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Performance Evaluation of Upland Rice (Oryza Sativa L.) and Variability Study for Yield and Related Traits in South West Ethiopia

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1. Abstract

This study aimed at assessing genetic variability and to evaluate the performance of 13 improved upland rice varieties for yield and its components based on morphological traits. The field experiment was conducted using randomized block design at Guraferda and Gimbo districts in 2019 main cropping season. The analysis of variance (ANOVA) over the two locations revealed significant differences ($p \leq 0.05$) among varieties for days to 50% heading, days to 85% maturity, panicle length, thousand grain weight and grain yield. Similarly, the ANOVA for variety by location interactions depicted significant differences among the tested varieties for days to 50% heading, days to 85% maturity and thousand grain weight. High heritability was obtained from days to heading (88.5%), panicle length (85.0%) and grain yield (85.2%), which indicates these traits can be easily improved through selection. High to medium broad sense heritability and genetic advance as percentage of the mean for days to heading, thousand grain weight and grain yield indicates good opportunity for improvement through selection using their phenotypic performance. This is mainly due to the high role of additive gene action for the expression of such traits. This study confirmed the presence of variability among varieties for most of the studied traits, which will create an opportunity for breeders to improve rice yield and other attributes.

2. Introduction

Rice is one of the most important cereal crops globally with annual production of 498.4 million metric tons on milled basis [12]. In Africa, about 20 million people of the continent cultivate and consume rice [5]. Its consumption is replacing teff, maize, cassava and other crops, but the continent has not met this shift of the crop, and hence, Africa imports large amount of rice.

In Ethiopia the crop is produced in the three main rice producing regions: namely, Amhara, Oromia, and SNNPR. Rice demand in the nations is steadily increasing due to; it's reaches in carbohydrate that provide energy, rice dishes are easy to prepare, long shelf-life not easily attacked by storage pest like weevils; besides, it has a higher market value next to tef. However, its production and productivities are limited despite 5 million hectares of the nations are highly suitable for rice production.

In SNNPR region upland rice is mainly produced in Benchi-sheko zone at Guraferda district and kaffa zone at Gimbo district. In the Guraferda district 17 kebeles produce rice as a major crop and more than 5500 hectares of lands are annually covered by the crop. However, in both of the districts rice productivity is very low mainly due to lack of improved varieties, weeds and other production challenges. Thereby, the productivity of the crops declined to 28.8 qha-1 in 2014 from 32 qha-1 in 2012 at Guraferda [6]. In the nation, from different regional and national research centers greater than 15 improved upland rice varieties were registered and released for production. In fact, out of the 15 released upland rice varieties some of them gave greater than 50 qha-1 in research field. Therefore, this study was initiated so as to evaluate released upland rice varieties for yield and related traits for the study area.

3. Materials and Methods

3.1. Description of the Study Areas: The field experiment was carried out during the main cropping season of 2019 in two locations at Gojeb and Guraferda districts in Southern Nations, Nationalities and Peoples Regional State of Ethiopia. The two locations represent two different major rice producing agro-ecologies of the region. Guraferda site is located 06° 50' 368" North, 035° 17' 16" East with an altitude of 1138 m.a.s.l. Also, Gojeb testing site is located 7° 24'49.722" North, 36° 28'22.560"East with altitude of 1401 m.a.s.l.

3.2. Experimental Plant Materials and Design: The materials used in this study consisted of 13 improved upland rice varieties, viz. Fogera 1, Adet, NERICA 4, Hiddassie, Andassa, Superica 1, NERICA 12, NERICA 13, Getachew, Pawe 1, Tana, Kokit and Chewaka; of which Superica 1 was used as standard check. The experiment was laid out using randomized complete block design. The plot has 5 m length and 1.5 m width with a total area of 7.5m2; plots and blocks were spaced 0.5m and 1m respectively. As per the national recommended seed rate i.e., 60 kg/ha, which is equivalent to 45g of seeds per plot were hand drilled along the line of each six rows. Similarly, on the basis of national recommendation fertilizers were applied. Throughout the growing stage, pertinent agronomic practices for rice were executed.

3.3. Data Collections and Statistical Analysis: According the standard evaluation system for rice [7], days to 50% heading, days to 85% maturity, plant height, panicle length, thousand grain weight and grain yield were collected on plot (from four central rows) and plant basis (average of five randomly taken plants). After homogeneity of error variance was inveterate, combined analysis of variance over the two locations was done using SAS statistical package (SAS, 2002).

4. Results and Discussions

The combined analysis of variance over the two locations depicted significant difference ($p \leq 0.05$) among the 13 tested upland rice varieties for all of the traits studied but plant height (Table 1). This might be due to the genetic differences existed among varieties for the studied traits. In this study, the presence of significant VL effects were obtained on traits, such as days to 50% heading, days to 85% maturity and thousand grain weight. According to Bramel-Cox [4] significant or sizable variety by location interactions have been frequently reported when contrasting levels of one major stress existed among location and/or using genetically dissimilar varieties. Across the two locations the consistent performance of varieties for yield were confirmed by the absence of considerable VL effects for grain yield. Therefore, a wide adaptation for the evaluated varieties was arising from this low VL interaction variance.

Table 1: Analysis of variance for 13 upland rice varieties tested at two locations

Traits	MSL (1)	MSV (12)	MSVXL (12)	MSE (50)	CV (%)	R2
DH	1456**	753.2**	86.6**	9.1	3.4	0.96
DM	2619.3**	266.2**	113.9**	1311.4	4	0.84
PH	6794.6**	723.3ns	375ns	432	20	0.48
PL	265.8**	10.7**	1.6ns	1.4	5	0.85
TGW	424.6**	78.8**	39**	2.3	5	0.94
GY	12582610**	4385014.7**	650690.9ns	553050	21	0.73

Where, MSL= mean square of locations, MSV=mean square of varieties, MSVXL, mean square of varieties by locations interactions, MSE= mean square of errors, CV= coefficient of variations, R^2 =coefficient of determination and figures in the parenthesis indicates degree of freedom

Among the 13 evaluated varieties except for two, 85% of grains on panicle were matured in the range of 119 to 129 days after seeding. Thereby, the maturity ranges of most of the studied varieties were clustered under medium maturity class. The presence of medium and early maturing varieties too, are important for climate mitigation as drought escape mechanism for areas with marginal rainfall. Besides, those varieties which takes 120 -130 days to finish their physiological maturity are believed to give higher yield when the level of nitrogen in the soil is optimum. This is supported by Yoshida [13], who stated about 120-130 days from seeding to maturity appears to be optimum for maximum yield in the tropics. However, a longer growth duration may produce higher yields when fertility is low presumably because there is more time to extract soil nitrogen [8].

Varieties differed significantly in plant height which ranged from 88 to 124 cm. According to IRRI4 [7], height of upland rice is classified as semi-dwarf (<90 cm), intermediate (90-125 cm), and tall (>125 cm). Subsequently, from the current study 31 and 69 percent of the tested varieties were grouped under semi-dwarf and intermediate class, respectively. According to Yoshida [13], a short and intermediate height along with stiffness culm makes the rice plant more lodging-resistant and this is most responsible for high yields.

In this study, grain yield also differed significantly among varieties which ranged from 2209 kg/ha to 5395.8 kg/ha. Higher grain yield was obtained from Chewaka, Hiddassie and Fogra-1 varieties at both Guraferda and Gojeb districts. Chewaka variety gave 5924.2 kg/ha at Guraferda and 5332.7 kg/hg at Gojeb. Similarly, the second-high yielder variety, Hiddassie gave 4685 kg/ha at

Guraferda and 4582 kg/ha at Gojeb. From the pooled data over the two locations Chewaka, Hiddassie and Fogra-1 varieties yields 5395.8, 4482.8 and 4232.8 kg/ha respectively. The yield advantage of Chewaka variety over standard check (Superica-1) is 25.8 and 35 percent at Gimbo and Guraferda districts, respectively (Table 2).

4.1. Coefficient of Variation: Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) values greater than 20% are viewed as high, whereas values less than 10% are considered as low and values between 10 and 20% as moderate. Thus, in this study high PCV and GCV was obtained for grain yield (Table 3). Whereas, the remaining traits were depicted the presence of low coefficient of variation, for GCV which ranged from 4.0 for days to maturity to 22.0 for grain yield and for PCV from 5.2 for days to maturity to 23.9 for grain yield. The analysis also showed that the magnitude of phenotypic coefficient of variation were to some extent higher than genotypic coefficient of variations. Minimum environmental influences on traits expression was determined by the slight difference between PCV and GCV. Therefore, the role of gene effect on traits expression was higher. Similar observations were also stated by [3, 9] in upland rice. In contrary to the present result close values between GCV and PCV, [1] reported a wide difference. The lower GCV for all of the traits but grain yield indicates the existence of narrow genetic bases, so that improvement program should start through inducing genetic variability.

4.2. Heritability: The estimate of broad sense heritability was ranged from 48.2 for plant height to 88.5 for days to 50% heading (Table 3). The estimates of broad sense heritability were classified as low (<30%), medium (30-60%) and high (>60%). Traits with high broad sense heritability estimate viz., days to 50% heading, panicle length and grain yield might respond effectively to selection since it is expected that, environmental influences on phenotypic expression is very low. Similarly, for panicle length [9] noted high broad sense heritability. Heritability alone does not determine the extent of genetic progress gained after one cycle of selection, which is possible through simultaneous estimation of heritability along with genetic advance as a percentage of the mean [2]. In this study high heritability along with high genetic advance as percentage of the mean was recorded for grain yield. The expression of such economically important characters through additive gene action make selection for crop improvement might be rewarding and can be confirmed by recording high value of broad sense heritability along with high genetic advance as percentage of the mean [10].

4.3. Correlation Coefficients: the results of phenotypic correlation coefficient between traits as shown in table 4 reveals grain yield had positive and significant correlation with thousand grain weight (rp=0.300**) and negative and significant correlation with days to 50% heading (rp= -0.249). The positive and significant results between grain yield and thousand grain yield was supported by [3, 10]. The detected positive correlation of thousand grain weight with grain yield indicated that increasing of one trait will result in increasing the correlated trait. Thus, from the current results, improving upland rice through selection would be effective with simultaneous consideration of grain yield with thousand grain weight.

4.4. Path Coefficient Analysis: phenotypic correlation coefficients partitioned into direct and indirect effect using path coefficient analysis, thus provides clear information on character association which helps to formulate efficient selection strategy for crop improvement. The path coefficient analysis (Table 5) revealed that, days to maturity, plant height and thousand grain weight exerted positive and direct effect on grain yield. The high and positive direct effect of plant height (0.618), thousand grain weight (0.246) and days to maturity (0.022) on grain yield indicates that, keeping other independent variables constant, an increase in these traits increases grain yield.

5. Conclusion

The results from pooled analysis of variance showed that there is a significant difference among varieties for all of the studied traits except plant height. This study confirmed varieties Chewaka, Hiddassie and Fogera-1 performed better among others where they were evaluated. The present study results indicated that there is adequate genetic variability exist in the varieties studied. Therefore, the low average yield of rice in Ethiopia will be increased through exploiting heterosis at F1 generation from the used materials.

Table 2: Mean performance of 13 upland rice varieties for six traits

Varieties	DH	DM	PH	PL	TGW	Grain yield (kg/ha)		
						Guraferda	Gojeb	pooled
Fogera 1	79efg	124bcd	94.8	22ab	29d	4582.1a-c	4354abc	4232.8b
Adet	76g	124bcd	89.5	21bcd	29d	4239.6b-d	4106.7bcd	3958bc
NERICA 4	77.7fg	126bc	88	20.7cd	28d	3225.3c-f	3693bcd	3320cde
Hiddassie	82.7de	119.7d	124	22abc	28.8d	4685.0ab	4582ab	4482.8b
Andassa	97c	127bc	107.2	22.5a	25.8ef	2875.0d-f	3971bcd	3312cde
Chewaka	102b	141a	114.7	23a	29d	5924.2a	5332.7a	5395.8a
Superica 1	83.8d	123bcd	103	23a	34.7b	3812.6b-e	3952bcd	3782bcd
NERICA 12	82.5de	127bc	98.8	22.7a	33bc	2286.1f-g	3505cd	
NERICA 13	803f	125bcd	97.7	22.7a	32c	2516.5e-g	3596.7bcd	3782bcd
								2943def
Getachew	107.2a	129b	104	22.8a	24.7f	1315.7g	3190d	2209f
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Where, DH= days to heading, DM= days to 85% maturity, PH= plant height, PL= panicle length, and TGW= thousand grain weight

Table 3: Estimates of parameters of variability for different traits in upland rice

Traits	Mean	Range	Phenotypic Variance	Genotypic Variance	Variability		Heritability (%)	Genetic advance (%) of mean
					GCV	PCV		
DH	144.5	72-117	125.5	111.1	7.3	7.8	88.5	14.1
DM	127.4	108-143	44.4	25.4	4	5.2	57.2	6.2
PH	97.3	73-132	120.6	58.1	7.6	11	48.2	10.9
PL	21.8	15-26	1.8	1.5	5.6	6.1	85	10.7
TGW	30	15-40	13.1	6.6	8.6	12.1	50.5	12.6
GY (kg/ha)	3581.1	820-6876	730835.8	622387.3	22	23.9	85.2	41.9

Where, DH= days to heading, DM= days to 85% maturity, PH= plant height, PL= panicle length, TGW= thousand grain weight, GCV=genotypic coefficient of variation and PCV=phenotypic coefficient of variation

Table 4: Estimation of genotypic (below diagonal) and phenotypic (above diagonal) correlation coefficients between yields, and yield component characters in 13 Upland rice genotypes

Variable	**DH**	**DM**	**PH**	**PL**	**TGW**	**GY**
DH		0.5509**	0.506**	0.284*	-0.379**	-0.249*
DM	0.688**		0.334**	0.385**	-0.066	-0.137
PH	0.495	0.25		0.479**	-0.271*	0.002
PL	0.036	-0.198	0.674*		-0.574**	-0.146
TGW	-0.175	0.272	-0.377	-0.623*		0.300**
GY	-0.156	0.182	0.425	0.098	0.03	

Where, DH= days to heading, DM= days to 85% maturity, PH= plant height, PL= panicle length, and TGW= thousand grain weight

Table 5: Phenotypic direct and indirect effects of five component characters on grain yield in upland rice

Traits	Phenotypic direct effect	DH	DM	PH	PL	TGW	rp
DH	-0.372		-0.051	0.023	0.014	-0.116	-0.249*
DM	0.022	-0.066		0.023	0.018	-0.02	-0.137
PH	0.618	-0.026	-0.019		0.023	-0.083	0.002
PL	-0.384	-0.034	-0.035	0.051		-0.175	-0.146
TGW	0.246	0.045	0.006	-0.029	-0.027		0.300*

Where, DH= days to heading, DM= days to 85% maturity, PH= plant height, PL= panicle length, and TGW= thousand grain weight

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