*Indian J. Genet.*, 53 (1): 34–39 (1993)

# COMBINING ABILITY FOR PHYSIOLOGICAL CHARACTERS AND OPIUM YIELD IN OPIUM POPPY (*PAPAVER SOMNIFERUM* L.)

V. S. KANDALKAR AND K. B. NIGAM

*Kailash Nath Katju College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus, Mandsaur, Madhya Pradesh 458001*

**(Received: January 31, 1992; accepted: March 23, 1992)**

## ABSTRACT

**The combining ability analysis was worked out in $F_1$ and $F_2$ generations of 8 x 8 parents half diallel for physiological characters and opium yield in opium poppy. Results revealed that both additive and nonadditive genetic components of variance governed the expression of opium yield and physiological characters studied, former being predominant in both the generations. Among the varieties, MOP 539 for opium yield, harvest index, days to 50% flowering, leaf area and leaf area index and MOP 507 for opium yield, biological yield, NBPGR 1 for opium yield and early flowering and NOP 4 for harvest index appeared to be good general combiners. They can be used as donors in future breeding for high opium yield with efficient harvest index. In respect of specific combining ability, crosses MOP 539 x NOP 4, NBPGR 1 x NBRI 3, and NOP 4 x UO 185 showed best cross combinations for opium yield with harvest index.**

**Key words:** Opium poppy, combining ability.

Improvement of plant type is basically a function of genetic manipulation to improve harvest index. The importance of favorable harvest index in terms of partitioning of photosynthate to the economically useful part of the plant has been well recognised. In improvement of plant type, harvest index appears to be more reliable selection criterion for high yield. No work on combining ability for harvest index in opium poppy by taking opium yield as a economic product, has yet been undertaken. Therefore, attempt has been made for identifying varieties with respect to their combining ability characteristics for physiological characters and opium yield in $F_1$ and $F_2$ generations of opium poppy to orient the breeding programme for developing efficient plant types for high yielding varieties or hybrids.

## MATERIALS AND METHODS

The material comprised eight promising diverse genotypes developed in all India Co-ordinated Research Project on Medicinal and Aromatic Plants at different centres (MOP 539, MOP 507 and MOP 278 from Madhya Pradesh, IC 128 from National Germplasm, NBPGR 1 from National Bureau of Plant Genetic Resources, New Delhi, NBRI 3 and NOP 4 from Uttar Pradesh, and UO 185 from Rajasthan). The $F_1$ and $F_2$ progenies of 8 x 8 diallel set excluding reciprocals along with parents were raised in randomised block design with two replications during rabi 1989. Plants in two-row plots of the parents and $F_1$s and four-row plots of $F_2$s were spaced at 30 cm between rows and 8-10 cm within rows. The observations were recorded on five random plants in parents and $F_1$s and 40 plants in $F_2$s for physiological traits (leaf area, leaf area index, biological yield and harvest index) and for number of effective lancing/plant, days to 50% flowering and opium yield. Harvest index was calculated as the ratio of opium yield to biological yield. The combining ability analysis was done according to Griffing Method 2 and Model 1 [1].

## RESULTS AND DISCUSSION

The analysis of variance for combining ability (Table 1) revealed that general combining ability (gca) were significant for all the characters in both the generations except leaf area index in $F_1$ generation, indicating the presence of additive gene effects for all the characters studied in the present material. Specific combining ability (sca) effects were highly significant for all the characters in $F_1$ generation except number of effective lancing/plant, whereas it was significant only for days to 50% flowering, harvest index, and opium yield

**Table 1. Combining ability analysis (mean squares) for physiological characters in $F_1$ and $F_2$ generations of opium poppy**

| Source | d.f. | Days to flowering | Leaf area | Leaf area index | Biological yield/plant | No. of effective lancing/plant | Harvest index | Opium yield per plant |
|---|---|---|---|---|---|---|---|---|
| **$F_1$ generation** | | | | | | | | |
| Gca | 7 | 3.47** | 307.2* | 0.94 | 8.65* | 0.129** | 1.64** | 0.0016** |
| Sca | 28 | 2.25** | 309.7* | 3.30** | 14.06** | 0.075 | 0.19** | 0.0047** |
| **$F_2$ generation** | | | | | | | | |
| Gca | 7 | 4.91** | 379.8* | 1.21* | 9.92* | 0.129* | 0.13* | 0.0023** |
| Sca | 28 | 0.93** | 156.3 | 0.59 | 5.23 | 0.085 | 0.1s* | 0.0017** |
| Error | 63 | 0.43 | 140.5 | 0.47 | 3.52 | 0.056 | 0.06 | 0.0004 |

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

in $F_2$ generations. Significant sca variance indicated the importance of nonadditive gene effects in $F_1$ generation for all the characters, except for effective lancing/plant and in both the generations for days to 50% flowering, harvest index and opium yield. The data also revealed that gca estimates were relatively higher than sca for days to 50% flowering, effective lancing/plant and harvest index in both generations, and for other characters in $F_2$ generation, which suggested predominance of additive gene action controlling all the characters. Further, it was observed that variance due to gca increased in $F_2$ generation, whereas sca variance decreased considerably for all the characters studied, indicating that the genetic variability in the present material may be associated with general combining ability variance in both the generations. Additive gene action for different characters was also reported earlier [2, 3] in opium poppy and for harvest index in sorghum [4].

In the present study, the magnitude of additive variance for all the characters were relatively high and thus it suggest that per se performance of the parent may be a good indication of their general combining ability, although it is not always so. Significant gca effects revealed that MOP 539 in both the generations, IC 128 in $F_1$ and MOP 507, MOP 278 in $F_2$ generation were identified as good general combiners for early flowering (Table 2). MOP 539 was identified as good general combiner for leaf area and leaf area index in $F_2$ generation. IC 128 in $F_1$ generation showed good general combiner for leaf area index and biological yield. MOP 507 recorded to be good general combiner for biological yield in both generations. UO 185 and MOP 507 showed good general combiners for number of effective lancing/plant in $F_1$ and $F_2$ generations, respectively. In respect of harvest index, MOP 539

**Table 2. General combining ability (gca) effects and mean performance (m)**

| Parent | Days to flowering | | | Leaf area | | | Leaf area index | | |
|---|---|---|---|---|---|---|---|---|---|
| | gca | | m | gca | | m | gca | | m |
| | $F_1$ | $F_2$ | | $F_1$ | $F_2$ | | $F_1$ | $F_2$ | |
| MOP 539 | -1.037** | -1.137** | 94.5 | 4.44 | 13.06** | 95.5 | 0.005 | 0.648** | 3.56 |
| MOP 507 | 0.112 | -0.587** | 96.0 | -1.04 | 3.30 | 75.7 | -0.347 | 0.151 | 3.15 |
| MOP 278 | 0.012 | -0.437** | 95.5 | -1.16 | -3.87 | 62.5 | 0.017 | -0.299 | 2.55 |
| IC 128 | -0.875** | 0.062 | 97.0 | 4.52 | -0.90 | 70.1 | 0.439* | 0.190 | 2.99 |
| NBPGR 1 | -0.387* | 0.031 | 97.5 | 1.72 | -4.01 | 62.8 | 0.255 | -0.409* | 2.45 |
| NBRI 3 | 0.162 | 0.062 | 96.5 | -7.57* | -1.38 | 49.6 | -0.472* | 0.059 | 2.04 |
| NOP 4 | 0.162 | 0.762** | 98.5 | 4.10 | 0.85 | 81.8 | -0.108 | -0.011 | 3.35 |
| UO 185 | 1.062** | 0.962** | 99.5 | -5.01 | -7.04 | 57.8 | 0.213 | -0.330 | 2.78 |
| SE ($g_{ii}$) | 0.194 | | | 3.506 | | | 0.203 | | |

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

and NOP 4 showed good general combiners over both the generations. MOP 278 also recorded good general combiner for harvest index in $F_1$ generation. MOP 507 and NBPGR 1 in $F_1$ generation and MOP 539 in $F_2$ generation were identified as good general combiners for opium yield. In few parents like MOP 539 for opium yield, harvest index, leaf area index, leaf area and days to 50% flowering, MOP 507 for opium yield, biological yield and days to 50% flowering, high performance was associated with favourable gca effects for number of characters. But rest of the parents did not show such relationship, thus selection of the parents for their good general combining ability cannot be based on their performance alone. Both gca and per se performance criteria should be considered while selecting the parent for future breeding. MOP 539 and MOP 507 were good general combiners for opium yield and other physiological characters, which means that these parents transmitted additive genes for yield and components characters in their progeny. Inconsistent results of gca effects over generations could possibly be attributed to genotype x environment interaction effects and also due to the role of nonadditive gene effects. The intermating population involving parents showing good general combiners for these traits and simultaneously subjected to mass or biparental mating in early generation will offer maximum promise in breeding for high yield through building efficient plant type.

Specific combining ability effects (sca) presented in Table 3 revealed that out of 28 crosses only eight crosses in $F_1$ generation and seven crosses in $F_2$ were significant for sca effects for high opium yield. Among these, the crosses MOP 539 x NOP 4, NBPGR 1 x NBRI 3, and NOP 4 x UO 185 showed consistant sca performance in both generations, which could

**for physiological characters in $F_1$ and $F_2$ generations of opium poppy**

| Biological yield per plant | | | No. of effective lancing/ | | | Harvest index | | | Opium yield/plant | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| gca | | m | plant (gca) | | m | gca | | m | gca | | m |
| $F_1$ | $F_2$ | | $F_1$ | $F_2$ | | $F_1$ | $F_2$ | | $F_1$ | $F_2$ | |
| -0.602 | 0.917* | 17.0 | -0.175* | -0.030 | 1.9 | 0.197** | 0.196** | 5.78 | -0.0032 | 0.026** | 0.291 |
| 1.677** | 1.097* | 19.6 | 0.135 | 0.200** | 2.1 | -0.0567 | -0.109* | 4.44 | 0.0235** | 0.006 | 0.236 |
| -0.392 | 0.697 | 13.4 | 0.055 | -0.030 | 2.2 | 0.111* | -0.062 | 5.55 | -0.0058 | 0.004 | 0.215 |
| 1.237* | 0.317 | 13.9 | 0.005 | -0.130 | 2.0 | -0.066 | -0.005 | 5.39 | 0.0078 | 0.004 | 0.239 |
| -0.292 | -0.512 | 11.4 | -0.105 | -0.070 | 1.6 | -1.118* | -0.035 | 5.10 | 0.0215** | -0.012 | 0.184 |
| -0.182 | -0.297 | 12.9 | -0.015 | 0.080 | 2.0 | 0.016 | -0.049 | 5.03 | -0.0007 | 0.002 | 0.211 |
| -0.842 | -1.422** | 8.3 | -0.055 | -0.090 | 1.5 | 0.243** | 0.162** | 5.52 | 0.0017 | 0.005 | 0.157 |
| -0.602 | -1.392* | 11.1 | 0.155* | -0.070 | 2.1 | -0.327** | -0.096 | 5.37 | -0.0019 | -0.026** | 0.161 |
| 0.555 | | | 0.070 | | | 0.048 | | | 0.006 | | |

**Table 3. Crosses showing significant specific combining ability effects for high opium yield along with other characters in opium poppy**

| Cross | Days to flowering | | Leaf area | | Leaf area index | Biological yield/ plant | Harvest index | | Opium yield per plant | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $F_1$ | $F_2$ | $F_1$ | $F_2$ | $F_1$ | $F_1$ | $F_1$ | $F_2$ | $F_1$ | $F_2$ |
| MOP 539 x MOP 507 | -1.45** | 0.88 | -5.15 | 6.30 | -1.456* | 0.773 | 0.393** | 0.285 | 0.004 | 0.203** |
| MOP 539 x MOP 278 | -1.35** | 0.73 | -9.93 | 6.28 | -0.551 | -1.952 | 0.455** | 0.068 | 0.043** | 0.022 |
| MOP 539 x IC 128 | -0.25 | 1.23* | -6.52 | -4.99 | 1.437* | -3.482 | -0.235 | -0.049 | 0.001 | 0.049** |
| MOP 539 x NBRI 3 | -0.50 | -0.27 | -10.02 | -6.51 | -0.742 | -1.866 | -0.389** | -0.015 | 0.135** | 0.018 |
| MOP 539 x NOP 4 | -0.50 | -1.47** | -15.40 | -10.95 | 0.954 | 1.298 | 0.617** | 0.473** | 0.064** | 0.048** |
| MOP 507 x IC 128 | 1.60* | -0.12 | 5.39 | -14.23 | 0.419 | -1.862 | 0.184 | 0.387** | 0.012** | -0.024 |
| MOP 278 x NBPGR 1 | 0.50 | -0.22 | -1.81 | -3.04 | 0.189 | -0.362 | 0.340* | -0.179 | -0.006 | 0.045** |
| MOP 278 x NOP 4 | 0.45 | 0.33 | 41.41** | 1.29 | 3.512* | 6.488* | -0.411** | -0.218 | 0.057** | -0.007 |
| MOP 128 x NOP 4 | -1.45* | 0.33 | 1.72 | 9.22 | -0.930 | 7.558** | 0.044 | -0.125 | -0.069** | 0.077** |
| NBPGR 1 x NBRI 3 | -1.15 | -0.72 | 22.00* | 24.25* | 1.348* | 3.028 | -0.364** | 0.347** | 0.095** | 0.062** |
| NBRI 3 x NOP 4 | -0.20 | 1.33** | 2.92 | -18.70 | 0.831 | 1.848 | 0.195 | 0.119 | 0.157** | -0.026 |
| NOP 4 x UO 18 5 | -0.60 | 0.43 | -24.64* | 1.16 | -1.704 | -0.102 | 0.167 | 0.146 | 0.078** | 0.098** |
| SE ($S_{ij}$) | 0.59 | | 10.75 | | 0.625 | 1.6887 | 0.147 | | 0.018 | |

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

be considered as good specific cross combinations for opium yield. The inconsistency in sca effects observed over generations is attributed to dominance x dominance interaction and genotypes x environment interaction. In respect of harvest index, six crosses in each generation recorded significant sca effects in desirable direction. However, only the crosses MOP 539 x NOP 4 and NBPGR 1 x NBRI 3 exhibited consistant desirable significant sca effect, indicating good specific cross combinations for harvest index. The crosses IC 128 x UO 185 for early flowering and NBPGR 1 x NBRI 3 for leaf area showed desirable specific combiners in both the generations. The crosses MOP 539 x IC 128, MOP 539 x NBPGR 1, MOP 507 x UO 185, MOP 278 x NOP 4, MOP 278 x UO 185, IC 128 x NBPGR 1, NBPGR 1 x NBRI 3 for leaf area, MOP 507 x UO 185, MOP 278 x NOP 4, IC 128 x NBRI 3 and IC 128 x NOP 4 for biological yield were identified good specific cross combinations. The crosses MOP 539 x NOP 4 and NBPGR 1 x NBRI 3 were identified as good specific combinations for both opium yield and harvest index. The parents and crosses showing favourable gca and sca effects for opium yield also showed significant favourable gca and sca effects, respectively, for physiological and other component characters in one or both generations. This indicates that both combining ability effects for opium yield may be attributed to component characters.

In the present material, additive and nonadditive components of genetic variation considerably contributed for the expression of all the physiological characters and opium yield, the former being predominant. This suggests that choice of parents for developing high yielding varieties could be based on gca effects, while for exploitation of heterosis, breeding should be based on their sca test. Biparental intermating of the selected plants in early segregating generations of crosses involving high sca effects and high per se performance for opium yield and component characters would effectively exploit both additive and fixable epistasis effects and would be most desirable.

## REFERENCES

1. B. Griffing. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., **9**: 463–493.

2. H. C. Saini and U. S. Kaicker. 1982. Combining ability analysis for opium yield in opium poppy (*Papaver somniferum* L.). South Indian Hort., **30**: 32–36.

3. U. S. Kaicker and B. Choudhary. 1982. Heterosis and combining ability in opium poppy. Herba Hung., **21**: 59–70.

4. Swarnlata and B. S. Rana. 1988. Combining ability for biological yield and harvest index in sorghum. Indian J. Genet., **44**: 243–247.