Indian J. Genet., **65**(2): 153-154 (2005)

Short Communication

Genotype × environmental interaction in relation to stable genotypes in opium poppy (*Papaver somniferum* L.)

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(Received: February 2004; Revised: March 2005; Accepted: March 2005)

Opium poppy (*Papaver somniferum* L.) is an important medicinal crop of many pharmacopoeal uses [1]. The opium yield is very erratic to environmental changes/ seasonal variations during developmental stages. The stability of varieties over wide range of environment has always been emphasized by breeders as base before releasing an ideal variety for commercial cultivation [2]. In the present study, 22 pure selections obtained through different intraspecific hybridization followed by rigorous selections upto 8 years including BROP-1 as check, were evaluated in randomized block design with 3 replications during 1998-99 to 2000-2001 to find out the genotype × environmental interactions and to identify stable genotypes as variety and also for further use in breeding programme. The plot size was 2.4 m × 1.50 m with 6 rows 30 cm apart. The observation on 20 plants/replication was recorded for seed yield (g) and opium yield (mg). The morphine estimation was done for each treatment over 3 replications following Pride and Stern [3]. Stability analysis was carried out following Eberhart and Russel [4].

Significant differences were observed among genotypes for all the characters. The joint regression analysis (Table 1) also showed that the variances due to genotypes were significant for all the traits, suggesting the presence of genetic variability for further genetic study. The variances due to environment were significant for all the 3 traits indicating that the environment played a major role in causing variation. Significant mean squares due to G × E interaction indicates that the genotypes interacted considerably with environmental conditions that existed over different years. The environment (linear) component was highly significant for all the traits while linear component of environmental interaction [G × E (linear)] was significant only for opium yield/plant and morphine percentage. Significant pooled deviation (non-linear) suggests that the performance of different varieties fluctuated considerably in respect to their stability for respective characters. Thus both predictable (linear) and unpredictable (nonlinear) components contribute significantly to differences in stability among genotypes. Accordingly 3 kinds of linear responses namely b = 1, b > 1 and b < 1 have generally been observed in all the characters (Table 2).

The genotypes *viz.*, 'BR-233', 'BR-241', 'BR-242' and 'BR-244' had significant regression coefficient for seed yield revealing that regression accounted for G × E interaction for these genotypes (Table 2). Nonlinear component (s^2di) was significant for 8 genotypes indicating that these genotypes are very sensitive and unpredictable to environmental changes. Consistently with this, was the result of pooled analysis where mean square due to nonlinear (pooled deviation) component was significant and higher than the linear component. Out of 22, 14 genotypes had nonsignificant 's^2di' values indicating that these genotypes are stable over changing conditions. Three genotypes ('BR-233', 'BR-242', 'BR-244') had high seed yield over the general mean (gj > x) over environments, non significant' s^2di' and high 'bi' (b > 1) values suggesting that these genotypes are stable and responsive to favourable environment. Under intensive agriculture where inputs are no limitation such varieties can yield maximum but under poor environment they miserably fail. However, three genotypes ('BR-230', 'BR-238', 'BR-243') may be considered ideal for seed yield over the environments as they have high mean (gi > x), non-significant deviation from linearity (s^2di) and regression coefficient approaching unity (b = 1). Remaining genotypes either suited for average or poor environments.

The test of significance for G × E interaction for opium yield indicated the absence of G × E interaction for five genotypes ('BR-228', 'BR-234', 'BR-235', 'BR-245', 'BR-246') where linear (bi) and nonlinear (s^2di) components were non significant. The regression coefficient was nonsignificant for all the genotypes and nonlinear (s^2di) was significant for 17 genotypes. This could be paralleled well with the pooled analysis where variance due to nonlinear component was higher than the linear component. Sixteen genotypes had only significant nonlinear component (s^2di) suggesting there by that these genotypes were most unpredictable for stability across the environments. In considering the result of 3 stability parameters it clearly stands that

Table 1. Analysis of variance for stability of seed yield, opium yield and morphine content in opium poppy

Source	df	Seed yield (g)	Opium yield (mg)	Morphine percentage
Treatment (G)	21	1.68**	3136.29**	4.02**
Year (E)	2	36.70**	29657.39**	103.71**
G × E	42	1.06**	1565.19**	1.01**
Env.+ (G × E)	44	2.68**	2842.10**	5.59**
Env. (linear)	1	72.60**	59300.78**	207.24**
G × E (linear)	21	0.54*	720.00**	0.85**
Pooled deviation	22	1.58**	2427.02**	1.20**
Pooled error	126	0.30	29.30	0.38

Significant at *P = 0.05; **P = 0.01

regression for 'BR-227' indicated that this genotype was also most unstable over the studied environments. Higher mean values than the general mean (gi > x), non significant S^2di values and regression coefficient approaching unity (b = 1) for 'BR-236', 'BR-242', 'BR-243' and 'BR-244' were suggestive of the fact that these genotypes are most ideal for having wide (general) adaptations for morphine content potential.

Taken together the results in the present study suggested that all the studied 22 genotypes possessing wide variations for adaptation reaction offered a good

Table 2. Estimate of stability parameters of individual genotypes for seed yield, opium yield and morphine content

	Varieties	Seed yield/plant (g)			Opium yield/plant (mg)			Morphine percentage		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BR-226	5.09	−0.78	0.32	156.6	−0.22	5313.73**	15.3	−0.06	−0.12
2.	BR-227	5.09	−0.21	−0.01	149.2	−0.49	430.19**	16.8	−0.35	1.16**
3.	BR-228	5.30	0.33	0.02	183.7	−1.07	−20.80	16.1	−0.69	0.02
4.	BR-229	5.72	0.22	−0.17	274.3	0.76	22933.85**	15.2	−0.21	0.64
5.	BR-230	6.12	0.08	−0.05	195.7	0.50	947.41**	15.0	0.06	0.38
6.	BR-231	4.90	−0.05	0.44	160.3	−0.43	122.87**	16.3	0.10	0.41
7.	BR-232	5.41	0.31	−0.01	150.4	−0.88	887.67**	15.9	−0.57	0.93
8.	BR-233	6.26	0.89	0.46	216.3	−0.91	6383.67**	16.7	−0.19	5.93**
9.	BR-234	7.46	−0.32	5.21**	198.6	0.65	−14.72	16.9	−0.41	0.29
10.	BR-235	5.76	−0.32	−0.14	157.7	−0.06	−21.76	17.4	0.06	1.79**
11.	BR-236	6.09	−0.57	2.70**	160.7	−0.58	2291.64**	18.2	−0.18	0.76
12.	BR-237	6.23	0.28	1.50**	185.3	−0.09	157.76**	16.7	0.46	1.06
13.	BR-238	5.79	−0.20	0.78	241.0	0.28	179.97**	15.4	0.39	0.15
14.	BR-239	5.38	−0.31	−0.07	207.5	−0.55	1014.98**	16.2	0.41	0.09
15.	BR-240	4.52	−0.83	1.41**	227.0	0.62	3352.18**	13.8	−0.03	0.97
16.	BR-241	4.74	0.35	6.11**	161.7	−0.11	1575.88*	16.0	−0.02	−0.02
17.	BR-242	7.01	0.40	0.53	194.7	0.09	3266.39**	18.8	0.27	0.16
18.	BR-243	5.86	0.18	0.05	171.8	−0.40	732.29**	16.8	−0.12	0.52
19.	BR-244	6.47	0.45	0.09	195.0	0.70	127.43**	16.4	−0.15	−0.10
20.	BR-245	6.44	−0.18	3.60**	166.3	−0.61	32.16	18.4	0.32	1.17**
21.	BR-246	5.53	0.39	2.81**	213.9	0.00	2.62	15.9	−0.06	−0.05
22.	BROP1	5.52	−0.61	2.92**	206.4	1.36	3054.44**	15.6	0.60	1.81**
Mean		5.76			189.7			16.35		
SE			0.69			0.95			0.36	

Significant at *P = 0.05; **P = 0.01.

the genotype 'BR-246' was the most ideal for having the wide adaptation. It has higher opium yield (213.9mg/plant) against the general mean (189.73mg/plant), non significant (s^2di) and unit regression coefficient. Two genotypes *viz.*, 'BR-228' and 'BR-245' were more suitable for unfavorable conditions as axiomatic to low 'bi' values (b < 1.0). On the other hand 'BR-234' having higher regression coefficient than unity showed its suitability for only high yielding environment. The genotype 'BR-235' showed its average response to low yielding environment.

In case of morphine content, the result of S^2di analysis for genotypes BR-233. BR-235, BR-242 and BROP-1 (Table 2) were in agreement with the results of pooled analysis (Table 1). It was thus indicated that non-linear component of G × E interaction are controlling these genotypes, so as to render them sensitive to the fluctuating environments. In other words, these genotypes were indicated to be unpredictable types against the changing environments. Significant non-linear scope of selecting the suitable genotypes for all the 3 characters. The Genotypes 'BR-230', 'BR-234', 'BR-244' and 'BROP-1' which were identified as ideal and stable over years for one or more of the characters have been put in advance breeding trial to test their stability over different locations to release for commercial cultivation.

References

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