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# Combining ability and heterosis for latex yield, seed yield and other agronomic traits in opium poppy (*Papaver somniferum* L.)

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## Abstract

**Twentyone hybrids alongwith seven parents and two checks *viz.*, Chetak Aphim and IC-42 were evaluated for combining ability and standard heterosis for latex yield/plant, seed yield/plant, husk yield, stem diameter, number of effective capsules/plant, plant height, peduncle length, days to flower initiation and days to 50% flowering. Both additive and non-additive gene effects were present in the material under study. However, the ratio of additive and non-additive genetic variance revealed that there was preponderance of non-additives gene action in the expression of all the traits under study. Among the parents, the UOP-82 was identified as good general combiner for latex yield/ plant, seed yield/plant, husk yield/plant, plant height and peduncle length. The hybrid UOP-82 x NOP-204 exhibited highest magnitude of positive significant *sca* effects with highest standard heterosis and *per se* performance for latex yield/plant. This hybrid also exhibited positive significant *sca* effects for stem diameter, number of effective capsules/plant and peduncle length. In general, close association between *sca* effects and standard heterosis was observed among the best hybrids identified on the basis of *sca* effects for latex yield.**

**Key words:** Combining ability, standard heterosis, diallel analysis, opium poppy, latex, seed yield

## Introduction

Opium poppy (*Papaver somniferum* L.) is a most important medicinal plants and chief source of opium latex. It contains about 41 alkaloids including morphine, codine, thebanine, papaverine and narkotine as major alkaloids [1]. The morphine is the most important alkaloid among major alkaloids of economic value found in the latex. Its seeds are also of very nutritive value besides containing high percentage of unsaturated fatty acids [2]. In India, very less emphasis was given for exploitation of heterosis for latex yield, seed yield and other agronomic traits in opium poppy. The present investigation aims is, therefore, aims at identification of superior parents and hybrids possessing high specific combining ability effects alongwith high heterotic response for latex yield, seed yield and its contributing traits.

## Materials and methods

Seven genetically diverse lines of opium poppy (*P. somniferum* L.) *viz.*, UOP-31, UOP-1585, UOP-17, UOP-82, UOP-39, NOP-204 and Chetak Aphim-2 were crossed in diallel mating design excluding reciprocals during rabi 2004-05 to produce 21 experimental hybrids for this study. The 21 $F_1$s, 7 parents alongwith two standard checks *viz.*, Chetak Aphim and IC-42 were grown in rabi 2005-06 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur (Raj.) India. Udaipur is situated on a latitude of 24°-35' North and longitude of 37°-42' East and at an elevation of 582.17 meters above mean sea level. The experiment was laid out in a randomized block design with two replications on a alfisols soil with a texture of clay loam pH 8.1 and organic matter content of 0.7%. There was no rainfall during the growing season and the average minimum and maximum temperatures were 5.8° and 34.2°C, respectively while average minimum and maximum relative humidity were 17.0% and 91.0% respectively. Each plot comprised single row of three meter length. The row to row and plant to plant distance was maintained at 30 cm and 10 .cm respectively. Fertilizers were applied at the rate of 120 kg N and 60

kg $P_2O_5$/ha as per the recommended agronomical practices. The total amount of $P_2O_5$ and half doses of nitrogenous fertilizer was applied as basal dose and rest of the nitrogenous fertilizer was applied in two equal doses 40 days after sowing and before flower initiation of the crop. Weeds were removed whenever they appeared. The plant protection operations were carried out as per recommended agronomical practices to raise a healthy crop. The observations were recorded on latex yield/plant (g), seed yield/plant (g), husk yield/plant (g), stem diameter (mm), number of effective capsules/plant (g), plant height (cm), peduncle length (cm) on fine randomly selected competitive plants of each genotype and each replication. The observations for days to flower initiation and days to 50% flowering were recorded on plot basis. Combining ability analysis were carried out as per procedure given by Griffing method 2 Model I [3], and standard heterosis was calculated as per standard procedure [4].

## Results and discussion

The analysis of variance revealed presence of significant amount of variability among the genotypes, parents and hybrids for all the traits. The analysis of variance for combining ability revealed presence of significant mean squares due to *gca* and *sca* for all the traits under study (Table 2), thereby suggesting that both additive and non-additive gene effects were important for the expression of these traits. However, the ratio of additive and non-additive variance showed that the non-additive gene action played great role in the inheritance of all traits under study (Table 2). Similar results were also reported by earlier workers [5-9].

The estimate of *gca* indicated that the parent UOP-82 was good general combiner for latex yield/plant, seed yield/plant, husk yield/plant, plant height and peduncle length while parent UOP-39 was good general combiner for seed yield/plant, latex yield/plant, husk yield/plant, stem diameter and plant height. The parent Chetak Aphim-2 was good general combiner for all the traits except plant height and peduncle length (Table 3).

A perusal of first five best hybrids on the basis of *sca* effects in relation to standard heterosis for latex yield/plant revealed that hybrid UOP-82 x NOP-204 exhibited highest magnitude of positive significant *sca* effect for latex yield/plant alongwith highest magnitude of standard heterosis for latex yield/plant against the Chetak Aphim. This hybrid also exhibited positive significant *sca* effect for stem diameter, number of effective capsules/plant and peduncle length alongwith highest *per se* performance for latex yield/plant (Table 4). It was in fact a cross of good x poor *gca* effect parents for latex yield/plant. Good x good *gca* effect hybrid UOP-1585 x Chetak Aphim-2 showed positive significant *sca* effects for latex yield/plant, stem diameter, number of effective capsules/plant, peduncle length, days to flower initiation and days to 50% flowering with higher estimate of standard heterosis for latex yield/plant and number of effective capsules/plant and good *per se* performance for all the traits. Another important hybrid UOP-17 x UOP-39 exhibited significant and positive *sca* effects for all the traits. It also exhibited significant standard heterosis for latex yield/plant, stem diameter and number of effective capsules/plant. It was a cross of poor x good *gca* effect parents for latex yield/plant (Table 4).

The hybrid UOP-1585 x UOP-39 exhibited positive significant *sca* effects for latex yield/plant and peduncle length but highest and positive significant *sca* effects for seed yield and husk yield/plant. This hybrid also

**Table 1.** Analysis of variance for nine characters in a 7 x 7 diallel cross of opium poppy

| Source | d.f. | Latex yield | Seed yield | Husk yield | Stem diameter | No. of effective capsule/plant | Plant height | Peduncle length | Days to flower initiation | Days to 50% flowering |
|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 1 | 0.000 | 0.039 | 0.056 | 0.600** | 0.003 | 1.080 | 3.863** | 0.893 | 1.750 |
| Genotypes | 27 | 0.117** | 12.722** | 12.894** | 6.564** | 1.478** | 60.133** | 5.181** | 10.759** | 10.838** |
| Parents (P) | 6 | 0.030* | 9.622** | 11.149** | 7.931** | 0.098* | 50.814** | 8.225** | 13.238** | 12.952** |
| Hybrids ($F_1$) | 20 | 0.143** | 13.140** | 13.133** | 5.558** | 1.804** | 37.131** | 4.226** | 10.100** | 10.245** |
| P v/s $F_1$ | 1 | 0.134** | 22.955** | 18.567** | 18.467** | 3.231** | 576.091** | 6.019** | 9.054** | 10.006 |
| Error | 27 | 0.005 | 0.749 | 0.792 | 0.036 | 0.019 | 1.569 | 0.294 | 0.298 | 0.356 |

*,**Significant at 5% and 1% level of significance, respectively

**Table 2.** Analysis of variance for combining ability in 7 x 7 diallel set of opium poppy for nine characters

| Source | d.f. | Latex yield | Seed yield | Husk yield | Stem diameter | No. of effective capsule/plant | Plant height | Peduncle length | Days to flower initiation | Days to 50% flowering |
|---|---|---|---|---|---|---|---|---|---|---|
| *gca* | 6 | 0.037** | 3.111** | 2.953** | 4.234** | 0.494** | 28.608** | 5.772** | 9.534** | 8.602** |
| *sca* | 21 | 0.064** | 7.289** | 7.445** | 3.009** | 0.809** | 30.483** | 1.681** | 4.192** | 4.509** |
| Error | 27 | 0.003 | 0.374 | 0.396 | 0.0181 | 0.009 | 0.785 | 0.149 | 0.149 | 0.178 |
| $s^2$ *gca* | | 0.023 | 1.825 | 1.704 | 2.811 | 0.323 | 18.549 | 3.749 | 6.257 | 5.616 |
| $s^2$ *sca* | | 1.307 | 145.22 | 148.03 | 62.825 | 16.784 | 623.67 | 32.174 | 84.903 | 90.958 |
| $s^2$ *gca*/$s^2$ *sca* | | 0.0177 | 0.0125 | 0.0115 | 0.0441 | 0.0192 | 0.0297 | 0.1165 | 0.0737 | 0.0617 |

*,** Significant at 5% and 1% level of significance, respectively

exhibited highest positive significant standard heterosis for seed yield/plant and husk yield/plant alongwith highest *per se* performance for seed yield/plant, husk yield/plant and peduncle length. This hybrid, however, did not exhibit standard heterosis for latex yield/plant and other traits. It was cross of good x good, poor x good and poor x good *gca* effect parents for latex yield, seed yield and husk yield/plant, respectively (Tables 3 and 4).

In general, parental lines and all the hybrids possessed good *per se* performance for latex yield/plant and other traits. It is apparent that the good x poor, good x good and poor x good general combiners depicted high *sca* effect. The parental lines in this study were having diverse genetic background of their source populations, and hence their hybrids exhibited high *sca* effects alongwith high standard heterosis for latex yield/plant.

**Table 3.** Estimates of *gca* effects and *per se* performance of seven parents for nine characters in a 7 x 7 diallel cross of opium poppy

| Parents | | Latex yield (g/p) | Seed yield (g/p) | Husk yield (g/p) | Stem diameter (mm) | No. of effective capsule/plant | Plant height (cm) | Peduncle length (cm) | Days to flower initiation | Days to 50% flowering |
|---|---|---|---|---|---|---|---|---|---|---|
| UOP-31 | *gca* | -0.08* | 0.34** | 0.15** | -0.36* | -0.26* | -0.40* | 0.81** | -1.87* | -1.94* |
| | P | 0.36 | 5.25 | 4.35 | 8.50 | 1.90 | 88.10 | 25.70 | 80.00 | 84.50 |
| UOP-1585 | *gca* | 0.02** | -0.13* | -0.09* | -0.79* | 0.10** | 0.45** | 1.25** | 0.74** | 0.67** |
| | P | 0.38 | 4.58 | 4.65 | 7.05 | 1.90 | 93.60 | 27.35 | 84.50 | 89.50 |
| UOP-17 | *gca* | -0001* | -0.37* | -0.34* | -0.11* | 0.33** | 1.02** | -0.72* | 1.18** | 0.78** |
| | P | 0.43 | 7.11 | 7.11 | 9.75 | 1.70 | 99.45 | 23.40 | 84.00 | 87.50 |
| UOP-82 | *gca* | 0.11** | 0.40** | 0.44** | -0.51* | -0.28* | 0.80** | 0.31** | -0.15* | -0.11* |
| | P | 0.65 | 8.75 | 9.00 | 9.40 | 1.50 | 100.40 | 23.95 | 85.50 | 90.50 |
| UOP-39 | *gca* | 0.02** | 0.76** | 0.80** | 0.11* | -0.46* | 1.57** | -0.38* | -0.71* | -0.50* |
| | P | 0.37 | 9.28 | 9.35 | 10.60 | 1.50 | 96.30 | 23.10 | 79.50 | 85.50 |
| NOP-204 | *gca* | -0.07* | -1.03* | -1.00* | 0.86** | 0.12** | 0.37** | -0.81* | 0.24** | 0.44** |
| | P | 0.26 | 6.61 | 6.65 | 13.20 | 1.30 | 93.70 | 21.70 | 85.00 | 90.50 |
| Chetak | *gca* | 0.01** | 0.04** | 0.04** | 1.02** | 0.15** | -3.80* | -0.47* | 0.57** | 0.67** |
| Aphim-2 | P | 0.32 | 10.61 | 10.50 | 11.35 | 1.60 | 87.55 | 21.95 | 85.50 | 90.50 |

*,**Significant at 5% and 1% level of significance, respectively and P = *per se* performance

**Table 4.** Estimates of *sca* effects for latex yield and other agronomic traits sowing the highest *sca* effects for latex yield with standard heterosis and *per se* performance in opium poppy

| Hybrids | | Latex yield (g/p) | Seed yield (g/p) | Husk yield (g/p) | Stem diameter (mm) | No. of effective capsule/plant | Plant height (cm) | Peduncle length (cm) | Days to flower initiation | Days to 50% flowering |
|---|---|---|---|---|---|---|---|---|---|---|
| UOP-82 x MOP-204 | *sca* | 0.58** | -0.57** | -0.57** | 0.67** | 1.52** | -5.92** | 2.44** | -2.82** | -2.96** |
| | EH | 37.50** | - | - | - | 16.00** | –2.50 | - | - | - |
| | P | 1.10 | 5.15 | 5.15 | 12.00 | 2.90 | 83.85 | 23.25 | 80.00 | 85.00 |
| UOP-1585xC.A.-2 | *sca* | 0.53** | -0.65** | -0.63** | 1.40** | -0.50** | -3.65** | 2.65** | 1.46** | 1.54** |
| | EH | 30.60** | - | - | - | 52.00** | - | - | - | - |
| | P | 1.04 | 5.61 | 5.70 | 12.60 | 3.80 | 87.90 | 23.60 | 85.50 | 90.50 |
| UOP-17xUOP-39 | *sca* | 0.33** | 0.87** | 0.85** | 3.20** | 1.48** | 5.81** | 1.24** | 0.29** | 0.10** |
| | EH | 2.50** | - | - | 1.82** | 48.00** | - | - | - | - |
| | P | 0.82 | 7.61 | 7.70 | 13.95 | 3.70 | 97.00 | 23.45 | 83.50 | 88.00 |
| UOP-82 x CA-2 | *sca* | 0.31** | 0.49** | 0.44** | -1.18** | -0.02** | -0.85** | 0.09 | -2.65** | -2.68** |
| | EH | 13.75** | - | - | - | - | -1.45** | - | - | - |
| | P | 0.91 | 7.28 | 7.30 | 10.30 | 1.90 | 84.75 | 23.25 | 80.50 | 85.50 |
| UOP-1585xUOP-39 | *sca* | 0.24** | 4.78** | 4.75** | -0.22** | -0.49** | -2.77** | 1.56** | -1.26** | -2.29** |
| | EH | - | 34.34** | 33.15** | - | - | - | - | - | - |
| | P | 0.76 | 11.75 | 11.85 | 9.85 | 1.50 | 87.85 | 25.75 | 81.50 | 85.50 |
| **Checks** | | | | | | | | | | |
| Chetak Aphim | P | P0.80 | 8.75 | 8.90 | 13.70 | 2.50 | 86.0 | 21.75 | 82.5 | 87.5 |
| IC-42 | P | P0.76 | 7.65 | 7.75 | 12.15 | 2.30 | 88.0 | 23.45 | 79.5 | 84.5 |

*,**Significant at 5% and 1% level of significance, respectively; EH = Standard heterosis; P = *per se* performance

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