Electronic Journal of Plant Breeding, 5(4): 702-707 (Sep 2014)
ISSN 0975-928X

Research Article

Correlation and path coefficient analysis in coconut (*Cocos nucifera* L.)

S. Geethanjali[1], D. Rajkumar[2]and N.Shoba[2]
[1]Department of Millets, Tamil Nadu Agricultural University, Coimbatore
[2]Coconut Research Station, Tamil Nadu Agricultural University, Aliyarnagar
Email: geethanjalitnau@yahoo.com

(Received: 18 Aug 2014; Accepted: 05 Dec 2014)

Abstract
A total of 43 coconut germplasm accessions were characterized for nut yield and fruit component traits. Correlation analysis showed that most of the fruit traits *viz.*, fruit length, fruit breadth, fruit weight, nut weight, kernel weight and copra weight per nut were positively correlated with each other but showed significant negative correlation with the number of nuts produced per palm per annum. Shell thickness and husk thickness were not correlated with any of the fruit component traits. Path analysis revealed that nut yield and copra content per nut had positive direct effect on the total copra yield per palm. The results of this study showed that equal consideration should be given for both nut yield and copra content per nut while selecting elite genotypes for dual purpose *viz.*, tender nut or culinary use and copra for oil extraction.

Key words
Coconut, correlation, path analysis

Introduction

Coconut palm (*Cocos nucifera* L.) (2n=2x=32) is an important tropical plantation crop in India. Coconut cultivation in India dates back to at least 1200 BC, the post-Vedic era in an Indian context (Menon and Pandalai, 1958). Coconut cultivars mostly comprise of the Tall types which are cross pollinated, and a small group of Dwarfs, which are self pollinated (Ratnambal and Nair, 1994). Although all the parts of the coconut are useful to mankind, the fruit is the most commercial part, which includes the copra for oil extraction, solid endosperm for cooking purposes and the liquid endosperm as a natural energy drink. In addition, the husk is used as raw materials in geotextiles and coir industries while the shell is an excellent source for activated biocharcoal. Coconut breeding is a time and space consuming process due to the perennial nature of the crop with a single breeding cycle lasting for more than 15 years (Baudoin *et al.*, 2006). The most common breeding method employed is selection although hybridization between tall and dwarfs is also being done to a certain extent to exploit the hybrid vigour. Furthermore, due to the multiple uses of the crop, breeding programme should take into account numerous fruit traits which would meet the demands of the farmers and preferences of the consumers. The knowledge on the nut yield and fruit traits is essential to assess the potential of a genotype and to assist in selection of desirable palms. Partitioning of total correlation into direct and indirect effect by path analysis helps in making the selection more effective. However such correlation and path analysis studies in coconut are limited (Natarajan *et al.*, 2010; Namboodhri *et al.*, 2007; Baudoin *et al.*, 2006; Sindhumole and Ibrahim, 2000). Most of these studies involved few genotypes and assessed the effects of vegetative and reproductive traits on nut yield. In this study, our aim was to assess the correlation and path coefficients among the fruit component traits and nut yield on copra yield per palm per annum in coconut.

Material and methods

A set of 43 coconut accessions maintained at the Coconut Research Station (CRS), Aliyarnagar, Tamil Nadu were characterized for fruit traits and nut yield for two consecutive years 2012 and 2013. The accessions comprised of exotic and indigenous ones which are more than 20 years old and hence are in the stabilized bearing phase. The details of these accessions are provided in Table 1. For each genotype, morphological observations on fruit traits were recorded on 12 nuts per palm per year as per the standard descriptors. The following traits were measured/weighted as follows: fruit length (FL), expressed as centimeter (cm) at the polar zone; fruit breadth (FB), measured at the equatorial zone of the fruit and expressed as cm; fruit weight (FW), assessed in 10-11 months old whole fruit and expressed as gram (g); husk thickness (HT), measured from the pericarp of the fruit to the outer shell of the nut and expressed as cm; nut weight (NW), estimated after dehusking the whole fruit measured and expressed as g; kernel thickness (KT), measured in matured fruit and expressed as cm; kernel weight (KW), assessed after separating kernel from the shell and expressed as g; shell thickness (ST), measured in a split nut and expressed as cm; water content (WC),

estimated in 10-11 month old nut and expressed as milliliter (ml); copra content (CC), weight of copra per nut expressed as g; nut yield (NY), mean number of harvested matured nuts per palm per annum, recorded from three to six palms per genotype; copra yield per palm (CYP), estimated from the copra content per nut and nut yield per palm and expressed as kilogram (Kg). The mean data for each year was subjected to correlation and path coefficient analysis using TNAUSTAT (https://sites.google.com/site/tnaustat/).

Results and discussion

Coconut is a highly heterozygous and heterogenous crop. Most morphological traits in coconut are highly influenced by environment. Hence, characterization of morphological traits over seasons and with large samples would be informative. However, among the morphological traits, fruit components exhibit low sensitivity to most changes in the environment and has been used with a fair degree of confidence to characterize coconut populations (Harries, 1982; Wickramaratna and Rathnasiri, 1986 and Perera *et al.*, 1996; Ashburner *et al.*, 1997). In the present study, 12 fruit traits were measured during two consecutive years. The correlation between the fruit traits and nut yield for the two years is presented in Table 2 and Table 3. During the first year, fruit length exhibited significant positive correlation with most fruit parameters *viz.*, fruit breadth (0.7804), fruit weight (0.7728), husk thickness (0.5987), nut weight (0.7183), kernel weight (0.7814), water content (0.7051) and copra content per nut (0.7485). Kernel thickness and shell thickness were not correlated with any of the fruit components. The copra yield per palm per annum showed significant positive correlation with the nut yield (0.5569), nut weight (0.3848), kernel weight (0.4375) and copra content per nut (0.5381). However, nut yield showed significant negative correlation with most fruit component traits such as fruit length (-0.4173), fruit breadth (-0.4303), fruit weight (-0.4246), nut weight (-0.3601), kernel weight (-0.3831), water content (-0.3909) and copra content per nut (-0.3683). A highly similar trend was observed in the second year also, except that kernel weight and nut weight showed a positive correlation with copra yield per palm, which was not significant (Table 3).

Over the years, all the fruit traits which were measured as weights *viz.*, fruit weight, nut weight, and kernel weight were positively correlated. Similar results were obtained by Baudoin *et al.* (2006), who indicated that such a positive correlation was due to the interdependence between the different fruit parts. This results in weight based fruit components to vary in the same direction, although they do not tend to vary in the same proportion. However, most fruit components exhibited a significant negative correlation with fruit number during the stabilized bearing phase of the palm. Some palms tend to produce fewer and larger fruits, while others tend to produce a larger number of smaller fruits. Bigger the size of the fruits as indicated in the present study *via* the fruit length, fruit breadth and other weight based fruit traits, the lesser is the number of nuts produced per bunch per palm. Hence a significant negative correlation is expected. These significant negative correlations between nut yield and fruit size depict differences between palms in their allocation of resources within bunches (Bourdeix, 1989). The competition for assimilates between fruits in developing bunches and newly opened inflorescence is a major determining factor in the allocation of resources within the bunches. The kernel and copra recovery from big sized nuts was comparatively higher than small fruited nuts. However, the total copra yield per palm was positively correlated with nut yield and nut parameters.

Path analysis revealed that during the two consecutive years, highest positive direct effect on the copra yield per palm was due to nut yield (0.8879 and 0.9027) and copra content per nut (0.9717and 0.7873) (Table 4 and 5). Although nut weight showed positive direct effect during the first year, it showed negative direct effect during the second year on copra yield per palm per annum and hence cannot be a dependable trait, while selecting for copra yield per palm per annum. This could be attributed to the fact that nut weight represents both water content as well as the kernel content. Water content in the nut varies largely with seasonal influence and harvest time. The residual effect on the overall copra yield per palm was less than 0.1640 and 0.1651, suggesting that the fruit component traits formed a major determinant for deciding the yield of coconut both in terms of nut and copra yield.

In coconut, tender nut, fresh solid endosperm and the dry copra, all find equal consumer utility. Since both nut yield and copra are important economical yardsticks in coconut, selecting genotypes which are either high nut yielders with small sized fruits or selecting genotypes which are big sized fruit bearers with low nut yield would be meaningless. Our data (unpublished) showed that genotypes with a nominal nut yield of above 100 nuts per palm per annum, producing medium sized fruits yielding above 150g copra per nut would be ideal to meet the dual demand for both nut and copra. Therefore equal consideration has to be given for both number of nuts and copra content per nut in the selection criteria for elite coconut genotypes suitable for dual purpose.

Acknowledgement: The study was supported by the Department of Science and Technology, New Delhi, under the fast track young scientist scheme No.SR/FT/LS-69/2010. We also acknowledge the Project Coordinators, All India Coordinated Research Programme on Palms.

References

Ashburner, G.R., Thompson, W.K. and Halloran, G.M. 1997. RAPD analysis of south Pacific coconut palm populations. *Crop Sci.*, **37**: 992–997.

Baudouin, L., Lebrun, P., Konan, J.L., Ritter, E., Berger, A. and Billotte, N. 2006. QTL analysis of fruit components in the progeny of a Rennell Island Tall coconut (*Cocos nucifera L.*) individual. *Theor. Appl. Genet.*, **112**: 258–268.

Bourdeix, R., Baudouin, L., Billotte, N., Labouisse, J.P., Noiret, J.M. 2001. Coconut. **In**: Charrier A, Jacquot M, Hamon S, Nicolas D (eds) Tropical Plant Breeding. Science, pp 106–127

Harries, H.C. 1982. Coconut varieties. *Indian Coconut J.*, **12 (11)**: 3–10

Menon, K.P.V. and Pandalai, K.M. 1958. The coconut palm. A Monograph. Ernakulum, Indian Central Coconut Committee pp384.

Namboothiri, C.G.N., Niral, V. and Parthasarathy V.A. 2007. Correlation and path coefficient analysis in the F_2 populations in coconut. *Indian J. Horti.*, **64** (4): 450-453

Natarajan, C., Ganesamurthy K. and Kavitha, M. 2010. Genetic variability in coconut (*Cocos nucifera*). *Electron. J. Plant Breed.*,**1**(5):1367-1370.

Perera, L., Peries, R.R.A. and Fernando, W.M.U. 1996. Collection and Conservation of coconut biodiversity in Sri Lanka. *Int. Plant Genet. Res. Newsrl.*, **106**: 1–4.

Ratnambal, M.J. and Nair, M.K. 1994. National Coconut Breeding Programme in India. In: Batugal PA, Ramanatha RV (eds) Coconut breeding, IPGRI, Rome, pp 1-54.

Sindhumole, P. and Ibrahim, K.K. 2000. Path analysis of nut yield in cultivars of coconut (*Cocos nucifera* L.). *South Indian Horti.*, **48** (1):160-162

Wickramaratna, M.R.T. and Rathnasiri, W.G.A. 1986. New variety block of crop museum. **In**: Mahindapala R (ed) Ann Rep Coconut Res Institute Sri Lanka. p-56.

Table 1. Details of coconut germplasm accessions used in the present study

S.No	Accessions	Category	Source / origin
1	Kenya Tall	Tall	Africa
2	Zanzibar Tall	Tall	East Africa
3	Seychelles Tall	Tall	Seychelles, Africa
4	Jamaica	Tall	Jamaica Islands
5	Sanblas	Tall	Panama, America
6	St.Vincent	Tall	Trinidad and Tobago
7	Thailand Tall	Tall	Thailand
8	Siam	Tall	Thailand
9	Cochin China Tall	Tall	Vietnam
10	Malayan Green Dwarf	Dwarf	Malaysia
11	Malayan Orange Dwarf	Dwarf	Malaysia
12	Malayan Yellow Dwarf	Dwarf	Malaysia
13	Java Tall	Tall	Indonesia
14	Philippines Lono	Tall	Phlippines
15	San Ramon	Tall	Philippines
16	Federated Malay States	Tall	Micronesia
17	Guam	Tall	Guam Islands
18	New Guinea Tall	Tall	Papua New Guinea
19	British Solomon Islands	Tall	Solomon Islands
20	Fiji Tall	Tall	Fiji Islands
21	Ceylon Tall	Tall	Srilanka
22	Gonthembili	Tall	Sri lanka
23	Andaman Giant Tall	Tall	South Andaman
24	Andaman Ordinary Tall	Tall	South Andaman
25	Andaman Ranguchan	Tall	South Andaman
26	Nicobar	Tall	Car Nicobar
27	Laccadive Ordinary Tall	Tall	Lakshadweep Islands
28	Nadora	Tall	Goa
29	Calangute	Tall	Goa
30	Hazari	Tall	West Bengal
31	Gangabondam	Dwarf	Andhra Pradesh
32	Tiptur Tall	Tall	Karnataka
33	Kenthali Dwarf	Dwarf	Karnataka
34	Chowghat Green Dwarf	Dwarf	Kerala
35	Chowghat Orange Dwarf	Dwarf	Kerala
36	Kappadam	Tall	Kerala
37	Spicata Tall	Tall	Kerala
38	Arasampatti Tall	Tall	Tamil Nadu
39	Ayiram Kaichi	Tall	Tamil Nadu
40	East Coast Tall	Tall	Tamil Nadu
41	Etamozhi Tall	Tall	Tamil Nadu
42	West Coast Tall	Tall	Tamil Nadu
43	Rajapalayam Tall	Tall	Tamil Nadu

Table2. Correlation estimates of fruit component traits in coconut based on the observations in the year 2012

Characters	FL	FB	FW	HT	NW	KT	KW	ST	WC	CC	NY
FB	0.7804**	1									
FW	0.7728**	0.8511**	1								
HT	0.5987**	0.7436**	0.6742**	1							
NW	0.7183**	0.7958**	0.7179**	0.535**	1						
KT	0.0301	0.1177	0.1081	0.2415	-0.0212	1					
KW	0.7814**	0.8395**	0.8932**	0.5638**	0.8748**	0.1856	1				
ST	0.1242	-0.0276	0.0905	0.0694	0.1264	0.0479	0.1354	1			
WC	0.7051**	0.8315**	0.8679**	0.553**	0.8777**	0.0175	0.9337**	0.029	1		
CC	0.7485**	0.7356**	0.7769**	0.4898**	0.7602**	0.267	0.915**	0.1374	0.8199**	1	
NY	-0.4173**	-0.4303**	-0.4246**	-0.2493	-0.3601*	0.0012	-0.3831*	0.0956	-0.3909**	-0.3683*	1
CYP	0.2998	0.2583	0.2553	0.1884	0.3848*	0.2161	0.4375**	0.1945	0.343*	0.5381**	0.5569**

Fruit length (FL) (cm); Fruit breadth (FB) cm; Fruit weight (FW) (g); Husk thickness (HT) (cm); Nut weight (NW) (g); Kernel thickness (KT) (cm); Kernel weight (KW) (g); Shell thickness (ST) (cm); Water content (WC) (ml); Copra content (CC) (g); Nut yield (NY) per annum; Copra yield per palm (CYP) (kg).

Table3. Correlation estimates of fruit component traits in coconut based on the observations in the year 2013

Characters	FL	FB	FW	HT	NW	KT	KW	ST	WC	CC	NY
FB	0.7458**	1									
FW	0.7347**	0.8875**	1								
HT	0.4291**	0.38*	0.4268**	1							
NW	0.6691**	0.8538**	0.8719**	0.3322*	1						
KT	0.0474	-0.188	-0.063	0.0351	-0.0397	1					
KW	0.6762**	0.7666**	0.7621**	0.2761	0.9317**	0.0481	1				
ST	0.2336	0.2036	0.0762	-0.0472	0.0751	-0.1786	0.1024	1			
WC	0.5351**	0.8037**	0.7873**	0.3171*	0.9459**	-0.0719	0.8568**	0.0944	1		
CC	0.6083**	0.6877**	0.7223**	0.2685	0.8931**	0.0622	0.859**	0.1244	0.8587**	1	
NY	-0.31*	-0.3588*	-0.2859	-0.0524	-0.3545*	0.1583	-0.3275*	-0.2254	-0.308*	-0.2965	1
CYP	0.0976	0.0962	0.2188	0.0568	0.2624	0.1867	0.2747	-0.1463	0.2837	0.4119**	0.7248**

Fruit length (FL) (cm); Fruit breadth (FB) cm; Fruit weight (FW) (g); Husk thickness (HT) (cm); Nut weight (NW) (g); Kernel thickness (KT) (cm); Kernel weight (KW) (g); Shell thickness (ST) (cm); Water content (WC) (ml); Copra content (CC) (g); Nut yield (NY) per annum; Copra yield per palm (CYP) (kg).

Table 4. Character associations for fruit component traits in coconut by path co-efficient analysis based on the observations in the year 2012

Characters	FL	FB	FW	HT	NW	KT	KW	ST	WC	CC	NY	Correlation coefficient with CYP
FL	**0.0549**	0.0235	0.0365	-0.0384	0.2504	0.0011	-0.2692	-0.0030	-0.1129	0.7273	-0.3705	0.2998
FB	0.0428	**0.0301**	0.0402	-0.0476	0.2774	0.0042	-0.2892	0.0007	-0.1331	0.7148	-0.3821	0.2583
FW	0.0424	0.0256	**0.0473**	-0.0432	0.2502	0.0039	-0.3077	-0.0022	-0.1390	0.7549	-0.3770	0.2553
HT	0.0329	0.0224	0.0319	**-0.0641**	0.1865	0.0087	-0.1942	-0.0017	-0.0885	0.4759	-0.2213	0.1884
NW	0.0394	0.024	0.0339	-0.0343	**0.3486**	-0.0008	-0.3013	-0.0031	-0.1405	0.7386	-0.3198	0.3848
KT	0.0017	0.0035	0.0051	-0.0155	-0.0074	**0.0361**	-0.0640	-0.0012	-0.0028	0.2595	0.0010	0.2161
KW	0.0429	0.0253	0.0422	-0.0361	0.3049	0.0067	**-0.3445**	-0.0033	-0.1495	0.8891	-0.3402	0.4375
ST	0.0068	-0.0008	0.0043	-0.0044	0.0441	0.0017	-0.0467	**-0.0243**	-0.0046	0.1335	0.0849	0.1945
WC	0.0387	0.0250	0.0410	-0.0354	0.3059	0.0006	-0.3216	-0.0007	**-0.1601**	0.7967	-0.3471	0.3430
CC	0.0411	0.0222	0.0367	-0.0314	0.2650	0.0096	-0.3152	-0.0033	-0.1313	**0.9717**	-0.3270	0.5381
NY	-0.0229	-0.0130	-0.0201	0.0160	-0.1255	0.0000	0.1320	-0.0023	0.0626	-0.3578	**0.8879**	0.5569

Residue: 0.1640

Fruit length (FL) (cm); Fruit breadth (FB) cm; Fruit weight (FW) (g); Husk thickness (HT) (cm); Nut weight (NW) (g); Kernel thickness (KT) (cm); Kernel weight (KW) (g); Shell thickness (ST) (cm); Water content (WC) (ml); Copra content (CC) (g); Nut yield (NY) per annum; Copra yield per palm (CYP) (kg).

Table 5. Character associations for fruit component traits in coconut by path co-efficient analysis based on the observations in the year 2013

Characters	FL	FB	FW	HT	NW	KT	KW	ST	WC	CC	NY	Correlation coefficient with CYP
FL	**0.0008**	-0.1105	0.1757	-0.0398	-0.2679	-0.0017	0.0915	-0.0079	0.0583	0.4789	-0.2799	0.0976
FB	0.0006	**-0.1482**	0.2123	-0.0352	-0.3419	0.0067	0.1037	-0.0069	0.0876	0.5415	-0.3239	0.0962
FW	0.0006	-0.1315	**0.2392**	-0.0395	-0.3491	0.0022	0.1031	-0.0026	0.0858	0.5687	-0.2581	0.2188
HT	0.0004	-0.0563	0.1021	**-0.0927**	-0.1330	-0.0012	0.0373	0.0016	0.0346	0.2114	-0.0473	0.0568
NW	0.0006	-0.1265	0.2085	-0.0308	**-0.4004**	0.0014	0.1260	-0.0025	0.1030	0.7032	-0.3200	0.2625
KT	0.0000	0.0279	-0.0151	-0.0032	0.0159	**-0.0354**	0.0065	0.0060	-0.0078	0.049	0.1429	0.1867
KW	0.0006	-0.1136	0.1823	-0.0256	-0.3731	-0.0017	**0.1353**	-0.0035	0.0933	0.6763	-0.2956	0.2747
ST	0.0002	-0.0302	0.0182	0.0044	-0.0301	0.0063	0.0138	**-0.0337**	0.0103	0.0979	-0.2035	-0.1463
WC	0.0005	-0.1191	0.1883	-0.0294	-0.3788	0.0025	0.1159	-0.0032	**0.1089**	0.6761	-0.2781	0.2837
CC	0.0005	-0.1019	0.1728	-0.0249	-0.3576	-0.0022	0.1162	-0.0042	0.0936	**0.7873**	-0.2676	0.4119
NY	-0.0003	0.0532	-0.0684	0.0049	0.1419	-0.0056	-0.0443	0.0076	-0.0336	-0.2334	**0.9027**	0.7248

Residue: 0.1651

Fruit length (FL) (cm); Fruit breadth (FB) cm; Fruit weight (FW) (g); Husk thickness (HT) (cm); Nut weight (NW) (g); Kernel thickness (KT) (cm); Kernel weight (KW) (g); Shell thickness (ST) (cm); Water content (WC) (ml); Copra content (CC) (g); Nut yield (NY) per annum; Copra yield per palm (CYP) (kg).