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Correlation and path coefficient analysis between yield and quality parameters in jackfruit (*Artocarpus heterophyllus* Lam.) local genotypes under coffee ecosystem of lower pulney hills, Tami Nadu, India

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Abstract

Evaluation of 35 local genotypes of jackfruit (*Artocarpus heterophyllus* Lam.) under coffee ecosystem of pulney hills was conducted to assess the correlation of different fruit components viz., fruit length, fruit diameter, fruit weight, fruit rind weight, total weight of flakes per fruit and number of fruits per tree per year recorded highly significant and positive correlation with yield per tree per year (0.581, 0.455, 0.781, 0.715 and 0.611 respectively). Path coefficient analysis revealed adequate genetic background for direct and indirect effect of various characters on yield per tree. Hence, at the time of selection of jackfruit genotypes, one has to put emphasis on the yield and quality parameters.

Keywords: Jackfruit, Yield characters, Quality characters, Positive correlation

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the family Moraceae, and can be considered as the largest fruit among the edible fruits. Jackfruit tree is native in South East Asia and popular in several tropical and sub-tropical countries (Haq, 2006) [6]. Jackfruit gives more yield per tree than most of the fruit crops but is still not classified as a commercial fruit and is rarely grown on regular plantation scale (underutilized crops). It is one of the most drought tolerant, hardy fruit crop and traditionally it is a farmer's household fruit. Owing to its numerous culinary uses and its availability in plenty during heavy monsoon rains, jackfruit has earned the well-deserved name "poor man's food".

The jackfruit is a multi-purpose species providing food, timber, fuel, fodder, and medicinal and industrial products. A mature tree produces up to 700 fruits per year, each weighing 0.5 to 50 kg. On an average, 50-80 tons of fruits can be harvested from a hectare of land. The tree is monoecious, producing male and female flowers. Stem of this plant is straight and rough whereas bark is green or black, 1.25 cm thick and exudes milky latex; leaves broad obovate, elliptic, decurrent, glabrous, entire; inflorescence solitary axillary, cauliferous and ramiflours on short leafy shoots. It has also been reported that the evergreen leaves are oblong, oval or elliptic in shape, 10-15 cm in length, alternate, glossy and dark green in colour. However, this crop gaining commercial importance now a days. So, there is need of systematic research on yield and quality parameters correlation in jackfruit in India. Correlation studies between traits help to select suitable genotypes. Correlation studies revealed that both positive and negative association with varying levels of significance. So, to evaluate a good genotype a correlation will provide reliable information on the nature and extent of relationship for bringing about improvement in the yield and quality traits. So, for further this investigation is being carried out.

Materials and Methods

A study entitled "Evaluation of Jackfruit (*Artocarpus heterophyllus* Lam.) local genotypes under coffee ecosystem of lower pulney hills" was conducted at Horticultural Research Station, Thadiyankudisai and its adjoining areas, Tamil Nadu Agricultural University,

Coimbatore during 2016-2017. Various morphometric and quality characters were observed in all the 35 genotypes. The descriptor developed for *Artocarpus heterophyllus* Lam. (Jackfruit) compiled by Bio-versity international was used in this study for characterising the selected genotypes from August 2016 to June 2017. The genotypes were marked and observations were made for morphological, yield and quality parameters. Correlation was computed as per the formula given by Robinson *et al.*, (1951) ^[7]. Path coefficient analysis as applied by Dewey and Lu (1959) ^[4] was used to partition the phenotypic correlation into components of direct and indirect effects.

Results and Discussion

The results obtained from through the correlation coefficients and path coefficients analysis indicate that strong association among the tree biometric traits, fruit physical attributes and yield. Genotypic correlation for selected biometrical characters was worked out and the results are furnished in table 1.

Fruit characters viz., fruit length, fruit diameter, fruit weight, fruit rind weight, total weight of flakes per fruit and number of fruits per tree per year recorded highly significant and positive correlation with yield per tree per year (0.581, 0.455, 0.781, 0.715 and 0.611 respectively). Fruit length registered highly significant and positive correlation with fruit diameter (0.521), fruit weight (0.578), fruit rind weight (0.563), number of flakes per fruit (0.394), total weight of flakes per fruit (0.399), flake width (0.403) and number of fruits per tree per year (0.450).

Fruit diameter registered highly significant and positive correlation with fruit weight (0.396), fruit rind weight (0.401), weight of individual flakes with seed (0.345), weight of individual flakes without seed (0.363) and number of fruits per tree per year (0.432). Fruit weight registered highly significant and positive correlation with fruit rind weight (0.876), number of flakes per fruit (0.542), total weight of flakes per fruit (0.827) and number of fruits per tree per year (0.510). Senjam *et al.* (2012) ^[8] revealed that fruit weight had significant positive correlation with skin thickness, flake length and flake width. Wangchu *et al.* (2013) ^[10] reported that fruit weight exhibited highly significant positive association with rind weight, rachis length, fruit length and flake length. Similar results were reported by Darjazi (2011) ^[2] and Gozlekci (2011) ^[5] in fig fruit.

Fruit rind weight exhibited highly significant and positive correlation with total weight of flakes (0.465), flake width (0.390) and number of fruits per tree per year (0.446) whereas negative correlation and significant with flake: fruit ratio (-0.489) and rind: flake ratio (-0.487).

Total weight of flakes per fruit registered highly significant and positive correlation with flakes: fruit ratio (0.501), rind: flakes ratio (0.514) and number of fruits per tree (0.426). Number of flakes per fruit recorded significant and negative correlation with weight of individual flake with seed (-0.480), weight of individual flake without seed (-0.407), flake length (-0.025) and flake width (-0.018). Wangchu *et al.* (2013) ^[10] revealed that weight of flakes per kg of fruit had significant positive correlation with flake length and flake width. Davamani (2010) ^[3] stated that number of fruits at harvest, mean fruit weight, number of leaves at harvest and flesh thickness had positive correlation with yield in papaya.

Weight of individual flake with seed exhibited high significant and positive correlation with weight of individual flake without seed (0.944), flake length (0.424) and number of

fruits per tree (0.436). Weight of individual flake without seed showed high significant and positive correlation with flake length (0.405) and number of fruits per tree (0.371).

Genotypic correlation for biochemical characters was worked out and the results were furnished in table 2. Total soluble solids registered highly significant and positive correlation with total sugars (0.925), reducing sugars (0.812) and non-reducing sugars (0.886). Total sugars exhibited highly significant and positive correlation with reducing sugars (0.782), non-reducing sugars (0.984) and ascorbic acid content (0.342). Reducing sugars recorded highly significant and positive correlation with non-reducing sugars (0.660). Non-reducing sugars registered significant and negative correlation with titrable acidity (-0.007). Titrable acidity had registered highly significant and positive correlation with ascorbic acid content (0.532) whereas negative correlation with carotene content (-0.211) and protein content (-0.194).

Path coefficient analysis (Table 3)

The correlation coefficient of yield per tree with other yield attributing traits was further partitioned into direct and indirect effects by path coefficient analysis

Direct effects of yield attributing traits on yield per tree

Path coefficient analysis revealed positive and direct effect by nine biometric characters on yield per tree. Among them, fruit weight (0.855) and number of fruits per tree (0.720), recorded high positive and direct effect on yield. Fruit length (0.174), flake length (0.165), flake: fruit ratio (0.131) and weight of individual without seed (0.107) registered low positive and direct effect on yield per tree. Fruit rind weight (-0.505), rind: flake ratio (-0.458), weight of individual flake without seed (-0.276), flake width (-0.196) and number of flakes per fruit (-0.194) exhibited negative and direct effects on yield per tree.

Indirect effect of yield attributing traits on yield per tree

Trunk circumference registered moderate positive and indirect effect on yield per tree via. number of fruits per tree (0.223) and low positive and indirect effect via., fruit weight (0.157). Fruit weight exhibited low positive and indirect effect via. fruit length (0.101). Spine density per 25 cm² recorded low positive and indirect effect via. fruit rind weight (0.161).

Fruit rind weight registered high positive and indirect effect on yield per tree via. number of fruits per tree (0.367). Number of flakes per fruit exhibited low positive and indirect effect via. weight of individual flakes without seed (0.132). Total weight of flakes per fruit recorded high positive and indirect effect via. number of fruits per tree (0.307). Weight of individual flakes with seed registered high positive and indirect effect via. number of fruits per tree (0.314). Weight of individual flakes without seed exhibited moderate positive indirect effect via. number of flakes per fruit (0.267).

Number of fruits per tree exhibited high positive and indirect effect via. number of flakes per fruit (0.720) and fruit weight (0.436), low positive and indirect effects via., fruit length, flake length, weight of individual flakes without seed and total weight of flakes per fruit.

Correlation studies between traits help to select suitable genotypes. Correlation studies revealed that both positive and negative association with varying levels of significance. Genotypic correlation coefficients indicated significant positive association for trunk circumference, fruit length, fruit diameter, fruit weight, fruit rind weight, total weight of flakes per fruit, number of fruits per tree per year with yield per tree. Number of fruits per tree per year exhibited significant

positive correlation with trunk circumference. Davamani (2010) [3] stated that number of fruits at harvest, mean fruit weight, number of leaves at harvest and flesh thickness had positive correlation with yield in papaya.

Fruit weight registered highly significant and positive correlation with fruit rind weight, number of flakes per fruit, total weight of flakes per fruit and number of fruits per tree per year. Fruit rind weight exhibited highly significant and positive correlation with total weight of flakes, flake width and number of fruits per tree per year whereas significant and negative correlation with rind: flakes ratio. Senjam *et al.* (2012) [8] revealed that fruit weight had significant positive correlation with skin thickness, flake length and flake width. Wangchu *et al.* (2013) [10] reported that fruit weight exhibited highly significant positive association with rind weight, rachis length, fruit length and flake length. Similar results were reported by Darjazi (2011) [2] and Gozlekci (2011) [5] in fig fruit. Total weight of flakes per fruit registered highly significant positive correlation with flakes: fruit ratio, rind: flakes ratio and number of fruits per tree per year. Wangchu *et al.* (2013) [10] revealed that weight of flakes per kg of fruit had significant positive correlation with flake length and flake width.

Among the fruit biochemical characters, total soluble solids exhibited significant and positive correlation with total sugar, reducing sugar, non-reducing sugars and yield per tree. Total sugars registered significant positive correlation with reducing sugar, non-reducing sugars and ascorbic acid content. Similar findings were reported by Senjam *et al.* (2012) [8] and Wangchu *et al.* (2013) [10].

As the number of independent variables influence a particular dependent variable which got increased, there is bound to be a certain amount of inter dependence among the independent variables. Due to their mutual association, the development of dependent variables is decided by the degree of direct effect of the independent variables and the indirect effects exerted through other characters arising integrated part of the growth pattern. Path coefficient analysis helps in furnishing the

method for separating out the direct and indirect effects (Bhatt, 1973) [1].

Yield, a complex character is predominantly governed by a large number of genes and is greatly influenced by environmental influence. Therefore, selection based on yield alone is not effective. An improvement in yield can be brought by effecting indirect selection for yield contributing components, whose heritability are high and show a strong association with yield. Path coefficient analysis in the present investigation revealed both direct and indirect association of yield and yield contributing traits.

From the path co-efficient analysis of present study, it was found, that the residual effect was 0.0903 which indicated the adequacy of characters chosen for the study. Among 16 characters, number of fruits per tree, fruit length, flakes; fruit ratio, flake length and fruit weight on yield per tree recorded high direct positive effect. Similar findings were reported by Manikandan (2015) [9].

The effects of fruit weight on yield per tree are mainly through number of fruits per tree per year. Number of fruits per tree exhibited high positive direct effects on yield per tree and fruit weight and number of fruits per tree recorded high positive and direct effect on yield. Fruit length, flake length, flake: fruit ratio and weight of individual without seed registered low positive and direct effect on yield per tree. Fruit rind weight registered high positive and indirect effect on yield per tree via., number of fruits per tree. Wangchu *et al.* (2013) [10] reported that fruit length and flake length were important characters which had maximum direct and indirect effects on fruit yield per tree and it helps in selecting the superior genotypes.

Finally, considering the economic parameters like number of fruits per tree per year and yield per tree and quality parameters like total soluble solids and carotene content, the genotypes namely HRS TKD AH-5, 9, 17, 24, 28, 31, 32 and 33 were found to be promising which needs further observation closely.

Table 1: Genotypic correlation coefficients between yield per tree and component characters in jackfruit genotypes

Traits	TH	TG	Fr.L	Fr.D	Fr.W	SpD	FRW	NFL/F	TWFI/F	WFIS	WFI	Fl:FR	R:FLR	FL.L	FL.W	NFr/T	Y/T
TH	1.000	0.579**	-0.159	0.095	-0.007	-0.160	-0.076	-0.160	0.089	0.299	0.331	0.255	0.216	0.145	-0.045	0.153	0.173
TG		1.000	-0.042	0.122	0.183	0.025	0.096	0.012	0.219	0.286	0.286	0.192	0.206	0.261	0.190	0.309	0.322
FrL			1.000	0.521**	0.578**	-0.071	0.563**	0.394*	0.399*	0.155	0.147	-0.212	-0.127	0.221	0.403*	0.450**	0.581**
FrD				1.000	0.396*	-0.151	0.401*	0.214	0.281	0.345*	0.363*	-0.099	-0.041	0.204	0.039	0.432**	0.455**
Fr.W					1.000	-0.106	0.876**	0.542**	0.827**	0.263	0.286	-0.051	-0.027	0.316	0.312	0.510**	0.781**
SpD						1.000	-0.319	0.147	0.174	-0.100	-0.116	0.396*	0.499**	-0.079	-0.107	0.164	-0.010
FRW							1.000	0.286	0.465**	0.275	0.286	-0.489**	-0.487**	0.314	0.390*	0.446**	0.715**
NFL/F								1.000	0.656**	-0.480**	-0.407*	0.235	0.327	-0.025	-0.018	0.073	0.238
TWFI/F									1.000	0.199	0.244	0.501**	0.514**	0.202	0.090	0.426*	0.611**
WFIS										1.000	0.944**	0.043	-0.035	0.424*	0.263	0.436**	0.421*
WFI											1.000	0.082	-0.003	0.405*	0.299	0.371*	0.380*
Fl:FR												1.000	0.951**	-0.079	-0.319	-0.039	-0.102
R:FLR													1.000	-0.056	-0.285	0.063	-0.037
FL.L														1.000	0.702**	0.413*	0.453**
FL.W															1.000	0.382*	0.403*
NFr/T																1.000	0.909**
Y/T																	1.000

* - Correlation is significant at the 0.05 level (2-tailed) ** - Correlation is significant at the 0.01 level (2-tailed)

TH: Tree height (m), **TG:** Trunk girth (cm), **FrL:** Fruit length (cm), **FrD:** Fruit diameter (cm), **FrW:** Fruit weight (kg), **SpD:** Spine density per 25 cm², **FRW:** Fruit rind weight (kg), **NFL/F:** Number of flakes per fruit, **TWFI/F:** Total weight of flakes per fruit (kg), **WFIS:** Weight of individual flake with seed (g), **WFI:** Weight of individual flake without seed (g), **Fl:FR:** Flakes: fruit ratio, **R:FLR:** Rind: flakes ratio, **FL.L:** Flake length (cm), **FL.W:** Flake width (cm), **NFr/T:** Number of fruits per tree per year and **Y/T:** Yield per tree (kg).

Table 2: Genotypic correlation coefficients between yield per tree and biochemical characters in jackfruit genotypes

Traits	TSS	TS	RS	NRS	TA	AA	CC	PRT	Y/T
TSS	1	0.925**	0.812**	0.886**	0.028	0.315	0.223	0.158	0.340*
TS		1	0.782**	0.984**	0.028	0.342**	0.202	0.159	0.305
RS			1	0.660**	0.148	0.287	0.061	0.188	0.184
NRS				1	-0.007	0.331	0.227	0.138	0.316
TA					1	0.532**	-0.211	-0.194	0.030
AA						1	0.066	-0.078	0.458**
CC							1	0.136	0.243
PRT								1	0.122
Y/T									1

* - Correlation is significant at the 0.05 level (2-tailed)

** - Correlation is significant at the 0.01 level (2-tailed)

TSS	:	Total soluble solids	AA	:	Ascorbic acid content
TS	:	Total sugars	CC	:	Carotene content
RS	:	Reducing sugars	PRT	:	Protein content
NRS	:	Non-reducing sugars	TA	:	Titration acidity
Y/T	:	Yield per tree			

Table 3: Path coefficient analysis showing direct and indirect effects of 16 characters on yield per tree

Traits	TH	TG	Fr.L	Fr.D	Fr.W	SpD	FRW	NFL/F	TWFI/F	WFIS	WFI	FI:FR	R: FIR	FLL	FL.W	NFr/T
TH	0.064	0.039	-0.028	-0.005	-0.006	0.003	0.038	0.031	0.006	-0.082	0.035	0.033	-0.099	0.024	0.009	0.110
TG	0.037	0.067	-0.007	-0.007	0.157	0.000	-0.048	-0.002	0.016	-0.079	0.031	0.025	-0.095	0.043	-0.037	0.223
FrL	-0.010	-0.003	0.174	-0.028	0.494	0.001	-0.284	-0.077	0.028	-0.043	0.016	-0.028	0.058	0.037	-0.079	0.325
FrD	0.006	0.008	0.091	-0.053	0.338	0.002	-0.202	-0.042	0.020	-0.095	0.039	-0.013	0.019	0.034	-0.008	0.311
Fr.W	0.000	0.012	0.101	-0.021	0.855	0.002	-0.442	-0.105	0.059	-0.073	0.031	-0.007	0.012	0.052	-0.061	0.367
SpD	-0.010	0.002	-0.012	0.008	-0.091	-0.016	0.161	-0.029	0.012	0.028	-0.012	0.052	-0.229	-0.013	0.021	0.118
FRW	-0.005	0.006	0.098	-0.021	0.749	0.005	-0.505	-0.056	0.033	-0.076	0.031	-0.064	0.223	0.052	-0.076	0.321
NFL/F	-0.010	0.001	0.069	-0.011	0.463	-0.002	-0.145	-0.194	0.046	0.132	-0.044	0.031	-0.150	-0.004	0.004	0.053
TWFI/F	0.006	0.015	0.069	-0.015	0.707	-0.003	-0.235	-0.127	0.071	-0.055	0.026	0.066	-0.236	0.033	-0.018	0.307
WFIS	0.019	0.019	0.027	-0.018	0.225	0.002	-0.139	0.093	0.014	-0.276	0.101	0.006	0.016	0.070	-0.052	0.314
WFI	0.021	0.019	0.026	-0.019	0.245	0.002	-0.144	0.079	0.017	-0.261	0.107	0.011	0.001	0.067	-0.059	0.267
FI:FR	0.016	0.013	-0.037	0.005	-0.043	-0.006	0.247	-0.046	0.036	-0.012	0.009	0.131	-0.436	-0.013	0.063	-0.028
R:FIR	0.014	0.014	-0.022	0.002	-0.023	-0.008	0.246	-0.064	0.036	0.010	0.000	0.125	-0.458	-0.009	0.056	0.045
FLL	0.009	0.018	0.039	-0.011	0.270	0.001	-0.158	0.005	0.014	-0.117	0.043	-0.01	0.026	0.165	-0.138	0.298
FL.W	-0.003	0.013	0.070	-0.002	0.267	0.002	-0.197	0.004	0.006	-0.073	0.032	-0.042	0.131	0.116	-0.196	0.275
NFr/T	0.010	0.021	0.078	-0.023	0.436	-0.003	-0.225	-0.014	0.030	-0.120	0.040	-0.005	-0.029	0.068	-0.075	0.720

Residual effect: 0.0903 Diagonal values in bold indicate direct effect

TH: Tree height (m), **TG:** Trunk diameter (cm), **FrL:** Fruit length (cm), **FrD:** Fruit diameter (cm), **FrW:** Fruit weight (kg), **SpD:** Spine density per 25 cm², **FRW:** Fruit rind weight (kg), **NFL/F:** Number of flakes per fruit, **TWFI/F:** Total weight of flakes per fruit (kg), **WFIS:** Weight of individual flake with seed (g), **WFI:** Weight of individual flake without seed (g), **FI:FR:** Flakes: fruit ratio, **R:FIR:** Rind: flakes ratio, **FLL:** Flake length (cm), **FL.W:** Flake width (cm) and **NFr/T:** Number of fruits per tree per year

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