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# Heterosis and inbreeding depression in chilli (*Capsicum annuum* L.)

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**Abtract**

Investigations were carried out at Jagudan (Gujarat) to study the extent of heterosis and inbreeding depression through six generation mean analysis for yield and yield attributing characters in chilli (*Capsicum annuum*). The magnitude of heterosis and heterobeltiosis was significant in desired direction with moderate to high for green fruit yield, secondary branches, fruit length; high for number of fruits plant$^{-1}$, ripe/dry fruit weight and seed to pericarp ratio and low for flowering and ripening of fruit. The cross combinations JCh-676 x JCh-659 showed the highest estimate of relative heterosis and heterobeltiosis for dry fruit yield. All the crosses also revealed inbreeding depression for most of the characters. These traits can be improved effectively through pedigree method of selection. In general, the crosses JCh-730 x JCh-725 and JCh-676 x JCh-659 were identified as promising hybrids since they depicted significant heterosis for green and dry fruit yield and its important yield contributing characters.

**Keywords:** *Capsicum annuum,* chilli, heterobeltiosis, inbreeding depression.

Though a number of hybrids have been developed in chilli (*Capsicum annuum* L.) they have not been fully exploited and adopted for commercial cultivation, for which high cost of $F_1$ seeds and quality of produce of the hybrids are limiting factors. In addition to developing hybrids for commercial cultivation, study of heterosis provides information on probable gene effects and helps in sorting out $F_1$S likely to yield better segregants. Whereas, the extent of inbreeding depression gives an idea about the productivity of hybrids, and also magnitude of transgressive segregants, which may be stabilized as improved inbreeds. Hence, the nature and magnitude of inbreeding depression was studied for green as well as dry fruit yield and 13 other characters with three crosses involving five parental genotypes of chilli at Jagudan (Gujarat).

Six generations, namely, $P_1$, $P_2$, $F_1$, $F_2$, $BC_1$ and $BC_2$ each of three crosses involving five diversified cultivars of chilli (JCh-676, JCh-734, JCh-659, JCh-730 and JCh-725) were used to study the genetic analysis of quantitative and qualitative traits. The five parents were selected with diversified promising genotypes developed at Centre for Research on Seed Spices, S D

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Agricultural University, Jagudan. The experiments were taken under two environments namely, different sowing dates and fertilizer levels. Enviroment-1($E_1$): Late grown (19th March 2007), high fertility (250 kg $N_2$ and 100 kg $P_2O_5$ $ha^{-1}$) and Enviroment-2 ($E_2$): Timely grown (10th October 2007), low fertility (150 kg $N_2$ and 60 kg $P_2O_5$ $ha^{-1}$). The material consisting of six generations ($P_1$, $P_2$, $F_1$, $F_2$, $BC_1$ and $BC_2$) of each of the crosses were grown during summer 2007 and *kharif* 2007-08 in a compact family block design with three replications. Each net plot had one row for parents and $F_1$'s, two rows for each of $BC_1$ and $BC_2$ and four rows of $F_2$ populations. Inter and intra row spacing of 90 cm and 60 cm was maintained, respectively, with row length of 6 m. Extra two rows were planted on both sides of experimental blocks to eliminate border effects. The recommended package of practices was followed as per need of crop in the nursery as well as in the field. Randomly selected 5 plants from each of the $P_1$, $P_2$ and $F_1$ and 20 plants from $F_2$ and 10 plants from each of the $BC_1$ and $BC_2$ generations were tagged for recording green as well as dry fruit yield and 13 other yield contributing characters (Table 1). Capsaicin content was estimated as per the procedure developed by Quagliotti & Ottaviano (1971) using composite sample of sun dried fruits. The formulae used in estimation of relative heterosis, (heterosis over mid parent) and heterobeltiosis (heterosis over better parent) were computed as per Fonseca & Patterson (1968). Whereas, inbreeding depression expressed in percentage was computed using following formula:

$$\text{Per cent inbreeding depression} = \frac{F_1 - F_2}{F_1} \times 100$$

Where, $F_1$ = mean value of $F_1$ generation; $F_2$ = mean value of $F_2$ generation.

The performance of $P_1$, $P_2$, $F_1$, $F_2$, $BC_1$ and $BC_2$ generations and estimates of various heterotic effects and inbreeding depression of the crosses in all environments under study are presented in Table 1. The magnitude of heterobeltiosis and relative heterosis was high for number of fruits $plant^{-1}$, average fruit weight, ripe fruit weight, dry fruit weight and seed to pericarp ratio suggesting presence of non-additive gene effects for inheritance of these traits. The results confirm the findings of Gopalkrishnan *et al.* (1987). Whereas, low and positive estimates of various heterotic effects were observed for 50% flowering, fruit ripening, primary branches, fruit girth and capsaicin content and suggesting the additivity of genes or partial dominance with preponderance of increasing genes for genetic control of the traits. These results are in accordance with the report of Mishra *et al.* (1989).

Significant heterosis and/or heterobeltiosis in desired direction was observed for green fruit yield in JCh-676 x JCh-659 and JCh-730 x JCh-725; for ripe and dry fruit yield in JCh-676 x JCh-659 and JCh-730 x JCh-725, among which for dry fruit yield, JCh-676 x JCh-659 registered the highest estimate of relative heterosis (83.21%) and heterobeltiosis (78.38%); this may be exploited for commercial cultivation.

The estimates of various heterotic effects for average fruit yield, green fruit yield and dry fruit yield were high, which had resulted as an outcome of combined effects of number of fruits and fruit girth as well as length of fruit. Heterotic effects were low to moderate/high revealing additivity of genes and/or partial dominance of gene effects for inheritance of above characters. For heterobeltiosis, significant and desirable estimate were observed for days to flowering, fruit girth, green fruit yield $plant^{-1}$, ripe fruit yield, seed to pericarp ratio and placental weight in JCh-676 x JCh-659. For dry fruit weight and days to 50% flowering, highly significant and low magnitude of heterosis was observed in JCh-676 x JCh-659 and JCh-730 x JCh-725, respectively. Primary and secondary branches $plant^{-1}$ and fruit length in JCh-734 X JCh-659 was significant with desirable heterosis. For number of fruits $plant^{-1}$ and green fruit yield, JCh-676 x JCh-659 and for ripe and dry fruit yield, JCh-730 x JCh-725 exhibited better

**Table 1.** Magnitude of heterosis and inbreeding depression (%) for different characters in three crosses of chilli

| Character | Env. | JCh-676 × JCh-659 | | | JCh-734 × JCh-659 | | | JCh-730 × JCh-725 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Heterosis (%) | | ID (%) | Heterosis (%) | | ID (%) | Heterosis (%) | | ID (%) |
| | | MP | BP | | MP | BP | | MP | BP | |
| Days to 50% flowering | $E_1$ | 1.963 | 4.00 | 3.11* | 0.893** | 2.86** | 2.15 | - | 7.51** | -0.26 |
| | $E_2$ | 1.963 | 4.00 | 3.11 | 0.893** | 2.87** | 2.15 | - | 7.52** | -0.26 |
| | $E_3$ | 2.001 | 4.10* | 3.13 | 0.881** | 2.81** | 2.18 | 0.867** | 8.43** | 0.53 |
| Days to fruit ripening | $E_1$ | 1.476* | 2.53 | - | -0.478* | 0.49** | 1.20 | -1.735** | -1.735** | 3.97** |
| | $E_2$ | 1.476* | 2.52 | - | -0.478* | 0.48 | 1.20** | -1.735** | -1.735** | 3.97** |
| | $E_3$ | 1.583** | 2.66 | 0.52 | -0.279 | 0.85** | 1.40 | -2.015** | -2.015** | 3.86** |
| Plant height (cm) | $E_1$ | 2.257** | -6.66 | 2.04* | 11.01** | -1.27** | 13.38** | 3.475** | -10.83** | 4.88** |
| | $E_2$ | 2.258** | -6.65 | 2.04** | 11.008** | -1.28** | 13.39** | 4.981** | -9.15** | 1.12 |
| | $E_3$ | -0.891 | -6.63* | 2.08 | 9.288** | -4.48** | 14.00** | 10.018** | -5.18** | 4.28** |
| Primary branches (no.) | $E_1$ | 17.647** | 13.63** | 26.50 | 22.000** | 14.45** | 25.68 | 7.143** | - | 20.00 |
| | $E_2$ | 17.647** | 13.68** | 26.51 | 22.014** | 14.45** | 25.67 | 7.143** | - | 20.00 |
| | $E_3$ | 17.510** | 13.54** | 27.82 | 21.875** | 14.79** | 24.36 | 7.296** | - | 20.80 |
| Secondary branches (no.) | $E_1$ | 7.328** | 2.85** | 17.27 | 18.868** | 13.51** | 21.03 | 37.662** | 8.59** | 9.45 |
| | $E_2$ | 7.328** | 2.89** | 17.27 | 18.868** | 13.51** | 21.03 | 37.662** | 8.65** | 9.45 |
| | $E_3$ | 11.681** | 7.05** | 20.41 | 16.185** | 11.11** | 19.40 | 20.947** | 35.97** | 18.24 |
| Fruits plant$^{-1}$ (no.) | $E_1$ | 14.015** | 9.46 | 13.62** | 26.116** | 25.83 | 18.23** | 37.662** | 4.51 | 28.03** |
| | $E_2$ | 14.015** | 9.46 | 13.62** | 26.116** | 25.83 | 18.23** | 37.662** | 4.51 | 28.03** |
| | $E_3$ | 5.734* | 1.99 | 11.50** | 17.857** | 16.57 | 14.45** | 20.947** | -1.19 | 21.99** |
| Fruit length (cm) | $E_1$ | 13.920** | 3.81** | 18.00* | 25.844** | 7.10** | 26.67** | 5.128 | -8.87** | 23.10** |
| | $E_2$ | 13.923** | 3.81** | 18.01* | 25.848** | 7.10** | 26.68 | 5.128 | -8.86** | 23.11** |
| | $E_3$ | 2.240 | -14.02 | 17.61* | 25.850** | 7.12** | 26.68** | 5.128 | -8.86** | 25.71** |

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**Table 1. Contd...**

| Character | Env. | JCh-676 × JCh-659 | | | JCh-734 × JCh-659 | | | JCh-730 × JCh-725 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Heterosis (%) | | ID (%) | Heterosis (%) | | ID (%) | Heterosis (%) | | ID (%) |
| | | MP | BP | | MP | BP | | MP | BP | |
| Fruit girth (cm) | $E_1$ | 7.794* | 5.61** | 7.77 | 11.929** | 8.08** | 12.83 | 6.760 | -10.98 | 11.98 |
| | $E_2$ | 7.799* | 5.81** | 7.78 | 11.905** | 8.13** | 12.77 | 6.817 | -10.89 | 12.02 |
| | $E_3$ | 7.887* | 6.91 | 12.47 | 9.289* | 5.56 | 17.00 | 5.194 | -11.46** | 10.24 |
| Average fruit weight (g) | $E_1$ | 3.334 | -6.59** | -1.20 | -18.473** | -24.21** | -3.30 | -3.994 | -8.52 | -1.24 |
| | $E_2$ | 3.263 | -6.64** | -1.26 | -18.445** | -24.21** | -3.30 | -3.970 | -8.47 | -1.19 |
| | $E_3$ | 22.894** | 2.26** | 19.40 | -13.913** | -18.21** | 1.85 | 11.346** | 5.60** | -0.95 |
| Green fruit yield plant$^{-1}$ (g) | $E_1$ | 19.566** | 11.43** | 6.06 | -2.719 | -4.52** | 15.58 | 34.223** | 5.73** | 17.46 |
| | $E_2$ | 19.578** | 11.67** | 5.02 | -0.234 | -4.09** | 15.57 | 34.214** | 6.06** | 17.46 |
| | $E_3$ | 19.578** | 11.86** | 26.42 | -5.336 | -4.39** | 16.10 | 33.217** | 4.48** | 21.22 |
| Ripe fruit weight (g) | $E_1$ | 11.414** | -4.05** | 15.22 | -3.831 | -9.90** | 8.00 | 30.989** | 9.09** | 17.30 |
| | $E_2$ | 11.417** | -4.23** | 15.22 | -3.805 | -9.09** | 8.02 | 30.961** | 9.15** | 17.28 |
| | $E_3$ | 29.240** | 12.00** | 29.32** | 2.965 | -5.60** | 11.32** | 8.482** | 7.46** | 17.15** |
| Dry fruit weight (g) | $E_1$ | 56.882* | 52.59** | -4.65** | 7.847 | 5.73** | 41.12** | 56.125** | 44.46** | 26.64** |
| | $E_2$ | 56.882 | 52.57** | -4.65** | 7.847 | 5.72** | 41.12 | 56.125** | 44.47** | 26.64** |
| | $E_3$ | 83.210** | 78.38** | 12.94** | 7.736 | 5.80** | 39.69** | 53.577** | 42.54** | 26.05** |
| Seed to pericarp ratio | $E_1$ | -20.346 | -19.81** | -3.75 | 10.912 | 23.19** | -3.35 | -33.39** | -22.25** | -34.92 |
| | $E_2$ | -20.333* | -20.83** | -3.71 | 10.927 | 23.33** | -3.31 | -33.763** | -23.33** | -34.92 |
| | $E_3$ | -1.879 | 121.31** | 26.24 | 22.382 | 30.00** | -16.71 | -5.186 | 13.33** | 20.72 |
| Placental weight (g) | $E_1$ | 1.628** | -20.00** | 29.17 | -50.877 | -67.86** | -3.57 | -4.615 | -44.44** | 9.68 |
| | $E_2$ | 10.345 | -28.57** | 25.00 | -10.0* | -14.29** | -5.56 | - | -41.67** | 9.52 |
| | $E_3$ | 13.043 | -33.33** | 30.77 | -11.765* | -16.67** | -6.67 | 5.882 | -33.33** | 11.11 |
| Capsaicin content (μ g$^{-1}$) | $E_1$ | 1.470** | -0.49 | 1.04** | 4.161 | -4.36 | 9.42 | -11.238 | -17.80 | 18.19** |
| | $E_2$ | 1.481** | -0.46 | 1.04** | 4.160 | -4.35 | 10.10 | -11.236 | -17.81 | 18.18** |
| | $E_3$ | 1.511** | -0.49** | 1.57** | 3.636 | -5.65 | 10.07 | -11.002 | -18.99 | 21.05** |

*, ** Significant at 5 and 1%, respectively; Enviroment-1($E_1$)=Late grown (19th March 2007), high fertility (250 kg $N_2$ and 100 kg $P_2O_5$ ha$^{-1}$); Enviroment-2 ($E_2$)=Timely grown (10th October 2007), low fertility (150 kg $N_2$ and 60 kg $P_2O_5$ ha$^{-1}$); MP=Heterosis; BP=Heterobeltiosis; ID=Inbreeding depression

performance in varying environments which had reflected as higher heterotic effects for number of fruits and green/ripe/dried fruit yield as well, which indicated the role of additive epistatic in above crosses. Thus, pedigree method of selection would be rewarding for green fruit yield improvement with high selection pressure for increase of number of fruits plant$^{-1}$.

The estimate of inbreeding depression in general was low to moderate for all characters irrespective of environments except in flowering and ripening characters. These results are in accordance with Jagadisha & Wali (2008). JCh-676 x JCh-659 showed high heterosis in summer with high fertility condition and moderate to low inbreeding depression for days to flowering, plant height, secondary branches plant$^{-1}$, average fruit weight, green fruit yield plant$^{-1}$, ripe fruit weight, dry fruit weight, seed to pericarp ratio, placental weight and capsaicin content and also moderate to high for placental weight of fruit and had higher estimates of relative heterotic effects. Parallel relationship between heterosis in $F_1$ and inbreeding depression in $F_2$ confirm the importance of non-additive gene effects for controlling the above characters; hence heterosis breeding method could be advocated for improvement of fruit yield in chilli, which was also indicated by Omar & Lipert (1975); green fruit yield had significant heterosis and/or heterobeltiosis in desired direction in JCh-676 x JCh-659 and JCh-730 x JCh-725. For ripe/dry fruit yield JCh-730 x JCh-725 and JCh-676 x JCh-659 had significant and desired relative heterosis and heterobeltiosis. All these exhibited significant and positive estimates of heterotic effects for important yield contributing component characters and may be exploited for commercial cultivation.

In general, JCh-730 x JCh-725 and JCh-676 x JCh-659 were identified as promising hybrids since they exhibited significant heterosis for green fruit yield and its important yield contributing characters.

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