ISSN: 0974 - 0376

The Ecoscan : Special issue, Vol. VII: 447-453: 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.in

GENETIC VARIABILITY, CHARACTER ASSOCIATION AND PATH COEFFICIENT STUDY IN GUAVA (*PSIDIUM GUAJAVA* L.) FOR YIELD AND FRUIT RELATED TRAITS

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KEYWORDS

Guava
Mid-hill subtropics
Heritability
Genetic advance
Path coefficient

Proceedings of National Conference on Harmony with Nature in Context of Bioresources and Environmental Health
(HORMONY - 2015)
November 23 - 25, 2015, Aurangabad,
organized by
Department of Zoology,
Dr. Babasaheb Ambedkar Marathwada University
Aurangabad (Maharashtra) 431 004
in association with
National Environmentalists Association, India
www.neaindia.org

The Ecoscan
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES

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ABSTRACT

An experiment was conducted with eleven genotype of guavaduring 2011-12 to study the genetic variability, characters association and path coefficient for yield and quality related traits. Being an open pollinated and heterozygous crop, wide range of phenotypic variation along with high heritability and genetic advance observed among the genotypes. Number of fruits/plant (41.68, 82.24%, 63.12), fruit weight (20.09, 82.48%, 41.23), fruit yield (50.36, 83.69%, 89.99), flesh: seed ratio (28.09, 80.09%, 44.24), number of seeds/fruit (27.23, 80.76%, 41.14), test weight (23.25, 70.15%, 42.88), phenol (23.60, 87.15%, 43.25) and pectin content (21.42, 89.66%, 41.18) shown high magnitude of gcv, heritability along with high genetic advance revealing that these characters are controlled by additive gene. Association studies revealed that fruit yield was significantly and positively correlated with number of fruits/tree, seeds/fruit, seed weight per fruit, specific gravity and phenol content at both genotypic and phenotypic levels. Maximum positive direct effect towards yield exhibited by number of fruits/tree (1.055) followed by phenol content (0.515), fruit diameter (0.450), flesh: seed ratio (0.277), number of seeds/fruit (0.276), test weight (0.268), TSS (0.221) and ascorbic acid (0.171). It indicated that these characters are very important while making selection for high yielding genotypes in further breeding programme.

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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. (Bisen *et al.*, 2014). 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 (Deshmukh *et al.*, 2013). The chances of success of any crop improvement programme increases to a large 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 (Man Bihari and Suryanarayan, 2011; Raghava and Tiwari, 2008; Rattanpal and Dhaliwal, 1999; Thimmappaiah *et al.*, 1985 and Bandopadhyay *et al.*, 1992). Attempts have been made through this paper 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.

MATERIALS AND METHODS

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 evaluated with respect to yield and quality traits of fruit at ICAR Research Complex for NEH Region, Umiam (Meghalaya) in 2011 and 2012. The observation was taken from well established five year old bearing orchard with three trees per

replication of each genotype. Ten fruits were randomly harvested from each replication. Yield and physico-chemical study was made in terms of yield (kg/tree), fruit weight (g), fruit length (cm), fruit diameter (cm), test weight (100 seed in g), pulp to seed ratio, TSS (%), acidity (%), ascorbic acid (mg/100g), total sugar (%), pectin (%) and phenol (mg GAE/100 g FW). The total soluble solids (TSS) of the pulp were determined by digital refractometer. Acidity was determined by titration value of the juice against N/10 NaOH and expressed as percentcitric acid. Ascorbic acid content of fruit was determined with the help of the method given in A.O.A.C. (2000). Sugars and pectin content of guava fruit was estimated as per method given by Ranganna (1997) and total phenol content was determined using the Folin-Ciocalteu's reagent (Singleton and Rossi, 1965). For path analysis, fruit yield per tree pooled over two years was taken as dependent variable and all the other nineteen traits of fruit and fruit quality 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).

RESULTS AND DISCUSSION

Coefficient of variation

Estimates of variability parameters for all 20 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 also indicates that the environmental factors having less influence over the expression to some degree or other.

Higher genotypic and phenotypic coefficient of variation (Table 1) was recorded for fruit yield (50.36 and 55.05) followed by number of fruits per plant (41.68 and 45.96), flesh: seed ratio (28.09 and 31.39), number of seeds per fruit (27.23 and 30.30), test weight (23.25 and 27.79) and fruit weight (20.09 and 22.12) while, moderate gcv with high pcv was recorded for seed weight per fruit (18.68 and 21.60) followed by flesh thickness (17.95 and 21.15) among the fruit and fruit yield traits studied. For fruit quality, high magnitude of gcv and pcv was recorded for phenol (23.60 and 25.28) and pectin content (21.42 and 23.63) while, moderate gcv with high pcv were observed for sugar: acid ratio (19.74 and 22.05) and total sugar content (17.97 and 21.27). Whereas, low gcv with moderate pcv was expressed by acidity (13.71 and 18.09) and ascorbic acid (13.70 and 17.89) indicating that selection would be effective for the improvement of these characters. Similar observations were recorded by Thimmappaiah *et al.* (1985) for the characters *viz.*, fruits per tree, acidity and fruit yield and Bandopadhyay *et al.* (1992) for characters *viz.*, fruit diameter, fruit length and fruit weight. In respect to gcv and pcv of various guava genotypes for the characters like number of seeds per fruit, fruit weight, 100-seed weight, fruit length, fruit diameter, acidity and ascorbic acid were noticed high magnitude (Raghava and Tiwari, 2008). However, Man Bihari and Suryanarayan (2011) observed the high gcv and pcv values for fruit diameter, fruit weight, seeds per fruit, acidity and sugar in guava. 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. Rest of the traits were showed the low magnitude of gcv and pcv.

Heritability and genetic advance

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

S. No.	Characters	Coefficient of variation (%) gcv	pcv	ecv	Heritability (%)	Genetic advance	Genetic advance as (%) mean
A.	Fruit and fruit yield attributes						
1	Fruit yield	50.36	55.05	23.88	83.69	18.17	89.99
2	Number of seeds/fruit	27.23	30.30	15.28	80.76	122.97	41.14
3	Seed test weight	23.25	27.79	13.63	70.15	0.57	42.88
4	Seed weight/fruit	18.68	21.60	15.24	74.21	0.80	22.85
5	Flesh thickness	17.95	21.15	12.08	72.01	2.71	29.82
6	Flesh recovery	0.84	1.06	0.64	62.61	1.51	1.55
7	Flesh: seed ratio	28.09	31.39	21.02	80.09	21.73	44.24
8	Number of fruits/plant	41.68	45.96	30.82	82.24	92.27	63.12
9	Fruit length	5.47	6.65	4.05	66.67	0.58	9.05
10	Fruit diameter	9.59	12.49	4.76	59.01	1.10	17.69
11	Fruit weight	20.09	22.12	7.54	82.48	61.36	41.23
12	Specific gravity	2.02	2.31	0.60	76.78	0.15	15.46
B.	Fruit quality attributes						
13	TSS	6.23	8.34	5.54	55.41	0.78	7.59
14	Acidity	13.71	18.09	11.81	57.30	0.10	18.88
15	Ascorbic acid	13.70	17.89	11.51	58.65	39.58	21.62
16	Reducing sugars	9.64	12.60	6.16	59.09	0.63	16.83
17	Total sugar	17.97	21.27	8.38	71.37	2.43	33.32
18	Sugar: acid ratio	19.74	22.05	11.37	80.14	5.19	36.26
19	Pectin content	21.42	23.63	9.44	89.66	0.44	41.18
20	Phenol content	23.60	25.28	7.12	87.15	123.87	43.25

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

Table 2: Pooled genotypic (rg) and phenotypic (rp) correlation coefficients among the fruit characters in guava

S.	Characters		1	2	3	4	5	6	7	8	9	10
1.	Number of seeds/fruit	rgrp	-	-0.889**	-0.735**	0.978**	0.731**	-0.821**	-0.594**	-0.789**	-0.495**	-0.870**	-0.738**	0.587**	0.460**	0.0620.023	-0.448**	-0.340**	0.2490.123
2.	Seed test weight	rgrp		-		-0.836**	-0.610**	0.967**	0.708**	0.923**	0.625**	0.993**	0.826**	-0.197-0.119		-0.263*-0.160	0.403**	0.347**	0.2010.177
3.	Seed weight/fruit	rgrp				-		-0.702**	-0.583**	-0.615**	-0.373**	-0.795**	-0.693**	0.477**	0.338**	0.1770.157	-0.105-0.097		0.2370.207
4.	Flesh thickness	rgrp						-		0.883**	0.674**	0.936**	0.808**	-0.259*-0.058		-0.431**-0.285	0.515**	0.331**	0.2510.053
5.	Flesh recovery	rgrp								-		0.913**	0.701**	-0.333**	-0.330**	-0.328**-0.123	0.779**	0.496**	0.362**0.224
6.	Flesh: seed ratio	rgrp										-		-0.297*-0.115		-0.409**-0.327**	0.389**	0.364**	0.2510.102
7.	Number of fruits/tree	rgrp												-		-0.431**-0.232	-0.371**	-0.385**	-0.381**-0.281*
8.	Fruit length	rgrp														-	0.335**	0.238	0.478**0.455**
9.	Fruit diameter	rgrp															-		0.982**0.828**
10.	Fruit weight	rgrp																	-
11.	Specific gravity	rgrp																	
12.	TSS	rgrp																	
13	Acidity	rgrp																	
14.	Ascorbic acid	rgrp																	
15.	Reducing sugars	rgrp																	
16.	Total sugar	rgrp																	
17.	Sugar: acid ratio	rgrp																	
18.	Pectin content	rgrp																	
19.	Phenol content	rgrp																	
20.	Fruit yield	rgrp																	

Table 2: Contd....

S.	Characters		11	12	13	14	15	16	17	18	19	20
1.	Number of seeds/fruit	rgrp	0.309*0.080	-0.608**-0.547**	0.1700.158	-0.653**-0.507**	-0.781**-0.529**	-0.751**-0.575**	-0.360**-0.319**	-0.843**-0.385**	-0.297*-0.284*	0.346**0.337**
2.	Seed test weight	rgrp	0.1540.124	0.832**0.752**	-0.149-0.137	0.685**0.658**	0.946**0.671**	0.894**0.805**	0.458**0.398**	0.917**0.639**	0.439**0.450**	0.1380.013
3.	Seed weight/fruit	rgrp	-0.185-0.019	-0.745**-0.513**	0.553**0.232	-0.419**-0.354**	-0.819**-0.482**	-0.764**-0.449**	-0.718**-0.319**	-0.272*-0.200	-0.137-0.125	0.367**0.308*
4.	Flesh thickness	rgrp	0.2510.127	0.918**0.618**	0.0520.014	0.767**0.539**	0.959**0.495**	0.895**0.505**	0.283*0.093	0.995**0.388**	0.582**0.508**	0.1990.191
5.	Flesh recovery	rgrp	0.1530.052	0.640**0.408**	0.1820.120	0.992**0.664**	0.949**0.442**	0.899**0.532**	0.2570.080	0.988**0.458**	0.623**0.531**	0.0430.032
6.	Flesh: seed ratio	rgrp	0.267*0.042	0.849**0.610**	0.0830.052	0.722**0.583**	0.894**0.499**	0.868**0.583**	0.328**0.196	0.881**0.406**	0.559**0.557**	0.1310122
7.	Number of fruits/tree	rgrp	-0.252-0.181	-0.206-0.144	-0.143-0.105	-0.283*-0.273*	-0.101-0.067	-0.072-0.060	0.1250.119	-0.118-0.097	0.010-0.242	0.886**0.850**
8.	Fruit length	rgrp	-0.220-0.079	-0.292*-0.181	-0.409**-0.222	0.1280.110	-0.099-0.031	0.001-0.156	0.339**0.159	-0.493**-0.181	-0.424**-0.380**	-0.327**-0.263*
9.	Fruit diameter	rgrp	0.308*0.136	0.2050.121	0.409**0.342**	0.892**0.699**	0.313*0.197	0.267*0.230	-0.197-0.151	0.443**0.345**	0.562**0.498**	0.038-0.059
10	Fruit weight	rgrp	0.298*0.129	-0.220-0.185	0.312*0.279*	0.786**0.398**	-0.173-0.100	-0.028-0.019	-0.227-0.131	0.1830.088	0.2590.245	0.0570.009
11	Specific gravity	rgrp	-	0.2690.251	0.894**0.081	0.389**0.140	-0.065-0.052	-0.086-0.079	-0.256-0.216	0.0850.067	0.991**0.227	0.992**0.348**
12	TSS	rgrp		-	-0.392**-0.318**	0.532**0.517**	0.848**0.728**	0.800**0.743**	0.530**0.555**	0.774**0.435**	0.1850.165	-0.458**-0.247
13	Acidity	rgrp			-	-0.246-0.106	-0.331**-0.224	-0.270*-0.135	-0.844**-0.785**	0.029-0.006	0.772**0.522**	-0.172-0.165
14	Ascorbic acid	rgrp				-	0.820**0.607**	0.779**0.740**	0.1940.137	0.666**0.459**	0.551**0.456**	0.0710.029
15	Reducing sugars	rgrp					-	0.989**0.862**	0.704**0.602**	0.749**0.496**	0.1810.131	-0.095-0.029
16	Total sugar	rgrp						-	0.629**0.628**	0.688**0.564**	0.298*0.242*	-0.152-0.142
17	Sugar: acid ratio	rgrp							-	0.0830.071	-0.515**-0.287*	-0.026-0.016
18	Pectin content	rgrp								-	0.533**0.522**	0.1870.158
19	Phenol content	rgrp									-	0.331**0.261*
20	Fruit yield	rgrp										-

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

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

S.n. Characters	Direct effect	1	2	3	4	5	6	7	8	9	10
1. Number of seeds/fruit	0.276	-	-0.246	0.270	-0.227	-0.218	-0.240	0.162	-0.045	-0.124	-0.097
2. Seed test weight	0.268	-0.240	-	-0.226	0.261	0.249	0.268	-0.032	-0.043	0.109	0.073
3. Seed weight/fruit	-0.086	-0.084	0.072	-	0.061	0.053	0.069	-0.041	0.007	0.008	0.003
4. Flesh thickness	-0.237	0.194	-0.229	0.166	-	-0.209	-0.221	0.014	0.068	-0.122	-0.083
5. Flesh recovery	0.013	-0.010	0.012	-0.008	0.011	-	0.012	-0.004	-0.002	0.010	0.009
6. Flesh: seed ratio	0.277	-0.241	0.275	-0.220	0.259	0.253	-	-0.032	-0.091	0.108	0.070
7. Number of fruits/tree	1.015	0.596	-0.121	0.484	-0.059	-0.335	-0.116	-	-0.437	-0.377	-0.387
8. Fruit length	0.061	-0.010	-0.010	-0.005	-0.017	-0.007	0.020	-0.026	-	0.020	0.029
9. Fruit diameter	0.450	-0.202	0.181	-0.043	0.232	0.350	0.175	-0.167	0.151	-	0.442
10. Fruit weight	0.070	0.025	-0.019	0.003	-0.025	-0.047	-0.018	0.027	-0.034	-0.069	-
11. Specific gravity	-0.056	-0.017	-0.009	-0.044	-0.020	-0.009	-0.015	-0.058	0.018	-0.028	-0.028
12. TSS	0.221	-0.134	0.184	-0.165	0.203	0.141	0.188	0.068	-0.040	0.045	0.027
13 Acidity	-0.348	-0.055	0.048	-0.192	-0.018	-0.063	-0.018	-0.050	0.142	-0.142	-0.109
14. Ascorbic acid	0.171	-0.111	0.117	-0.071	0.131	0.171	0.123	-0.048	0.022	0.152	0.134
15. Reducing sugars	-0.058	0.045	-0.055	0.047	-0.055	-0.055	-0.052	0.006	0.002	-0.024	-0.016
16. Total sugar	-0.395	0.296	-0.353	0.302	-0.353	-0.355	-0.343	0.028	-0.001	-0.170	-0.113
17. Sugar: acid ratio	0.024	-0.009	0.011	-0.017	-0.007	0.006	0.008	-0.001	0.008	-0.004	-0.003
18. Pectin content	-0.213	0.180	-0.217	0.155	-0.254	-0.216	-0.234	0.021	0.105	-0.095	-0.060
19. Phenol content	0.515	-0.153	0.227	0.019	0.300	0.321	0.288	0.005	-0.218	0.290	0.236

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 percentage of mean is more reliable than either of these two parameters alone in predicting the resultant effect of selecting the best individual. Moderate to high heritability estimates was observed for most of the traits during study (Table 1).

Heritability estimates revealed that all the characters among fruit and fruit yield traits ranged from 59.01 (moderate) in fruit diameter to 85.56 (high) in number of seeds per 100 g fruit whereas, the heritability value among the fruit quality parameters ranged from 55.41 (moderate) for TSS to 89.66 (high) for pectin content.

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. Similarly, Subramanyan and Iyer (1981) noticed high heritability estimates in papaya for fruit weight, length and diameter of fruit and yield per plant and 100-seed weight.

Genetic advance as percent of mean varied from 7.59 (TSS) to 89.99 percent (fruit yield). Also high values were shown by number of fruits per plant (63.12), flesh: seed ratio (44.24), phenol content (43.25), seed test weight (42.88), fruit weight (41.23), pectin (41.18) and number of seeds per fruit (41.14). Sugar: acid ratio (36.26), total sugar (33.32) and flesh thickness (29.82) exhibited the moderate values for genetic advance whereas, rest of the traits exhibited low values for genetic advance.

High heritability estimates associated with high genetic advance as percent of mean were obtained for number of fruits per plant, fruit weight, number of seeds per fruit, flesh: seed ratio, sugar: acid ratio, pectin and phenol content, which indicated that selection of these character would be more effective. Such association may be attributed to the action of additive genes. These characters also exhibited high gcv, therefore, selection based on phenotypic performance for these traits would be effective in improving these characters 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.

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 fruit characters in all possible combinations (Table 2).

Number of seeds per fruit was significantly and positively associated with seed weight per fruit, number of fruits per tree, fruit yield at both genotypic and phenotypic level and with specific gravity at genotypic level. Test weight of hundred seed had shown significant and positive relationship with flesh thickness, flesh recovery, flesh: seed ratio, fruit diameter, TSS, ascorbic acid, reducing sugar, total sugar, sugar: acid ratio, pectin and phenol content while, significant and negative correlation of test weight was recorded with seed weight per fruit at both the levels and fruit length at genotypic level. Similarly, seed weight per fruit recorded positive and significant correlation with number of fruits per tree, fruit yield at both the levels and with acidity at genotypic level. Flesh thickness had positive and significant correlation with flesh recovery, flesh: seed ratio, fruit diameter, TSS, ascorbic acid, reducing sugar, total sugar, pectin and phenol content both at genotypic and

Table 3: Contd....

S.n.	Characters	Direct effect	11	12	13	14	15	16	17	18	19	rg
1.	Number of seeds/fruit	0.276	0.085	-0.168	0.044	-0.180	-0.216	-0.207	-0.099	-0.233	-0.082	0.346**
2.	Seed test weight	0.268	0.042	0.224	-0.037	0.185	0.255	0.241	0.124	0.274	0.119	0.138
3.	Seed weight/fruit	-0.086	-0.068	0.064	-0.048	0.036	0.071	0.066	0.062	0.063	-0.003	0.367**
4.	Flesh thickness	-0.237	-0.083	-0.217	-0.012	-0.181	-0.227	-0.212	-0.067	-0.282	-0.138	0.199
5.	Flesh recovery	0.013	0.002	0.008	0.002	0.013	0.012	0.012	0.003	0.013	0.008	0.043
6.	Flesh: seed ratio	0.277	0.074	0.235	0.015	0.200	0.248	0.240	0.091	0.303	0.155	0.131
7.	Number of fruits/tree	1.015	1.055	0.310	0.145	-0.287	-0.102	-0.073	-0.025	-0.098	0.011	0.886**
8.	Fruit length	0.061	-0.019	-0.011	-0.025	0.008	-0.002	0.001	0.021	-0.030	-0.026	-0.327**
9.	Fruit diameter	0.450	0.228	0.092	0.184	0.401	0.190	0.194	-0.068	0.199	0.253	0.038
10	Fruit weight	0.070	-0.035	-0.009	-0.022	-0.055	-0.019	-0.020	0.009	-0.020	-0.032	0.057
11	Specific gravity	-0.056	-	-0.026	-0.067	-0.022	0.003	-0.012	0.038	-0.005	-0.060	0.992**
12	TSS	0.221	0.104	-	-0.042	0.114	0.187	0.177	0.117	0.171	0.041	-0.458**
13	Acidity	-0.348	-0.415	0.067	-	-0.120	0.078	0.047	0.294	-0.032	-0.268	-0.172
14	Ascorbic acid	0.171	0.066	0.088	0.059	-	0.140	0.133	0.023	0.114	0.094	0.071
15	Reducing sugars	-0.058	0.003	-0.049	0.013	-0.047	-	-0.061	-0.041	-0.043	-0.010	-0.095
16	Total sugar	-0.395	-0.081	-0.316	0.053	-0.308	-0.416	-	-0.248	-0.271	-0.118	-0.152
17	Sugar: acid ratio	0.024	-0.016	0.013	-0.020	0.003	0.017	0.015	-	0.002	-0.012	-0.026
18	Pectin content	-0.213	-0.018	-0.165	-0.020	-0.142	-0.160	-0.147	-0.018	-	-0.114	0.187
19	Phenol content	0.515	0.556	0.095	0.398	0.284	0.093	0.153	-0.265	0.275	-	0.331**

Residual effect = 0.117; *, ** = Significant at 5 and 1% levels of probability, respectively.

phenotypic level and with sugar: acid ratio at genotypic level. Flesh recovery exhibited positive and significantly high correlation with flesh: seed ratio, fruit diameter, TSS, ascorbic acid, reducing sugar, total sugar, pectin and phenol content at both the levels while, fruit weight at genotypic level. Flesh: seed ratio revealed significantly and positive correlations with fruit diameter, TSS, ascorbic acid, reducing sugar, total sugar, pectin and phenol content both at genotypic and phenotypic level while, with specific gravity and sugar: acid ratio at genotypic level. Significantly high and positive correlation was recorded between number of fruits per tree and fruit yield but, number of fruits per tree showed significant and negative association with fruit diameter, fruit weight and ascorbic acid both at genotypic and phenotypic level and with fruit length at genotypic level.

Fruit length showed positive and significant correlation with fruit weight at both the levels and with fruit diameter and sugar: acid ratio at genotypic level. Fruit diameter had significant positive genotypic and phenotypic correlation with fruit weight, acidity, ascorbic acid, pectin and phenol content while with specific gravity, reducing sugar and total sugar at genotypic level.

Significant and positive correlation of fruit weight was recorded with acidity and ascorbic acid at both the levels while, with specific gravity at genotypic level. Correlation coefficient among the fruit quality traits both at genotypic and phenotypic level exhibited that TSS was positively and significantly correlated with ascorbic acid, reducing sugar, total sugar, sugar: acid ratio and pectin content whereas, significant but negative correlation was recorded with acidity at both the levels and fruit yield at genotypic level. Significant and positive correlation of acidity was observed with phenol content at both the levels. Ascorbic acid exhibited positive and significant genotypic and phenotypic relationship with reducing sugar, total sugar, pectin and phenol content.

Significant and positive genotypic and phenotypic correlation was observed between reducing and total sugar and both with sugar: acid ratio and pectin content while, total sugar also exhibited significantly positive correlation with phenol content but they showed negative and non-significant correlation with yield. Significantly, high and positive correlation of pectin content was recorded with phenol content whereas, phenol content showed positive and significant correlation with fruit yield.

Fruit yield was significantly and positively correlated with number of seeds per fruit, seed weight per fruit, number of fruits per tree, specific gravity and phenol content while, significantly negative correlated with fruit length and TSS while, it was showed positively and non-significant correlation with seed test weight, flesh thickness, flesh recovery, flesh: seed ratio, fruit diameter, fruit weight, ascorbic acid and pectin content. Whereas, acidity, reducing sugar, total sugar and sugar: acid ratio showed negatively non-significant correlation with fruit yield indicating that the yield and quality can not be improved simultaneously rather independent selection for both will be beneficial. These results are in line with the findings of Thimmappaiah *et al.* (1985), Pandey *et al.* (2002), Raghava and Tiwari (2008) in guava.

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 (Mc Giffen *et al.*, 1994). The coefficients generated by path analysis measure the direct and indirect influence of variable upon other (Dewy and Lu, 1959).

Phenotypic path coefficient analysis revealed that positive direct effect on yield were depicted by number of fruits per tree (1.055) followed by phenol content (0.515), fruit diameter (0.450), flesh: seed ratio (0.277), number of seeds per fruit (0.276), test weight (0.268), TSS (0.221), ascorbic acid (0.171) and very low magnitude with fruit weight (0.070), fruit length (0.061), sugar: acid ratio (0.024) and flesh recovery (0.013) indicate good scope for improvement in fruit yield of guava

(Table 3).

Positive direct effect of number of fruits per tree, number of seeds per fruit and phenol content also showed significant and positive correlation with fruit yield whereas, fruit weight, fruit diameter, flesh recovery, flesh: seed ratio, seed test weight and ascorbic acid also showed direct effect along with positive correlation on fruit yield suggested that these traits should be given due importance while selecting a genotype. Though TSS, fruit length and sugar: acid ratio depicted positive direct effect on fruit yield but, their correlation with fruit yield was negative indicating that a high yielding genotypes could be improved for these traits through selection. These results are in tune with the findings of Prasad (1987) observed the direct positive effect of number of fruits per tree and fruit weight on fruit yield of mango. Rai *et al.* (2001_a) recorded direct positive effect of average fruit weight, fruit volume, skin weight and percent edible pulp on fruit yield of mango. Singh *et al.*(2001) conducted path coefficient analysis on eleven papaya cultivars which revealed that fruit length, number of fruits per plant and peel weight showed the greatest positive effect on crop yield. Raghava and Tiwari (2008) also noticed that fruit length and fruit weight depicted positive high direct effect on fruit yield of guava.

Indirect effects for most of the traits were mostly via of number of fruits per tree, fruit weight, fruit diameter, specific gravity, flesh recovery, flesh thickness, flesh: seed ratio, seed test weight,ascorbic acid, pectin content and total sugar hence these traits are the important traits for selection. These results are in tune with the findings of Prasad (1987) observed the indirect effects for fruit yield were mostly via number of fruits per tree, fruit diameter and fruit volume in mango. Similar results were reported by Patil and Patil (1995) they observed that fruit yield in grapes was mainly the result of bunches per vine, bunch weight and 100-seed weight.

Negative direct effect on fruit yield were imposed by total sugar (-0.395) followed by acidity (-0.348), flesh thickness (-0.237), pectin content (-0.213), seed weight per fruit (-0.086), reducing sugar (-0.058) and specific gravity (-0.056). However, seed weight per fruit, specific gravity showed significantly positive correlation with yield while, flesh thickness and total sugar had positive non-significant 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 (0.117) was fairly low, which revealed that variables included in this study had significant contribution in determining fruit yield.

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