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 Rice in Omo-Kuraz which is one of the new sugar development projects in order to identify suitable crop varieties.

Rice belongs to family Poaceae and genus *Oryza* and most probably originated in India or southeastern Asia. It has two cultivated and 22 wild species. The cultivated species are the Asian rice, *Oryza sativa* L. and the African rice, *Oryza glaberrima* Steud. The Asian rice is grown all over the world while African rice has originated and been cultivated in West Africa for about more than 3500 years (Martin *et al.*, 2006). Rice, a diploid species with a chromosome number of 2n = 24, is normally a self pollinated crop but up to 3% natural out crossing may occur depending on the cultivar and the environment, although about 0.5% is the average out-crossing level (Poehlman and Sleper,1995).

Rice is currently considered as a strategic food security crop in Ethiopia as Teshome and Dawit, (2011) reported. Rainfed rice, is cultivated in Amhara, Tigray, Oromia, South NNPR, Gambella and Benshangule Gumuze Regions of Ethiopia (MoA , 2010). According to Shahi (1994), in Ethiopia rainfed upland rice could be grown in the altitudinal range of 1000 to 2000 m.a.s.l. and also the country has an estimated thirty million hectares of land suitable for rice production (MoA, 2010). The total cultivated area at national level has increased from 30,649 in 2011/2012 to 41,811.97 hectares in 2012 / 2013 about 36.42% increment were recorded nationally with considerable difference across regions. Accordingly, production has increased from a total of 886,158 quintal, in 2011/12 to 1,210,415 quintal in 2012/13, While productivity in quintal per hectare has increased from 28.91in 2012 to 28.97 as CSA (2014) reported.
Therefore, this study was initiated with the objective to evaluate adaptation performance of Rice genotypes thereby to identify high yielding and heat tolerant varieties in Kuraz sugar estate.

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. The estimated land coverage of Kuraz Sugar Development project is 175, 000 ha.

The project area receives modest rainfall annually and close to the Kefa Skeka Zone in the North West. 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^{o}c and 22.91^{o}c 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.

Experimental Materials and Design

Five candidate Rice varieties (Nerica- 12, Adet, Edget, Hibir and Fogera -2) were used for rice genotypes adaptation performance trial at Omo Kuraz Sugar Development Projects.

Some of the candidate varieties have been in production and have proved their potential in selected agro-ecologies. Pertaining to this fact, the trial were set to be organized as two independent activities but related to help achieve the specific objectives of evaluating varieties for their adaptation and demonstration of more promising ones on larger plots at the same time.

In mother trial, the candidate varieties were tested using RCBD design with three replications following appropriate statistical procedures. This study was targeted to evaluate adaptation ability and yield potential of the candidate varieties and identify the best performing under Omo Kuraz conditions. The plot size for this trial was 10 m by 10 m. The trial was carried out using surface irrigation and following others recommended agronomic practices.

Crop performance data were recorded on number of fertile tillers per plant (TP), plant height (PH), panicle length (PL), number of panicle lets per plant (NPL) in sample base; whereas days to emergence (DE), days to heading (HD), days to maturity (MD), harvest index (HI), thousand seed weight (TSW), biological yield (BY), straw biomass (SBM), plot yield, grain yield per hectare (GYH) in measurements on plot basis.

Analysis of variance:

The data obtained for different traits was statistically analyzed using GenStat 15th Edition Software. Analysis of Variance for RCBD design was computed for the characters such as number of tillers per plot, Date of heading, number of panicle lets, Date of maturity, Plant height in cm at maturity, harvest index and thousand seed weight, biological yield, grain yield per hectare.

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), and 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 shown in table (1) indicates that genotypes included in the test differed highly and significantly at ($p<0.05$) probability level with respect to days of heading, panicle length, plant height at maturity, thousand seed weight, biomass and harvest index; Sabouri *et al.* (2008) recommended plant height as an important trait for selection of high yielding rice plants where as Pantuwan *et al*. (2002) also reported significant variation in plant height; Variation in days to maturity in different genotypes have also been reported by Sabouri *et al.* (2008). This indicates that there was significant amount of phenotypic variability and all the genotypes differs each other with regard to the studied characters that opened a way to proceed for further improvement through simple selection.

Variability is the occurrence of differences among individuals due to differences in their genetic composition and/or the environment in which they are raised (Allard, 1960). If the character expression of two individuals could be measured in an environment identical for both, differences in expression would result from genetic control and hence such variation is called genetic variation (Falconer and Mackay, 1996). Information on the nature and magnitude of genetic variability present in a crop species is important for developing effective crop improvement program (Dabholkar, 1999). Genetic variability, which is due to the genetic differences among individuals within a population, is the core of plant breeding because proper management of diversity can produce permanent gain in the performance of plant and can buffer against seasonal fluctuations (Sharma, 1998) Genetic variability among traits is important for breeding and in selecting desirable types.

Table 1. ANOVA result of nine characters of Five Rice Genotypes at Omo Kuraz

Characters	TMS	Mse	GM
DE	0.7333	0.4833	11.6
DH	192.67*	23.32	84.34
NT	9433	6005	381.8
PL	5.857*	1.028	22.474
PHM	613.81*	40.5	63.68
TSW	127.1*	13.15	33.532
BM	181.58*	30.06	24.84
BMp	184.29	79.1	56.08
Yp	20.02	36.5	31.26
Y_t_ha	0.2002	0.365	3.126
BM_t_ha	1.8429	0.791	5.608
HI	0.020835*	0.004834	0.5622

Where:* significant at 0.05% probability level, DE= days of emergency, DF= days of flowering, NT= number of tillers, PL= panicle length, PHM= plant height at maturity, TSW= thousand seed weight, BM= biomass yield, BMp= plot biomass yield, Yp= plot yield, Y_t_ha= grain yield per hectare, BM_t_ha= biomass yield tone per hectare and HI= harvest index

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 Plant height at maturity PHM (21.71 and 23.90) and straw Biomass (28.61 and 36.13), while Moderate GCV and PCV were recorded for TSW, BMp, BM_t/ha and HI (Tabel 2)

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 nine characters and presented in Table 2. It ranged from 13.08 for (grain yield) to 82.51 (plant height at maturity). High heritability were recorded for DH, PL, PHM, TSW, SBM and HI while moderate heritability were recorded for BM and low heritability were recorded for DE, NT and Yp.

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 DE, NT, PL and Yp while; moderate value were recorded for DH, BMp, BMt/ha and HI; whereas high genetic advance as the percentage of the mean (GAM) at 5% selection intensity were recorded for PHM, TSW and SBM.

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

Characters	Tret MS	EMS	GM	σ2 e	σ2g	σ2ph	σg	σph	GCV	PCV	hb2	EGA	GA
DE	0.7333	0.4833	11.6	0.4833	0.08	0.57	0.29	0.753	2.49	6.49	14.71	22.81	1.97
DH	192.67	23.32	84.34	23.32	56.45	79.77	7.51	8.931	8.91	10.59	70.77	1302.00	15.44
NT	9433	6005	381.8	6005	1142.67	7147.67	33.80	84.544	8.85	22.14	15.99	2784.23	7.29
PL	5.857	1.028	22.474	1.028	1.61	2.64	1.27	1.624	5.65	7.23	61.03	204.17	9.08
PHM	613.81	40.5	63.68	40.5	191.10	231.60	13.82	15.219	21.71	23.90	82.51	2586.80	40.62
TSW	127.1	13.15	33.532	13.15	37.98	51.13	6.16	7.151	18.38	21.33	74.28	1094.23	32.63
SBM	181.58	30.06	24.84	30.06	50.51	80.57	7.11	8.976	28.61	36.13	62.69	1159.15	46.66
BMp	184.29	79.1	56.08	79.1	35.06	114.16	5.92	10.685	10.56	19.05	30.71	676.02	12.05
Yp	20.02	36.5	31.26	36.5	5.49	41.99	2.34	6.480	7.50	20.73	13.08	174.63	5.59
Y_t_ha	0.2002	0.365	3.126	0.365	0.05	0.42	0.23	0.648	7.50	20.73	13.08	17.46	5.59
BM_t_ha	1.8429	0.791	5.608	0.791	0.35	1.14	0.59	1.068	10.56	19.05	30.71	67.60	12.05
HI	0.020835	0.004834	0.5622	0.004834	0.01	0.01	0.07	0.101	12.99	17.94	52.46	10.90	19.38

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 G genetic advance as percent of population mean= GA

The mean value comparison

Even if there were no statistical significant variability among tested genotypes for Grain Yield per hectare (GY(t/ha) as indicated in Table 3, the obtained grain yield result of Nerica- 12 and Hibir were greater than the national Rice productivity (2.89t/ha) as CSA 2014 reported. Highest yield were recorded for Nerica- 12 (3.48t/ha) followed by Hibir (3.27t/ha) and Edget (3.07t/ha).

Table 3. Mean Comparison among tested genotype for grain yield

Genotypes	Grain Yield t/ha
Nerica- 12	3.48a
Adet	2.81a
Edget	3.07a
Hibir	3.27a
Fogera -2	3a
Gmean	3.126
LSD	1.137
CV	19.3

Economic Advantage

As indicated in table 4 the highest genotype Nerica- 12 with 34.8qt/ha grain yield value recorded 5.9 qt/ha more yield over the national productivity average (28.9qt/ha) which indicate producing this genotype could earn 20% more yield over the national productivity average followed by Hibir with 32.7qt/ha grain yield value recorded 3.8 qt/ha more yield which indicate producing this genotype could earn 13.1 % more yield over the national productivity average.

Table 4. Yield Advantage of Tested genotypes over the national average

Genotypes	Grain Yield t/ha	Comparative Yield advantage (28.9qt/ha)	Yield Advantage in %
Nerica- 12	34.8	5.9	20.4
Hibir	32.7	3.8	13.1
Edget	30.7	1.8	6.2
Fogera -2	30	1.1	3.8
Adet	28.1	-0.8	

Profit Analysis of Rice Production

The economic analysis result shown that producing Rice could provide additional income to the Factory with net profit per quintal 365.79 birr. With the current finding 47 quintals per hectare the net profit will be 17192.17 birr considering the current selling price 700 birr/quintal (table 5). We can project the current finding to calculate the net profit before tax by producing 1000 hectares in Omo-Kuraz, with this simple analysis the profit could be 17,192,170 birr.

Table 5: Profit analysis of Rice

Description	Unit Measurement	Quantity/amount	Remark
Production (quintals/hectare)	Qt	47	700 birr/ quintal were considered as Grain selling price
Production cost per hectare	Birr	15707.83	
Total Income per hectare (production* grain selling price)	Birr	32900	
Gross Net Profit before tax per hectare	Birr	17192.17	
Production cost per quintal	Birr	334.21	
Net Profit from a quintal	Birr	365.79	

Conclusion and Recommendations

As indicated in the result and discussion section highest yield were recorded for Nerica- 12 with 34.8qt/ha followed by Hibir with 32.7qt/ha grain yield value and recorded 5.9 qt/ha and 3.8 qt/ha more yield over the national productivity average (28.9qt/ha) as CSA (2014) respectively. The obtained grain yield value indicate producing these two genotypes could earn 20% and 13.1 % more yield over the national productivity average respectively. As Ministry of Agriculture and Natural Resources Variety release, protection and seed quality control regulation demands 10% yield advantage is required for specific variety adaptation registration, therefore based on the result obtained these two genotypes Nerica- 12 and Hibir with 20% and 13.1 % yield advantage than the national average with relative better adaptability for Kuraz Agro Ecology and similar environment in similar season.

Based on the result obtained Nerica- 12 and Hibir shall be recommended for commercial production for Omo-Kuraz. Since the result obtained is one season and one location the experiment should have to be done in different soil types, seasons and similar experiments coupled with soil and agronomic practices research.

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