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Research Article

Genetic variability and correlation for nut and yield characters in arecanut (*Areca catechu* L.) germplasm

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Abstract
A study on genetic variability and correlation for nut and yield characters was carried out among 25 arecanut accessions of diverse geographic origins. High GCV and PCV values were observed for the number of female flowers/inflorescence/palm/year, the number of nut/inflorescence, the number of nuts/palm/year, dry weight of husk, fresh fruit weight, dry weight of nut, dry weight of kernel and fresh nut yield. High estimates of heritability coupled with high genetic advance as per cent mean (GAM) were observed for stem girth above the fixed mark, the number of female flowers/inflorescence/palm/year, fruit length, fruit breadth, fresh fruit weight, kernel length, kernel breadth, dry weight of nuts, dry weight of kernel, fresh nut yield, dry kernel yield and kernel recovery indicating amenability for phenotypic selection of these characters in early generations. The observations revealed that the palm height, kernel breadth and dry weight of kernel can be considered for improvement of arecanut as these characters had high positive direct effects on the dry weight of kernel.

Key words: Genetic variability, Arecanut, Heritability, Genetic advance, Germplasm.

INTRODUCTION

Arecanut (*Areca catechu* L.) is one of the important plantation crops grown extensively in Southeast Asian countries. It belongs to the family Arecaceae with the chromosome number of 2n = 32. The palm is widely distributed from East Africa, Tropical Asia and Indonesia to the Central Pacific Island (Ananda *et al.*, 2004). Arecanut is commercially cultivated in India, Bangladesh, Sri Lanka and China mainly for its masticatory nuts popularly known as betelnut or supari and for its medicinal properties (Norton, 1997). It has cultural and traditional prominence in the Indian subcontinent. Genetic variability is a prerequisite for the meaningful selection of germplasm. Genetic parameters like heritability coupled with genetic advance over per cent of mean largely determine the success of selection. Hence, the basic information on genetic parameters is essential in formulating appropriate selection approaches in arecanut breeding programme (Ananda and Rajesh, 2004).

Yield is a complex character dependent on several attributes. Before initiating an effective selection programme, it is necessary to know the importance and association of various components for yield traits. A simple correlation measure of characters does not quantify the relative contribution of causal factors to the ultimate yield. Since component traits themselves are inter-dependent, often affect their direct relationship with yield and consequently restrict the reliability of selection indices based upon correlation coefficients. The correlation coefficient becomes more evident when genotypic correlations are partitioned into direct and indirect effects of various attributes contributing to correlation. Path coefficient provides an effective means of entangling direct and indirect causes of association and measures the relative importance of each causal factor. Partitioning of total correlation into direct and indirect effects would be worthwhile for an effective selection program. Therefore, the present study was attempted to assess the nature of genetic variation for various morphological characteristics and the association of different yield components on yield in arecanut germplasm.

MATERIALS AND METHODS

A total of 25 indigenous accessions were collected from different states, conserved and maintained by following recommended package of practice in the germplasm bank at ICAR- Central Plantation Crops Research Institute, Regional Station, Vittal formed the experimental material for the study. These accessions were evaluated in a randomized block design with two replications, each having two palms.

The quantitative observations were recorded on plant height, crown length, stem girth above one meter fixed mark, internodal length, the number of leaves per palm, the number of leaflets (left side of the midrib), the number of leaflets (right side of the midrib), the number of midribs (left), the number of midribs (right), leaf length, leaf breadth, length of the leaf sheath, breadth of the leaf sheath, the number of bunches produced per palm per year, the number of female flowers per inflorescence per palm per year, the number of nuts per inflorescence, the number of nuts per palm per year, fruit set (%), fruit length, fruit breadth, fresh fruit weight, husk thickness. The mean data were subjected to standard statistical analysis to work out variance, phenotypic and genotypic coefficient of variation, heritability (Hanson *et al*., 1956), genetic advance (Johnson *et al*., 1955), correlation (Al-Jibouri *et al.,* 1958) and path coefficient analysis was done according to the method of Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance showed significant differences for various traits among the germplasm studied indicate the existence of genetic variability. The magnitude of the phenotypic coefficient of variation (PCV) was found slightly higher than the genotypic coefficient of variations (GCV) for all the characters under study which might be the result of the influence of the environment on the development of characters over time (**Table 1**). A high estimate of GCV was observed for dry weight of husk (39.21%) followed by the number of female flowers per inflorescence per palm per year (32.48%), the number of nuts per palm per year (29.53%), dry weight of nuts (28.03%), dry weight of kernel (25.59%), the number of nuts per inflorescence (25.54%), fresh fruit weight (22.39%) and fresh nut yield (21.76%). High PCV was observed for inter nodal length (21.26 %) and moderate PCV was noticed for the rest of the characters. Moderate GCV was observed for all the characters except for the number of leaves per palm (8.30%) and direct selection for these characters will be effective. The results are in accordance with the findings of Rajesh (2007) in arecanut and Natarajan *et al.* (2010) Talukder *et al.* (2011) and Suchithra and Paramaguru (2018) in coconut.

The effectiveness of selection for any character depends not only on the amount of phenotypic and genotypic variability but also on estimates of broad sense heritability (h^2). High heritability was observed for dry weight of nuts (96.80%), dry weight of husk (96.50 %), dry weight of kernel (95.30 %), fresh fruit weight (95.00%), fruit breadth (92.90 %), kernel length (92.60 %), fruit length (91.70 %), fresh nut yield (89.50%), husk thickness (89.20 %), kernel breadth (86.40 %), dry kernel yield (85.60%), kernel recovery (%) (75.60%) stem girth above fixed mark (74.40 %), total chlorophyll (70.40 %), the number of midribs (R) (68.90 %), leaf sheath length (66.10 %) and the number of female flowers per inflorescence per palm per year (64.70 %) (**Table 2**) which indicates the prevalence of additive gene action and lesser influence of environment in the expression of these traits. Hence, these characters are amenable for selection. Similar results were observed by Rajesh (2007), Archana (2017) and Ananda *et al.* (2000). Very often, heritability in a broad sense is not the true indicator of the inheritance of traits. Since the only additive component of genetic variance is efficiently transferred from generation to generation. Therefore, heritability in a broad sense may mislead in judging the effectiveness of selection for the trait. High heritability coupled with high genetic advance indicates the prevalence of additive gene effects and hence, selection would be effective for such traits. From the present investigation characters *viz., the* number of midribs (R) and total chlorophyll exhibited high heritability coupled with a low genetic advance which represents non-additive gene action hence these traits can be selected for hybridization programme.

The high estimates of heritability coupled with high values of genetic advance as per cent mean (GAM) were observed for stem girth above the fixed mark, leaf sheath breadth, the number of female flowers per inflorescence per palm per year, fruit length, fruit breadth, fresh fruit weight, husk thickness, kernel length, kernel breadth, dry weight of nuts, dry weight of kernel, dry weight of husk, fresh nut yield, dry kernel yield, kernel recovery (%) (**Table 1**). This indicates the predominance of additive gene action and amenability for phenotypic selection in early generations for improving the yield potential in arecanut varieties. The results are in accordance with the findings of Ananda *et al.* (2000) and Archana (2017). Rajesh (2007) suggested that the higher heritability

Table 1. Estimation of mean, range, genetic components, heritability and genetic advance for different parameters in arecanut

Characters	Mean ± SE	Range		Variance		Coefficient of variation (%)		h^2 (%)	GA	GAM (%)
		Min.	Max.	σ^2g	σ^2p	GCV	PCV			
Plant height (m)	11.80 ± 0.79	8.44	14.45	1.79	3.02	11.33	14.73	59.20	2.12	17.95
Crown length (m)	2.75 ± 0.24	1.99	3.86	0.17	0.29	15.13	19.57	59.80	0.67	24.09
Stem girth above fixed mark(cm)	40.68 ± 2.43	31.08	61.25	34.09	45.85	14.35	16.64	74.40	10.37	25.49
Inter nodal length (cm)	17.55 ± 1.71	11.88	24.00	8.10	13.93	16.21	21.26	58.10	4.47	25.46
Number of leaves per palm	9.73 ± 0.74	7.00	11.25	0.65	1.73	8.30	13.53	37.60	1.02	10.49
Number of leaflets L	39.05 ± 3.3	27.00	51.25	17.38	39.15	10.68	16.02	44.40	5.72	14.65
Number of leaflets R	38.89 ± 2.86	28.75	53.50	18.77	35.11	11.14	15.24	53.50	6.53	16.78
Number of midribs L	68.38 ± 3.99	53.00	77.25	23.86	55.65	7.14	10.91	42.90	6.59	9.64
Number of midribs R	70.77 ± 3.41	57.75	94.50	51.44	74.69	10.14	12.21	68.90	12.26	17.33
Leaf length (cm)	182.49 ± 13.73	145.3	221.10	236.68	613.78	8.43	13.58	38.60	19.68	10.78
Leaf breadth (cm)	106.42 ± 5.93	79.90	123.50	74.83	145.22	8.13	11.32	51.50	12.79	12.02
Leaf sheath length (cm)	85.23 ± 5.18	60.13	114.80	104.53	158.10	12.00	14.75	66.10	17.13	20.09
Leaf sheath breadth (cm)	44.76 ± 4.39	31.45	54.95	21.41	60.02	10.34	17.31	35.70	5.69	12.72
Number of bunches produced/ palm / year	3.35 ± 0.45	2.25	4.75	0.23	0.64	14.43	23.90	36.50	0.60	17.95
Number of female flowers / inflorescence / palm / years	105.52 ± 17.92	59.25	198.75	1175.03	1817.26	32.48	40.40	64.70	56.78	53.81
Number of nuts per inflorescence	63.96 ± 10.38	29.25	109.25	266.83	482.39	25.54	34.34	55.30	25.03	39.13
Number of nuts / palm / year	154.54 ± 33.95	61.00	288.00	2083.21	4388.43	29.53	42.87	47.50	64.78	41.92
Fruit set (%)	62.30 ± 6.26	30.69	78.30	88.67	167.02	15.11	20.74	53.10	14.13	22.68
Fruit length (cm)	5.02 ± 0.18	2.37	7.03	0.71	0.77	16.71	17.45	91.70	1.66	32.96
Fruit breadth (cm)	3.92 ± 0.14	2.01	5.57	0.53	0.57	18.48	19.18	92.90	1.44	36.69
Fresh fruit weight (g)	33.46 ± 1.22	15.61	48.40	56.15	59.11	22.39	22.98	95.00	15.05	44.96
Husk thickness (cm)	0.47 ± 0.02	0.27	0.67	0.01	0.01	18.70	19.79	89.20	0.17	36.39
Kernel length (cm)	2.21 ± 0.08	1.21	2.98	0.16	0.17	18.00	18.71	92.60	0.79	35.69
Kernel breadth (cm)	2.39 ± 0.09	1.35	2.93	0.09	0.11	12.82	13.79	86.40	0.59	24.56
Dry weight of nuts (g)	14.49 ± 0.53	8.43	26.91	16.52	17.07	28.03	28.50	96.80	8.24	56.81
Dry weight of kernel (g)	8.35 ± 0.34	4.49	15.52	4.57	4.80	25.59	26.22	95.30	4.30	51.45
Dry weight of husk (g)	6.18 ± 0.21	3.40	12.31	5.88	6.09	39.21	39.91	96.50	4.91	79.35
Fresh nut yield (kg / palm / year)	10.08 ± 0.53	5.31	13.80	4.81	5.38	21.76	23.00	89.50	4.28	42.39
Dry kernel yield (kg / palm / year)	2.31 ± 0.13	1.20	2.94	0.21	0.24	19.81	21.40	85.60	0.87	37.76
Kernel recovery (%)	23.23 ± 1.08	19.00	31.81	7.25	9.59	11.59	13.33	75.60	4.83	20.77
Total chlorophyll (mg / g)	2.01 ± 0.08	1.58	2.36	0.03	0.05	9.12	10.87	70.40	0.32	15.75

GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, h^2: Heritability in a broad sense, σ^2g: Genetic variance, σ^2p: Phenotypic variance, GA: Genetic advance, GAM: Genetic advance as per cent of mean, SE=Standard Error estimates of the characters indicate a higher degree of inheritance of the characters and selection based on these characters would be rewarding in the breeding programme for improvement of yield.

Prevalence of high degree of additive components of genetic variance, high heritability coupled with high genetic advance as per cent mean, high GCV and PCV for the number of female flowers per inflorescence per palm per year, the number of nuts per inflorescence, fresh fruit weight, dry weight of nuts, dry weight of kernel, dry weight of husk and fresh nut yield indicated the lesser influence of environment in expression of these traits and prevalence of additive gene action in their inheritance. Hence, these traits are amenable to selection for genetic improvement.

The correlation coefficient is a measure of the relationship established for specific characters and aids in determining the most effective breeding method to choose superior genotypes based on the most desirable characters (Wright, 1921). Further, many of these yield contributing characters interact in a desirable and direction. Hence, knowledge regarding the association of various characters is necessary for making an indirect selection for the improvement of economic characters. In the present investigation, the genotypic and phenotypic correlations of different biometrical traits with the production of dry kernel yield per palm were computed.

A narrow difference between genotypic and phenotypic correlation coefficients was observed for various traits indicates the influence of the environment in the expression of these traits. Higher genotypic correlation coefficients than the phenotypic correlation coefficients indicate low environmental effects on the expression of association between the traits **(Table 2 and 3).** In the present study, dry kernel yield was significantly and positively correlated with plant height, husk thickness, kernel breadth and dry weight of kernel at both phenotypic and genotypic level (Archana, 2017) and Rajesh (2007) for per cent nut set, the number of female flowers per inflorescence and the number of female flowers per inflorescence. Since these associated characters were in the desirable direction, it indicated that simultaneous selection for these characters would be rewarding in improving the dry kernel yield.

Positive genotypic and phenotypic correlation for dry kernel yield was observed with crown length, the number of leaves per palm, the number of nuts per inflorescence, the number of nuts per palm per year, fruit set, kernel length and dry weight of nut (**Table 2 and 3**). Talukder *et al.* (2011) observed that nut weight showed a positive and significant correlation with husk weight, the volume of water, shell weight, kernel weight and kernel thickness in coconut.

The plant height exhibited a significant and positive correlation with the number of nuts per inflorescence,

Table 2. Phenotypic correlation coefficients among yield and fifteen yield components in arecanut accessions

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
X_1	**1.00**	0.18	-0.13	0.22	-0.06	0.04	-0.14	-0.06	-0.09	-0.16	-0.23	0.09	0.04	-0.12	0.28	0.35*
X_2		**1.00**	0.23	0.23	0.44**	0.24	-0.06	0.33*	0.06	0.32*	0.04	0.01	0.41**	0.31*	-0.18	0.13
X_3			**1.00**	0.18	0.19	0.09	0.08	0.22	-0.16	0.01	-0.07	-0.22	0.32*	0.17	-0.11	-0.24
X_4				**1.00**	0.26	0.24	0.33*	0.25	-0.08	0.23	0.22	0.10	0.38**	0.32*	-0.02	0.08
X_5					**1.00**	0.33*	0.13	0.20	-0.08	0.05	-0.07	-0.19	0.16	0.05	-0.15	-0.12
X_6						**1.00**	0.01	0.05	-0.11	0.08	-0.02	-0.21	0.05	-0.04	0.07	-0.28*
X_7							**1.00**	0.53**	0.21	0.16	0.27	0.32*	0.05	0.15	-0.01	0.03
X_8								**1.00**	0.33*	0.14	0.27	0.18	0.28*	0.40**	0.37**	0.19
X_9									**1.00**	0.19	0.19	0.21	0.01	0.08	-0.05	0.01
X_{10}										**1.00**	0.67**	0.65**	0.66**	0.72**	-0.05	0.31*
X_{11}											**1.00**	0.68**	0.67**	0.73**	-0.07	0.14
X_{12}												**1.00**	0.53**	0.64**	0.16	0.49**
X_{13}													**1.00**	0.86**	-0.12	0.26
X_{14}														**1.00**	-0.13	0.38**
X_{15}															**1.00**	0.08

*Significant at 5% level **Significant at 1% level

X_1=Plant height , X_2=Crown length , X_3=Inter nodal length , X_4=Number of leaves per palm, X_5=Leaf length , X_6=Leaf breadth , X_7=Number of nuts per inflorescence, X_8=Number of nuts/ palm/year, X_9=Fruit setting percentage, X_{10}=Husk thickness , X_{11}=Kernel length , X_{12}= Kernel breadth , X_{13}=Dry weight of nut , X_{14}= Dry weight of kernel, X_{15}=Kernel recovery , X_{16}=Dry kernel yield

Table 3. Genotypic correlation coefficients among yield and fifteen yield components in arecanut accessions

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
X_1	**1.00**	-0.04	-0.42**	0.12	-0.01	-0.13	-0.48**	-0.44**	0.01	-0.31*	-0.34*	0.09	0.08	-0.17	0.30*	0.44**
X_2		**1.00**	0.19	0.22	0.75**	0.26	-0.26	0.30	0.02	0.40**	0.02	0.07	0.55**	0.39**	-0.41**	0.12
X_3			**1.00**	0.25	0.50**	-0.07	0.00	0.17	-0.43**	-0.09	-0.03	-0.31*	0.43**	0.21	-0.14	-0.34*
X_4				**1.00**	0.23	0.17	0.39**	0.29*	-0.02	0.41**	0.45**	0.31*	0.67**	0.54**	-0.07	0.12
X_5					**1.00**	0.17	-0.21	-0.02	-0.37**	0.12	-0.06	-0.25	0.24	0.11	-0.08	-0.27
X_6						**1.00**	-0.13	-0.22	-0.15	0.01	-0.06	-0.32*	0.05	-0.11	0.18	-0.50**
X_7							**1.00**	0.37**	0.09	0.19	0.39**	0.48**	0.08	0.24	0.15	0.13
X_8								**1.00**	0.20	0.23	0.40**	0.27*	0.41**	0.61**	0.53**	0.13
X_9									**1.00**	0.35*	0.28*	0.33*	0.02	0.13	0.05	0.02
X_{10}										**1.00**	0.69**	0.66**	0.69**	0.74**	-0.10	0.35*
X_{11}											**1.00**	0.70**	0.70**	0.76**	-0.14	0.11
X_{12}												**1.00**	0.56**	0.68**	0.22	0.58**
X_{13}													**1.00**	0.89**	-0.16	0.28*
X_{14}														**1.00**	-0.19	0.42**
X_{15}															**1.00**	0.02

*Significant at 5% level   **Significant at 1% level

X_1=Plant height , X_2=Crown length , X_3=Inter nodal length , X_4=Number of leaves per palm, X_5=Leaf length , X_6=Leaf breadth , X_7=Number of nuts per inflorescence, X_8=Number of nuts/ palm/year, X_9=Fruit setting percentage, X_{10}=Husk thickness , X_{11}=Kernel length , X_{12}= Kernel breadth , X_{13}=Dry weight of nut , X_{14}= Dry weight of kernel, X_{15}=Kernel recovery , X_{16}=Dry kernel yield

the number of nuts per palm per year, kernel length and kernel recovery at the genotypic level only. The chali yield performance of the palm mainly depends on the number of nuts per palm and fruit characters. The characters such as kernel breadth, dry weight of nuts and dry weight of kernel exhibited significant positive association at both genotypic and phenotypic levels with dry kernel yield indicating their influence on yield performance of arecanut accessions. Plant height, length of leaf, the number of leaflets (left), whole nut weight, kernel weight and kernel thickness showed positive and non-significant association with nut yield per palm (Suchithra and Paramgaru, 2018; Ananda and Rajesh, 2004; Ananda *et al.,* 2004).

The fruit set showed a positive correlation with crown length, the number of nuts per inflorescence and the number of nuts per palm per year at both genotypic and phenotypic levels. Hence, selection for this trait would be beneficial. Husk thickness showed a significant positive correlation at both genotypic and phenotypic levels with kernel length, kernel breadth, dry weight of nuts and dry weight of kernel since fruits with higher length and breadth would have thick husk and produce large-sized kernels but the husk thickness was negatively correlated with kernel recovery.

Kernel breadth showed a significant and positive association with the number of nuts per inflorescence, husk thickness at kernel length both phenotypic and genotypic level but it was non-significantly and positively correlated with dry kernel yield. A dry weight of nuts was significantly and positively associated with crown length, internodal length, the number of leaves per palm, the number of nuts per palm per year, husk thickness, kernel length and kernel breadth both at the phenotypic and genotypic level (**Table 2 and 3**). These results are in agreement with Rajesh (2007) for individual nut weight with the number of nuts and concluded that the promising accessions produce more nuts with moderate to high nut weight. This indicated that in arecanut production of nuts is not affected due to the individual nut weight and *vice versa*.

The dry weight of kernel was positively and significantly correlated with crown length, the number of leaves per palm, the number of nuts per palm per year, kernel length and kernel breadth which is mainly due to an increase in crown length would accommodate a greater number of leaves which in response produce high quantities of photosynthates. So, there would be an increase in the number of nuts produced along with the profound increase in kernel size which positively contributes to the increase in dry weight of kernel and also the trait had a significant and positive correlation with a dry weight of nuts and husk thickness both at the phenotypic and genotypic level. The results were confirmed with the findings of Rajesh (2007). Highly significant positive correlations were observed among whole nut weight, dehusked nut weight and copra weight by Natarajan *et al.* (2010). In arecanut, plant height, husk thickness, kernel breadth and dry weight of kernel are important characters to be accounted for gaining improvement in yield per palm. Since these characters had a high direct association on dry kernel yield at the phenotypic and genotypic levels.

Correlation being the result of a cause-and-effect relationship existing between different characters may not always provide complete information. They simply represent the overall influence of a particular trait on yield rather than providing a cause and effect relationship. The technique of path analysis facilitates partitioning the correlation coefficients into the direct and indirect contributions of various characters to the yield. Path analysis also measures the relative importance of causal factors involved. In the present study, path analysis was performed at both phenotypic and genotypic levels for dry kernel yield (**Table 4 and 5**).

The direct effects *via* plant height, leaf length, the number of nuts per palm per year, fruit set, husk thickness, kernel length and kernel recovery positively contributed towards dry kernel yield at both phenotypic and genotypic levels. Thus, the higher magnitude of the positive direct effect of these traits explains a higher value of association between these traits and dry kernel yield. Therefore, direct selection for these traits would reward for improvement of yield. Rajesh (2007) observed the direct effects on dry kernel yield via nut set, breadth of leaflet, internodal length, the number of leaves, the number of inflorescences per palm, length of leaf, fresh fruit weight. The traits *viz*., crown length, internodal length and leaf breadth were negatively contributed towards dry kernel yield. Similar results were observed by Ganesamurthy *et al.* (2002) in coconut and Natarajan *et al.* (2010) in Arecanut. Hence, it can be concluded that among characters in arecanut, plant height, leaf length, the number of nuts per palm per year, fruit set, husk thickness, kernel length and kernel recovery exhibited positive direct effects on dry kernel yield. Hence, these characters could be important in formulating the selection criteria for obtaining a high yield in arecanut. The traits *viz*., plant height, leaf length, the number of nuts per palm per year, fruit set, husk thickness, kernel length and kernel recovery are important characters to be accounted for gaining improvement in dry kernel yield. Since these characters had high positive direct effects on dry kernel yield.

In the present investigation, the traits recorded high GCV and PCV along with high estimates of heritability coupled with high genetic advance as per cent mean (GAM) can

Table 4. Phenotypic path coefficients among yield and fifteen yield components in arecanut accessions

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
X_1	**0.217**	0.039	-0.027	0.047	-0.013	0.008	-0.031	-0.014	-0.019	-0.035	-0.050	0.019	0.008	-0.026	0.061	0.35*
X_2	-0.020	**-0.111**	-0.025	-0.026	-0.049	-0.026	0.007	-0.037	-0.006	-0.035	-0.004	-0.001	-0.046	-0.035	0.020	0.13
X_3	0.033	-0.058	**-0.258**	-0.047	-0.049	-0.022	-0.021	-0.056	0.041	-0.001	0.019	0.057	-0.083	-0.044	0.029	-0.24
X_4	0.012	0.013	0.010	**0.057**	0.015	0.014	0.019	0.014	-0.004	0.013	0.013	0.006	0.022	0.018	-0.001	0.08
X_5	-0.001	0.009	0.004	0.005	**0.020**	0.007	0.003	0.004	-0.002	0.001	-0.001	-0.004	0.003	0.001	-0.003	-0.12
X_6	-0.009	-0.062	-0.022	-0.062	-0.089	**-0.262**	-0.002	-0.012	0.028	-0.021	0.006	0.055	-0.013	0.010	-0.019	-0.28*
X_7	0.042	0.019	-0.025	-0.097	-0.039	-0.002	**-0.299**	-0.159	-0.063	-0.047	-0.081	-0.096	-0.016	-0.044	0.002	0.03
X_8	-0.030	0.161	0.105	0.121	0.097	0.023	0.258	**0.484**	0.160	0.069	0.133	0.088	0.135	0.193	-0.183	0.19
X_9	0.016	-0.011	0.030	0.014	0.016	0.020	-0.039	-0.062	**0.187**	-0.036	-0.036	-0.039	-0.002	-0.016	0.009	0.01
X_{10}	-0.057	0.113	0.001	0.081	0.018	0.029	0.056	0.051	0.068	**0.355**	0.237	0.229	0.235	0.255	-0.018	0.31*
X_{11}	0.110	-0.018	0.035	-0.107	0.031	0.010	-0.129	-0.130	-0.091	-0.317	**0.475**	-0.327	-0.318	-0.348	0.033	0.14
X_{12}	0.030	0.003	-0.078	0.037	-0.066	-0.074	0.113	0.064	0.074	0.228	0.242	**0.353**	0.186	0.229	0.057	0.49**
X_{13}	-0.001	-0.013	-0.010	-0.012	-0.005	-0.002	-0.002	-0.009	0.000	-0.021	-0.021	-0.017	**-0.032**	-0.027	0.004	0.26
X_{14}	-0.027	0.071	0.039	0.073	0.011	-0.009	0.034	0.091	0.019	0.164	0.167	0.148	0.197	**0.228**	-0.030	0.38**
X_{15}	0.033	-0.021	-0.013	-0.002	-0.017	0.008	-0.001	-0.044	-0.006	-0.006	-0.008	0.019	-0.015	-0.015	**0.118**	0.08

Residual effect = 0.63, Bold diagonal values indicate direct effect

X_1=Plant height , X_2=Crown length , X_3=Inter nodal length , X_4=Number of leaves per palm, X_5=Leaf length , X_6=Leaf breadth , X_7=Number of nuts per inflorescence, X_8=Number of nuts/ palm/year, X_9=Fruit setting percentage, X_{10}=Husk thickness , X_{11}=Kernel length , X_{12}= Kernel breadth , X_{13}=Dry weight of nut , X_{14}= Dry weight of kernel, X_{15}=Kernel recovery , X_{16}=Dry kernel yield

Table 5. Genotypic path coefficients among yield and fifteen yield components in arecanut accessions

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
X_1	**2.207**	-0.094	-0.918	0.274	-0.024	-0.280	-1.053	-0.963	0.012	-0.690	-0.746	0.188	0.179	-0.367	0.662	0.44**
X_2	0.060	**-1.403**	-0.270	-0.312	-1.057	-0.359	0.360	-0.416	-0.024	-0.565	-0.031	-0.100	-0.771	-0.544	0.573	0.12
X_3	0.512	-0.237	**-1.233**	-0.303	-0.614	0.089	-0.003	-0.211	0.529	0.113	0.031	0.378	-0.535	-0.254	0.169	-0.34*
X_4	-0.303	-0.543	-0.600	**-2.437**	-0.569	-0.402	-0.942	-0.697	0.054	-0.999	-1.086	-0.756	-1.622	-1.314	0.162	0.12
X_5	-0.006	0.393	0.260	0.122	**0.522**	0.086	-0.110	-0.009	-0.193	0.065	-0.033	-0.130	0.127	0.059	-0.041	-0.27
X_6	0.047	-0.095	0.027	-0.061	-0.061	**-0.371**	0.049	0.081	0.055	-0.002	0.023	0.120	-0.017	0.042	-0.066	-0.50**
X_7	-1.093	-0.587	0.006	0.885	-0.481	-0.301	**2.291**	0.850	0.200	0.432	0.904	1.101	0.179	0.547	0.345	0.13
X_8	-0.513	0.349	0.202	0.336	-0.021	-0.257	0.437	**1.177**	0.230	0.270	0.477	0.322	0.479	0.724	-0.627	0.13
X_9	-0.003	-0.011	0.268	0.014	0.231	0.093	-0.054	-0.122	**0.625**	-0.216	-0.174	-0.203	-0.014	-0.079	-0.028	0.02
X_{10}	-0.828	1.066	-0.244	1.085	0.329	0.016	0.499	0.607	0.915	**2.647**	1.836	1.736	1.829	1.951	-0.255	0.35*
X_{11}	0.289	-0.019	0.022	-0.381	0.055	0.053	-0.337	-0.346	-0.238	-0.593	**0.854**	-0.599	-0.595	-0.646	0.118	0.11
X_{12}	-0.249	-0.208	0.897	-0.908	0.727	0.945	-1.407	-0.799	-0.952	-1.919	-2.052	**-0.925**	-1.647	-1.993	-0.629	0.58**
X_{13}	0.247	1.676	1.325	2.029	0.742	0.138	0.238	1.241	0.070	2.107	2.124	1.716	**3.049**	2.704	-0.495	0.28*
X_{14}	0.067	-0.157	-0.084	-0.218	-0.046	0.046	-0.097	-0.249	-0.051	-0.298	-0.306	-0.276	-0.359	**-0.405**	0.076	0.42**
X_{15}	0.006	-0.008	-0.003	-0.001	-0.002	0.004	0.003	-0.011	0.001	-0.002	-0.003	0.004	-0.003	-0.004	**0.021**	0.02

Residual effect = 0.55, Bold diagonal values indicate direct effect

X_1=Plant height , X_2=Crown length , X_3=Inter nodal length , X_4=Number of leaves per palm, X_5=Leaf length , X_6=Leaf breadth , X_7=Number of nuts per inflorescence, X_8=Number of nuts/ palm/year, X_9=Fruit setting percentage, X_{10}=Husk thickness , X_{11}=Kernel length , X_{12}= Kernel breadth , X_{13}=Dry weight of nut , X_{14}= Dry weight of kernel, X_{15}=Kernel recovery , X_{16}=Dry kernel yield

be improved through direct selection from the existing accessions in early generations, as these characters have a high degree of additive components of genetic variance. Plant height, husk thickness, kernel breadth and dry weight of kernel are important characters to be accounted for the improvement in yield. Since these characters showed high direct association on dry kernel yield at the phenotypic and genotypic levels. The characters *viz*., palm height, husk thickness, kernel breadth and dry weight of kernel are important characters to be accounted for gaining improvement in arecanut as these characters had high positive direct effects on the dry weight of kernel at both phenotypic and genotypic level.

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