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Character Association Studies among Naturally Occurring Seedling Population of Guava (*Psidium guajava* L.)

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ABSTRACT

Character association studies in seedling origin guava (*Psidium guajava* L.) plants growing in Jammu, Samba and Akhnoor areas lying in sub-tropical zone of Jammu region indicated that fruit yield was positively and significantly affected by plant spread, trunk girth, trunk cross sectional area, fruit diameter, fruit weight, fruit volume, number of per fruit, 100 seed weight, seed weight per fruit, pulp weight and percentage. Positive and direct effect on fruit yield was observed with fruit volume, fruit diameter, fruit weight, tree spread, pulp percentage and pulp weight. Positive direct effect of fruit volume, fruit diameter, fruit weight, tree spread and pulp percentage also showed significant and positive correlation with fruit yield, whereas, trunk girth, TCSA, leaf area, seed weight per fruit, 100 seed weight also showed direct effect along with positive correlation on fruit yield suggesting that these traits should be given due importance while selecting a genotype. Principle component analysis grouped 29 morphological and bio-chemical parameters into five major principal components contributing 86.07% of the total variation.

Keywords Guava, *Psidium guajava*, Correlation, Path analysis, PCA.

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INTRODUCTION

Guava (*Psidium guajava* L.) is the most important and commercially cultivated fruit crop belonging to the family Myrtaceae. It has originated in tropical America, stretching from Mexico to Peru and gradually became a crop of commercial significance in several countries like Brazil, Mexico, China, Malaysia, Hawaiian Islands, Cuba and India. Guava was introduced to India during 17th century by Portuguese (Semwal *et al.* 2024), and now grown commercially in Uttar Pradesh, Bihar, Punjab, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, West Bengal, Madhya Pradesh

and Tamil Nadu. Presently, in India it is cultivated on 3.10 lakh hectare area with annual production of 44.69 lakh metric tonnes (Anonymous 2021). The crop has gained considerable prominence in India on account of its high nutritive value, pleasant aroma, good flavor and availability at moderate price. Besides, it is one of the hardiest among the fruits in productivity, adaptability with nutritional quality and hence aptly known as 'Poor man's apple' and 'Apple of tropics'. The fruit contains 165 mg of vitamin C as against a mere 69 mg in orange. It is also an excellent source of beta carotene, lycopene, potassium and soluble fibers. Guava is very rich in antioxidants acting against the free radicals which damage cells and cause cancer, diabetes and coronary diseases. Guava possesses antiseptic, astringent and anti-helminthic properties useful to cure many diseases and ailments. It is also rich in Vitamin A and B and thus very useful in the preparation of products for anti-aging skin care. Pink pulped guava varieties supply a carotenoid called as Lycopene which is considered a potential agent for prevention of some types of cancers, particularly prostate cancer (Garbanzo *et al.* 2017). Being adapted very well to sub-tropical regions, guava is also grown in Kathua, Samba, Jammu, Reasi, Rajouri and Udhampur districts of Jammu region. Guava has long back been introduced in to this area and there is lot of natural population of seedling origin in this region. Being a heterozygous and cross-pollinated crop, each guava plant of seedling origin possesses unique gene combination, therefore morphologically they are different from each other. From fruit quality point of view these seedling plants varies from inferior to superior. This natural population if screened properly can lead to identification of germplasm having particular characters which could be used in further breeding programs. The characters like fruit yield, fruit weight, fruit size are affected by number of different genes, therefore indirect selection for a quantitative trait like yield is sometimes more rewarding than direct selection. The information pertaining to genetic behavior of different characters can be deciphered by undertaking character association enabling to understand the nature and extent of association among different characters and effect of one character on another. This will also help to screen the progeny at early stage which is substantially large in case of guava breeding. Therefore, studies were undertaken to study the character association studies among seedling origin guava with the hope that such information may be useful for further crop improvement programs.

MATERIALS AND METHODS

Character association studies in seedling origin guava (*Psidium guajava* L.) plants growing in Jammu sub-tropics has been undertaken in Jammu, Samba and Akhnoor areas lying in sub-tropical zone of Jammu province. The area is situated at 300-400 m above mean sea level experiencing an average annual rainfall of 110-140 cm, mostly during rainy season. For undertaking the character association studies among the seedling origin guava plants, 70 plants showing morphological variations which had attained full bearing age were identified in the area. Data on tree and fruit characters were recorded at appropriate time of the year following standard procedure for measuring each characteristic. Tree height and spread were measured with the measuring staff and expressed in meters. Trunk girth of each tree was measured in centimeters with the help of measuring tape at a height of 25 cm from the ground level. Leaf length and width were measured with the help of measuring scale and expressed in centimeters. Leaf area was recorded with the help of automatic leaf area meter (221 Systronics) having a sensor and read out unit and expressed in square centimeter. For fruit characters, ten fruits/plant were collected randomly and observations were recorded on each fruit separately. Parameters like fruit length, fruit diameter were measured using digital Vernier Calliper. Fruit weight was recorded by calculating the average weight of 10 fruits from each tree and expressed in grams. Seed number/fruit were counted manually for each fruit and then averaged for 10 fruits. The hundred seed weight was determined by weighing counted 100 seeds and expressed in grams. Pulp percentage was worked out by multiplying the ratio of pulp weight of the fruit and total fruit weight with hundred and expressed as percent. Total soluble solids content, titratable acidity, reducing sugars, total sugars, non-reducing sugars, ascorbic acid content and dietary fiber were recorded as per the method suggested by AOAC (1990). The collected data recorded on different horticultural traits on the

selected trees was analyzed for various statistical parameters. The data collected was analyzed for different character association parameters. The correlation coefficients were estimated as per the procedure described by Johnson *et al.* (1955). The genotypic correlation coefficients were used to work out path coefficients according to the method suggested by Dewey and Lu (1959). Principal component analysis was performed on the correlation matrix of traits thereby removing effective scale according to procedure described by Banfield (1978). The principal components having eigen values more than one were considered as major components.

RESULTS AND DISCUSSION

Correlation coefficients: Correlation between traits could be due to linkage or pleiotropy. Correlation due to linkage can be manipulated or changed through recombination but it could be impossible to overcome the correlation due to pleiotropy. High coefficients of correlation between the characters allows indirect selection, while the existence of low coefficients does not represent lack of association between the character, but rather the lack of a cause-effect relationship (Sau *et al.* 2016). Correlation studies are very important from breeding point of view because they reveal the magnitude of association between one or more traits and also give the indication of traits that could be useful so as to identify more important ones for a particular improvement program. The correlation coefficients presented in Table 1 revealed that tree height showed a positive correlation with tree volume, TCSA, leaf area, leaf length, dietary fiber, yield and yield efficiency, whereas, it was negatively correlated with tree spread, trunk girth and leaf width. Tree spread was found to be positively correlated with tree volume, trunk girth, TCSA, leaf area, specific gravity and seed number per fruit, hundred seed weight, TSS, acidity, ascorbic acid, dietary fiber, yield and yield efficiency and negatively correlated with tree height. Tree volume showed a positive correlation with trunk girth, TCSA, leaf area, leaf length, leaf length-width ratio, TSS, total sugars, acidity, ascorbic acid, dietary fiber, yield and yield efficiency and negatively correlated with tree height, tree spread. Trunk girth and trunk cross sectional area revealed significant positive correlation with yield and yield efficiency. Gupta and Kour (2019) recorded that the trunk girth was significantly positively correlated with fruit yield. Gupta *et al.* (2015) also observed similar correlation with yield and other characters in grape. Leaf area showed a positive correlation with tree volume, TCSA, leaf area, leaf length, leaf length-width ratio, fruit volume, specific gravity and seed number per fruit, hundred seed weight, TSS, total sugars, reducing sugars, non-reducing sugars, ascorbic acid, dietary fiber, yield and yield efficiency

Table 1. Correlation among different character in seedling origin guava plants. 1: Tree height, 2: Tree spread, 3: Tree volume, 4: Trunk girth, 5: TCSA, 6: Leaf area, 7: Leaf length, 8: Leaf width, 9: Leaf LW ratio, 10: Fruit length, 11: Fruit diameter, 12: Fruit weight, 13: Fruit volume, 14: Specific gravity, 15: Seed no./fruit, 16: 100 seed weight, 17: Seed wt. per fruit, 18: Pulp percentage, 19: Pulp weight, 20: TSS, 21: Titratable acidity, 22: TSS/Acid ratio, 23: Ascorbic acid, 24: Dietary fibre, 25: Total sugars, 26: Reducing sugars, 27: Non-reducing sugars, 28: Yield, 29: Yield efficiency.

Characters	1	2	3	4	5	6	7	8	9	10
1	-	-0.418*	0.335	-0.447*	-0.421*	0.289	0.224	-0.250	0.181	0.211
2		-	0.380*	0.336	0.381*	0.382*	0.111	0.288	0.191	0.230
3			-	-0.271	-0.243	-0.211	-0.170	-0.143	-0.065	0.254
4				-	0.830**	0.371*	0.161	0.268	0.116	0.144
5					-	0.261	0.218	0.262	0.182	0.261
6						-	0.397*	0.561*	0.369*	0..233
7							-	-0.130	0.260	0.132
8								-	-0.257	0.101
9									-	0.155
10										-

Table 1. Continued.

Characters	11	12	13	14	15	16	17	18	19	20
1	0.170	0.189	0.190	0.081	0.111	0.107	0.098	0.131	0.166	0.172
2	0.350	0.290	0.316	0.056	0.130	0.225	0.156	0.253	0.259	0.271
3	0.252	0.288	0.227	0.068	0.051	0.038	0.036	0.178	0.009	0.258
4	0.106	0.147	0.191	0.121	0.058	-0.056	0.020	0.098	0.107	0.022
5	0.276	0.296	0.290*	0.110	0.099	0.009	0.101	0.072	0.044	0.032
6	0.348	0.298	0.265	0.047	0.072	0.054	0.066	0.180	0.102	0.278
7	0.077	0.193	0.172	0.061	0.067	0.101	0.056	0.012	0.085	0.016
8	0.221	0.198	0.280	0.090	0.081	0.032	0.090	0.058	0.056	0.120
9	0.130	0.181	0.102	0.072	0.062	0.020	0.033	0.031	0.008	0.026
10	0.121	0.358	0.367*	0.160	0.378*	0.342	0.210	0.280	0.182	0.150
11	-	0.653**	0.731*	0.248	0.598*	0.395	0.478	0.354	0.381	0.133
12		-	0.543*	0.219	0.4.38	0.380	0.655	0.410	0.663	0.035
13			-	0.163	0.533*	0.380	0.370	0.628	0.541	0.110
14				-	0.234	0.162	0.115	0.052	0.086	0.259
15					-	-0.245	-0.278	-0.448	-0.377	0.344
16						-	0.625	0.299	0.221	0.310
17							-	0.235	0.304	0.291
18								-	0.777	0.204
19									-	0.258
20										-

Table 1. Continued.

Characters	21	22	23	24	25	26	27	28	29
1	0.246	0.180	0.109	0.134	0.224	0.272	0.262	0.145	0.170
2	0.249	0.252	0.051	0.252	0.468*	0.455*	0.398	0.405*	0.398*
3	0.253	0.258	0.002	0.040	0.351	0.282	0.350	0.290	0.220
4	0.085	0.011	0.050	0.005	0.267	0.259	0.249	0.540**	0.495**
5	-0.051	0.034	0.101	0.069	-0.052	0.075	0.058	0.522**	0.510**
6	0.195	0.114	0.088	0.158	0.278	0.255	0.216	0.177	0.102
7	0.053	0.084	0.026	0.025	0.156	0.147	0.128	0.178	0.130
8	0.130	0.048	0.049	0.167	0.231	0.255	0.110	0.189	0.179
9	0.011	0.012	0.009	0.008	0.095	0.087	0.082	0.128	0.194
10	0.051	0.075	0.163	0.098	0.270	0.121	0.140	0.225	0.245
11	0.159	0.080	0.174	0.117	0.084	0.350	0.290	0.480*	0.309*
12	0.131	0.014	0.076	0.253	0.222	0.190	0.152	0.609*	0.591*
13	0.098	0.088	0.055	0.116	0.196	0.150	0.080	0.585*	0.411*
14	0.069	0.231	-0.102	0.348	0.398	0.382	0.241	0.048	0.087
15	-0.171	0.046	0.087	0.036	0.497	0.364	0.211	0.386*	0.370*
16	0.102	0.022	-0.085	0.015	0.058	0.098	-0.069	0.371*	0.386*
17	0.075	0.045	0.025	0.128	0.245	0.158	0.122	0.368*	0.387*

Table 1. Continued.

Characters	21	22	23	24	25	26	27	28	29
18	0.145	0.010	0.056	0.385	0.222	0.112	0.010	0.384*	0.409*
19	0.130	0.025	0.087	0.391	0.252	0.184	0.131	0.439*	0.484**
20	0.325	0.385	0.332	0.552	0.623	0.550	0.332	0.144	0.195
21	-	-0.151	0.522	0.156	0.196	0.125	0.198	-0.301	-0.158
22		-	-0.112	0.224	0.203	0.198	0.140	0.099	0.050
23			-	0.047	0.091	0.053	0.048	0.085	0.048
24				-	0.055	0.011	0.087	0.110	0.104
25					-	0.601	0.649	0.339	0.255
26						-	0.268	0.051	0.024
27							-	0.183	0.080
28								-	0.883*
29									-

Table 2. Path coefficients among different characters in seedling origin guava plants.

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**0.032**	0.116	0.102	0.009	-0.159	0.180	-0.094	-0.137	0.147	-0.021	0.005	-0.114	0.032	-0.102
2	0.013	**0.256**	0.120	0.001	0.012	-0.013	-0.007	-0.009	0.010	-0.001	0.022	-0.009	0.001	-0.008
3	0.006	0.006	**0.019**	-0.002	-0.009	-0.008	-0.003	-0.007	0.010	0.004	0.005	-0.007	0.006	0.001
4	-0.001	0.037	0.050	**0.111**	-0.002	-0.003	-0.009	-0.006	0.001	-0.004	-0.001	0.040	0.019	-0.002
5	0.061	0.060	0.065	-0.008	**0.133**	-0.069	-0.028	-0.053	0.069	0.015	0.027	-0.052	0.036	-0.016
6	-0.148	-0.142	-0.135	0.023	0.148	**0.140**	0.087	0.128	-0.142	0.006	-0.029	0.091	-0.045	0.072
7	-0.101	-0.099	-0.057	0.105	0.078	0.014	**-0.035**	0.154	-0.067	0.146	0.109	0.003	0.063	0.141
8	0.346	0.293	0.331	-0.163	-0.350	-0.394	-0.361	**0.057**	0.354	-0.154	-0.034	-0.230	0.051	-0.227
9	0.035	0.031	0.046	-0.003	-0.044	-0.041	-0.015	-0.034	**0.012**	0.021	0.023	-0.032	0.031	-0.002
10	0.008	0.007	-0.026	-0.017	0.014	-0.003	-0.050	-0.023	-0.033	**0.036**	-0.066	0.013	-0.056	-0.060
11	0.001	-0.001	0.020	0.003	-0.014	-0.007	0.020	0.003	0.019	0.034	**0.286**	-0.020	0.026	0.026
12	0.009	0.009	0.010	0.000	-0.011	-0.009	-0.001	-0.007	0.010	0.003	0.008	**0.278**	0.004	0.003
13	0.006	0.002	0.021	0.016	-0.016	-0.009	0.010	-0.004	0.022	0.026	0.023	-0.009	**0.288**	-0.014
14	0.176	0.188	0.001	-0.040	-0.072	-0.152	-0.227	-0.156	0.015	-0.282	-0.235	0.057	-0.144	**-0.076**
15	-0.106	-0.103	-0.017	0.026	0.051	0.092	0.166	0.127	-0.042	0.164	0.132	-0.011	0.053	0.157
16	-0.046	-0.046	0.014	-0.042	-0.003	0.017	0.005	-0.004	0.032	0.088	0.053	0.001	0.039	0.085
17	0.038	0.059	-0.033	-0.009	-0.008	-0.034	-0.060	-0.011	-0.041	-0.108	-0.107	0.057	-0.076	-0.128
18	0.021	0.024	0.163	-0.025	-0.122	-0.056	0.144	0.009	0.161	0.254	0.270	-0.190	0.177	0.198
19	0.244	0.251	0.181	-0.135	-0.220	-0.292	-0.262	-0.256	0.194	-0.199	-0.132	-0.062	-0.030	-0.282
20	0.015	0.007	0.069	0.036	-0.056	-0.025	0.070	0.001	0.076	0.147	0.134	-0.104	0.102	0.112
21	0.117	0.091	0.160	-0.013	-0.153	-0.149	-0.047	-0.129	0.167	0.071	0.088	-0.115	0.114	0.003
22	-0.018	-0.015	-0.029	-0.003	0.028	0.026	0.001	0.016	-0.034	-0.021	-0.019	0.015	-0.028	-0.005
23	0.025	0.021	0.057	0.017	-0.047	-0.027	0.034	-0.007	0.060	0.086	0.082	-0.059	0.067	0.057
24	0.025	0.042	0.040	0.030	0.069	0.015	0.052	0.038	0.092	0.166	0.127	-0.042	0.164	0.103
25	-0.074	-0.028	-0.037	-0.067	-0.003	-0.044	-0.103	-0.048	0.164	0.132	-0.011	0.053	0.066	-0.003

Table 2. Continued.

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
26	-0.004	0.031	-0.047	0.029	0.062	0.052	0.038	0.013	0.026	-0.026	0.025	0.042	0.040	0.030
27	0.037	-0.031	0.136	-0.028	-0.130	-0.103	-0.048	-0.052	-0.063	-0.042	-0.074	-0.028	-0.037	-0.067
28	-0.016	-0.365	-0.003	0.346	0.201	-0.016	-0.365	-0.003	0.346	0.201	0.040	0.070	-0.278	-0.264

Table 2. Continued.

Characters	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	-0.106	-0.060	-0.050	0.014	-0.138	0.020	0.124	0.088	0.053	0.026	0.380	-0.087	-0.088	0.011
2	-0.008	-0.005	-0.006	0.001	-0.011	0.001	0.007	0.006	0.004	0.010	0.000	-0.011	-0.150	-0.061
3	-0.001	0.001	0.002	0.006	-0.005	0.005	0.009	0.007	0.006	0.001	-0.004	-0.001	0.003	-0.007
4	-0.002	0.005	-0.001	0.002	-0.007	-0.005	0.001	-0.001	0.003	0.188	0.001	-0.040	-0.072	0.046
5	-0.019	0.002	-0.004	0.031	-0.047	0.029	0.062	0.052	0.038	0.092	0.166	0.127	-0.042	0.132
6	0.075	0.018	0.037	-0.031	0.136	-0.028	-0.130	-0.103	-0.048	0.164	0.132	-0.011	0.053	-0.089
7	0.178	0.007	0.084	0.104	0.160	0.103	-0.054	-0.007	0.077	0.188	0.001	-0.040	-0.072	0.055
8	-0.318	0.013	-0.037	-0.016	-0.365	-0.003	0.346	0.201	0.040	0.070	0.001	0.076	0.147	0.009
9	-0.010	0.010	0.013	0.026	-0.026	0.025	0.042	0.040	0.030	0.069	0.015	0.027	-0.052	-0.069
10	-0.060	-0.043	-0.052	-0.063	-0.042	-0.074	-0.028	-0.037	-0.067	-0.003	-0.044	-0.041	-0.015	-0.005
11	0.025	0.013	0.027	0.035	0.014	0.035	0.018	0.018	0.033	0.021	0.024	0.163	-0.025	-0.056
12	0.001	-0.000	0.006	0.010	-0.003	0.011	0.010	0.006	0.010	-0.008	-0.003	-0.007	0.010	0.005
13	-0.009	0.009	0.017	-0.021	0.003	-0.024	0.021	0.024	-0.025	-0.046	0.014	-0.042	-0.003	0.005
14	-0.272	-0.192	-0.289	-0.231	-0.278	-0.264	-0.006	-0.045	-0.210	0.006	-0.005	0.005	0.009	0.006
15	**0.148**	0.057	0.110	0.139	0.147	0.122	-0.032	0.002	0.098	0.046	-0.003	-0.044	-0.041	-0.034
16	0.043	**0.112**	0.094	0.066	0.048	0.068	0.037	0.052	0.073	-0.227	-0.156	0.015	-0.282	0.057
17	-0.084	-0.094	**0.132**	-0.094	-0.086	-0.116	-0.057	-0.059	-0.099	-0.008	-0.003	-0.007	0.010	0.005
18	0.207	0.128	0.182	**0.220**	0.096	0.286	0.140	0.139	0.272	-0.014	-0.007	0.020	0.003	0.034
19	-0.258	-0.111	-0.199	-0.113	**0.156**	0.141	0.132	0.105	-0.076	0.015	0.027	-0.052	0.036	-0.019
20	0.089	0.065	0.111	0.142	0.059	**0.068**	0.083	0.059	0.142	0.003	-0.014	-0.007	0.020	0.019
21	-0.030	0.045	0.069	0.088 -	0.070	0.107	**-0.155**	0.136	0.120	-0.153	-0.149	-0.047	-0.129	0.071
22	-0.001	-0.014	-0.016	-0.019	0.012	-0.016	-0.029	**0.011**	-0.025	-0.033	-0.009	-0.008	-0.034	-0.011
23	0.046	0.045	0.061	0.086 0	0.020	0.091	0.060	0.058	**-0.015**	0.020	0.003	0.019	-0.062	-0.282
24	0.002	0.163	-0.025	-0.122	-0.056	0.144	0.009	0.161	0.025	**0.039**	0.015	-0.013	-0.153	-0.060
25	0.031	0.181	-0.135	-0.220	-0.292	-0.262	-0.256	0.194	-0.199	0.021	**0.041**	-0.003	0.028	0.144
26	-0.031	-0.074	-0.028	-0.037	-0.067	-0.003	-0.044	0.069	0.036	-0.056	0.011	**0.024**	-0.074	-0.262
27	0.104	-0.004	0.031	-0.047	0.029	0.062	0.052	0.160	-0.013	-0.153	-0.052	0.036	**0.010**	0.070
28	-0.006	-0.034	0.041	-0.019	0.015	0.067	-0.003	-0.044	-0.103	-0.048	0.164	0.008	0.007	**0.148**

1. Tree height, 2. Tree spread, 3. Tree volume, 4. Trunk girth, 5. TCSA, 6. Leaf area, 7. Leaf length, 8. Leaf width, 9. Leaf LW ratio, 10. Fruit length, 11. Fruit diameter, 12. Fruit weight, 13. Fruit volume, 14. Specific gravity, 15. Seed no./fruit, 16. 100 seed weight, 17. Seed wt. per fruit, 18. Pulp percentage, 19. Pulp weight, 20. TSS, 21. Titratable acidity, 22. TSS/Acid ratio, 23. Ascorbic acid, 24. Dietary fiber, 25. Total sugars, 26. Reducing sugars, 27. Non-reducing sugars, 28. Yield, 29. Yield efficiency (Dependent Character).

and showed a negative correlation with acidity. Pulp percentage also showed a positive correlation with hundred seed weight, seed weight per fruit, pulp weight, acidity, yield and yield efficiency and neg-

Table 3. Eigen values and component loadings in seedling origin guava genotypes.

Component	Initial eigen values			Extraction sums of squared loadings		
	Total	Percent of variance	Cumulative percentage	Total	Percent of variance	Cumulative percentage
1	12.904	51.617	51.617	12.904	51.617	51.617
2	4.524	18.095	69.712	4.524	18.095	69.712
3	1.675	6.700	76.413	1.675	6.700	76.413
4	1.241	4.963	81.376	1.241	4.963	81.376
5	1.174	4.695	86.071	1.174	4.695	86.071
6	0.843	3.371	89.442			
7	0.565	2.262	91.704			
8	0.476	1.903	93.607			
9	0.387	1.549	95.156			
10	0.317	1.269	96.425			
11	0.302	1.208	97.633			
12	0.164	0.654	98.287			
13	0.130	0.518	98.806			
14	0.109	0.434	99.240			
15	0.068	0.271	99.511			
16	0.054	0.218	99.729			
17	0.024	0.096	99.824			
18	0.013	0.052	99.876			
19	0.009	0.037	99.913			
20	0.007	0.026	99.940			
21	0.006	0.025	99.965			
22	0.004	0.015	99.980			
23	0.002	0.010	99.990			
24	0.002	0.009	99.999			
25	0.000	0.001	100.000			

ative correlated with TSS, acidity and ascorbic acid. Total sugars was positively correlated with reducing sugars, yield and yield efficiency and negatively correlated with non-reducing sugars. Ascorbic acid showed a positive correlation with dietary fiber, total sugars, reducing sugars, non-reducing sugars, yield and yield efficiency showed a highly positive correlation with yield efficiency. Paras *et al.* (2024) also found significant positive correlation of fruit weight with fruit diameter. Pelea *et al.* (2019) also reported positive correlation of fruit weight with fruit length, fruit diameter and seed number per fruit. Positive correlation ensures simultaneous improvement in two or more variables and negative correlation brings out need to obtain a compromise between the desirable characters. Correlation studies between fruit weight and its components and their relative contribution to quantitative characters are of great value in planning and evaluating breeding programs.

Path 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 (Patel *et al.* 2015). The coefficients generated by path analysis measure the direct and indirect influence of variable upon other (Dewy and Lu 1959). Phenotypic path coefficient analysis (Table 2) revealed that positive direct effect on yield were depicted by fruit volume (0.288) followed by Fruit diameter (0.286), fruit weight (0.278), tree spread (0.256) and pulp percentage (0.220), pulp weight (0.156) indicates good scope for improvement in fruit yield of guava. Positive direct effect of fruit volume, fruit diameter, fruit weight, tree spread and pulp percentage also showed significant and positive correlation with fruit yield whereas, trunk girth, TCSA, leaf area, seed weight per fruit, 100 seed weight also showed direct effect along with positive correlation on fruit yield suggested that these traits should be given due importance while selecting a genotype. These results are in tune with the findings of Dolkar *et al.* (2017) in grape. Gupta and Kour (2019)

recorded direct positive effect of average fruit weight, fruit volume, skin weight and percent edible pulp on fruit yield of mango. Paras *et al*. (2024) 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 Sau *et al.* (2016) 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 Negative direct effect on fruit yield were imposed by leaf length, specific gravity, acidity, ascorbic acid content, total sugar and reducing sugar content 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.

Principle component analysis:

Principal component analysis (Table 3) revealed five major components explaining 86.071% of the total variation. The percent variation explained by PC1, PC2, PC3, PC4 and PC5 was 51.617%, 18.095 percent, 6.700%, 4.963%, 4.695% respectively. These results are in conformity with the results of Hussain *et al.* (2016), who found that the first four PC's revealed maximum variation in walnut genotypes and PC1 and PC2 contributed total variance of 41.65% and 23.42%, respectively with total variance (65.05%), showing maximum factor loadings by kernel ratio, shell per cent, kernel yield and nut width by the first two PC's. Gangappa *et al.* (2022) also found similar results through correlation matrix analysis for variation wherein eight principal components (with an Eigen value greater than 1) accounted for 81.34% of the total variation.

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