Int.J.Curr.Microbiol.App.Sci (2017) *6*(11): 2102-2111

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 11 (2017) pp. 2102-2111**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.611.248

Stability Analysis for Grain Yield and Its Attributing Traits of Rice across Locations

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Keywords

Grain yield, Stability, G x E interaction, Rice.

Article Info

Accepted:
17 September 2017
Available Online:
10 November 2017

A B S T R A C T

Forty rice hybrids along with their parents were evaluated for their stability parameters with respect to yield and its attributing characters like Days to 50 per cent flowering, Productive tillers per plant, Plant height (cm), Panicle length (cm), Grains per panicle, Grain yield per plant (g), Straw yield per plant (g) and test weight (g) in a multi-locational trial at three different sites of Gujarat viz., Main Rice Research centre, Navsari, Regional Rice Research Station, Vyara and Hill Millet Research Station, Waghai during Kharif 2015. Pooled analysis of variance reflects existence of genotype x environment interaction. Stability analysis revealed significant differences among all the characters for genotype and environment except for test weight (g) in environment. The results on environmental index revealed that Navsari was the most congenial location for grain yield per plant and majority of yield related traits in addition to productive tillers per plant, panicle length, grains per panicle and test weight. The best three high yielding and stable hybrids over environments for grain yield per plant were GAR-13 x IET-24767, NAUR-1 x IET-23833 and GAR-13 x IET-23833. The hybrid GAR-13 x IET-24767 was found to be stable for plant height (cm), panicle length (cm), grains per panicle and test weight (g). Among the parents, male IET-24774 reflected better suitability for favourable environments for grain yield per plant.

Introduction

In India, rice is being grown as a major food crop under diverse agro-climatic conditions. Rice accounts for 35-60% of the caloric intake of three billion Asians (Guyer *et al.*, 1998). It is very much necessary to develop varieties having stable yield performance over diverse environments. In breeding programme, it is necessary to screen and develop stable genotypes, which perform more or less uniform under varying environmental conditions. Thus knowledge of genotype x environment interaction helps the breeder to select high yielding and most adaptable varieties and hybrids. In any crop, plant breeders are mostly interested and continuously engaged in improvement of yield character. Yield is complex character which depends on many component characters, type of genotype, environmental conditions and genotype x environment interactions. Hence, knowledge on the nature and magnitude of genotype x environment

interactions is important in understanding the stability of a particular variety before it is being recommended for a given situation. Testing of genotypes under different environments differing in unpredictable variation is an accepted approach for selecting stable genotypes (Eberhart and Russel, 1966). Present Investigation reports these facts with rice crop.

Materials and Methods

The present experiment material comprised of four lines, ten testers, their forty hybrids and two checks. The trials were conducted in a randomized block design with three replications at three locations *viz.,* Main Rice Research centre, Navsari, Regional Rice Research Station, Vyara and Hill Millet Research Station, Waghai representing diverse agro climatic condition during *Kharif* 2015. Observations were recorded on five randomly selected plants in each replication in each environment in respect of eight quantitative characters *viz.*, Days to fifty per cent flowering, Number of productive tillers per plant, Plant height (cm), Panicle length (cm), Grains per panicle, Grain yield per plant (g), Straw yield per plant (g) and Test weight (g). The statistical analysis for genotype x environment interactions and stability parameters were worked out according to Eberhart and Russell (1966) for all the characters under study.

Results and Discussion

Pooled analysis of variance showed highly significant mean sum of squares for genotypes and environments for all the characters studied, indicating the presence of substantial variation among the genotypes over environments (Table 1). Mean sum of squares due to genotypes found highly significant for all the characters when tested against pooled error and pooled deviation. The differences due to environment component were found highly significant except for test weight when tested against pooled error. The environment (linear) mean square was observed significant for all characters except for test weight when tested against pooled error. Coincidence of genotypic performance with environmental values for all the characters was observed due to significant Genotype x Environment (Linear) for all the traits except for plant height, indicated that cultivars performance may differ markedly for these characters. Significant pooled deviation found significant for all traits except for test weight (g) suggested that the performance of different genotypes fluctuated considerably in respect to their stability for respective characters. Thus both predictable and unpredictable components contributed significantly to differences in stability among genotypes. These results are in agreement to those reported by Nayak (2008), Shadakshari (2001) and Rashmi *et al.*, (2017) in rice.

Environmental index can provide the basis for identifying the favourable environments for the expression of maximum potential of the genotype (Table 2). Navsari found to be congenial for days to 50 per cent flowering, numbers of productive tillers per plant, panicle length (cm), grains per panicle, grain yield per plant (g), straw yield per plant (g) and test weight (g). While it was favourable for days to 50 per cent flowering and plant height (cm) at Vyara location and location Waghai was found to be favourable for plant height (cm).

In the present, stability of 40 rice hybrid, 14 parental line and two check varieties with respect to 8 characters was judged by three parameters *viz.*, mean (x), regression coefficient (bi) and deviation from regression (S^2di) using the model proposed by Eberhart and Russell (1966).

Table.1 Pooled MSS values for phenotypic stability for different quantitative traits over three environments

Source of variation	d.f.	Days to 50% flowering	Productive tillers/plant	Plant height (cm)	Panicle length (cm)	Grains per panicle	Grain yield per plant (g)	Straw yield per plant (g)	Test weight (g)
Genotypes (G)	55	140.51^{**++}	18.29^{**++}	476.42^{**++}	32.64^{**++}	2753.31^{**++}	78.06^{**++}	112.61^{**++}	34.56^{**++}
Environments (E)	2	40.23^{**++}	5.76^{*++}	768.65^{**++}	4.82^{++}	684.73^{**++}	94.28^{**++}	142.17^{**++}	0.62
G x E	110	8.25^{++}	1.55^{++}	51.73	2.73^{++}	91.03^{+}	6.40^{++}	8.49^{++}	1.69
Environments (Linear)	1	80.46^{**++}	11.52^{**++}	1537.30^{**++}	9.65^{++}	1369.46^{**++}	188.55^{**++}	284.34^{**++}	1.24
G x E (Linear)	55	8.44^{++}	1.82^{++}	33.37	2.82^{++}	100.62^{++}	6.82^{++}	8.65^{++}	1.74^{+}
Pooled deviation	56	7.91SS	1.26SS	68.83SS	2.60SS	79.97SS	5.87SS	8.18SS	1.62
Pooled error	330	1.35	0.31	44.95	1.10	48.10	3.04	3.04	1.27

SS= Significant when pooled deviation tested against pooled error,
*, ** - indicates 5 % and 1 % probability levels of significance, respectively tested against pooled deviation
+, ++ - indicates 5 % and 1 % probability levels of significance, respectively tested against pooled error.

Table.2 Estimates of environmental index for various traits under different environments in rice

Characters	Environmental index		
	L-I	L-II	L-III
Days to 50 per cent flowering	-0.35	-0.62	0.97
Productive tiles per plant	0.34	-0.05	-0.29
Plant height (cm)	3.87	-3.52	-0.35
Panicle length (cm)	0.34	-0.13	-0.21
Grains per panicle	3.87	-0.94	-2.93
Grain yield per plant(g)	1.32	-0.04	-1.28
Straw yield per plant (g)	1.64	-0.10	-1.54
Test weight (g)	0.12	-0.08	-0.04

Note: L-I: Navsari, L-II: Vyara, L-III: Waghai

Table.3 Mean performance and stability parameters of different genotypes for different characters in rice

Sr. No	Genotypes	Days to 50 % flowering			Productive tillers per plant			Plant height (cm)			Panicle length (cm)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1.	NAUR-1	96.78	2.36	21.20**	8.82	2.82	0.15	98.86	2.67	-35.60	28.71	1.53	-0.81
2.	GNR-3	94.67	0.67	-1.33	8.16	4.74*	-0.30	127.54	0.39	-11.72	24.73	2.92	-0.98
3.	Gurjari	95.22	1.79	7.46*	7.07	1.36	0.84	127.74	-1.06	47.45	18.89	2.41	3.20
4.	GAR-13	101.89	1.25	9.81**	7.53	1.81	-0.23	126.44	1.59	19.07	22.94	-0.49	9.59**
5.	NVSR-306-6	92.00	-3.55	-0.78	7.27	-1.12	0.35	113.14	-1.59	219.46*	18.72	6.87	-1.09
6.	NVSR-306-14	90.56	-0.42	14.48**	7.62	2.00	-0.19	108.06	2.21	83.17	20.98	-7.87	2.66
7.	IET-23814	89.33	2.81	3.53	7.69	-0.63*	-0.31	154.65	1.63	161.52*	16.72	-1.39	2.08
8.	IET-23825	98.00	-2.76	5.28*	7.51	-1.11	1.32*	123.91	1.45	-21.46	16.59	-1.56	-0.09
9.	IET-23829	98.78	2.12	0.50	8.27	-2.32	0.89*	154.36	1.06	51.78	16.58	-0.42	-0.63
10.	IET-24767	85.89	0.14	4.48*	10.20	-0.94	0.16	131.10	3.03	-42.18	25.04	1.24	8.38**
11.	IET-24774	94.00	-0.43	9.27**	9.29	-0.70	0.04	127.00	1.54	33.89	20.94	7.70	0.07
12.	IET-23832	96.00	-4.10 *	-1.25	9.27	-2.80	2.39**	121.99	2.15	-18.32	18.65	6.62	0.69
13.	IET-23833	81.11	2.49	0.70	10.73	-0.68	-0.02	108.10	1.16	-1.78	26.31	-3.60	-0.92
14.	IET-23834	82.44	-0.88	8.72**	9.42	-3.36*	-0.31	145.38	0.80	-0.52	18.12	3.70	-0.08
	Parental mean	92.62			8.49			126.31			20.99		
15.	NAUR-1 x NVSR-303-6	90.89	-3.10	-0.64	9.58	3.95	1.37*	114.13	1.31	44.26	22.92	2.51	0.63
16.	NAUR-1 x NVSR-303-14	85.11	2.80	-0.06	10.96	2.05	3.34**	123.64	1.58	-44.19	21.63	2.70	-1.12
17.	NAUR-1 x IET-23814	85.33	6.98	-1.03	10.24	1.98	1.84**	139.36	0.74	-10.43	23.95	0.18	0.17
18.	NAUR-1 x IET-23825	92.67	3.19	8.94**	10.21	4.12	0.58	129.46	-0.81	52.38	23.61	4.23	-1.03
19.	NAUR-1 x IET-23829	94.89	-0.23	5.32*	10.93	3.98	0.24	132.97	0.72	-18.57	24.75	1.64	-0.93
20.	NAUR-1 x IET-24767	84.22	3.56	5.37*	15.04	-3.35	1.62*	133.30	0.90	-3.87	27.74	0.97	-0.74
21.	NAUR-1 x IET- 24774	86.00	-3.67	1.49	11.96	0.34	1.91**	130.04	-0.49	2.60	26.19	0.15	1.95
22.	NAUR-1 x IET-23832	90.33	-1.95	10.74*	10.47	-4.59	0.30	125.07	0.58	-10.89	25.79	-8.43	1.84
23.	NAUR-1 x IET-23833	77.56	-2.86	1.21	15.96	1.28	0.09	127.07	-1.02	24.23	28.13	0.83	0.05
24.	NAUR-1 x IET-23834	78.11	2.18	-0.55	10.02	7.58	0.33	129.33	1.09	38.30	25.11	6.37	-0.15
25.	GNR-3 x NVSR-303-6	89.33	0.86	13.80**	9.04	-3.73	2.29**	124.15	0.52	5.11	22.60	-3.28	-0.86
26.	GNR-3 x NVSR-303-14	86.89	3.76	0.69	11.53	-2.48	3.24**	120.80	-0.65	11.35	20.17	-0.57	-0.62
27.	GNR-3 x IET-23814	87.67	-0.25	18.78**	8.91	3.91	0.05	122.07	0.88	-0.38	21.12	1.57	0.81
28.	GNR-3 x IET-23825	95.78	3.10	-0.65	9.49	0.83	5.92**	119.69	2.42	-41.19	23.90	3.17	8.65**

Sr. No	Genotypes	Days to 50 % flowering			Productive tillers per plant			Plant height (cm)			Panicle length (cm)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
29.	GNR-3 x IET-23829	96.56	0.44	6.00	9.64	2.26	5.01**	117.70	0.73	-11.66	23.35	2.27	-0.25
30.	GNR-3 x IET-24767	87.11	1.01	18.81**	15.31	2.07	2.44**	125.71	0.71	15.12	27.08	-1.28	2.38
31.	GNR-3 x IET-24774	88.11	3.04	-1.21	12.31	4.82	0.23	124.26	-0.81	7.11	21.69	7.08	-0.84
32.	GNR-3 x IET-23832	92.44	1.39	11.27**	10.49	5.28*	-0.29	145.50	1.16	16.22	22.65	5.19	2.01
33.	GNR-3 x IET-23833	78.00	2.70	3.10	15.38	3.79	-0.15	123.55	1.34	56.24	28.02	-0.71	-1.12
34.	GNR-3 x IET-23834	79.67	1.10	3.15	9.07	-4.01*	-0.30	126.71	-0.66	16.42	21.15	-1.37	-0.97
35.	Gurjari x NVSR-303-6	93.33	3.73	-1.12	7.20	-0.86	0.29	119.64	0.84	-26.75	17.56	-3.83	0.97
36.	Gurjari x NVSR-303-14	90.00	-0.68	24.87**	10.24	3.13	1.51*	125.99	1.66	-38.68	16.40	0.91	-0.93
37.	Gurjari x IET-23814	83.56	-2.43	-0.41	8.07	-1.29	2.40**	128.01	1.37	57.60	18.81	3.13	0.12
38.	Gurjari x IET-23825	97.67	3.05	7.49*	8.29	0.33	-0.13	116.17	2.28	-40.88	18.42	-2.33	0.33
39.	Gurjari x IET-23829	96.11	3.84	0.03	7.36	-0.74	1.63*	121.98	0.62	103.15	19.37	1.06	2.13
40.	Gurjari x IET-24767	82.44	-2.53	5.50*	14.42	4.83	0.16	121.69	1.04	54.72	24.67	4.69	-0.99
41.	Gurjari x IET-24774	86.89	1.30	0.73	10.40	4.10	0.13	106.58	1.80	99.30	20.69	6.34	-0.57
42.	Gurjari x IET-23832	90.11	-1.18	4.29*	7.73	-2.68	-0.28	131.39	-0.64	100.86	19.79	-5.30	-0.03
43.	Gurjari x IET-23833	76.11	0.60	6.21*	14.84	4.04	-0.03	131.53	-0.72	-8.40	24.54	6.00	3.43*
44.	Gurjari x IET-23834	77.00	2.75 *	-1.35	7.91	3.47	-0.20	121.27	2.01	114.08	20.54	5.25	-0.76
45.	GAR-13 x NVSR-303-6	98.00	3.36	9.34*	7.82	4.13	0.00	103.94	1.86	209.32*	19.55	-7.15	2.12
46.	GAR-13 x NVSR-303-14	90.78	3.41	-1.06	10.82	-0.88	3.60**	127.88	1.90	73.36	16.92	-1.45	4.43*
47.	GAR-13 x IET-23814	82.33	-0.29	29.42**	8.13	-2.83	1.63*	128.34	2.20	-34.52	20.48	-3.65	1.69
48.	GAR-13 x IET-23825	96.89	3.39	13.74**	8.42	2.21	2.89**	122.43	1.17	39.91	19.92	6.69	0.39
49.	GAR-13 x IET-23829	97.22	2.66	11.24**	6.76	-1.95	-0.29	138.96	1.16	32.29	21.18	0.14	14.75**
50.	GAR-13 x IET-24767	82.78	1.15	17.27**	14.96	2.34	3.16**	105.10	2.05	-41.43	25.17	2.75	-0.16
51.	GAR-13 x IET-24774	90.11	4.02	5.26*	11.18	-2.95	-0.21	113.23	1.22	39.61	19.78	-8.38	1.38
52.	GAR-13 x IET-23832	99.56	0.27	12.84**	6.64	1.33	-0.29	107.78	2.25	-6.70	20.25	6.06	0.55
53.	GAR-13 x IET-23833	80.78	3.23	1.78	13.11	6.77	-0.03	113.17	0.78	-43.38	25.05	-1.08	7.46**
54.	GAR-13 x IET-23834	79.00	2.27	15.46**	8.02	-0.93	2.99**	102.34	2.96	-34.87	20.46	-0.57	5.16*
55.	GNR-4	96.78	1.46	14.79**	9.87	2.99	-0.04	87.22	-0.75	26.29	19.12	4.71	-0.56
56.	Kala Namak	95.44	-2.89	4.73*	7.96	2.30*	-0.31	114.39	1.69	65.41	20.56	1.15	9.29**
	Cross mean	87.93			10.47			123.05			22.91		
	General mean	89.40	1.00		9.92	1.00		123.1	1.00		21.87	1.00	
	S.E. $\pm$	1.99	2.35		0.79	2.48		5.90	1.60		1.14	3.88	

Table.3 Contin...

Sr. No	Genotypes	Grains per panicle			Grain yield per plant (g)			Straw yield per plant (g)			Test weight (g)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1.	NAUR-1	238.00	1.08	42.27	17.12	2.06	16.28*	20.54	2.07	23.39**	23.68	9.90	-1.17
2.	GNR-3	224.26	6.64	-37.36	18.80	3.25	-2.24	22.57	3.16	-1.59	30.52	4.04	0.59
3.	Gurjari	190.42	3.91	161.27*	12.59	1.95	-2.95	15.11	1.90	-2.98	26.66	0.53	-0.51
4.	GAR-13	223.00	2.57	56.03	12.78	1.33	2.87	15.34	1.34	4.90	20.24	0.84	-0.95
5.	NVSR-306-6	196.67	2.29	-46.22	10.13	1.26	-3.00	12.16	1.23	-3.10	19.07	11.55	0.24
6.	NVSR-306-14	207.68	-0.69	-24.13	10.24	-0.60	-0.55	12.29	-0.61	0.30	21.52	-7.88*	-1.31
7.	IET-23814	187.58	1.33	122.83	11.66	0.79	12.02*	13.99	0.72	18.97**	21.60	-5.77	-1.05
8.	IET-23825	206.59	-0.80	260.02*	10.15	-0.51	-0.82	12.17	-0.48	0.14	22.53	-4.96	-0.86
9.	IET-23829	212.51	-1.07	191.92*	10.85	-0.53	2.31	13.02	-0.49	4.71	21.36	-5.32	0.00
10.	IET-24767	255.91	0.41	77.32	23.92	1.83	35.17**	28.70	1.70	53.43**	21.83	-1.19	0.58
11.	IET-24774	205.12	3.02	1.65	14.92	2.39**	-2.99	17.90	2.34	-3.12	20.62	9.47	-0.54
12.	IET-23832	225.83	3.11	5.36	13.32	1.11	-2.99	15.98	1.08	-3.09	18.77	9.55	-0.69
13.	IET-23833	262.20	1.23	60.95	22.14	0.68	23.54**	26.57	0.59	35.49**	23.55	3.96	-0.37
14.	IET-23834	210.53	1.32	67.76	15.07	1.86	13.96*	18.08	1.87	20.16**	20.41	6.17*	-1.31
	Parental mean	217.59			14.55			17.46			22.31		
15.	NAUR-1 x NVSR-303-6	217.88	1.54	205.27*	19.30	1.30	9.56*	23.50	1.30	8.23	25.79	17.75*	-1.28
16.	NAUR-1 x NVSR-303-14	221.01	1.40	73.18	17.61	2.13	-1.79	21.47	1.76	-2.15	20.59	12.33	2.01
17.	NAUR-1 x IET-23814	235.18	1.33	114.16	20.26	0.78	10.71*	24.32	0.72	16.98*	24.72	-2.33	4.91*
18.	NAUR-1 x IET-23825	210.18	2.95*	-48.19	17.74	2.48	-2.89	21.29	2.42	-3.06	25.50	8.61	-0.12
19.	NAUR-1 x IET-23829	242.33	2.24	-10.38	19.26	2.88	-2.90	23.11	2.81	-2.83	21.72	-14.22	-0.26
20.	NAUR-1 x IET-24767	265.53	1.62	156.03*	28.53	1.64	20.45**	34.24	1.54	31.65**	27.83	-7.14	2.02
21.	NAUR-1 x IET- 24774	246.76	-0.20	-15.25	24.08	-0.73	8.20	27.23	1.19	5.94	23.89	11.16	-1.20
22.	NAUR-1 x IET-23832	225.67	-2.75	-7.19	21.86	-1.58*	-3.00	26.23	-1.54*	-3.12	25.46	-0.17	-0.23
23.	NAUR-1 x IET-23833	271.05	4.69	207.81*	27.75	2.60	-1.82	33.29	2.53	-1.03	26.71	-8.34	2.94
24.	NAUR-1 x IET-23834	227.90	2.27	-43.78	23.02	1.95	-2.81	27.62	1.89	-2.72	22.74	-2.08	4.68*
25.	GNR-3 x NVSR-303-6	229.33	-0.91	-27.44	22.68	-0.58	15.21*	28.55	0.67	9.93*	24.68	-9.61	-0.76
26.	GNR-3 x NVSR-303-14	222.24	-0.16	53.24	21.72	-0.63	8.75*	26.06	-0.57	14.04*	22.40	0.12	7.60**
27.	GNR-3 x IET-23814	238.00	1.52	-0.70	22.56	2.24	-2.45	27.41	1.88	-2.79	25.04	14.75*	-1.31
28.	GNR-3 x IET-23825	215.95	2.25	-39.22	21.37	2.49	-2.78	25.65	2.43	-2.63	24.48	7.92	0.22

Sr. No	Genotypes	Grains per panicle			Grain yield per plant (g)			Straw yield per plant (g)			Test weight (g)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
29.	GNR-3 x IET-23829	234.31	1.46	-16.95	18.73	1.23	1.41	22.48	1.23	2.92	21.46	10.04	-0.65
30.	GNR-3 x IET-24767	276.05	2.56	258.51*	30.40	1.57	11.07*	36.18	1.85	12.99*	26.13	14.91	-0.32
31.	GNR-3 x IET-24774	225.81	2.62	-16.43	25.18	3.04	-2.10	30.88	2.35	-2.95	22.07	7.97	1.72
32.	GNR-3 x IET-23832	203.41	1.25	-18.47	23.49	2.09	-2.95	28.19	2.04	-2.97	25.35	-3.92	2.59
33.	GNR-3 x IET-23833	223.12	2.34	-44.55	26.26	2.41	-2.79	31.51	2.35	-2.65	26.55	11.21	0.60
34.	GNR-3 x IET-23834	225.21	-1.96	95.38	17.81	-1.95*	-2.98	21.37	-1.90*	-3.04	24.10	-15.76	-0.94
35.	Gurjari x NVSR-303-6	189.44	-1.68	-10.33	15.81	-0.65	5.91	18.97	-0.68	9.40*	19.23	-17.31*	-1.27
36.	Gurjari x NVSR-303-14	211.72	0.91	-4.85	15.19	1.43	4.92	18.23	1.43	7.71	19.15	5.89	5.36*
37.	Gurjari x IET-23814	208.63	-0.36	33.49	17.79	-0.62	6.17	21.34	-0.56	10.33*	20.14	9.03	3.03
38.	Gurjari x IET-23825	183.20	-2.56	40.13	15.43	-0.55	3.67	18.51	-0.57	6.28	18.24	-11.60	0.85
39.	Gurjari x IET-23829	209.76	-0.58	6.14	15.25	-0.24	1.41	18.32	-0.20	3.12	16.63	-5.93	0.98
40.	Gurjari x IET-24767	248.56	1.95	-46.66	25.82	2.34	-2.62	30.98	2.28	-2.37	24.77	-10.75	-0.91
41.	Gurjari x IET-24774	200.87	-1.27	6.43	18.83	2.25	-2.61	22.93	1.88	-2.94	20.82	14.58	-0.85
42.	Gurjari x IET-23832	186.92	-1.63	-45.94	16.61	-1.17*	-2.99	19.93	-1.14*	-3.07	18.57	3.51	1.17
43.	Gurjari x IET-23833	249.49	-0.67	71.93	25.96	2.53*	-2.97	31.48	2.17*	-3.12	25.77	7.45	-1.29
44.	Gurjari x IET-23834	153.51	2.43	-12.00	17.77	2.07	-2.96	21.33	2.02	-2.99	18.19	6.96	2.46
45.	GAR-13 x NVSR-303-6	143.60	-2.01	4.52	15.82	-0.70	3.43	18.98	-0.72	5.90	17.36	-10.34*	-1.30
46.	GAR-13 x NVSR-303-14	181.75	1.81	-36.60	15.29	-0.18	2.59	18.35	-0.14	4.95	16.63	-1.26	1.05
47.	GAR-13 x IET-23814	174.52	-2.24	70.83	15.79	-0.80	3.19	18.95	-0.81	5.52	15.68	-4.52	-0.67
48.	GAR-13 x IET-23825	150.85	3.51	-35.23	15.25	1.68	-2.83	18.29	1.64	-2.76	17.67	-7.62	-1.27
49.	GAR-13 x IET-23829	184.39	-2.02	-43.66	16.09	-1.16	-2.09	19.31	-1.12	-1.67	21.57	-10.01	-0.58
50.	GAR-13 x IET-24767	245.83	1.36	-1.96	28.09	1.34	7.92	33.71	1.36	12.01*	24.59	7.56	0.57
51.	GAR-13 x IET-24774	170.27	1.15	55.75	17.94	-1.38	-2.39	23.86	-0.33	11.00*	19.54	-9.90	-0.58
52.	GAR-13 x IET-23832	159.74	1.83	12.87	15.14	1.58	-2.58	18.17	1.54	-2.37	15.75	0.24	-0.19
53.	GAR-13 x IET-23833	242.26	2.83*	-47.80	26.62	2.83*	-3.00	31.95	2.76*	-3.10	25.53	8.98	-1.14
54.	GAR-13 x IET-23834	175.21	-2.77*	-47.84	16.08	-0.54	9.31*	19.30	-0.48	14.84*	16.79	-6.88	-1.25
55.	GNR-4	223.76	2.99	-7.94	20.54	1.32	-2.75	22.35	0.02	1.33	19.06	1.17	-1.21
56.	Kala Namak	199.92	2.72	13.63	15.35	2.35**	-3.00	18.43	2.29*	-3.12	22.69	3.06	-0.68
	Cross mean	213.19			20.40			24.59			22.00		
	General mean	214.20	1.00		18.85	1.00		22.66	1.00		22.03	1.00	
	S.E. ±	6.30	1.80		1.71	1.32		2.02	1.27		0.90	8.57	

Table.4 Stable hybrids identified on the basis of high means for grain yield per plant and other characters over three and specific environments

Sr. No.	Hybrids	Grain yield per plant (g)	bi value	Nature of adaptation	Average stable
1	GAR-13 x IET-24767	28.09	1.34	Average responsive suitable for environment and recommended	PH, PL, GPP, GY, TW
2	NAUR-1 x IET-23833	27.75	2.60	Average responsive suitable for environments	DF, PPP, PH, PL, GY, SY, TW
3	GAR-13 x IET-23833	26.62	2.83*	Highly responsive suitable for favourable environments	DF, PPP, PH, TW
4	GNR-3 x IET-23833	26.26	2.41	Average responsive suitable for environments	DF, PPP, PH, PL, GPP, GY, SY, TW
5	Gurjari x IET-23833	25.96	2.53*	Highly responsive suitable for favourable environments	PPP, PH, GPP, TW

DF = Days to 50% flowering PPP = Productive tillers per plant PH = Plant height (cm) PL = Panicle length (cm)
GPP = Grains per panicle GY = Grain yield per plant (g) SY = Straw yield per plant (g) TW = Test weight (g)

Stability was observed in some of the genotypes by Belhekar (2012) and Subudhi *et al.,* (2012). Taking these parameters into consideration, the results obtained are discussed character wise.

Days to 50 per cent flowering

Among parents lowest mean value (81.11) accompanied by non-significant bi (2.49) as well as least deviation from zero (0.70) was found for IET-23833, identified as a stable line. Among 40 rice hybrids, NAUR-1 x IET-23833 showed early flowering with non-significant bi value and minimum deviation from regression classified as highly stable hybrid across all the environments followed by GNR-3 x IET-23833 and NAUR-1 x IET-23834 (Table 3).

Number of productive tillers per plant

Four parental line *viz.,* NAUR-1, IET-24767, IET-24774 and IET-23833 exhibited higher mean value, bi value near unity and non-significant S^2di, shows average stability. Out of 40 hybrids, ten hybrids were constituted to be stable for this trait. Among these stable hybrids, best three were NAUR-1 x IET-23833, GNR-3 x IET-23833 and GNR-3 x IET-24767. GNR-3 x IET-23832 hybrid found to be more stable in rich environment (Table 3).

Plant height (cm)

For plant height, mean sum of square due to G x E interaction was observed to be non-significant (Table 1). It revealed that all parents and hybrids along with standard checks were consistently performing across environments (Table 3).

Panicle length (cm)

Among the parents, NAUR-1, GNR-3, GAR-13, IET-24767 and IET-23833 showed higher mean value than parental mean and displayed average stability over environment for this character (bi>1 and S2di: 0). Total 19 hybrids manifested higher mean value, bi around unity and non-significant S^2di identified as stable across the environments. The best three stable hybrids were NAUR-1 x IET-23833, GNR-3 x IET-23833 and NAUR-1 x IET-24767. None of the hybrids showed specific adaptability for this trait (Table 3).

Numbers of grains per panicle

Three lines viz., NAUR-1, GNR-3 and GAR-13 and three testers viz., IET-24767, IET-23832 and IET-23833 mark highest number of grains per panicle, with unit bi value and non-significant S2di, hence were considered average stable over environments. Hybrid GAR-13 x IET-23833 identified as stable in rich environment with significant regression greater than unity. In contrast, GAR-13 x IET-23834 had significant regression less than one, classified as low responsive and better in unfavourable environment. The best three hybrids based on their stable performance over environments were Gurjari x IET-23833, Gurjari x IET-24767 and NAUR-1 x IET-24774 (mean > general mean, bi: 1 and S^2di: 0) (Table 3).

Grain yield per plant (g)

Line GNR-3 exhibited greater mean than general men along with regression coefficient near unity and non-significant S^2di, classified as average responsive suitable for all environment and tester IET-24774 suitable for favourable environment (Table 4).

Highest yield and average stable hybrids were observed for GAR-13 x IET-24767 followed by NAUR- 1 x IET-23833 and GNR-3 x IET-23833. The hybrid NAUR-1 x IET-23832 showed above average stability best in poor environment. Likewise the hybrids Gurjari x IET-23833 and GAR-13 x IET-23833 displayed specific adaptability toward

favourable environment. Grafius (1959) also reported similarly (Table 3).

Straw yield per plant (g)

Among the parents, GNR-3 and IET-24774 exhibited stability across the environments. Whereas among the hybrids, nine hybrids exhibited average stability across the environments. Two hybrids, Gurjari x IET-23833 and GAR-13 x IET-23833 showed high mean value, bi value significantly greater than unity and non-significant S^2di suggesting that these hybrids were stable for favourable environments. On the other hand, hybrid NAUR-1 x IET-23832 depicted high mean value, bi value significantly lower than unity and non-significant S^2di indicating that these were stable for poor environments (Table 3).

Test weight (g)

The mean sum of square due to G x E interaction was recorded to be non-significant for this trait. This revealed consistent performance of this trait across the environments for all forty genotypes (Table 3). The most stable five hybrids are listed in Table 4 along with their grain yield per plant and component trait for which they had exhibited stability. The best five stable hybrids *viz.*, GAR-13 x IET-24767, NAUR-1 x IET-23833, GAR-13 x IET-23833, GNR-3 x IET-23833 and Gurjari x IET-23833 had higher grain yield per plant and higher stability for some characters.

In conclusion, the present study provided an evaluation of genotypic and environmental performance of forty hybrids of rice over varied environments. Stability analysis demonstrated that hybrids *viz.*, GAR-13 x IET-24767, NAUR-1 x IET-23833 and GNR-3 x IET-23833 is average responsive suitable for all environment while two hybrids, GAR-13 x IET-2383 and Gurjari x IET-23833 is highly responsive suitable for favourable environment in terms of yield.

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How to cite this article:

Patel Unnati, Patel Pathik, Mahatma Lalit and Bhimshinh Bilwal. 2017. Stability Analysis for Grain Yield and Its Attributing Traits of Rice across Locations. *Int.J.Curr.Microbiol.App.Sci.* 6(11): 2102-2111. doi: https://doi.org/10.20546/ijcmas.2017.611.248