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# Genotype × environment interaction and stability analysis for yield and biochemical traits in pumpkin (*Cucurbita moschata* Duch. ex Poir.)

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## Abstract

The present investigation was conducted with aim to know the interaction of genotype with environment of parents (6) and their off-springs (15) developed through diallel mating design excluding reciprocals. The trials were conducted during *Kharif*, 2015 ($E_1$), *Rabi,* 2015-16 ($E_2$) (Off-season), *Zaid* (summer season,) 2016 ($E_3$). The observations were recorded for twenty one traits (14 yield & yield attributing traits and 7 biochemical traits). The present study revealed that the mean squares due to environment + G×E, environment linear, genotype × environment and G×E linear were found significant for all traits except G×E for average fruit weight and G×E linear for flesh thickness. The present investigation revealed that the *Kharif* and Summer-season favourable for most of the traits studied. The top five stable $F_1$/genotypes on the basis of *per se* performance, phenotypic index and $S^2di$ were Narendra Upkar ($P_1$) × Kashi Harit ($P_5$), NDPK-39-2 ($P_4$) × NDPK-11-3 ($P_6$), Narendra Agrim ($P_3$) × Kashi Harit ($P_5$), Narendra Upcar ($P_1$) × NDPK-120 ($P_2$), NDPK-39-2 ($P_4$) × Kashi Harit ($P_5$) for maturity traits and NDPK-39-2 ($P_4$) × NDPK-11-3 ($P_6$), Narendra Upkar ($P_1$) × Kashi Harit ($P_5$), Narendra Upkar ($P_1$) × NDPAK-120 ($P_2$), Narendra Agrim ($P_3$) × Kashi Harit ($P_5$), Narendra Upkar ($P_1$) × NDPK-39-2 ($P_4$) for fruit yield per plant, number of fruits per plant and other yield attributes while, crosses namely, $P_2$ × $P_3$, Narendra Upcar ($P_1$) × NDPK-39-2 ($P_4$), NDPK-120 ($P_2$) × Kashi Harit ($P_5$), Narendra Upkar ($P_1$) × NDPK-120 ($P_2$), Narendra Upkar ($P_1$) × Narendra Agrim ($P_3$) for biochemical traits. The present study further revealed that the top five stable genotypes for any of the characters are only $F_1$ rather than either of parental line/varieties which reveals that $F_1$ are more stable than the parental lines/varieties. Hence it can be concluded that $F_1$s are more suitable for stable performance under varying environmental condition than the parental lines/varieties. Thus, $F_1$s should prefer for cultivation under changing/adverse environmental condition for high and stable yield for secure production in future.

**Key words:** Pumpkin, Diallel Mating Design, stability analysis, fruit yield and biochemical traits

## Introduction

Cucurbita (2x = 2n = 40) is an important cucurbitaceous plant that is widely grown as a commercial crop across the globe. It is known to have high nutritional value and health protective properties; therefore, it has attracted an increased interest in recent years. Cucurbita includes five cultivated species: *Cucurbita maxima*, *Cucurbita moschata*, *Cucurbita pepo*, *Cucurbita ficifolia* and *Cucurbita mixta* (Naik et al. 2015). *C. pepo* is the species with the greatest economic value (Paris et al. 2008). The edible portions of *C. pepo*, such as the fruit, flower, leaf and seeds, are rich in sugars, fatty acids, fiber, protein, vitamins and minerals, so they can play a protective role as part of a healthy diet, in cancer prevention and in the treatment of benign

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prostate hyperplasia (Schmidlin and Kreuter 2004). However, the few high-quality varieties of *C. pepo* are not enough to satisfy the huge market demand and have limitations in the development of *Cucurbita* breeding programs. The color of pumpkins is derived from the orange pigments abundant in them. The main nutrients are lutein and both alpha and beta carotene, the latter of which generates vitamin A in the body. Pumpkins are very versatile in their uses for cooking. Most parts of the pumpkin are edible, including the fleshy shell, seeds, leaves, and even flowers. Pumpkin purée is sometimes prepared and frozen for later use.

Pumpkin is relatively high in energy and carbohydrates with a good source of vitamins, especially high caretenoid pigments and minerals. It may certainly contribute to improve nutritional status of the people, particularly the vulnerable groups in respect of vitamin A requirement. Night-blindness is a serious problem of South Asian countries. Encouraging the mass people to take more pumpkin can easily solve this problem. The total area of pumpkin in India is 78000 hectares whereas, the total production is 1.71 million tonne with productivity 21.97 MT/ha (NHB 2018). Varietal adaptability to environmental fluctuation is important for the stabilization of crop production both over regions and years. Stability analysis helps in the identification of location specific and widely adapted genotype and it can be performed with both parental as well as segregating populations (Admassu et al. 2008). Selection of best genotypes adapted to the wide range of environment specifically suitable for each of the growing seasons may help to improve the selection efficiency as well as the productivity of pumpkin. Therefore, to identify stable varieties or genotypes over different environments, study of genotype × environment (G×E) interactions was felt essential as preliminary step (Eberhart and Russell 1966). For developing better and stable varieties for yield components, it is necessary to screen the available genotypes over a wide range of climate for their commercial exploitation or effective utilization in breeding programme. Grafuis (1959) emphasized that the study of individual yield components can lead to signification in genetic explanation of yield stability.

## Materials and Methods

The experiments of the present research work was conducted during *Kharif,* 2015 ($E_1$), *Rabi* 2015-16 ($E_2$) and *Zaid,* ($E_3$) of 2016 at Main Experiment Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.) which falls under humid sub-tropical climate and is located in between 24.47º and 26.56º N latitude, and 82.12º and 83.58º E longitude at an altitude of 113 m above the mean sea level. The experimental materials for the present study comprised of six promising diverse inbreds and varieties of pumpkin, selected on the basis of genetic variability from the germplasm stock. The selected parental lines *i.e.* Narendra Upkar ($P_1$), NDPK-120 ($P_2$), Narendra Agrim ($P_3$), NDPK-39-2 ($P_4$), Kashi Harit ($P_5$) and NDPK-11-3 ($P_6$) were raised and crossed with the all possible combinations, excluding reciprocals in diallel mating design, during *Zaid*, 2015 to get 15 $F_1$ hybrid seeds for the study of stability for twenty one quantitative traits including biochemical traits. Observations were recorded on fourteen horticultural traits *viz.*, days to first female flower anthesis, days to first male flower anthesis, node number to first male flower appearance, node number to first female flower appearence, days to first fruit harvest, vine length (m), internodal length (cm), number of primary branches per plant, fruit weight (kg), number of fruits per plant, equatorial circumference of fruit (cm), polar circumference of fruit (cm), flesh thickness (cm), fruit yield per plant (kg) and seven biochemical traits viz., dry matter content (%), total soluble solids (°B), reducing sugars (%), non-reducing sugars (%), total sugars (%), ascorbic acid (mg/100g) and β-carotene (mg/100g).

*Ascorbic acid:* Ascorbic acid content was estimated by crushing 10 g fresh fruit with 3% metaphosphoric acid ($HPO_3$) as buffer. The extract was filtered and 100 ml volume was made with 3% $HPO_3$. 10 ml aliquot was titrated against, 2,6-dichlorophenol-indophenol dye solution till the light pink colour appeared. The results were expressed as mg/100g of fresh fruit (AOAC 1970).

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titrated value (ml)} \times \text{Dye factor x Vol. made up (ml)}}{\text{Aliquot of extract taken (ml)} \times \text{Weight of sample taken for estimation (g)}} \times 100$$

*Reducing sugars:* Reducing sugars were estimated by Fehling 'A' and 'B' solution method given by Ranganna (1991). 10 g fresh fruit was macerated in the small amount of distilled water and filtered through muslin cloth and maintained volume up to 100 ml. An aliquot of 5 ml diluted fruit juice was taken from 100 ml as above for titration and mixed with 10 ml of Fehling 'A' and 'B' solution each. This mixture was titrated against 1.0% glucose. A blank with 10 ml of Fehling 'A' and 'B' was also run. The results were expressed as per cent reducing sugars. For estimation invert sugar, out of 100 ml sample, 5 ml aliquot was taken, mixed with three drops of HCl and kept overnight. Next day 2-3 drops of phenolphthalein indicator was added and neutralized with 30 per cent sodium hydroxide (NaOH) solution containing 10 ml Fehling 'A' and 'B'. This mixture was titrated against 1.0% glucose in boiling solution using methylene blue indicator. The appearance of red or black colour was marked as the end point. The results were expressed as per cent total invert sugars.

*Non-reducing sugars:* Non-reducing sugars was calculated by deducting the quantity of reducing sugars from total invert sugars and multiplied by factor 0.95. The results were expressed as per cent non-reducing sugars.

*Total sugars:* Total sugars were calculated by adding the quantity of reducing and non-reducing sugars. The results were expressed as total sugars in per cent.

Total sugars (%) = Reducing sugar (%) + Non-reducing sugars (%)

*Dry matter:* It was estimated as per procedure of Arora *et al*. (5).

$$\text{Dry matter (\%)} = \frac{W2 - W1}{W} \times 100$$

where, W2 = Weight of dried sample + Weight of empty Petri dish (g)

W1 = Weight of empty Petri dish (g)

W = Weight of sample taken (g)

*Total soluble solids*: Total soluble solids of the juice of fresh fruit of each lines and $F_1$'s were determined with the help of hand refractometer (Erma, Japan) of 0-32%. The values were expressed as per cent TSS of fresh fruit juice.

*β-carotene*: The β- carotene content (mg/100g) was determined in mature fruit sample using the method develoed by Rangana (1997).

The statistical model proposed by Eberhart and Russell (1966) was utilized to estimate stability parameters and genotype x environment interactions for different genotypes of turmeric with respect to different characters. The phenotypic index (Ram et al. 1970) has been introduced in the Eberhart and Russels model for easy interpretation and quick conclusion.

## Results and Discussion

In the present investigation, combined analysis of variance (Table 1) revealed that the mean squares due to genotypes were highly significant for all traits under studied. The mean squares due to environment were also significant for all traits. The mean squares due to environment + G×E, environment linear, genotype × environment and G×E linear were found significant for all traits except G×E for average fruit weight and G×E linear for flesh thickness. Singh et al. (1991), Prasad and Singh (1990), Krishna and Singh (1990) and Ahmed (2010) also observed significant G x E interaction for yield and its attributing traits.

The results of present study based on five parameters of stability model given by Eberhart and Russell (1966) revealed that none of genotypes had favorable environmental index, positive or negative phenotypic index high Xi, b = 1 and $S^2di = 0$ for all twenty one traits. The environmental index (Ij) directly reflects the favorable and unfavorable environments in terms of positive and negative Ij, respectively. For the maturity traits and internodal length negative (Ij) is favorable. The present investigation revealed (Table 2) that the *Kharif* and Summer-season were found favorable for days to first male and female flower anthesis, node number to first male flower appearance, days to first fruit harvest, equatorial circumference of fruit, polar circumference of fruit, flesh thickness, vine length, average fruit weight, fruit yield per plant, non-reducing sugars. While *Rabi* season was found good for node number to first female flower appearance, number of primary branches per plant, total sugars, reducing sugars, ascorbic acid and β-carotene. However, only summer-season observed good for intermodal length, number of fruits per plant, dry matter content, total soluble solids, total sugars and β-carotene

**Table 1:** Combined analysis of variance of 21 characters for stability (Eberhart and Russell 1966) in pumpkin

| Source of variation | d.f. | Mean squares | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Days to first male flower anthesis | Days to first female flower anthesis | Node no. to first male flower | Node no. to first female flower | Days to first fruit harvest | No. of primary branches per plant | Equotorial circumf. of fruit | Polar circumf. of fruit | Flesh thickness | Inter-nodal length (cm) | Vine length (m) | Average fruit weight | No. of fruits/ plant | Fruit yield per plant | Dry matter content | Total soluble solids | Total sugars | Reducing sugars | Non-reducing sugars | Ascorbic acid | β-carotene |
| G | 20 | 38.48** | 28.02** | 1.07** | 5.55** | 65.40** | 5.30** | 56.81** | 11.07** | 0.08* | 2.36** | 1.095** | 0.11** | 1.09** | 4.56** | 1.42** | 1.43*** | 0.69** | 0.51** | 0.20** | 2.93** | 3.85** |
| E | 2 | 22775.56** | 19231.49** | 31.02** | 234.69** | 19672.99 | 1.82** | 112.86** | 46.90** | 0.004 | 0.20*** | 10.58** | 2.14** | 0.41** | 23.84** | 0.66** | 0.83** | 0.39** | 1.96** | 1.03** | 3.22** | 1.89** |
| ENV + (G×E) | 42 | 1093.12** | 926.46** | 1.80** | 12.63** | 951.03 | 0.83** | 11.23** | 5.32** | 0.037 | 0.99** | 0.83** | 0.10** | 0.057** | 1.26** | 0.51** | 0.31** | 0.50** | 3.14** | 0.18** | 1.10** | 0.64** |
| G x E | 40 | 9.00** | 11.21** | 0.34** | 1.53** | 14.93 | 0.78** | 6.15** | 3.24** | 0.03* | 1.03** | 0.35** | 0.001 | 0.039** | 0.13** | 0.51** | 0.29** | 0.51** | 0.26** | 0.14** | 0.99** | 0.58** |
| E linear | 1 | 45551.13** | 38462.99** | 62.05** | 469.39** | 39345.98 | 3.65** | 225.72** | 93.80** | 0.001 | 0.40** | 21.17** | 4.29** | 0.82** | 47.68** | 1.33** | 1.66** | 0.78** | 35.65** | 2.06** | 6.44** | 3.78** |
| G×E linear | 20 | 15.20** | 15.11** | 0.599** | 2.44** | 17.78 | 1.48** | 10.41** | 4.18** | 0.08* | 0.77** | 0.65** | 0.000 | 0.02* | 0.09* | 0.22** | 0.08* | 0.29 | 0.41** | 0.22** | 1.32** | 0.90** |
| Pooled Deviation | 21 | 2.66** | 6.95** | 0.084 | 0.58 | 11.78 | 0.081 | 1.80 | 2.20 | -0.004 | 1.23 | 0.04 | 0.001 | 0.05 | 0.16 | 0.76** | 0.47 | 0.69 | 0.11 | 0.05 | 0.63 | 0.24 |
| Pooled error | 120 | 0.073 | 0.420 | 0.04 | 0.28 | 0.59 | 0.02 | 1.92 | 0.42 | 0.016 | 0.05 | 0.09 | 0.004 | 0.01 | 0.09 | 0.06 | 0.05 | 0.05 | 0.04 | 0.05 | 0.023 | 0.03 |

G; Genotype; E: Environment; *,**Significant at 5% and 1% levels, respectively

**Table 2:** Stability analysis for growth, yield and biochemical traits of 21 genotypes of pumpkin evaluated in three seasons during 2015-2016

| Genotypes | Days to first female flower anthesis | | | | | | | Days to first male flower anthesis | | | | | | | Node number to first male flower appearance | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ |
| $P_1 \times P_2$ | 41.33 | 90.33 | 40.66 | 57.44 | -2.68 | 0.86 | -0.02 | 43.11 | 90.11 | 42.89 | 58.70 | -2.17 | 0.89 | -0.13 | 3.89 | 6.78 | 3.89 | 4.85 | -0.24 | 1.37 | -0.01 |
| $P_1 \times P_3$ | 39.22 | 93.44 | 38.55 | 57.07 | -2.90 | 0.95 | 0.08 | 46.22 | 92.11 | 42.66 | 60.33 | -0.54 | 0.90 | 5.49** | 3.89 | 5.83 | 4.09 | 4.60 | -0.49 | 0.87 | 0.01 |
| $P_1 \times P_4$ | 38.66 | 96.33 | 37.99 | 57.66 | -2.46 | 1.02 | -0.02 | 43.33 | 94.22 | 43.11 | 60.22 | -0.65 | 0.97 | -0.14 | 3.64 | 6.45 | 3.64 | 4.58 | -0.51 | 1.33 | -0.01 |
| $P_1 \times P_5$ | 38.22 | 99.44 | 37.55 | 58.40 | -5.38 | 0.88 | -0.02 | 38.82 | 85.44 | 38.60 | 54.29 | -6.58 | 0.89 | -0.13 | 4.33 | 5.00 | 4.33 | 4.56 | -0.54 | 0.31 | -0.01 |
| $P_1 \times P_6$ | 39.67 | 101.22 | 39.00 | 59.96 | -0.31 | 1.08 | 0.10 | 42.89 | 98.33 | 46.00 | 62.41 | 1.53 | 1.02 | 5.44** | 4.09 | 6.42 | 3.89 | 4.80 | -0.29 | 1.15 | 0.01 |
| $P_2 \times P_3$ | 38.85 | 96.44 | 38.18 | 57.82 | -2.29 | 1.01 | -0.02 | 43.83 | 93.44 | 43.61 | 60.29 | -0.57 | 0.94 | -0.13 | 3.82 | 6.50 | 3.82 | 4.71 | -0.38 | 1.27 | -0.01 |
| $P_2 \times P_4$ | 41.33 | 98.88 | 40.66 | 60.29 | 0.16 | 1.01 | -0.02 | 42.78 | 96.66 | 42.56 | 60.67 | -0.20 | 1.03 | -0.14 | 4.79 | 7.37 | 4.79 | 5.65 | 0.55 | 1.22 | -0.01 |
| $P_2 \times P_5$ | 47.00 | 94.44 | 46.33 | 62.59 | 0.17 | 0.89 | 23.24** | 40.22 | 92.00 | 48.33 | 60.18 | -0.68 | 0.91 | 34.44** | 5.44 | 5.55 | 4.22 | 5.07 | -0.02 | 0.34 | 0.72 |
| $P_2 \times P_6$ | 40.11 | 96.33 | 39.44 | 58.63 | -1.72 | 0.97 | -0.02 | 42.56 | 94.88 | 42.33 | 59.92 | -0.94 | 1.00 | -0.14 | 5.33 | 6.77 | 5.33 | 5.81 | 0.71 | 0.68 | -0.01 |
| $P_3 \times P_4$ | 40.11 | 99.44 | 39.44 | 59.66 | 1.84 | 0.98 | 23.77** | 48.56 | 97.55 | 40.00 | 62.04 | 1.16 | 1.01 | 34.57** | 4.22 | 4.90 | 5.44 | 4.85 | -0.24 | 0.03 | 0.72 |
| $P_3 \times P_5$ | 37.55 | 95.22 | 36.88 | 56.55 | -3.57 | 1.01 | -0.02 | 39.56 | 94.89 | 39.33 | 57.93 | -2.94 | 1.05 | -0.13 | 3.78 | 5.45 | 3.78 | 4.33 | -0.76 | 0.79 | -0.01 |
| $P_3 \times P_6$ | 41.00 | 99.22 | 40.33 | 60.18 | 0.06 | 1.02 | -0.03 | 42.40 | 95.89 | 42.17 | 60.15 | -0.71 | 1.02 | -0.14 | 3.34 | 6.08 | 3.34 | 4.25 | -0.84 | 1.30 | -0.01 |
| $P_4 \times P_5$ | 41.78 | 96.44 | 41.11 | 59.78 | -1.35 | 0.99 | 4.44** | 38.34 | 93.55 | 46.22 | 59.37 | -1.49 | 0.97 | 32.70** | 3.92 | 5.68 | 4.40 | 4.67 | -0.43 | 0.72 | 0.10 |
| $P_4 \times P_6$ | 36.45 | 100.22 | 35.78 | 57.48 | -6.34 | 0.92 | -0.02 | 40.22 | 87.55 | 40.00 | 55.92 | -4.94 | 0.90 | -0.13 | 4.30 | 5.20 | 4.30 | 4.60 | -0.50 | 0.42 | -0.01 |
| $P_5 \times P_6$ | 38.78 | 103.66 | 38.11 | 60.18 | 1.05 | 1.11 | 4.23** | 46.45 | 98.55 | 38.11 | 61.04 | 0.16 | 1.07 | 32.61** | 4.40 | 6.50 | 3.92 | 4.94 | -0.15 | 1.11 | 0.10 |
| $P_1$ | 43.22 | 100.33 | 42.55 | 62.03 | 1.91 | 1.00 | -0.02 | 41.77 | 99.11 | 41.54 | 60.81 | -0.06 | 1.09 | -0.14 | 5.56 | 7.85 | 5.56 | 6.32 | 1.22 | 1.08 | -0.01 |
| $P_2$ | 50.33 | 103.00 | 49.66 | 67.66 | 7.53 | 0.92 | -0.02 | 50.89 | 100.11 | 50.67 | 67.22 | 6.35 | 0.94 | -0.14 | 4.44 | 7.30 | 4.44 | 5.40 | 0.29 | 1.35 | -0.01 |
| $P_3$ | 48.22 | 101.33 | 47.55 | 65.70 | 5.57 | 0.93 | -0.02 | 49.56 | 98.22 | 49.33 | 65.70 | 4.83 | 0.93 | -0.14 | 5.00 | 7.50 | 5.00 | 5.83 | 0.73 | 1.18 | -0.01 |
| $P_4$ | 47.28 | 104.22 | 46.61 | 66.04 | 5.9 | 1.00 | -0.02 | 49.11 | 100.33 | 48.89 | 66.11 | 5.24 | 0.97 | -0.14 | 4.56 | 8.27 | 4.56 | 5.79 | 0.69 | 1.76 | -0.01 |
| $P_5$ | 41.00 | 106.33 | 40.33 | 62.55 | 2.42 | 1.15 | -0.02 | 42.45 | 104.11 | 42.22 | 62.93 | 2.05 | 1.17 | -0.13 | 5.14 | 7.25 | 5.14 | 5.85 | 0.74 | 1.0 | -0.01 |
| $P_6$ | 40.28 | 107.66 | 39.61 | 62.52 | 2.39 | 1.18 | -0.01 | 40.65 | 105.00 | 40.43 | 62.03 | 1.15 | 1.22 | -0.13 | 4.44 | 7.88 | 4.44 | 5.59 | 0.48 | 1.63 | -0.01 |
| $I_j$ | -18.67 | 38.02 | -19.34 | | | | | -17.35 | 34.94 | -17.58 | | | | | -0.70 | 1.40 | -0.70 | | | | |

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index; Ij: Env. Index

**Table 2: Contd…**

| Genotypes | Node number to first female flower appearance | | | | | | | Days to first fruit harvest | | | | | | | Number of primary branches | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ |
| $P_1 \times P_2$ | 18.33 | 9.50 | 18.33 | 15.39 | -0.17 | 1.52 | -0.09 | 61.00 | 110.75 | 59.55 | 77.10 | -2.55 | 0.87 | -0.17 | 9.17 | 8.31 | 9.17 | 8.88 | 0.21 | -1.67 | -0 .01 |
| $P_1 \times P_3$ | 16.67 | 11.00 | 18.44 | 15.37 | -0.19 | 1.13 | 1.45** | 62.00 | 113.20 | 55.89 | 77.03 | -2.62 | 0.94 | 10.89** | 8.47 | 6.11 | 9.50 | 8.03 | -0.64 | -5.62** | 052 |
| $P_1 \times P_4$ | 18.33 | 12.67 | 18.33 | 16.44 | 0.88 | 0.97 | -0.09 | 57.33 | 115.08 | 55.89 | 76.10 | -3.55 | 1.01 | -0.18 | 9.09 | 8.72 | 9.09 | 8.97 | 0.29 | -0. 02 | -0.01 |
| $P_1 \times P_5$ | 19.00 | 12.61 | 19.00 | 16.87 | 1.31 | 1.10 | -0.9 | 54.22 | 108.11 | 50.55 | 70.96 | -8.69 | 0.96 | 2.28** | 9.16 | 8.80 | 9.16 | 9.04 | 0.37 | -0.71 | -0.01 |
| $P_1 \times P_6$ | 18.44 | 9.97 | 16.67 | 15.03 | -0.53 | 1.30 | 1.51** | 57.33 | 123.22 | 60.22 | 80.26 | 0.60 | 1.11 | 10.16** | 9.50 | 8.97 | 8.47 | 8.98 | 0.30 | -0.03 | 0.52 |
| $P_2 \times P_3$ | 15.53 | 12.28 | 15.53 | 14.45 | -1.11 | 0.56 | -0.09 | 63.22 | 115.19 | 61.55 | 79.99 | 0.33 | 0.91 | -0.14 | 7.80 | 9.68 | 7.80 | 8.43 | -0.24 | 3.67** | -0.01 |
| $P_2 \times P_4$ | 19.33 | 9.87 | 19.33 | 16.18 | 0.62 | 1.63 | -0.09 | 64.33 | 118.30 | 57.55 | 80.06 | 0.40 | 0.99 | 13.81** | 8.83 | 9.88 | 8.83 | 9.18 | 0.50 | 2.04** | -0.01 |
| $P_2 \times P_5$ | 17.67 | 10.33 | 15.22 | 14.41 | -1.15 | 1.05 | 2.93** | 55.67 | 114.10 | 68.22 | 79.33 | -0.32 | 0.89 | 96.37** | 9.46 | 7.31 | 8.67 | 8.48 | -0.19 | -3.42** | 0.30 |
| $P_2 \times P_6$ | 16.78 | 10.75 | 17.11 | 14.88 | -0.68 | 1.06 | -0.04 | 57.67 | 117.88 | 56.22 | 77.26 | -2.39 | 1.05 | -0.18 | 8.23 | 9.92 | 8.23 | 8.79 | 0.12 | 3.29** | -0.09 |
| $P_3 \times P_4$ | 15.22 | 9.75 | 17.67 | 14.21 | -1.34 | 1.15 | 2.85** | 69.67 | 122.33 | 54.22 | 82.07 | 2.41 | 1.04 | 96.18** | 8.67 | 10.50 | 9.46 | 9.54 | 0.86 | 2.81** | 0.30 |
| $P_3 \times P_5$ | 13.78 | 11.00 | 13.78 | 12.85 | -2.71 | 0.47 | -0.09 | 52.33 | 117.65 | 51.55 | 73.85 | -5.80 | 1.13 | 0.23 | 10.19 | 10.59 | 10.19 | 10.33 | 1.65 | 0.78 | -0.01 |
| $P_3 \times P_6$ | 15.44 | 11.92 | 15.44 | 14.27 | -1.29 | 0.60 | -0.09 | 63.00 | 118.43 | 61.55 | 81.00 | 1.34 | 0.97 | -0.19 | 8.12 | 11.08 | 8.12 | 9.11 | 0.43 | 5.80** | -0.01 |
| $P_4 \times P_5$ | 17.22 | 11.14 | 19.00 | 15.79 | 0.22 | 1.20 | 1.44** | 60.44 | 116.55 | 63.55 | 80.18 | 0.52 | 0.94 | 10.01** | 10.28 | 11.29 | 10.41 | 10.66 | 1.99 | 1.85* | -0.01 |
| $P_4 \times P_6$ | 17.11 | 11.87 | 17.11 | 15.36 | -0.19 | 0.90 | -0.09 | 59.00 | 108.44 | 57.55 | 75.00 | -4.65 | 0.86 | -0.18 | 11.56 | 10.85 | 11.56 | 11.33 | 2.65 | -1.39* | -0.01 |
| $P_5 \times P_6$ | 19.00 | 14.56 | 17.22 | 16.92 | 1.36 | 0.61 | 1.49** | 65.00 | 121.21 | 58.33 | 81.51 | 1.86 | 1.03 | 12.94** | 10.41 | 9.12 | 10.28 | 9.94 | 1.26 | -2.4** | -0.01 |
| $P_1$ | 20.33 | 12.44 | 20.33 | 17.70 | 2.14 | 1.36 | -0.09 | 62.33 | 118.77 | 59.22 | 80.11 | 0.45 | 1.00 | 1.10 | 5.35 | 7.35 | 5.35 | 6.02 | -2.65 | 3.91** | -0.01 |
| $P_2$ | 18.65 | 11.50 | 18.65 | 16.27 | 0.70 | 1.23 | -0.09 | 68.66 | 120.77 | 68.78 | 86.07 | 6.41 | 0.90 | 0.87 | 6.47 | 7.09 | 6.47 | 6.68 | -1.99 | 1.22* | -0.01 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_3$ | 14.38 | 10.98 | 14.38 | 13.25 | -2.31 | .58 | -0.09 | 65.55 | 123.54 | 68.11 | 85.73 | 6.08 | 0.98 | 7.88** | 7.65 | 7.87 | 7.65 | 7.72 | -0.94 | 0.42 | -0.01 |
| $P_4$ | 19.56 | 13.83 | 19.56 | 17.65 | 2.08 | 0.98 | -0.09 | 67.44 | 124.32 | 66.66 | 86.14 | 6.48 | 0.99 | 0.05 | 5.83 | 8.51 | 5.83 | 6.73 | -1.94 | 5.23** | -0.01 |
| $P_5$ | 18.04 | 12.78 | 18.04 | 16.29 | 0.72 | 0.90 | -0.09 | 59.44 | 127.43 | 60.55 | 82.48 | 2.82 | 1.16 | 3.87** | 6.83 | 8.72 | 6.83 | 7.46 | -1.21 | 3.68** | -0.01 |
| $P_6$ | 18.33 | 14.95 | 18.33 | 17.21 | 1.64 | 0.58 | -0.09 | 58.22 | 126.55 | 56.77 | 80.51 | 0.85 | 1.19 | -0.13 | 7.44 | 8.58 | 7.44 | 7.82 | -0.84 | 2.23** | -0.01 |
| $I_j$ | 1.92 | -3.86 | 1.94 | | | | | -18.54 | 38.52 | -20.01 | | | | | -0.17 | 0.34 | -0.17 | | | | |

.*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index

**Table 2: Contd…**

| Genotypes | Equatorial circumference of fruit (cm) | | | | | | | Polar circumference of fruit (cm) | | | | | | | Flesh thickness (cm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ |
| $P_1 \times P_2$ | 61.00 | 50.66 | 61.29 | 57.65 | 4.12 | 2.61** | -0.53 | 53.11 | 42.67 | 53.71 | 49.83 | 3.48 | 2.07** | -0.29 | 2.55 | 2.60 | 2.55 | 2.57 | -0.03 | -7.20** | -0.005 |
| $P_1 \times P_3$ | 60.43 | 53.67 | 63.09 | 59.06 | 5.53 | 2.04** | 1.49* | 46.65 | 44.63 | 50.83 | 47.37 | 1.03 | 0.86 | 6.27** | 2.61 | 2.80 | 2.92 | 2.78 | 0.17 | -5.33** | 0.04 |
| $P_1 \times P_4$ | 54.42 | 57.67 | 54.71 | 55.60 | 2.07 | -0.76 | -0.50 | 52.45 | 45.12 | 53.05 | 50.21 | 3.87 | 1.47* | -0.46 | 2.62 | 2.43 | 2.62 | 2.55 | -0.04 | 27.05** | -0.008 |
| $P_1 \times P_5$ | 54.42 | 52.28 | 54.71 | 53.81 | 0.28 | 0.57 | -0.63 | 44.67 | 44.00 | 45.27 | 44.65 | -1.69 | 0.19 | -0.38 | 2.66 | 2.82 | 2.66 | 2.71 | 0.11 | -22.40** | -0.007 |
| $P_1 \times P_6$ | 62.80 | 53.75 | 60.72 | 59.09 | 5.56 | 1.96* | 2.87** | 50.23 | 48.00 | 47.25 | 48.49 | 2.15 | 0.09 | 4.12** | 2.92 | 2.97 | 2.61 | 2.83 | 0.23 | -29.09** | 0.037 |
| $P_2 \times P_3$ | 53.25 | 42.83 | 53.54 | 49.87 | -3.65 | 2.63** | -0.53 | 44.89 | 37.13 | 45.49 | 42.50 | -3.83 | 1.55* | -0.45 | 2.16 | 3.02 | 2.16 | 2.44 | -0.15 | -122.91** | -0.072 |
| $P_2 \times P_4$ | 55.50 | 53.40 | 55.79 | 54.90 | 1.37 | 0.56 | -0.63 | 45.63 | 47.33 | 46.23 | 46.40 | 0.05 | -0.25 | -0.21 | 2.75 | 2.68 | 2.75 | 2.73 | 0.12 | 9.41** | -0.005 |
| $P_2 \times P_5$ | 57.42 | 54.67 | 54.96 | 55.68 | 2.115 | 0.34 | 2.64** | 56.11 | 48.23 | 45.60 | 49.98 | 3.64 | 0.32 | 57.45** | 2.73 | 2.65 | 2.73 | 2.71 | 0.10 | 11.83** | -0.006 |
| $P_2 \times P_6$ | 53.00 | 51.75 | 53.29 | 52.68 | -0. 84 | 0.35 | -0.62 | 51.78 | 48.07 | 52.39 | 50.74 | 4.40 | 0.78 | -0.49 | 2.72 | 2.12 | 2.72 | 2.52 | -0.08 | 85.64** | -0.372 |
| $P_3 \times P_4$ | 54.67 | 49.25 | 57.71 | 53.87 | 0.34 | 1.76* | 2.56** | 44.99 | 46.50 | 56.72 | 49.40 | 3.06 | 1.03* | 61.71** | 2.73 | 2.67 | 2.73 | 2.71 | 0.11 | 9.38** | -0.005 |
| $P_3 \times P_5$ | 51.67 | 46.25 | 51.96 | 49.96 | -3.56 | 1.38 | -0.63 | 48.89 | 52.93 | 49.50 | 50.44 | 4.10 | -0.70 | 0.03 | 2.82 | 2.76 | 2.82 | 2.80 | 0.19 | 7.99** | -0.005 |
| $P_3 \times P_6$ | 58.83 | 50.75 | 59.12 | 56.24 | 2.70 | 2.04** | -0.59 | 51.21 | 42.55 | 51.82 | 48.53 | 2.19 | 1.73* | -0.41 | 2.52 | 2.63 | 2.52 | 2.56 | -0.04 | -16.76** | -0.006 |
| $P_4 \times P_5$ | 57.83 | 54.25 | 63.37 | 58.49 | 4.95 | 1.65* | 12.21** | 46.73 | 45.94 | 54.49 | 49.05 | 2.71 | 1.03 | 25.25** | 2.57 | 3.08 | 2.48 | 2.71 | 0.11 | -79.80** | -0.03 |
| $P_4 \times P_6$ | 55.50 | 55.75 | 55.79 | 55.68 | 2.15 | -0.02 | -0.59 | 44.78 | 50.93 | 45.39 | 47.03 | 0.69 | -1.11 | 0.31 | 2.89 | 2.28 | 2.89 | 2.69 | 0.08 | 86.07** | -0.03 |
| $P_5 \times P_6$ | 63.08 | 60.50 | 58.12 | 60.57 | 7.04 | -0.04 | 11.65** | 53.89 | 46.79 | 47.33 | 49.34 | 2.99 | 0.62 | 23.75** | 2.48 | 2.52 | 2.57 | 2.52 | -0.07 | 1.14 | -0.002 |
| $P_1$ | 54.67 | 48.37 | 54.96 | 52.66 | -0.86 | 1.60* | -0.62 | 48.00 | 37.00 | 48.61 | 44.54 | -1.80 | 2.18** | -0.25 | 2.82 | 2.53 | 2.82 | 2.72 | 0.12 | 40.35** | -0.01 |
| $P_2$ | 46.38 | 47.16 | 46.67 | 46.74 | -6.78 | -0.15 | -0.58 | 46.51 | 37.79 | 47.11 | 43.80 | -2.53 | 1.74* | -0.40 | 2.13 | 2.28 | 2.13 | 2.18 | -0.41 | -20.51** | -0.004 |
| $P_3$ | 47.75 | 45.40 | 48.04 | 47.06 | -6.46 | 0.62 | -0.63 | 40.53 | 34.57 | 41.13 | 38.74 | -7.59 | 1.21* | -0.49 | 2.32 | 2.32 | 2.32 | 2.32 | -0.28 | -0.07 | -0.005 |
| $P_4$ | 50.58 | 45.20 | 50.87 | 48.89 | -4.64 | 1.37* | -0.63 | 44.84 | 34.55 | 45.45 | 41.61 | -4.72 | 2.04** | -0.31 | 2.45 | 2.03 | 2.45 | 2.31 | -0.29 | 59.44** | -0.02 |
| $P_5$ | 48.19 | 46.28 | 48.48 | 47.65 | -5.87 | 0.51 | -0.62 | 42.85 | 33.67 | 43.45 | 39.99 | -6.35 | 1.83* | -0.38 | 2.58 | 2.69 | 2.58 | 2.62 | 0.01 | -16.70** | -0.006 |
| $P_6$ | 47.67 | 48.12 | 47.96 | 47.91 | -5.61 | -0.07 | -0.59 | 44.11 | 32.62 | 44.71 | 40.48 | -5.85 | 2.27** | -0.21 | 2.67 | 2.63 | 2.67 | 2.66 | 0.05 | 4.64** | -0.005 |
| $I_j$ | 1.19 | -2.67 | 1.48 | | | | | 1.41 | -3.43 | 2.01 | | | | | 0.002 | -0.005 | 0.002 | | | | |

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index; Ij: Env. Index

**Table 2: Contd…**

| Genotypes | Intermodal length (cm) | | | | | | | Vine length (m) | | | | | | | Average fruit weight (kg) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ |
| $P_1 \times P_2$ | 7.20 | 5.47 | 7.00 | 6.56 | -0.69 | 1.12 | 0.09 | 3.75 | 2.97 | 4.05 | 3.59 | 0.36 | 0.78 | -0.02 | 2.07 | 1.62 | 2.24 | 1.98 | 0.19 | 1.00 | -0.001 |
| $P_1 \times P_3$ | 7.56 | 6.11 | 6.38 | 6.68 | -0.56 | 5.87** | 0.08 | 4.58 | 2.85 | 4.96 | 4.13 | 0.90 | 1.58* | -0.02 | 2.02 | 1.64 | 2.26 | 1.97 | 0.19 | 0.96 | 0.001 |
| $P_1 \times P_4$ | 9.00 | 5.56 | 8.80 | 7.79 | 0.53 | 1.65* | 2.99** | 4.89 | 2.53 | 5.19 | 4.20 | 0.97 | 2.03** | 0.02 | 1.92 | 1.48 | 2.10 | 1.83 | 0.05 | 1.00 | -0.001 |
| $P_1 \times P_5$ | 6.78 | 5.07 | 6.58 | 6.14 | -1.10 | 1.12 | 0.08 | 3.56 | 1.93 | 3.86 | 3.12 | -0.10 | 1.45 | -0.02 | 2.19 | 1.74 | 2.36 | 2.10 | 0.31 | 1.00 | -0.001 |
| $P_1 \times P_6$ | 6.58 | 6.05 | 7.36 | 6.66 | -0.58 | -4.07** | 0.02 | 4.66 | 2.20 | 4.88 | 3.92 | 0.68 | 2.07** | 0.05 | 2.09 | 1.57 | 2.19 | 1.95 | 0.17 | 1.03 | 0.001 |
| $P_2 \times P_3$ | 9.31 | 5.38 | 9.11 | 7.93 | 0.68 | 1.81* | 4.56** | 4.47 | 2.40 | 4.77 | 3.88 | 0.65 | 1.80* | 0.00 | 2.01 | 1.57 | 2.19 | 1.92 | 0.14 | 1.00 | -0.001 |
| $P_2 \times P_4$ | 8.50 | 7.11 | 8.30 | 7.97 | 0.72 | 1.02 | -0.1 | 3.36 | 2.55 | 3.66 | 3.19 | -0.03 | 0.80 | -0.02 | 1.84 | 1.40 | 2.02 | 1.75 | -0.02 | 1.00 | -0.001 |
| $P_2 \times P_5$ | 7.91 | 6.99 | 6.32 | 7.07 | -0.17 | 7.71** | 0.84 | 3.20 | 2.67 | 3.28 | 3.05 | -0.17 | 0.46 | -0.02 | 1.76 | 1.23 | 1.85 | 1.61 | -0.16 | 1.03 | 0.003 |
| $P_2 \times P_6$ | 7.29 | 6.24 | 7.09 | 6.87 | -0.37 | 0.91 | 0.02 | 4.16 | 2.50 | 4.46 | 3.71 | 0.47 | 1.48* | -0.01 | 1.92 | 1.48 | 2.09 | 1.83 | 0.05 | 1.00 | -0.001 |
| $P_3 \times P_4$ | 6.52 | 4.47 | 7.71 | 6.23 | -1.01 | -5.60** | 1.48* | 2.98 | 2.04 | 3.50 | 2.84 | -0.38 | 1.02 | -0.02 | 1.68 | 1.32 | 1.94 | 1.64 | -0.13 | 0.96 | 0.003 |
| $P_3 \times P_5$ | 6.45 | 6.15 | 6.25 | 6.29 | -1.06 | 0.78 | 0.31 | 2.78 | 2.15 | 3.08 | 2.67 | -0.55 | 0.66 | -0.02 | 1.74 | 1.30 | 1.91 | 1.65 | -0.12 | 1.0 | -0.001 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_3 \times P_6$ | 8.67 | 5.43 | 8.47 | 7.52 | 0.17 | 1.68* | 3.29** | 3.28 | 2.00 | 3.58 | 2.96 | -0.27 | 1.18 | 0.01 | 1.56 | 1.12 | 1.73 | 1.47 | -0.30 | 1.00 | -0.001 |
| $P_4 \times P_5$ | 6.78 | 8.18 | 10.14 | 8.36 | 1.01 | -17.22** | 0.12 | 3.00 | 2.59 | 2.78 | 2.79 | -0.43 | 0.20 | 0.03 | 1.67 | 1.32 | 1.94 | 1.64 | -0.13 | 0.95 | 0.005 |
| $P_4 \times P_6$ | 5.83 | 5.07 | 5.64 | 5.51 | -1.83 | 0.92 | 0.02 | 4.67 | 2.18 | 4.97 | 3.94 | 0.70 | 2.14** | 0.28 | 1.83 | 1.39 | 2.00 | 1.74 | -0.03 | 1.00 | -0.01 |
| $P_5 \times P_6$ | 10.33 | 7.79 | 6.58 | 8.24 | 0.88 | 18.95** | 0.09 | 2.48 | 2.85 | 3.30 | 2.88 | -0.34 | 0.15 | -0.02 | 1.77 | 1.20 | 1.84 | 1.60 | -0.17 | 1.07 | 0.005 |
| $P_1$ | 8.67 | 6.83 | 8.47 | 7.99 | 0.63 | 1.25 | 0.43 | 3.92 | 2.68 | 4.22 | 3.61 | 0.38 | 1.14 | 0.01 | 2.08 | 1.55 | 2.25 | 1.96 | 0.21 | 0.96 | -0.001 |
| $P_2$ | 7.50 | 6.44 | 7.30 | 7.08 | 0.63 | 0.18 | 4.67** | 2.26 | 2.47 | 2.56 | 2.43 | -0.79 | -0.01 | -0.01 | 2.13 | 1.68 | 2.30 | 2.04 | 0.25 | 1.00 | -0.001 |
| $P_3$ | 8.51 | 7.27 | 8.31 | 8.03 | 1.64 | 0.17 | 4.76** | 3.73 | 2.07 | 4.03 | 3.27 | 0.04 | 1.48 | -0.01 | 1.89 | 1.44 | 2.06 | 1.80 | 0.01 | 1.00 | -0.001 |
| $P_4$ | 7.87 | 7.10 | 7.68 | 7.55 | 0.53 | 0.61 | 0.99 | 3.65 | 1.97 | 3.95 | 3.19 | -0.03 | 1.50 | -0.01 | 1.96 | 1.45 | 2.13 | 1.85 | 0.09 | 1.00 | -0.001 |
| $P_5$ | 8.62 | 6.79 | 8.42 | 7.95 | 0.59 | 1.25 | 0.42 | 1.82 | 2.55 | 2.12 | 2.17 | -1.06 | -0.41 | 0.06 | 1.63 | 1.19 | 1.81 | 1.54 | -0.23 | 1.00 | -0.001 |
| $P_6$ | 6.92 | 6.14 | 6.72 | 6.59 | -0.63 | 0.81 | 0.21 | 1.82 | 2.80 | 2.12 | 2.24 | -0.98 | -0.61 | 0.09 | 1.50 | 1.05 | 1.67 | 1.41 | -0.37 | 1.00 | -0.001 |
| $I_j$ | 0.10 | -0.006 | -0.09 | | | | | 0.25 | -0.80 | 0.55 | | | | | 0.09 | -0.35 | 0.26 | | | | |

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index; Ij: Env. Index

**Table 2: Contd…**

| Genotypes | Number of fruits per plant | | | | | | | Fruit yield per plant (Kg) | | | | | | | Dry Matter content (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2$di | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2$di | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2$di |
| $P_1 \times P_2$ | 3.34 | 3.28 | 3.58 | 3.40 | 0.65 | 1.13 | -0.004 | 6.92 | 5.31 | 8.05 | 6.76 | 1.86 | 1.29 | -0.24 | 7.04 | 7.70 | 7.36 | 7.37 | 0.23 | 0.08 | 0.19 |
| $P_1 \times P_3$ | 2.72 | 2.49 | 2.73 | 2.65 | -0.09 | 0.50 | 0.02 | 5.49 | 4.09 | 6.17 | 5.25 | 0.35 | 0.98 | 0.014 | 7.58 | 7.90 | 7.96 | 7.81 | 0.67 | 0.76 | 0.02 |
| $P_1 \times P_4$ | 3.00 | 3.00 | 3.24 | 3.08 | 0.33 | 1.01 | -0.006 | 5.76 | 4.44 | 6.80 | 5.66 | 0.77 | 1.11 | -0.03 | 6.56 | 8.00 | 6.88 | 7.14 | 0.01 | -1.03 | 1.05 |
| $P_1 \times P_5$ | 3.53 | 3.62 | 3.78 | 3.64 | 0.90 | 0.85 | -0.003 | 7.72 | 6.31 | 8.92 | 7.65 | 2.75 | 1.22 | -0.032 | 6.62 | 8.33 | 6.94 | 7.30 | 0.16 | -1.41 | 1.50 |
| $P_1 \times P_6$ | 2.49 | 2.72 | 2.97 | 2.73 | -0.01 | 1.52* | 0.018 | 5.18 | 4.29 | 6.50 | 5.32 | 0.43 | 1.03 | 0.034 | 7.64 | 5.95 | 7.90 | 7.16 | 0.03 | 3.25** | 1.53 |
| $P_2 \times P_3$ | 2.15 | 2.15 | 2.40 | 2.23 | -0.51 | 1.01 | -0.006 | 4.34 | 3.39 | 5.25 | 4.33 | -0.56 | 0.87 | -0.029 | 7.05 | 7.97 | 7.37 | 7.46 | 0.33 | -0.28 | 0.41 |
| $P_2 \times P_4$ | 2.34 | 2.17 | 2.59 | 2.37 | -0.37 | 1.36 | 0.011 | 4.32 | 3.03 | 5.23 | 4.19 | -0.69 | 1.03 | -0.027 | 8.05 | 7.62 | 8.37 | 8.01 | 0.87 | 1.65* | 0.09 |
| $P_2 \times P_5$ | 2.70 | 2.33 | 2.58 | 2.54 | -0.20 | 0.22 | 0.061 | 4.76 | 2.88 | 4.77 | 4.14 | -0.75 | 0.91 | 0.442 | 7.11 | 7.79 | 7.87 | 7.59 | 0.45 | 1.46 | 0.188 |
| $P_2 \times P_6$ | 2.76 | 2.75 | 3.00 | 2.84 | 0.09 | 1.02 | -0.006 | 5.29 | 4.06 | 6.28 | 5.21 | 0.31 | 1.04 | -0.032 | 7.73 | 7.78 | 8.05 | 7.86 | 0.72 | 0.96 | -0.021 |
| $P_3 \times P_4$ | 2.33 | 2.70 | 2.95 | 2.66 | -0.07 | 1.80* | 0.055 | 3.91 | 3.57 | 5.70 | 4.39 | -0.49 | 0.98 | 0.418 | 7.55 | 6.37 | 7.43 | 7.12 | -0.01 | 1.30 | 0.70 |
| $P_3 \times P_5$ | 3.20 | 3.17 | 3.45 | 3.27 | 0.53 | 1.08 | -0.005 | 5.56 | 4.10 | 6.59 | 5.42 | 0.52 | 1.17 | -0.026 | 8.68 | 6.17 | 9.00 | 7.95 | 0.81 | 4.61** | 3.40** |
| $P_3 \times P_6$ | 2.60 | 2.60 | 2.85 | 2.68 | -0.05 | 1.01 | -0.006 | 4.07 | 2.89 | 4.95 | 3.97 | -0.92 | 0.96 | -0.031 | 7.55 | 6.17 | 7.87 | 7.20 | 0.06 | 3.00** | 1.03 |
| $P_4 \times P_5$ | 3.13 | 2.17 | 2.39 | 2.56 | -0.17 | -1.15 | 0.44 | 5.22 | 2.86 | 4.65 | 4.24 | -0.65 | 0.88 | 1.235 | 6.23 | 7.10 | 7.15 | 6.83 | -0.30 | 1.72* | 0.32 |
| $P_4 \times P_6$ | 4.00 | 4.00 | 4.25 | 4.08 | 1.34 | 1.01 | -0.006 | 7.32 | 5.55 | 8.51 | 7.12 | 2.23 | 1.39 | -0.016 | 6.43 | 7.77 | 6.75 | 6.98 | -0.14 | -0.87 | 0.89 |
| $P_5 \times P_6$ | 2.15 | 3.10 | 3.38 | 2.88 | 0.13 | 3.19** | 0.426 | 3.79 | 3.74 | 6.22 | 4.58 | -0.31 | 1.12 | 1.089 | 6.83 | 8.74 | 6.55 | 7.38 | 0.24 | -3.63** | 1.96* |
| $P_1$ | 2.22 | 2.29 | 2.47 | 2.33 | -0.366 | 0.60 | 0.01 | 4.61 | 3.56 | 5.55 | 4.57 | -0.16 | 0.71 | 0.008 | 5.71 | 6.70 | 6.03 | 6.15 | -0.98 | -0.39 | 0.48 |
| $P_2$ | 1.50 | 1.50 | 1.75 | 1.58 | -1.15 | 1.01 | -0.006 | 3.20 | 2.53 | 4.03 | 3.25 | -1.63 | 0.69 | -0.017 | 8.18 | 6.62 | 8.50 | 7.77 | 0.63 | 3.27** | 1.33* |
| $P_3$ | 1.61 | 1.77 | 1.85 | 1.74 | -0.99 | 0.69 | 0.005 | 3.03 | 2.56 | 3.81 | 3.13 | -1.75 | 0.58 | -0.001 | 7.19 | 6.48 | 7.51 | 7.06 | -0.07 | 2.04** | 0.26 |
| $P_4$ | 2.75 | 2.75 | 3.00 | 2.83 | 0.09 | 1.01 | -0.006 | 5.39 | 3.98 | 6.39 | 5.25 | 0.42 | 1.04 | -0.032 | 6.27 | 6.12 | 6.59 | 6.32 | -0.81 | 1.24 | -0.005 |
| $P_5$ | 3.26 | 3.26 | 3.51 | 3.34 | 060 | 1.01 | -0.006 | 5.33 | 3.88 | 6.34 | 5.18 | 0.29 | 1.15 | -0.025 | 5.33 | 5.03 | 5.65 | 5.34 | -1.79 | 1.46* | 0.03 |
| $P_6$ | 1.96 | 1.96 | 2.21 | 2.04 | -0.69 | 1.01 | -0.006 | 2.93 | 2.07 | 3.69 | 2.89 | -1.99 | 0.75 | -0.032 | 6.07 | 5.56 | 6.39 | 6.00 | -1.12 | 1.75** | 0.12 |
| $I_j$ | -0.08 | -0.07 | 0.16 | | | | | 0.06 | -1.09 | 1.03 | | | | | -0.1 | -0.09 | 0.20 | | | | |

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index; Ij: Env. Index

**Table 2: Contd…**

| Genotypes | Total soluble solids | | | | | | | Total sugars (%) | | | | | | | Reducing sugars (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2$di | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2$di | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2$di |
| $P_1 \times P_2$ | 6.17 | 6.70 | 6.56 | 6.48 | 0.44 | 0.81 | 0.08 | 5.22 | 5.57 | 5.47 | 5.42 | 0.53 | 1.23 | -0.008 | 3.20 | 2.93 | 3.45 | 3.19 | 0.23 | -0.51 | 0.071 |
| $P_1 \times P_3$ | 6.12 | 7.00 | 6.28 | 6.46 | 0.42 | 0.02 | 0.42 | 4.29 | 5.87 | 5.75 | 5.30 | 0.41 | 6.36** | 0.027 | 2.20 | 3.96 | 2.85 | 3.00 | 0.04 | 2.90** | -0.011 |
| $P_1 \times P_4$ | 5.75 | 7.00 | 6.14 | 6.30 | 0.26 | 0.49 | 0.77 | 5.43 | 5.87 | 5.68 | 5.66 | 0.77 | 1.36 | 0.007 | 2.85 | 3.93 | 3.10 | 3.29 | 0.33 | 1.81* | 0.010 |
| $P_1 \times P_5$ | 6.40 | 7.07 | 6.79 | 6.75 | 0.71 | 0.75 | 0.15 | 4.71 | 5.97 | 4.96 | 5.21 | 0.32 | 2.77** | 0.584 | 2.83 | 4.06 | 3.08 | 3.32 | 0.36 | 2.05** | 0.027 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_1 \times P_6$ | 5.88 | 5.04 | 6.51 | 5.81 | -0.22 | 2.08** | 0.72 | 5.50 | 4.01 | 4.54 | 4.68 | -0.20 | -4.96** | 0.209 | 2.60 | 2.77 | 2.45 | 2.61 | -0.35 | 0.3 | 0.017 |
| $P_2 \times P_3$ | 6.13 | 6.97 | 6.53 | 6.54 | 0.50 | 0.67 | 0.29 | 5.77 | 5.94 | 6.02 | 5.91 | 1.02 | 0.92 | -0.018 | 3.17 | 4.04 | 3.42 | 3.54 | 0.57 | 1.45* | -0.006 |
| $P_2 \times P_4$ | 6.17 | 6.43 | 6.56 | 6.39 | 0.35 | 0.94 | -0.009 | 4.15 | 5.40 | 4.40 | 4.65 | -0.03 | 2.76** | 0.576 | 2.20 | 3.67 | 2.45 | 2.77 | -0.18 | 2.49** | 0.068 |
| $P_2 \times P_5$ | 6.23 | 6.49 | 7.14 | 6.62 | 0.58 | 2.34** | -0.01 | 5.06 | 5.46 | 5.85 | 5.46 | 0.56 | 2.65** | 0.030 | 3.17 | 3.71 | 4.10 | 3.66 | 0.69 | 0.84 | 0.314 |
| $P_2 \times P_6$ | 6.18 | 6.48 | 6.58 | 6.41 | 0.37 | 0.92 | -0.003 | 4.47 | 5.45 | 4.72 | 4.88 | -0.01 | 2.30** | 0.308 | 3.10 | 3.71 | 3.35 | 3.39 | 0.42 | 0.99 | -0.014 |
| $P_3 \times P_4$ | 6.75 | 5.44 | 6.63 | 6.27 | 0.23 | 0.26 | 1.02 | 5.60 | 4.41 | 5.31 | 5.11 | 0.21 | -2.75** | 0.468 | 3.85 | 3.00 | 3.42 | 3.42 | 0.46 | -1.38 | -0.010 |
| $P_3 \times P_5$ | 7.23 | 5.07 | 7.63 | 6.64 | 0.60 | 2.05** | 3.42** | 5.70 | 4.04 | 5.95 | 5.23 | 0.34 | -2.19** | 1.940* | 3.83 | 2.75 | 4.08 | 3.56 | 0.59 | -1.91* | 0.304 |
| $P_3 \times P_6$ | 6.03 | 5.27 | 6.43 | 5.91 | -0.12 | 1.41* | 0.50 | 4.46 | 4.27 | 4.71 | 4.48 | -0.40 | 0.30 | 0.073 | 2.58 | 2.90 | 2.83 | 2.77 | -0.18 | 0.50 | -0.005 |
| $P_4 \times P_5$ | 5.65 | 6.12 | 7.00 | 6.26 | 0.22 | 3.45** | -0.01 | 3.38 | 5.09 | 4.74 | 4.40 | -0.48 | 6.31** | 0.124 | 1.77 | 3.46 | 2.65 | 2.62 | -0.33 | 2.74** | 0.008 |
| $P_4 \times P_6$ | 6.40 | 6.87 | 6.79 | 6.69 | 0.65 | 0.85 | 0.04 | 3.66 | 5.84 | 3.91 | 4.47 | -0.41 | 4.33** | 2.109** | 2.17 | 3.98 | 2.42 | 2.85 | -0.10 | 3.07** | 0.146 |
| $P_5 \times P_6$ | 6.61 | 7.59 | 6.04 | 6.75 | 0.71 | -1.98* | 0.88 | 4.49 | 6.56 | 3.63 | 4.89 | 0.01 | 1.36 | 4.444** | 2.40 | 4.47 | 2.02 | 2.96 | -0.00 | 3.63** | 0.987 |
| $P_1$ | 5.60 | 5.58 | 5.99 | 5.73 | -0.30 | 1.07 | -0.003 | 4.44 | 4.55 | 4.69 | 4.56 | -0.32 | 0.82 | -0.013 | 2.48 | 2.39 | 2.73 | 2.54 | -0.42 | -0.20 | 0.039 |
| $P_2$ | 4.14 | 5.25 | 4.53 | 4.64 | -1.39 | 0.55 | 0.58 | 4.22 | 4.22 | 4.47 | 4.30 | -0.58 | 0.62 | 0.008 | 2.62 | 2.87 | 2.87 | 2.78 | -0.17 | 0.38 | -0.000 |
| $P_3$ | 4.43 | 5.22 | 4.83 | 4.83 | -0.82 | 0.70 | 0.24 | 4.88 | 4.19 | 5.13 | 4.73 | -0.15 | -0.55 | 0.443 | 2.17 | 2.84 | 2.42 | 2.48 | -0.48 | 1.11 | -0.014 |
| $P_4$ | 5.02 | 5.22 | 5.41 | 5.21 | -1.20 | 0.97 | -0.01 | 4.03 | 4.19 | 4.28 | 4.17 | -0.72 | 0.89 | -0.016 | 2.02 | 2.71 | 2.27 | 2.33 | -0.63 | 1.15 | -0.013 |
| $P_5$ | 5.02 | 4.47 | 5.41 | 4.96 | -1.07 | 1.31* | 0.29 | 4.67 | 3.44 | 4.92 | 4.34 | -0.54 | -1.48 | 1.166* | 2.23 | 2.34 | 2.48 | 2.35 | -0.61 | 0.14 | 0.012 |
| $P_6$ | 5.07 | 4.68 | 5.46 | 5.07 | -0.96 | 1.24 | 0.15 | 5.25 | 3.65 | 5.50 | 4.80 | -0.08 | -2.09** | 1.823* | 2.77 | 2.48 | 3.02 | 2.76 | -0.20 | -0.53 | 0.074 |
| $I_j$ | -0.17 | -0.03 | 0.21 | | | | | -0.15 | 0.06 | 0.09 | | | | | -0.28 | 0.32 | -0.03 | | | | |

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index; Ij: Env. Index

**Table 2: Contd…**

| Genotypes | Non-reducing sugars (%) | | | | | | | Ascorbic acid (mg/100g) | | | | | | | B-carotene (mg /100g) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ | $E_1$ (M) | $E_2$ (M) | $E_3$ (M) | Pooled (M) | PI | (bi) | $S^2di$ |
| $P_1 \times P_2$ | 1.95 | 2.64 | 2.02 | 2.20 | 0.27 | -1.72* | -0.017 | 7.98 | 8.87 | 8.14 | 8.33 | 1.91 | 1.20 | -0.007 | 6.88 | 7.23 | 7.24 | 7.12 | 1.70 | 0.62 | 0.003 |
| $P_1 \times P_3$ | 2.09 | 1.91 | 2.90 | 2.30 | 0.37 | 1.48* | 0.325 | 4.98 | 7.82 | 7.69 | 6.83 | 0.41 | 2.81** | 2.683** | 6.10 | 5.47 | 5.48 | 5.68 | 0.26 | -1.11 | 0.027 |
| $P_1 \times P_4$ | 2.58 | 1.94 | 2.58 | 2.37 | 0.44 | 1.68* | -0.017 | 6.52 | 8.68 | 6.67 | 7.29 | 0.87 | 3.05** | 0.044 | 4.03 | 4.38 | 4.39 | 4.27 | -1.14 | 0.62 | 0.003 |
| $P_1 \times P_5$ | 1.87 | 1.91 | 1.88 | 1.89 | -0.03 | -0.10 | -0.018 | 5.52 | 7.83 | 5.67 | 6.34 | -0.07 | 3.27** | 0.055 | 3.57 | 7.40 | 3.93 | 4.96 | -0.45 | 5.98** | 2.49** |
| $P_1 \times P_6$ | 2.90 | 1.34 | 2.09 | 2.11 | 0.18 | 3.06** | 0.282 | 7.54 | 7.14 | 5.14 | 6.61 | 0.19 | 0.56 | 3.207** | 5.12 | 6.49 | 6.46 | 6.02 | 0.60 | 2.41** | 0.162* |
| $P_2 \times P_3$ | 2.30 | 1.90 | 2.60 | 2.27 | 0.34 | 1.40* | 0.032 | 6.93 | 7.21 | 7.09 | 7.08 | 0.66 | 0.32 | -0.002 | 5.36 | 5.75 | 5.72 | 5.61 | 0.19 | 0.68 | -0.001 |
| $P_2 \times P_4$ | 1.96 | 1.73 | 1.95 | 1.88 | -0.04 | 0.59 | -0.018 | 6.72 | 8.91 | 6.87 | 7.50 | 1.08 | 3.07** | 0.046 | 4.14 | 4.53 | 4.50 | 4.39 | -1.02 | 0.68 | -0.001 |
| $P_2 \times P_5$ | 1.91 | 1.75 | 1.75 | 1.80 | -0.12 | 0.21 | -0.005 | 4.73 | 9.34 | 7.73 | 7.27 | 0.85 | 5.24** | 2.490** | 6.78 | 4.13 | 4.11 | 5.01 | -0.41 | -4.69** | 0.741 |
| $P_2 \times P_6$ | 1.52 | 1.75 | 1.37 | 1.55 | -0.42 | -0.94 | 0.027 | 5.72 | 6.05 | 5.87 | 5.88 | -0.53 | 0.40 | -0.003 | 7.80 | 8.18 | 8.16 | 8.05 | 2.62 | 0.66 | 0.001 |
| $P_3 \times P_4$ | 1.73 | 1.41 | 1.89 | 1.68 | -0.24 | 1.02 | -0.004 | 7.58 | 5.20 | 4.89 | 5.89 | -0.52 | -2.16** | 2.88** | 3.75 | 6.99 | 7.14 | 5.96 | 0.54 | 5.75** | 1.348* |
| $P_3 \times P_5$ | 1.88 | 1.29 | 1.86 | 1.68 | -0.24 | 1.50* | -0.018 | 5.02 | 7.08 | 5.17 | 5.76 | -0.65 | 2.91** | 0.030 | 4.31 | 4.70 | 4.67 | 4.56 | -0.86 | 0.68 | -0.001 |
| $P_3 \times P_6$ | 1.88 | 1.37 | 1.88 | 1.71 | -0.21 | 1.31* | -0.018 | 6.05 | 6.89 | 6.20 | 6.38 | -0.03 | 1.14 | -0.007 | 3.33 | 3.82 | 3.69 | 3.62 | -1.80 | 0.83 | -0.008 |
| $P_4 \times P_5$ | 1.61 | 1.63 | 2.09 | 1.78 | -0.15 | 0.54 | 0.100 | 7.16 | 8.19 | 6.34 | 7.23 | 0.81 | 1.87* | 0.634 | 5.95 | 5.41 | 5.39 | 5.58 | 0.16 | -0.95 | 0.023 |
| $P_4 \times P_6$ | 1.50 | 1.86 | 1.50 | 1.62 | -0.30 | -0.94 | -0.018 | 8.45 | 6.70 | 8.60 | 7.92 | 1.50 | -2.60** | 0.150 | 6.20 | 6.59 | 6.56 | 6.45 | 1.02 | 0.68 | -0.001 |
| $P_5 \times P_6$ | 2.39 | 2.09 | 1.61 | 2.03 | 0.10 | -0.18 | 0.288 | 6.18 | 6.48 | 7.31 | 6.66 | 0.24 | -0.10 | 0.674 | 5.03 | 7.31 | 6.31 | 6.22 | 0.79 | 3.78** | -0.005 |
| $P_1$ | 1.95 | 2.16 | 1.95 | 2.02 | 0.09 | -0.53 | -0.018 | 6.11 | 5.74 | 6.22 | 4.63 | -1.78 | 2.44** | 0.017 | 6.13 | 6.38 | 6.49 | 6.34 | 0.91 | 0.46 | 0.017 |
| $P_2$ | 1.60 | 1.35 | 1.60 | 1.52 | -0.40 | 0.6 | -0.018 | 6.38 | 5.13 | 6.54 | 6.02 | -0.39 | 1.88* | 0.094 | 5.92 | 6.17 | 6.28 | 6.12 | 0.70 | 0.46 | 0.017 |
| $P_3$ | 2.71 | 1.33 | 2.71 | 2.25 | 0.3 | 3.60** | -0.017 | 5.38 | 4.85 | 5.53 | 5.25 | -1.16 | -0.83 | 0.033 | 5.00 | 5.25 | 5.36 | 5.20 | -0.21 | 0.47 | 0.017 |
| $P_4$ | 2.01 | 1.47 | 2.01 | 1.83 | -0.09 | 1.40* | -0.018 | 4.72 | 5.44 | 4.87 | 5.01 | -1.40 | 0.97 | -0.007 | 4.28 | 4.61 | 4.64 | 4.51 | -0.90 | 0.58 | 0.005 |
| $P_5$ | 2.45 | 1.10 | 2.45 | 2.00 | 0.06 | 3.51** | -0.017 | 5.83 | 4.63 | 5.98 | 5.48 | -0.93 | -1.80* | 0.088 | 3.22 | 3.58 | 3.58 | 3.46 | -1.95 | 0.64 | 0.002 |
| $P_6$ | 2.48 | 1.17 | 2.48 | 2.05 | 0.11 | 3.41** | -0.017 | 5.08 | 5.84 | 5.23 | 5.38 | -1.03 | 1.03 | -0.007 | 4.17 | 5.23 | 4.53 | 4.64 | -0.77 | 1.72* | 0.048 |
| $I_j$ | 0.13 | -0.25 | 0.12 | | | | | -0.29 | 0.44 | -0.14 | | | | | **-0.31** | **0.27** | **0.04** | | | | |

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively; PI: Phenotypic index; Ij: Env. Index

**Table 3:** The top five $F_1$ on the basis of *per se* performence, phenotypic index and $S^2di$ for twenty-one traits in pumpkin

| Traits | Best five $F_1$ | | | | |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th |
| Days to first male flower anthesis | $P_1 \times P_5$ | $P_4 \times P_6$ | $P_3 \times P_5$ | $P_1 \times P_2$ | $P_4 \times P_5$ |
| Days to first female flower anthesis | $P_3\times P_5$ | $P_1\times P_3$ | $P_1\times P_2$ | $P_4\times P_6$ | $P_2\times P_3$ |
| Node number to first male flower appearence | $P_3\times P_6$ | $P_3\times P_5$ | $P_1\times P_5$ | $P_1\times P_4$ | $P_4\times P_6$ |
| Node number to first female flower appearence | $P_3\times P_5$ | $P_3\times P_4$ | $P_3\times P_6$ | $P_2\times P_5$ | $P_2\times P_3$ |
| Days to first fruit harvest | $P_3\times P_5$ | $P_4\times P_6$ | $P_1\times P_4$ | $P_1\times P_2$ | $P_2\times P_6$ |
| Number of primary branches per plant | $P_4\times P_6$ | $P_4\times P_5$ | $P_3\times P_5$ | $P_5\times P_6$ | $P_2\times P_4$ |
| Equatorial circumference of fruit | $P_1\times P_2$ | $P_1\times P_4$ | $P_2\times P_5$ | $P_3\times P_6$ | $P_2\times P_4$ |
| Polar circumference of fruit | $P_2\times P_6$ | $P_3\times P_5$ | $P_1\times P_4$ | $P_1\times P_2$ | $P_3\times P_6$ |
| Flesh thickness | $P_1\times P_6$ | $P_3\times P_5$ | $P_1\times P_3$ | $P_1\times P_5$ | $P_2\times P_5$ |
| Internodal length (cm) | $P_4\times P_6$ | $P_1\times P_5$ | $P_3\times P_5$ | $P_1\times P_2$ | $P_1\times P_3$ |
| Vine length (m) | $P_1\times P_4$ | $P_1\times P_3$ | $P_4\times P_6$ | $P_1\times P_6$ | $P_2\times P_3$ |
| Average fruit weight | $P_1\times P_5$ | $P_1\times P_2$ | $P_1\times P_3$ | $P_1\times P_6$ | $P_2\times P_3$ |
| No. of fruits per plant | $P_4\times P_6$ | $P_1\times P_5$ | $P_1\times P_2$ | $P_3\times P_5$ | $P_1\times P_4$ |
| Fruit yield per plant | $P_1\times P_5$ | $P_4\times P_6$ | $P_1\times P_2$ | $P_1\times P_4$ | $P_3\times P_5$ |
| Dry matter content | $P_2\times P_4$ | $P_2\times P_6$ | $P_1\times P_3$ | $P_2\times P_5$ | $P_2\times P_3$ |
| Total soluble solids | $P_5\times P_6$ | $P_1\times P_5$ | $P_4\times P_6$ | $P_2\times P_5$ | $P_2\times P_6$ |
| Total sugars | $P_2 \times P_3$ | $P_1 \times P_4$ | $P_2 \times P_5$ | $P_1 \times P_2$ | $P_1 \times P_3$ |
| Reducing sugars | $P_2 \times P_5$ | $P_3 \times P_5$ | $P_2 \times P_3$ | $P_3 \times P_4$ | $P_2 \times P_6$ |
| Non-reducing sugars | $P_1\times P_3$ | $P_2\times P_3$ | $P_1\times P_4$ | $P_1\times P_6$ | $P_4\times P_5$ |
| Ascorbic acid | $P_4 \times P_6$ | $P_1\times P_2$ | $P_2\times P_5$ | $P_1\times P_3$ | $P_5\times P_6$ |
| β-carotene | $P_2\times P_6$ | $P_1\times P_2$ | $P_4\times P_6$ | $P_5\times P_6$ | $P_1\times P_6$ |

The top five stable $F_1$/genotypes (Table 2 & 3) on the basis of *per se* performance, phenotypic index and $S^2di$ were $P_1$ (Narendra Upkar) × $P_5$ (Kashi Harit), $P_4$ (NDPK-39-2) × $P_6$ (NDPK-11-3), $P_3$ (Narendra Agrim) × $P_5$ (Kashi Harit), $P_1$ (Narendra Upkar) × $P_2$ (NDPK-120), $P_4$ (NDPK-39-2) × $P_5$

(Kashi Harit), for days to first male flower anthesis, $P_3 \times P_5$, $P_1 \times P_3$, $P_1 \times P_2$, $P_4 \times P_6$, $P_2 \times P_3$, for days to first female flower anthesis, $P_3 \times P_6$, $P_3 \times P_5$, $P_1 \times P_5$, $P_1 \times P_4$, $P_4 \times P_6$ for node number to first male flower appearance, $P_3 \times P_5$, $P_3 \times P_4$, $P_3 \times P_6$, $P_2 \times P_5$, $P_2 \times P_3$ for node number to first female flower appearance, $P_3 \times P_5$, $P_4 \times P_6$, $P_1 \times P_4$, $P_1 \times P_2$, $P_2 \times P_6$ for days to first fruit harvest, $P_4 \times P_6$, $P_4 \times P_5$, $P_3 \times P_5$, $P_5 \times P_6$, $P_2 \times P_4$ for number of primary branches per plant, $P_1 \times P_2$, $P_1 \times P_4$, $P_2 \times P_5$, $P_3 \times P_6$, $P_2 \times P_4$ for equatorial circumference of fruit, $P_2 \times P_6$, $P_3 \times P_5$, $P_1 \times P_4$, $P_1 \times P_2$, $P_3 \times P_6$ for polar circumference of fruit, $P_1 \times P_6$, $P_3 \times P_5$, $P_1 \times P_3$, $P_1 \times P_5$, $P_2 \times P_5$ for flesh thickness, $P_4 \times P_6$, $P_1 \times P_5$, $P_3 \times P_5$, $P_1 \times P_2$, $P_1 \times P_3$ for intermodal length, $P_1 \times P_4$, $P_1 \times P_3$, $P_4 \times P_6$, $P_1 \times P_6$, $P_2 \times P_3$ for vine length, $P_1 \times P_5$, $P_1 \times P_2$, $P_1 \times P_3$, $P_1 \times P_6$, $P_2 \times P_3$ for average fruit weight, $P_4 \times P_6$, $P_1 \times P_5$, $P_1 \times P_2$, $P_3 \times P_5$, $P_1 \times P_4$ for number of fruits per plant, $P_1 \times P_5$, $P_4 \times P_6$, $P_1 \times P_2$, $P_1 \times P_4$, $P_3 \times P_5$ for fruit yield per plant, $P_2 \times P_4$, $P_2 \times P_6$, $P_1 \times P_3$, $P_2 \times P_5$, $P_2 \times P_3$ for dry matter content, $P_5 \times P_6$, $P_1 \times P_5$, $P_4 \times P_6$, $P_2 \times P_5$, $P_2 \times P_6$ for total soluble solids, $P_2 \times P_3$, $P_1 \times P_4$, $P_2 \times P_5$, $P_1 \times P_2$, $P_1 \times P_3$ for total sugars, $P_2 \times P_5$, $P_3 \times P_5$, $P_2 \times P_3$, $P_3 \times P_4$, $P_2 \times P_6$, for reducing sugars, $P_1 \times P_3$, $P_2 \times P_3$, $P_1 \times P_4$, $P_1 \times P_6$, $P_4 \times P_5$ for non-reducing sugars, $P_4 \times P_6$, $P_1 \times P_2$, $P_2 \times P_5$, $P_1 \times P_3$, $P_5 \times P_6$ for ascorbic acid and $P_2 \times P_6$, $P_1 \times P_2$, $P_4 \times P_6$, $P_5 \times P_6$, $P_1 \times P_6$ for β-carotene. The similar results have also been reported by Prasad and Singh (1970), Krishna and Singh (1990) and Ahmed (2010).

The best five $F_1$/genotypes on the basis of *per se* performance, phenotypic index and $S^2$di were Narendra Upkar ($P_1$) × Kashi Harit ($P_5$), NDPK-39-2 ($P_4$) × NDPK-11-3 ($P_6$), Narendra Agrim ($P_3$) × Kashi Harit ($P_5$), Narendra Upcar ($P_1$) × NDPK-120 ($P_2$), NDPK-39-2 ($P_4$) × Kashi Harit ($P_5$) for maturity traits and NDPK-39-2 ($P_4$) × NDPK-11-3 ($P_6$), Narendra Upkar ($P_1$) × Kashi Harit ($P_5$), Narendra Upkar ($P_1$) × NDPAK-120 ($P_2$), Narendra Agrim ($P_3$) × Kashi Harit ($P_5$), Narendra Upkar ($P_1$) × NDPK-39-2 ($P_4$) for fruit yield per plant, number of fruits per plant and other yield attributes while, crosses namely, $P_2 \times P_3$, Narendra Upcar ($P_1$) × NDPK-39-2 ($P_4$), NDPK-120 ($P_2$) × Kashi Harit ($P_5$), Narendra Upkar ($P_1$) × NDPK-120 ($P_2$), Narendra Upkar ($P_1$) × Narendra Agrim ($P_3$) for biochemical traits.

## Conclusion

The present study further revealed that the top five stable genotypes for any of the characters are only $F_1$ rather than either of parental lines/varieties. Hence it can be concluded that $F_1$s are more suitable for stable performance under varying environmental condition than the parental lines/varieties. Thus, $F_1$s should be preferred for cultivation under changing/off season conditions for high and stable yield and to secure production in future.

## सारांश

वर्तमान अध्ययन में (6) लाइन और उनके पंद्रह वंशों के साथ जननद्रव्य का इंटरेक्शन जानने के उद्देश्य से अध्ययन की गई, जो रेसिप्रोकल को छोड़कर डायलेल मेटिंग डिजाइन के माध्यम से विकसित हुई थी। परीक्षण खरीफ, 2015 (ई$_1$), रबी, 2015–16 (ई$_2$) (बे–मौसमी), जायद (गर्मी के मौसम), 2016 (ई$_3$) के दौरान किये गये थे। कुल 21 ट्रेट्स का अध्ययन किया गया जिसमें 14 उपज तथा उपज से संबन्धित ट्रेट्स और 7 जैव रासायनिक लक्षणों के लिए दर्ज किया गया था। वर्तमान अध्ययन से पता चला है कि पर्यावरण के साथ जीनोटाइप (जी) × पर्यावरण (ई), पर्यावरण रैखिक जीनोटाइप × पर्यावरण और जी× ई रैखिक फलों के वजन के लिए जी × ई और पेरिकार्प थिकनेश के लिए जी × ई रैखिक को छोड़कर सभी लक्षणों के लिए महत्वपूर्ण पाये गये। वर्तमान शोध से यह भी पता चला है कि खरीफ और ग्रीष्म ऋतु में अध्ययन किये गये अधिकांश लक्षणों के लिए अनुकूल हैं। प्रति प्रदर्शन, फेनोटाइपिक इंडेक्स और एस$_2$डीआई प्रदर्शन के आधार पर शीर्ष पांच स्थिर एफ$_1$/ जनन द्रव्य फेनोटाइपिक सूचकांक और एस$^2$ कप थे अध्ययन में नरेन्द्र उपकार (पी$_1$) ग काशी हरित (पी$_5$), एन.डी.पी.के.–39–2(पी$_4$) ग एन.डी.पी.के. –11–3 (पी$_6$) थे। नरेन्द्र अग्रिम(पी$_3$) ग काशी हरित (पी$_5$), नरेन्द्र उपकार (पी$_1$) ग एन.डी.पी.के.–120, एन.डी.पी.के. –39–2(पी$_4$) ग काशी हरित (पी$_5$),परिकल्पना लक्षणों के लिए और एन.डी.पी.के.–39–2(पी$_4$) ग एन.डी.पी.के.–11–3 (पी$_6$), नरेन्द्र उपकार (पी$_1$) ग काशी हरित (पी$_5$), नरेन्द्र उपकार (पी$_1$) ग एन.डी.पी.के.–120 (पी$_2$), नरेन्द्र उपकार (पी$_1$) ग एन. डी.पी.के.–39–2(पी$_4$), प्रति पौधा फल उपज, प्रति पौधे फलों की संख्या और अन्य उपज विशेषताओं के लिए, जबकि एन.डी. पी.के.–120 (पी$_2$) ग नरेन्द्र अग्रिम (पी$_3$), नरेन्द्र उपकार (पी$_1$) ग एन.डी.पी.के.–39–2(पी$_4$), एन.डी.पी.के.–120 (पी$_2$) ग काशी हरित (पी$_5$), नरेन्द्र उपकार (पी$_1$) ग एन.डी.पी.के.–120 (पी$_2$), नरेन्द्र उपकार (पी$_1$) ग नरेन्द्र अग्रिम (पी$_3$) जैव रासायनिक गुणों के लिए। वर्तमान अध्ययन से यह भी पता चला है कि किसी भी वर्ण के लिए शीर्ष पांच स्थिर जनन द्रव्य केवल एफ$_1$ हैं, न कि वंशावली/किस्मों के जिससे पता चलता है कि एफ$_1$ पैतृक लाइनों/किस्मों की तुलना में अधिक स्थिर हैं। इसलिए यह निष्कर्ष निकाला जा सकता है कि एफ$_1$ पैतृक वंश/किस्मों की तुलना में बदलती पर्यावरणीय परिस्थितियों में स्थिर प्रदर्शन के लिए अधिक उपयुक्त है। इस प्रकार, एफ$_1$ को भविष्य में सुरक्षित उत्पाद के लिए, उच्च और स्थिर उपज के लिए

बदलती/प्रतिकूल पर्यावरणीय स्थिति के तहत खेती के लिए प्राथमिकता देनी चाहिए।

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