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COMBINING ABILITY FOR SEED YIELD AND ITS COMPONENTS IN *PAPAVER SOMNIFERUM* L.

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ABSTRACT

Line x tester analysis involving 4 male and 31 female parents in opium poppy (*Papaver somniferum* L.) along with their F_1 hybrids was carried out in four environments. The results indicated that both general and specific combining abilities were important in the expression of seed yield and its components, viz., husk yield, plant height, stem diameter, and leaf area index. However, nonadditive components of genetic variances was predominant. The parent varieties MOP 3, MOP 379, MOP 319, IC 7 and IC 128 were good general combiners for seed and husk yield, the latter two parents also extended their good general combining ability to stem diameter. The best specific cross combinations were NOP 1 x IC 42, IC 19 x MOP 3 for seed yield and leaf area index, and MOP 539 x JA 16, IC 7 x MOP 3 for seed and husk yield.

Key words: Line x tester analysis, combining ability, opium poppy, opium yield, gene effects.

Opium poppy (*Papaver somniferum* L.) is grown for opium (latex) and seed. Beside, the poppy seed is also a rich source of protein, minerals, vitamins and oil [1]. Breeding work in opium poppy is bidirectional, i.e. improvement for latex yield and high alkaloid content. At present, due to higher cost of seed, a third dimention, i.e. breeding for high seed yield has been added. Since very little information is available on genetics of these traits in this crop, the present study has been undertaken to know the type of gene action governing seed yield and its component traits and to identify the parents and crosses which could be exploited in future breeding programmes.

MATERIALS AND METHODS

The experimental material comprised four cultivars, viz., JA (Jawahar Aphim) 16, IC (Indigenous collection) 42, IC 30 and MOP (Mandsaur opium poppy) 3 used as male parents and 31 cultivars, viz. MOP 187, MOP 278, MOP 319, MOP 379, MOP 409, MOP 503, MOP 506, MOP 507, MOP 539, IC 1, IC 3, IC 7, IC 18, IC 19, IC 88, IC 90, IC 91, IC 95, IC 111, IC

114, IC 128, UO (Udaipur opium) 177-2, UO 185, UO 285, NBRI (National Botanical Research Institute) 3, NBPGR (National Bureau of Plant Genetic Resources) 3, NOP (Narendradev opium poppy) 1, NOP 4, Ranzatak, Posta 91, and Posta 149 as female parents. One hundred twenty four crosses were obtained in line x tester mating design. These parents and hybrids were grown in randomised block design with two replications in four different combinations of environments, involving early (1st week of November) and late (1st week of December) sowings, and high (NPK 100:50:30 kg/ha) and low (NPK 0:0:0 kg/ha) fertility levels. Each entry was raised in two 1 m long rows at 30 x 10 cm spacing. Observations were recorded on five random plants in each plot for seed yield, husk yield, plant height, stem diameter, and leaf area index. The analysis of general and specific combining ability (gca, sca) effects and variances obtained from the lines x tester set was done as per Kempthorne [2].

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that mean squares due to lines and testers were significant for all the traits, except leaf area index in late sowing with high fertility, and testers for stem diameter in late sowing under low fertility, leaf area index in early sown-low fertility, and husk yield in early sown-high fertility, seed yield in early sown-high as well as low fertility, and also late sown-low fertility environments. These results indicate the presence of additive gene action for the expression of all the characters. Variances due to line x tester were significant for seed and husk yield in all environments, plant height in early and late sown with low fertility environments, leaf area index in early-low and high fertility environments; and stem diameter in late- high fertility environment, suggesting the presence of nonadditive gene effects for these traits. Similar results for these traits were reported earlier in opium poppy [3, 4] while predominance of additive genetic variance were reported for only seed yield [5]. The gca variance of females was higher than that of males for seed and husk yield, whereas variance due to males was higher than that of females only for plant height, indicating predominance of additive variance through males and females for the respective traits. The higher values of σ^2 sca than σ^2 gca (pooled) for all characters in all environments indicates the importance of nonadditive variances in control of all the characters studied. Environments played important role in the expression of gca and sca variances.

Genotypes with significant gca effects in desired direction are expected to transmit genes with desirable effects to their progeny. One tester and 12 lines for seed yield, 2 testers and 11 lines for husk yield, 3 testers and 14 lines for plant height, 1 tester and 17 lines for stem diameter, and 1 tester and 10 lines for leaf area index showed desired significant gca effects for the respective traits in different environments (Table 1). Among the testers, MOP 3, had desired significant gca effects for plant height, seed and husk yield, Similarly,

Table 1. Gca effects and mean performance of parents for five characters in opium poppy over four environments

Environment sowing	Environment fertility	Parent	Gca	Mean
		Seed yield/plant, g		
Early	High	IC 7	1.69^{**}	4.6
		IC 3	0.87^{**}	5.0
		MOP 319	0.78^{*}	4.5
		IC 128	0.70^{*}	4.5
		SE (gi-gj)	0.48	
Early	Low	IC 90	1.15^{**}	4.3
		MOP 379	0.95^{*}	4.2
		SE(gi-gj)	0.55	
		MOP 3	0.16^{*}	3.0
		SE (gi-gj)	0.10	
Late	High	MOP 319	0.72^{**}	2.6
		UO 177-2	0.52^{*}	4.2
		IC 114	0.49^{*}	2.4
		NOP 4	0.47^{*}	2.3
		Ranzatak	0.44^{*}	2.4
		SE (gi-gj)	0.27	
Late	Low	MOP 506	0.50^{**}	2.3
		IC 1	0.31^{*}	2.4
		SE (gi-gj)	0.23	
		Husk yield/plant, g		
Early	High	IC 7	0.83^{*}	5.2
		IC 128	0.82^{*}	5.0
		SE (gi-gj)	0.51	
Early	Low	IC 42	0.24^{*}	3.7
		SE (gi-gj)	0.17	
		IC 19	1.01^{**}	4.2
		IC 90	0.07^{**}	3.6
		MOP 278	0.92^{**}	4.7
		SE (gi-gj)	0.41	
Late	High	MOP 3	0.18^{*}	1.7
		SE (gi-gj	0.11	
		MOP 319	0.98^{**}	3.3
		NOP 4	0.59^{**}	2.8
		IC 114	0.55^{*}	2.7
		MOP 278	0.53^{*}	4.5
		MOP 507	0.49^{*}	3.5
		SE (gi-gj)	0.31	
Late	Low	IC 42	0.15^{*}	2.1
		SE(gi-gj)	0.09	
		MOP 506	0.64^{**}	1.6
		IC 128	0.37^{*}	2.8
		IC 111	0.36^{*}	1.9
		SE (gi-gj)	0.25	
		Plant height, (cm)		
Early	High	IC 42	-3.45^{**}	92.9
		SE (gi-gj)	0.84	
		MOP 539	-9.00^{**}	84.7
		IC 111	-4.40^{**}	88.2
		IC 114	-4.00^{*}	87.8
		NOP 4	-3.80^{*}	84.4
		MOP 319	-3.30^{*}	89.0
		UO 185	-3.30^{*}	87.7
		IC 91	-3.24^{*}	90.1
		SE (gi-gj)	2.33	
Early	Low	MOP 3	-1.86^{**}	84.8
		JA 16	-1.64^{**}	84.5
		SE (gigj)	0.67	
		NOP 4	-4.90^{**}	78.1
		MOP 539	-4.72^{**}	79.8
		UO 185	-3.68^{**}	84.2
		MOP 506	-3.55^{**}	77.0
		MOP 319	-3.40^{**}	82.3
		MOP 507	-3.28^{*}	89.3
		IC 18	-2.63^{*}	85.8
		SE (gi-gj)	1.87	
Late	High	JA 16	-1.73^{*}	79.1
		SE (gi-gj)	0.07	
		UO 285	-6.94^{**}	80.4
		MOP 409	-6.27^{**}	71.8
		SE (gi-gj)	2.77	
Late	Low	JA 16	-2.87^{**}	64.0
		SE (gi-gj)	0.84	
		MOP 539	-7.96^{**}	66.2
		MOP 379	-6.47^{**}	54.4
		NBPGR 3	-5.37^{**}	65.0
		IC 91	-4.79^{**}	64.9
		MOP 409	-3.27^{*}	54.5
		SE (gi-gj)	0.84	

(Contd.)

Table 1 *(contd.)*

Environment sowing	Environment fertility	Parent	Gca	Mean
		Stem diameter, cm		
Early	High	IC 7	0.12^{**}	0.90
		IC 3	0.08^{**}	0.87
		IC 128	0.08^{**}	0.87
		IC 95	0.05^{*}	0.81
		SE (gi-gj)	0.03	
Early	Low	IC 42	0.10^{*}	0.79
		SE (gi-gj)	0.01	
		IC 7	0.06^{**}	0.82
		IC 95	0.06^{**}	0.85
		Posta 149	0.05^{**}	0.86
		IC 3	0.04^{*}	0.88
		MOP 187	0.03^{*}	0.78
		MOP 409	0.03^{*}	0.75
		SE (gi-gj)	0.02	
Late	High	IC 42	0.14^{**}	0.81
		SE (gi-gj)	0.01	
		IC 18	0.07^{**}	0.90
		IC 7	0.05^{**}	0.88
		MOP 319	0.05^{**}	0.82
		MOP 379	0.04^{**}	0.82
		IC 88	0.03^{*}	0.83
		IC 91	0.03^{*}	0.86
		SE (gi-gj)	0.02	
Late	Low	IC 128	0.08^{**}	0.62
		UOP 177-2	0.07^{**}	0.54
		IC 111	0.07^{**}	0.56
		NOP 1	0.06^{**}	0.59
		NOP 4	0.05^{*}	0.54
		UO 185	0.04^{*}	0.56
		SE (gi-gj)	0.03	
		Leaf area index, cm^2		
Early	High	IC 42	0.44^{*}	7.38
		SE (gi-gj)	0.27	
		IC 7	2.84^{**}	6.58
		IC 3	1.92^{**}	9.07
		IC 18	1.32^{*}	5.00
		IC 95	1.30^{*}	6.19
		Posta 91	1.10^{*}	6.22
		SE (gi-gj)	0.76	
Early	Low	Posta 91	2.14^{**}	9.15
		MOP 187	1.82^{**}	6.38
		IC 3	1.73^{**}	3.95
		IC 90	1.53^{*}	4.73
		SE (gi-gj)	0.84	
Late	High	IC 42	0.48^{*}	7.91
		SE (gi-gj)	0.31	
Late	Low	IC 42	0.25^{*}	4.50
		SE (gi-gj)	0.15	
		MOP 507	1.24^{**}	4.13
		MOP 187	1.06^{**}	2.72
		IC 1	0.77^{*}	3.92
		SE (gi-gj)	0.41	

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

IC 42 was a poor combiner for seed yield but best combiner for husk yield, plant height, stem diameter and leaf area index. JA 16 had desired significant gca effects for plant height. None of the parents showed desirable combining ability for all characters in all the environments tested. Among the lines MOP 379, MOP 319 and NOP 4 were good general combiners for seed yield, plant height and stem diameter. The two latter parents also displayed good combining ability for husk yield; IC 7 and IC 128 for seed yield, husk yield and stem diameter; IC 90 for seed yield, husk yield and leaf area index; and IC 3 for seed yield, stem diameter and leaf area index.

Table 2. Crosses with high sca effects for seed yield and its component characters in opium poppy in four environments

Environment sowing	Environment fertility	Cross	Sca effects	Mean
		Seed yield/plant g,		
Early	High	MOP 506 x JA 16	1.71^{*}	6.6
		IC 19 x MOP 3	1.68^{*}	6.1
		NOP 1 x IC 42	1.67^{*}	6.7
		IC 88 x JA 16	1.40^{*}	5.3
		SE (Sij-Skl)	0.95	
Early	Low	MOP 539 x JA 16	2.00^{*}	7.0
		MOP 506 x IC 42	1.84^{*}	7.1
		MOP 503 x MOP 3	1.69^{*}	6.7
		UO 285 x JA 16	1.62^{*}	5.4
		Ranzatak x IC 30	1.56^{*}	4.7
		SE (Sij-Skl)	1.11	
Late	High	MOP 506 x IC 30	1.18^{**}	4.8
		IC 3 x IC 30	0.97^{**}	4.8
		UO 285 x IC 42	0.86^{*}	4.5
		NOP 4 x MOP 3	0.78^{*}	5.0
		NOP 1 x IC 42	0.76^{*}	4.5
		SE (Sij-Skl)	0.53	
Late	Low	IC 7 x MOP 3	1.21^{**}	4.1
		MOP 379 x IC 30	0.98^{**}	3.8
		MOP 409 x IX 30	0.96^{**}	3.3
		IC 19 x JA 16	0.70^{*}	2.8
		Posta 91 x JA 16	0.63^{*}	3.4
		SE (Sij-Skl)	0.46	
		Husk yield/plant, g		
Early	High	IC 19 x MOP 3	2.14^{**}	7.3
		IC 128 x IC 42	1.82^{*}	8.2
		MOP 379 x IC 30	1.69^{*}	7.4
		MOP 506 x JA 16	1.48^{*}	7.1
		UO 177-2x JA 16	1.43^{*}	6.3
		SE (Sij-Skl)	1.02	
Early	Low	MOP 506 x IC 42	1.74^{**}	6.2
		NOP 4 x JA 16	1.66^{*}	6.2
		MOP 539 x JA 16	1.44^{*}	5.9
		SE (Sij-Skl)	0.94	
Late	High	MOP 506 x IC 30	1.31^{**}	5.0
		MOP 278 x MOP 3	1.18^{**}	5.6
		Ranzatak x IC 42	1.30^{**}	5.3
		IC 88 x JA 16	0.95^{*}	3.7
		Posta 91 x MOP 3	0.95^{*}	5.3
		SE (Sij-Skl)	0.62	
Late	Low	MOP 187 x IC 30	1.31^{**}	4.1
		IC 7 x MOP 3	1.17^{*}	3.7
		MOP 506 x IC 42	0.90^{*}	4.2
		IC 111 x MOP 3	0.72^{*}	3.5
		SE (Sij-Skl)	0.51	
		Plant height, cm		
Early	Low	MOP 506 x MOP 3	-7.89^{*}	77.8
		IC 128 x JA 16	-5.84^{*}	83.0
		IC 88 x IC 42	-5.27^{*}	94.9
		SE (Sij-Skl)	3.75	
Late	Low	MOP 507 x JA 16	-9.93^{**}	56.4
		MOP 379 x IC 30	-7.88^{*}	55.2
		IC 1 x IC 42	-7.54^{*}	66.7
		MOP 506 x IC 30	-6.81^{*}	63.9
		SE (Sij-Skl)	4.58	
		Stem diameter, cm		
Late	High	IC 3 x MOP 3	0.13^{**}	0.97
		Posta 91 x JA 16	0.07^{**}	0.80
		MOP 506 x IC 30	0.06^{*}	0.91
		SE (Sij-Skl)	0.04	
		Leaf area index, cm^2		
Early	High	IC 3 x MOP 3	3.90^{**}	11.98
		NOP 1 x IC 42	3.62^{**}	10.29
		UO 285 x IC 42	2.17^{*}	8.49
		IC 128 x IC 42	2.12^{*}	9.55
		SE (Sij-Skl)	1.52	
Early	Low	IC 90 x IC 42	3.42^{**}	11.38
		NBPGR 3 x MOP 3	2.91^{*}	9.19
		IC 19 x MOP 3	2.62^{*}	8.60
		SE (Sij-Skl)	1.83	

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

A comparison of parents on the basis of mean performance and general combining ability effects (Table 1) revealed that IC 7 was superior to the remaining parents in the seed yield, stem diameter and leaf area index due to its high gca and high mean performance value but this concept was not true for other entries. The variety Posta 91 gave higher per se performance but had relatively low combining ability for grain yield. The performance of the parents and their gca effects varied in different environments which may be attributed to genotype x environment interaction.

Eighteen crosses for seed yield, 16 for husk yield, 7 for plant height, 7 for leaf area index, and 3 for stem diameter (Table 2) revealed significant desired sca effects for these traits in different environments. Among the crosses, NOP 1 x IC 42, IC 19 x MOP 3 and UO 285 x IC 42 were the best specific combinations for seed yield and leaf area index. The crosses MOP 379 x IC 30, MOP 506 x IC 30, MOP 539 x JA 16 and IC 7 x MOP 3 gave significant sca effects of desirable kind for seed and husk yield along with other yield components. For seed yield, only the cross NOP 1 x IC 42 involving both low x low gca parents had significant sca effects in more than one environment combined with high seed yield. Therefore, this cross should be utilised extensively for increasing seed yield. The crosses showing high sca effects for seed yield also involved high gca parents for seed yield and other characters.

In the present investigation, both additive and nonadditive types of gene action are involved in controlling seed yield and other related traits. Thus, biparental mating in selected F_2 on the basis of gca and sca effects and further selections in segregating generation or recurrent selection will be effective in breeding for high seed yield.

REFERENCES

1. J. S. Chawala. 1978. Poppy straw a new source of fibre boards. Indian Pulp and Paper, **32**: 3–4.

2. O. Kempthorne. 1957. An Introduction to Genetical Statistics. John Willey and Sons, New York: 458–471.

3. H. C. Saini and U. S. Kaicker. 1983. Combining ability in opium poppy. Indian J. Genet., **43**: 252–256.

4. K. R. Khanna and Sudhir Shukla. 1989. Gene action in opium poppy (*Papaver somniferum* L.). Indian J. agric. Sci., **59**: 124–126.

5. K. B. Nigam, S. P. Singh and V. S. Kandalkar. 1985. Genetical studies in *Papaver somniferum* L. Seed yield and its components. Abstr. V Intern. Symp. Medicinal, Aromatic and Spices Plants. Mangpoo, Darjeeling: 16.