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Correlation and path coefficient analysis of fruit yield and quality related traits of custard apple (*Annona squamosa* L.). Indigenous accessions from Northern Bastar of Chhattisgarh

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Abstract
The field experiment was conducted at Research cum Instructional Farm, College of Agriculture & Research Station, Singarbhat, Kanker, Indira Gandhi Krishi Viswavidyalaya, Raipur (Chhattisgarh) during *Kharif* 2013-14. The experiment was laid out in Randomized Block Complete Design with four replication, *in-situ* sixty genotypes of about 10 year age were selected for investigation, which were found as wild seedling plants on forest land and rice bunds in Kanker District- (Chhattisgarh). The treatments comprised of sixty genotypes for with different qualitative character *viz* total soluble solid, total sugar, reducing sugar, non-reducing sugar, titration acetic acid, keeping days, pulp ratio, pulp seed ratio, peel percentage and fruit yield per plant. Correlation coefficient analysis revealed that direct selection for quantitative traits *i.e.*, length of pedicel, number of seeds per fruits, number of fruits per tree, areole weight, pulp weight, fruit yield per plant and qualitative traits *viz.*, reducing sugar, pulp-seed ratio, peel percentage and pulp ratio may lead to the development of high-yielding custard apple genotypes. Peel percentage showed negligible positive direct effect on fruit yield per plant due to low positive indirect effect *via* total sugar, reducing sugar and negligible positive indirect effect *via* keeping days, pulp ratio. The result acidity and non-reducing sugar have negligible negative indirect effect.

Keywords: Correlation, path, custard apple, indigenous accessions, Bastar and Chhattisgarh

Introduction
Custard apple (*Annona squamosa* L.), is an important dry-land fruit crop in India and belongs to family 'Annonaceae' having chromosome number 2n=14. It is also known as *Sitaphal* or *Sharifa* The fruit tree belongs to tropical climate and is native of tropical America and surrounding regions. *Annona* means year's harvest and *squamosa* means scaly referring to the scale like structure of the fruit surface. It is cultivated in Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Chhattisgarh, Karnataka, Bihar, Orissa, Assam and Tamil Nadu. Besides India, it is common in China, Philippines, Egypt and Central Africa. In India, it is presently grown in an area of about 29.87 thousand hectares with a production of 228.37 metric tones and the average productivity is 765 q/ha and it ranges from 673 q/ha in Andhra Pradesh to 685 q/ha in Maharashtra (2014-15). Chhattisgarh and Maharashtra occupies 55.74 per cent of the total area in the country. Whereas Gujarat covered 5.34 thousand hectare and the average productivity is 768 q/ha (Chandra, 2010) [2]. Chhattisgarh, state of India occupies an area of approximately 7.99 thousand hectare with an annual production of 39.73 metric tones having the productivity of 497.25 q/ha under custard apple. In the range of forest scattered across Jagdalpur, Beejapur, Dantewada, Kanker, Dhamtari, Rajnandgaon, Durg, Jashpur, Surguja and Bilaspur districts, only Kanker district is blessed with natural biodiversity of the custard apple. Its wild land races are found distributed all along as a natural stand over an area of about 7.20 thousand hectare with an annual production of 35.60 metric tones having the productivity of 494.45 q/ha (Anonymous, 2013) [1]. The edible portion or pulp is creamy or custard like, granular, with a good blend of sweetness, possessing pleasant flavor and mild aroma have a universal liking, being rich in carbohydrates 23.0 g per 100 g fruits. The fruit is reported to have moisture 70.5 g, protein 1.6 g, fat 0.4 g, minerals 0.9 g, fiber 3.1 g, calcium 17.0 mg, phosphorous 47.1 mg, iron 1.5 mg, thiamine 0.07 mg, riboflavin 0.17 mg, niacin 1.30 mg, Vitamin C 37.0 mg and energy 104 Kcal Gopalan *et al.*, (1987) [5].

The evolution of custard apple through natural and human se lection in diverse elevation zones and under different cropping systems with involvement of honey bees being the carrier of cross pollination has resulted in a wide variety of locally adapted land races. These land races have evolved over years to fit into local cropping patterns and diverse end uses and represent a wide range of patterns of crop diversity. The knowledge of patterns of genetic variation of a crop species in any given region or country is very important for planning future germplasm exploration missions and there after it's efficient utilization in crop improvement programme. Yield is a complex character, influenced by environmental fluctuations. Therefore, direct selection for yield as such will not be reliable and fruitful. Hence, selection criteria based on yield components would be helpful in selection suitable plant types. The knowledge of inter-relationship between yield components and the relative weight age that should be given to different yield components to obtain maximum gain is therefore the most important. Thus constructions of selection indices will be helpful to discriminate desirable genotypes on the basis of their phenotypic performance. Assessment of correlation and path for yield and its components is useful to predict the extent of improvement possible for fruits yield and other important characters.

Materials and methods

An experiment comprised of 60 genotype accessions (Table-1) was conducted at 10 years old *In-situ* plants at Northern Bastar, Research cum Instructional Farm College of Agriculture & Research Station, Singarbhat, Kanker, Indira Gandhi Krishi Viswavidyalaya, Raipur (Chhattisgarh) during *Kharif* 2013-14. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications recommended package of practices were applied to raise the normal crop. Observations were recorded on one randomly selected competitive plants from each genotype, in each replication on 10 qualitative characters *viz*. total soluble solid, total sugar, reducing sugar, non-reducing sugar, titration acetic acid, keeping days, pulp ratio (%), pulp seed ratio, peel percentage and fruit yield per plant (kg). The statistical analysis for Correlation coefficient (r) is the measurement of relationship between two variables. It was estimated by using the formula given by Miller *et al.* (1958) [10] and the genotypic correlation coefficients (r) were further partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by Wright (1921) [13].

Results and discussion

Correlation coefficient analysis

Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variables. Correlation coefficient analysis measures the mutual relationship between various characters and determines the component characters on which selection can be based for genetic improvement. Knowledge about inter-relationship between yield and yield-contributing characters facilitates the choice of efficient breeding method to be adopted. To estimate the association between two characters, correlation coefficient at phenotypic, genotypic and environmental levels were worked out in all possible combinations among yield components.

Correlation analysis clearly revealed that the phenotypic and genotypic correlations in general are similar in direction but the magnitude of genotypic correlation was higher than the phenotypic correlations. The low phenotypic correlation could be attributed to masking influence and modifying effect of the environment on the association of characters. Pandey and Gritton (1975) [11] pointed out no suitable test of significance of genetic correlation is available. Therefore, their primary utility is in strengthening interpretations based on phenotypic correlation and in better predicting correlated responses to selection. Hence, important findings based on phenotypic correlation are discussed here. In the present investigation, correlation coefficients at genotypic and phenotypicl level have been worked out among fruit yield and its components and the data are presented in Table-2.

Genotypic and Phenotypic correlation coefficients

The data on qualitative traits for genotypic and phenotypic correlation coefficient have been given in Table-2. The character total soluble solids exhibited highly significant positive correlation with total sugar, reducing sugar, keeping days, pulp ratio, pulp-seed ratio, peel % and fruit yield per plant with both the genotypic and phenotypic level, while highly significant negative correlation was found with acidity at both the phenotypic and genotypic level. Total sugar is showed highly significant positive correlation with reducing sugar, keeping days, pulp ratio, pulp-seed ratio, peel % and fruit yield per plant with both the phenotypic and genotypic level, while highly significant negative correlation with acidity was observed at both the phenotypic and genotypic level. Reducing sugar recorded highly significant positive correlation with keeping days, pulp ratio, pulp-seed ratio, peel % and fruit yield per plant at both the phenotypic and genotypic level, while highly significant negative correlation was seen with non-reducing sugar and acidity at both the phenotypic and genotypic level. Non-reducing sugar recorded highly significant negative correlation with keeping days, pulp ratio, pulp-seed ratio and peel % at both the phenotypic and genotypic level and the character acidity registered highly significant negative correlation with keeping days, pulp ratio, pulp-seed ratio, peel % and fruit yield per plant at both the phenotypic and genotypic level. Highly significant positive correlation of keeping days with pulp ratio, pulp- seed ratio, peel % and fruit yield per plant was exhibited at both the phenotypic and genotypic level and the character pulp ratio had also shown highly significant positive correlation with pulp-seed ratio, peel % and fruit yield per plant at both the phenotypic and genotypic level. The character pulp-seed ratio found highly significant positive correlation with peel % and fruit yield per plant at both the phenotypic and genotypic level and the character peel percentage was found highly significant positive correlation with fruit yield per plant at both the phenotypic and genotypic level.

An overall observation of correlation coefficient analysis revealed that direct selection for quantitative traits *i.e.*, length of pedicel, number of seeds per fruits, number of fruits per tree, areole weight, pulp weight, fruit yield per plant and qualitative traits *viz.*, reducing sugar, pulp-seed ratio, peel percentage and pulp ratio may lead to the development of high-yielding custard apple genotypes. The experimental findings on correlation coefficient analysis are in general agreement with the earlier reporter of Deshmukh *et al.* (2001) [3], Joshi *et al*. (2003) [6], Lima *et al.* (2004) [8], Paulo *et al*. (2009) [12], Mariguele and Silva (2010) [9] and Keny *et al.* (2010) [7].

Path coefficient analysis

Path coefficient analysis measures the direct and indirect contribution of various independent characters on a dependent character. Path coefficient analysis given by Dewey and Lu

(1959) [4] has been used to estimate the magnitude and direction of direct and indirect effects of various yield-contributing characters. Correlation coefficients along with path coefficients together provide more reliable information which can be effectively predicted in crop improvement programme. If the correlation between yield and a character is due to direct effect of a character, it reveals true relationship between them and direct selection for this trait will be rewarding for yield improvement. However, if the correlation coefficient is mainly due to indirect effects of the character through another component trait, indirect selection through such trait will be effective for yield improvement. Genotypic correlation coefficients of various yield attributing characters for fruit yield per plant were further partitioned into direct and indirect effects. The data on quantitative and qualitative traits for genotypic path have been given in Table-3.

Path coefficients showing direct and indirect effects

The direct and indirect effects of different qualitative traits on fruit yield per plant are presented in table-3. Path coefficient analysis of different qualitative traits contributing towards fruit yield per plant revealed that reducing sugar had highest positive direct effect (0.742) relationship with fruit yield per plant followed by pulp- seed ratio (0.556), peel percentage (0.082) and non-reducing sugar (0.067). The quality character, total soluble solid showed low negative direct effect on fruit yield per plant due to low positive indirect effect *via* acidity, non-reducing sugar and low negative indirect effect *via* pulp ratio, peel percentage, reducing sugar, pulp- seed ratio, total sugar and keeping days. Total sugar had shown high negative direct effect on fruit yield per plant due to high positive indirect effect *via* acidity and low positive indirect effect *via* non-reducing sugar. Such results also due to the high negative indirect effect *via* pulp ratio peel percentage, reducing sugar, pulp-seed ratio, keeping days and total soluble solid. Reducing sugar showed high positive direct effect on fruit yield per plant due to high positive indirect effect *via* peel percentage, pulp ratio, total sugar, pulp-seed ratio, total soluble solid, keeping days and high negative indirect effect *via* acidity and low negative indirect effect *via* non-reducing sugar. Non-reducing sugar had shown negligible positive direct effect on fruit yield per plant due to negligible positive indirect effect *via* acidity and negligible negative indirect effect *via* pulp ratio, peel percentage, keeping days and reducing sugar. Acidity showed moderately negative direct effect on fruit yield per plant due to moderate positive indirect effect *via* pulp ratio, peel percentage, total soluble solid and low positive indirect effect *via* reducing sugar, total sugar, pulp-seed ratio, keeping days. Keeping days had shown negligible negative direct effect on fruit yield per plant due to negligible positive indirect effect *via* acidity and negligible negative indirect effect *via* pulp ratio, peel percentage, total sugar, reducing sugar, pulp-seed ratio and total soluble solids. Pulp ratio had shown negligible negative direct effect on fruit yield per plant due to negligible positive indirect effect *via* acidity, non-reducing sugar and negligible negative indirect effect *via* total soluble solid, reducing sugar, total sugar, pulp-seed ratio and keeping days. Pulp-seed ratio showed high positive direct effect on fruit yield per plant due to high positive indirect effect *via* pulp ratio, peel percentage, reducing sugar, total soluble solid, total sugar, keeping days and high negative indirect effect *via* acidity. Peel percentage showed negligible positive direct effect on fruit yield per plant due to low positive indirect effect *via* total sugar, reducing sugar and negligible positive indirect effect *via* keeping days, pulp ratio.

The result acidity and non-reducing sugar have negligible negative indirect effect. Hence, direct selection for these traits could be practiced for developing high- yielding custard apple genotypes. The present findings are in general agreement with the report of Deshmukh *et al.* (2001) [3], Joshi *et al*. (2003) [6], Lima *et al.* (2004) [8], Mariguele and Silva (2010) [9], Paulo *et al*. (2009) [12] and Keny *et al.* (2010) [7].

Table 1: The list of experimental material used for correlation and path analysis in custard apple

S. No.	Name of Genotypes	S. No.	Name of Genotypes
1.	IGCA-1	31.	IGCA-31
2.	IGCA-2	32.	IGCA-32
3.	IGCA-3	33.	IGCA-33
4.	IGCA-4	34.	IGCA-34
5.	IGCA-5	35.	IGCA-35
6.	IGCA-6	36.	IGCA-36
7.	IGCA-7	37.	IGCA-37
8.	IGCA-8	38.	IGCA-38
9.	IGCA-9	39.	IGCA-39
10.	IGCA-10	40.	IGCA-40
11.	IGCA-11	41.	IGCA-41
12.	IGCA-12	42.	IGCA-42
13.	IGCA-13	43.	IGCA-43
14.	IGCA-14	44.	IGCA-44
15.	IGCA-15	45.	IGCA-45
16.	IGCA-16	46.	IGCA-46
17.	IGCA-17	47.	IGCA-47
18.	IGCA-18	48.	IGCA-48
19.	IGCA-19	49.	IGCA-49
20.	IGCA-20	50.	IGCA-50
21.	IGCA-21	51.	IGCA-51
22.	IGCA-22	52.	IGCA-52
23.	IGCA-23	53.	IGCA-53
24.	IGCA-24	54.	IGCA-54
25.	IGCA-25	55.	IGCA-55
26.	IGCA-26	56.	IGCA-56

27.	IGCA-27	57.	IGCA-57
28.	IGCA-28	58.	IGCA-58
29.	IGCA-29	59.	IGCA-59
30.	IGCA-30	60.	IGCA-60

Table 2: Genotypic and Phenotypic correlation coefficients for qualitative traits of fruit yield and its components in custard apple during the year 2013-14 and 2014-15

S. No.	Characters		Total Soluble Solids	Total Sugar	Reducing Sugar	Non-reducing Sugar	Acidity	Keeping Days (Shelf Life)	Pulp Ratio	Pulp-Seed Ratio	Peel Percentage	Fruit Yield Per Plant
1.	Total Soluble Solids	G	1.000	0.821**	0.867**	-0.153*	-0.859**	0.759**	0.997	0.865**	0.998**	0.836**
		P	1.000	0.633**	0.684**	-0.120	-0.615**	0.548**	0.291**	0.659**	0.3174**	0.638**
2.	Total Sugar	G		1.000	0.970**	-0.139*	-0.819**	0.829**	0.991	0.863**	0.995**	0.866**
		P		1.000	0.919**	-0.128*	-0.697**	0.715**	0.356**	0.810**	0.393**	0.775**
3.	Reducing Sugar	G			1.000	-0.225**	-0.824**	0.857**	0.996	0.928**	0.959**	0.919**
		P			1.000	-0.212**	-0.697**	0.699**	0.361**	0.854**	0.372**	0.797**
4.	Non-reducing Sugar	G				1.000	0.037	-0.274**	-0.605	-0.154*	-0.593**	-0.130*
		P				1.000	0.030	-0.239**	-0.194**	-0.151*	-0.212**	-0.126
5.	Acidity	G					1.000	-0.812**	-0.991	-0.816**	-0.910**	-0.834**
		P					1.000	-0.672**	-0.342**	-0.732**	-0.329**	-0.728**
6.	Keeping Days (Shelf Life)	G						1.000	0.994	0.831**	0.998**	0.818**
		P						1.000	0.362**	0.738**	0.341**	0.718**
7.	Pulp Ratio	G							1.000	0.998**	0.989**	0.998**
		P							1.000	0.457**	0.668**	0.394**
8.	Pulp-Seed Ratio	G								1.000	0.978**	0.941**
		P								1.000	0.342**	0.889**
9.	Peel Percentage	G									1.000	0.944**
		P									1.000	0.325**
10.	Fruit Yield Per Plant	G										1.000
		P										1.000

Table 3: Genotypic path coefficients for qualitative traits of fruit yield and its components in custard apple during the year 2013-14 and 2014-15

S. No	Characters	Total Soluble Solids	Total Sugar	Reducing Sugar	Non-reducing Sugar	Acidity	Keeping Days	Pulp Ratio	Pulp-Seed Ratio	Peel Percentage	Correlation with Fruit yield/ plant (r)
1.	Total Soluble Solids	-0.116	-0.096	-0.101	0.018	0.101	-0.088	-0.181	-0.101	-0.125	0.836**
2.	Total Sugar	-0.379	-0.462	-0.448	0.065	0.378	-0.383	-0.643	-0.399	-0.626	0.866**
3.	Reducing Sugar	0.643	0.719	0.742	-0.167	-0.612	0.636	0.869	0.688	0.967	0.919**
4.	Non-reducing Sugar	-0.010	-0.009	-0.015	0.067	0.003	-0.019	-0.041	-0.010	-0.039	-0.130*
5.	Acidity	0.208	0.198	0.199	-0.008	-0.242	0.196	0.279	0.197	0.220	-0.834**
6.	Keeping Days	-0.026	-0.029	-0.029	0.009	0.028	-0.035	-0.042	-0.029	-0.038	0.818**
7.	Pulp Ratio	-0.052	-0.046	-0.051	0.020	0.039	-0.041	-0.033	-0.042	-0.039	0.998**
8.	Pulp-Seed Ratio	0.481	0.479	0.515	-0.085	-0.453	0.461	0.691	0.556	0.543	0.941**
9.	Peel Percentage	0.089	0.111	0.107	-0.048	-0.075	0.099	0.097	0.080	0.082	0.944**

Genotypic path Coefficients Residual effect = 0.4361; Direct effects on main diagonal (bold figures)

Conclusions

Correlation for qualitative traits on character total soluble solid exhibited highly significant positive correlation with total sugar, reducing sugar, keeping days, pulp ratio, pulp-seed ratio, peel % and fruit yield per plant at both the phenotypic and genotypic level. Path coefficients showing direct and indirect effects of different qualitative traits on fruit yield the direct and indirect effects of different qualitative traits on fruit yield per plant. Path coefficient analysis of different qualitative traits contributing towards fruit yield per plant revealed that reducing sugar had highest positive direct effect relationship with fruit yield per plant followed by pulp-seed ratio, peel percentage and non-reducing sugar. Varieties from geographically diverse localities are generally included in hybridization programmes presuming genetic diversity. The problem of selection may further be simplified if one could identify the characters responsible for discrimination between parents.

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References

1. Anonymous. Indian Horticulture Database. National Horticulture Board, India 2013, 6-14.
2. Chandra A. Participatory approaches in precision farming. In: Souvenir of National Seminar on Precision Farming in Horticulture, College of Horticulture and Forestry, Jhalawar 2010, 650-657.
3. Deshmukh PR, Wakle PK, Kapse PS, Londhe GK, Wangikar SD. Correlates of adoption of custard apple technology. J Soils and Crops 2001;11(2):210-211.
4. Dewey DR, Lu KHA. Correlation and path coefficient analysis of component in crested wheat grass seed production. Agron. J 1959;51:515-518.
5. Gopalan Rama C, Shastri BV, Balasubramanin SC. Nutritive value of Indian Foods. NIN, ICMR, Hyderabad, 1987, 93.
6. Joshi PS, Bhalerao PS, Jahagirdar SW, Mahorkar VK, Patil BR. Correlation studies in propagation of custard apple (*Annona squamosa* L.). Annals of Plant Physiology 2003;13(2): 175-177.

7. Keny HM, Paulo SLeS. Relationship between fruit traits of custard apple trees (*Annona squamosa* L.). Revists Ceres 2010;57(4):231-233.
8. Lima e Silva PS, Barbin D, Goncalves RJdeS, Firmino JDdaC, Fonseca IC. Leaf area estimates of custard apple tree progenies. Revista Brasileira de Fruticultura, 2004;26(3):558-560.
9. Mariguele KH, Fonseca e Silva. Methods of longitudinal data analysis for the genetic improvement of sugar apple. Pesquisa Agropecuaria Brasileira 2010a;46(12):1657-1664.
10. Miller PA, Williams JE, Robinson HF, Comstock RE. Estimates of variance and co-variance in upland cotton and their implications in selection. Agron J 1958;50:126-131.
11. Pandey S, Gritton ET. Genotypic and Phenotypic variances and correlation in pea. Crop Science 1975;15:353-356.
12. Paulo S, Lima eS, Rafaela PA, Keny HM, Kathia MBeS, Lidiane KdeL, Julio Cdo VS. Estimates of genetic parameters for fruit yield and quality in custard apple progenies. Revista. Brasileira de Fruticultura 2009;29(3):155-159.
13. Wright S. Correlation of causation. J Agric. Res 1921;2(20):257-287.