International Journal of Research and Review
Vol.7; Issue: 1; January 2020
Website: www.ijrrjournal.com
Original Research Article E-ISSN: 2349-9788; P-ISSN: 2454-2237

Performance of Early Maturing Rice Genotypes under Rain Fed Upland Production System in Ethiopia

Abebaw Dessie[1], Taddesse Lakew[1], Zeynu Tahir[2]

[1]Fogera National Rice Research & Training Center/Ethiopian Institute of Agricultural Research Center, Ethiopia
[2]Gondar Agricultural Research Center/ Amhara Regional Agricultural Research Center, Ethiopia

Corresponding Author: Abebaw Dessie

ABSTRACT

The experiment was conducted in Woreta, Metema, Pawe, Chewaka and Shire-Maitsebri from 2012-2014 main cropping seasons with the major objectives of early maturing, high yielding and pest resistance rice varieties for the upland rice production system in Ethiopia. A total of 20upland genotypes including one check were used in the study. The trial was laid out in randomized complete block design with three replications with plot size of 6.0 m^2. The combined analysis of variance revealed significant difference on grain yield, days to maturity, filled grain per panicle and plant height ($P \leq 0.001$). Three genotypes (G16, G13 and G19) showed significant difference than the standard check on grain yield and gave grain yield advantage of 43.3 %, 42.3 % and 42.1 %, respectively. The genotype main effect plus genotype x environment interaction (GE) biplots were used to analyse and visualize pattern of the interaction component. The first two principal components (PC1 and PC2) of the GGE explained 55.02 % with PC1= 38.31 % and PC2=16.71 % of GGE sum of squares, respectively. Genotypes, G16 (ARCCU15 Bar-7-16-30-2-B-B) combined both high stability performance and high mean grain yield across the test environments and characterized as an ideal genotype to the tested locations. Following evaluation of candidate genotypes (G16, G13) and collecting farmer's feedback, the National Variety Release Committee also recommended G16 as variety for cultivation in Fogera and other areas of similar cultivation conditions and this variety is under demonstration and popularization.

Key words: Stability, GGE bi-plot, early maturing, upland rice

INTRODUCTION

Rice (Oryza sativa L.) which was originated from the tropics and subtropics is widely cultivated in diverse environments. The tremendous growth of human population worldwide has increased the demand for rice production, [1] requiring an improvement of 50% by the year 2025. [2] Due to its origin in tropical and subtropical regions, rice is more sensitive to different stresses like drought, cold, submergence, salinity and different insect pests than other cereals crop such as Wheat and Barley. Therefore, the production of rice is severely limited by different type of stresses. [3] Drought stress is the major factor affecting rice growth, productivity, its distribution worldwide. [4] Production of rice is affected primary due to its vulnerability to drought and cold stress at seedling stage, as well as reproductive stage leading to spikelet sterility. [5] Early maturing varieties allow escape unpredicted terminal drought as well as rice producers can use the land for double cropping. [6]

In Africa, rice also constantly increasing as staple food and there has been increasing demand in Africa in the past three decades from 1999-2018. [7] In most of sub-Saharan Africa (SSA), rice is the most-demanded staple food and the food product traded in the highest quantities. [8,9] However, these demands have not been commensurate with the total production because of different reasons like declining rainfall and water scarcity; flooding and rising average temperatures [10] have put pressure on domestic rice value chains. As a result most of African countries are net importer of milled rice, which costs 6.4 billion USD annually. [6]

Efforts to introduction of rice had probably been started in Ethiopia when the wild rice (*O. longistaminata*) was observed in the swampy and waterlogged areas of Fogera and Gambella Plains. Different literatures confirmed that rice introduced to Ethiopia in late 1960s. Although rice has recently introduced to Ethiopia, it is recognized its importance as a food security crop, a source of income and employment opportunity. [11] The production, productivity and consumption of rice are constantly increasing in the country. [12,13] The grain production of rice increased from 71, 393.7 tons (2009) to 171,854 tons (2019), however importing of rice increased dramatically form 30, 082 tons (2009) to 312,900 tons (2016). This proved that rice consumption in the Ethiopia is dramatically increasing which declared that production and demand have huge gap and needs especial attention. Ethiopia's geography is noticeable by immense depressions and mountains. Consequently vast arable lands are located at different parts of the country. Rice can grow in wide agro climatic zones; however, abiotic stresses like drought, low temperature and salinity stresses are serious challenges for rice farmers. Lack of early to medium maturing upland rice varieties are demanding for rain fed rice production system especially for short rainy seasoned countries like Ethiopia. Therefore, the major objective of this study was to evaluate the performance and stability of early upland rice genotypes for their wider or specific recommendation in the North-West Ethiopia and similar agro ecologies.

MATERIALS AND METHODS

The experiment was conducted for 3 years (2012-2014) in six locations; Woreta, Pawe, Metema, Mytsebri, Bako and Jimma. The locations are where the trials conducted (Table 1). A total of 20 genotypes including one check used (Table 2). The trial was laid out in randomized complete block design with three replications with a plot size of 6 m^2 (Six rows with 5 m long with 0.20 m row spacing). Seed rate of 60 kg/ha was used and direct seeding methods in a row was applied. Fertilizer (UREA and DAP) were applied based on each location recommendation. All DAP was applied at the time of sowing. For UREA, split application was applied; 1/3 at sowing, 1/3 at active tillering and the remaining 1/3 during panicle initiations. Other agronomic practices were applied according to each location recommendations. The data were subjected to the GLM procedure for analysis of variance using SAS software V.9.0. And Genotype x environment and stability analysis were done by using Genstat 18th edition software.

Table 1: Description of study environments for lowland ecosystem

Location	Altitude (m)	Latitude	Longitude	Annual rainfall	Temperature ^{0}c (Mean)	
					Maximum	Minimum
Fogera	1810	11^{0}58'N	37^{0}41'E	1300	27.9	11.5
Pawe	1050	11^{0}09'N	36^{0}3'E	1457	32.8	17.2
Metema	685	12^{0}58N	36012,E	1100	37	25
Shire/Mitsebri	1350	11^{0}08'N	38^{0}08'E	1296	36	15.0
Bako	1650	NA	NA	NA	NA	NA
Jimma	NA	NA	NA	NA	NA	NA

Data Collection and Statistical analysis

Data were collected for days to heading, days to maturity, panicle length, plant height, filled grains/panicle, fertile tillers/plant, leaf blast, panicle blast, brown spot and grain yield. Grain yield (kg ha^{-1}) was estimated based on adjustment at 14% moisture level on the basis of four central harvestable rows. The grain yield and other agronomic parameters were subjected to analysis of variance using the SAS version 8.1software. The grain yield data were also subjected to GGE-biplot analysis for ranking of genotypes based on grain yield performance and stability and also for detecting wider and /or specifically adapted genotype(s).

Table 2: List of genotypes used for the study

S/N	Genotypes	Code	Seed source
1	ARCCU16Bar-22-1-1-2-B-1	G1	Africa rice
2	ARCCU16Bar-9-2-10-4-B-1	G2	Africa rice
3	ARCCU16Bar-4-14-4-B-1	G3	Africa rice
4	ARCCU16Bar-13-15-18-1-B-1	G4	Africa rice
5	ARCCU16Bar-9-9-24-4-B-1	G5	Africa rice
6	ARCCU16Bar-12-17-29-2-B-1	G6	Africa rice
7	ARCCU16Bar-1-18-2-B-1	G7	Africa rice
8	ARCCU16Bar-1-1-16-2-B-1	G8	Africa rice
9	ARCCU16Bar-4-14--2-2-B-1	G9	Africa rice
10	ARCCU16Bar-12-17-3-4-B-1	G10	Africa rice
11	ARCCU16Bar-9-20-6-1-1-1	G11	Africa rice
12	ARCCU16Bar9-13-1-2-1	G12	Africa rice
13	ARCCU16Bar-12-12-33-3-B-2	G13	Africa rice
14	ARCCU15Bar-5-12-37-5-B-B-	G14	Africa rice
15	ARCCU15Bar-7-16-17-1-B-B	G15	Africa rice
16	ARCCU15Bar-7-16-30-2-B-B	G16	Africa rice
17	ARCCU16Bar-12-13-14-2-B-B	G17	Africa rice
18	ARCCU16Bar-5-10-12-2-B-B	G18	Africa rice
19	ARCCU16Bar-12-12-16-3-B-B	G19	Africa rice
20	Hidassie (check)	G20	FNRRTC

RESULT AND DISCUSSION

The combined analysis of variance revealed highly significant variation (P<0.001) in genotypes and the environments for days to maturity, fertile tillers per plant, filled grains per panicle and grain yield (Table 3). The genotype by environment interaction was also significant for days to maturity, plant height, filled grains per panicle and grain yield which signified differential response of genotypes to environments. However, the genotype by environment interaction of panicle length and fertile tiller per plant was not significant difference. Based on the combined mean yield, the grain yield was ranged from 2629.3 kgha^{-1} (G20) to 3768.1 kgha^{-1} (G16) with the mean yield of3465.6 kgha^{-1}. The highest yielding genotypes were, G16 (ARCCU15Bar-7-16-30-2-B-B) and G13 (ARCCU16Bar-12-12-33-3-B-2) with grain yield of 3768.1 and 3740.7 kg/ha, respectively(Table 3). These genotypes (G16 and G13) had 43.3 % and 42.3 % yield advantage than the check (G20), respectively. In addition G16 and G13 scored minimum value of leaf blast, panicle blast and brown spot. Based on GGE biplot analysis, grain yield performance and stability ranking of genotypes (Figure 1) showed that G16 and G13 were the most stable and had the highest grain yield. Following combined mean yield and stability analysis, two candidate genotypes (G16 and G13) were identified and verified against the standard check (G20).

Table3. Over all combined mean grain yield and other yield related parameters of 20 upland early type rice genotypes

Genotypes	Code	DTM	PL	PH	FTP	FGP	Gy	LB	PB	BS
ARCCU16Bar-22-1-1-2-B-1	G1	115.4	18.6	82.2	6.7	84	3605.5	1.3	1.4	2.6
ARCCU16Bar-9-2-10-4-B-1	G2	116.2	17.7	80.6	6.4	87	3709.0	1.1	1.2	1.7
ARCCU16Bar-4-14-4-B-1	G3	115.8	17.7	80.5	6.8	82.6	3161.2	1.2	1.2	2.8
ARCCU16Bar-13-15-18-1-B-1	G4	117.7	17.6	85.2	6.2	88.5	3706.6	1.4	0.9	1.8
ARCCU16Bar-9-9-24-4-B-1	G5	118.8	19.5	85.3	7	87.6	3526.3	1.2	1.1	2.2
ARCCU16Bar-12-17-29-2-B-1	G6	116.8	20.2	88.1	7.6	83.7	3295.0	1.9	1.2	2.3
ARCCU16Bar-1-18-2-B-1	G7	116.7	18.7	80	6.7	82	3231.0	1.7	1.4	3.1
ARCCU16Bar-1-1-16-2-B-1	G8	114.6	18.3	78.2	6.6	81	3483.7	1	1.2	2.8
ARCCU16Bar-4-14--2-2-B-1	G9	114.5	17.4	81.6	6	76.6	3461.0	1.2	1	2.4
ARCCU16Bar-12-17-3-4-B-1	G10	116	22.5	79.4	6.6	78	3356.8	1	0.9	4.1
ARCCU16Bar-9-20-6-1-1-1	G11	117.4	18.6	84.4	6.6	90.4	3594.3	1.6	1	2.3
ARCCU16Bar9-13-1-2-1	G12	118.3	18.5	84.4	7.1	81.5	3460.8	1.3	1.6	3.6
ARCCU16Bar-12-12-33-3-B-2	G13	117.7	18.5	80.7	7.3	82.7	3740.7	1.1	0.9	1.2
ARCCU15Bar-5-12-37-5-B-B-	G14	114.3	18.5	77.8	6.4	76.8	3273.4	1.5	1.1	3.1
ARCCU15Bar-7-16-17-1-B-B	G15	118.8	19	83.3	6.7	77.8	3611.3	1.4	1.4	3.7
ARCCU15Bar-7-16-30-2-B-B	G16	118.3	18.8	82.7	6.5	84.3	3768.1	1.1	0.9	1
ARCCU16Bar-12-13-14-2-B-B	G17	117	19.5	85.6	7.6	94.5	3263.0	1.2	1.3	3.6
ARCCU16Bar-5-10-12-2-B-B	G18	120	21	93.4	7	90.5	3698.1	1.4	1.3	3.6
ARCCU16Bar-12-12-16-3-B-B	G19	117.8	19.3	80.6	6.2	89.4	3736.5	1.4	0.9	1.8
Hidassie(check)	G20	117	18	78.7	6.5	80.8	2629.3	0.8	1	2.2
Mean		116.9	18.8	82.6	6.7	83.9	3465.6			
CV (%)		1.94	35	6.49	30	17.5	20.94			
LSD (5%)		1.05	3.07	2.48	1.48	6.78	336.23			
Genotype(G)		***	NS	***	NS	***	***			
Environment(E)		***	***	***	***	***	***			
G x E		***	NS	***	NS	***	***			

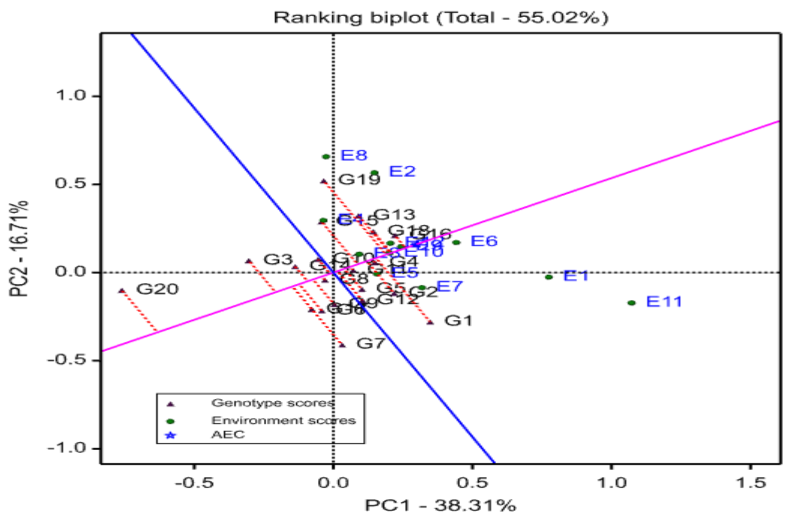
Note:*,**, *** significant at 5%, 1% and 0.1% respectively, NS= not significant, DTH= days to 50% heading, DTM= days to 85% heading, PL= panicle length (cm), PH= plant height (cm), FTP = number of fertile tillers per plant , FGP= number of filled grains per panicle, PFG= percent of filled grains per panicle, , Gy= grain yield (kg/ha), LB=leaf blast, PB= panicle blast, and BS= brown spot.

As result of evaluation by the National Variety Release Technical Committee and farmers feedback, of the two winning genotypes, G16 (ARCCU15Bar-7-16-30-2-B-B) was released for cultivation by name 'Fogera 1'. This variety recommended for cultivation in Fogera, Pawe, Metema, Maitsebri, Bako-Chewaka and other areas of similar conditions. Therefore, this variety has been demonstrated and it is under popularizing and promoting widely to make use its merits.

Ranking of genotypes based on mean and stability performance

In the present study the stability and yielding performance of twenty upland rice genotypes
were evaluated using average environment coordination (AEC) method as shown in the Fig.
1. This method stated that the abscissa of the average environment coordination (AEC) is a line that passes through the average environment which represented by a purple line (mean PC1 and PC2 scores) and the biplot origin while the coordinate of the AEC is a line (blue line)that passes through the origin and perpendicular to the abscissa of AEC [14] reported that AEC abscissa has a one directional arrow which is important for approximating the mean yield performance of the genotypes.

The partitioning of GGE through GGE biplot analysis showed that PCA 1 and PCA 2 accounted for 38.31 % and 16.71 % of GGE sum of squares respectively for yield, explaining a total of 55.02% variation as shown in Figure 1. The GGE biplot revealed the best genotypes under different environments and accurately identified the best genotype with respect to site. [15] Therefore, in this investigation, genotype G16, G18, G13 and G4 had showed highest average yielding performance, whereas genotypes G and G7 are the least performing genotypes (Fig 1). Besides to the genotypic grain yield performance, stability of genotypes across the testing environments is very important. A genotype which has shorter absolute length of projection in either of the two directions of AEC ordinate (located closer to AEC abscissa), represents a smaller tendency of GEI, which means it is the most stable genotype across different environments or vice versa. Hence, genotype G16 was identified as the most stable and high yielding genotypes across the twelve environments. Among twenty genotypes, genotypes G19, G1, G7 and G20 were identified as the least stable low yielding genotypes.



E1= Woreta 2012, E2= Jimma 2012, E3= Maitsebri2012, E4= Woreta 2013, E5= Bako 2013, E6= Maitsebri2013,E7= Pawe2013, E8= Metema2013, E9= Woreta2014, E10= Maitsebri2014, E11= Pawe2014, E12= Metema2014

Figure 1. Ranking of 20 upland early type rice genotypes based on mean yield performance and stability evaluated across diverse environments.

CONCLUSION AND RECOMMENDATION

The present study revealed that yield performance of upland rice genotypes were influenced by genotype x interaction effect, the environment and genotype. Grain yield can be affected by a number of characters along with the environments. G16 (ARCCU15 Bar-7-16-30-2-B-B) was released as 'Fogera 1' for its high yield performance, earliness, stable and diseases resistant. The studies revealed the importance of earliness, high yield and diseases resistance in the evaluation of genotypes. Early maturing varieties allow escape unforeseen terminal drought as well as rice producers can use the land for double cropping. The released variety is critical to boost rice production and enhance productivity in the rain fed upland rice production system of Ethiopia. Hence, this variety should be continuing its popularization and pre scale up in large scale in Fogera and in other ecologies of similar conditions to reach significant number of rice farmers.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Ethiopian Institute of Agricultural Research Institute (EIAR) for financially supporting the execution of this experiment. The technical staffs of rice improvement sections at Fogera, Pawe, Gondar, Bako, Mai-Tsebri and Adet research centers are highly appreciated.

REFERENCES

1. Khush G (2001). Green revolution: the way forward. *Nat. Rev*. 2: 815–22.
2. Liang J, Lu Y, Xiao P, Sun M, Corke H and Bao J (2010). Genetic diversity and population structure of a diverse set of rice germplasm for association mapping. *Theor. Appl. Genet.* 121:475–87.
3. Africa Rice Center (Africa Rice). 2018. Continental Investment Plan for accelerating Rice Self-Sufficiency in Africa (CIPRiSSA). Abidjan, Cote dIvoire: 204pp.
4. Moraes F, Basu S, Ramegowda V, Braga E and Pereira A (2016). Comparative analysis of gene expression in response to cold stress in diverse rice genotypes, Biochemical and Biophysical Research Communications, http://dx.doi.org/10.1016/j.bbrc.2016.02.004
5. AbebawDessie, Irie Kenji, Hironobu Shiwachi (2014). Phenotypic Expression in Upland NERICA Rice under Low Temperature Condition at Germination Stage. *International Journal of Agricultural Sciences and Natural Resources.* Vol. 1, No. 5, pp. 107-114.
6. TadesseL, Abebaw D, SewagegneT and Desta A (2017). Evaluation of Performance and Yield Stability Analysis Based on AMMI and GGE Models in Introduced Upland Rice Genotypes Tested across Northwest Ethiopia.International Journal of Research Studies in Agricultural Sciences (IJRSAS) Volume 3, Issue 2, PP 17-24 http://dx.doi.org/10.20431/2454-6224.0302003www.arcjournals.org
7. Zhang Q, Chen Q, Wang S, HongY and Wang Z (2014). Rice and cold stress: methods for its evaluation and summary of cold tolerance-related quantitative trait loci. Rice, 7(1): 24.
8. Tollens E (2006). Markets and institutions for promoting rice as a tool for food security and poverty reduction in sub-Sahara Africa. *Afr. Crop Sci. J.*, *15*, 237–242.
9. Laroche D. and Postolle A (2013). Food sovereignty and agricultural trade policy commitments: How much leeway do West African nations have? *Food Policy*, *38*, 115–125.
10. Roudier P, Sultan B, Quirion P and Berg A (2011). The impact of future climate change on West African crop yields: What does the recent literature say? *Glob. Environ. Chang.*
11. Rice. Ethiopia's millennium crops. http://www.africarice.org/publications/ricetoday/Ethiopia%E2%80%99s%20millennium%20crop.pdf
12. CSA (2016). Central Statistical Agency. The Federal Democratic Republic of Ethiopia, Central Statistical Agency, Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season), Statistical Bulletin, Addis Ababa, Ethiopia
13. Alemu D. Tesfaye A., Assaye A., Addis D., Tadesse T. and Thompson J. (2018). A Historical Analysis of Rice Commercialisation in Ethiopia: The Case of the Fogera Plain. APRA Working Paper 18, Future Agricultures Consortium.

14. Yan W, Hunt L (2002). Biplot analysis of multi-environment trial data. Quantitative Genetics, Genomics and Plant Breeding: CAB International, Willing ford.
15. Agyeman A, Parkes E and Peprah B (2015). AMMI and GGE biplot analysis of root yield performance of cassava genotypes in the forest and coastal ecologies. International Journal of Agricultural Policy and Research Vol.3 (3), pp. 222-232. Available at: http://www.jouranissues.org/IJAPR/

How to cite this article: Dessie A, Lakew T, Tahir Z. Performance of early maturing rice genotypes under rain fed upland production system in Ethiopia. International Journal of Research and Review. 2020; 7(1): 306-311.

******