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**RESEARCH ARTICLE**

**Genetic variability and character association studies in bittergourd (*Momordica charantia* L.)**

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**Abstract**

The investigation was conducted at the vegetable block in the Department of Vegetable Science, College of Horticulture, Mysuru. Forty genotypes of bitter gourd collected from different sources were evaluated in randomized block design with 2 replications during kharif 2017. The analysis of variance revealed significant differences among the genotypes for all the characters studies indicating the presence of wide range of variability in the genotypes. Among the 16 characters studied, the higher GCV and heritability estimates coupled with high genetic advance over mean (GAM) were observed for the characters like fruit length, average fruit weight, fruit yield per vine, fruit yield per hectare, number of seeds per fruit and flesh thickness. This indicates predominance of additive component for these traits and hence direct selection would be more effective in improving these traits. The results on correlation and path analysis revealed high positive and significant association of fruit yield per vine with characters viz., fruit length, fruit diameter, duration of crop and average fruit weight and these characters also had high direct and indirect effect on fruit yield per vine. Hence, direct selection for these traits

would be more useful in the improvement of fruit yield per vine.

**Key words:** Bitter gourd, GCV, PCV, heritability, variability

**Introduction**

Bitter gourd, being an important vegetable crop with medicinal properties requires a systematic breeding programme for enhancement in its yield potential and other horticultural traits. The wild species are good source for breeding of common cultivated bitter gourd varieties with good qualitative traits and tolerance to various stresses (Maneesh *et al.*, 2014). Improvement in any crop depends upon magnitude of genetic variability and extent to which desired characters are heritable. Large amount of variation provides the better chance of selecting desired genotypes (Vavilov, 1951). Moreover, correlation and path coefficient analysis have been of immense help in selecting suitable plant type. Although, correlation co-efficient indicates the nature of association among the traits and form a basis for selecting desirable plant type. Path analysis splits the correlation co-efficient into direct and indirect effects to measure the relative importance of each character (Islam *et al.*, 2009).

Information on character association and direct and indirect effects of component traits on yield would greatly help in formulating the selection criteria and using them effectively in crop improvement programme in bitter gourd. Therefore, the present investigation was carried out to study the genetic variability and character association among different genotypes of bitter gourd with regard to yield and yield contributing traits.

### Materials and methods

The experiment was conducted at the Department of Vegetable Science, College of Horticulture, Yelachenahalli, Mysuru district, Karnataka. The present study was carried out with 40 genotypes collected from different sources (Table 1). The experiment was laid out in a randomized

complete block design (RCBD) with two replication during kharif 2017. Each genotype in a replication was represented by a plot of 10.8 m<sup>2</sup> with 10 plants. The observations were taken for 16 different parameters including vegetative, flowering, yield and yield attributing parameters along with quality parameters. Genetic variability components included range, mean, Coefficient of variation (C<sub>Ve</sub>), Phenotypic Coefficient of Variability (PCV), Genotypic coefficient of variability (GCV), heritability in broad sense and genetic advance. The correlation coefficients were calculated to determine the degree of association of character with yield, quality and its components. Phenotypic and genotypic correlation coefficients were estimates employing formula (Al-Jibouri *et al.*, 1958).

**Table 1. Forty genotypes used in the study and their sources**

| Genotypes           | Source                    | Genotypes           | Source                                |
|---------------------|---------------------------|---------------------|---------------------------------------|
| Preethi             | KAU, Vellanikkara         | Bit-10-1-1          | COH, Kolar, Karnataka                 |
| Yellapur Local-2    | Yellapur, Karnataka       | West Bengal Local-2 | West Bengal                           |
| Bit-25-2-1          | COH, Kolar, Karnataka     | Kotla Local-1       | Rajasthan                             |
| Meghnaa-2           | Masood seeds, Bangladesh  | Bit-10-1-2          | COH, Kolar, Karnataka                 |
| Jhalawar Local-3    | Jalawar, Rajasthan        | Bit-5-1-4-1         | COH, Kolar, Karnataka                 |
| CO-1                | TNAU, Coimbatore          | Contai Bolder       | BarasatAgri Hybrid seeds, West Bengal |
| Bit-22-1-1-3        | COH, Kolar, Karnataka     | Bit-1-2-2-4         | COH, Kolar, Karnataka                 |
| Bit-9-2-4-1         | Maharashtra               | Bit-18-1-1          | Varanasi, Uttar pradesh               |
| GYB-3-1-2           | Tamil Nadu                | Jhalawar Local-1    | Jalawar, Rajasthan                    |
| Bit-1-2-3           | COH, Kolar, Karnataka     | Bit-3-1-1-1         | Tamil Nadu                            |
| Yellapur Local-1    | Yellapur, Karnataka       | GYB-5-1-5-2         | COH, Kolar, Karnataka                 |
| Bit-37-2-1          | COH, Kolar, Karnataka     | Bit-22-1-1-1        | COH, Kolar, Karnataka                 |
| DEB-505             | Debgiri Pvt Ltd. Kolkatta | Bit-9-2-1-2         | Maharashtra                           |
| Bit-3-1-2-1         | Tamil Nadu                | GYL-2               | COH, Kolar, Karnataka                 |
| Bit-9-3-2-3         | Maharashtra               | GYB-2-2             | COH, Kolar, Karnataka                 |
| Bit-5-1-2-1         | COH, Kolar, Karnataka     | Katahi              | Hyderabad                             |
| West Bengal Local-1 | West Bengal               | Bit-35-1-1          | Odisha                                |
| Jhalawar Local-2    | Jalawar, Rajasthan        | Bit-31-2-2          | COH, Kolar, Karnataka                 |
| Super Green         | Super Seeds, Odisha       | ArkaHarit           | IIHR, Bengaluru                       |
| IC-68238            | NBPGR, New Delhi          | Bit-9-1-4-1         | Maharashtra                           |

## Results and discussion

The results from the analysis of variance for 16 characters are presented in Table 2 indicated that there are highly significant differences among 40 genotypes of bitter gourd. It is indicated that, sufficient variability existed for the characters studied and considerable improvement could be achieved. However, the analysis of variance by itself is not enough and conclusive to explain all the inherent genotypic variances in the genotypes.

The estimates of genetic parameters viz., phenotypic and genotypic co-efficient of variation (PCV and GCV), heritability in broad sense, genetic advance and genetic advance as per cent of mean (GAM) were computed for 16 characters and were presented in Table 3. The phenotypic variance was higher than genotypic variance for all the characters studied. PCV ranged from 7.32 per cent (duration of crop) to 29.67 per cent (fruit length). GCV ranged from 4.94 per cent (days to first fruit picking) to 29.02 per cent (fruit length). The estimates of heritability ranged from 32.4 per cent (days to first fruit picking) to 96.80 per cent (fruit length). GAM ranged from 5.79 per cent (days to first fruit picking) to 59.19 per cent (fruit length). Similar trend was noticed in studies of Maneesh *et al.*, (2014), Subhasmita (2015), Yadagiri *et al.*, (2017) in bitter gourd.

Means of genotypes varied greatly for several traits, indicating the higher magnitude of variability. The range in the values reflects the amount of phenotypic variability. In the present study, wide range of variability was observed for all the characters especially fruit length.

In the present investigation, high GCV and PCV were observed for fruit length, number of seeds

per fruits, average fruit weight, fruit yield per vine, fruit yield per hectare and flesh thickness. Moderate GCV and high PCV were observed for vine length, node at which first female flower appears and number of fruits per vine. Moderate GCV and PCV were observed for number of branches per vine and fruit diameter. The similar results were also observed for fruit length by Maneesh *et al.*, (2014). It indicates existence of broad genetic base, which would be amenable for further selection. Low GCV and PCV were observed for duration of crop, days to first fruit picking and ascorbic acid and the similar trend was observed by Devendra *et al.*, (2018). This indicates the narrow genetic base and hence variability has to be generated for these characters either through introduction or hybridizing divergent genotypes to recover transgressive segregants or by mutation breeding (Tiwari *et al.*, 2018 and Jandong *et al.*, 2019 in soybean).

Co-efficient of variation indicates only the extent of variability present in germplasm for different characters, but for the prediction of responses to selection, heritability estimates are very useful. Very high (>80%) broad sense heritability was observed for days to first female flower opening, fruit length, fruit diameter, number of seeds per fruit, flesh thickness and ascorbic acid. The similar results were also observed for days to first female flower opening by Maneesh *et al.*, (2014), Rani *et al.*, (2015), Vivek *et al.*, (2017) in bitter gourd. High (60-80%) broad sense heritability was observed for fruit yield per vine, average fruit weight, vine length and number of branches per vine. The similar results were also observed for fruit yield per vine by Tyagi *et al.*, (2018) in bitter gourd. High heritability indicates the traits were less influenced by environment and selection of such traits is economical.

**Table 2. Analysis of variance for different characters in bitter gourd**

| S. No. | Trait                                     | Replication | Treatments | Error   |
|--------|-------------------------------------------|-------------|------------|---------|
|        | Degrees of freedom                        | 1           | 39         | 39      |
|        | <b>Growth parameters</b>                  |             |            |         |
| 1      | Vine length (m)                           | 3.732       | 0.497**    | 0.076   |
| 2      | Number of branches per vine               | 2.329       | 3.290**    | 0.449   |
| 3      | Duration of crop (days)                   | 1.250       | 70.108**   | 25.670  |
|        | <b>Earliness parameters</b>               |             |            |         |
| 4      | Node at which first female flower appears | 6.272       | 15.626**   | 5.540   |
| 5      | Days to first female flower opening       | 3.490       | 26.050**   | 1.550   |
| 6      | Days to 50 per cent flowering             | 37.812      | 26.364*    | 13.241  |
| 7      | Days to first fruit picking               | 6.610       | 33.567*    | 17.152  |
|        | <b>Yield parameters</b>                   |             |            |         |
| 8      | Fruit length (cm)                         | 4.627       | 47.943**   | 0.772   |
| 9      | Fruit diameter (cm)                       | 0.066       | 0.781**    | 0.048   |
| 10     | Average fruit weight (g)                  | 617.820     | 805.676**  | 111.060 |
| 11     | Number of fruits per vine                 | 112.100     | 10.578*    | 5.064   |
| 12     | Fruit yield per vine (kg)                 | 0.190       | 0.1287**   | 0.029   |
| 13     | Fruit yield per hectare (t)               | 16.45       | 11.009**   | 2.510   |
| 14     | Number of seeds per fruit                 | 0.078       | 39.883**   | 4.052   |
|        | <b>Quality parameters</b>                 |             |            |         |
| 15     | Flesh thickness (mm)                      | 0.092       | 3.207**    | 0.253   |
| 16     | Ascorbic acid (mg/100g)                   | 0.780       | 124.67**   | 7.672   |

\* Significant at 5%

\*\* Significant at 1%

**Table 3: Estimates of variability parameters in bitter gourd**

| S. No. | Trait                               | Mean  | Range       | GCV (%) | PCV (%) | h <sup>2</sup> (%) | GA   | GAM (%) |
|--------|-------------------------------------|-------|-------------|---------|---------|--------------------|------|---------|
| 1      | Vine length (m)                     | 2.6   | 1.5-3.6     | 17.4    | 20.4    | 73.30              | 0.8  | 30.8    |
| 2      | Number of branches per vine         | 10.23 | 6.8-13.5    | 11.6    | 13.3    | 75.9               | 2.1  | 20.9    |
| 3      | Duration of crop (days)             | 94.46 | 83.2-108.7  | 4.9     | 7.3     | 46.4               | 6.6  | 7.0     |
| 4      | Node at first female flower         | 14.95 | 10.0-20.9   | 15.0    | 21.7    | 47.7               | 3.1  | 21.3    |
| 5      | Days to first female flower opening | 40.89 | 32.9-48.2   | 8.5     | 9.0     | 88.8               | 6.7  | 16.6    |
| 6      | Days to 50 % flowering              | 43.52 | 35.2-50.5   | 5.8     | 10.2    | 33.1               | 3.0  | 6.9     |
| 7      | Days to first fruit picking         | 57.92 | 48.2-65.7   | 4.9     | 8.6     | 32.4               | 3.3  | 5.7     |
| 8      | Fruit length (cm)                   | 16.63 | 4.8-30.0    | 29.0    | 29.6    | 96.8               | 9.8  | 59.1    |
| 9      | Fruit diameter (cm)                 | 4.74  | 2.8-5.7     | 12.7    | 13.5    | 88.2               | 1.1  | 24.6    |
| 10     | Average fruit weight (g)            | 80.06 | 25.4-107.6  | 23.2    | 26.7    | 75.8               | 33.4 | 41.7    |
| 11     | Number of fruits per vine           | 12.98 | 7.7-21.6    | 12.7    | 21.5    | 35.2               | 2.0  | 15.6    |
| 12     | Fruit yield per vine (kg)           | 1.04  | 0.3-1.3     | 21.4    | 27.0    | 62.9               | 0.3  | 35.0    |
| 13     | Fruit yield per hectare (t)         | 9.62  | 3.61-12.74  | 21.4    | 27.0    | 62.9               | 3.3  | 34.9    |
| 14     | Number of seeds per fruit           | 17.14 | 7.5-25.0    | 24.6    | 27.3    | 81.6               | 7.8  | 45.9    |
| 15     | Flesh thickness (mm)                | 5.95  | 3.6-9.4     | 20.3    | 22.0    | 85.3               | 2.3  | 38.8    |
| 16     | Ascorbic acid (mg/100g)             | 95.78 | 81.29-112.4 | 7.9     | 8.4     | 88.4               | 14.8 | 15.4    |

The high estimates of heritability coupled with high values of genetic advance over mean (GAM) were observed for characters viz., fruit length, fruit diameter, number of seeds per fruit, flesh thickness, fruit yield per vine, fruit yield per hectare, average fruit weight, vine length and number of branches per vine. This indicates predominance of additive component for these characters and selection would be more effective in improving their traits. High heritability with low genetic advance (GA) shows the importance of non-additive gene action.

These results are in accordance with the findings of Maneesh *et al.*, (2014), Rani *et al.*, (2015), Yadagiri *et al.*, (2017), Vivek *et al.*, (2017), Devendra *et al.*, (2018) and Tyagi *et al.*, (2018) in bitter gourd. The higher GCV and heritability estimate coupled with high GAM was observed for fruit length, average fruit weight, fruit yield per vine, fruit yield per hectare, number of seeds per fruit and flesh thickness. This Indicates additive gene action hence, higher degree of genetic improvement for these traits can be achieved through selection using the existing germplasm.

### **Correlation and path analysis**

Average fruit weight had highly significant and positive association with number of seeds per fruit and flesh thickness but it was negatively and significantly correlated with number of fruits per vine. These results are in line with the observations of Rana and Pandit (2011) in snake gourd for flesh thickness; Yadagiri *et al.*, (2017) in bitter gourd and Kumar *et al.*, (2013) for number of seeds per fruit in sponge gourd. This indicates, there is a strong association between average fruit weight, fruit length, fruit diameter and number of seeds per fruit.

Fruit yield per vine had highly significant and positively associated with average fruit weight, number of branches per vine, days to first fruit picking, number of seeds per fruit, duration of crop, fruit length, fruit diameter, node at which

first female flower appears, flesh thickness days to 50 per cent flowering and vine length and it was significant and positively correlated with days to first female flower opening but it was negatively and significantly associated with number of fruits per vine. This indicated that direct selection for these characters might be effective and there is a possibility of improving yield per vine through selection based on these traits. The table 5 shows path co-efficient analysis for fruit yield per vine of 15 independent characters. At genotypic level, number of branches per vine, duration of crop, days to 50 per cent flowering, average fruit weight, number of fruits per vine, number of seeds per fruit and flesh thickness had direct and positive effect on fruit yield per vine. This is in agreement with results of Yadagiri *et al.*, (2017) in bitter gourd. Node at which first female appears had positive direct effect (0.2) on fruit yield per vine and it had high positive indirect effect through days to first fruit picking, average fruit weight, number of branches per vine and number of seeds per fruit (0.13). Days to first female flower opening had high negative direct effect (-0.4) on fruit yield per vine and it had positive indirect effect through number of fruits per vine (0.23).

Fruit length had high positive direct effect (0.5) on fruit yield per vine and it had positive indirect effect through days to first fruit picking (0.4), average fruit weight (0.39). Similar observations made by Kundu *et al.*, (2012) and Khan *et al.*, (2015) in bitter gourd. Therefore, fruit length needs to be considered along with average fruit weight, days to first fruit picking, number of seeds per fruit and day to 50% flowering would be rewarding in improvement of yield. The characters viz., fruit length, fruit diameter, duration of crop and average fruit weight are important characters to be accounted for gaining improvement in fruit yield per vine since, these characters had high positive direct and indirect effects on fruit yield per vine.

Table 4. Genotypic correlation co-efficient for growth, earliness and yield characters in bitter gourd

| Trait                                         | Vine length (m) | Number of branches /vine | Duration of crop (days) | Node at which 1 <sup>st</sup> female flower | Days to first female flower opening | Days to 50 per cent flowering | Days to first fruit picking | Fruit length (cm) | Fruit diameter (cm) | Average fruit weight (g) | Number of fruits per vine | Number of seeds / fruit | Flesh thickness (mm) | Ascorbic acid (mg /100g) | Fruit yield / vine (kg) |
|-----------------------------------------------|-----------------|--------------------------|-------------------------|---------------------------------------------|-------------------------------------|-------------------------------|-----------------------------|-------------------|---------------------|--------------------------|---------------------------|-------------------------|----------------------|--------------------------|-------------------------|
| Vine length (m)                               | 1.00            | 0.44**                   | 0.30**                  | 0.32**                                      | 0.29**                              | 0.53**                        | 0.56**                      | 0.45**            | 0.19                | 0.44**                   | -0.13                     | 0.6358**                | 0.17                 | -0.45**                  | 0.36**                  |
| Number of branches/vine                       |                 | 1.00                     | 0.58**                  | 0.63**                                      | 0.32**                              | 0.51**                        | 0.61**                      | 0.46**            | 0.40**              | 0.72**                   | 0.12                      | 0.57**                  | 0.34**               | -0.00                    | 0.90**                  |
| Duration of crop (days)                       |                 |                          | 1.00                    | 0.38**                                      | 0.37**                              | 0.77**                        | 0.68**                      | 0.47**            | -0.18               | 0.67**                   | -0.42**                   | 0.67**                  | -0.00                | -0.14                    | 0.63**                  |
| Node at which 1 <sup>st</sup> female flower   |                 |                          |                         | 1.00                                        | 0.65**                              | 0.69**                        | 0.90**                      | 0.41**            | 0.33**              | 0.69**                   | -0.67**                   | 0.67**                  | 0.37**               | 0.00                     | 0.51**                  |
| Days to 1 <sup>st</sup> female flower opening |                 |                          |                         |                                             | 1.00                                | 1.17**                        | 1.15**                      | 0.50**            | 0.12                | 0.52**                   | -0.49**                   | 0.47**                  | 0.24*                | 0.04                     | 0.28*                   |
| Days to 50 per cent flowering                 |                 |                          |                         |                                             |                                     | 1.00                          | 1.67**                      | 0.70**            | 0.20                | 0.88**                   | -0.89**                   | 0.61**                  | 0.43**               | 0.02                     | 0.44**                  |
| Days to first fruit picking                   |                 |                          |                         |                                             |                                     |                               | 1.00                        | 0.783**           | 0.21                | 0.97**                   | -0.74**                   | 0.74**                  | 0.33**               | -0.05                    | 0.71**                  |
| Fruit length (cm)                             |                 |                          |                         |                                             |                                     |                               |                             | 1.00              | -0.09               | 0.73**                   | -0.48**                   | -0.70**                 | 0.09                 | 0.05                     | 0.58**                  |
| Fruit diameter (cm)                           |                 |                          |                         |                                             |                                     |                               |                             |                   | 1.00                | 0.36**                   | 0.22*                     | 0.17                    | 0.63**               | -0.08                    | 0.54**                  |
| Average fruit weight (g)                      |                 |                          |                         |                                             |                                     |                               |                             |                   |                     | 1.00                     | -0.59**                   | 0.67**                  | 0.34**               | -0.02                    | 0.94**                  |
| Number of fruits per vine                     |                 |                          |                         |                                             |                                     |                               |                             |                   |                     |                          | 1.00                      | -0.18                   | 0.05                 | -0.13                    | -0.29**                 |
| Number of seeds / fruit                       |                 |                          |                         |                                             |                                     |                               |                             |                   |                     |                          |                           | 1.00                    | 0.22*                | -0.30**                  | 0.69**                  |
| Flesh thickness (mm)                          |                 |                          |                         |                                             |                                     |                               |                             |                   |                     |                          |                           |                         | 1.00                 | -0.18                    | 0.479**                 |
| Ascorbic acid (mg/100g)                       |                 |                          |                         |                                             |                                     |                               |                             |                   |                     |                          |                           |                         |                      | 1.00                     | -0.13                   |
| Fruit yield / vine (kg)                       |                 |                          |                         |                                             |                                     |                               |                             |                   |                     |                          |                           |                         |                      |                          | 1.00                    |

\* Significant nt at 5%

\*\* Significant at 1%

Table 5. Genotypic path co-efficient analysis for fruit yield per vine and its components in bitter gourd

| Trait                                               | Vine length (m) | Number of branches / vine | Duration of crop (days) | Node at which 1 <sup>st</sup> female flower appears | Days to first female flower opening | Days to 50 % flowering | Days to first fruit picking | Fruit length (cm) | Fruit diameter (cm) | Average fruit weight (g) | Number of fruits / vine | Number of seeds / fruit | Flesh thickness (m) | Ascorbic acid (mg/100g) | Genotypic correlation with fruit yield / vine |
|-----------------------------------------------------|-----------------|---------------------------|-------------------------|-----------------------------------------------------|-------------------------------------|------------------------|-----------------------------|-------------------|---------------------|--------------------------|-------------------------|-------------------------|---------------------|-------------------------|-----------------------------------------------|
| Vine length (m)                                     | -0.24           | -0.10                     | -0.07                   | -0.07                                               | -0.07                               | -0.12                  | -0.13                       | -0.10             | -0.04               | -0.10                    | 0.03                    | -0.15                   | -0.04               | 0.11                    | 0.36**                                        |
| Number of branches / vine                           | 0.24            | 0.09                      | 0.05                    | 0.06                                                | 0.03                                | 0.04                   | 0.05                        | 0.04              | 0.03                | 0.06                     | 0.01                    | 0.05                    | 0.03                | 0.00                    | 0.90**                                        |
| Duration of crop (days)                             | 0.12            | 0.00                      | 0.40                    | 0.15                                                | 0.15                                | 0.31                   | 0.27                        | 0.19              | -0.07               | 0.27                     | -0.17                   | 0.27                    | -0.00               | -0.05                   | 0.63**                                        |
| Node at which 1 <sup>st</sup> female flower appears | 0.07            | 0.14                      | 0.08                    | 0.22                                                | 0.17                                | 0.15                   | 0.20                        | 0.09              | 0.07                | 0.15                     | -0.15                   | 0.13                    | 0.08                | 0.00                    | 0.51**                                        |
| Days to first female flower opening                 | -0.14           | -0.15                     | -0.18                   | -0.31                                               | -0.48                               | -0.56                  | -0.55                       | -0.24             | -0.05               | -0.25                    | 0.23                    | -0.22                   | -0.11               | -0.01                   | 0.28*                                         |
| Days to 50 % flowering                              | 0.10            | 0.10                      | 0.15                    | 0.13                                                | 0.23                                | 0.19                   | 0.33                        | 0.14              | 0.04                | 0.17                     | -0.17                   | 0.12                    | 0.08                | 0.00                    | 0.44**                                        |
| Days to first fruit picking                         | -0.01           | -0.01                     | -0.01                   | -0.01                                               | -0.02                               | -0.03                  | -0.02                       | -0.01             | -0.00               | -0.02                    | 0.01                    | -0.01                   | -0.00               | 0.00                    | 0.71**                                        |
| Fruit length (cm)                                   | 0.24            | 0.24                      | 0.25                    | 0.22                                                | 0.26                                | 0.37                   | 0.41                        | 0.53              | -0.05               | 0.39                     | -0.25                   | 0.37                    | 0.04                | 0.03                    | 0.58**                                        |
| Fruit diameter (cm)                                 | 0.09            | 0.20                      | -0.09                   | 0.16                                                | 0.05                                | 0.10                   | 0.10                        | -0.04             | 0.49                | 0.18                     | 0.11                    | 0.08                    | 0.31                | -0.04                   | 0.54**                                        |
| Average fruit weight (g)                            | 0.16            | 0.27                      | 0.25                    | 0.25                                                | 0.19                                | 0.33                   | 0.36                        | 0.27              | 0.13                | 0.37                     | -0.22                   | 0.25                    | 0.12                | -0.01                   | 0.94**                                        |
| Number of fruits / vine                             | -0.02           | 0.02                      | -0.09                   | -0.14                                               | -0.10                               | -0.19                  | -0.15                       | -0.10             | 0.04                | -0.12                    | 0.21                    | -0.03                   | 0.01                | -0.02                   | -0.29**                                       |
| Number of seeds / fruit                             | -0.14           | -0.12                     | -0.15                   | -0.13                                               | -0.10                               | -0.13                  | -0.16                       | -0.15             | -0.03               | -0.15                    | 0.04                    | -0.22                   | -0.05               | 0.06                    | 0.69**                                        |
| Flesh thickness (m)                                 | -0.00           | -0.01                     | 0.00                    | -0.01                                               | -0.01                               | -0.02                  | -0.01                       | -0.00             | -0.03               | -0.01                    | -0.00                   | -0.01                   | -0.04               | 0.00                    | 0.47**                                        |
| Ascorbic acid (mg/100g)                             | 0.09            | 0.00                      | 0.02                    | -0.00                                               | -0.00                               | -0.00                  | 0.01                        | -0.01             | 0.01                | 0.00                     | 0.02                    | 0.06                    | 0.03                | -0.20                   | -0.13                                         |

Residual effect = 0.1876 \* Significant at 5% \*\* Significant at 1% Direct effect values at diagonal and others are indirect effect on fruit yield / vine

## Conclusion

The characters viz., fruit length, average fruit weight, number of seeds per fruit, fruit yield per vine, fruit yield per hectare and flesh thickness were recorded high GCV, PCV, heritability and GAM. Hence, these characters had lot of variability with additive gene actions. Therefore,

these traits can be improved by simple selection. Fruit yield per vine was positively and significantly associated with fruit length, fruit diameter, duration of crop and average fruit weight. These characters have to be considered while selecting the genotypes for fruit yield per vine. These characters also recorded high direct effect on fruit yield per vine.

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