



Correlation and path coefficient analysis of nut yield and ancillary component traits in cashew

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Cashew (*Anacardium occidentale* L.) is a valuable commercial crop in India with highest production (7.3 lakh tonnes) owing to its wide adaptability to varying agroclimatic conditions. It earns huge foreign exchange (\$ 919 million) during 2014-15 from cashew products (Cashew kernel: \$ 910 million and Shell oil: \$ 9 million) (<http://www.thehindu.com/news/national/kerala/cashew-exports-reach-alltime-high/article7828878.ece>). The crop is widely adapted to varying agro-climatic conditions. However, productivity of cashew in India continues to be low (772 kg ha⁻¹) due to cultivation of inferior, indigenous clones (Ferreira-Silva *et al.*, 2009) under marginal lands. Nut yield is a complex trait and it is determined by mutual relationship among morpho-economic traits. Indiscriminate selection of plants on a massive scale in any crop often results in an immense wastage of time and resources. Often, unfavourable linkages among the agro-economic traits do exist, resulting in genetic slippage and limited genetic advance. The strength of inter-relationship among traits varies depending on the composition of the test materials, characters studied, previous selection history and the environment under which the breeding materials are tested. Correlation analysis reveals the direction and magnitude of the relationship between any given pair of traits without regards to cause/effect relationship. The study of path analysis (a standardized partial regression analysis) is more important over correlation, in that, it partitions the total correlation coefficients with nut yield into

various direct and indirect effects. Therefore, an attempt has been made to estimate the correlation and path coefficients of morpho-economic traits to formulate an effective selection strategy in cashew. Under cashew hybridization programme, 60 genetically different hybrids comprising ten cross combinations *viz.*, A) - RP-1 x Kalyanpur Bold Nut, B) - RP-1 x VTH -711/4, C) - RP-2 x Kankadi, D) - M-44/3 x VTH 711/4, E) - RP-1 x Kankadi, F) - RP-2 x VTH711/4, G) - RP-2 x Kalyanpur Bold Nut, H) - M-44/3 x Kalyanpur Bold Nut, I) - Vittol-44/3 x VTH 711/4 and J) BPP-30/1 x Kalyanpur Bold Nut were developed in the year 2001 using eight parents (having desirable traits such as bold nut type, profuse flowering, cluster bearing, high shelling percentage and nut yield). These cashew hybrids were designated in terms of alphabetical letters followed by numerical numbers to refer cross combination and hybrid clone number. The nuts of different crosses were collected at full maturity and seedlings were raised in the nursery as per standard package of practices. After attaining desired growth, the seedlings were planted in the main field with a spacing of 7.5 x 7.5 m in the year 2002. The experimental materials included 71 cashew nut test genotypes (Sethi, 2015) comprising above 60 experimental hybrids, eight parents and three standard checks laid out in an augmented design with three blocks (to accommodate 20 hybrids and all parents and checks in each block) for evaluation and selection of promising hybrid(s) over two years (2011 and 2012). Observations on

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vegetative growth, yield and yield attributing traits were recorded wherever applicable, as per the standard descriptor of cashew (Swamy *et al.*, 1998) and pooled over two years. Statistical procedures were followed for analysis of variance and covariance (Singh and Choudhury, 1985). The simple correlation coefficients for each pair of characters were computed and the path co-efficients (direct and indirect effects) were calculated as per Dewey and Lu (1959).

Study of the mode and extent of inter-relationship of different component traits and direct and indirect effects on nut yield can provide useful information for choice of characters for effective selection and successful utilization of germplasm resources in the development of superior cashew varieties. Since, nut yield is largely affected by environment; selection of genotypes is *in vogue* carried out based on component traits (Esan and Omolaja, 2002). Among the component traits, all yield contributing traits had shown significant positive correlation with nut yield, except nut weight, number of staminate flowers per panicle, total number of flowers per panicle, kernel weight and apple weight (Table 1). Plant height, canopy spread, flowering laterals per m² and number of nuts

per panicle could be considered as major yield contributing traits as evidenced from their strength of significant positive association with nut yield per plant. This corroborated the findings of Nayar *et al.* (1981), Reddy *et al.* (1996) and Rao *et al.* (2002). However, no significant correlation was reported between yield and tree height by Parameswaran *et al.* (1984). Nuts per panicle (N/P) had significant positive correlation with nut yield per plant. This may be ascribed to its favourable positive relationship with canopy spread (N-S), number of flowering laterals per m², number of perfect flowers and sex ratio. Aliyu and Awopetu (2011) revealed consistent relationships between nut number and total nut yield at both inter- and intra-population levels. Aliyu (2006) reported that nuts per panicle, number of nuts per tree and number of hermaphrodite flowers per panicle were positively correlated with nut yield and could be used as primary components for improving yield.

Nut weight, kernel weight and apple weight exhibited very strong *inter se* correlation ($r > 0.808$) which indicated that selection for one of these characters would automatically result shift in mean of other two associated yield component traits in the same positive direction (Table 1). Trunk girth

Table 1. Simple correlation among agro-economic traits associated with nut yield in 71 cashew genotypes

Characters	PHT	TG	CS (E-W)	CS (N-S)	FL m ²	NSF	NPF	TF	SR	NW	KW	AW	N/P
TG	0.344 **												
CS (E-W)	0.359 **	0.479 **											
CS (N-S)	0.479 **	0.409 **	0.404 **										
FL m ²	0.293 *	0.210	0.236 *	0.445 **									
NSF	0.107	0.115	0.154	0.024	-0.059								
NPF	-0.001	-0.043	0.238 *	0.077	0.165	0.453 **							
TF	0.078	0.066	0.214	0.050	0.027	0.925 **	0.757 **						
SR	-0.044	-0.064	0.217	0.081	0.263 *	0.065	0.902 **	0.431 **					
NW	0.013	0.268 *	0.126	0.118	-0.259 *	0.048	0.039	0.052	-0.057				
KW	0.169	0.330 **	0.093	0.130	-0.163	0.162	0.162	0.188	0.048	0.895 **			
AW	0.207	0.283 *	0.171	0.188	-0.161	0.065	0.117	0.097	0.057	0.842 **	0.808 **		
N/P	-0.094	0.108	0.044	0.350 **	0.532 **	-0.065	0.270 *	0.067	0.40 **	-0.393 **	-0.240 *	-0.335 **	
NY	0.400 **	0.310 **	0.439 **	0.664 **	0.693 **	0.138	0.277 *	0.219	0.298 *	-0.286 *	0.222	-0.212	0.571 **

N.B. *, ** Significance at $p_{0.05}$ and $p_{0.01}$ PHT-Plant height, TG-Trunk Girth, CS (E-W)- Canopy Spread (East-West), CS (N-S)- Canopy Spread (North-South), FL- Flowering laterals m², SF- Staminate flower, PF- Perfect flower, TF- Total flower, SR-Sex ratio, NW- Nut weight, KW- Kernel weight, AW-Apple weight, N/P- Nuts panicle⁻¹, NY- Nut yield (kg plant⁻¹)

significantly correlated in positive direction with nut weight, kernel weight and apple weight as well as canopy spread in both direction (East-West and North-South). The fast growing cashew nut trees usually have enhanced plant height with reduced canopy spread and trunk diameter while, cashew plant types with apical dominance led to enlarged canopy spread and more trunk girth due to mobilization of reserve food materials towards growth of lateral branches. Besides, the excess food materials are in fact translocated to sink leading to enlarged size of nut, kernel and apple. But, nuts per panicle were found to have significant negative association with size of nut, kernel and apple (Table 1). Anitha *et al.* (1991) reported negative correlation of nut weight with the number of nuts per panicle that reached maturity. In the present investigation, nut weight has shown significant negative correlation, while apple weight had non-significant negative association with nut yield indicating that selection for larger size nut and apple may not give any advantage for genetic improvement of nut yield.

In the present pursuit, it is evident that total number of flowers increased mainly due to number of staminate flowers ($r=0.925$) followed by number

of perfect flowers($r=0.757$). However, the estimates of sex ratio largely depends upon the number of perfect flowers($r=0.902$) and both had significant association with nut yield. Whereas, total number of flowers and total staminate flowers individually seem to have negligible contribution to total nut productivity. Fruit set was reported (Dorajeerao *et al.*, 2002) to be positively and significantly associated with the number of bisexual flowers in a panicle and the clones having wider sex ratio are usually high yielder in cashew. Rao (1974) found a positive correlation between cashew production and the percentage of hermaphrodite flowers.

Thus, it is evident that nut yield can be improved by more number of flowering laterals per m^2 and nuts per panicle. Each of these component traits could be improved through correlated response of other component traits. Number of flowering laterals per m^2 could be increased by enlarged canopy spread, while more number of nuts per panicle could be achieved by enlarged canopy and more number of perfect flowers per panicle. Besides, number of flowering laterals per m^2 and nuts per panicle being positively correlated, selection for one of these traits can improve nut yield.

Table 2. Phenotypic path-coefficient analysis showing direct and indirect effects of 14 different traits on nut yield of cashew hybrids

Chara- cters	PHT	TG	CS (E-W)	CS (N-S)	FL m^{-2}	SNF	NPF	TF	SR	NW	KW	AW	N/P	r (x,y)
PHT	0.153	0.019	0.044	0.168	0.086	0.021	0.000	0.037	0.004	0.016	0.045	0.035	0.019	0.400**
TG	0.053	0.054	0.058	0.144	0.062	0.023	0.007	0.031	0.005	0.042	0.087	0.047	-0.022	0.310**
CS (E-W)	0.055	0.026	0.122	0.142	0.070	0.031	0.039	0.101	0.019	0.020	0.025	0.029	0.009	0.439**
CS (N-S)	0.073	0.022	0.049	0.352	0.131	0.005	0.013	0.024	0.007	0.018	0.034	0.031	0.071	0.664**
FL m^{-2}	0.045	0.011	0.029	0.156	0.295	0.012	0.027	0.013	0.022	0.041	0.043	0.027	0.108	0.693**
NSF	0.016	0.006	0.019	0.008	0.017	0.200	0.075	0.435	0.006	0.008	0.043	0.011	0.013	0.138
NPF	0.000	0.002	0.029	0.027	0.049	0.091	0.166	0.356	0.077	0.006	0.043	0.020	0.055	0.277*
TF	0.012	0.004	0.026	0.018	0.008	0.185	0.126	0.047	0.037	0.008	0.050	0.016	0.014	0.219
SR	0.007	0.003	0.026	0.028	0.077	0.013	0.150	0.203	0.086	0.009	0.013	0.010	0.081	0.298*
NW	0.016	0.015	0.015	0.041	0.076	0.010	0.006	0.024	0.005	0.157	0.237	0.140	0.080	0.286*
KW	0.026	0.018	0.011	0.046	0.048	0.032	0.027	0.088	0.004	0.140	0.265	0.135	0.049	-0.222
AW	0.032	0.015	0.021	0.006	0.047	0.013	0.019	0.046	0.005	0.132	0.214	0.167	0.068	-0.212
N/P	0.014	0.006	0.005	0.123	0.157	0.013	0.045	0.031	0.034	0.062	0.064	0.056	0.202	0.571**

Residual: -0.459

Canopy spread (N-S), number of flowering laterals per m² and nuts per panicle emerged as the predominant yield contributing component traits as revealed from their direct effects on nut yield following path co-efficient analysis (Table 2). Besides, plant height, canopy spread (E-W) and nut weight had shown considerable influence on nut yield per ha in the present set of cashew hybrids along with their parents and three popular cashew standard check varieties. The traits contributing directly to nut yield, had also revealed their significant association with nut yield, except nut weight, which had shown negative relationship. Lenka *et al.* (2001) reported that number of staminate and perfect flowers, number of nuts per panicle and nut weight were the important selection criteria for improvement of nut yield in cashew. In contrast, Aliyu (2006) revealed very high positive direct effect (0.317) of nut weight on nut yield and that both the direct and indirect effects of whole fruit weight and tree canopy on nut yield were negative and appeared to be detrimental. However, in the present study, canopy spread (N-S) and number of flowering laterals per m² was shown to have high indirect effect (0.131) *via* each other. The third most nut yield contributing trait *i.e.*, nuts per panicle had also revealed high indirect effect through both canopy spread (0.123) and number of flowering laterals per m² (0.157) indicating that the above three important yield contributing traits were articulated with strong *inter se* relationship among themselves. Therefore, nut yield can be improved by selection of cashew genotypes with higher mean performance of any one of these traits. However, Reddy *et al.* (1996) reported importance of collar growth in nut yield as most of the yield component traits had high positive indirect effect on yield through collar girth.

Kernel weight and apple weight individually exhibited major negative indirect effects (-0.237 and -0.140) on nut yield *via* nut weight. Besides, nut weight had negligible negative indirect effect *via* several component traits *e.g.*, number of flowering laterals per m², number of staminate flowers, number of perfect flowers, sex ratio and nuts per panicle. Reddy *et al.* (1996) reported high negative indirect effect of most of the yield component traits on yield through apple weight. This indicates that selection for cashew genotypes with bigger kernel and larger apple size will have

negative impact on genetic improvement of nut yield. The cashew apple serves as the storage of food materials and the growth and development of kernel depends upon mobilization of food reserves from apple. The greater the apple size, the more would be the kernel dimension in cashew nut. However, it was noted that either of these traits (kernel weight and apple weight) has considerable negative indirect effect (-0.135) on nut yield. Thus, neither bigger apple size nor large kernel size would increase nut yield. In contrast, Sena *et al.* (1994) opined that fruit set per panicle and single nut weight had the greatest effect on nut yield in cashew. Hence, higher yield can be expected from trees with larger canopy area with more number of flowering laterals per m², perfect flowers per panicle and moderate sized nuts per panicle.

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