Genetic Variability, Character Association and Path Coefficient Study in Guava (*Psidium guajava* L.) for Plant growth, Floral and Yield Attributes

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Abstract

Guava (*Psidium guajava* L.) is one of the major fruit crops of India. The present investigation was carried out with eleven genotype of guava under mid-hill subtropics of Meghalaya during 2011 and 2012 with respect to plant growth, floral and yield related traits. Being an open pollinated and heterozygous crop, wide range of phenotypic variation along with high heritability and genetic advance has been observed among the genotypes. High heritability estimates associated with high genetic advance as % of mean were obtained for fruit yield which indicated that selection of this character would be more effective. Such association may be attributed to the action of additive genes. This character also exhibited high gcv, therefore, selection based on phenotypic performance for this trait would be effective in improving directly in the population. Association studies revealed that fruit yield was significantly and positively correlated with plant height, stem diameter, canopy spread, shoot diameter, number of leaves, days to flowering, fruit set, bud length, bud diameter, petal length, stamen length, number of stamens per flower and pistil length at both genotypic and phenotypic levels while, with flowering duration, fruit drop, number of petals per flower and petal width at genotypic level. Positive direct effect of petal length, bud length, plant height, bud diameter, stamen length, number of leaves per shoot, petal width, pistil length, days to flowering, flowering duration, fruit drop, fruit set, stem diameter, canopy spread along with significant and positive correlation with fruit yield suggested that these traits must be given due importance while selecting a genotype.

1. Introduction

Guava (*Psidium guajava* L.) is one of the most well known edible tree fruits grown widely in more than sixty countries throughout the tropical and subtropical regions of the world. The fruits are delicious, rich in vitamin ‘C’, pectin and minerals like calcium, phosphorus and iron. Guava fruits are used as fresh as well as for making jam, jelly, nectar, paste etc. (Patra et al., 2004). Besides, high concentrations of pectin in guava fruit may play a significant role in the reduction of cholesterol and thereby decrease the risk of cardiovascular disease. It is considered as “poor man’s apple”, the guava truly happens to be the fruit for masses in terms of its availability in the market and accessibility to the poor (Jayachandran et al., 2005). The agro-climatic condition of the north eastern region of India is quite suitable for commercial cultivation of guava and the farmers are looking for diversification of fruit crops to enhance their income. It is primarily grown in Assam, Nagaland, Sikkim and Tripura. It is also becoming popular amongst the fruit growers of Meghalaya. The production potential of guava have shown that it can successfully and profitably be grown up to mid and high altitude under various farming system.

The guava clones are varying greatly with respect to their fruit quality and yield potentials. The chances of success of any crop improvement programme increases to a greater extent due to genetic divergence within the available germplasm. Thus, the greater variability in the initial material will ensure evolution of desirable recombination by using suitable breeding methods. Guava being an open pollinated and heterozygous crop with adequate genetic variation helps in selection of desirable commercial types (Nakasone and Paull, 1999). Improvement in any fruit crop needs to be undertaken through breeding and genetic manipulation which has sufficient genotypes. The extent of variability in guava for vegetative and fruit characteristics has been estimated by several workers (Bandopadhyay et al., 1992; Thimmappaiah et al., 1985; Rattanpal and Dhaliwal, 1999; Raghava and Tiwari, 2008 and Man Bihari and Suryanarayan, 2011) Attempts have been made to utilize this inherent variability of guava germplasm pool and many varieties have been developed through selection. For continued improvement of guava through breeding to overcome threats from diseases, insect pests or biotic stresses and to evolve varieties according to consumer preferences, a diverse gene pool is essential. An accurate knowledge about the availability of the genetic diversity and the origin of cultivars would assist in the selection of parents in a hybridization programme. Phenotypic correlations of yield with growth attributes and path analysis become useful for crop improvement programmes to select the desirable types (Ray et al., 2014)

2. Materials and Methods

2.1. Study site

The present investigation was carried out at Horticultural Research Farm of ICAR Research complex for North Eastern Hills Region, Umiam, Meghalaya, India during 2011 and 2012. The experimental site was situated at 25°41'-21" North latitude and 91°55'-25"East longitude and at an elevation of 1010 m above mean sea level. The climate of the site can be characterized as subtemperate with minimum and maximum temperatures ranging from 6 to 29°C and with average annual rainfall of 2841 mm.

2.2. Selection of plant

Five years old eleven genetically diverse guava genotypes viz., RCG-1, RCG-2, RCG-3, RCG-11, RCGH-1, RCGH-4, RCGH-7, Allahabad Safeda, L-49, Lalit and Sangam were selected for recording observation with regards to plant growth, floral and fruit yield attributes.

2.3. Experimental design and observations recorded

The experiment was laid out in Randomized Block Design with three trees per replication of each genotype. All cultural operations were followed as suggested by Patel et al. (2008). The observation on plant growth, floral and yield character study was made in terms of plant height (m), stem diameter (cm), canopy spread (m^2), shoot length (cm), shoot diameter (mm), number of leaves/shoot, leaf length & breadth, days to flowering , days to maturity, flowering duration, fruit set (%), fruit drop (%), flower bud length (cm), flower bud diameter (mm), pedicel length (cm), flower length (cm), number of petals/flower, petal length (cm), petal width (mm), stamen length, number of stamens/flower, pistil length (cm) and fruit yield (kg tree^{-1}). For path analysis, fruit yield per tree pooled over two years was taken as dependent variable and all the other twenty three traits of plant growth and floral were considered as casual/independent variables. Data obtained during the experimentation were statistically analysed by the using of programme SPAR-I (Doshi and Gupta, 1991).

3. Results and Discussion

3.1. Coefficient of variation

Estimates of variability parameters for all 24 selected characters (Table 1) showed low difference between gcv and pcv indicating the influence of environmental factors on the expression of trait was low for most of the characters. The magnitude of genotypic coefficient of variation was higher than environmental coefficient of variation for all the characters. This indicates that the environmental factors having less influence over the expression to some degree or other. Pooled analysis over two years (Table 1) revealed higher genotypic and phenotypic coefficient of variation for canopy spread (34.07 and 40.67) while, plant height (16.63 and 19.73) and stem diameter (16.48 and 19.49) exhibited the moderate degree of gcv and pcv. Whereas, low gcv (13.30) accompanied with moderate pcv (16.55) was noticed in leaf width and shoot length (13.25 and 15.73). Among flowering and floral traits, high magnitude of gcv and pcv was expressed by flowering duration (24.61 and 29.55) whereas, moderate gcv (18.92) with high pcv (21.67) was observed in fruit drop followed by days to fruit set (18.91 and 21.65) and stamen length (18.03 and 21.52). While, pedicel length (14.05 and 18.29) followed by number of stamen per flower (13.40 and 15.94) and number of petals per flower (13.31 and 17.54) recorded the low gcv accompanied with moderate pcv. Higher magnitude of genotypic and phenotypic coefficient of variation was recorded for fruit yield (50.36 and 55.05). Similar observations were recorded by Thimmappaiah et al. (1985) for the characters viz., thickness of primary branches, fruits per tree and fruit yield and Bandopadhyay et al. (1992) for characters viz., leaf dry matter, leaf area, leaf length and leaf breadth. Thus, the high magnitude of gcv and pcv indicates a scope for improvement of these traits through selection. Closeness between gcv and pcv for some traits indicates that the phenotypic expression of all the genotypes is mostly under the genetic control of such traits and those are comparatively stable to environmental variations.

3.2. Heritability and genetic advance

Estimates of heritability (h^2) and genetic advance (GA) are important to find out the heritable portion of variability and genetic gain, which is likely to be achieved in the next generation. Heritability along with genetic advance as % of mean is more reliable than either of these two parameters alone in predicting the resultant effect of selecting the best individual. Heritability estimates in pooled analysis (Table 1) revealed that all the characters among plant growth, flowering and floral traits showed the moderate values of heritability, whereas yield showed the high value of heritability. However, the magnitude of heritability among the plant growth traits ranged from 60.67 in leaf length to 72.22 in plant height while, among the floral and fruit yield traits under study heritability varied from

Table 1: Variability, heritability, genetic advance and genetic advance as % of mean for different traits in guava genotypes (pooled)

Sl. No.	Characters	Coefficient of variation (%)			Heritability (%)	Genetic advance	Genetic advance as (%) mean
		gcv	pcv	ecv			
A.	Plant growth characters						
1.	Plant height	16.63	19.73	13.24	72.22	0.99	32.33
2.	Stem diameter	16.48	19.49	12.19	71.22	2.11	34.93
3.	Canopy spread	34.07	40.67	25.40	70.21	4.35	57.37
4.	Shoot length	13.25	15.73	7.78	70.95	14.10	17.92
5.	Shoot diameter	11.63	14.40	8.67	65.08	1.83	19.19
6.	Number of leaves/shoot	8.46	10.58	6.33	63.96	5.37	13.99
7.	Leaf length	8.48	10.98	7.00	60.67	3.53	26.74
8.	Leaf width	13.30	16.55	9.85	64.57	1.16	17.34
B.	Floral and fruit yield characters						
9.	Days to flowering	9.49	12.45	8.06	58.06	2.93	10.74
10.	Days to fruit maturity	5.75	6.71	3.45	73.44	10.87	8.65
11.	Flowering duration	24.61	29.55	18.10	69.36	16.16	40.83
12.	Fruit set	9.59	12.51	4.99	58.76	16.76	20.73
13.	Fruit drop	18.92	21.67	14.23	76.24	8.18	27.62
14.	Flower bud length	9.45	12.38	7.26	57.69	0.20	15.43
15.	Flower bud diameter	9.19	12.20	8.02	56.58	1.30	14.29
16.	Pedicel length	14.05	18.29	11.71	60.98	0.33	15.48
17.	Flower length	10.37	12.80	6.63	66.13	0.42	21.70
18.	Number of petals/flower	13.31	17.54	11.42	57.94	1.37	23.33
19.	Petal length	9.29	12.25	9.31	56.90	0.27	13.54
20.	Petal width	9.18	11.45	6.83	62.96	0.26	18.40
21.	Stamen length	18.03	21.52	9.48	68.89	0.45	32.87
22.	Number of stamens/flower	13.40	15.94	8.63	70.67	76.70	23.21
23.	Pistil length	9.93	12.66	9.90	60.98	0.33	20.48
24.	Fruit yield	50.36	55.05	23.88	83.69	18.17	89.99

gcv=Genotypic coefficient of variation, pcv = Phenotypic coefficient of variation, ecv = Environmental coefficient of variation

56.58 for flower bud diameter to 83.69 for fruit yield. Genetic advance as f mean varied from 8.65 (days to fruit maturity) to 89.99 % (fruit yield). Also high values were shown by canopy spread (57.37) and flowering duration (40.83). Stem diameter (34.93), days to fruit set (34.42), stamen length (32.87), plant height (32.33), fruit drop (27.62) and leaf length (26.74) exhibited the moderate values for genetic advance whereas, rest of the traits exhibited low values for genetic advance. All the characters among plant growth, flowering and floral traits showed the moderate values of heritability. However, the heritability value for fruit yield was high. The observation in accordance with these findings for heritability estimates were reported by Thimmappaiah et al. (1985), Bandopadhyay et al. (1992), Raghava and Tiwari (2008) and Man Bihari and Suryanarayan (2011) for the various plant and fruit characters in guava. Shah et al. (2010) also reported in almond for tree height, tree spread and nut length.

Genetic advance is the improvement over the base population. Lerner (1958) has suggested that heritability along with genetic advance will be more useful in selecting the best individuals. Panse (1942) and Johnson et al. (1955) impressed that heritability values along with estimates of genetic gain were more effective and reliable than heritability alone in predicting the improvement through selection. High heritability estimates associated with high genetic advance as % of mean were obtained for fruit yield which indicated that selection of this character would be more effective. Such association may be attributed to the action of additive genes. This character also exhibited high gcv, therefore, selection based on phenotypic performance for this traits would be effective in improving directly in the population. High values of gcv and heritability estimates supplements with greater genetic gains are also indicative of additive gene effects regulating the inheritance of such traits (Narayan et al., 1996); therefore, these characters reflect greater selective values and offer ample scope for selection. The high heritability along with high genetic advance for different traits in guava were reported by Thimmappaiah et al. (1985), Bandopadhyay et al. (1992), Raghava and Tiwari (2008) and Man Bihari and Suryanarayan (2011) in guava. Moderate heritability with high genetic advance as % of mean was obtained for canopy spread and flowering duration might also be attributed to additive gene action controlling their expression and phenotypic selection for their amelioration could be brought about by simple mass selection. Analogous observation were made by Dwivedi et al. (1995) and Mondal and Chanta (1993) in papaya, Sarkar et al. (1991) in litchi, Samanta et al. (1999) in mango. Moderate heritability with moderate genetic advance as % of mean was observed for plant height, stem diameter, leaf length, stamen length, days to fruit set, fruit drop indicating influence of environment on expression of these characters to a certain extent. Therefore, improvement of such traits will need high selection intensity (Yadav et al., 1993).

3.3. *Genotypic and phenotypic correlation coefficient*

Correlation coefficient studies help in determining the mutual relationship between various characters. It suggests the advantage of a scheme of selection for more than one trait at a time. Thus, the degree of closeness between characters is determined by correlation coefficient between them. Correlation coefficients pooled over two years at genotypic and phenotypic levels were worked out among different characters in all possible combinations (Table 2).

Fruit yield was significantly and positively correlated with plant height, stem diameter, canopy spread, shoot diameter, number of leaves, days to flowering, fruit set, bud length, bud diameter, petal length, stamen length, number of stamens per flower and pistil length at both genotypic and phenotypic levels while, with flowering duration, fruit drop, number of petals per flower and petal width at genotypic level. These findings were akin to the findings of Prasad (1987) recorded the significantly positive correlation for fruit yield with plant height, stock diameter and canopy spread in mango. Similarly, Ranpise and Desai (1994) found that growth parameters like plant height, tree volume and stem girth were positively correlated with each other as well as with number of fruits per plant and yield in lime.

Plant height has shown positive and significantly high genotypic and phenotypic correlation with stem diameter, shoot length, days to flowering and number of stamens per flower. Similar observation was recorded by Thimmappaiah et al. (1985) in guava and Prasad (1987) in mango. Stem diameter had positively and significant association with canopy spread, shoot diameter, number of leaves per shoot and fruit yield. The analogous findings in guava were also recorded similar correlation by Shikhamany et al. (1978) with trunk girth of the tree and yield; Thimmappaiah et al. (1985) observed the significantly positive association of stem girth with canopy spread and yield. Marak and Mukunda (2007) recorded that the trunk girth was significantly positive correlation with fruit yield. Similarly, Prasad (1987) reported that the stock diameter was significantly correlated with plant spread and fruit yield in mango. Canopy spread had significant positive correlation with shoot length, days to flowering, flowering duration, number of petals per flower, petal width, stamen length, number of stamens per flower, pistil length and fruit yield both at genotypic and phenotypic level and days to fruit maturity at genotypic level only. Shikhamany et al. (1978) and Thimmappaiah et al. (1985) in guava and Prasad (1987) in mango were also observed the similar correlation with yield and other characters. Shoot diameter showed significant positive correlation with bud length, bud diameter and fruit yield. Thimmappaiah et al. (1985) recorded positive correlations for thickness of primary branches with yield in guava. Number of leaves per shoot exhibits positive and significant correlation with leaf length, leaf width, fruit set, bud length, bud diameter, petal length and fruit yield at both the levels and with flower length at genotypic level. Roocha et al. (1994) observed a positive correlation between the number of leaves, number of flowers and fruits, indicating a relationship between the number of leaves and fruit set in orange.

Significant and positive correlation of fruit set was observed with stamen length and fruit yield while, it showed significant but, negative association with number of petals per flower, petal width and pistil length both at genotypic and phenotypic level but, with fruit drop and flower length at genotypic level. Among the floral traits, bud length had positive and significant association with all floral traits except petal width and stamen length which showed positive and non-significant correlation whereas, it also showed positive and significant correlation with fruit yield at genotypic level. There was a significant and positive correlation of the stamen length with pistil length and fruit yield at both the levels. Similarly, number of stamens per flower also exhibited positive and significant correlation with pistil length and fruit yield at both the levels. Pistil length was significantly and positively correlated with fruit yield at genotypic level.

3.4. *Path coefficient analysis*

Yield being a complex trait, it is difficult to exploit various yield contributing characters through the knowledge of correlation, therefore it is important to carry out other analysis including path coefficient that provide a clear indication for selection criterion (McGiffen et al., 1994). The coefficients generated by path analysis measure the direct and indirect influence of variable upon other (Dewy and Lu, 1959). Fruit yield per tree pooled over two years was taken as dependent variable and all the other twenty three plant growth, leaf and floral traits were considered as casual/independent variables (Table 3).

Table 2: Pooled genotypic (rg) and phenotypic (rp) correlation coefficients among the plant growth, floral characters and yield in guava

Sl. no.	Characters		1	2	3	4	5	6	7	8	9	10	11	12
1.	Plant height	rg	-	0.975**	0.240	0.284**	0.115	0.228	-0.215	-0.791**	0.848**	-0.121	-0.131	-0.235
		rp		0.847**	0.235	0.277*	0.112	0.221	-0.211	-0.589**	0.502**	-0.118	-0.130	-0.229
2.	Stem diameter	rg		-	0.633**	-0.051	0.914**	0.999**	-0.534**	-0.669**	-0.740**	-0.106	-0.188	-0.267*
		rp			0.583**	-0.015	0.504**	0.464**	-0.383**	-0.427**	-0.431**	-0.104	-0.184	-0.238
3.	Canopy spread	rg			-	0.278*	-0.982**	-0.952**	-0.304**	-0.756**	0.988**	0.249*	0.612**	-0.771*
		rp				0.278*	-0.771**	-0.688**	-0.303**	-0.603**	0.587**	0.239	0.289**	-0.495**
4.	Shoot length	rg				-	0.116	0.164	0.563**	0.372**	-0.068	-0.269*	0.078	-0.114
		rp					0.152	0.160	0.281*	0.338**	-0.066	-0.028	0.049	-0.111
5.	Shoot diameter	rg					-	-0.235	-0.419*	-0.799**	-0.994**	-0.221	-0.297*	0.184
		rp						-0.231	-0.289*	-0.662**	-0.673**	-0.056	-0.147	0.181
6.	Number of leaves/shoot	rg						-	0.612**	0.901**	-0.996**	0.043	0.049	0.638**
		rp							0.457**	0.769**	-0.635**	0.040	0.043	0.431**
7.	Leaf length	rg							-	0.825**	-0.358**	0.779**	0.584**	0.015
		rp								0.724**	-0.250*	0.462**	0.577**	0.012
8.	Leaf width	rg								-	-0.809**	0.352**	0.229	0.525**
		rp									-0.544**	0.305**	0.226	0.399**
9.	Days to flowering	rg									-	-0.096	0.266*	-0.771**
		rp										-0.089	0.195	-0.435**
10.	Days to fruit maturity	rg										-	0.985**	-0.195
		rp											0.713**	-0.151
11.	Flowering duration	rg											-	-0.611**
		rp												-0.289*
12.	Fruit set	rg												-
		rp												
13	Fruit drop	rg												
		rp												
14.	Flower bud length	rg												
		rp												
15.	Flower bud diameter	rg												
		rp												
16	Pedicel length	rg												
		rp												
17	Flower length	rg												
		rp												
18	Number of petals/flower	rg												
		rp												
19	Petal length	rg												
		rp												
20	Petal width	rg												
		rp												
21	Stamen length	rg												
		rp												
22	Number of stamens/flower	rg												
		rp												
23	Pistil length	rg												
		rp												
24	Fruit yield	rg												
		rp												

Table 2: Contd…

S1. No.	Characters		13	14	15	16	17	18	19	20	21	22	23	24
1.	Plant height	rg	-0.185	-0.585**	-0.210	-0.206	-0.288*	-0.136	-0.797**	-0.118	0.214	0.505**	-0.303**	0.875**
		rp	-0.181	-0.508**	-0.201	-0.197	-0.280**	-0.129	-0.649**	-0.061	0.209	0.469**	-0.292*	0.807**
2.	Stem diameter	rg	-0.056	-0.622**	-0.192	-0.245	-0.442**	-0.094	-0.219	-0.051	-0.216	-0.237	-0.260*	0.827**
		rp	-0.050	-0.459**	-0.162	-0.169	-0.426**	-0.090	-0.206	-0.050	-0.209	-0.161	-0.092	0.712**
3.	Canopy spread	rg	0.184	-0.066	-0.099	0.105	0.214	0.631**	-0.592**	0.537**	0.589**	0.824**	0.695**	0.990**
		rp	0.148	-0.066	-0.090	0.102	0.189	0.364**	-0.287*	0.256*	0.587**	0.573**	0.400**	0.689**
4.	Shoot length	rg	-0.231	0.131	-0.148	-0.242	-0.139	-0.097	0.238	0.182	-0.079	0.075	-0.204	-0.240*
		rp	-0.119	0.129	-0.131	-0.227	-0.136	-0.092	0.233	0.150	-0.078	0.037	-0.194	-0.129
5.	Shoot diameter	rg	-0.181	0.253*	0.292*	-0.024	-0.090	-0.147	0.118	-0.243*	-0.137	-0.780**	0.228	0.992**
		rp	-0.163	0.240*	0.263*	-0.023	-0.089	-0.132	0.110	-0.144	-0.118	-0.613**	0.224	0.797**
6.	Number of leaves/shoot	rg	-0.213	0.503**	0.526**	0.124	0.258*	-0.219	0.953**	0.193	-0.911**	-0.223	-0.334**	0.396**
		rp	-0.145	0.376**	0.331**	0.118	0.234	-0.153	0.478**	0.139	-0.531**	-0.215	-0.244*	0.388**
7.	Leaf length	rg	0.301*	0.217	0.953**	0.039	0.447**	0.224	0.854**	0.241*	0.289*	-0.045	0.413**	0.238
		rp	0.291*	0.212	0.759**	0.035	0.350**	0.220	0.626**	0.237	0.201	-0.038	0.324**	0.205
8.	Leaf width	rg	-0.116	0.239	0.727**	0.029	0.085	0.136	0.834**	0.316**	0.291	-0.459**	0.090	-0.842**
		rp	-0.017	0.230	0.583**	0.028	0.061	0.131	0.591**	0.314**	0.286	-0.344**	0.078	-0.695**
9.	Days to flowering	rg	0.347**	-0.051	-0.239	0.238	0.309**	0.192	-0.249*	0.241*	0.290*	0.162	0.728**	0.993**
		rp	0.339**	-0.049	-0.123	0.176	0.248*	0.186	-0.242*	0.184	0.281*	0.155	0.412**	0.626**
10	Days to fruit maturity	rg	0.869**	0.935**	0.941**	0.265*	0.808**	0.985**	0.648**	0.986**	0.240*	0.283*	0.995**	0.211
		rp	0.513**	0.610**	0.519**	0.168	0.339**	0.605**	0.432**	0.335**	0.223	0.243*	0.557**	0.134
11	Flowering duration	rg	0.767**	0.237	-0.237	-0.189	0.204	-0.295*	-0.231	0.196	-0.238	0.251	0.990**	0.370**
		rp	0.599**	0.231	-0.221	-0.185	0.199	-0.238	-0.209	0.191	-0.224	0.244	0.743**	0.143
12	Fruit set	rg	-0.284*	-0.190	-0.062	-0.062	-0.242*	-0.335**	0.201	-0.318**	0.707**	-0.230	-0.716**	0.290*
		rp	-0.211	-0.131	-0.033	-0.061	-0.167	-0.317**	0.145	-0.282**	0.379**	-0.223	-0.364**	0.242*
13	Fruit drop	rg	-	-0.476**	-0.305**	0.294*	0.274*	-0.686**	0.199	-0.800**	0.699**	0.292*	-0.816**	0.443**
		rp		-0.405**	-0.302**	0.183	0.186	-0.433**	0.195	-0.351**	0.382**	0.262*	-0.484**	0.175
14	Flower bud length	rg		-	0.801**	0.638**	0.659**	0.767**	0.672**	0.217	0.019	0.250*	0.698**	0.268*
		rp			0.743**	0.375**	0.597**	0.603**	0.627**	0.211	0.015	0.241*	0.548**	0.231
15	Flower bud diameter	rg			-	0.327**	0.634**	0.801**	0.843**	0.701**	0.282*	0.245*	0.561**	0.322**
		rp				0.320**	0.340**	0.542**	0.639**	0.451**	0.277*	0.241*	0.499**	-0.281*
16	Pedicel length	rg				-	0.708**	0.215	0.364**	0.209	0.276	0.227	0.550**	0.031
		rp					0.421**	0.209	0.323**	0.204	0.145	0.219	0.281*	0.030
17	Flower length	rg					-	0.703**	0.649**	0.873**	0.124	0.239	0.747**	0.026
		rp						0.418**	0.449**	0.376**	0.117	0.236	0.477**	0.022
18	Number of petals/flower	rg						-	0.370**	0.194	0.541**	0.206	0.990**	0.461**
		rp							0.336**	0.188	0.312**	0.199	0.622**	0.153
19	Petal length	rg							-	0.462**	0.429**	0.142	0.248*	0.691**
		rp								0.460**	0.318**	0.138	0.242*	0.585**
20	Petal width	rg								-	0.653**	0.164	0.998**	0.407**
		rp									0.280*	0.156	0.612**	0.147
21	Stamen length	rg									-	0.230	0.735**	0.920**
		rp										0.226	0.523**	0.748**
22	Number of stamens/flower	rg										-	0.712**	0.703**
		rp											0.305*	0.619**
23	Pistil length	rg											-	0.572**
		rp												0.248
24	Fruit yield	rg												-
		rp												

*, ** = Significant at 5 and 1% levels of probability, respectively.

Table 3: Path coefficient analysis of various plant growth and floral characters towards fruit yield of guava (pooled)

Sl. No.	Characters	Direct effect	1	2	3	4	5	6	7	8	9	10	11	12
1.	Plant height	0.174	-	0.174	0.129	0.009	-0.159	0.180	-0.094	-0.137	0.147	-0.021	0.005	-0.114
2.	Stem diameter	0.013	0.013	-	0.008	0.001	0.012	-0.013	-0.007	-0.009	0.010	-0.001	-0.0002	-0.009
3.	Canopy spread	0.009	0.006	0.006	-	-0.002	-0.009	-0.008	-0.003	-0.007	0.010	0.004	0.005	-0.007
4.	Shoot length	-0.016	-0.001	-0.001	0.005	-	-0.002	-0.003	-0.009	-0.006	0.001	-0.004	-0.001	0.0002
5.	Shoot diameter	-0.066	0.061	0.060	0.065	-0.008	-	-0.069	-0.028	-0.053	0.069	0.015	0.027	-0.052
6.	Number of leaves/ shoot	0.142	-0.148	-0.142	-0.135	0.023	0.148	-	0.087	0.128	-0.142	0.006	-0.029	0.091
7.	Leaf length	0.187	-0.101	-0.099	-0.057	0.105	0.078	0.114	-	0.154	-0.067	0.146	0.109	0.003
8.	Leaf width	-0.434	0.346	0.293	0.331	-0.163	-0.350	-0.394	-0.361	-	0.354	-0.154	-0.034	-0.230
9.	Days to flowering	0.041	0.035	0.031	0.046	-0.003	-0.044	-0.041	-0.015	-0.034	-	0.021	0.023	-0.032
10.	Days to fruit maturity	-0.064	0.008	0.007	-0.026	-0.017	0.014	-0.003	-0.050	-0.023	-0.033	-	-0.066	0.013
11.	Flowering duration	0.033	0.001	-0.001	0.020	0.003	-0.014	-0.007	0.020	0.003	0.019	0.034	-	-0.020
12.	Fruit set	0.014	0.009	0.009	0.010	0.0002	-0.011	-0.009	-0.0002	-0.007	0.010	0.003	0.008	-
13	Fruit drop	0.030	0.006	0.002	0.021	0.016	-0.016	-0.009	0.010	-0.004	0.022	0.026	0.023	-0.009
14.	Flower bud length	0.301	0.176	0.188	0.001	-0.040	-0.072	-0.152	-0.227	-0.156	0.015	-0.282	-0.235	0.057
15.	Flower bud diameter	0.174	-0.106	-0.103	-0.017	0.026	0.051	0.092	0.166	0.127	-0.042	0.164	0.132	-0.011
16	Pedicel length	0.133	-0.046	-0.046	0.014	-0.042	-0.003	0.017	0.005	-0.004	0.032	0.088	0.053	0.001
17	Flower length	-0.133	0.038	0.059	-0.033	-0.009	-0.008	-0.034	-0.060	-0.011	-0.041	-0.108	-0.107	0.057
18	Number of petals/ flower	0.258	0.021	0.024	0.163	-0.025	-0.122	-0.056	0.144	0.009	0.161	0.254	0.270	-0.190
19	Petal length	0.306	0.244	0.251	0.181	-0.135	-0.220	-0.292	-0.262	-0.256	0.194	-0.199	-0.132	-0.062
20	Petal width	0.128	0.015	0.007	0.069	0.036	-0.056	-0.025	0.070	0.001	0.076	0.147	0.134	-0.104
21	Stamen length	0.163	0.117	0.091	0.160	-0.013	-0.153	-0.149	-0.047	-0.129	0.167	0.071	0.088	-0.115
22	Number of stamens/ flower	-0.035	-0.018	-0.015	-0.029	-0.003	0.028	0.026	0.001	0.016	-0.034	-0.021	-0.019	0.015
23	Pistil length	0.082	0.025	0.021	0.057	0.017	-0.047	-0.027	0.034	-0.007	0.060	0.086	0.082	-0.059

Table 3: Contd…..

Sl. No.	Characters	Direct effect	13	14	15	16	17	18	19	20	21	22	23	rg
1.	Plant height	0.174	0.032	-0.102	-0.106	-0.060	-0.050	0.014	-0.138	0.020	0.124	0.088	0.053	0.875**
2.	Stem diameter	0.013	0.001	-0.008	-0.008	-0.005	-0.006	0.001	-0.011	0.001	0.007	0.006	0.004	0.827**
3.	Canopy spread	0.009	0.006	0.001	-0.001	0.001	0.002	0.006	-0.005	0.005	0.009	0.007	0.006	0.990**
4.	Shoot length	-0.016	-0.009	-0.002	-0.002	0.005	-0.001	0.002	-0.007	-0.005	0.001	-0.001	0.003	-0.240*
5.	Shoot diameter	-0.066	0.036	-0.016	-0.019	0.002	-0.004	0.031	-0.047	0.029	0.062	0.052	0.038	0.992**
6.	Number of leaves/ shoot	0.142	-0.045	0.072	0.075	0.018	0.037	-0.031	0.136	-0.028	-0.130	-0.103	-0.048	0.396**
7.	Leaf length	0.187	0.063	0.141	0.178	0.007	0.084	0.104	0.160	0.103	-0.054	-0.007	0.077	0.238
8.	Leaf width	-0.434	0.051	-0.227	-0.318	0.013	-0.037	-0.016	-0.365	-0.003	0.346	0.201	0.040	-0.842**
9.	Days to flowering	0.041	0.031	-0.002	-0.010	0.010	0.013	0.026	-0.026	0.025	0.042	0.040	0.030	0.993**
10	Days to fruit maturity	-0.064	-0.056	-0.060	-0.060	-0.043	-0.052	-0.063	-0.042	-0.074	-0.028	-0.037	-0.067	0.211
11	Flowering duration	0.033	0.026	0.026	0.025	0.013	0.027	0.035	0.014	0.035	0.018	0.018	0.033	0.370**
12	Fruit set	0.014	0.004	0.003	0.001	-0.0001	0.006	0.010	-0.003	0.011	0.010	0.006	0.010	0.290*
13	Fruit drop	0.030	-	-0.014	-0.009	0.009	0.017	-0.021	0.003	-0.024	0.021	0.024	-0.025	0.443**
14	Flower bud length	0.301	-0.144	-	-0.272	-0.192	-0.289	-0.231	-0.278	-0.264	-0.006	-0.045	-0.210	0.268*
15	Flower bud diameter	0.174	0.053	0.157	-	0.057	0.110	0.139	0.147	0.122	-0.032	0.002	0.098	0.322**
16	Pedicel length	0.133	0.039	0.085	0.043	-	0.094	0.066	0.048	0.068	0.037	0.052	0.073	0.031
17	Flower length	-0.133	-0.076	-0.128	-0.084	-0.094	-	-0.094	-0.086	-0.116	-0.057	-0.059	-0.099	0.026
18	Number of petals/ flower	0.258	0.177	0.198	0.207	0.128	0.182	-	0.096	0.286	0.140	0.139	0.272	0.461**
19	Petal length	0.306	-0.030	-0.282	-0.258	-0.111	-0.199	-0.113	-	0.141	0.132	0.105	-0.076	0.691**
20	Petal width	0.128	0.102	0.112	0.089	0.065	0.111	0.142	0.059	-	0.083	0.059	0.142	0.407**
21	Stamen length	0.163	0.114	0.003	-0.030	0.045	0.069	0.088	-0.070	0.107	-	0.136	0.120	0.920**
22	Number of stamens/ flower	-0.035	-0.028	-0.005	-0.001	-0.014	-0.016	-0.019	0.012	-0.016	-0.029	-	-0.025	0.703**
23	Pistil length	0.082	0.067	0.057	0.046	0.045	0.061	0.086	0.020	0.091	0.060	0.058	-	0.572**

Residual effect = 0.379; *, ** = Significant at 5 and 1% levels of probability, respectively.

A perusal of path coefficient analysis indicated that positive direct effect on yield were exhibited by petal length (0.306), bud length (0.301), number of petals per flower (0.258), leaf length (0.187), plant height & bud diameter (0.174 each), stamen length (0.163), number of leaves per shoot (0.142), pedicel length (0.133), petal width (0.128), pistil length (0.082), days to flowering (0.041), flowering duration (0.033), fruit drop (0.030), fruit set (0.014), stem diameter (0.013) and canopy spread (0.009) indicate good scope for improvement in fruit yield. Positive direct effect of petal length, bud length, plant height, bud diameter, stamen length, number of leaves per shoot, petal width, pistil length, days to flowering, flowering duration, fruit drop, fruit set, stem diameter, canopy spread along with significant and positive correlation with fruit yield suggested that these traits must be given due importance while selecting a genotype. These findings are in accordance with the findings of previous workers, Prasad (1987) observed direct positive effect of canopy spread, plant height and stock diameter on fruit yield of mango. Rai et al. (2001) they reported the direct positive effect of tree volume on fruit yield of mango. Raghava and Tiwari (2008) also recorded that leaf length and maximum leaf breadth showed positive high direct effect on fruit yield of guava.

The indirect effects for most of the traits were mostly via plant height, stem diameter, canopy spread, leaf length, leaf width, number of leaves, flowering duration, bud length, bud diameter, pistil length, stamen length and number of stamens per flower, hence these traits are the important for selection. Prasad (1987) also observed the indirect effects for fruit yield were mostly via plant height, stem diameter and canopy spread in mango.

Negative direct effect on fruit yield were imposed by leaf width and flower length followed by shoot diameter, days to fruit maturity, number of stamens per flower and shoot length. However, flower length, shoot diameter, days to fruit maturity and number of stamens per flower had positive correlation with yield indicating that less emphasis should be given to these traits while, selecting a genotype as compared to those traits which showed positive direct effect with positive and significant correlation with fruit yield. The residual path value was 0.379, which indicates the importance of these characters towards contributing the fruit yield.

4. Conclusion

High heritability estimates associated with high genetic advance as % of mean were obtained for fruit yield which indicated that selection of this character would be more effective. Such association may be attributed to the action of additive genes. This character also exhibited high gcv, therefore, selection based on phenotypic performance for this traits would be effective in improving directly in the population. Positive direct effect of petal length, bud length, plant height, bud diameter, stamen length, number of leaves per shoot, petal width, pistil length, days to flowering, flowering duration, fruit drop, fruit set, stem diameter, canopy spread along with significant and positive correlation with fruit yield suggested that these traits must be given due importance while selecting a genotype.

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