



Adaptation Evaluation of Released Irrigated Rice (*Oryza sativa* L.) Varieties in Tendaho Sugar Factory, Afar Regional State of Ethiopia

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Abstract: Field experiment on adaptation evaluation of five irrigated rice varieties was conducted using Randomized Complete Block Design replicating three times with surface irrigation. This study was executed for the objective of assessing the adaptation capacity of the varieties to isolate the high yielding and heat tolerant varieties in the study area to produce at commercial level for additional income of the factory using freely available resources, like labor and free land not covered by sugarcane. Necessary data were collected at their right stage following their suitable data collection procedures. All collected data were analyzed using SAS software and mean comparisons among treatment means were made by LSD (5%). Significant variation ($p < 0.05$) among the tested varieties were reported owing to their DH, DM, ET, PH, NSLSP, NKPP, GY and TKW characters. However, the varieties didn't vary significantly ($P < 0.05$) due to their EMD, PL and AGBM traits. Likewise, the yield in the tested varieties shown positively significant correlation ($P < 0.05$) with all yield traits except DH and DM which shown negatively significant correlation ($P < 0.05$). In this trial, highest grain yield of 22.5 Qt/ha was noted from Edget variety. Hibir and Adet varieties also gave statistically similar yield with 19.8 and 19.4 Qt/ha respectively. Therefore, Edget rice variety with highest net profit is recommended for commercial production. However, if any inconvenient condition is faced with this variety, Hibir and Adet varieties can be used as an additional option for commercial production of rice in the study area.

Keywords: Correlation, Income, Rice, Variation, Yield

1. Introduction

As Agriculture played a principal role in Ethiopia's entire economic development, the government's policy considers it as the mainstay of the economy that provides the population with employment, foreign exchange earnings, source of raw materials for industry, and source of food for the population [1]. Similar to other developing countries, Ethiopia depends greatly on agriculture to bring development. Because, Ethiopia is gifted by large crop varieties production, with a total area of 111.5 million ha of which 74.3 million ha is appropriate for agriculture. This makes the country to become one of the preferred investment destinations in East

Africa [2]. But, most of the irrigable lands are located in lightly populated lowland areas having high temperature and with little infrastructures [3]. Much of the irrigable low lands are owned by Ethiopian Sugar Corporation (ESC) and most of the recently started sugar projects' lands are not fully utilized due to various reasons. But, according to the global experiences, there is an opportunity and interest to use these lands for additional complementary crops productions till the factories become fully functional [4].

As compared to other cereals, rice is very important crop as a food security, source of income and employment opportunity due to its productivity potential [5]. Even if rice farming is a latest practice in Ethiopia [6], its significance is

well recognized and the production area increased from 10,000 ha in 2006 to over 50,000 ha in 2018 [7]. The crop is named as the “Millennium crop” which is now considered as a strategic food security crop in Ethiopia [8]. Amhara, Southern Nations, Nationalities and Peoples Region (SNNPR), Oromiya, Somali, Gambella, Beni Shangul Gumuz and Tigray regions are the major rice producing areas [5]. Moreover, rice production has generated business opportunity for actors along the rice value chain such as rice processors and traders’ private business-men [9].

The country has a predictable thirty million hectares of land apposite for rice production [5]. But, only around 0.1 million ton of the gross annual grain production is contributed by rice in 2009 production season [10]. This forced the country to import rice for food source. For instance, the government of Ethiopia imported 25,667 and 30,082 tons of rice in 2008 and 2009 respectively [11]. But, the country will substitute these imports and start to export in the near future if rice production continues. Accordingly, the Government of Ethiopia (GoE) has established national strategy for rice research and development to guide the integrated and focused promotion of the rice sector in the effort to ensure food security in the country [5]. For this reason, the 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 28.91 in 2011/12 to 28.97 in 2012/13 [12].

Ethiopian Sugar Corporation is applying efforts on

complementary crop development with sugarcane, horticulture and livestock production to improve product diversification [13] and to play its vital role in food self-sufficiency program of the country. But, since most of the proposed low land areas are owned by ESC, it has not been covered by national agricultural research system in developing improved crop varieties yet [13, 14]. Furthermore, since the agro ecology of the sugar development projects are quite different, it is decisive to make adaptation trial of all crops in all sites. Therefore, this rice adaptation trial was done to evaluate the adaptation capacity of different rice varieties to identify the high yielding and heat tolerant rice variety that could easily adapt the study area agro-ecology for enhancing the net national crop production in general and product diversification in particular in sugar estates.

2. Material and Methods

2.1. Description of the Study Area

Tendaho Sugarcane Plantation Estate is found in Afar Regional State, North Eastern part of Ethiopia, that is located at 41°3'E longitude and 11°50' N latitude, 374 m above sea level elevation and receiving annual rainfall of about 200 mm annually. The area has a mean minimum, mean average and mean maximum temperatures of 16.8°C, 27.8°C and 38.8°C, respectively. The dominant soil type in the area is Fluvisols followed by Vertisols [15].

Table 1. Monthly Mean Maximum, Mean Minimum and Mean Average Temperature of Tendaho Sugarcane Estate (1963 – 2018).

Temperature (0c)	JAN	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Mean
Mean Maximum	33.0	35.9	38.4	39.9	40.9	41.8	42.8	41.5	39.8	40.2	37.1	34.8	38.8
Mean Minimum	12.4	13.9	15.0	17.1	18.3	20.1	20.5	20.3	20.1	16.6	13.9	13.0	16.8
Mean Average	22.7	24.9	26.7	28.5	29.6	30.9	31.6	30.9	30.0	28.4	25.5	23.9	27.8

Source: Tendaho Research and Development Center

2.2. Soil Condition of the Study Area

Dubti area was previously cultivated by Tendaho state farm enterprise since about 56 years back using furrow irrigation [13]. Soil and land suitability study of Dubti farm is classified as marginally suitable (S3s) with limitation of soil characteristics [16]. Zeleke et al [17] characterized the current status of soil of Dubti area as high pH, low electrical

conductivity (ECe) and very high Cation exchange capacity (CEC) with dominance of magnesium and sodium typically which implies sodic soil. Sleshi [18] also reported more than 80% of the state farm is dominated by salt affected soils. He also revealed that the soil pH is qualified under strongly alkaline (>8.5) in irrigated soils while moderately alkaline (8.08 – 8.20) in non- irrigated soils.

2.3. Experimental Design and Treatments

Table 2. Five Rice Varieties (Treatments) used in the Experiment.

S/N	Treatment	Time of Release	Category	Area of released
1	Adet	2014	Upland rice	Adet ARC/ARARI
2	Nerica-12	2013	Upland rice	Adet ARC
3	Hiber	2013	Lowland rice	Adet ARC/AARC
4	Edget	2011	Lowland rice	ADARC/ARARI
5	Fogera-2	2016	Lowland rice	Fogera ARC

Source: MoANR, 2016.

The experiment was executed in RCBD replicated three times using surface irrigation during the cold season of the

study area (December 5/2017 to April 25/2018 G. C) to evaluate the adaptation potential of the tested rice varieties to

identify the best performed variety with high yield under Tendaho condition. The plot size of the trial was 100 m². The spaces between each replication and plot were 2 m and 1.2 m respectively. 60 cm furrow width was also used. Field preparation, fertilization and other agronomic practices were implemented following Adaptation and Promotion of Selected Cereal and Forage Crops package. Sowing was done using drilling method. DAP was also applied at sowing time at the rate of 50 kg/ha and UREA was applied in the rate of 150 kg/ha in two splits in which half was applied at sowing time and the remained at early tasseling stage. Irrigation was also given continuously at 5-7 days interval up to the end of maturity according the growth stage of the crop. Continuous inspection of disease and insect pests was also made.

2.4. Methods of Data Collection

The following crop performance data were collected from the trial using the following standard Procedures; i.e.;

Days to emergence (DE): Number of days to emergence was recorded when 50% of the sown crop in each plot germinated and expressed in hectare basis.

Days to Flowering (DF): The number of days to flowering was recorded when 50% of the plants in each plot had produced flower or spikes.

Days to maturity (DAM): The number of days to maturity was recorded when 80% of the plants in each plot became physiologically matured and when 85% of the crop stands; stems, leaves and floral bracts changed to light yellow color.

Plant height (PLH): Plant height was measured from ground level to the top of the spike excluding the awn from twenty randomly taken plants from all rows of the plot and recorded as the average height per plant in centimeter.

Number of effective tillers per plot (ET): The total fertile tiller populations were recorded from five randomly taken samples using 1m² quadrants in each plot after heading.

Panicle length (PL): The main spikes length (panicle length) was measured from twenty randomly taken plant samples of each plot and averaged to represent the spike length per plant in cm.

Number of spikelet's per panicle (SLSP): The number of spikelets in each panicle of main tillers were counted from twenty randomly taken plants and averaged to represent the number of spikelets per panicle of each plant.

Number of normal kernels per panicle (NKSP): The number of normal seeds in each panicle were recorded from 20 randomly selected plants of each plot and averaged to represent number of normal (fully filled grain) seeds per single panicle.

Above ground biomass (ABGM): The total above ground biomass in kilo gram was recorded by collecting and weighing the samples taken from five random places of each plot using 1m² quadrants at harvest and finally converted to ha basis.

Grain Yield (GY) per hectare: The grain yield in kilo gram was measured by harvesting all grains in whole plot at 14 % seed moisture content and measured per plot basis and converted to quintals per hectare basis.

Thousand-kernel weight (TKW): Grain weight of thousand seeds was recorded from randomly taken sample from total harvested grains of the experimental plot measured by analytical balance and expressed per gm.

2.5. Method of Data Analysis

I). Data analysis for data collected from rice traits

The data collected from different crop performance traits rice varieties, i.e., days to emergence, heading, maturity, height, panicle length, effective tiller count, spikelet per spike number, kernels per panicle number, above ground biomass, grain yield and thousand kernels weight were statistically analyzed using SAS Software. Mean comparison among treatment means were made by LSD at 5%. Simple correlation coefficient of all components of tested rice varieties were analyzed using SAS software. The RCBD design analysis of variance was used to derive variance components as stated by Cochran and Cox [19].

II). Data Analysis for Profitability Analysis

In this trial, descriptive statistics was executed as a tool for profitability analysis. Gross income and net income of the farm was used to compare the profitability of each rice varieties. Johnson [20] recommended the use of net farm income (NFI) in determining the profitability of farmers. NFI, according to them is derived after obtaining the gross margin (GM) of a farm. GM is the amount of money realized after subtracting variable expenses. NFI, according to Kay [21] is the only true measure of profit for the accounting period since it includes the above adjustment which could be quite large. NFI is the profit from the year's operation and represents the return to the farm owner for personal and family labor, management and equity capital used in the farm business.

Total Income Analysis

$$R_i = Q_i P_i \quad (1)$$

Where:

R_i = Total average income per hectare of individual crops

Q_i = Annual average yield (Qt/ha) of individual crops

P_i = Average selling price (ETB/Qt) of individual crops

Net Farm Income Analysis

$$NFI = TI - TC \quad (2)$$

Where:

TC = Total Cost

NFI = Net Farm Income

TI = Total Income

3. Result and Discussion

3.1. Analysis of Variance

The analysis of variance shown that varieties of the trial significantly varied at p 0.05 in their days of flowering, days of maturity, height, Panicle length, spikelet/spike, grain yield

and TKW characters. However, non-significant variation at p 0.05 significant level were recorded among the varieties due to their days to emergency, Effective tillers number and above ground Biomass traits (Table 3).

Morphological traits provide a simple way of measuring

genetic diversity while studying genotype performance under normal growing conditions. Since, they are influenced by environmental factors [22]; simple selection was used for variety selection based on the studied crop characters [14].

Table 3. Mean comparison of five rice varieties for their studied traits in Tendaho (2017/18).

	GY (Qt/ha)	EMD (Days)	DF (Days)	DAM (Days)	PH (cm)	ET /plot	PL (cm)	SLPN /pant	NKPP /Plant	AGBMS (Qt/ha)	TKW (gm)
Edget	22.5 ^A	9 ^{BA}	94 ^B	103 ^D	79.300 ^A	42207 ^A	18.7667 ^A	12 ^B	89 ^A	115.93 ^A	40.667 ^A
Hibir	19.8 ^{BA}	8 ^B	87 ^C	104 ^D	79.000 ^A	41773 ^A	17.067 ^{BA}	13 ^{BA}	85 ^B	73.23 ^B	39.533 ^A
Adet	19.4 ^{BA}	8 ^B	93 ^B	112 ^C	68.833 ^B	40327 ^{BA}	17.333 ^A	14 ^A	86 ^{BA}	67 ^B	38.10 ^A
Nerica-12	18.6 ^{BC}	9 ^{BA}	93 ^B	116 ^B	68.1333 ^B	37240 ^{BA}	16.467 ^{BA}	10 ^C	80 ^C	65.33 ^B	38.633 ^A
Fogera-2	15.3 ^C	10 ^A	117 ^A	147 ^A	60.667 ^C	35033 ^B	14.967 ^B	10 ^C	74 ^D	48.33 ^B	16.5 ^B
Gmean	19.12	9	96.983	116.66	71.187	39316	16.92	11.6	82.3	73.967	34.687
CV	9.54	7.74	1.747	1.816	3.278	8.22	7.264	5.452	2.318	25.51	6.339
S. l.(p 0.05)	*	Ns	*	*	*	*	ns	*	*	*	*
LSD (5%)	3.434	1.263	3.188	3.987	4.393	6088	2.314	1.191	3.614	35.53	4.14

Where: * = significant at p = 0.05, ns = non-significant at p = 0.05, Gmean= Grand mean, CV= Coefficient variation, S. l.= Significance level, LSD=Least significant level, E MD= Days of Emergency, DF= Days of Flowering, DM=Days of Maturity, PH= plant height, ET= Effective Tiller, PL= Panicle length, SLPN= No of spikelet/spike, NKPP= N0 of kernels (seeds) per panicle (spike), AGBMS= Above ground biomass, GY= Grain yield and TKW = Thousand kernel (seed) weight.

3.2. Effect of Varieties on Plant Phenology of Rice Crop

3.2.1. Effect of Variety on Day of Emergency, Day of Heading and Days of Maturity Traits

As shown in Table 3, the tested varieties significantly differed at (p 0.05) significance level in their days of flowering and maturity. However, the varieties didn't vary significantly at (p 0.05) significance level in days to emergency. Accordingly, all the tested varieties germinate at statistically similar days around 9 days after sowing. In the other case, Hibir variety flowered earlier at 87 days after sowing while fogera-2 variety flowered lately at 117 days after sowing. Furthermore, both Edget and Hibir varieties mature early at 103 and 104 days after sowing respectively whereas Fogra-2 mature lately in 147 days after sowing. This result agree with the result of Wubale et al. [23] who reported days to 50% heading an 85% maturing of the crop was highly significantly affected mainly due to the effect of varieties. He also reported Fogera-2 rice variety as late matured which is analogous to this result. Early maturity is an important trait under stress conditions because early maturing variety can escape from the late season drought stress [24].

3.2.2. Effect of Variety on Number of Effective (Fertile) Tiller Trait

The varieties used in the experiment shown a significant difference at (p 0.05) significance level in their number of effective (fertile) tillers. This indicates all tested varieties produce statistically different amount of effective tillers. This is supported by Wubale et al. [23] and Ramasamy et al. [25] who stated difference in tillers number due to varietal variation.

3.2.3. Effect of Variety on Plant Height Trait

As indicated in Table 3, all rice varieties in experiment

have revealed significant variance at (p 0.05) significant level due to their height. This is similar with the result released by Wubale et al. [23] and Das et al. [26]. Plant height is a complex character which is the end product of several genetically controlled factors mostly governed by the genetic make-up of the genotypes which depends on their number of internodes and length of internodes [27]. It is also an important yield related parameter which is stated to be a genetic character that is affected least by environmental factors [28]. In the experiment, the tallest height data was recorded from Edget and Hibir varieties with 91.53 cm and 97.20 cm plant height respectively while the shortest height was recorded from Fogera-2 variety with 60.7 cm plant height. The change in plant height could be attributed to the varietal characteristics of the crops planted [23].

3.2.4. Effect of Variety on Panicle Length, Number of Spikelets Per Spike and Number of Seeds Per Spike Traits

As shown in Table 3, the tested varieties significantly changed at (p 0.05) significance level due to their panicle length, number of spikelets per spike and number of kernels per spike characters. In this experiment, the maximum panicle length was recorded from Adet, Edget and Hibir with 17.3 cm, 18.8 cm and 17.1 cm respectively while the shortest panicle length was recorded from Fogera-2 with 15 cm. In the other case, highest number of spikelets per spike (panicle) was recorded from Adet and Hibir varieties with 13 and 12 respectively while the lowest number of spikelets per sipike was recorded from Fogera-2 and Nerica-12 varieties with 10 in both varieties. Furthermore, the highest number of normal kernels in each panicle was recorded from Edget and Adet varieties with 89 and 86 respectively while the lowest kernel number was recorded from Fogera-2 with 74. This result is as similar as the report of Zinaw et al. [14] who reported panicle length, number of spikelets per spike and number of normal

kernels per spike can be influenced by variety. Idris and Matin [29] also reported these traits can be influenced by variety. In contradiction to this report, Wubale et al. [23] reported that panicle length cannot be affected by variety.

3.2.5. Effect of Variety on Grain Yield and Above Ground Biomass Yield Traits

As shown in Table 3, the tested varieties had shown significant difference ($p < 0.05$) to their grain yield and above ground biomass. This means, the tested varieties gave statistically different quantity of grain yield and above ground biomass. From this result, highest grain yield of 22.5 Qt/ha was documented from Edget rice variety while lowest grain yield of 15.3 Qt/ha was recorded from Fogera-2. Hibir and Adet varieties also gave statistically similar grain yield with Edget variety with 19.8 Qt/ha and 19.4 Qt/ha yield respectively. This result is in contradiction with the result of Wubale et al. [23] who reported Edget produced the lowermost grain yield (24 Q/ha) while Fogera-2 produced the largest grain yield (53.17 Qt/ha) among the varieties tested at Tana beles. The variation in yield can also be attributed due to the number of productive tillers, varietal yielding capabilities and also to the growth performance of every variety [30].

In this result, varieties with shorter growth duration gave higher yield while varieties with comparatively longer growth duration gave lower grain yield. Opposite result was reported from Wubale et al. [23] and Islam et al. [31] who reported varieties with longer growth duration usually produce more yield than the varieties with shorter growth duration. This variation may be occurred due to agro ecology

difference of the experimental sites.

3.2.6. Effect of Variety on Thousand Seeds Weight Trait

The tested rice varieties had shown significant differences ($P \leq 0.05$) in thousand kernels weight (Table 3). Related results were stated by Wubale et al. [23] and Gupta and Sharma [32]. The highest thousand-kernel weight of 40.7 g was recorded from Edget followed by Hibir, Adet and Nerica-12 rice varieties which gave 39.5 g, 38.1 g and 38.6 g respectively. The lowest thousand-kernel weight was also documented from the Fogera-2 with of 15.3 g which was statistically different from all tested rice varieties. This finding is similar with the result of Wubale et al. [23] who revealed highest TKW from Edget, Hibir and Nerica-12 while lowest TKW from Fogera-2 rice varieties. Ashraf et al. [33] also described thousand-grain weight as an important yield determining component which is a genetic character least influenced by environment.

3.3. Economic Advantage and Profit Analysis of Rice Production

As shown in Table-4, the yield of Edget, Hibir in addition to Adet were less than the national rice average yield, i.e., 28.9 Qt/ha [12]. However, by applying maximum effort to increase the productivity of the crop, producing rice is very vital to help the fulfillment of country's food supply need, additional income for the sugar factory from idle land and labor since rice has higher cost in market than wheat, sorghum and maize as well as for saving hard currency of the country that needed to import rice from abroad.

Table 4. Profit analysis of rice production at Tendaho sugarcane plantation estate (2017/18).

Parameters	Edget	Hibir	Adet	Nerica-12	Fogera-2	Grand Mean
Total Production (Yield) (Qt/ha)	22.5	19.8	19.4	18.6	15.3	19.1
Total Cost of Production (ETB/ha)	18,216.51	18,216.51	18,216.51	18,216.51	18,216.51	18,216.51
Selling Price (ETB/Qt)	1500	1500	1500	1500	1500	1500
Gross Income (ETB/ha)	33,750.00	29,700.00	29,100.00	27,900.00	22,950.00	28,650.00
Net Income/Net Profit (ETB/ha)	15,533.49	11,483.49	10,883.49	9,683.49	4,733.49	10,433.49

Based on the profit analysis, farming rice could provide additional income to the sugar project with net profit per quintal of 15,533.5 ETB/ha, 11,483.5 ETB/ha and 10,883.5 ETB/ha from Edget, Hibir and Adet varieties respectively (Table 4). So, by producing 22.5 Qt/ha, 19.8 Qt/ha and 19.4 Qt/ha from Edget, Hibir and Adet varieties, the net profit per hectare will be 15,533.5 ETB/ha, 11,483.5 ETB/ha and

10,883.5 ETB/ha respectively by considering the grain selling price of 1500 ETB/qt at that period. If the factory can scale up the current finding a project of 1000 hectares target, with this simple analysis, the net profit before tax could be 15,533,490 ETB, 11,483,490 ETB and 10,883,490 ETB by producing Edget, Hibir and Adet varieties respectively.

3.4. Simple Correlation Coefficient of Rice Yield Components

Table 5. Simple correlation coefficients of 11 yield traits of 5 rice varieties at Tendaho sugarcane plantation estate (2017/18).

	EMD	DH	DAM	PH	ET	PL	SLPN	NKPP	AGBM	YLD	TKW
EMD	1.00										
DH	0.63*	1.00									
DAM	0.62*	0.94*	1.00								
PH	-0.47 ^{ns}	-0.80*	-0.87*	1.00							
ET	0.21 ^{ns}	0.56*	0.41 ^{ns}	-0.18 ^{ns}	1.00						
PL	-0.18 ^{ns}	-0.52*	-0.60*	0.63*	0.28 ^{ns}	1.00					
SLPN	-0.66*	-0.60*	-0.64*	0.54*	0.05 ^{ns}	0.64 ^{ns}	1.00				
NKPP	0.59 ^{ns}	0.47 ^{ns}	-0.36 ^{ns}	-0.3 ^{ns}	0.38 ^{ns}	-0.3 ^{ns}	-0.08 ^{ns}	1.00			

	EMD	DH	DAM	PH	ET	PL	SLPN	NKPP	AGBM	YLD	TKW
AGBM	0.36 ^{ns}	0.53*	0.48*	-0.38 ^{ns}	0.59*	-0.31 ^{ns}	-0.004 ^{ns}	0.81*	1.00		
YLD	0.34 ^{ns}	-0.65*	-0.81*	0.69*	0.46*	0.6*	0.52*	0.53*	0.72*	1.00	
TKW	-0.70*	-0.94*	-0.95*	0.74*	0.52*	0.60*	0.54*	0.77*	-0.194 ^{ns}	0.73*	1.00

The correlation analysis indicated that most of the growth and yield related parameters had either negative or positive relation with each other. Rice yield shown a positively significant correlation at ($P < 0.05$) significance level with plant height, number of effective tillers, panicle length (cm), number of spikelet per spike, number of normal kernels per spike, above ground biomass (AGBM) and thousand kernels weight. Grain yield also shown a negatively significant correlation at ($P < 0.05$) significance level with days of flowering and days of maturity. Non-significant correlation at ($P < 0.05$) significance level was also shown with days of emergence. This result is similar with the result of Merkeb and Techale [34] who informed that rice yield had a positive significant correlation with panicle length, number of kernels per panicle and thousand kernel weight and also negative correlation with other traits.

4. Conclusion and Recommendation

Rice which is also named as the "Millennium crop" is nowadays considered as a strategic food security crop in Ethiopia. To produce the crop potentially, an adaptation trial using different rice varieties was conducted. Accordingly, highest yield of 22.5 Qt/ha was documented from Edget rice variety while lowest grain yield of 15.3 Qt/ha was recorded from Fogera-2. Hibir and Adet varieties also gave a little bit lower but statistically similar grain yield as compared to Edget variety with 19.8 Qt/ha and 19.4 Qt/ha yield respectively. Therefore, based on the economic advantage of rice, Edget rice variety with highest net benefit shall be suggested for commercial production in the study area. However, if any awkward condition is faced with this variety, Hibir and Adet varieties can be used as an additional option for commercial rice production. Furthermore, the below listed recommendations are also suggested for enhancing productivity and reduce yield loss of the crop.

1. In commercial level, sowing should be started from the beginning of November to produce high yield by completing their maturity early before the start of harsh season (hot season) that coincides to their maturity time.
2. Adaptational performance research should be also continued using other new high yielding lowland varieties to get other alternative high yielding rice varieties
3. Due consideration should be given to reduce losses at field and warehouses.

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Appendix



Figure 1. Field experiment of Rice varieties at early growth stage in Tendaho sugarcane plantation estate (2017/8).

References

- [1] EFDR, 2001. Agricultural and rural development policy and strategy. Federal Democratic Republic of Ethiopia EFDR. 2002. Ethiopian Federal Democratic Republic. Industry Development Strategy. Addis Ababa, Ethiopia. Federal Democratic Republic of Ethiopia. Addis Ababa EIA. 2009. Ethiopian Investment Agency. Annual Report (2009). Addis Ababa, Ethiopia.
- [2] MoARD, 2005. Ministry of Agriculture and Rural Development. Major Agro-ecologies of Ethiopia. Forest, Land Use and Soil Conservation Department, MoARD, Addis Ababa, Ethiopia.
- [3] Hailu Beyene, 2008. Adoption of Improved Tef and Wheat Production Technologies in Crop Livestock Mixed System in Northern and Western Shewa Zones of Ethiopia. A PhD. Dissertation Presented to The University of Pretoria, South Africa.
- [4] Adaptation and Promotion of Selected Cereal and Forage Crops in Newly Established Sugar Estates Ethiopian Agricultural Research Council Secretariat, July 2016, Addis Ababa, Ethiopia.
- [5] MoARD (Ministry of Agriculture and Rural Development), 2010. National Rice Research and Development Strategy of Ethiopia. The Federal Democratic Republic of Ethiopia, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia. 48pp.
- [6] Tilahun Tadesse, 2020. History, Current Status and Future Directions of Rice Research in Ethiopia. Journal of Emerging Technologies and Innovative Research (JETIR). 7 (2): 2349-5162.

- [7] Tilahun Tadesse, Abebaw Assaye and Dawit Alemu, 2018. Ethiopia: Enriching Livelihoods with Rice Research. A blog posted in Future Agricultures Consortium website. Posted on October 5, 2018. Link: <https://www.future-agricultures.org/blog/ethiopia-enriching-livelihoods-with-rice-research/>.
- [8] Teshome Negussie and Dawit Alemu. (2011). An Overview of the National Rice Research and Development Strategy and its Implementation. FRG II project. Empowering Farmers' Innovation Series No. 2. pp. 1-16.
- [9] Dawit Alemu, Agajie Tesfaye, Abebaw Assaye, Degu Addis, Tilahun Tadesse and John Thompson, 2018. A HISTORICAL ANALYSIS OF RICE COMMERCIALISATION IN ETHIOPIA: THE CASE OF THE FOGERA PLAIN. Working Paper, December 2018, WP 18. Published by APRA (Agricultural Policy Research in Africa).
- [10] CSA, 2010. Agricultural sample survey 2009/2010, Addis Ababa, Ethiopia ECA. 1997-2006. Ethiopian Customs Authority. External Trade Statistics 1997-2006, Addis Ababa, Ethiopia.
- [11] Biruhalem Kassa. 2010. Rice value chain in Metema district, North gondar, Ethiopia: challenges and opportunities for innovation. Msc. Thesis. College of Development Studies. Addis Ababa University.
- [12] CSA (Central Statistical Agency), 2014. Agricultural sample survey Report on area and Production of major crops. Central Statistical Agency of Ethiopia, Addis Ababa, Ethiopia. V. 1. Statistical bulletin. 532.
- [13] Welday Gebreegziabher, Zinaw Dilnesaw, Tesfay Hailu, Mekuria Tadesse and Mohammed Berhie, 2018. Adaptation and Promotion of Irrigated Wheat Genotypes at Tendahoo Sugar Factory, Afar Regional State of Ethiopia. Int. J. Adv. Res. Biol. Sci. 5 (10): 70-83.
- [14] Zinaw Dilnesaw, Mohamd Ebrahim, Belete Getnet, Fikadu Fanjana, Fikadu Dechassa, Yohanisse Mequaninnet, Hadush Hagose, Getinet Alemaw, Abiwa Adane, Tadesse Negi and Abiy Getaneh, 2019. Evaluation of Rice (*Oryza sativa* L.) Variety Adaptation Performance at Omo Kuraz Sugar Development Project Salamago District South Omo Zone, SNNPR state, Ethiopia. Int. J. Adv. Res. Biol. Sci. 6 (5): 78-85.
- [15] Water Works Design and Supervision Enterprise (WWDSE), 2005. Tendaho Dam and Sugar Project. Main Report. Ministry of Water Resources, Addis Ababa, Ethiopia.
- [16] Water works Design and supervision Enterprise, 2007. Tendaho Dam and Irrigation project feasibility study final report. Addis Ababa, Ethiopia.
- [17] Zeleke Teshome, Mengistu Bosie, Dereje Bishaw and Mohammed Ibrahim, 2015. Assessment of Irrigation Practices and Salt Affected Soils in some Sugarcane Fields at Tendaho Sugar Factory.
- [18] Sleshi Abbi, 2016. Status of salt affected soils, irrigation water quality and land suitability of Dubti/Tendaho area, north eastern Ethiopia. PhD. Dissertation. Haromaya University, Ethiopia.
- [19] Cochran, W. G. and Cox, G. M., 1957. Experimental Designs. New York: Wiley.
- [20] Johnson, DT, 1982. The Business of Farming: A Guide to Farm Business Management in the Tropics. London and Basingstoke: ELBS/Macmillan.
- [21] Kay, R. D., 1986. Farm Management, Planning, Control and Implementation. London: McGraw Hill. pp 65-126.
- [22] 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.
- [23] Wubale Tefera, Zinaw Dilnesaw, Kidane T/Michael, Abiwa Adane and Ashebir Getie, 2019. Performance Evaluation of Six Rice (*Oryza sativa* L.) Varieties at Beles Sugar Development Project, Ethiopia. Int. J. Adv. Res. Biol. Sci. (2019). 6 (2): 121-128.
- [24] Cooper M and Somrith B (1997). Implications of genotype by environment interaction for yield adaptation of rain fed lowland rice. Proceeding of an International Workshop held at Ubon Ratchatani. ACIAR, Canberra.
- [25] Ramasany S, Chandrasekaran B, Sankaran S., 1987. Effect of spacing and seedlings hill-1 on rice yield. International Rice Research Newsletter, IRRI, Philippines; 12 (4): 49.
- [26] Das, M.; Ganguly, A.; Haldar, P., 2012. Annual biomass production of two acridids (Orthoptera: Acrididae) as alternative food for poultry. Spanish J. Agric. Res., 10 (3): 671-680.
- [27] Sadiqur Rahman, Taslima Jahan, Syed Md. Mizanur Rahman, Musfiqur Rahman, M. Moynul Haque, Md. Abu Ashraf Khan, 2018. Evaluation of Some Transplanted AUS Rice Genotypes for Morphology, Yield and Disease Incidence. European Academic Research. Bangladih. P. 295.
- [28] Hailu Tefera, 2010. Variability and association of characters in rice (*Oryza sativa* L.) cultivars. M. Sc. Thesis, Alemaya university of Agriculture Dire Dawa, Ethiopia.
- [29] Idris M, Matin MA, 1990. Response of four exotic strains of aman rice to urea. Bangladesh Journal of Agricultural Science; 17 (2): 271-275.
- [30] Romualdo M. Ortuoste, Jesusa D. Ortuoste, 2014. Testing and Evaluation of Upland Rice Varieties in Sultan Kudarat Province. International Conference on Biological, Civil and Environmental Engineering (BCEE-2014) March 17-18, 2014 Dubai (UAE). P. 212.
- [31] Islam, S. M., S. Peng, R. M. Visperas, M. S. U. Bhuiya, S. M. A. Hossain and A. W. Julfikar, 2010. Comparative study on yield and its attributes of hybrid, inbred and NPT rice genotypes in a tropical irrigated ecosystem. Bangladesh J. Agric. Res., 35: 343-353.
- [32] Gupta AK, Sharma RS, 1991. Effect of plant spacing and fertility level on grain yield of early, medium, indica rice (*Oryza sativa*). Indian Journal of Agronomy; 36 (supplement): 223-225.
- [33] Ashraf A, Khalid A, Ali K., 1999. Effect of seedling age and density on growth and yield of rice in saline soil. Pak J Biol Sci.; 2 (30): 860-862.
- [34] Merkeb Getachew and Techale Birhan, 1986. Growth and Yield of Rice (*Oryza sativa* L.) as Affected by Time and Ratio of Nitrogen Application at Jimma, South-West Ethiopia. International Journal of Agriculture Innovation and Research: 4 (1): 175-182.