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Genotype x Environment Interaction for Yield and its Components in Upland Rice (*Oryzasativa* L.)

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Abstract: *Twelve upland rice genotypes were evaluated during* kharif*2011, 2012 and 2013 for stability and suitability under rainfed conditions of subzone V of Jharkhand.The present investigation was conducted at Zonal Research station (*Birsa Agricultural University*), Chianki, Palamau to identify the suitable upland varieties which has givenconsistence yields over the years. Variance due to genotypes, environments were significant for all the characters while genotype x environment interaction was significant for seed yield, number of filled grains per panicle, paniclelength and 1000-seed weight. Mean performance over three years for seed yield ranges from 17.34 q/ha (BVD-109) to 28.59 q/ha (BAU-438-6-2).On the basis of performance and stability parameters, it was observed that the two genotypes* viz. *BAU-438-6-2 and RR-616-B-2-75-2 were the most ideal, as they have showed higher mean seed yield and adaptability to wide range of climatic conditions because these genotypes had regression coefficient approaching to unity (bi=1) and least deviation from regression coefficient (S^2d_i=0). The genotype BVD-111 was other promising and suited to poor environment whereas genotype IR-78906REWA648 was also another most desirable and suited to high responsive environment. Other important yield attributing character is filled grain per panicle in which BAU-438-6-2was adjudged as most stable genotype (bi=1, S^2d_i=0). On the basis of above findings the genotypes BAU-438-6-2was found most suitable genotype for the Palamau region.*

Key words: *Genotype x environment interaction, stability, yield upland rice*

INTRODUCTION

Rice (*Oryzasativa* L.) is one of the most important staple food cropof India in terms of area and production. In Jharkhand, rice is grown in 18 lakh hectares out of 28 lakh total cultivated areas whereas upland rice has important place in *kharif* crop of the state and grown in an area of two lakh hectares. Of all the ecotypes, the upland ecology is more variable and the varietal improvement is challenging. Only 15 % of the varieties released so far are for rainfedupland ecology and thus there is a need to develop varieties with yield potential and stable performance over a wide range of environments. Identification of such varieties will have a considerable significance in crop improvement. Therefore, an effort has been made to identify stable upland rice genotypes under rainfedupland ecology.

MATERIALS AND METHODS

The experimental material of the present investigation comprised of twelve upland rice genotypes collected from different institute. The genotypes were grown during*Kharif*2011, 2012 and 2013 at Zonal Research station (*Birsa Agricultural University*), Chianki, Palamau. The experimental materials were sown as direct seeded in randomized complete block design with three replications. Each entry was sown in 15 rows plot of 5 metre length with 20 cm row spacing. Ten plants from each replication were selected randomly and observation were recorded on ten characters *viz*; plant height (cm), panicle length (cm), panicles/ plant, spikelets/ panicle, days to maturity , filled grain/ panicle, unfilled grain/ panicle, harvest index %, test weight (g), grain yield (q/ha), days to maturity and they were computed on plot basis. The mean data of each

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Table 1
ANOVA for stability performance for yield and its related traits in upland rice

Sourceof variation	d.f.	Plant height	Panicles/ Plant	Panicle length	Spikelets/ Panicle	Filled grain	Unfilled grain	Days to maturity	Harvest index	Test weight	Grain yield (q/ha)
Rep within Env.	6	5.06	0.16	0.54	3.16	3.67	1.38	2.50	3.92	0.14	0.34
Genotypes	19	612.71**	0.46**	4.14**	122.24**	152.32**	36.47**	411.94**	97.31**	25.97**	12.69**
Env.+(Geno.*Env.)	40	353.77**	0.12**	1.43**	20.81**	22.61**	7.24*	4.61**	16.78**	0.54**	0.96**
Environments	2	724.91**	2.56**	30.15**	271.21**	351.85**	37.38**	75.48**	436.56**	10.21**	23.68**
Geno.* Env.	38	19.29**	0.07	0.78	14.14*	16.30**	6.55*	2.89*	5.98**	0.36	0.54*
Environments(Lin.)	1	5124.36**	18.22**	220.35**	1894.48**	2411.95**	257.64**	546.77**	3295.92**	65.58**	168.75**
Geno.* Env. (Lin.)	19	30.26**	0.06	0.79	16.99	27.67**	12.38**	1.09	18.48**	0.29	0.85**
Pooled Deviation	20	15.10**	0.07**	0.76**	14.61**	13.21**	5.46**	3.21**	3.62**	0.33**	0.44**
Pooled Error	114	0.59	0.02	0.08	0.66	0.79	0.85	0.44	0.65	0.06	0.08
Total	59	113.50	0.16	1.76	33.00	38.37	11.61	54.22	27.11	4.39	2.39

*,**: Significant at 5% and 1%, respectively.

Table 2
Estimation of stability parameters of the twenty genotypes of upland rice for plant height, panicle/plant and panicle length

Genotypes	Plant height (cm)			Panicles /plant			Panicles length (cm)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
Birsa Dhan -108	74.83	0.32**	1.29	4.10	0.49	0.01	21.84	1.13*	0.89
Birsa VikasDhan -109	87.38	0.65	12.72**	4.15	0.53	0.08*	22.64	0.72	0.34**
Birsa VikasDhan -110	90.96	0.80	29.94**	4.27	0.47	0.02	22.02	0.43	1.96**
Vandana	94.12	1.03	1.20	4.41	0.83	0.01	21.75	0.54	0.22*
RR-6161-B-2-72-2	90.58	1.66	7.55	4.24	0.80	0.03	21.14	0.26*	0.47
IR-78906REWA648	81.50	1.48*	12.21	4.36	1.47*	0.09	22.10	1.19	1.09**
BVD-111	74.42	0.73*	0.79	4.12	1.21*	0.04	21.12	0.92	0.22*
R-R-F-25	96.75	1.20*	0.04	4.38	0.95	0.15	22.88	1.28	0.63**
BAU 438-6-2	97.08	0.97	3.35	4.64	0.99	0.04	21.90	0.98	0.97
BAU 414-05	96.50	1.37	9.42**	3.88	0.77*	0.07	21.73	0.58	0.69**
BAU 408-05	96.42	1.21	4.11*	4.06	0.96	0.03	22.56	0.97	0.69**
CRR-427-14B-1-1-1	69.25	0.30*	0.59	4.22	0.74	0.08	21.36	0.51	0.48**

*,**: Significant at 5% and 1%, respectively.

character was subjected to analysis of variance. For computation of stability parameters, pooled analysis over environments was carried out after following the Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The analysis of variance for stability revealed that there was a significant difference among genotypes in all the environments (table-1). The significant genotype x environment interaction were also observed for the characters like plant height , spikelets/ panicle, filled grain/ panicle, unfilled grain/ panicle, harvest index and yield (q/ha) indicating that all the genotypes interacted considerably well with the varying environmental condition. The above results are in close agreement with the earlier findings of Kumar and Prasad (1991), Mishra and Das (1997), Kumar Raja *et al.* (2004), Pande*et al.* (2006), Uma Devi *et al.* (2008) and Panwar*et al.* (2008). The significant pooled deviation for all the characters indicated the importance of non-linear components in determining the interaction of

Table 3
Estimation of stability parameters of the twenty genotypes of upland rice for spikelets/plant, filled grains/plant and days to maturity

Genotypes	Spikelets/panicle			Filled grain/panicle			Days to maturity		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
Birsa VikashDhan -108	70.10	1.53	2.09**	64.20	0.522	5.17*	82.42	1.05	0.704
Birsa VikasDhan -109	66.97	-0.04*	9.76**	62.35	-0.457*	26.6**	88.21	1.32	2.48
Birsa VikasDhan -110	66.52	-0.07*	20.69**	60.72	-0.48*	18.3*	90.42	1.14	4.39**
Vandana	68.39	0.54	13.38**	65.28	0.16	8.39**	95.38	0.99	-0.21
RR-6161-B-2-72-2	65.50	1.29*	6.18	61.25	0.56	2.01	94.00	1.25	2.02**
IR-78906REWA648	71.73	1.76*	27.54	63.70	1.34*	0.27	94.71	1.25*	0.07
Birsa VikashDhan-111	73.48	0.49*	0.27	63.30	0.58*	0.53	101.29	0.78*	3.58
R-R-F-25	67.62	-0.26*	62.20**	61.27	-0.00	49.91**	103.71	1.13	0.70
BAU 438-6-2	75.51	1.01	0.141	64.92	1.01	0.14	105.08	0.69	9.11
BAU 414-05	75.31	2.28*	11.75	67.51	1.05	0.59	96.13	1.13	0.33
BAU 408-05	67.53	0.31*	2.46**	61.90	0.11*	4.35*	93.63	1.16	6.72*
CRR-427-14B-1-1-1	71.27	0.94	0.79	64.18	0.64**	-0.70	102.83	1.13	5.24*

*,**: Significant at 5% and 1%, respectively.

genotypes with grain yield and their deviation from linear response. It had also indicated that genotypes differed considerably with respect to their stability for grain yield. The similar findings were also reported by Arumugan*et al*. (2007), Bastia *et* al. (2010), Chaudhari*et al*. (2002), Kumar and Prasad (1991),Nanita Devi *et al.* (2009) PatilAtul*et al*.(2013), Ramanjaneyulu (2014) andRamezani and Torabi (2011).

Genotypes were considered to be stable when the regression coefficient (bi) was near unity and the deviation from regression (S^2di) was zero or nearby zero with high mean performance. The estimates on the three stability parameters *viz;* mean performance (μi); regression coefficient (bi) and deviation from regression (S^2di) for different characters are presented in tables-2, 3 and 4.

In the present study BirsaVikasDhan -108 was earliest in maturity. Considering all the three stability parameters five genotypes namely BirsaVikasDhan -108, Birsa VikasDhan-109, Birsa VikasDhan-110, BAU-438-6-2 and BAU-408-05 had lower mean value i.e. desirable and stable for days to maturity. In respect of plant height BAU-438-6-2 and Vandana were found to be stable which received higher mean plant height. The genotype BirsaVikasDhan-111 having bi < 1 andS^2di =0 expected to give better plant height in poor rice growing environment.

Threegenotypes were found to be stable for panicles per plantnamely, BAU-438-6-2 Birsa VikashDhan-111 and R-R-F-25and they had higher mean panicles per plant. Therefore, these genotypes were considered as stable and desirable for panicles per plant. BAU-414-05 had bi <1 and S^2di =0 was found better in poor rice growing condition.

The genotypes BAU-414-05 and R-R-F-25 were found as stable for panicle length and they had higher average mean panicle length. Although the genotype BAU-408-05 having maximum panicle length with bi as unity but S^2di significant therefore it is unstable. In respect of spikelets per panicle two genotypes *viz.*,BAU-438-6-2 and CRR-427-14B-1-1-1 were found as stable. Among these four genotypes, the BAU-438-6-2 had the highest average mean of spikelets per panicle and found as desirable one.

For filled grain per panicle, two genotypes were found as stable and they are BAU-438-6-2 and BAU-414-05 and they had higher average mean filled grain and considered as desirable and stable genotypes. The Birsa Vikash Dhan-111 had bi<1 and S^2di =0 may give better performance in poor or unfavorable environments.

Table 4
Estimation of stability parameters of the twenty genotypes of upland rice for harvest index, test weight and yield

Genotypes	Harvest index (%)			Test weight G)			Grain yield (q/ha)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
Birsa Dhan -108	33.54	1.06	4.399	20.37	0.94	0.01	22.24	0.79	0.03
Birsa VikasDhan -109	37.00	0.73	1.40	22.95	1.07	0.03	17.34	0.45	0.60
Birsa VikasDhan -110	36.49	0.31*	1.96	23.68	1.59	1.03**	21.50	0.35*	0.38
Vandana	43.08	0.96	4.49	24.25	1.34	0.25**	24.27	2.34*	0.49
RR-6161-B-2-72-2	39.52	0.98	0.05	23.86	0.98	0.14	28.52	0.99	0.73
IR-78906REWA648	39.26	1.21*	0.02	23.97	1.37*	-0.03	23.60	1.45*	0.41
BVD-111	34.12	0.20	5.71	23.91	0.70*	0.01	21.50	0.79*	0.12
R-R-F-25	35.30	0.80	1.15	23.34	0.46*	-0.04	19.98	1.29	0.02
BAU 438-6-2	39.55	0.92	2.61	23.95	0.99	0.12	28.59	0.98	0.15
BAU 414-05	32.68	0.53*	0.88	22.79	0.81	-0.02	20.98	1.26	0.16*
BAU 408-05	31.83	0.27**	1.88*	24.89	1.09	0.28	21.44	0.90	0.07
CRR-427-14B-1-1-1	35.87	0.79	2.45**	23.47	0.79	0.000	21.35	0.85*	0.13

*,**: Significant at 5% and 1%, respectively.

Table 5
Classification of genotypes according to stability parameters for seed yield and related important characters

Name of group	Criteria	Name of the genotypes						
		Panicles/ plant	Panicle length	Filled grain	Days to maturity	100-seed Weight (g)	Yield (q/ha)	Suitable for cultivation
Average stable	High mean, b_i=1 but non-significant and S^2d_i Non significant	BAU-438-6-2	BAU-438-6-2	BAU-438-6-2	Vanadana	BAU-438-6-2	BAU-438-6-2, RR-6161-B-2-72-2	Suitable for general cultivation
Above average response	High mean, b_i>1 & significant and S^2d_i Non significant	Birsa Vikash Dhan-111	Birsa Vikash Dhan-109	IR-78906 REWA648, Birsa Vikash Dhan-109	IR-78906 REWA648	IR-78906 REWA648	Vandana, IR-78906 REWA648	Suitable for favourable environment
Below average response	High mean, b_i<1 & sig-nificant and S^2d_i Non significant	BAU-414-05	RR-6161-B-2-72-2	Birsa Vikash Dhan-111	Birsa Vikash Dhan-111	Birsa Vikash Dhan-111	Birsa Vikash Dhan-111, CRR-427-14 B-1-1-1	Suitable for poor/ unfavourable environment
Unstable	High or Low mean, b_i=1, >1 or <1 and S^2d_i significant	R-R-F-05	BAU-408-05	BAU-408-05	CRR-427-14 B-1-1-1	Birsa Vikash Dhan-110, Vandana	BAU-408-05	Unpredict-able response in all environ-ments

Regarding harvest index, four genotypes were stable. Of these stable genotypes Birsa Vikash Dhan-108, Vandana, BAU-438-6-2 and RR-6161-B-2-72-2 were found with higher mean harvest index and therefore they are desirable genotypes for harvest index. Although highest harvest index was observed in the genotype BAU-438-6-2. The genotypes Birsa Vikash Dhan-110 and Birsa Vikash Dhan-111 having, bi<1 and S^2di =0 may perform well in poor environment whereas IR-78906REWA648having bi>1 and S^2di =0 were although not stable but expected to perform better in rich rice growing condition.

The genotypes Birsa Vikash Dhan-109, BAU-438-6-2 and R-R-F-25 were found stable with higher average mean test weight than population mean. The genotype BAU-408-05 having highest test weight bi = 1 (unity) and S^2di =0 was adjudged as the best desirable and stable genotype.

The characters grain yield (q/ha), which is one of the most economic character was found to the stable in two genotypes*viz.*, BAU-438-6-2 and RR-6161-B-2-72-2and they were of commercial interest, because they had higher average grain yield and stable also. The genotypeBAU-438-6-2 although recorded as medium group maturity and of highest yielder but it had stability. Therefore this variety is also suitable for rainfed upland situation

Further the genotypes IR-78906REWA648 having bi >1 and S^2di=0 is suitable for rich or favourable environment while Birsa Vikash Dhan-111 and CRR-427—14B-1-1-1 had bi <1 and S^2di=0, therefore suitable for cultivation in poor environment. The genotype BAU-438-6-2 had commercial interest, because it had higher average grain yield as well as stable along with other desirable characters likes panicle/plant, panicle length, filled grain and test weight.

The important genotypes were summarised in table-5 according to their stability parameters and suitability condition for yield ad its contributing traits.

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