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PERFORMANCE OF EXOTIC x INDIGENOUS CROSSES FOR COMBINING ABILITY OVER ENVIRONMENTS IN OPIUM POPPY (*PAPAVER SOMNIFERUM* L.). IV. CAPSULE SIZE AND CAPSULE NUMBER

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ABSTRACT

Combining ability worked out from 5 x 10 (line x tester) data revealed that nonadditive gene action was more important than additive gene action for capsule number and capsule size. Year effects were pronounced for both characters. Magnitude of variance for gca x year interaction was much less than the corresponding magnitude of sca x year interaction for capsule number. For capsule size, sca x year interaction variance was of less magnitude than the gca x year interaction variance. Crosses EC 11552 x KP and EC 11571 x Hariana for capsule number, and EC 11540 x DCG and EC 11556 x KD for capsule size were the best specific combinations. Single plant selection after inter-se mating in segregating generations would be the best way to improve these traits. Pedigree method would be a better approach in the cross EC 11548 x DCG for capsule size where additive gene effects were more important.

Key words: Line x tester, combining ability, opium poppy.

Opium poppy, a medicinal plant, has positive association of characters like opium and seed yield with capsule number and capsule size [1–3]. To these traits it is customary to study the behaviour of parents and F_1 crosses for combining ability, heterosis and mean performance etc. The present investigation covers the above aspects for 50 F_1 crosses of opium poppy grown for two successive years for the two characters individually and pooled over the years.

MATERIALS AND METHODS

Ten exotic female parents, namely, EC 11538, EC 11540, EC 11544, EC 11547, EC 11548, EC 11551, EC 11552, EC 11556, EC 11569 and EC 11571 were crossed with five indigenous male parents, i.e. DCG (Dhola - Chhota - Gotia), KTD (Katala-Dandi), KP (Kantia Pink), KD

(Kali Dandi) and Hariana, resulting in 50 crosses. These crosses along with 15 parents were sown in complete randomized block design during the winter season at IARI farms in three replications in two successive years. In both the years, the spacings between plant to plant and row to row were kept at 15 and 30 cm, respectively. Each parent and F_1 was grown in 4-row plot of 3.6 m length. Sufficient number of irrigations and interculture operations were provided during the crop season. Observations were recorded for capsule number and capsule size (cm^2) on five plants selected at random from each parent and hybrid in both years and the means over plants were used for statistical analysis for combining ability [4] for each character separately. Pooled F_1 data were analysed for combining ability for the two characters according to the procedure developed by Daljit Singh (personal communication). Heterosis as percentage over better parent was estimated as per the standard procedure.

RESULTS AND DISCUSSION

A critical examination of the data reveals that female parents produced more capsules per plant than the highest number of capsules produced by any male parent. The male parents (indigenous origin) produced bigger capsules in comparison to the female parents (Table 1). By and large, the average estimates worked out on pooled data basis revealed that the male parents produced capsules of 56.1 cm^2 size and the female parent of 43.4 cm^2 size. Similarly, the capsule number was maximum in female (2.34) and minimum in male (2.04) parent. However, capsule number of F_1 hybrids ranged from 3.50 to 4.65 and capsule size from 56.25–86.50 cm^2, which indicated substantial gain over the better parent for capsule size and capsule number per plant. Moreover, ANOVA (Table 1) also showed significant mean squares due to parents and hybrids in both years. This indicated that there was diversity among parents as well as among the hybrids for these two characters. The diversity observed in the material under study may probably be related with geographical diversity, as 10 out of the 15 parents belonged to 10 different foreign countries of the world. Such genetic differences may have arisen due to geographical isolation accompanied by a combination of genetic drift and natural selection in different environments [5]. Further, the superiority of F_1 hybrids over the parents could be observed by the significant single degree of freedom mean squares in respect of parents vs. F_1 for both characters in both seasons as also the differences in respective means. However, an increase of 102.4% for capsule size and 228.5% for capsule number over the better parent in the crosses EC 11551 x DCG and EC 11569 x KD possibly reflects the maximum genetic diversity among the parents involved in these crosses.

The combining ability estimates worked out on pooled data basis revealed that the magnitude of sca variances was larger than those of gca variances for capsule number and capsule size. Since nonadditive genetic variance is predominant as indicated by the present study and also earlier in the same material for other traits, such as, husk yield [6], opium

Table 1. ANOVA for the design of experiment and combining ability for capsule number and capsule size in opium poppy

Source	d.f.	Mean Squares					
		capsule number			capsule size		
		1977–78	1978–79	F_1 pooled	1977–78	1978–79	F_1 pooled
Blocks	2	0.76**	6.79**		111.55**	184.01**	
Parents	14	0.84**	0.95**		431.76**	343.65**	
Hybrids	49	1.99**	1.05**		569.34**	643.44**	
P vs F_1	1	31.48**	41.78**		83.93**	730.15**	
Lines (L)	9	1.34**	1.66**	2.08**	277.96**	216.99**	473.94**
Testers (T)	4	1.60**	0.14*	1.03**	2564.15**	213.66**	482.60**
L x T	36	2.20**	1.00**	2.61**	420.55**	269.46**	488.74**
Years (Y)	1			73.82**			1742.40**
Y x L	9			0.92**			19.15**
Y x T	4			0.67**			18.55
Y x L x T	36			0.59**			13.70
Error		0.06	0.12	0.09	10.49	22.87	14.17
		(98)	(98)	(196)	(98)	(98)	(196)
σ^2gca		—	—	—	44.46	—	—
σ^2sca		0.71	0.29	0.34	136.68	82.19	79.17
σ^2gca x year				0.09			0.22
σ^2sca x year				0.16			—

Degrees of freedom are given in parentheses.

*,**Significant at P = 0.5 and 0.01 levels, respectively

yield [7] and seed yield [8], the best way for rapid improvement would be by inter se matings [9], followed by selection.

Genotype x environment interaction worked out from pooled data revealed that year effects were very pronounced for capsule number and capsule size. Moreover, the significant mean squares due to years x lines, years x testers, and years x lines x testers for capsule number alone and year x lines for capsule size indicate instability in performance of the parents and hybrids over two years for these characters. The male parents of indigenous origin, showed stable performance for capsule size in comparison to female parents, which were of exotic origin. It is therefore emphasized that selection of hybrids for mean performance across environment should be carried out first followed by testing of the relative stability of high yielding hybrids [10]. In the present study, the estimates of combining ability variances are less distorted as the estimates for sca x year and gca x year are nonsignificant. Earlier studies [6, 7] conducted for husk yield, opium yield and seed yield also supported the present findings.

Table 2. Average performance of parents in two years for capsule numbers and capsule size in opium poppy

Parents	Capsule number			Capsule size, cm^2		
	1977–78	1978–79	Pooled	1977–78	1978–79	pooled
Females:						
EC 11544	2.7	2.9	2.8	49.7	54.6	52.1
EC 11540	3.0	2.5	2.7	42.3	45.7	43.9
EC 11538	1.6	1.9	1.7	32.7	39.8	37.7
EC 11547	2.6	2.8	2.7	36.8	39.6	38.2
EC 11548	2.2	2.9	2.5	44.1	44.2	44.1
EC 11551	2.4	3.2	2.8	41.5	41.3	41.4
EC 11552	2.0	2.6	2.3	30.2	36.4	33.3
EC 11556	2.8	2.9	2.8	25.6	29.3	27.4
EC 11569	1.4	1.7	1.5	57.2	56.4	56.8
EC 11571	1.6	1.8	1.7	60.2	59.3	59.7
Males:						
DCG	1.8	2.3	2.0	40.0	62.4	51.2
KTD	2.6	2.9	2.7	61.5	61.6	61.5
KP	1.8	1.6	1.7	61.8	61.9	61.8
Hariana	2.3	2.9	2.6	59.3	55.4	57.3
KD	1.4	1.6	1.5	48.0	49.6	48.8

Estimates of sca effects, heterosis, and mean performance of the selected crosses picked up from different sets of analysis for capsule number and capsule size are presented in Table 3. Out of the 50 crosses, 20, 12 and 8 crosses showed significant sca effects in individual and pooled data analysis for capsule number and 17, 18 and 18 crosses for capsule size, respectively. Similarly, the number of crosses showing significant positive heterosis over better parent were 34, 20 and 30 for capsule number and 10, 15 and 16 for capsule size. However, the best crosses chosen on the basis of sca effects and mean performance were EC 11552 x KP for capsule number and EC 11540 x KD for capsule size. The most heterotic crosses were EC 11552 x KD and EC 11569 x Hariana for capsule number, and EC 11540 x DCG and EC 11551 x DCG for capsule size.

A critical examination of Table 3 reveals that in most cases the estimates of sca effects, heterosis percentage and mean performance of F_1 crosses in one year deviate from the estimates of the other year both in magnitude and direction. This is concluded to be due to genotype x environment interaction [11]. In view of the presence of nonadditive gene effects in some of the crosses like EC 11540 x DCG, EC 11552 x KD for capsule size, and EC 11569 x KD and EC 11552 x KP for capsule number, the best way for further improvement in these

Table 3. Selected elite crosses for capsule number and capsule size

Cross	1977–78			1978–79			Pooled		
	m	sca	h	m	sca	h	m	sca	h
Capsule number									
EC 11552 x KP	4.6	1.25**	130.0**	4.7	1.10**	80.7**	4.6	1.18**	102.1**
EC 11569 x KD	4.6	1.32**	228.5**	4.5	0.29	164.7**	4.5	0.81*	203.3**
EC 11571 x KD	4.4	0.47**	176.8	3.9	0.01	116.6**	3.6	0.24**	115.8**
EC 11540 x DCG	4.3	0.73**	43.3**	3.9	0.51**	56.0**	4.1	0.62**	51.8**
EC 11548 x KP	4.2	1.15**	61.5**	3.9	0.84**	34.4	4.0	1.0**	62.0**
EC 11547 x KP	4.0	0.95**	53.85	3.7	0.38**	32.1	3.8	0.65**	42.5**
EC 11551 x KTD	4.0	0.95**	53.9**	3.9	0.50**	21.8	3.9	0.73**	41.0**
EC 11571 x Har.	3.9	1.02**	69.5**	4.7	0.91**	62.0**	4.3	0.96**	65.3**
EC 11544 x KD	3.8	0.58**	40.7**	4.2	0.71**	44.8	4.0	0.65**	42.8
EC 11538 x KP	3.8	0.19	111.1**	3.3	–0.06	73.7**	3.5	0.07	108.8**
EC 11547 x Har.	3.22	0.68**	18.5**	3.8	0.55**	31.0	3.5	0.62*	29.6**
Capsule size									
EC 11551 x DCG	86.0	15.51**	102.4**	89.0	16.63**	42.6	86.5	16.07	68.9**
C 11540 x DCG	80.0	16.55**	89.5**	84.3	17.21**	35.1	82.1	16.88**	69.3**
EC 11548 x DCG	72.0	11.19**	63.3**	79.3	11.29**	–27.0	75.1	11.21**	46.6**
EC 11556 x KD	61.4	20.49**	27.9	69.3	23.37**	39.7**	65.3	21.93**	33.8**
EC 11551 x Har.	60.0	9.63**	–1.1	68.3	14.07**	23.28**	64.1	11.85**	11.8
EC 11552 x KD	55.0	16.83**	14.5**	57.5	14.85**	15.93**	56.2	15.84**	15.1**
EC 11552 x KD	55.0	16.83**	14.5**	57.5	14.85**	15.93**	56.2	15.84**	15.1**

*,**Significant at P = 0.05 and P = 0.01, respectively.

crosses would be through biparental matings in F_2 generation. Some of the crosses having substantial additive genetic control like EC 11548 x DCG may be improved through pedigree method.

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