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Genetic Variability among Yield and Yield Related Traits in Selected Upland Rice (*Oryza sativa* L. and *Oryza glaberrima* Steud) Genotypes in Northwestern Ethiopia

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ABSTRACT

This study was carried out to assess the extent of variability for yield and yield related traits in upland rice genotypes. Twenty-two selected rainfed upland rice varieties were evaluated in randomized complete block design with three replications during 2014 cropping season. The analysis of variance revealed significant differences between the genotypes for all traits except harvest index, indicating the presence of a considerable amount of variability among the genotype. The disease reaction of different genotypes showed a significant variation for blast and brown spot. The highest disease severity was scored by variety Andaasa which is moderately susceptible to leaf blast. Tana, Andassa, Getachew, FOFIFA-4129 and FOFIFA-3730 showed moderately susceptible response to panicle blast. Severity of brown spot ranged from 1.13-6.03. The highest disease severity value was scored by variety Andasa followed by Tana, Getachew and FOFIFA-3730 which showed moderate resistance to brown spot.

Keywords**:** Blast; Brown spot; Upland Rice; Variability

1. INTRODUCTION

Rice (*Oryza sativa* L. and *Oryza glaberrima* Steud.) is central to the lives of billions of people around the world. About 3.5 billion people depend on rice as a daily food staple for 20 % of their calories (OLAM International, 2015). Rice is the most important food crop and a major food grain for more than a third of the world's population (Zhao *et al,* 2011).

It is among the important cereal crops grown in different parts of Ethiopia as a food crop next to teff, maize, wheat and sorghum. A wide production of rice in the country is believed to make a great contribution to food security. Considering the importance and potential of the crop, it has been recognized by the Government as "the new millennium crop of Ethiopia" to attain food security (MoA, 2010). Ethiopia has a huge potential for rice production that is estimated to about thirty million hectares (MoA, 2010). Accordingly, in the last two years rice production has increased from a total of 88,615.8 ton, in 2011/12 to 121,041.5 ton in 2012/13. While productivity in ton per hectare has increased from 2.89 ton 2012 to 2.9 ton. According to CSA (2014) the number of participant farmers increased from 115,832 to 119, 4970 in 2013 cropping season. The low productivity of rice in Ethiopia is attributed to a number of factors, important of which is seed-borne diseases, causing 50% to 80 % yield losses. In view of the suitable environmental factors, blast and brown spot are becoming the most serious problem in Ethiopia for both improved as well as local varieties in hot humid rice growing area. In order to meet the fastest growing demand for rice grain, developing high yielding genotypes with desirable agronomic traits for diverse ecosystem is, therefore, a requisite.

A successful breeding program depends on the genetic diversity of a crop for achieving the goals of improving the crop and producing high yielding varieties (Padulosi, 1993). Grain yield is a complex polygenic quantitative trait, greatly affected by environment.

Hence, the present study was undertaken with the objectives of; - To assess the extent of genetic variability for yield and yield related traits in rainfed upland rice genotypes and to identify blast and brown spot resistant released upland rice genotypes.

2. MATERIALS and METHODS

A field experiment was conducted using 22 rainfed upland rice genotypes in the Northwestern part of Ethiopia at Pawe agricultural research center during 2014 main cropping season. Randomized complete block design with three replications was used. Each experimental plot had a total area of 6 m^2 (1.2 m x 5 m) and six rows at 0.2 m interval. There was a 0.5 m distance between two consecutive plots within a replication. Seeds were sown in rows with manual drilling at a rate of 60 kg per ha. Fertilizer was applied at a rate of 100 kg DAP and 100 kg Urea per ha. Nitrogen was applied three times in the form of urea. All DAP was applied during planting while urea was applied in three splits at planting tillering and at panicle initiation stages.

Data collection and analysis

Data like number of fertile tillers per plant, plant height, panicle length, number of filled grains per panicle and number of unfilled grains per panicle were collected on plant base and days to heading, days to maturity, harvest index, thousand-grain weight, biological yield and grain yield were collected on plot base. Blast infection type was measured on the scale of zero to nine (IRRI, 2002). Analysis of variance (ANOVA) was carried out on the data to assess the genotypic effects and their interaction using general linear model (GLM) procedure for randomized complete blocks design (RCBD) using SAS (2004) version 9.1.3. Mean comparisons among treatment means were conducted by the least significant difference (LSD) test at 5% levels of significance. The RCBD design analysis of variance was used to derive variance components as structured in Table 1 (Cochran and Cox, 1957).

Table 1. ANOVA for RCBD.

Source of Variation	d f	Means square	Expected mean square
Genotypes	g-1	Msg	$\sigma^2 e + g\sigma^2_r$
Replication	r-1	Msr	$\sigma^2_e + r\sigma^2_g$
Error	(r-1)(g-1)	Mse	σ^2_e

where: r = number of replications; g = number of genotypes; Ms_g = mean square due to genotypes; Ms_r = mean square due to replications; Ms_e = mean square of error; σ^2_g, σ^2_r and σ^2_e are variances due to genotype, replication and error, respectively

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 i^{th} genotype and the j^{th} replication,
μ = the grand mean of trait Y

r_j = the effect of the j^{th} replication

g_i = the effect of the i^{th} genotype

ε_{ij} = experimental error effect

Table 2. Pawe Agricultural Research Center Agro-meteorological Observation record in 2014 cropping season.

Month	Total R.F (mm)	Max Temp (°C)	Min Temp (°C)	RH (%)	Soil temperature in depth	
					10 cm	20 cm
May	192.6	31.8	19.4	80	27.8	27.6
June	234.7	30.2	18.7	86	26.2	25.9
July	279.3	28.4	17.4	86	26.4	23.0

August	303.0	27.8	18.0	88	25.1	24.6
September	284.7	28.8	17.5	87	26.0	25.0
October	226.4	29.8	17.5	84	26.5	25.1
November	0.9	31.0	15.1	77	27.3	26.0

"Total R.F. (mm)" = "Total rainfall"; "RH (%)" = "relative humidity"

3. RESULTS AND DISCUSSION

Table 3. The mean squares for different sources of variation for 11 Traits of 22 genotypes evaluated under rainfed upland condition.

Source of var	Replication	Genotype	Error
d.f	2	21	42
DH	10.92	61.74**	25.15
DM	1.7	20.58**	3.01
PL	6.28	6.31**	2.35
PH	115.44	140.06**	40.87
FTPP	4.8	2.25*	0.96
GF	43.45	215.98*	121.96
UFGPP	1.46	2.69*	1.27
HI	0.0003	0.005NS	0.006
BY	271867	1446863.28*	575738
TGW	3.61	11.40***	1.62
GY	2326975	717166.85*	317754

"*, ** indicate significance at 0.05 and 0.01 probability levels."

NS = Non Significant

where: GY = grain yield, DH = number of days to heading, DM = number of days to mature, PL = panicle length, PH = plant height, GF = filled grains per panicle, BY = biomass yield, HI= harvest index, TGW = thousand grain weight, UFGPP = unfilled grains per panicle and FTPP = fertile tiller per plant

The analysis of variance showed highly significant differences ($p \leq 0.01$) for days to flowering, days to maturity, hundred seed weight, plant height and panicle length and differed significantly ($p < 0.05$) for fertile tiller per plant, filled grains per panicle, unfilled grains per panicle, biomass yield and grain yield per plot except harvest index, indicating the existence of variability (Table 3).

Genotypes significantly differed in plant height that ranged from 90.27 to 110.8 cm. Maximum height was noted in genotype FOFIFA-4129 (110.8 cm) which was statistically at par with lines Andassa (110.53), Tana (110.53) and FOFIFA-3730 (110). The genotypes NERICA-3, Kokit, NERICA-4, NERICA-14 and WAB450-1-B-P-462-HB showed short stand with plant height of 90.2, 92.6, 91.93 and 92.93 cm. Sabouri *et al.* (2008) recommended plant height as an important trait for selection of high yielding rice plants.

Panicle length also differed significantly in different genotypes with a range of 21.67 to 24.07 cm. Maximum panicle length (24.07 cm) was noted in genotype Andassa followed by FOFIFA-3730, Variety-3 and Variety-1. It was observed that genotypes showing tall plant height had also shown long panicles and vice versa. This might be attributed due to positive association between plant height and panicle length.

Number of tiller in rice is a major determinant for panicle production and as a result, it affects total yield. The genotypes which produced higher number of effective tillers per plant showed higher grain yield in rice (Dutta *et al*., 2002). The lines with higher number of total tillers also excelled in a number of productive tillers per plant. Significant variation in the number of fertile tillers ranging from 5.13 to 8.4 per plant was observed among the genotypes. Higher number of tillers (8.4) per plant was produced by genotype Pawe-1 followed by Tana (8.0), WAB450-1-B-P-462HB (7.73) and Andasa (7.67). Medium numbers of fertile tillers per plant were observed in VARIETY-1 (6.8), Hidassie (6.6), WAB515-B-16A1-2 (6.6), FOFIFA-412 (6.67), FOFIFA-3737 (6.53) and VARIETY-2 (5.64).

Table 4. Performance of 22 rice genotypes for 10 yield and yield-attributing trait under rainfed upland condition.

Trt	Dh	Dm	pnl	ph	Ft	GF	Ufg	Bio	TGW	GY
Hidassie	72.33bcdefg	108.33cdefgh	22.07abcd	98.8bcd	6.67bcdefgh	116.4abc	5.47bcde	3233.33ef	27.2jk	3416.67cdef
Getachew	74bcdefg	110.67bcd	21.87abcd	107.4ab	7.2abcdef	88.73f	7ab	5533.33a	31.33bcde	4206.67ab
Andassa	76.33bcdef	109bcdef	24.07a	110.53a	7.67abcd	104.2abcdef	6.93bc	5100abc	31.17bcdef	4161.67abc

NERICA-18	NERICA-15	NERICA-14	NERICA-12	Kokit (IRAT-2)	SUPERICA-1	NERICA-4	NERICA-3	Tana
77bcde	72.67bcdefg	72bcdefg	68.67fg	72bcdef	76.67bcdef	70.33cd e fg	69.33defg	77.33bcd
109.67bcde	107.33efghi	111bc	108defghi	105.33ij	110bcde	104j	104j	111.67b
21.2bcde	23ab	20.33cdef	21.87abcd	20.33cdef	19ef	21.2bcde	20.93bcde	22.2abcd
95.2cd	97.27bcd	104.27abc	96.67cd	92.6d	99.2bcd	91.93d	90.27d	110.53a
5.13h	7.07abcdefg	6.67bcdefgh	6.07defgh	5.93efgh	5.6fgh	5.6fgh	5.53gh	8ab
100.07cdef	118.6ab	113.6abcd	110.13abcde	92.87f	108.67abcde	103.47bcdef	104.53abcdef	100cdef
5.93bcde	6.53bcd	5.13cde	5.33bcde	5.8bcde	5.26bcde	5.13cde	4.73de	8.8a
3666.67def	3366.67ef	3600def	4166.67bcdef	3666.67def	3800def	3066.67f	2966.67f	4833.33abcd
29.17fghij	29.27efghij	33ab	29.67defghi	31.5bcd	30.67cdef	27.83ijk	27.5jk	31.17bcdef
2755f	3205ef	3495.83bcde	3780abcde	2805.83f	3180ef	3188.33ef	3240.83def	4538.33a

PAWE-1	VARIETY-3	VARIETY-2	VARIETY-1	WAB450-1-B-P-462-HB	ARCCUFfa11-L1P1-B-B-1	FOFIFA-3730	FOFIFA-4129
87.33a	78.67b	78.33bc	76.33bcdef	71bcdefg	67.33g	75.67bcdef	78.33bc
115a	108.67cdefg	108defghi	110.33bcd	106.67fghij	105.67hij	108.67cdefg	110bcde
18.27f	23.4ab	22.73abc	23.33ab	21.4bcde	20def	23.4ab	21.8abcd
103.93abc	99.07bcd	95.8cd	98.27bcd	90.87d	92.93d	110a	110.8a
8.4a	7.2abcdef	6.53bcdefg	6.8abcdefg	7.73abc	6.13cdefgh	7.2abcdef	6.67bcdefgh
100.07cdef	121.73a	107.2abcde	105abcdef	102.13bcdef	97.67def	94.67ef	102.47bcdef
5.4bcde	5.66bcde	5.4bcde	4.66 e	5.46bcde	5.53bcde	6.73bc	5.46bcde
5266.7ab	3833.33.67def	3833.33def	3550ef	3766.67def	3366.67ef	4366.67abcde	4666.67bcdef
33.83a	27k	28.33hijk	28.17ijk	28ijk	28.17ijk	29ghijk	30.33cdefgh
4345.83ab	3856.67abce	4029.17abcde	3488.33bcdef	3481.67bcdef	3193.33ef	4090abcd	3792.5abcde

Mean	74.26	108.42	21.6	99.92	6.72	104.06	5.8	3949.24	29.8	3624.81
CV	6.75	1.6	7.1	6.39	14.64	10.61	19.43	19.21	4.27	15.5
LSD	8.26	2.86	2.52	10.53	1.62	18.19	1.85	1250.3	2.09	928.83

"Means with the same letter are not significantly different"
Where: GY = grain yield, DH = number of days to heading, DM = number of days to mature, PL = panicle length, PH = plant height, GF = filled grains per panicle, BY = biomass yield, HI = harvest index, TGW = thousand grain weight, UFGPP = unfilled grains per panicle and FTPP = fertile tiller per plant.

Analysis of variance for days to 85% maturity showed significant mean sum of square due to genotypes difference. The mean value ranged from 104 to 115 days. Genotypes NERICA-3 and NERICA-4 were earlier in maturity (104 days each) followed by Kokit (105.33), ARCCUF-fall-LIPI-B-B-I (105.67) and WAB451BP462-HB (106.67). Variation in days to maturity in different genotypes has also been reported by Sabouri *et al.* (2008). Days to maturity showed almost the same trend with days to heading. Yaqoob *et.al*. (2012) also observed that early headed lines matured earlier. Like other traits, thousand grain weight also differed significantly in different rice genotypes which ranged from 27 to 33.83 g. Maximum grain weight was recorded by genotype Pawe-1 (33.83g) followed by NERICA-14 (33 g) NERICA-13 (32.17g), FOFIFA-3737 (31.17g), Getachew (31.33g), Andassa (31.29) and Tana (31.17g) which were significantly better than the rest of the genotypes. Earlier workers (Zheng-jin *et.al*., 2006) have reported significant differences in 1000-grain weight in rice genotypes. In this study grain yield of genotypes ranged from 2.7 ton to 4.5 ton per hectare. Higher grain yield (4.5 ton / ha) was harvested from cultivar Tana, closely followed by genotypes Pawe-1 (4.3 ton / ha) and Getachew (4.2 ton / ha). Lafarge and Bueno (2009) reported a significant variation in yield and other traits of rice genotypes grown under irrigated and rainfed conditions. Analysis of variance for biomass yield showed significant mean sum of square due to genotypes difference .The mean value ranged from 2.96 to 5.53 kg / plot.

The Reaction of Different Rice Genotype against Blast and Brown Spot

The disease level was dependent on variety and suitability of climatic condition during the growing season. It is well documented that the environmental conditions, especially relative humidity, are one of the most important factors affecting sporulation, release and germination of blast conidia (Ou, 1985).

Table 5. Reaction of 22 rice genotypes against blast and brown spot at Pawe agricultural research center (2014)

No	Genotypes	LB			PB			BS		
		Disease severity (%) (0-9 scale)	Disease reaction	AUDPC	Disease severity (%) (0-9 scale)	Disease reaction	AUDPC	Mean disease severity (1-9) sscale	Disease reaction	AUDPC
1	Hidassie	6.79cde	R	431.41bcde	9.38ef	R	189.51def	1.80cd	R	408.46fghijk
2	Getachew	26.67ab	MR	648.35ab	30.99ab	MS	303.63a	5.47a	MR	716.256ab
3	Andassa	30.74a	MS	706.61a	31.23ab	MS	309.09a	6.03a	MR	764.19a
4	Tana	20.62abc	MR	608.16abcd	34.32a	MS	313.22a	5.53a	MR	674.82abcd
5	NERICA-3	5.31ed	R	386.28de	8.52ef	R	188.21def	1.80cd	R	412.56fghijk
6	NERICA-4	4.32e	R	388.67de	8.15ef	R	183.17def	1.87cd	R	333.43ijk

7	SUPERICA-1	7.41cde	R	417.03de	14.69def	MR	220.64cdef	2.93cd	R	570.82bcdefg
8	Kokit (IRAT-2)	12.47bcde	R	495.69abcde	17.78cde	MR	234.50bcd	3.33c	R	460.74efghij
9	NERICA-12	8.15cde	R	434.47bcde	13.70ef	MR	210.10def	1.80 cd	R	416.71fghijk
10	NERICA-13	8.89cde	R	427.00cde	11.11ef	MR	198.37def	2.37cd	R	400.60ghijk
11	UPLAND NERICA-14	9.75cde	R	446.22bcde	13.33ef	MR	209.7def	3.55bc	R	594.30bcde
12	UPLAND NERICA-15	16.17bcde	MR	537.45abcde	16.42cdef	MR	228.09bcde	2.00cd	R	500.11efghij
13	UPLAND NERICA-18	14.20cde	MR	515.77abcde	16.54cdef	MR	231.65bcde	3.13cd	R	523.47cdefgh
14	FOFIFA-4129	11.73cde	MR	487.08bcde	26.17abc	MS	274.23ab	2.87cd	R	510.66defghi

Table 5. Continued

15	FOFIFA-3737	9.14cde	R	451.50bcde	23.70bcd	MR	265.22abc	3.53bc	R	581.52bcdef
16	FOFIFA-3730	20.37abcd	MR	639.81abc	26.05abc	MS	280.17ab	5.33ab	MR	689.27abc
17	ARCCUFfa11-L1P1-B-B-1	4.81e	R	391.98de	7.53ef	R	176.63ef	1.73cd	R	374.44hijk
18	WAB450-1-B-P-462-HB	4.94e	R	380.41e	12.72ef	MR	211.35def	1.73cd	R	333.54ijk
19	VARIETY-1	4.44e	R	398.37de	8.89ef	R	188.19def	1.53cd	R	300.05k
20	VARIETY-2	5.43cd	R	394.86de	10.62ef	R	197.51def	1.13d	R	308.03k
21	VARIETY-3	3.46e	R	364.92e	11.85ef	MR	202.97def	1.80cd	R	324.85jk
22	PAWE-1	4.32e	R	387.14de	6.17f	R	169.16ef	1.70cd	R	328.8652jk
	MEAN	10.914		469.965	16.358		226.608	2.862		478.536

	C/V	70.544		24.034	32.313		12.501	37.121		19.365

"Means with the same letter are not significantly different"
LB = leaf blast, PB = panicle blast, BS = brown spot
R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible

The data regarding the reaction of various rice genotypes against leaf blast and panicle blast disease were given in Table **5.** The highest disease severity value (30.74%) and AUDPC (706) was scored by variety Andaasa which is moderately susceptible for leaf blast response. Moderately resistance response was scored by varieties Getachew, Tana, FOFIFA 3730, NERICA-15, NERICA-18 and FOFIFA 4129. The lowest disease severity value was scored by genotypes VARIETY-3, NERICA-4 and Pawe-1. Moreover, varieties with the lowest disease score were highly resistant to leaf blast. Depending on the statistical analysis, there was a significant difference among genotypes for panicle blast résistance. Genotypes; Tana (34.09 %), Andassa (31.23%), Getachew (30.99%), FOFIFA-4129 (26.17%) and FOFIFA-3730 (26.01%) which showed moderately susceptible response to panicle blast and Superica-1, Kokit, NERICA-12, NERICA-13, NERICA-14, NERICA-15, NERICA-18, FOFIFA-3737, WAB450-1-B-P-462-HB and VARIETY-3 showed moderately resistance response to panicle blast. The lowest diseases severity was scored by Pawe-1 (6.17%), ARCCUFfa11-L1P1-B-B-1 (7.53%), NERICA-4 (8.15%), NERICA-3 (8.52%) VARIETY-1 (8.89%), Hidassie (9.38%) and VARIETY-2 (10.26%) which indicated variable level of resistance response against blast.

Brown spot especially occurs in environments where water supply is scarce and it is often combined with imbalances in plant mineral nutrition. Due to high and regular rainfall pattern with high day and night temperature which suppress the severity of brown spot. The severity of brown spot ranged from 1.13 to 6.03. The highest value was scored by variety Andasa (6.03) followed by Tana (5.53), Getachew (5.47) and FOFIFA-3730 (5.33).

4. CONCLUSION

The Analysis of variance showed the presence of significant differences among the tested genotypes for all characters considered, indicating the existence of variability. Even if varieties Andasa Tana, Getachew and FOFIFA-3730 scored higher grain yield, similarly they scored the highest disease severity value for both blast and brown spot. Therefore; these varieties are not recommended for Pawe district and /or similar agro-ecology where rice was grown. However, NERICA varieties (NERICA-3 and NERICA-4), New varieties (VARIETY-1 and VARIETY-2), Hidassie and Pawe-1 had the lowest diseases severity for blast and brown spot disease and also produce good grain yield. In the present investigations, the lines showing resistance against blast and brown spot disease can be utilized as a source of resistance for breeding disease resistant lines of rice.

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