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GENETICAL STUDY FOR EARLINESS IN *PAPAVER SOMNIFERUM* L.

SUDHIR SHUKLA AND K. R. KHANNA

Genetics and Plant Breeding Division, National Botanical Research Institute Lucknow 226001

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ABSTRACT

The nature and magnitude of genetic variance and combining ability were studied in a 10-parent diallel of opium poppy (*Papaver somniferum* L.) for days to flowering and maturity. The analysis revealed partial dominance in F_1 and overdominance in F_2 for days to flower and overdominance in both the generations for days to maturity. Combining ability analysis indicated the predominance of nonadditive gene action (σ^2s) for both traits. The parent BR-9 possesses maximum number of recessive genes and was also the best general combiner for both the traits. The crosses Gz x KDB and Gz x BR-9 for days to flower and KDB x BR-9 for days to maturity were the best combinations with additive x additive gene interaction. A breeding programme to develop early maturing genotypes is discussed.

Key words: Combining ability, diallel, *Papaver somniferum*.

The opium poppy (*Papaver somniferum* L.) is the source of commercial opium from which a number of alkaloids of great medicinal value are extracted. Breeding for earliness is desirable to encourage its intensive cultivation. However, no information is available on the genetics of earliness. Keeping this in view, the present investigation has been carried out in opium poppy in a ten-parent full diallel.

MATERIALS AND METHODS

Ten inbred lines of opium poppy (*Papaver somniferum*) were crossed in all possible combinations including reciprocals to obtain 90 F_1 hybrids. The F_1 generation was advanced to produce F_2 seeds in the following year. The 190 entries including 10 parents, 90 F_1s, and 90 F_2s were grown in randomized block design with three replications at the National Botanical Research Institute, Lucknow. All the materials were grown in two-row plot of each replication size 3.0 x 0.50 m with plant to plant distance at 15 cm. Five random plants from each parent and F_1, and 10 plants each from F_2 in each replication, were taken for detailed observations on days to flower and maturity. Diallel analysis was done according to Hayman [1]. Combining ability was assessed following Griffing's Method I and Model I [2].

RESULTS AND DISCUSSION

Analysis of variance due to treatments, parents and hybrids was significant, indicating diversity among the parents.

COMPONENTS OF VARIANCES

The estimates of genetic components of variances and their proportions are presented in Table 1. The estimates of additive ($\hat{D}$) and dominance ($\hat{H}$) components were highly significant for days to maturity in both generations, while for days to flower only additive component was significant in F_1 and F_2. The mean degree of dominance over all loci, estimated by $(\hat{H}1/\hat{D})^{\frac{1}{2}}$ indicated partial dominance in F_1 and overdominance in F_2 for days to flower and overdominance for days to maturity in both generations. Overdominance for days to flower seemed to be the consequence of complementary nonallelic interaction and genetic diversity among the parents [3]. Therefore, overdominance may not be a true cause of heterosis. Complementary epistasis coupled with genetic diversity may cause heterosis. The significant negative estimates of $\hat{F}$ in F_1 and negative in F_2 for days to flower and, consequently, low values of KD/KR indicated an increase in recessive alleles among the parents. Days to maturity both in F_1 and F_2 showed significant positive estimates of $\hat{F}$ coupled with high positive values of KD/KR, which indicates increase in the dominant alleles among the parents. The proportion of dominance, i.e. $(\hat{H}_2/4\hat{H}_1)$, was not close to the

Table 1. Estimates of components of variance for earliness in opium poppy

Component of variance	Days to flower		Days to maturity	
	F_1	F_2	F_1	F_2
$\hat{D}$	$0.44^{**} \pm 0.16$	$0.43^{**} \pm 0.15$	$1.909^{**} \pm 0.18$	$1.89^{**} \pm 0.26$
$\hat{H}_1$	0.24 ± 0.33	$4.42^{**} \pm 1.32$	$2.723^{**} \pm 0.38$	$7.57^{**} \pm 2.23$
$\hat{H}_2$	0.27 ± 0.28	$-3.54^{**} \pm 0.12$	$1.209^{**} \pm 0.33$	2.41 ± 1.90
$\hat{F}$	$-0.75^{*} \pm 0.05$	0.66 ± 0.71	$3.324^{**} \pm 0.42$	$6.41^{**} \pm 1.21$
$\hat{E}$	$0.65^{**} \pm 0.05$	$0.65^{**} \pm 0.05$	$0.484^{**} \pm 0.05$	$0.50^{**} \pm 0.08$
Proportions of components of variance				
$(\hat{H}_1/\hat{D})^{\frac{1}{2}}$	0.74	−1.60	1.19	1.00
$\hat{H}_2/4\hat{H}_1$	0.28	0.20	0.11	0.08
KD/KR	0.79	0.36	6.38	−3.88
$\hat{h}^2/\hat{H}_2$	3.83	1.90	−0.13	−2.59
t^2	0.08	1.62	0.20	1.17
Heritability (ns)	13.15	18.98	58.86	73.07
r	-0.47 ± 0.31	0.14 ± 0.35	0.003 ± 0.35	-0.31 ± 0.34

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

expected value of 0.25 for either of the traits, suggesting asymmetrical distribution of positive and negative alleles among the parents. The value of $\hat{H}_2/4\hat{H}_1$ is slightly higher in F_1 for days to flower than the expected value, which may be due to environmental effects. The groups of genes ($\hat{h}^2/\hat{H}_2$) were three and two for days to flower in F_1 and F_2 generations, respectively. It was very low for days to maturity, which may be due to underestimation. Such a situation may arise from cancelling the effects of positive and negative alleles. The heritability (ns) was high for days to maturity but low for days to flower in both generations, indicating a major role of additive and nonadditive gene effects, respectively.

COMBINING ABILITY

Mean squares due to general and specific combining ability (Table 2) were significant for days to flower and maturity in both generations. This suggests the importance of both the components in breeding programmes. The estimates of $\sigma^2 s$ were higher than $\sigma^2 g$, indicating preponderance of nonadditive gene action for both the traits, except days to flower in F_2. Further, the magnitude of potence ratio $(\sigma^2 s/\sigma^2 g)^{0.5}$ was more than 1, except for days to flower in F_2, indicating major role of overdominance in the expression of the traits. The flowering time is reported to be controlled by both additive and dominance variations earlier [4–7].

On the basis of gca effects (Table 3), varieties Gz and BR-9 in F_1 and F_2 and Bk in F_2 were significantly superior combiners for days to flower. For days to maturity, cvs. BR-9 and Te were significantly superior combiners in F_2, BR-9 was also a superior combiner in F_1 but not significantly. The stable behaviour of BR-9 in F_1 and F_2 for both the traits may be due to an

Table 2. ANOVA for combining ability and some genetic parameters in opium poppy

Source	d.f.	Days to flower		Days to maturity	
		F_1	F_2	F_1	F_2
Gca	9	3.07**	4.00**	1.04*	1.00*
Sca	45	0.75**	0.70**	1.05**	1.16**
Rec	45	0.92**	0.73**	0.66**	1.27**
Error	198	0.64	0.65	0.48	0.50
Gca/sca		4.07	5.70	0.99	0.86
		Components of variances			
	$\sigma^2 g$	0.11	0.16	0.001	–0.01
	$\sigma^2 s$	0.59	0.02	0.31	0.36
	$\sigma^2 r$	0.14	0.04	0.09	0.38
	$\sigma^2 e$	0.64	0.65	0.48	0.50
	$(\sigma^2 s/\sigma^2 g)^{0.5}$	2.29	0.40	17.66	7.16

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

excess of recessive alleles in it. This was also accompanied by the lower per se values for both the traits. Thus, it may be utilized as one of the parents to evolve promising early genotypes. Per se performance of the parents was closely associated with gca effects in F_2 for both traits, as rank correlation was significant. It would, therefore, suggest that per se performance of genotypes in F_2 may be useful for predicting combining ability of the parents in early generation.

Table 3. Estimates of gca effects and parental mean in opium poppy

Parent	Days to flower			Days to maturity		
	per se performance	gca effects		per se performance	gca effects	
		F_1	F_2		F_1	F_2
Gz	106.6	-0.71^{**}	-0.61^{**}	140.3	−0.15	0.07
Bk	108.2	0.20	-0.44^{*}	142.7	−0.01	−0.06
KD	109.7	−0.06	0.40^{*}	141.0	−0.01	0.09
BR-4	109.0	0.31	0.73^{**}	140.0	-0.36^{*}	0.10
NB-2	109.5	0.10	0.01	142.3	0.30	0.15
SP	108.2	0.23	0.34	138.7	0.04	−0.01
KDB	107.7	−0.17	−0.11	142.7	0.32	0.30
Te	108.9	0.13	0.11	139.3	0.12	-0.38^{*}
BR-9	106.9	-0.57^{**}	-0.59^{**}	139.7	−0.28	-0.35^{*}
DCG	108.9	0.54^{*}	0.17	142.7	0.04	0.09
SE (gi)		0.17	0.17		0.15	0.15
Rank correlation (RS)		0.53	0.79^{*}		0.55	0.69^{*}

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

Gz—Gazipur, Bk—Bakhua, KD—Kali Dandi, BR-4—Botanical Research-4, NB-2—NBRI-2, SP—Suga Pankhi, KDB—Kali Dandi Baunia, Te—Telia, BR-9—Botanical Research-9, and DCG—Dhola Chotta Ghotia.

The best five crosses based on gca effects and per se performance are presented in Table 4. The common cross combinations were BR-4 x Te for days to flower and Bk x KD, NB-2 x DCG and KDB x DCG for days to maturity, in both generations, indicating the stability in these crosses over two generations. Among the five crosses, crosses 3 and 2 for days to flower and 3 crosses each for days to maturity were common in respect of sca effects and per se performance in F_1 and F_2 generations, respectively. A comparison of sca effects of the crosses with gca effects of the parents revealed that all the promising crosses had high x low or low x low general combiners, except Gz x KDB in F_1 and Gz x BR-9 in F_2 for days to flower, and KDB xBR-9 in F_2 for days to maturity, which involved high x high combiners. Thus, it is obvious that a good cross combination is not always the result of high x high or high x low combiners but might also result from low x low combiners. The crosses Gz x KDB and Gz

Table 4. Best five crosses on the basis of sca effects and per se performance for earliness in opium poppy

Sca effects	Per se performance	Combiners	Rec.	Per se performance	Combiners
		Days to flower			
		F_1			
Gz x KDB	Te x BR-9	H x H	BR-4 x DCG	KDB x Gz	L x L
Gz x KD	KD x NB-2	H x L	KD x BR-9	KD x Gz	L x H
BR-4 x Te	Gz x KD	L x L	Bk x BR-9	KD x BR-9	L x H
KD x NB-2	NB-2 x KDB	L x L	Te x DCG	BR-4 x Gz	L x L
Bk x KDB	Gz x KDB	L x H	NB-2 x SP	KDB x SP	L x L
		F_2			
BR-4 x KDB	Gz x NB-2	L x H	Te x DCG	BR-9 x Gz	L x L
Gz x BR-9	Gz x Bk	H x H	Gz x BR-4	BR-9 x Bk	H x L
BR-4 x Te	Te x DCG	L x L	KDB x Te	KD x Gz	H x L
Te x DCG	Gz x BR-9	L x L	Bk x DCG	DCG x BR-9	L x L
NB-2 x SP	Bk x DCG	L x L	SP x BR-9	NB-2 x Gz	L x H
		Days to maturity			
		F_1			
Bk x KD	NB-2 x DCG	L x L	Gz x BR-9	KD x BK	H x H
NB-2 x DCG	BK x KD	L x L	Gz x KD	KDB x BR-4	H x L
KDB x DCG	Gz x KD	H x L	KD x SP	Te x BR-4	L x L
BR-4 x KDB	Bk x BR-9	L x H	NB-2 x DCG	BR-9 x BR-4	L x L
Bk x BR-9	KD x BR-4	L x H	Gz x KDB	BR-9 x BK	H x H
		F_2			
KDB x BR-9	KDB x BR-9	H x H	KDB x BR-9	Te x Gz	H x H
Bk x KD	KDB x DCG	L x L	KDB x DCG	Te x NB-2	H x L
NB-2 x DCG	BK x BR-9	L x L	BK x KDB	Te x BR-4	L x H
KDB x DCG	BK x KD	H x L	SP x DCG	Te x SP	L x L
NB-2 x SP	BK x KDB	L x L	BK x DCG	DCG x NB-2	L x L

H—high, L—low.
Note. Abbreviations of variety names as in Table 3.

x BR-9 for days to flower and KDB x BR-9 for days to maturity, which have high x high combiners, indicate additive x additive type of gene action between favourable alleles contributed by both the parents, which is fixable and hence may be utilized to develop earliness in opium poppy. A biparental progeny selection based on North Carolina Design II may be best suited, as it accumulates the favourable genetic effects and thereby releases a greater reservoir of genetic variability. In F_2 progenies, such intermating has been found to increase the population mean in F_3 and break up linkages [8, 9]. Among the reciprocal crosses, only the cross Te x DCG for days to flower was common in both the generations and involved low x low general combiners. No cross was common for days to maturity in both generations.

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