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Evaluation of Adaptability and Stability of Late Duration Ragi (*Eleusine coracana*) Genotypes in Linear Regression Model

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Abstract

Fifteen late duration ragi genotypes were evaluated under early and late transplanting condition at Bhubaneswar and early direct-sown condition at Berhampur for three years (2004—2006) during *kharif* season. The average yield during 3 years varied from 27.87 to 31.97 q/ha under early planting and from 27.68 to 29.46 q/ha under late planting at Bhubaneswar, while yield level under direct seeded condition at Berhampur varied between 15.69 and 18.66 q/ha. Average yield of the genotypes over nine environments ranged from 22.61 to 27.82 q/ha. Genotype × environment interaction analysis of grain yield in linear regression model revealed highly significant differences among genotypes and environments. The G×E interaction component was also significant indicating differential performance of genotypes over environments. Considering mean, *b*-values and S^2d values of the genotypes jointly, four of the nine genotypes giving average yield showed stability of performance, of which VR 849 and Indaf 5 showed general adaptation to all environmental conditions and GPU 58 and Chilika exhibited specific adaptability to rich environments.

Key words : Adaptability, Stability, Ragi genotypes, Linear regression model.

Ragi or finger millet (*Eleusine coracana*) is the most important small millet crop and it accounts for 7% of the area and 11% of production under course cereals in the country (1). It covers an area of 1.7 million hectares in India with a production of 2.44 million tonnes and productivity of 1,481 kg/ha, which is much lower than world average productivity. In Orissa the crop is generally grown under direct seeded condition in low rainfall zones and in transplanted condition in high rainfall zones. Lack of high yielding varieties adapted to diverse agro-ecological conditions is the major reason of low productivity. Though more than 120 finger millet varieties have been released in India and the number is increasing every year, majority of them have been out of cultivation due to inconsistent performance in diverse environments and only few varieties with stable performance continue to be under cultivation even after 15—20 years of release. Evaluation of interaction of genotypes with locations and other agro-management conditions would help in getting information on adaptability and stability of performance of genotypes. The linear regression model of Eberhart and Russell (2) is the most frequently used for analysis of genotype-environment interaction and evaluation of adaptability and stability of performance of genotypes. The present study aimed at assessing the interaction of pre-release and released ragi varieties under diverse environmental conditions and to identify promising genotypes with stability of grain yield performance.

Methods

Fifteen late duration (106—125 days) ragi genotypes were evaluated under three environmental conditions : early and late transplanting at Bhubaneswar and early direct-sown at Berhampur for 3 years (2004—2006) during *kharif* season. The genotypes included ten pre-release and five released varieties (PR 202, PES 110, Indaf 5, AKP 7 and Chilika). At Bhubaneswar, nursery sowing was done in the last week of June for early planting and in the last week of July for late planting. 21—25 days old seedling were transplanted with 22.5 cm × 10 cm spacing. At Berhampur, the trials were conducted under early direct seeded condition and sowing was done in first week of July each year. Seedling was done in rows with 22.5 cm spacing between rows. All the nine trials were laid out in randomized block design with three

Table 1. Grain yield (q/ha) of late duration ragi genotypes in three environmental conditions during 2004 to 2006.

Genotypes	Early transplanted (Bhubaneswar) 2004	2005	2006	Late transplanted (Bhubaneswar) 2004	2005	2006	Direct seeded (Berhampur) 2004	2005	2006	Grand mean
1. OEB 82	33.34	21.34	25.68	25.35	24.06	22.38	21.27	15.02	19.45	23.10
2. OEB 56	36.30	36.86	27.82	28.97	23.32	30.45	20.77	19.65	26.23	27.82
3. OEB 71	32.22	36.51	29.30	32.92	22.57	26.50	16.81	25.54	22.53	27.21
4. PR 202	28.64	27.51	25.18	23.04	26.76	22.88	14.84	13.61	20.99	22.61
5. GPU 57	30.87	32.10	21.81	29.96	32.58	30.53	8.41	7.72	14.20	23.13
6. PES 110	27.14	40.21	30.95	28.65	35.72	29.22	18.79	18.24	20.68	27.73
7. VR 849	28.64	34.92	31.28	26.01	29.89	33.25	13.85	18.24	22.53	26.51
8. VR 822	30.00	31.92	28.97	30.29	28.10	28.97	14.34	33.68	18.83	27.23
9. MR 33	25.68	34.39	29.14	28.97	33.78	31.03	8.90	9.75	14.51	24.02
10. VR 768	27.06	31.92	22.05	22.06	30.79	24.20	15.83	18.24	17.29	23.27
11. GPU 58	29.63	35.10	26.50	27.65	32.58	33.74	9.89	21.75	14.20	25.67
12. Indaf 5	28.64	28.75	32.10	26.66	27.95	33.33	18.30	19.22	18.83	25.98
13. AKP 7	31.11	24.52	28.65	25.68	28.25	32.10	20.77	16.49	18.21	25.09
14. OEB 52	30.80	32.10	29.63	28.64	24.21	28.73	20.77	27.36	12.96	26.13
15. Chilika	32.10	31.39	28.98	30.29	32.58	34.57	11.87	15.43	17.59	26.09
Average	30.15	31.97	27.87	27.68	28.88	29.46	15.69	18.66	18.60	25.44
CD (5%)	4.98	7.13	4.39	4.60	6.44	4.98	2.53	4.11	4.07	1.21

replications and plot size was 2.25 m× 3 m. Fertilizers were applied at 50 kg N, 40 kg P_2O_5 and 25 kg K_2O per hectare. Normal cultural practices and plant protection measures were followed in each trial. At Bhubaneswar the rainfall received during the crop growth period in 2004, 2005 and 2006 were 1,071, 1,239 and 1,367 mm for early planted crop and 914, 1,068 and 1,045 mm for late planted crop. At Berhampur the direct seeded crop received 762, 767 and 827 mm rainfall during 2004, 2005 and 2005. Grain yield data on 15 genotypes of the nine environments were taken for genotype-environment interaction analysis using the linear regression model (2) and adaptability and stability parameters of genotypes were estimated.

Results and Discussion

The genotypes showed significant differences in grain yield in all the three environmental conditions in all the 3 years (Table 1). The average yield during the 3 years varied from 27.87 to 31.97 q/ha under early planting and from 27.68 to 29.46 q/ha under late planting at Bhubaneswar. Yield level under direct seeded condition at Berhampur was generally low varying between 15.69 and 18.66 q/ha and the low yield level was due to low rainfall and the crop was grown under direct seeded condition. Average yield of the 15 genotypes over the nine environments ranged from 2.61 to 27.82 q/ha. Ranking of the genotypes for yield in the nine different environments indicated interaction of genotypes with the environments.

Grain yield of the 15 genotypes in the nine environments was taken for G×E interaction analysis on linear regression model of Eberhart and Russell (2). Analysis of variance for G×E interaction revealed highly significant differences among genotypes and among environments (Table 2). G×E interaction component was also highly significant. Partitioning of E + G × E effects revealed that E (linear) components were highly significant and the pooled deviation was also highly significant. This indicated that some genotypes showed linear response over environments, while others showed significant deviation from linear relationship. Similar G×E interaction analyses of multi-

Table 2. Pooled analysis of varience for grain yield (q/ha) in late duration ragi genotypes. **Significant at 1% level.

Source	df	MS	*F*
Genotypes (G)	14	29.17	5.91**
Environments (E)	8	546.25	110.63**
G × E	112	16.25	3.29**
E + G × E	120		
Environment (linear)	1	4370.05	350.03**
G × E (linear)	14	36.35	2.91**
Pooled deviation	105	12.49	2.53**
Pooled error	252	4.94	

Table 3. Stability parameters of late duration ragi genotypes for grain yield (q/ha) on linear regression model. * and, ** Significant at 5 and 1% levels, respectively.

Genotypes			Mean	*a*	*b*	SE (b)	r^2	Predicted yield DMS	S^2d	LYE	HYE
1.	OEB	82	23.10	10.35	0.50	0.25	36.04	18.56	13.62**	18.21	26.32
2.	OEB	56	27.82	7.60	0.80	0.24	61.11	16.73	11.79**	20.07	33.02
3.	OEB	71	27.21	7.30	0.78	0.25	58.83	17.85	12.91**	19.59	32.33
4.	PR	202	22.61	2.45	0.79	0.15	80.01	6.53	1.59	14.88	27.77
5.	GPU	57	23.13	– 18.63	1.64	0.20	90.58	11.67	6.73*	7.13	33.86
6.	PES	110	27.73	– 0.36	1.10	0.22	78.40	143.98	9.05**	16.97	34.94
7.	VR	849	26.51	– 1.50	1.10	0.15	88.37	6.64	1.70	15.78	33.70
8.	VR	822	27.23	9.41	0.70	0.30	44.11	25.89	20.95**	20.41	31.82
9.	MR	33	24.02	– 17.01	1.61	0.19	91.51	10.04	5.10	8.29	34.55
10.	VR	768	23.27	1.81	0.84	0.17	77.93	8.39	3.45	15.05	28.79
11.	GPU	58	25.67	– 9.40	1.34	0.18	89.59	9.19	4.25	12.24	34.69
12.	Indaf	5	25.98	3.89	0.87	0.15	82.39	6.70	1.76	17.51	31.64
13.	AKP	7	25.09	5.78	0.76	0.20	67.43	11.58	6.64*	17.69	30.05
14.	OEB	52	26.13	7.55	0.73	0.26	53.60	19.22	14.28**	19.00	30.89
15.	Chilika		26.09	– 9.25	1.39	0.12	94.89	4.32	– 0.62	12.55	35.16
	Average		25.49	–	1.00	–	–	12.49	7.55		
	CD (5%)		1.21								

environment yield data of different sets of finger millet varieties / genotypes, using linear regression model of Eberhart and Russel have been reported earlier (2—10). But these studies were, with some selected sets of genotypes tested in specified environments. In all these studies G×E interaction was significant indicating differential response of genotypes to changes in environment and some genotypes showed stable performance over the range of environments, while many showed unstable performance due to high G×E interaction.

The G×E interaction parameters mean, regression coefficient (*b*), coefficient of determination (r^2) and deviation from linear regression (S^2d) of the 15 ragi genotypes were estimated following Eberhart and Russell's model (Table 3). Mean yield of the genotypes ranged from 22.61 to 27.82 q/ha with an average of 25.44 q/ha. The genotypes OEB 56, PES 110, VR 822, OEB 71, VR 849, OEB 52, Chilika, Indaf 5 and GPU 58 gave above average yield. The intercept (a) values of genotypes ranged from -18.63 to 10.35. The genotypes OEB 82, OEB 56, OEB 71 and OEB 52 having high positive *a*-values would be better adapted to poorer environments. Regression coefficient (*b*) values of the genotypes ranged from 0.50 to 1.61. The coefficient of determination (r^2) was more than 70% for nine genotypes, indicating good fit of the response of these genotypes to linear regression model. The genotypes GPU 57, MR 33, Chilika and GPU 58 showed *b*-values greater than unity (> 1.2), indicating their specific adaptation to rich environments and OEB 82, VR 822, AKP 7 and OEB 52 had *b*-values less than unity (< 0.8), indicating their specific adaptation to poor environments. The remaining seven genotypes showed unit regression (*b*=0.8–1.2) indicat-ingtheir general adaptation to all environments. Predicted yield of the genotypes on the linear regression model in the lowest and highest-yielding environments (LYE and HYE) showed that genotypes VR 822, OEB 56, OEB 71 and OEB 52 would perform better in poor environments, whereas Chilika, PES 110, GPU 58 and MR 33 would perform better in rich environments.

The deviation from linear regression (S^2d) of the genotypes ranged from -0.62 to 20.95. The S^2d values of the genotypes PR 202, VR 849, MR 33, VR 768, GPU 58, Indaf 5 and Chilika were not significantly different from zero, indicating that these genotypes possess stability of performance over environments. The S^2d of the remaining 8 genotypes (including three top yielding genotypes OEB 56, PES 110, VR 822) were significantly greater than zero indicating that these genotypes lacked stability of performance over varied environments. Considering mean, *b*-values and S^2d values of the genotypes jointly, four of the nine genotypes giving above average yield showed stability of performance of which VR 849 and

Indaf 5 showed general adaptation to all environmental conditions and GPU 58 and Chilika exhibited specific adaptability to rich environments.

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