International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 2950-2956

Received: 14-03-2018
Accepted: 16-04-2018

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# Diallel analysis for combining ability studies in castor (*Ricinus communis* L.)

**Jayesh J Patel, DA Patel, Hitiksha K Parmar, Azadchandra S Damor and Dixita K Patel**

**Abstract**
The present experiment was conducted with forty-five $F_{1s}$ developed through diallel mating design excluding reciprocals along with ten parents and a check in RBD with three replications. Mean sum of squares for general combining ability found significant for all the characters except days to maturity, 100 seed weight and shelling out turn. Whereas, for specific combining ability, it was significant for all the characters except 100 seed weight, shelling out turn and oil content, indicating the importance of both additive and non- additive gene actions in the inheritance of these traits. The magnitude of combining ability variance revealed prime role of additive genetic variance for inheritance of plant height up to primary raceme, number of nodes up to primary raceme and oil content. Whereas, non-additive gene action was preponderant for days to 50% flowering, days to maturity, total length of primary raceme, effective length of primary raceme, number of capsules on primary raceme, number of effective racemes per plant, total seed weight of primary raceme and seed yield per plant. Among the parents, SKI-324 was found good general combiner for seed yield per plant and some of its component traits and hence this parents would be of immense value for development of high yielding inbred line. Parents, SH-1 and JI-358 were found good general combiners for earliness. The estimates of sca effect revealed that cross SKI-324 x VH-63-1-3, JI-358 x SKI-324 and SH-42 x PCS-124 were found promising cross combinations for development of high yielding variety.

**Keywords:** General combining ability, Specific combining ability, castor seed yield

## Introduction
Castor (*Ricinus communis* L., 2n = 2x = 20) is an industrially important non-edible oilseed crop widely cultivated in the arid and semi-arid regions of the world. Castor belongs to monospecific genus *Ricinus* of *Euphorbiaceae* family. Its monoecious nature favours cross-pollination and it is up to the extent of 50 percent. The choice of suitable parents for evolving better hybrids is aalways matter of concern to the plant breeders. For these purpose, the combining ability is a powerful tool to discriminate good as well as poor combiners for choosing appropriate parental materials for a particular character in the plant breeding programme (Lyngdoh *et al*., 2011) [5]. At the same time, it also provides information about the nature of gene action involved in the inheritance of seed yield and its component characters. In a systematic breeding programme, selection of parents with desirable characteristics having good general combining ability effects for yield and its components and high estimates of specific combining ability effects are essential (Baloch *et al*., 2001) [1]. Hence, the present investigation was undertaken to study the gene action in different quantitative traits and to study the combining ability for seed yield and its components in castor.

## Materials and Method
### Experiment material
The experimental material consisting ten inbred line of castor were crossed in diallel fashion excluding reciprocals to generate fourty five hybrids. A complete set of56 entries comprising ten parents, forty-five hybrids and one standard check hybrid (GCH-7) were sown in a randomized complete block design with three replications during *rabi* 2015-16 at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. Each entry was grown in a single row of 6 m length keeping inter row 120 cm and intra row 60 cm distance and all recommended agronomic practices and plant protection measures were adopted for raising healthy crop. Observations on castor yield and its component traits were recorded on

five randomly selected plants for each entries in each replication and the average value per plot was computed except days to 50 percent flowering and days to maturity. The observations for days to 50 percent flowering and days to maturity were recorded on plot basis. Combining ability analysis was carried out on the data obtained for parents and F1s following Griffing (1956) [3] method- II and model-I.

## Results and Discussion

### Variance for Combining Ability

The analysis of variance for combining ability (Table 1) revealed that general combining ability variances were significant for most of the characters except days to maturity, 100 seed weight and shelling out turn, whereas, specific combining ability variances were significant for majority of the characters except 100 seed weight, shelling out turn and oil content, which indicated the importance of both additive and of non-additive gene actions in the expression of majority of the characters.

The ratio of gca to sca variance indicated the preponderance of non-additive gene action in the expression of days to 50% flowering, days to maturity, total length of primary raceme, effective length of primary raceme, number of capsules on primary raceme, number of effective raceme per plant, total seed weight of primary raceme and seed yield per plant. The characters *viz.*, plant height up to primary raceme, number of nodes up to primary raceme and oil content were mainly governed by additive gene action. These results are in accordance with the reports of Thakkar *et al.* (2005) [9], Maheshwari (2007) [6], Barad *et al*. (2009) [2], Padhar *et al.* (2010) [7], Patel *et al.* (2010) [8] and Kasture *et al.* (2014) [4]. In a view of involvement of both additive and non-additive gene actions for the control of most of the characters, bi-parental mating or reciprocal recurrent selection could be employed for further improvement of the traits in the population.

### General and Specific Combining Ability Effects

Estimates of gca effects (Table 2) in the present study showed that it was difficult to pick one good general combiner for all the traits together, as the combining ability effects of parents were not consistent for all the traits.

An overall appraisal of gca effects revealed that only one parent SKI-324 was good general combiner for seed yield per plant. The parental genotype SKI-324 was also good general combiner for total length of primary raceme, effective length of primary raceme, number of capsules on primary raceme, total seed weight of primary raceme and oil content. Parent ANDCI-8 was good combiner for plant height up to primary raceme and number of nodes up to primary raceme. Whereas, parent JI-358 was good general combiner for days to 50% flowering, number of nodes up to primary raceme, total length of primary raceme and effective length of primary raceme. Hence, the parental lines ANDCI-8 and JI-358 could be utilized in hybridization programme for development of early and short stature inbred lines, along with higher seed yield.

The perusal of data on sca effects (Table 3) revealed that none of the hybrid was consistently superior for all the traits. Out of 45 hybrids studied, three hybrids exhibited significant positive sca effects for seed yield per plant. The cross SKI-324 x VH-63-1-3 expressed the highest significant sca effect for seed yield per plant, which also recorded significant desirable sca effect for effective length of primary raceme. Another cross JI-358 x SKI-324 showed significant positive sca effect for seed yield per plant, which also had significant desirable sca effect for days to maturity, plant height up to primary raceme, number of nodes up to primary raceme and number of effective racemes per plant. The cross SH-42 x PCS-124 also recorded significant sca effects in desirable direction for seed yield per plant. These hybrids could be exploited through heterosis breeding and may also give transgressive segregants in subsequent generations. Therefore, it would be worthwhile to use them for improvement of in seed yield *per se*, in castor.

The results on *per se*, gca and scaeffects (Table 4) revealed that crosses having higher estimates of sca resulted from good x good, good x average, good x poor, average x good, poor x good and poor x poor general combiners. High sca effects due to good x good combiners reflect additive x additive type of gene interaction and superiority of favourable genes contributed by the parents. The crosses showing high sca effects involving one good general combiner (good x poor, poor x good, good x average and average x good) indicated additive x dominance type of gene interaction, which could produce desirable type of transgressive segregants in subsequent generations.

**Table 1:** Mean square due to general and specific combining ability for yield and its component characters in castor

| Source of variation | d.f. | Days to 50% flowering | Days to maturity | Plant height up to primary raceme | Number of nodes up to primary raceme | Total length of primary raceme | Effective length of primary raceme | Number of capsules on primary raceme | Number of effective raceme per plant | Total seed weight of primary raceme | 100 seed weight | Shelling out turn | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General combining ability | 9 | 19.24** | 31.75 | 602.38** | 7.01** | 231.57** | 243.24** | 432.73** | 3.63** | 523.43** | 3.86 | 32.06 | 1494.99** | 1.91* |
| Specific combining ability | 45 | 17.73** | 45.49** | 73.27** | 0.68* | 27.20** | 28.46** | 58.22** | 0.98** | 82.65** | 2.54 | 18.83 | 1002.41** | 0.87 |
| Error | 108 | 5.84 | 18.41 | 37.42 | 0.43 | 8.11 | 6.66 | 24.37 | 0.30 | 34.37 | 3.24 | 20.66 | 485.37 | 0.78 |
| $\hat{\sigma}^2_{gca}$ | | 0.126 | -- | 44.092 | 0.528 | 17.031 | 17.899 | 31.209 | 0.220 | 36.731 | 0.11 | 1.103 | 41.048 | 0.087 |
| $\hat{\sigma}^2_{sca}$ | | 11.882 | 27.087 | 35.852 | 0.245 | 19.096 | 21.801 | 33.855 | 0.682 | 48.282 | -- | -- | 517.035 | 0.075 |
| $\hat{\sigma}^2_{gca} / \hat{\sigma}^2_{sca}$ | | 0.011 | -- | 1.230 | 2.151 | 0.892 | 0.821 | 0.922 | 0.323 | 0.761 | -- | -- | 0.079 | 1.152 |

*, ** significant at 5% and 1% levels, respectively. (--) Variances and ratios are negative so it is not mention.

**Table 2:** General combining ability (*gca*) effects for different characters in castor

| Sr. No. | Parents | Days to 50% flowering | Days to maturity | Plant height up to primary raceme | Number of nodes up to primary raceme | Total length of primary raceme | Effective length of primary raceme | Number of capsules on primary raceme | Number of effective racemeper plant | Total seed weight of primary raceme | 100 seed weight | Shelling out turn | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | ANDCI-10-6 | -0.59 | 2.07 | 1.96 | -0.11 | -3.83** | -0.89 | 2.48 | -0.29 | 0.36 | -0.92 | -0.20 | 4.99 | -0.13 |
| 2. | ANDCI-10-7 | 1.02 | -0.63 | 3.24 | 0.08 | 0.73 | -0.36 | 1.82 | -0.09 | 6.02** | 0.54 | 0.47 | 3.47 | -0.14 |
| 3. | ANDCI-8 | -0.95 | 0.40 | -14.86** | -1.07** | -0.18 | -0.93 | -1.69 | 0.28 | -1.73 | 0.31 | 2.35 | 3.17 | -0.07 |
| 4. | JI-358 | -2.06** | 1.68 | -1.28 | -0.62** | 2.81** | 3.85** | 1.48 | 0.10 | -2.67 | 0.39 | -2.45 | 2.33 | -0.30 |
| 5. | SH-42 | 1.02 | -0.27 | 2.06 | 0.02 | 4.43** | 3.61** | 4.50** | -0.56** | 3.02 | -0.07 | -0.48 | -3.86 | 0.35 |
| 6. | SH-1 | -0.48 | -2.66* | 2.34 | 0.60** | 2.87** | 2.64** | 6.86** | 0.01 | 3.98* | -0.45 | 0.77 | -0.10 | -0.69** |
| 7. | SKI-324 | 1.05 | -0.52 | 6.55** | 0.68** | 5.46** | 5.22** | 5.91** | -0.16 | 11.08** | 0.66 | 0.76 | 12.59* | 0.79** |
| 8. | VH-63-1-3 | 0.33 | -1.32 | 7.69** | 0.64** | -4.61** | -6.72** | -8.82** | 0.58** | -6.65** | -0.76 | 0.98 | 10.93 | 0.19 |
| 9. | PCS-124 | -1.28 | -1.16 | -9.91** | -1.22** | -8.43** | -8.35** | -11.34** | 1.02** | -12.37** | -0.21 | 0.84 | -6.41 | 0.14 |
| 10. | JH-109 | 1.94** | 2.40 | 2.21 | 0.99** | 0.75 | 1.93** | -1.18 | -0.90** | -1.03 | 0.50 | -3.04* | -27.11** | -0.14 |
| S.E. $_{(gi)}$ | | 0.687 | 1.220 | 1.739 | 0.187 | 0.809 | 0.734 | 1.403 | 0.156 | 1.667 | 0.512 | 1.292 | 6.263 | 0.254 |

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

**Table 3:** Specific combining ability (sca) effects of hybrids for different characters in castor

| Sr. No. | Hybrids | Days to 50% flowering | Days to maturity | Plant height up to primary raceme | Number of nodes up to primary raceme | Total Length of primary raceme | Effective Length of primary raceme | Number of capsules on primary raceme |
|---|---|---|---|---|---|---|---|---|
| 1. | ANDCI-10-6 x ANDCI-10-7 | -3.77 | 2.03 | -11.25* | 0.20 | -9.50** | -6.28** | -3.92 |
| 2. | ANDCI-10-6 x ANDCI-8 | 2.87 | 7.67 | 6.78 | 0.55 | 2.21 | 5.99* | 0.66 |
| 3. | ANDCI-10-6 x JI-358 | -0.69 | 2.72 | 0.94 | -1.16 | -7.44** | -2.47 | -8.91 |
| 4. | ANDCI-10-6 x SH-42 | -4.77* | -2.00 | -8.33 | -0.93 | -10.13** | -7.22** | -11.46* |
| 5. | ANDCI-10-6 x SH-1 | -2.27 | 1.39 | -3.88 | -0.85 | 1.43 | 2.42 | 16.25** |
| 6. | ANDCI-10-6 x SKI-324 | -4.47* | -7.42 | 2.77 | 0.27 | 9.44** | 8.79** | 13.07** |
| 7. | ANDCI-10-6 x VH-63-1-3 | -1.41 | -3.61 | -8.70 | -1.09 | -0.76 | -2.48 | 4.53 |
| 8. | ANDCI-10-6 x PCS-124 | -0.47 | -7.78* | 10.51 | 0.70 | 7.27** | 8.68** | 16.32** |
| 9. | ANDCI-10-6 x JH-109 | -3.36 | -7.00 | 0.24 | -0.51 | 8.02** | 4.14 | 6.35 |
| 10. | ANDCI-10-7 x ANDCI-8 | 0.92 | -2.97 | -5.03 | -0.51 | -3.89 | -10.74** | -0.75 |
| 11. | ANDCI-10-7 x JI-358 | -0.97 | -3.58 | 7.93 | -0.88 | 1.19 | 0.95 | -4.38 |
| 12. | ANDCI-10-7 x SH-42 | -2.05 | -3.97 | -11.54* | -1.00 | 0.57 | 0.72 | -8.14 |
| 13. | ANDCI-10-7 x SH-1 | -0.55 | -1.25 | 15.37** | 0.23 | 4.33 | 2.56 | -0.70 |
| 14. | ANDCI-10-7 x SKI-324 | 3.59 | -2.39 | -0.84 | 0.01 | -1.86 | 0.05 | 7.79 |
| 15. | ANDCI-10-7 x VH-63-1-3 | -0.36 | 4.75 | 14.76** | 0.98 | 3.94 | 2.59 | 1.32 |
| 16. | ANDCI-10-7 x PCS-124 | -0.74 | -2.75 | -3.17 | -0.16 | -2.43 | -2.79 | 4.44 |
| 17. | ANDCI-10-7 x JH-109 | -1.97 | 2.03 | 5.63 | -0.23 | 1.52 | 1.21 | 1.28 |
| 18. | ANDCI-8 x JI-358 | 2.67 | 2.06 | 9.63 | 0.60 | 5.97* | 8.02** | 5.06 |
| 19. | ANDCI-8 x SH-42 | -3.74 | -10.33** | -3.98 | -1.05 | 1.55 | 1.09 | 0.30 |
| 20. | ANDCI-8 x SH-1 | -7.24** | -5.28 | -5.86 | -1.16 | -4.96 | -6.64** | -7.05 |
| 21. | ANDCI-8 x SKI-324 | -0.44 | 3.58 | -14.81** | -0.44 | -3.08 | -4.78* | 0.97 |
| 22. | ANDCI-8 x VH-63-1-3 | -0.72 | -0.61 | -0.14 | 0.40 | 5.38* | 3.01 | 7.89 |
| 23. | ANDCI-8 x PCS-124 | -2.44 | -1.78 | -3.54 | -0.67 | -4.26 | -6.61** | -5.58 |
| 24. | ANDCI-8 x JH-109 | -6.33** | -11.67** | 8.27 | 0.05 | 5.96* | 6.45** | -0.88 |
| 25. | JI-358 x SH-42 | -5.63* | -11.94** | -10.29 | 0.11 | 4.56 | 0.49 | 3.74 |
| 26. | JI-358 x SH-1 | -1.47 | 3.44 | -7.84 | -0.67 | -2.48 | -2.51 | 8.32 |
| 27. | JI-358 x SKI-324 | -4.33 | -11.69** | -18.65** | -1.48* | 1.20 | -0.09 | -4.60 |
| 28. | JI-358 x VH-63-1-3 | -3.61 | -7.89* | -6.72 | 0.02 | -5.21* | -6.49** | -3.61 |
| 29. | JI-358 x PCS-124 | -3.99 | -3.72 | 6.28 | -0.12 | 2.42 | 2.23 | -3.75 |
| 30. | JI-358 x JH-109 | -3.55 | -6.28 | -5.24 | -1.00 | 1.71 | -0.94 | 3.29 |
| 31. | SH-42 x SH-1 | 2.45 | 2.06 | 0.36 | 0.95 | -0.90 | 1.52 | 10.76* |
| 32. | SH-42 x SKI-324 | -1.08 | 4.92 | 9.08 | 0.34 | 1.12 | 4.67 | 2.31 |
| 33. | SH-42 x VH-63-1-3 | 2.98 | 4.72 | 5.27 | 0.51 | -2.36 | -5.05* | 3.04 |
| 34. | SH-42 x PCS-124 | -2.08 | -1.78 | -0.26 | -0.70 | -0.26 | -4.49 | -6.57 |
| 35. | SH-42 x JH-109 | 2.03 | -3.00 | -1.85 | 0.56 | -5.11 | -5.57* | 6.20 |
| 36. | SH-1 x SKI-324 | 1.09 | -0.36 | -6.27 | 0.49 | 0.21 | -4.22 | -0.11 |
| 37. | SH-1 x VH-63-1-3 | 0.48 | -2.22 | -5.14 | -0.13 | -3.07 | -3.14 | -7.65 |
| 38. | SH-1 x PCS-124 | -2.24 | -0.06 | -5.47 | -0.81 | 2.16 | -0.38 | 1.40 |
| 39. | SH-1 x JH-109 | -2.13 | -2.61 | 3.27 | 0.25 | 5.04 | 5.26* | -4.29 |
| 40. | SKI-324 x VH-63-1-3 | 0.95 | -2.03 | 14.18* | 0.38 | 4.28 | 6.61** | -5.03 |
| 41. | SKI-324 x PCS-124 | -0.44 | -2.19 | -4.35 | 0.64 | -5.22* | -5.16* | -9.58* |
| 42. | SKI-324 x JH-109 | -1.33 | -1.42 | 3.32 | 0.03 | 2.53 | -1.34 | 3.26 |
| 43. | VH-63-1-3 x PCS-124 | -0.05 | 0.61 | -6.89 | 0.48 | 5.24* | 5.71* | 0.48 |
| 44. | VH-63-1-3 x JH-109 | -0.27 | 0.72 | -0.55 | 0.14 | 3.59 | 4.65 | 5.92 |
| 45. | PCS-124 x JH-109 | 1.34 | 6.56 | 3.59 | 0.47 | 3.88 | 5.36* | 8.98* |
| S.E. (sij) | | 2.212 | 3.924 | 5.594 | 0.601 | 2.604 | 2.360 | 4.514 |
| | | | | | | | | |

*,** significant at 5% and 1% level, respectively.

| Sr. No. | Hybrids | Number of effective racemes per plant | Total Seed weight of primary raceme | 100 seed weight | Shelling out turn % | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|
| 1. | ANDCI-10-6 x ANDCI-10-7 | -0.52 | -0.64 | -0.31 | 3.22 | -18.40 | 1.35 |
| 2. | ANDCI-10-6 x ANDCI-8 | 0.98 | 11.31* | -3.87* | 0.98 | 20.40 | 0.56 |
| 3. | ANDCI-10-6 x JI-358 | 1.22* | -4.28 | 0.90 | 1.41 | -42.19* | 0.44 |
| 4. | ANDCI-10-6 x SH-42 | 1.22* | -0.78 | 1.41 | -0.50 | 26.77 | 0.16 |
| 5. | ANDCI-10-6 x SH-1 | 0.18 | -4.95 | -0.71 | 2.33 | 35.67 | 0.71 |
| 6. | ANDCI-10-6 x SKI-324 | -0.18 | 14.88** | -1.31 | 0.83 | -10.36 | 0.37 |
| 7. | ANDCI-10-6 x VH-63-1-3 | -0.85 | 3.16 | 1.65 | 1.27 | 23.98 | 0.50 |
| 8. | ANDCI-10-6 x PCS-124 | -1.03* | 6.04 | 0.44 | -3.35 | -7.48 | 0.60 |
| 9. | ANDCI-10-6 x JH-109 | -0.64 | -10.69* | 1.02 | 5.55 | 32.01 | -0.04 |
| 10. | ANDCI-10-7 x ANDCI-8 | 1.51** | -19.34** | -2.10 | 4.51 | 30.59 | -0.71 |
| 11. | ANDCI-10-7 x JI-358 | -1.71** | 5.33 | 1.35 | -2.51 | -11.23 | 0.47 |
| 12. | ANDCI-10-7 x SH-42 | -0.38 | -4.56 | 1.16 | -3.83 | -1.57 | -0.54 |
| 13. | ANDCI-10-7 x SH-1 | -0.62 | 21.12** | 2.36 | 2.76 | 17.79 | 0.65 |
| 14. | ANDCI-10-7 x SKI-324 | 0.56 | 7.18 | 1.61 | -2.81 | 29.17 | -0.50 |
| 15. | ANDCI-10-7 x VH-63-1-3 | -0.39 | -3.23 | 0.19 | -2.43 | 15.50 | 0.41 |
| 16. | ANDCI-10-7 x PCS-124 | 0.90 | -13.37* | -0.55 | -0.02 | 8.14 | -1.12 |
| 17. | ANDCI-10-7 x JH-109 | 1.30* | 5.69 | 1.60 | -0.94 | -13.80 | 0.11 |
| 18. | ANDCI-8 x JI-358 | -0.54 | 7.48 | 3.49* | 2.63 | 29.19 | 0.71 |
| 19. | ANDCI-8 x SH-42 | 1.45** | 6.12 | -1.21 | 5.48 | -12.75 | -1.07 |
| 20. | ANDCI-8 x SH-1 | -0.65 | -0.73 | -0.13 | 5.96 | 25.68 | 0.67 |
| 21. | ANDCI-8 x SKI-324 | 0.26 | -9.41 | 1.50 | -6.40 | -16.54 | -1.24 |
| 22. | ANDCI-8 x VH-63-1-3 | -0.22 | 10.99* | -0.72 | -1.91 | 22.00 | 0.81 |
| 23. | ANDCI-8 x PCS-124 | -0.40 | -8.16 | 3.00 | -4.74 | -32.70 | -0.14 |
| 24. | ANDCI-8 x JH-109 | -1.34** | 9.44 | 0.08 | 6.44 | 39.16 | -0.34 |
| 25. | JI-358 x SH-42 | 0.36 | 10.19 | -1.75 | 3.82 | 35.50 | -0.26 |
| 26. | JI-358 x SH-1 | 0.12 | -0.93 | 0.96 | -0.79 | 0.33 | 0.97 |
| 27. | JI-358 x SKI-324 | 1.10* | -1.53 | -1.75 | 6.91 | 42.31* | 1.04 |
| 28. | JI-358 x VH-63-1-3 | 1.16* | -4.27 | 0.63 | 6.78 | 25.31 | 0.36 |
| 29. | JI-358 x PCS-124 | 0.11 | 0.98 | -1.16 | 1.68 | 9.51 | 1.20 |
| 30. | JI-358 x JH-109 | 1.17* | 4.44 | -0.72 | -12.26** | -29.86 | -0.46 |
| 31. | SH-42 x SH-1 | 0.05 | -2.73 | 0.67 | -0.35 | 17.19 | 0.18 |
| 32. | SH-42 x SKI-324 | 0.43 | -0.70 | -0.02 | 1.66 | -13.23 | 1.61 |
| 33. | SH-42 x VH-63-1-3 | -0.45 | -0.30 | -1.11 | 3.42 | -3.17 | -0.50 |
| 34. | SH-42 x PCS-124 | 0.17 | -3.45 | -0.68 | -2.40 | 42.17* | -0.41 |
| 35. | SH-42 x JH-109 | -1.30* | -5.72 | -0.42 | -6.04 | -8.40 | 0.45 |
| 36. | SH-1 x SKI-324 | 1.19* | 5.08 | -0.60 | 2.62 | 8.73 | 0.52 |
| 37. | SH-1 x VH-63-1-3 | -0.62 | -6.33 | -0.50 | -3.11 | -23.60 | 0.74 |
| 38. | SH-1 x PCS-124 | 1.47** | 5.66 | -3.18 | -0.43 | 37.74 | 0.09 |
| 39. | SH-1 x JH-109 | 1.40** | 11.06* | 0.10 | 2.50 | 9.63 | 0.29 |
| 40. | SKI-324 x VH-63-1-3 | -1.38** | 5.71 | 1.19 | 1.68 | 48.38* | -0.12 |
| 41. | SKI-324 x PCS-124 | -1.02* | -13.77* | -0.34 | 4.87 | 9.05 | -1.13 |
| 42. | SKI-324 x JH-109 | 0.84 | 11.02* | 0.73 | -2.67 | 9.08 | -0.75 |
| 43. | VH-63-1-3 x PCS-124 | 1.23* | 5.69 | -2.13 | 0.81 | 4.72 | -0.58 |
| 44. | VH-63-1-3 x JH-109 | 0.03 | 2.75 | -0.58 | -0.73 | -3.92 | -0.74 |
| 45. | PCS-124 x JH-109 | -0.62 | -2.26 | 1.24 | 3.49 | 11.42 | 0.42 |
| S.E. (sij) | | 0.502 | 5.362 | 1.647 | 4.157 | 20.148 | 0.817 |

*,** significant at 5% and 1% level, respectively.

**Table 4:** Summary of three best performing parents, best general combining parents and best performing hybrids along with their *per se* performance and sca effects

| Sr. No. | Characters | Best performing parents | Best general combiners | Best performing hybrids | *Per se* performance | sca effects |
|---|---|---|---|---|---|---|
| 1. | Days to 50% flowering | VH-63-1-3 | JI-358 | ANDCI-8 x SH-1 | 39.00 | -7.24** |
| | | PCS-124 | PCS-124 | JI-358 x PCS-124 | 40.33 | -3.99 |
| | | SH-1 | ANDCI-8 | JI-358 x SH-42 | 41.00 | -5.63* |
| 2 | Days to maturity | SH-1 | SH-1 | JI-358 x SH-42 | 102.67 | -11.94** |
| | | VH-63-1-3 | VH-63-1-3 | JI-358 x SKI-324 | 102.67 | -11.69** |
| | | ANDCI-10-7 | PCS-124 | ANDCI-8 x SH-42 | 103.00 | -10.33** |
| 3 | Plant height up to primary raceme (cm) | ANDCI-8 | ANDCI-8 | ANDCI-8 x PCS-124 | 52.00 | -3.54 |
| | | PCS-124 | PCS-124 | ANDCI-8 x SKI-324 | 57.20 | -14.81** |
| | | JH-109 | JI-358 | ANDCI-8 x SH-1 | 61.93 | -5.86 |
| 4 | Number of nodes up to primary raceme | PCS-124 | PCS-124 | ANDCI-8 x PCS-124 | 13.20 | -0.67 |
| | | ANDCI-8 | ANDCI-8 | ANDCI-8 x SH-42 | 14.07 | -1.05 |
| | | VH-63-1-3 | JI-358 | ANDCI-10-6 x JI-358 | 14.27 | -1.16 |
| 5 | Total length of primary raceme (cm) | SH-42 | SKI-324 | JI-358 x SH-42 | 74.27 | 4.56 |
| | | SKI-324 | SH-42 | ANDCI-10-6 x SKI-324 | 73.53 | 9.44** |
| | | SH-1 | SH-1 | SH-42 x SKI-324 | 73.47 | 1.12 |
| 6 | Effective length of primary raceme (cm) | SH-42 | SKI-324 | SH-42 x SKI-324 | 66.60 | 4.67 |
| | | SKI-324 | JI-358 | ANDCI-10-6 x SKI-324 | 66.22 | 8.79** |
| | | JI-358 | SH-42 | ANDCI-8 x JI-358 | 64.03 | 8.02** |
| 7 | Number of capsules on primary raceme | SH-42 | SH-1 | ANDCI-10-6 x SH-1 | 93.20 | 16.25** |
| | | SKI-324 | SKI-324 | SH-42 x SH-1 | 89.73 | 10.76** |
| | | JI-358 | SH-42 | ANDCI-10-6 x SKI-324 | 89.07 | 13.07** |
| 8 | Number of effective racemes per plant | VH-63-1-3 | PCS-124 | VH-63-1-3 x PCS-124 | 9.27 | 1.23* |
| | | PCS-124 | VH-63-1-3 | SH-1 x PCS-124 | 8.93 | 1.47** |
| | | ANDCI-8 | ANDCI-8 | JI-358 x VH-63-1-3 | 8.27 | 1.16* |
| 9 | Total seed weight of primary raceme (g) | ANDCI-10-7 | SKI-324 | ANDCI-10-7 x SH-1 | 86.58 | 21.12** |
| | | SKI-324 | ANDCI-10-7 | ANDCI-10-6 x SKI-324 | 81.78 | 14.88** |
| | | SH-42 | SH-1 | ANDCI-10-7 x SKI-324 | 79.73 | 7.18 |
| 10 | 100 seed weight (g) | PCS-124 | SKI-324 | ANDCI-8 x JI-358 | 33.31 | 3.49* |
| | | SH-42 | ANDCI-10-7 | ANDCI-8 x PCS-124 | 32.22 | 3.00 |
| | | SKI-324 | JI-358 | ANDCI-10-7 x SKI-324 | 31.94 | 1.61 |
| 11 | Shelling out turn (%) | ANDCI-10-7 | ANDCI-8 | ANDCI-8 x SH-1 | 72.45 | 5.96 |
| | | PCS-124 | VH-63-1-3 | ANDCI-8 x SH-42 | 70.71 | 5.48 |
| | | VH-63-1-3 | PCS-124 | ANDCI-10-7 x ANDCI-8 | 70.69 | 4.51 |
| 12 | Seed yield per plant (g) | ANDCI-10-6 | SKI-324 | SKI-324 x VH-63-1-3 | 273.93 | 48.38* |
| | | ANDCI-10-7 | VH-63-1-3 | JI-358 x SKI-324 | 259.27 | 42.31* |
| | | JI-358 | ANDCI-10-6 | ANDCI-10-7 x SKI-324 | 247.27 | 29.17 |
| 13 | Oil content (%) | SKI-324 | SKI-324 | SH-42 x SKI-324 | 50.18 | 1.61 |
| | | SH-42 | SH-42 | JI-358 x SKI-324 | 48.96 | 1.04 |
| | | PCS-124 | VH-63-1-3 | ANDCI-10-6 x ANDCI-10-7 | 48.51 | 1.35 |

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

## Conclusion

SKI-324 was the best among the ten parents as it showed desirable GCA effects for most of yield and its contributing traits. Therefore these parents could be used extensively in hybrid breeding program with a view to increase castor seed yield with quality. Furthermore, based on SCA effects 3 hybrids SKI-324 x VH-63-1-3, JI-358 x SKI-324 and ANDCI-10-7 x SKI-324 were proved to be the best to increase the castor yield with better yield attributing characters. For varietal improvement, these crosses could also be utilized for exploiting promising recombinants and it could be useful towards enhancing castor seed yield and other characters.

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