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Performance Evaluation of Six Rice (*Oryza sativa* L.) Varieties at Beles Sugar Development Project, Ethiopia

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Abstract

Rice is currently considered as a strategic food security crop in Ethiopia. A field experiment was conducted with the objective of evaluating the adaptation and yield potential of six rice varieties at Beles sugar development project. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications using rain fed during 2017/18 cropping season. The plot size of the experiment was 10 m x 10 m. The result of this experiment indicated differences among the six rice varieties for plant Height, number of tiller per plant, days to flowering, and number of days to maturity, 1000 grain weight and grain Yield ($P < 0.05$) but no significant differences among panicle lengths. The highest grain yield was obtained from the variety Fogera-2 (53.17 Qt/ha). Therefore it is recommended to use Fogera-2 rice variety for commercial production at Beles sugar development project area.

Keywords: Rice Varieties, Adaptation, Beles

1. Introduction

Rice (*Oryza sativa L.*), belonging to the family Graminae, is one of the most important cereal crops and serves as the primary source of staple food for more than half of the global population (Emani *et.al*; 2008). Approximately, 90% of the world's rice is grown in the Asian continent and constitutes a staple food for 2.7 billion people worldwide (Salim *et.al*; 2003). In Sub-Sahara Africa, over 20 million farmers grow rice and about 100 million people depend on it for their livelihoods (WARDA, 2005). The demand for rice in Sub-Sahara Africa is expected to grow substantially as the population is currently growing rapidly and rice consumption is growing faster than that of any major food. The world's rice production has doubled during the last 25 years, largely due to the use of improved technology such as high yielding varieties and better crop management practices (Byerlee 1996).

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 meter above sea level and also the country has an estimated thirty million hectares of land suitable for rice production (MoA, 2010). 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.

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.

Among newly established sugar estates Kuraz, Beles and Tendaho have bigger farm land size that ranges between 50 and 175 thousands of hectares. 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. 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 Beles which is one of the new sugar development projects in order to identify suitable crop varieties. Therefore, the objective of this experiment were to evaluate adaptation performance of different Rice varieties thereby to identify high yielding and heat tolerant Rice varieties adapted to Beles Sugar Development project in order to enhance the net national crop production in general and product diversification in sugar estates in particular in the near future.

2. Materials and Methods

2.1 Description of the study area

The study was carried out at Tana Beles sugar development project. It is located at $11^0$07'N and $36^0$20'E latitude with an altitude of 1119 m.a.s.l, in Amhara regional state, Awi Zone, Jawi Woreda, at a distance of 600 km far from Addis Ababa. The study area receives average annual rainfall of 1490 mm and mean minimum and maximum temperatures of 16.4 ^{0}C and 32.5^{0}C, respectively (Zeleke and Netsanet, 2015). Tana Beles sugar project planned to cover about 75,000 hectare of land for cane cultivation is covered by more than 50 % Vertisol, 9 % Luvisol, 5 % Nitosol, 5% Cambisol, and 6 % Liptosol; and also the mean clay, silt and sand percentages of the study area are 77.62, 15.69 and 6.69, respectively (Zeleke and Netsanet, 2015).

2.2 Treatments and experimental design

Table 1. Six Varieties (Treatments) of the experiment

S/N.	Treatments (Varieties)	Category	Area where it was released
1	Adet	Upland	Adet ARC
2	Nerica-12	Upland	Adet ARC
3	Hiber	Lowland	Adet ARC
4	Edget	Lowland	ADARC/ARARI
5	Fogera-2	Lowland	Fogera ARC
6	FOFIFA-3737	Upland	Gode ARC

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

2.3. Land preparation and sowing

The land was ploughed and harrowed well. Planting furrows were prepared and the land was divided to three blocks and eighteen plots each block having six plots. The size of experimental plots was 10 m by 10 m with the path of 1.0 m and 2.0 m between plots and blocks, respectively.

The trial was carried out using rain fed. NPS-Z was applied during sowing to all plots uniformly as starter with the rate of 65 kg ha^{-1}. Urea fertilizer was applied in two splits during the time of sowing and panicle initiation with the rate of 95 kg ha^{-1}. Seed sowing was conducted manually in drilling method with the rate of 60 kg ha^{-1}.

2.4. Data Collection

The following data were collected:-

Number of fertile tillers per plant (TP): The average number of fertile tillers from five randomly selected sample plants was taken.

Plant height (PH): Height of the plant in centimeter from the base of the main stem to the tip of the panicle was recorded as the average of five randomly selected plants.

Panicle length (PL): Length of the panicle in centimeter from the node where the first panicle branch starts to the tip of the panicle as the average of five randomly selected plants.

Days to flowering (DF): Number of days from sowing up to the date when the tips of the panicles first emerged from the main shoots on 50% of the plant in a plot.

Days to maturity (MD): Number of days from the date of sowing to the date when 85% of the crop stand stems, leaves, and floral bracts in a plot changed to light yellow color was recorded.

Thousand-grain weight (GW): Weight in g of 1000 grains from bulked grains, which was collected at central rows of each plot and was recorded.

Grain Yield (GY) per hectare: Grain yield in kg obtained from each plot was converted to kilograms per hectare.

2.5. Data analysis

Data collected from experiment were subjected to analysis of variance using proc GLM technique with SAS soft ware (SAS, 2002). Means of the treatments were separated using LSD (Least Significant Difference).

3. Results and Discussion

3.1. Weather condition during the Study period

A Total rainfall of 230.42 mm was recorded during the study period and the maximum and minimum rainfall was recorded during August and November months with the value of 478 mm and 0 mm respectively. The mean maximum and minimum temperature during the study period were 27.28 ^{O}C and 14.05 ^{O}C respectively (Table 2).

Table 2. Monthly total rainfall distribution and the mean maximum and minimum temperature variation during the study period.

Months	Temperature (^{O}C)		Rainfall (mm)
	Max.	Min.	
June, 2017	29.06	12.99	170.70
July, 2017	27.36	14.16	327.10
August , 2017	26.72	11.87	478.00
September, 2017	27.61	15.77	265.10
October, 2017	21.88	14.40	141.60
November, 2017	31.04	15.09	0.0
Total	163.67	84.28	1382.50
Mean	**27.28**	**14.05**	**230.42**

Table-3: Results of agronomic parameters of candidate rice varieties

Treatments (varieties)	Number of days to 50 % flowering (DF)	Number of fertile tillers per plant (TP)	Panicle length in cm (PL)	Number of days to maturity (MD)	Plant height in cm (PH)	Thousand-grain weight in gm (GW)	Grain yield per hectare in Qt (GY)
Nerica-12	70.00[c]	10.00[bc]	21.33[a]	137[d]	112.27[a]	35.41[a]	38.33[b]
Adet	70.00[c]	10.00[bc]	21.33[a]	137[d]	102.00[b]	28.94[bc]	35.50[b]
Edget	77.00[b]	8.00[c]	19.67[a]	142[b]	105.73[ab]	32.39[ab]	24.00[c]
Hibir	76.00[b]	9.00[bc]	18.67[a]	140[c]	97.20[bc]	33.27[a]	28.83[c]
Fogera-2	92.00[a]	14.00[a]	21.00[a]	160[a]	91.53[c]	26.15[c]	53.17[a]
FOFIFA-3737	67.00[c]	11.00[b]	20.33[a]	137[d]	111.40[a]	32.24[ab]	26.17[c]
Mean	75.33	10	20.39	142	103.36	31.4	34.33
LSD	4.11	1.47	4.06	3.24	8.55	3.87	5.56
CV	2.99	7.88	10.96	5.61	4.55	6.77	8.88

3.2 Effects of variety on plant height

Plant height is one of the important growth parameters of any crop as it determines or modifies yield contributing characteristics and finally shapes the grain yield (Reddy and Redd, 1997). It is a complex character and is the end product of several genetically controlled factors mostly governed by the genetic make-up of the genotypes, generally depends on their number of internodes and length of internodes (Sadiqur *et.al*., 2018).

The result of this study showed that significant differences among rice varieties in plant height (Table 3). Among the rice varieties tested, Nerica-12 was found out to be the tallest (112.27 cm) variety followed by Fofifa-3737 (111.40 cm) and Edget (105.73). Fogera-2 variety was significantly the shortest in plant height among the varieties used (91.53 cm) except Hibir variety (97.20 cm). This result was in consistent to those of Khatun (2001) and Das *et al*. (2012) who observed variable plant height among the rice varieties. The difference in plant height could be attributed to the varietal characteristics of the crops planted. Shorter plant height is an important character of the varieties to withstand lodging (Malini *et al*., 2006).

3.3 Effects of variety on number of tiller per plant

Significant varietal differences were observed for number of tillers per plant in the varieties tested (Table 3). The reason of difference in number of effective tiller per plant is the variation in the genetic makeup of the variety. Similar result was also reported by Ramasamy *et al*. (1987) who stated that number of tillers differed due to varietal variation. Tillering ability plays a vital role in determining rice grain yield. Too few tillers result fewer panicle, but excessive tillers enhance high tiller mortality, small panicle, poor grain filling and consequent reduction in grain yield (Peng *et al*., 1994). Among the various yield components productive tillers are very important as the final yield is mainly a function of the number of panicles bearing tillers per unit area (Roy et.al. 2014).

In the result of this study, Fogera-2 variety produced the highest number of tillers (14) per plant followed by Fofifa-3737 that produced 11 tillers per plant. The lowest number of tillers (8) was recorded for Edget which was significantly lower than 14 and 11 recorded for Fogera-2 and Fofifa-3737 varieties, respectively (Table 3).

3.4 Effects of variety on panicle Length

There was no significant difference in panicle length among varieties tested (Table 3). Opposite results were recorded by Idris and Matin (1990) and Anonymous (1993) who reported that panicle length influenced by variety. Although there was no significant difference in panicle length among varieties the longest panicle length was observed in varieties Nerica-12 and Adet which were obtained a similar panicle length of 21.33 cm followed by Fogera-2 and Fofifa-3737 which were obtained a panicle length of 21.00 and 20.33 respectively. While the Hibir variety got the shortest panicle length with a mean of 18.67 cm.

3.5 Effects of variety on number of days to flowering

Highly significant varietal differences were observed for Days to 50% flowering in the varieties tested (Table 3). This result is in agreement with Sadiqur *et.al*.,(2018) and Merkebu and Techale (2015) who reported days to 50% heading of the crop was highly significantly affected by the main effect of the varieties. The days to 50% flowering ranged from 67 days for Fofifa-3737 to 92 days for Fogera-2 varieties.

3.6 Effects of variety on number of Days to Maturity

The candidate rice varieties exhibited highly significant differences on the number of days to maturity from sowing (Table 3). The result implies that these differences could be attributed to the agronomic characteristics and to the climate adaptability of different rice varieties to the local condition (Romualdo *et.al.* 2014). The number of days to maturity plays a significant role in the cropping system. Early maturing crops are timely handled, evacuate the land early for the next crops and escape from insect pest attack. Cooper and Somrith (1997) also reported that early maturity has been shown to be an important trait under stress conditions because early maturing rice can escape from the late season drought stress. The duration to maturity ranged between 137 to 160 days with the varieties Nerica-12, Adet and Fofifa-37373 taking the shortest time (137 days) to mature. Hibir and Edget rice varieties were taken 140 and 142 days to mature respectively. The Fogera-2 rice variety was found to be late to mature with the mean of 160 days.

3.7 Effects of variety on 1000 grain weight

The candidate rice varieties exhibited highly significant differences on 1000 grain weight (Table 3). Similar results were reported by Gupta and Sharma (1991).Thousand-grain weight, an important yield determining component, is a genetic character least influenced by environment (Ashraf *et al.,* 1999).The variation in thousand seed weight might be due to the differences in length and breadth of the seeds that were partly controlled by the genetic make-up of the genotypes (Sadiqur *et.al*.,2018). The highest 1000-grain weight of 35.41 g was exhibited by the variety Nerica-12 followed by the rice varieties Hibir, Edget and Fofifa-37373 which recorded 33.27 g, 32.29 g and 32.24 g, respectively. The lowest value in 1000 grain weight was recorded in the variety Fogera-2 with the weight of 26.15 gm which was statistically different from all other rice varieties tested.

3.8 Effects of variety on grain Yield

The six rice varieties exhibited highly significant differences on grain yield as shown in table 3. It was found out that the top yielder among the 6 entries was Fogera-2 with a mean yield of 53.17 Qt/ha followed by Nerica-12 and Adet with the mean yield of 38.33 Qt/ha and 35.50 Qt/ha respectively. Edget produced the lowest **grain yield** (24 Q/ha) among the varieties tested. Fogera-2 variety recorded the longest days to maturity and also produced the largest grain yield. This confirms the report of Islam *et al*. (2010) that varieties with longer growth duration usually produce more **grain yield** than the varieties with shorter growth duration. The difference in yield was also attributed to the number of productive tillers, varietal yielding capabilities and also to the growth performance of every variety tested (Romualdo et.al., 2014).

3.9 Periodic experimental field observation

During the period of field experimentation any lodging problem and symptoms of disease was not happened in all the varieties tested. Cut worm insect was observed in all the varieties except Fogera-2. But, the incidence of rice Cut worm was very low (negligible) or insignificant.

3.10 Correlation analysis

Correlations of parameters is presented in Table 4.The results of correlation coefficient indicated that the grain yield was significantly and positively correlated with number of tiller (r = 0.87*) and panicle length (r=0.83*). Even though it was not significant, date of flowering, date of maturity and 1000 grain weight were positively correlated with grain yield. Plant height also had a non-significant negative correlation with grain yield.

Table 4. Correlations of parameters

	DF	TP	PL	MD	PH	GW	GY
DF	1.00						
TP	0.66	1.00					
PL	0.53	0.72	1.00				
MD	0.96**	0.85*	0.65	1.00			
PH	-0.62	0.22	0.57	-0.54	1.00		
GW	0.64	-67	-0.41	-0.75	0.62	1.00	
GY	0.65	0.87*	0.83*	0.80	-0.39	0.67	1.00

*where, DF= date of flowering, TP= tiller per plant, PL= panicle length, MD= maturity date, PH= plant height, GW= 1000 grain weight, GY= grain yield

3.11 Economic Advantage of rice production over the check

As indicated in the table-3 below the grain yield result of Fogera-2, was greater than the check rice variety Pawi-1 (45 Qt/ha) in which the variety Fogera-2 has 8.17 Qt/ha more yield over the check that indicate producing this variety could earn 18.16 **%** more yield over the check.

Table 5. Yield Advantage of Tested varieties over the local check

Varieties	**Grain yield (Qt/ha)**	**Comparative yield advantage (45 Qt/ha)**	**Yield Advantage in %**
Fogera-2	53.17	8.17	18.16
Nerica- 12	38.33	-6.67	-
Adet	35.50	-9.5	-
Hibir	28.83	-16.17	-
FOFIFA-37373	26.17	-18.83	-
Edget	24.00	-21	-

3.12 Profit Analysis of Rice Production

The economic analysis result shown that producing Rice could provide additional income to the sugar project with net profit per quintal of 821.45 birr for Fogera-2 rice variety (Table-6). Based on the result of this experiment by producing 53.17 Qt/ha for the variety Fogera-2, the net profit per hectare will be 43,676.64 birr, considering the current grain selling price of 1000 birr/qt (Table 6). We can project the current finding to calculate the net profit before tax by producing 1000 hectares in Beles, with this simple analysis the profit could be 43,676,640 birr for the rice variety Fogera-2.

Table 6. Profit analysis of Rice production

Description	Measurement unit	Quantity/amount Fogera-2	Remark
Production (quintals/hectare)	Qt	53.17	1000 birr/qt was considered as current grain selling price
Production cost per hectare	Birr	9493.36	
Total Income per hectare (production* grain selling price)	Birr	53,170	
Gross Net Profit before tax per hectare	Birr	43,676.64	
Production cost per quintal	Birr	178.55	
Net Profit from a quintal	Birr	821.45	

4. Conclusion and Recommendations

The results indicated significant differences among rice varieties for plant Height, number of tiller per plant, days to flowering, number of days to maturity, 1000 grain weight and grain Yield. Panicle length was not significantly affected by the candidate varieties. The highest grain yield was obtained from the variety Fogera-2 (53.17 Qt/ha) followed by Nerica-12 (38.33 Qt/ha) and Adet (35.50 Qt/ha). The grain yield obtained from Fogera-2 variety was greater than the check Pawi-1 (45 Qt/ha) in which the variety Fogera-2 have 8.17 Qt/ha more yield over the check that indicate producing this variety could earn 18.16 % more yield over the check. The economic analysis result shown that producing Fogera-2 Rice variety could provide additional income to the sugar project with net profit per quintal of 821.45 birr for the variety Fogera-2.

Using of high yielding varieties is crucial for successful crop production; therefore it is advisable to use Fogera-2 rice variety for commercial production at Beles sugar development project area. Further research may require to evaluate rice seed quality in addition to evaluating grain yield of different rice varieties.

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