Vegetable Science (2016) 43 (1) : 121-124

**Short Communication**

# Genetic analysis for developmental characters in chilli (*Capsicum annuum* L.)

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Received: September 2015 / Accepted: February 2016

Chilli (*Capsicum annuum* var. Longum D.C. Sendt) is an important spice cum vegetable cash crop. Though India is leading country for chilli cultivation, its productivity is quite low. The main reason is use of open pollinated varieties, which have in general perennial growth habit but cultivated annually. Therefore, developmental characters largely influence the yielding potentiality of a genotype. For improvement of developmental characters, information on gene effects of such characters is prerequisite. Hence, a study was carried out to assess gene effects for important developmental characters through generation mean analysis.

The six generations ($P_1$, $P_2$, $F_1$, $F_2$, $BC_1$ and $BC_2$) of six crosses were evaluated in compact family block design with three replications at MVRS, AAU, Anand during the year 2007-08. The various generations were represented as single row for each $P_1$, $P_2$ and $F_1$, two rows for $BC_1$ and $BC_2$ and four rows for $F_2$ generations to maintain the effective population size. Total 12 plants were accommodated in each row with 60 x 60 cm plant geometry, of which 5 plants were randomly selected and tagged from each row for recording observations *viz.,* days to flower, days to fruit ripening, plant height, number of primary branches, number of secondary branches and plant width. Finally, the data were subjected to simple scaling test analysis (Hayman and Mather, 1955) to test adequacy of additive dominance model. The various components of gene effects were estimated with application of six parameter model proposed (Hayman, 1958). More précised estimates of these parameters were then obtained by applying weighted joint scaling test (Cavalli, 1952).

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The mean performance of various generations suggested involvement of complete and/or partial dominance gene effect for the inheritance of days to flower and fruit ripening. For plant height in general additivity of genes and co-dominance were evidenced. Additive, co-dominance and over dominance as well as digenic interactions were detected for number of primary and secondary branches. Whereas, for plant width complete and over dominance gene actions were evidenced.

The non significant estimates of A, B, C and D scaling tests as well as joint scaling tests with ACS 97-1 x Punjab Guchhadar and Jwala x DPS-120 for days to flower suggested absence of digenic interactions, whereas with rest of crosses additive-dominance model was inadequate. For ACS 98-9 x SG-5, and SG-5 x Punjab Guchhadar all the components of six parameter model except real epistatic (a x d) were significant with preponderance of non-additive gene effect. For Arka lohit x SG-5 dominance as well as pseudo dominance and pseudo additive gene effects were significant. Whereas, for ACG-77 x S 49 dominance and real epistatic had a significant estimates. Magnitude of estimates of gene effects revealed involvement of duplicate and complementry type of digenic interactions and preponderance of non-additive gene effects for days to flowering. The results in accordance with findings of Ganesh Reddy *et al*. (2008), Anandhi and Abdul Khader (2011) and Hasanuzzaman and Golam (2011).

For days to fruit ripening adequacy of additive dominance model was detected for SG-5 x Punjab Guchhadar. Whereas, for Arka lohit x SG-5 all components of six parameter model were significant with preponderance of non-additive gene effect and decreasing genes contributed largely. Additive gene effect was preponded with ACS 97-1 x Punjab Guchhadar and Jwala x DPS-120, though various interallellic interactions were significant. With ACS 98-9 x SG-5, additive as well as dominance gene effects significant but positive estimates

of pseudo additive gene effects balanced additive gene effects and preponderance of dominance gene effects was established. For ACG-77 x S 49 real epistatic and pseudo dominance digenic interactions were significant with influence of decreasing genes. Both duplicate and complementry interallelic interactions were evidenced through magnitude of various gene effects. As a whole importance of both additive and non-additive gene effects were observed for this trait. The results are in conformity with reports of Ganesh Reddy *et al*. (2008) and Hasanuzzaman and Golam (2011).

Additive dominance model was found inadequate for all the crosses of plant height trait. For ACS 97-1 x Punjab Guchhadar, all the components of six parameter model except real epistatic (a x d) were significant with preponderance of non-additive gene effect. Additive gene effect was preponded with ACS 98-9 x SG-5 and SG-5 x Punjab Guchhadar through various interallelic interaction were significant. For Arka lohit x SG-5 additive, dominance and additive epistasis had significant estimates. Significance of additive component and a x a digenic interaction for ACG-77 x S 49 revealed additivity of genes. Whereas, with Jwala x DPS-120 both additive and non-additive components were significant with preponderance of non-additive gene effect. For plant height magnitude of estimate indicated both involvements of both duplicate and complementry type of digenic interactions. The results are in agreements with reports of Ganesh Reddy *et al*. (2008), Anandhi and Abdul Khader (2011) and Hasanuzzaman and Golam (2011).

For number of primary branches additive dominance model was adequate. With SG-5 x Punjab Guchhadar, for which additive and dominance gene effect were of equal magnitude. For ACS 98-9 x SG-5 dominance component and real epistatic and for Arka lohit x SG-5 dominance component and additive epistatic was significant revealing importance of non-additive gene effect. Preponderance of non-additive gene effect was evidenced with ACG-77 x S 49. Both duplicate and complementry types of digenic interactions were evidenced through magnitude of various gene effects. Similar results reported by Ganesh Reddy *et al*. (2008), Somashekar *et al.* (2008) and Anandhi and Abdul Khader (2011)

Additive dominance model was adequate with SG-5 x Punjab Guchhadar, Arka lohit x SG-5, ACG-77 x S 49, whereas it was inadequate with rest of the crosses. For number of secondary branches, preponderance of additive gene effect was observed with crosses SG-5 x Punjab Guchhadar, Arka lohit x SG-5, ACG-77 x S 49. Significance estimates of dominance component of major gene effect and real epistatic (a x d) of digenic interaction with ACS 97-1 x Punjab Guchhadar, additive and pseudo dominance with ACS 98-9 x SG-5 and real epistatic with Jwala x DPS-120 revealed preponderance of non additive gene effect for this trait. The results are in conformity with the findings of Ganesh Reddy *et al*. (2008), and Somashekar *et al.* (2008).

For plant width, additive dominance model was inadequate for all the crosses except SG-5 x Punjab Guchhadar. Decreasing alleles largely influence additivity of genes with all the crosses. With ACS 98-9 x SG-5 all

**Table 1:** Mean performance of parents, $F_1$ and $F_2$ for various characters

| Cross | $P_1$ | $P_2$ | $F_1$ | $F_2$ | S.Em | $P_1$ | $P_2$ | $F_1$ | $F_2$ | S.Em |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Days to flower** | | | | | **Days to fruit ripening** | | | | |
| ACS 97-1 x Pb. Guchhadar | 32.73 | 36.53 | 29.93 | 30.70 | 0.93 | 90.87 | 101.33 | 87.00 | 79.82 | 3.55 |
| ACS 98-9 x SG-5 | 26.20 | 45.33 | 31.07 | 29.62 | 1.17 | 75.60 | 95.00 | 91.27 | 78.65 | 4.40 |
| SG.5 x Pb. Guchhadar | 39.67 | 35.00 | 34.53 | 39.78 | 1.54 | 97.13 | 96.53 | 98.20 | 99.48 | 3.44 |
| Arka lohit x SG 5 | 39.47 | 43.60 | 39.47 | 43.48 | 1.12 | 100.40 | 99.87 | 91.40 | 102.77 | 2.49 |
| ACG 77 x S 49 | 41.67 | 32.67 | 33.07 | 39.10 | 1.68 | 108.80 | 79.07 | 87.67 | 99.77 | 3.35 |
| Jwala x DPS 120 | 28.87 | 34.73 | 28.47 | 29.65 | 0.62 | 69.40 | 87.47 | 64.33 | 78.15 | 2.85 |
| | **Plant height (cm)** | | | | | **Number of primary branches** | | | | |
| ACS 97-1 x Pb. Guchhadar | 54.93 | 63.07 | 68.33 | 62.55 | 2.68 | 2.93 | 2.93 | 2.33 | 3.30 | 0.13 |
| ACS 98-9 x SG-5 | 35.07 | 54.53 | 50.87 | 53.17 | 2.71 | 3.33 | 3.00 | 3.47 | 3.02 | 0.09 |
| SG 5 x Pb. Guchhadar | 59.40 | 61.60 | 61.13 | 63.38 | 4.04 | 3.60 | 3.40 | 3.47 | 3.18 | 0.16 |
| Arka lohit x SG 5 | 72.40 | 53.33 | 67.00 | 90.48 | 2.18 | 3.07 | 3.00 | 3.07 | 2.85 | 0.18 |
| ACG 77 x S 49 | 72.93 | 53.07 | 73.87 | 80.38 | 3.26 | 2.73 | 3.00 | 2.60 | 2.37 | 0.15 |
| Jwala x DPS 120 | 58.00 | 68.40 | 60.27 | 49.23 | 3.14 | 2.13 | 3.80 | 2.67 | 2.48 | 0.21 |
| | **Number of secondary branches** | | | | | **Plant width (cm)** | | | | |
| ACS 97-1 x Pb. Guchhadar | 8.67 | 11.53 | 9.27 | 11.12 | 0.35 | 53.13 | 59.73 | 69.23 | 59.64 | 3.11 |
| ACS 98-9 x SG-5 | 9.00 | 9.33 | 10.13 | 10.20 | 0.30 | 53.83 | 46.10 | 62.80 | 54.68 | 3.23 |
| SG 5 x Pb. Guchhadar | 9.93 | 11.13 | 10.87 | 10.38 | 0.65 | 42.40 | 62.20 | 66.33 | 59.72 | 3.14 |
| Arka lohit x SG 5 | 9.53 | 9.33 | 10.27 | 10.07 | 0.46 | 67.37 | 49.93 | 65.30 | 77.52 | 3.74 |
| ACG 77 x S 49 | 9.33 | 10.07 | 9.87 | 9.08 | 0.23 | 54.37 | 46.73 | 65.10 | 73.50 | 3.21 |
| Jwala x DPS 120 | 8.47 | 11.67 | 9.47 | 8.77 | 0.76 | 53.83 | 59.20 | 50.67 | 50.49 | 4.18 |

(Punjab Guchhadar – Pb. Guchhadar)

the components of non additive gene effects were significant. For Arka lohit x SG-5 and ACG-77 x S 49, though significance of simple scaling tests and joint scaling test suggested presence of digenic interactions, but none of the components of principle gene effect or digenic interaction was significant, that might be due to presence of higher order interaction and/or linkages. With cross Jwala x DPS-120 all the components of six parameter model except real epistatic (a x d) were significant, with preponderance of non-additive genes. The magnitude of estimates of various gene effects suggested presence of duplicate and/or complementry digenic interactions for ACS 97-1 x Punjab Guchhadar, ACS 98-9 x SG-5 and Jwala x DPS-120. The findings are in accordance with report of Hasanuzzaman and Golam (2011).

In general for developmental character preponderance of intra and interallelic interactions with marginal influence of additive gene effect was evidenced. As the green fruit yield and its components are largely dependent on developmental characters before crop enters into reproductive stage. Therefore to take advantage of developmental characters for increasing green fruit yield, heterosis breeding is suggested. For crosses, in which additive gene effect or pseudo additive gene effect had significant estimates such crosses may be advanced to develop new inbred lines through pedigree selection.

Six crosses were evaluated for six different developmental characters through generation mean analysis. For days to flower, days to fruit ripening, plant height and plant width both additives as well various components of non-additive gene effects were at work with preponderance of dominance and pseudo additive gene effects. Non-additive gene effect was found more

**Table 2** Estimates of scaling tests and gene effects for green fruit yield and its components in chilli

| Cross | Scaling tests | | | | $X^2$ (3d.f) | Gene effects | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | | M | D | h | I | j | l |
| **Days to flower** | | | | | | | | | | | |
| ACS 97-1 x Pb. Guchhadar | -1.60 | 3.20 | -6.33 | 3.96 | 5.81 | 34.35** | -1.98** | -4.89** | - | - | - |
| ACS 98-9 x SG-5 | -0.80 | -0.53 | -15.20** | -6.93** | 27.79** | 29.61** | -9.70** | 9.16* | 13.87** | -0.13 | -12.53** |
| SG-5 x Punjab Guchhadar | 0.60 | -2.73 | 15.40** | 8.77** | 17.41** | 39.78** | 4.00* | 20.33** | -17.53** | 1.67 | 19.67* |
| Arka Lohit x SG-5 | -1.13 | -10.27** | 11.80 | 11.60** | 19.87** | 43.48** | 2.43 | -25.33** | -23.20** | 4.57 | 34.59** |
| ACG 77 x S 49 | -4.13 | 9.33** | 15.93** | 5.37 | 21.86** | 39.10** | -2.23 | -14.83* | -10.73 | -6.73** | 5.53 |
| Jwala x DPS 120 | 0.27 | 1.33 | -1.93 | -1.77 | 1.08 | 31.82** | -3.10** | -3.31** | - | - | - |
| **Days to fruit ripening** | | | | | | | | | | | |
| ACS 97-1 x Pb. Guchhadar | -21.80** | 1.27 | -46.93** | -13.20** | 32.45** | 79.81** | -16.76** | 17.30 | 26.40** | -11.53** | -5.87 |
| ACS 98-9 x SG-5 | -11.00 | -0.60 | -38.53** | -13.43* | 17.08** | 78.65** | -14.90** | 32.90** | 26.93** | -5.20 | -15.33 |
| SG-5 x Punjab Guchhadar | 5.53 | -4.33 | 7.87 | 3.33 | 4.97 | 96.99** | 1.12 | 2.98** | - | - | - |
| Arka Lohit x SG-5 | -14.80* | 1.00 | 28.00** | 20.90** | 27.09** | 102.77** | -7.63* | -50.53** | -41.80** | -7.90* | 55.60** |
| ACG 77 x S 49 | 3.67 | 33.53** | 35.87** | -0.67 | 34.70** | 99.77** | -0.07 | -4.93 | 1.33 | -14.93** | -38.53** |
| Jwala x DPS 120 | 3.80 | 29.93** | 27.06** | -3.33 | 39.78** | 78.15** | -22.10** | -7.43 | 6.67 | -13.07** | -40.40** |
| **Plant height (cm)** | | | | | | | | | | | |
| ACS 97-1 x Pb. Guchhadar | 7.33* | 15.60* | -4.47 | -13.70** | 10.35** | 62.55** | -8.20* | 36.73** | 27.40** | -4.13 | -50.33** |
| ACS 98-9 x SG-5 | 6.87 | 21.23** | 21.33** | -3.33 | 19.60** | 53.17** | -16.86** | 12.73 | 6.67 | -7.13* | -34.67** |
| SG-5 x Punjab Guchhadar | -10.53 | 34.53** | 10.27 | -6.87 | 41.52** | 63.28** | -23.63** | 14.36 | 13.73 | -22.53** | -37.73* |
| Arka Lohit x SG-5 | 20.73* | 17.60** | 102.20** | 31.93** | 83.70** | 90.48** | 11.10** | -59.73** | -63.86** | 1.57 | 25.53 |
| ACG 77 x S 49 | 12.20 | 11.93 | 47.80** | 11.83** | 20.28** | 80.38* | 10.06* | -12.80 | -23.66** | 0.13 | -0.47 |
| Jwala x DPS 120 | -2.60 | 14.60* | -50.00** | -31.00** | 56.42** | 49.23** | -13.80** | 59.07** | 61.99** | -8.60* | -74.00** |
| **Number of primary branches** | | | | | | | | | | | |
| ACS 97-1 x Pb. Guchhadar | 0.63 | 0.60 | 2.67** | 0.73* | 19.76** | 3.30** | 0.00 | -2.77** | -1.47* | 0.00 | 0.27 |
| ACS 98-9 x SG-5 | -0.53 | 0.33 | -1.20 | -0.50 | 9.66** | -3.10** | 0.04 | 0.24 | - | - | - |
| SG-5 x Punjab Guchhadar | -0.60 | -0.27 | -1.20 | 0.17 | 3.53 | 3.36** | 0.05 | 0.08 | - | - | - |
| Arka Lohit x SG-5 | 0.20 | 0.27 | -0.80 | -0.63* | 4.86 | 2.85** | 0.00 | 1.30* | 1.27* | -0.03 | -1.73 |
| ACG 77 x S 49 | -0.27 | -0.47 | -1.47** | -0.37 | 11.29** | 2.37** | -0.03 | 0.47 | 0.73 | 0.10 | 0.00 |
| Jwala x DPS 120 | 0.27 | -2.00** | -1.33* | 0.20 | 49.04** | 2.48** | 0.30 | 0.70 | -0.40 | 1.13** | 2.13* |
| **Number of secondary branches** | | | | | | | | | | | |
| ACS 97-1 x Pb. Guchhadar | 2.87** | -0.27 | 5.73** | 1.57 | 21.10** | 11.11* | 0.13 | -3.97* | -3.13 | 1.57* | 0.53 |
| ACS 98-9 x SG-5 | 0.87 | 2.87* | 2.20 | -0.77 | 9.65* | 10.20** | -1.16* | 2.50 | 1.53 | -1.00 | -5.27* |
| SG-5 x Punjab Guchhadar | -0.20 | -1.13 | -1.26 | 0.03 | 1.52 | 10.40** | -0.48 | 0.18 | - | - | - |
| Arka Lohit x SG-5 | 1.53 | 0.53 | 0.87 | -0.60 | 2.78 | 9.56** | 0.24 | 0.11 | - | - | - |
| ACG 77 x S 49 | -0.33 | 0.47 | -1.47 | -0.80 | 1.86 | 9.64** | -0.43 | -0.05 | - | - | - |
| Jwala x DPS 120 | 1.40 | -2.80** | -4.00** | -1.30 | 16.11** | 8.77** | 0.50 | 2.00 | 2.60 | 2.10 | 1.20 |
| **Plant width (cm)** | | | | | | | | | | | |
| ACS 97-1 x Pb. Guchhadar | 1.13 | 9.95 | -12.75 | -11.92* | 6.08 | 59.64** | -7.72* | 36.63** | 23.84** | -4.41 | -34.93 |
| ACS 98-9 x SG-5 | 3.10 | 10.80** | -6.80 | -14.35** | 10.69* | 54.68** | -3.98 | 41.53** | 28.70** | -7.85* | -50.60** |
| SG-5 x Punjab Guchhadar | 0.57 | 9.13 | 3.63 | -3.03 | 2.40 | 51.92** | -9.67** | 15.75** | - | - | - |
| Arka Lohit x SG-5 | 22.00** | 28.37** | 62.18** | 5.90 | 29.31** | 77.52** | 5.53 | -5.16 | -11.80 | -3.18 | -38.55 |
| ACG 77 x S 49 | 10.63 | 20.80** | 62.70** | 15.63** | 25.11** | 73.50** | -1.27 | -16.72 | -31.27** | -5.08 | -0.16 |
| Jwala x DPS 120 | 11.90* | 23.43** | -12.40 | -23.87** | 19.68** | 50.49** | -8.45* | 41.88** | 47.73** | -5.76 | -83.07* |

*, ** Significant at 5 and 1 per cent level of significance, respectively (Punjab Guchhadar – Pb. Guchhadar)

important in the inheritance of number of primary as well as secondary branches. Duplicate, complementary and/or both types of epistatic gene actions were evidenced for all above developmental characters. For earliness importance of additive and non-additive gene effects, with larger contribution of dominance gene effect was observed, and for plant growth attributes non-additive gene effects prepondend. Therefore, heterosis breeding is suggested and crosses/genotypes may be identified by which most of the photosynthates (source) converted into economic yield (sink).

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