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Research Article

Correlation and Path Coefficient Analysis in Twenty Ber Genotypes under Semi-Arid Conditions of Rajasthan

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Abstract

A study was undertaken to analyses the correlation and path coefficient for different characters in twenty ber (*Ziziphus mauritiana* Lamk.*)* genotypes grown at Asalpur Farm, Department of Horticulture, SKN College of Agriculture, Jobner during two consecutive years of 2014-15 and 2015-16. In general, the genotypic correlation coefficients were higher than the respective phenotypic correlations which might be from modifying effect of environment on the association of characters at genotypic level. Further, the fruit yield/ tree showed significant positive correlation at phenotypic level with fruit set, fruit retention, number of fruit pickings, pulp weight, specific gravity, fruit breadth, fruit weight, pulp: stone ratio, fruit length, plant spread (E-W), duration of fruiting, stone weight, plant spread (N-S), total acidity and canopy volume. However it had significant negative correlation with fruit drop, TSS: acid ratio, total days taken to first harvesting, total days taken to complete harvesting and reducing sugar in fruit. Similarly, path coefficient analysis at phenotypic level revealed that total days taken to first harvesting had highest positive direct effect on fruit yield/ tree followed by pulp weight, fruit length, specific gravity, duration of fruiting, fruit breadth, fruit set, volume of fruit, plant height, fruit weight, stem girth, canopy volume, non-reducing sugar, ascorbic acid content, reducing sugar and duration of flowering. These characters may be simultaneously selected to develop the high yielding varieties as they exerted high positive direct effect as well as had positive association with fruit yield.

Keywords: Ber, correlation analysis, path coefficients analysis

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Introduction

Indian jujube (*Ziziphus mauritiana* Lamk.) commonly known as *Ber* belongs to family Rhamnaceae, consists of 45 genera and 550 species. The genus *Zizyphus* has approximately 40 species, including *Zizyphus mauritiana* Lamk., which is indigenous to India. Ber is one of the important fruit trees that can be successfully cultivated in the hot arid regions of India. It is one of most ancient and common fruits in India [1]. Ber is widely distributed in tropical and subtropical regions of the world [2]. It is found wild as well as in cultivated forms throughout the warmer regions up to an altitude of 1500 meters above mean Sea level. Ber is cultivated in Madhya Pradesh, Bihar, Punjab, Haryana, Gujarat and Rajasthan. In Rajasthan, ber orchards are manly spread around Tijara, Alwar, Deeg, Chomu, Jaipur and Jodhpur. Ber is quite popular due to high economic returns, low cost of cultivation, wider adaptability and ability to stand with drought [3]. It can provide food security, due to sustained production of the fruit, irrespective of drought, as the tree is drought and saline tolerant and can grow on poor degraded land [4]. Ber fruits are very nutritious and usually eaten fresh. Fruits are also consumed in dried and preserved form as candy, pickle, juice and ber butter [5]. Arid regions are now facing a grave situation because of ecological deterioration. These areas have been subjected to unprecedented biotic pressure creating variety of scarcity conditions and need increased food supply. Inherently, desert environment imposes biophysical constraints for intensive production. Therefore, there is need for greater attention on drought and heat tolerant fruit tree species and ber is the most predominant among them. The chance of a suitable cultivar is of paramount importance for successful cultivation. Correlation estimates between fruit yield and its components are useful in developing suitable selection criteria for selecting desired plant types or developing high yielding varieties. Path analysis is helpful in choosing the character (s) that has direct or indirect effect on yield. Such a study may be useful in effective selection and simultaneous improvement of the component characters that

contribute towards yield. The present studies were conducted to find out the suitable ber cultivars in semi-arid condition of Rajasthan.

Materials and Methods

The present study was conducted during 2014-15 and 2015-16 seasons in order to study the correlation and path coefficient analysis in twenty ber genotypes under semi-arid conditions of Rajasthan**.** The genotypes consisted of Saphar Chandni, Gola, Tikadi, Phalisa Alwari, Thornless, Katha, Katha Bombay, Tabes Taso, Meharun, Dharkhi, Lakhan, Ilaichi, Pathani, Chhuhara, Nazuk, Kheera, ZG-3, Kathaphal, Sukhawani and Ashapuri-2. The age of trees was 14 year planted in Randomized Block Design with three replications at Asalpur Farm, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur. The soil of experimental site was loamy sand in texture, alkaline with low in available nitrogen and phosphorus and medium in potash. The PH and Ec of water were 8.5 and 5.2 dsm^{-1} respectively during 2014-15 and 8.7 and 6.1 dsm^{-1} respectively during 2015-16. The mean daily maximum and minimum temperature during the growing season of experimental crop fluctuated between 20.2 to 30.7^{0}C and 3.3 to 13.0^{0}C, respectively during 2014-15. The corresponding values for 2015-16 were between 18.5 to 32.5^{0}C and 2.3 to 14.2^{0}C. Similarly, the mean daily relative humidity fluctuated between 52 to 70 per cent during 2014-15 and 50 to 77 per cent during 2015-16. Rainfall received during the crop period was 21.2 and 19.0 mm during 2014-15 and 2015-16, respectively. The data on different characters were recorded during 2014-15 and 2015-16.

Results and Discussion

Association analysis

The potential productivity of any crop is basically valued in terms of fruit yield per tree. Its improvement by direct selection is generally difficult because yield is a complex polygenic character largely influenced by its various component characters as well as by the environment. Hence, it becomes essential to estimate association of yield with component characters and among themselves. The efficiency of selection thus, can be increased if it is simultaneously practiced for characters which are correlated with yield. In the quantitative traits the genotype is influenced by the environment thereby, affecting the phenotypic expression as well as association and consequently direction of association between the characters.

The knowledge of magnitude and direction of correlation is used for judging how improvement in one character will cause simultaneous change in the other characters. High magnitude of positive correlation coefficient at genotypic level between component characters and yield is important for indirect selection. Since, suitable test for significance of genotypic correlation is not available therefore, major emphasis has been put on phenotypic correlation coefficients, which are tested by 't-test'.

In general, the genotypic correlation coefficients were higher than the respective phenotypic correlations which might be from modifying effect of environment on the association of characters at genotypic level. Selection of yield as such may not be effective since there may be number of genes for fruit yield per tree and it may be resultant of interaction among its various components. Knowledge of relation between fruit yield and its components is essential and selection for one component may bring about a simultaneous change in the other. Therefore, for a rational approach to improve fruit yield per tree, it may be useful to collect information on character association.

All possible phenotypic and genotypic correlation coefficients between fruit yield/ tree and its components during pooled data are given in **Table 1** and discussed as under.

The correlation of fruit yield/ tree was positive and significant at phenotypic level in pooled data with fruit set (0.801), fruit retention (0.788), number of fruit pickings (0.722), pulp weight (0.660), specific gravity (0.632), fruit breadth (0.625), fruit weight (0.593), pulp: stone ratio (0.565), fruit length (0.552), plant spread in E-W (0.364), duration of fruiting (0.362), stone weight (0.328), plant spread in N-S (0.290), total acidity (0.285) and canopy volume (0.279). Although it showed negative and significant correlation at phenotypic level in pooled data with fruit drop (-0.784), TSS: acid ratio (-0.507), total days taken to first harvesting (-0.407), total days taken to complete harvesting (-0.382) and reducing sugar (-0.264). Similarly, positive association of fruit yield has been earlier reported with fruit weight, fruit size, fruit retention, stone weight and pulp: stone ratio [6, 7, 8]; with fruit set, fruit length, fruit breadth, fruit weight, stone diameter, pulp weight, specific gravity and harvest duration [9]; with plant height, plant

spread and stem girth [10]; with spread, weight and stone size [11]; with pulp: stone ratio [12]; with fruit weight, stone weight, fruit length, fruit breadth and pulp: stone ratio [13]; with fruit length, fruit width, fruit weight, fruit volume and specific gravity [14] and with fruit weight and fruit breadth [15] with fruit yield in ber and these results are in agreement with the present study.

Table 1 Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients among different characters in ber (Pooled data)

Characters	Plant height	Plant spread (E-W)	Plant spread (N-S)	Canopy volume	Stem girth	Duration of flowering	Duration of fruiting	Fruit weight	Volume of fruit	Fruit length	Fruit breadth	Stone weight	Pulp weight	Pulp: Stone ratio	Specific gravity
Plant height	–	0.414**	0.580**	0.720**	0.332**	-0.077	0.122	0.068	0.014	0.177	-0.071	-0.148	0.042	0.220	0.044
Plant spread (E-W)	0.846**	–	0.847**	0.867**	0.746**	0.140	0.289*	-0.023	0.216	-0.031	0.021	-0.210	-0.020	0.138	0.135
Plant spread (N-S)	0.904**	0.988**	–	0.942**	0.714**	0.047	0.292*	-0.050	0.217	0.005	-0.060	-0.279*	-0.080	0.157	0.138
Canopy volume	0.956**	0.984**	0.993**	–	0.681**	0.082	0.229	-0.030	0.200	0.056	-0.060	-0.292*	-0.047	0.184	0.111
Stem girth	0.612**	0.875**	0.889**	0.779**	–	0.000	0.278*	-0.134	0.175	-0.194	-0.168	-0.428**	-0.175	0.093	-0.033
Duration of flowering	-0.371**	0.134	0.039	0.040	-0.020	–	0.452**	-0.033	0.117	-0.020	0.053	-0.071	0.048	0.086	0.058
Duration of fruiting	-0.024	0.515**	0.408**	0.278*	0.376**	0.498**	–	0.060	0.103	-0.009	0.183	0.145	0.095	0.123	0.153
Fruit weight	0.070	-0.150	-0.177	-0.127	-0.263*	-0.083	0.127	–	0.011	0.794**	0.874**	0.609**	0.960**	0.729**	0.634**
Volume of fruit	-0.636**	-0.285*	-0.547**	-0.735**	-0.004	-0.861**	-0.005	-0.045	–	-0.000	0.040	-0.062	0.024	0.035	0.109
Fruit length	0.255*	-0.034	-0.019	0.050	-0.250	-0.040	0.000	0.858**	-0.101	–	0.709**	0.498**	0.815**	0.631**	0.602**
Fruit breadth	-0.049	-0.060	-0.115	-0.105	-0.196	0.100	0.331**	0.976**	-0.437**	0.773**	–	0.674**	0.899**	0.637**	0.669**
Stone weight	-0.248	-0.332**	-0.368**	-0.361**	-0.553**	-0.071	0.220	0.623**	0.326*	0.531**	0.703**	–	0.573**	0.022	0.288*
Pulp weight	0.054	-0.061	-0.092	-0.058	-0.202	0.021	0.123	0.898**	-0.206	0.847**	0.976**	0.582**	–	0.796**	0.709**
Pulp: Stone ratio	0.249	0.213	0.181	0.202	0.150	0.042	0.096	0.779**	-0.336**	0.657**	0.746**	0.046	0.818**	–	0.705**
Specific gravity	0.082	0.173	0.165	0.125	-0.043	0.062	0.168	0.688**	-0.795**	0.616**	0.724**	0.301*	0.737**	0.748**	–
Total days taken to first harvesting	-0.205	-0.529**	-0.427**	-0.353**	-0.467**	-0.159	-0.584**	-0.153	-0.456**	0.145	-0.257*	-0.168	-0.140	-0.059	-0.135
Total days taken to complete harvesting	-0.316*	-0.224	-0.226	-0.211	-0.224	0.262*	-0.124	-0.298*	-0.578**	-0.048	-0.287*	-0.301*	-0.268*	-0.094	-0.198
Fruit set	0.088	0.322*	0.240	0.160	0.216	-0.009	0.535**	0.653**	-0.415**	0.422**	0.667**	0.493**	0.648**	0.449**	0.517**
Fruit drop	-0.039	-0.284*	-0.211	-0.126	-0.171	-0.010	-0.545**	-0.641**	0.335**	-0.388**	-0.673**	-0.520**	-0.633**	-0.409**	-0.490**
Fruit retention	0.031	0.279*	0.209	0.121	0.168	0.011	0.545**	0.646**	-0.363**	0.392**	0.673**	0.524**	0.637**	0.412**	0.492**
Number of fruit pickings	0.120	0.456**	0.373**	0.274*	0.245	0.015	0.575**	0.772**	-0.104	0.608**	0.766**	0.508**	0.779**	0.582**	0.652**
TSS	0.311*	0.492**	0.541**	0.387**	0.514**	-0.197	0.412**	-0.000	-0.478**	0.015	-0.019	-0.075	-0.047	0.014	0.212
Total acidity	-0.356**	0.140	0.046	-0.043	0.127	0.088	0.004	0.129	-0.576**	0.039	0.284*	0.156	0.156	0.070	0.313*
Ascorbic acid	-0.026	0.109	0.097	0.042	0.242	-0.253	0.159	0.172	-0.891**	-0.084	0.310*	0.144	0.155	0.164	0.366**
Total sugars	-0.080	0.135	0.244	0.104	0.214	-0.459**	0.094	-0.215	-0.326*	-0.289*	-0.142	0.039	-0.255*	-0.275*	0.112
Reducing sugar	0.427**	0.376**	0.433**	0.222	0.035	-0.947**	0.984**	0.302*	-0.681**	0.340**	0.350**	0.738**	0.242	0.400**	0.799**
Non-reducing sugar	0.000	0.126	0.217	0.146	0.147	-0.462**	-0.410**	-0.412**	-0.792**	-0.409**	-0.429**	-0.365**	-0.397**	-0.194	0.102
TSS: acid ratio	0.442**	-0.225	-0.065	0.005	-0.025	-0.243	-0.041	-0.228	-0.391**	-0.166	-0.401	-0.212	-0.306*	-0.241	-0.361**
Fruit yield/ tree	0.224	0.464**	0.383**	0.338**	0.244	0.208	0.425**	0.655**	0.798**	0.581**	0.687**	0.345**	0.696**	0.613**	0.648**

*Significant at p=0.05 or at 5% and **Significant at p=0.01 or at 1%

Characters	Total days taken to first harvesting	Total days taken to complete harvesting	Fruit set	Fruit drop	Fruit retention	Number of fruit pickings	TSS	Total acidity	Ascorbic acid	Total sugars	Reducing sugar	Non-reducing sugar	TSS: acid ratio	Fruit yield/ tree
Plant height	-0.169	-0.177	0.042	-0.026	0.028	0.157	0.152	-0.202	-0.006	0.097	0.012	0.078	0.233	0.074
Plant spread (E-W)	-0.257*	-0.208	0.254*	-0.247	0.246	0.297*	0.315*	0.105	0.071	0.069	-0.158	0.065	-0.186	0.364**
Plant spread (N-S)	-0.248	-0.168	0.213	-0.182	0.177	0.273*	0.380**	0.044	0.073	0.071	-0.225	0.107	-0.069	0.290*
Canopy volume	-0.236	-0.176	0.148	-0.119	0.118	0.251	0.284*	-0.032	0.032	0.074	-0.163	0.103	-0.012	0.279*
Stem girth	-0.307*	-0.164	0.148	-0.141	0.134	0.210	0.336**	0.099	0.166	0.074	-0.147	0.066	-0.032	0.204
Duration of flowering	-0.154	0.192	-0.004	-0.018	0.020	0.048	-0.175	0.082	-0.233	-0.187	0.261*	-0.256*	-0.224	0.181
Duration of fruiting	-0.515**	-0.122	0.405**	-0.441**	0.438**	0.343**	0.353**	0.014	0.145	0.061	-0.180	-0.205	-0.037	0.362**
Fruit weight	-0.102	-0.275*	0.604**	-0.600**	0.599**	0.483*	0.017	0.111	0.154	-0.125	-0.222	-0.239	-0.195	0.593**
Volume of fruit	-0.302*	-0.142	0.018	-0.020	0.006	0.159	0.098	0.164	0.109	-0.080	-0.029	-0.192	-0.156	0.171
Fruit length	0.125	-0.075	0.396**	-0.362**	0.365**	0.341**	0.021	0.038	-0.080	-0.164	-0.272*	-0.246	-0.153	0.552**
Fruit breadth	-0.159	-0.271*	0.629**	-0.617**	0.624**	0.485**	0.028	0.260*	0.293*	-0.076	-0.210	-0.241	-0.350**	0.625**
Stone weight	-0.131	-0.253	0.477**	-0.504**	0.502**	0.346**	-0.052	0.146	0.141	0.025	-0.105	-0.238	-0.196	0.328*
Pulp weight	-0.133	-0.278*	0.592**	-0.592**	0.594**	0.467**	0.000	0.145	0.153	-0.151	-0.207	-0.239	-0.274*	0.660**
Pulp: Stone ratio	-0.072	-0.125	0.377**	-0.365**	0.367**	0.327*	0.056	0.063	0.157	-0.139	-0.212	-0.090	-0.209	0.565**
Specific gravity	-0.124	-0.173	0.482**	-0.464**	0.467**	0.430**	0.202	0.313*	0.365**	0.076	-0.339**	0.066	-0.357**	0.632**
Total days taken to first harvesting	–	0.696**	-0.471**	0.511**	-0.500**	-0.356**	-0.451**	-0.213	-0.418**	-0.304*	0.139	-0.002	0.053	-0.407**
Total days taken to complete harvesting	0.948**	–	-0.479**	0.503**	-0.506**	-0.300*	-0.403**	-0.242	-0.428**	-0.332**	0.221	-0.143	0.036	-0.382**
Fruit set	-0.651**	-0.621**	–	-0.973**	0.969**	0.694**	0.400**	0.234	0.108	0.199	-0.259*	-0.088	-0.326*	0.801**
Fruit drop	0.659**	0.620**	-0.987**	–	-0.997**	-0.717**	-0.400**	-0.215	-0.119	-0.210	0.201	0.099	0.308*	-0.784**
Fruit retention	-0.660**	-0.615**	0.998**	-0.978**	–	0.722**	0.400**	0.215	0.117	0.214	-0.203	-0.095	-0.309*	0.788**
Number of fruit pickings	-0.564**	-0.568**	0.897**	-0.896**	0.956**	–	0.313*	0.192	0.012	0.218	-0.120	-0.073	-0.307*	0.722**
TSS	-0.505**	-0.455**	0.468**	-0.453**	0.449**	0.516**	–	0.289*	0.248	0.402**	-0.380**	0.184	0.045	0.237
Total acidity	-0.233	-0.269*	0.257*	-0.234	0.233	0.267*	0.302*	–	0.354**	0.163	-0.140	0.080	-0.769**	0.285*
Ascorbic acid	-0.471**	-0.503**	0.121	-0.130	0.127	0.008	0.249	0.358**	–	0.262*	-0.249	0.091	-0.012	0.015
Total sugars	-0.417**	-0.498**	0.305*	-0.293*	0.284*	0.214	0.551**	0.221	0.342**	–	-0.091	0.710**	-0.069	0.083
Reducing sugar	-0.187	-0.317*	0.488**	-0.490**	0.481**	0.167	0.951**	0.701**	0.368**	0.305*	–	-0.024	0.022	-0.264*
Non-reducing sugar	0.020	-0.101	-0.136	0.153	-0.159	-0.137	0.177	0.088	0.124	0.800**	0.453**	–	-0.085	-0.115
TSS: acid ratio	0.062	0.063	-0.349**	0.325*	-0.327*	-0.451**	0.013	-0.778**	-0.016	-0.104	-0.219	-0.153	–	-0.507**
Fruit yield/ tree	-0.481**	-0.461**	0.890**	-0.852**	0.852**	0.968**	0.253	0.292*	0.017	0.140	0.498**	-0.104	-0.531**	–

*Significant at p=0.05 or at 5% and **Significant at p=0.01 or at 1%

Among other attributes, the plant height showed positive and significant correlation at phenotypic level in pooled data with plant spread (E-W), plant spread (N-S), canopy volume and stem girth; plant spread (E-W) with plant height, plant spread (N-S), canopy volume, stem girth, duration of fruiting, fruit set, number of fruit pickings and TSS; plant spread (N-S) with plant height, plant spread (E-W), canopy volume, stem girth, duration of fruiting, number of fruit pickings and TSS; canopy volume with plant height, plant spread (E-W), plant spread (N-S), stem girth and TSS; stem girth with plant height, plant spread (E-W), plant spread (N-S), canopy volume, duration of fruiting and TSS; duration of flowering with duration of fruiting and reducing sugar; duration of fruiting with plant spread (E-W), plant spread (N-S), stem girth, duration of flowering, fruit set, fruit retention, number of fruit pickings and TSS; fruit weight with fruit length, fruit breadth, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit set, fruit retention and number of fruit pickings; fruit length with fruit weight, fruit breadth, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit set, fruit retention and number of fruit pickings; fruit breadth with fruit weight, fruit length, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit set, fruit retention, number of

fruit pickings, total acidity and ascorbic acid; stone weight with fruit weight, fruit length, fruit breadth, pulp weight, specific gravity, fruit set, fruit retention and number of fruit pickings; pulp weight with fruit weight, fruit length, fruit breadth, stone weight, pulp: stone ratio, specific gravity, fruit set, fruit retention and number of fruit pickings; pulp: stone ratio with fruit weight, fruit length, fruit breadth, pulp weight, specific gravity, fruit set, fruit retention and number of fruit pickings; specific gravity with fruit weight, fruit length, fruit breadth, stone weight, pulp weight, pulp: stone ratio, fruit set, fruit retention, number of fruit pickings, total acidity and ascorbic acid; total days taken to first harvesting with total days taken to complete harvesting and fruit drop; total days taken to complete harvesting with total days taken to first harvesting and fruit drop; fruit set with plant spread (E-W), duration of fruiting, fruit weight, fruit length, fruit breadth, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit retention, number of fruit pickings and TSS; fruit drop with total days taken to first harvesting, total days taken to complete harvesting and TSS: acid ratio; fruit retention with duration of fruiting, fruit weight, fruit length, fruit breadth, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit set, number of fruit pickings and TSS; number of fruit pickings with plant spread (E-W), plant spread (N-S), duration of fruiting, fruit weight, fruit length, fruit breadth, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit set, fruit retention and TSS.

TSS was found significantly and positively correlated with plant spread in (E-W), plant spread (N-S), canopy volume, stem girth, duration of fruiting, fruit set, fruit retention, number of fruit pickings, total acidity and total sugar; total acidity with fruit breadth, specific gravity, TSS and ascorbic acid; ascorbic acid with fruit breadth, specific gravity, total acidity and total sugar; total sugars with TSS, ascorbic acid and non-reducing sugar; reducing sugar with duration of flowering; non-reducing sugar with total sugars and TSS: acid ratio had significant and positive correlation with fruit drop. It confirms the findings [11, 14, 15] in ber.

Plant spread (E-W) exhibited significant negative correlation at phenotypic level with total days taken to first harvesting; plant spread (N-S) with stone weight; canopy volume with stone weight; stem girth with stone weight and total days taken to first harvesting; duration of flowering with non-reducing sugar; duration of fruiting with total days taken to first harvesting and fruit drop; fruit weight with total days taken to complete harvesting and fruit drop; volume of fruit with total days taken to complete harvesting; fruit length with fruit drop and reducing sugar; fruit breadth with total days taken to complete harvesting, fruit drop and TSS: acid ratio; stone weight with plant spread (N-S), canopy volume, stem girth and fruit drop; pulp weight with total days taken to complete harvesting, fruit drop and TSS: acid ratio; pulp: stone ratio with fruit drop; specific gravity with fruit drop, reducing sugar and TSS: acid ratio; total days taken to first harvesting with plant spread (E-W), stem girth, duration of fruiting, volume of fruit, fruit set, fruit retention, number of fruit pickings, TSS, ascorbic acid and total sugar; total days taken to complete harvesting with fruit weight, fruit breadth, pulp weight, fruit set, fruit retention, number of fruit pickings, TSS, ascorbic acid and total sugar; fruit set with total days taken to first harvesting, total days taken to complete harvesting, fruit drop, reducing sugar and TSS: acid ratio; fruit drop with duration of fruiting, fruit weight, fruit length, fruit breadth, stone weight, pulp weight, pulp: stone ratio, specific gravity, fruit set, fruit retention, number of fruit pickings and TSS; fruit retention with total days taken to first harvesting, total days taken to complete harvesting, fruit drop and TSS: acid ratio; number of fruit pickings with total days taken to first harvesting, total days taken to complete harvesting, fruit drop and TSS: acid ratio.

TSS was found significantly and negative correlated with total days taken to first harvesting, total days taken to complete harvesting, fruit drop and reducing sugar; total acidity with TSS: acid ratio; ascorbic acid with total days taken to first harvesting and total days taken to complete harvesting; total sugars with total days taken to first harvesting and total days taken to complete harvesting; reducing sugar fruit length, specific gravity, fruit set and TSS; non-reducing sugar with duration of flowering and TSS: acid ratio had significant and negative correlation with fruit breadth, pulp weight, specific gravity, fruit set, fruit retention, number of fruit pickings and total acidity. These findings are in agreement with the findings [8, 14, 10] in ber.

Path coefficient analysis

The correlation analysis provide an information which is incomplete in the sense that it does not throw light on the underlying causes that are operative for the various interrelationship. The expression of a complex character such as fruit yield/ tree depends upon the interplay of a number of component attributes. A better picture of the contribution of each component building up the total genetic architecture of a complex character may be obtained through the analysis of causal schemes. Hence, in such a situation [16] had been useful in partitioning direct and indirect causes of association which allow a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of each causal character. Such a study provides a realistic basis for allocation of weightage to each attribute in deciding suitable criteria for genetic improvement. The aim of this

analysis in the present investigation was to compare the results obtained from simple correlation analysis and to demonstrate the significance of path coefficient analysis in determining the true nature of character association.

In the present study path coefficient analysis was computed both at genotypic and phenotypic level for all the characters. Path coefficient analysis was carried out by taking fruit yield/ tree as dependent variable to partition the correlation coefficients into direct and indirect effects in order to determine the contribution of different characters towards the fruit yield/ tree. Direct and indirect effects of various characters on fruit yield/ tree indicated that there is agreement between direction and magnitude of direct effect of various characters and correlation with fruit yield/ tree. Thus, a significant improvement in fruit yield/ tree can be expected through selection in the component traits with high positive direct effects.

The data of path coefficient analysis of pooled analysis are presented in **Tables 2** and **3** and discussed as under.

Table 2 Estimates of direct and indirect effects at genotypic (G) levels of various traits with fruit yield/ tree (Pooled data)

Characters	Plant height	Plant spread (E-W)	Plant spread (N-S)	Canopy volume	Stem girth	Duration of flowering	Duration of fruiting	Fruit weight	Volume of fruit	Fruit length	Fruit breadth	Stone weight	Pulp weight	Pulp: Stone ratio	Specific gravity
Plant height	0.0018	0.0015	0.0016	0.0017	0.0011	-0.0007	0.0000	0.0001	-0.0011	0.0005	-0.0001	-0.0004	0.0001	0.0004	0.0001
Plant spread (E-W)	0.0021	0.0024	0.0026	0.0024	0.0021	0.0003	0.0013	-0.0004	-0.0056	-0.0001	-0.0001	-0.0008	-0.0001	0.0005	0.0004
Plant spread (N-S)	0.0028	0.0033	0.0031	0.0031	0.0028	0.0001	0.0013	-0.0006	-0.0048	-0.0001	-0.0004	-0.0011	-0.0003	0.0006	0.0005
Canopy volume	-0.0084	-0.0087	-0.0088	-0.0088	-0.0069	-0.0004	-0.0025	0.0011	0.0153	-0.0004	0.0009	0.0032	0.0005	-0.0018	-0.0011
Stem girth	0.0013	0.0018	0.0018	0.0016	0.0021	0.0000	0.0008	-0.0005	-0.0021	-0.0005	-0.0004	-0.0011	-0.0004	0.0003	-0.0001
Duration of flowering	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000	-0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Duration of fruiting	0.0000	0.0002	0.0002	0.0001	0.0002	0.0002	0.0004	0.0001	-0.0004	0.0000	0.0001	0.0001	0.0001	0.0000	0.0001
Fruit weight	-0.0001	0.0002	0.0003	0.0002	0.0004	0.0001	-0.0002	0.0016	0.0001	-0.0014	-0.0016	-0.0010	-0.0016	-0.0013	-0.0011
Volume of fruit	0.0002	0.0007	0.0005	0.0006	0.0003	0.0006	0.0003	0.0000	-0.0003	0.0000	0.0001	-0.0001	0.0001	0.0001	0.0003
Fruit length	0.0010	-0.0001	-0.0001	0.0002	-0.0010	-0.0002	0.0000	0.0033	-0.0004	0.0039	0.0030	0.0021	0.0033	0.0026	0.0024
Fruit breadth	0.0000	0.0000	0.0001	0.0001	0.0001	-0.0001	-0.0002	-0.0005	0.0002	-0.0004	-0.0006	-0.0004	-0.0005	-0.0004	-0.0004
Stone weight	0.0005	0.0007	0.0008	0.0008	0.0012	0.0001	-0.0005	-0.0013	-0.0007	-0.0011	-0.0015	-0.0021	-0.0012	-0.0001	-0.0006
Pulp weight	0.0002	-0.0002	-0.0004	-0.0002	-0.0008	0.0001	0.0005	0.0041	-0.0008	0.0035	0.0040	0.0024	0.0041	0.0033	0.0030
Pulp: Stone ratio	-0.0011	-0.0010	-0.0008	-0.0009	-0.0007	-0.0002	-0.0004	-0.0035	0.0015	-0.0030	-0.0034	-0.0002	-0.0037	-0.0045	-0.0034
Specific gravity	0.0001	0.0002	0.0002	0.0001	0.0000	0.0001	0.0002	0.0008	-0.0009	0.0007	0.0008	0.0003	0.0008	0.0008	0.0011
Total days taken to first harvesting	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	-0.0003	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
Total days taken to complete harvesting	0.0002	0.0002	0.0002	0.0001	0.0002	-0.0002	0.0001	0.0002	-0.0007	0.0000	0.0002	0.0002	0.0002	0.0001	0.0001
Fruit set	0.0003	0.0012	0.0009	0.0006	0.0008	0.0000	0.0019	0.0024	-0.0015	0.0015	0.0024	0.0018	0.0023	0.0016	0.0019
Fruit drop	-0.0005	-0.0035	-0.0026	-0.0016	-0.0021	-0.0001	-0.0068	-0.0080	0.0042	-0.0048	-0.0084	-0.0065	-0.0079	-0.0051	-0.0061
Fruit retention	0.0004	0.0037	0.0028	0.0016	0.0022	0.0001	0.0072	0.0086	-0.0048	0.0052	0.0090	0.0070	0.0085	0.0055	0.0066
Number of fruit pickings	-0.0001	-0.0003	-0.0002	-0.0002	-0.0002	0.0000	-0.0004	-0.0005	0.0001	-0.0004	-0.0005	-0.0003	-0.0005	-0.0004	-0.0004
TSS	-0.0006	-0.0009	-0.0010	-0.0007	-0.0009	0.0004	-0.0007	0.0000	0.0021	0.0000	0.0000	0.0001	0.0001	0.0000	-0.0004
Total acidity	0.0004	-0.0002	-0.0001	0.0001	-0.0001	-0.0001	0.0000	-0.0002	0.0017	0.0000	-0.0003	-0.0002	-0.0002	-0.0001	-0.0004
Ascorbic acid	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total sugars	0.0001	-0.0002	-0.0004	-0.0002	-0.0004	0.0008	-0.0002	0.0004	0.0023	0.0005	0.0002	-0.0001	0.0004	0.0005	-0.0002
Reducing sugar	0.0002	0.0001	0.0001	0.0001	0.0001	-0.0001	0.0001	0.0001	-0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Non-reducing sugar	0.0000	0.0003	0.0005	0.0003	0.0003	-0.0011	-0.0010	-0.0010	-0.0042	-0.0010	-0.0010	-0.0009	-0.0009	-0.0005	0.0002
TSS: acid ratio	-0.0006	0.0003	0.0001	0.0000	0.0000	0.0004	0.0001	0.0003	-0.0020	0.0002	0.0006	0.0003	0.0004	0.0004	0.0005

*Significant at p=0.05 or at 5% and **Significant at p=0.01 or at 1%

Characters	Total days taken to first harvesting	Total days taken to complete harvesting	Fruit set	Fruit drop	Fruit retention	Number of fruit pickings	TSS	Total acidity	Ascorbic acid	Total sugars	Reducing sugar	Non-reducing sugar	TSS: acid ratio	Correlation with fruit yield/ tree
Plant height	-0.0004	-0.0006	0.0002	-0.0001	0.0001	0.0002	0.0006	-0.0006	0.0000	-0.0001	0.0044	0.0000	0.0008	0.224
Plant spread (E-W)	-0.0013	-0.0005	0.0008	-0.0007	0.0007	0.0011	0.0012	0.0003	0.0003	0.0003	0.0033	0.0003	-0.0005	0.464**
Plant spread (N-S)	-0.0013	-0.0007	0.0007	-0.0007	0.0006	0.0012	0.0017	0.0001	0.0003	0.0008	0.0044	0.0007	-0.0002	0.383**
Canopy volume	0.0031	0.0019	-0.0014	0.0011	-0.0011	-0.0024	-0.0034	0.0004	-0.0004	-0.0009	-0.0108	-0.0013	0.0000	0.383**
Stem girth	-0.0010	-0.0005	0.0004	-0.0004	0.0003	0.0005	0.0011	0.0003	0.0005	0.0004	0.0021	0.0003	-0.0001	0.244
Duration of flowering	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	-0.0001	-0.0002	-0.0001	-0.0001	0.208
Duration of fruiting	-0.0002	-0.0001	0.0002	-0.0002	0.0002	0.0002	0.0002	0.0000	0.0001	0.0000	0.0004	-0.0002	0.0000	0.425**
Fruit weight	0.0002	0.0005	-0.0011	0.0010	-0.0010	-0.0012	0.0000	-0.0002	-0.0003	0.0003	-0.0021	0.0007	0.0004	0.655**
Volume of fruit	-0.0005	-0.0003	0.0001	-0.0001	0.0001	0.0000	0.0004	0.0005	0.0003	0.0004	0.0009	0.0006	-0.0004	-1.000**
Fruit length	0.0006	-0.0002	0.0016	-0.0015	0.0015	0.0024	0.0001	0.0002	-0.0003	-0.0011	0.0052	-0.0016	-0.0006	0.581**
Fruit breadth	0.0001	0.0002	-0.0004	0.0004	-0.0004	-0.0004	0.0000	-0.0002	-0.0002	0.0001	-0.0008	0.0002	0.0002	0.687**
Stone weight	0.0003	0.0006	-0.0010	0.0011	-0.0011	-0.0011	0.0002	-0.0003	-0.0003	-0.0001	-0.0015	0.0008	0.0004	0.345**
Pulp weight	-0.0006	-0.0011	0.0026	-0.0026	0.0026	0.0032	-0.0002	0.0006	0.0006	-0.0010	0.0051	-0.0016	-0.0012	0.696**
Pulp: Stone ratio	0.0003	0.0004	-0.0020	0.0018	-0.0019	-0.0026	-0.0001	-0.0003	-0.0007	0.0012	-0.0063	0.0009	0.0011	0.613**
Specific gravity	-0.0002	-0.0002	0.0006	-0.0005	0.0006	0.0007	0.0002	0.0004	0.0004	0.0001	0.0020	0.0001	-0.0004	0.648**
Total days taken to first harvesting	-0.0002	-0.0002	0.0001	-0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0000	0.0000	-0.481**
Total days taken to complete harvesting	-0.0007	-0.0007	0.0004	-0.0004	0.0004	0.0004	0.0003	0.0002	0.0003	0.0003	0.0009	0.0001	0.0000	-0.461**
Fruit set	-0.0023	-0.0022	0.0036	-0.0036	0.0036	0.0044	0.0017	0.0009	0.0004	0.0011	0.0054	-0.0005	-0.0013	0.890**
Fruit drop	0.0082	0.0077	-0.0126	0.0124	-0.0125	-0.0145	-0.0056	-0.0029	-0.0016	-0.0037	-0.0186	0.0019	0.0041	-0.852**
Fruit retention	-0.0088	-0.0082	0.0134	-0.0133	0.0133	0.0154	0.0060	0.0031	0.0017	0.0038	0.0197	-0.0021	-0.0044	0.852**
Number of fruit pickings	0.0003	0.0003	-0.0007	0.0007	-0.0007	-0.0006	-0.0003	-0.0002	0.0000	-0.0001	-0.0013	0.0001	0.0003	1.000**
TSS	0.0009	0.0008	-0.0008	0.0008	-0.0008	-0.0009	-0.0018	-0.0005	-0.0004	-0.0010	-0.0035	-0.0003	0.0000	0.253
Total acidity	0.0003	0.0003	-0.0003	0.0003	-0.0003	-0.0003	-0.0004	-0.0012	-0.0004	-0.0003	-0.0008	-0.0001	0.0009	0.292*
Ascorbic acid	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	-0.0001	0.0000	0.0000	0.0000	0.017
Total sugars	0.0007	0.0008	-0.0005	0.0005	-0.0005	-0.0004	-0.0009	-0.0004	-0.0006	-0.0017	-0.0022	-0.0014	0.0002	0.140
Reducing sugar	-0.0001	-0.0001	0.0001	-0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	1.000**
Non-reducing sugar	0.0000	-0.0002	-0.0003	0.0004	-0.0004	-0.0003	0.0004	0.0002	0.0003	0.0019	0.0011	0.0023	-0.0004	-0.104
TSS: acid ratio	-0.0001	-0.0001	0.0005	-0.0005	0.0005	0.0007	0.0000	0.0011	0.0000	0.0002	0.0003	0.0002	-0.0015	-0.531**

*Significant at p=0.05 or at 5% and **Significant at p=0.01 or at 1%
Residual effect: genotypic=0.0004

Table 3 Estimates of direct and indirect effects at phenotypic (P) levels of various traits with fruit yield/ tree (Pooled data)

Characters	Plant height	Plant spread (E-W)	Plant spread (N-S)	Canopy volume	Stem girth	Duration of flowering	Duration of fruiting	Fruit weight	Volume of fruit	Fruit length	Fruit breadth	Stone weight	Pulp weight	Pulp: Stone ratio	Specific gravity
Plant height	0.0009	0.0004	0.0005	0.0007	0.0003	-0.0001	0.0001	0.0001	0.0000	0.0002	-0.0001	-0.0001	0.0000	0.0002	0.0000
Plant spread (E-W)	-0.0005	-0.0013	-0.0011	-0.0011	-0.0010	-0.0002	-0.0004	0.0000	-0.0003	0.0000	0.0000	0.0003	0.0000	-0.0002	-0.0002
Plant spread (N-S)	0.0000	-0.0001	-0.0001	-0.0001	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Canopy volume	0.0002	0.0002	0.0002	0.0003	0.0002	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0000
Stem girth	0.0002	0.0005	0.0005	0.0005	0.0007	0.0000	0.0002	-0.0001	0.0001	-0.0001	-0.0001	-0.0003	-0.0001	0.0001	0.0000
Duration of flowering	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Duration of fruiting	0.0002	0.0004	0.0004	0.0003	0.0003	0.0006	0.0012	0.0001	0.0001	0.0000	0.0002	0.0002	0.0001	0.0002	0.0002
Fruit weight	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0007	0.0000	-0.0005	-0.0006	-0.0004	-0.0006	-0.0005	-0.0004
Volume of fruit	0.0000	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0000	0.0009	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0001
Fruit length	0.0003	0.0000	0.0000	0.0001	-0.0003	0.0000	0.0000	0.0012	0.0000	0.0015	0.0011	0.0007	0.0012	0.0009	0.0009
Fruit breadth	-0.0001	0.0000	-0.0001	-0.0001	-0.0002	0.0001	0.0002	0.0009	0.0000	0.0007	0.0010	0.0007	0.0009	0.0007	0.0007
Stone weight	0.0004	0.0006	0.0008	0.0008	0.0012	0.0002	-0.0004	-0.0017	0.0002	-0.0014	-0.0018	-0.0027	-0.0016	-0.0001	-0.0008
Pulp weight	0.0001	0.0000	-0.0001	-0.0001	-0.0003	0.0001	0.0001	0.0015	0.0000	0.0013	0.0014	0.0009	0.0016	0.0013	0.0011
Pulp: Stone ratio	-0.0007	-0.0005	-0.0005	-0.0006	-0.0003	-0.0003	-0.0004	-0.0024	-0.0001	-0.0021	-0.0021	-0.0001	-0.0027	-0.0033	-0.0024
Specific gravity	0.0001	0.0002	0.0002	0.0001	0.0000	0.0001	0.0002	0.0008	0.0001	0.0008	0.0009	0.0004	0.0009	0.0009	0.0013
Total days taken to first harvesting	-0.0004	-0.0006	-0.0006	-0.0006	-0.0007	-0.0004	-0.0012	-0.0002	-0.0007	0.0003	-0.0004	-0.0003	-0.0003	-0.0002	-0.0003
Total days taken to complete harvesting	0.0004	0.0005	0.0004	0.0004	0.0004	-0.0005	0.0003	0.0007	0.0003	0.0002	0.0007	0.0006	0.0007	0.0003	0.0004
Fruit set	0.0000	0.0003	0.0002	0.0002	0.0002	0.0000	0.0004	0.0006	0.0000	0.0004	0.0007	0.0005	0.0006	0.0004	0.0005
Fruit drop	0.0001	0.0010	0.0007	0.0005	0.0006	0.0001	0.0017	0.0024	0.0001	0.0014	0.0024	0.0020	0.0023	0.0014	0.0018
Fruit retention	0.0000	-0.0004	-0.0003	-0.0002	-0.0002	0.0000	-0.0006	-0.0009	0.0000	-0.0005	-0.0009	-0.0007	-0.0009	-0.0005	-0.0007
Number of fruit pickings	-0.0001	-0.0002	-0.0002	-0.0002	-0.0002	0.0000	-0.0003	-0.0004	-0.0001	-0.0003	-0.0004	-0.0003	-0.0004	-0.0003	-0.0003
TSS	-0.0001	-0.0002	-0.0002	-0.0002	-0.0002	0.0001	-0.0002	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001
Total acidity	0.0003	-0.0002	-0.0001	0.0001	-0.0002	-0.0001	0.0000	-0.0002	-0.0003	-0.0001	-0.0004	-0.0002	-0.0002	-0.0001	-0.0005
Ascorbic acid	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total sugars	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Reducing sugar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Non-reducing sugar	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TSS: acid ratio	-0.0006	0.0005	0.0002	0.0000	0.0001	0.0006	0.0001	0.0005	0.0004	0.0004	0.0009	0.0005	0.0007	0.0006	0.0009

*Significant at p=0.05 or at 5% and **Significant at p=0.01 or at 1%

Characters	Total days taken to first harvesting	Total days taken to complete harvesting	Fruit set	Fruit drop	Fruit retention	Number of fruit pickings	TSS	Total acidity	Ascorbic acid	Total sugars	Reducing sugar	Non-reducing sugar	TSS: acid ratio	Correlation with fruit yield/ tree
Plant height	-0.0002	-0.0002	0.0000	0.0000	0.0000	0.0001	0.0001	-0.0002	0.0000	0.0001	0.0000	0.0001	0.0002	0.074
Plant spread (E-W)	0.0003	0.0003	-0.0003	0.0003	-0.0003	-0.0004	-0.0004	-0.0001	-0.0001	-0.0001	0.0002	-0.0001	0.0002	0.364**
Plant spread (N-S)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.290*
Canopy volume	-0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.279*
Stem girth	-0.0002	-0.0001	0.0001	-0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0000	-0.0001	0.0000	0.0000	0.204
Duration of flowering	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.181
Duration of fruiting	-0.0006	-0.0002	0.0005	-0.0006	0.0005	0.0004	0.0004	0.0000	0.0002	0.0001	-0.0002	-0.0003	0.0000	0.362**
Fruit weight	0.0001	0.0002	-0.0004	0.0004	-0.0004	-0.0003	0.0000	-0.0001	-0.0001	0.0001	0.0001	0.0002	0.0001	0.593**
Volume of fruit	-0.0003	-0.0001	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	-0.0001	0.0000	-0.0002	-0.0001	0.171

Fruit length	0.0002	-0.0001	0.0006	-0.0005	0.0005	0.0005	0.0000	0.0001	-0.0001	-0.0002	-0.0004	-0.0004	-0.0002	0.552**
Fruit breadth	-0.0002	-0.0003	0.0006	-0.0006	0.0006	0.0005	0.0000	0.0003	0.0003	-0.0001	-0.0002	-0.0002	-0.0004	0.625**
Stone weight	0.0004	0.0007	-0.0013	0.0014	-0.0014	-0.0009	0.0001	-0.0004	-0.0004	-0.0001	0.0003	0.0006	0.0005	0.328*
Pulp weight	-0.0002	-0.0004	0.0009	-0.0009	0.0009	0.0007	0.0000	0.0002	0.0002	-0.0002	-0.0003	-0.0004	-0.0004	0.660**
Pulp: Stone ratio	0.0002	0.0004	-0.0013	0.0012	-0.0012	-0.0011	-0.0002	-0.0002	-0.0005	0.0005	0.0007	0.0003	0.0007	0.565**
Specific gravity	-0.0002	-0.0002	0.0006	-0.0006	0.0006	0.0006	0.0003	0.0004	0.0005	0.0001	-0.0004	0.0001	-0.0005	0.632**
Total days taken to first harvesting	0.0024	0.0016	-0.0011	0.0012	-0.0012	-0.0008	-0.0011	-0.0005	-0.0010	-0.0007	0.0003	0.0000	0.0001	-0.407**
Total days taken to complete harvesting	-0.0017	-0.0024	0.0012	-0.0012	0.0012	0.0007	0.0010	0.0006	0.0010	0.0008	-0.0005	0.0003	-0.0001	-0.382**
Fruit set	-0.0005	-0.0005	0.0010	-0.0010	0.0010	0.0007	0.0004	0.0002	0.0001	0.0002	-0.0003	-0.0001	-0.0003	0.801**
Fruit drop	-0.0020	-0.0020	0.0038	-0.0039	0.0039	0.0028	0.0016	0.0008	0.0005	0.0008	-0.0008	-0.0004	-0.0012	-0.784**
Fruit retention	0.0007	0.0007	-0.0014	0.0015	-0.0015	-0.0011	-0.0006	-0.0003	-0.0002	-0.0003	0.0003	0.0001	0.0005	0.788**
Number of fruit pickings	0.0003	0.0002	-0.0006	0.0006	-0.0006	-0.0008	-0.0003	-0.0002	0.0000	-0.0002	0.0001	0.0001	0.0002	0.722**
TSS	0.0002	0.0002	-0.0002	0.0002	-0.0002	-0.0002	-0.0005	-0.0002	-0.0001	-0.0002	0.0002	-0.0001	0.0000	0.237
Total acidity	0.0003	0.0004	-0.0004	0.0003	-0.0003	-0.0003	-0.0005	-0.0016	-0.0006	-0.0003	0.0002	-0.0001	0.0012	0.285*
Ascorbic acid	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.015
Total sugars	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	-0.0001	0.0000	-0.0001	-0.0002	0.0000	-0.0002	0.0000	0.083
Reducing sugar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	-0.264*
Non-reducing sugar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0000	-0.115
TSS: acid ratio	-0.0001	-0.0001	0.0009	-0.0008	0.0008	0.0008	-0.0001	0.0020	0.0000	0.0002	-0.0001	0.0002	-0.0026	-0.507**

*Significant at p=0.05 or at 5% and **Significant at p=0.01 or at 1%
Residual effect: phenotypic=0.0021

It is revealed from the Table that high order positive direct effect at phenotypic level in pooled data towards fruit yield/ tree was exerted by total days taken to first harvesting (0.0024) followed by pulp weight (0.0016), fruit length (0.0015), specific gravity (0.0013), duration of fruiting (0.0012), fruit breadth (0.0010), fruit set (0.0010), volume of fruit (0.0009), plant height (0.0009), fruit weight (0.0007),stem girth (0.0007), canopy volume (0.0003), non-reducing sugar (0.0002), ascorbic acid (0.0001), reducing sugar (0.0001) and duration of flowering (0.000001), whereas, the negative direct effect at phenotypic level towards fruit yield/ tree was exerted by fruit drop (-0.0039) followed by pulp: stone (-0.0033), stone weight (-0.0027), TSS: acid ratio (-0.0026), total days taken to complete harvesting (-0.0024), total acidity (-0.0016), fruit retention (-0.0015), plant spread in E-W (-0.0013), number of fruit pickings(-0.0008), TSS (-0.0005), total sugars (-0.0002) and plant spread in N-S (-0.0001). These findings are in agreement with the findings [17, 6, 7, 9, 10, 11, 12, 13, 15] in ber.

The magnitude of residual effect was moderate which indicated that major portion of contribution towards fruit yield might be explained on the basis of characters included in the present study. However, some more characters not included in the present study may contribute to account for the residual effect.

Conclusions

Thus on the basis of present study it may be concluded that the characters like total days taken to first harvesting, pulp weight, fruit length, specific gravity, duration of fruiting, fruit breadth, fruit set, volume of fruit, plant height, fruit weight, stem girth, canopy volume, non-reducing sugar, ascorbic acid content, reducing sugar and duration of flowering may be of merit value when making selection for desirable genotypes.

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