Research Article

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Collecting coconut diversity of Orissa, India

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Abstract

Ten coconut populations of Orissa, India were collected from Konark, Sakhigopal and Puri. During the survey, data pertaining to vegetative, reproductive and fruit component characters were recorded on source populations. The same has been subjected to principal component analysis individually for understanding the divergence. Of the three sets of data used, fruit component characters gave very good results with 82 % of variation explained by PC1 and PC2. The accessions 'Odissi' 'Giant' and 'Bana' were found to be distinct considering this data. When we used the characters having high PC loadings in all the three sets of data, the accession Narangi also joined the cluster containing Bana, although only 66% of variation was explained by PC1 and PC2. During recent cyclone that hit the region severely took toll of many humans and perennial plants. This effort conserved most of coconut diversity of the state which otherwise would have been vanished.

Key words: Coconut diversity, Principal component analysis, divergence

Introduction

Improvement in coconut has been attempted systematically using introduction, hybridization and selection. Collection of diversity from within and outside the country was attempted by CPCRI (erstwhile, CCRS) from 1924. To further enrich the gene bank, a prospecting and collecting trip was made in May- June 1998 to Orissa. The survey resulted in ten accessions.

Orissa is one of the coconut growing states of India with an area of more than 50,000 ha The coconut cultivation of this state is as old as first century B.C. (Menon and Pandalai, 1958).

Orissa New Year starts as a symbol called Sunian Gift offering 108 coconuts to Lord Jagganath (592 A.D.) Breaking of Ladehi coconut (having strong shell) is a part of social ceremony still being practised in the state. The state is known to contain the varieties and / or forms of coconut introduced by sailors or traders of Kalinga Era and cultivated from time immemorial (Panda, 1982). There were interesting types found in this state that could also be the variants of Sakhigopal evolved by mutation and character stabilization.

In 1948, a coastline of 300 miles in Orissa was found with coconut palms in a strip of land of about 50 miles interior from sea. At that time, the total area of coconut in the state was 3,750 hectares only of which 90 % was concentrated in Puri District (Damodar Chhotray, 1948). Coconut research in Orissa State received a boost with the establishment of a Regional Coconut Research Station at Sakhigopal under Central Coconut Research Station. Presently, the research is being continued at Konark under All India Co-ordinated Research Project (Palms). The Center at Sakhigopal has been active in collecting seeds of elite high yielding coconut palms from various parts of the state and maintains their progenies for generating quality planting material of the Sakhigopal Tall and its hybrids with Dwarf. Initially the coconuts were used for fresh consumption and copra alone. Coir fiber industry has developed in the state due to the utilization of husk. In 1988, about 13, 470 tones of coconut fiber was produced from the state although it could go up to 27, 361 tones if all the husk is used for fiber production (Reddy, 1989).

Panda (1982) has made an extensive survey throughout the state from 1976-1980. The survey work was carried out in 600 plantations of coastal districts where the data was recorded on 5128 plants, which led to conclusion of the existence of seven forms. These new types were collected and planted at Birmagiri farm. Orissa is a state blessed with canals covering 8, 665 Km distance, which covers 1708 ha of land. Coconut palms were planed at the canal embankments of the state. These palms flourished well due to the continuous water available to the roots. They also helped in preventing the soil erosion apart from adding to landscape beauty to the area. This activity helped as a demonstration to the farmers, which enhanced the area under the crop in 1985-86 by 41 % over 1982-83 (Reddy, 1989). Cashew interplanted with Casuarina or coconut served as shelterbelt in preventing the ill effects of sand dunes in the state (Patro and Behera, 1979). Coconut palms of Orissa responded well to the drip irrigation (Behera and Sahoo, 1998). Cocoa has performed as suitable intercrop in coconut in this state (Pradhan,2000).

Dash et al., (1995) documented the various native types and forms of coconut available in Orissa. The existence of 17 forms of coconut in Orissa was reported in annual report of AICRP (Palms) in 1998. Studying the coconut divergence has been of great importance in the recent years to know and preserve the unique genotypes as well as to favorably utilize them for obtaining the heterosis in the hybrid progenies. Methods such as Mahalanobis D- square (Balakrishnan and Namboodiri, 1987), Canonical (N'Cho *et al.*, 1993) and Principal component analysis (Sugimura *et al.*, 1997; Kumaran *et al.*, 2000) were tried for the same. This work was initiated with an objective of collecting the coconut diversity from Orissa and to understand the genetic divergence of the populations. Data recorded on the source palms were subjected to principal component analysis.

Materials and Methods

The survey work was carried out during May-June 1998 in the farmer's fields (Nuhadi village) and farms (RCS, Sakhigopal; Birmagiri Farm, Rebena Farm; CRS, Konark and Isaneshwar hybrid coconut farm, Konark) located in Orissa as per the prescribed guidelines for coconut germplasm collection. 25 farms in the villages nearing Puri, Konark and Sakhigopal were also covered in the survey. The present tertiary survey follows the preliminary work by Dash et al., (1995) in the nearby sites. The Birmagiri Farm contains the collections made by the initial survey of Panda (1982). For understanding the divergence, the principal component analysis has been used as done by Kumaran *et al.*, (2000) in the prospection and collection trip to three Indian Ocean islands. They were able to isolate the accession having rare recessive allele(s) using this method from the data. Sugimura *et al.*, (1997) were able to classify the *typical, nana* and *javaica* forms of coconut by biometrical analysis.

We have collected few individuals in some of the accessions mainly because of unavailability of mature nuts. The data was recorded in 3 representative palms per accession except Odissi Giant. Only one palm possessed this rare trait. Edapho-climatic data of collection site is given in Table.5.

Preliminary clustering was attempted three times using vegetative, reproductive and fruit component data. Important characters contributing to divergence from each set were selected. We have selected the characters recording high PC loadings in the PC1, PC2 and PC3 in all the three two sets of data. Final clustering was attempted using these selected characters alone.

The survey resulted in the collection of ten accessions viz., They are Orissa Brown(24), Narangi (33), Bana(3), Goja(85), Odissi Giant(56), Jahaji(13), Gol(56), Tinisera(89), Dhanei(51) and Suryabana (2 embryos). Out of the 17 forms described by Dash *et al.*, (1995), ten could be collected. Number given in parenthesis is number of seed nuts collected. The season of our visit being summer, there was maximum demand for tender nuts thus; mature nuts especially of other seven types could not be collected.

Results and Discussion

Based on Principal component analysis, clustering was attempted on the data of ten accessions. The details are seen in Tables 1-4. Among the vegetative characters used in clustering; collar girth, length of leaf bearing portion, length and breadth of leaflet were found to be the important characters. Similar use of characters such as length and breadth of leaflet in divergence was observed by earlier workers (Kumaran *et al.*, (2000), Balakrishnan and Namboodiri (1987). Collar girth was also a character relating to diversity in this group, which was also seen by Sugimura et al., (1997). Breadth of leaflet was found to be highest in palms producing horned fruits. A horned fruit is a botanical peculiarity in coconut.

Of the reproductive characters used, length of inflorescence, length of stalk and number of spikelets were found to be important. In case of PC2 of reproductive characters Narangi, Odissi Giant, Suryabana recorded negative scores. These accessions are peculiar either in color or fruit composition and could possibly be recessive to normal types. High positive

Table 1a. Compostion of clusters based on vegetative characters.

Cluster no.	Accessions
I	Odissi Giant, Suryabana
II	Goja, Dhanei
III	Narangi, Bana
IV	Orissa Brown, Jahaji, Gol, Tinisira

Table 1b. Intra and inter cluster distance based on vegetative characters

	I	II	III	IV
I	1.768	3.275	4.569	5.551
II		1.217	2.785	3.434
III			1.185	3.059
IV				1.491

Table 1c. Cluster means based on vegetative characters.

Cluster	Collar girth (cm)	No. of leaves	Petiole length (cm)	Length of leaf bearing portion (cm)	No. of leaflets	Leaflet breadth (cm)	Leaflet length (cm)	Leaf scars/m	Internodal length (cm)
I	122.00	28.50	91.00	270.00	98.50	4.65	96.00	20.00	5.06
II	140.75	34.00	117.25	366.25	117.25	5.28	105.25	20.00	5.03
III	120.83	36.67	108.17	322.34	101.34	4.97	112.83	19.67	5.10
IV	152.00	38.33	117.58	341.83	112.17	5.38	115.25	14.83	6.90
Mean	133.90	34.38	108.50	325.11	107.32	5.07	107.33	18.63	5.52
Std dev	15.13	4.30	12.45	40.89	8.86	0.33	8.67	2.53	0.92
Sem	7.57	2.15	6.23	20.45	4.43	0.16	4.34	1.27	0.46

Table 1d. Latent vectors and latent roots for vegetative characters

Sl. No.	Character	PC 1	PC 2	PC 3
1	Collar girth (cm)	0.359*	0.326	0.351
2.	No. of leaves	-0.101	-0.078	-0.389
3.	Length of petiole (cm)	-0.055	-0.129	-0.131
4.	Length of leaf bearing portion (cm)	-0.572*	0.623	0.060
5.	No. of leaflets	-0.326	-0.684	0.374
6.	Breadth of leaflet (cm)	-0.296*	0.005	0.605
7.	Length of leaflet (cm)	-0.564*	-0.026	-0.349
8.	No. of leafscars /m	0.136	-0.097	-0.304
9.	Internodal length (cm)	0.021	0.068	-0.062
	Eigen root	5.294	1.399	1.007
	% variation	58.83	15.55	11.19
	% cumulative variation	58.83	74.38	85.57

* Collar girth, length of leaf bearing portion, length and breadth of leaflet were found to be the important characters.

Table 2a. Composition of clusters based on reproductive characters.

Cluster no.	Accessions
I	Narangi, Odissi Giant, Suryabana
II	Dhanei
III	Bana
IV	Orissa Brown, Goja, Jahaji, Gol, Tinisira

Table 2b. Intra and inter cluster distance based on reproductive characters

	I	II	III	IV
I	2.073	4.147	4.942	4.185
II		1.217	6.755	3.363
III			0.000	4.304
IV				1.491

Table 2 c. Cluster means based on reproductive characters.

Cluster	Inflorescence length (cm)	Length of spikelet bearing portion (cm)	Length of stalk (cm)	Length of spikelet (cm)	No. of spikelets	Female flavers/ inflorescence	No. of bunches	Nuts/ bunch	Bunches with buttons	Bunches with nuts
I	64.17	26.83	37.33	32.33	27.00	12.83	8.67	6.33	1.67	6.83
II	84.50	32.50	55.00	45.00	32.00	13.00	5.00	6.50	0.50	4.50
III	68.00	32.00	36.00	37.00	34.00	49.00	11.00	22.00	2.00	9.00
IV	87.80	39.00	48.40	41.60	36.80	38.67	9.20	12.53	1.53	8.20
Mean	76.12	32.58	44.18	38.98	32.45	28.38	8.47	11.84	1.43	7.13
S.D	11.77	4.99	9.11	5.52	4.13	18.34	2.52	7.36	0.65	1.97
SEm	5.88	2.49	4.55	2.76	2.07	9.17	1.26	3.68	0.32	0.99

Table 2d. Latent vectors and latent roots for reproductive characters

Sl. No.	Character	PC 1	PC 2	PC 3
1	Inflorescence length (cm)	0.431 *	0.455	0.324
2	Spikelet bearing portion length (cm)	-0.187	-0.010	-0.358
3	Length of stalk (cm)	-0.251*	-0.210	-0.182
4	Length of spikelet (cm)	0.077	-0.149	0.270
5	No. of spikelets	-0.023	0.061	-0.073
6	No. of female flowers / inflores.	-0.288*	0.114	-0.404
7	No. of bunches	-0.068	-0.592	0.486
8	Nuts / bunch	-0.111	-0.447	-0.074
9	Bunches with buttons	0.052	0.100	-0.202
10	Bunches with nuts	-0.779 *	0.386	0.457
	Eigen root	4.325	3.117	1.041
	% variation	43.25	31.17	10.41
	% cumulative variation	43.25	74.42	84.83

* Inflorescence length, length of stalk, No. of female flowers per inflorescence and number of bunches with nuts were found to be important.

Table 3a. Composition of clusters based on fruit component characters

Cluster no.	Accessions
I	Orissa Brown, Goja, Suryabana, Dhanei
II	Bana
III	Odissi Giant
IV	Narangi, Jahaji, Gol, Tinisira

Table 3b. Intra and inter cluster distance based on fruit component characters

	I	II	III	IV
I	1.930	7.551	8.754	3.449
II		0.000	10.628	7.473
III			0.000	4.304
IV				1.960

Table 3c. Cluster means based on fruit component characters

Cluster	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Husk thickness up (cm)	Husk thickness mid. (cm)	Husk thickness bottom (cm)	Husked nut weight (g)	Kernel thickness (cm)	Kernel weight (g)
I	22.03	13.79	957.29	6.59	3.03	1.82	354.17	1.13	197.00
II	29.10	19.50	1725.00	12.00	7.00	3.50	470.00	1.50	160.00
III	20.70	16.70	1900.00	7.25	2.60	2.40	630.00	1.80	300.00
IV	22.10	15.50	1281.49	7.28	3.27	2.28	481.67	1.34	219.00
Mean	23.48	16.37	1465.95	8.28	3.98	2.50	483.96	1.44	219.00
S.D.	3.80	2.40	427.50	2.50	2.04	0.71	113.10	0.28	59.23
S.Em	1.90	1.20	213.75	1.25	1.02	0.36	56.55	0.14	29.62

Cluster	Shell thickness (cm)	Shell weight (g)	Qty. of water (ml)	Husk %	Kernel %	Shell %	Water %	Avg. husk thickness (cm)
I	0.32	100.00	61.88	62.81	20.65	10.49	6.42	3.82
II	0.60	120.00	70.00	79.57	6.96	5.22	3.04	7.50
III	0.30	150.00	240.00	52.27	22.73	11.36	18.18	4.08
IV	0.43	151.67	108.75	63.34	16.55	11.54	8.37	4.28
Mean	0.41	130.42	120.16	64.50	16.72	9.65	9.00	4.92
S.D.	0.14	24.96	82.47	11.27	7.00	2.99	6.50	1.73
S.Em	0.07	12.48	41.24	5.63	3.50	1.50	3.25	0.87

Table 3d. Latent vectors and latent roots for fruit component characters

Sl. No.	Character	PC 1	PC 2	PC 3
1	Length of fruit (cm)	0.285*	0.285	0.190
2.	Breadth of fruit (cm)	-0.059	0.195	0.329
3.	Fruit weight (gm)	0.186	-0.129	0.037
4.	Husk thickness (cm) up	-0.330*	-0.204	-0.107
5.	Husk thickness (cm) mid.	0.526*	-0.022	-0.212
6.	Husk thickness (cm) bot.	0.273*	0.093	-0.113
7.	Husked nut weight (gm)	0.303*	0.432	0.291
8.	Kernel thickness (cm)	0.122	-0.425	0.741
9.	Kernel weight (gm)	-0.038	0.123	-0.017
10.	Shell thickness (cm)	0.117	0.128	-0.225
11.	Shell weight (gm)	0.059	-0.106	0.205
12.	Qty. of water (ml)	-0.239	-0.063	0.030
13.	Husk %	0.383*	-0.534	-0.133
14.	Kernel %	-0.123	0.327	0.163
15.	Shell %	-0.087	-0.029	0.063
16.	Water %	-0.134	-0.082	0.099
17.	Husk thickness (cm) avg.	-0.011	-0.008	-0.003
	Eigen root	8.442	5.536	1.309
	% variation	49.66	32.57	7.70
	% cumulative variation	49.66	82.23	89.93

* Length of fruit, husk thickness at three places, husk (%) was found to be important in divergence

Table 4a. Composition of clusters based on selected characters.

Cluster no.	Accessions
I	Dhanei, Suryabana
II	Odissi Giant
III	Narangi, Bana
IV	Orissa Brown, Goja, Jahaji, Gol, Tinisira

Table 4b. Intra and inter cluster distance based on selected characters

	I	II	III	IV
I	2.194	5.523	4.608	4.278
II		0.000	7.188	5.973
III			1.383	3.413
IV				1.869

Table 4c. Cluster means based on selected characters

Cluster	Collar girth (cm)	Length of leaf bearing portion(cm)	Leaflet breadth (cm)	Leaflet length (cm)	Inflorescence length (cm)	Length of stalk (cm)	No. of spikelets	Husk thickness up (cm)	Husk thickness mid. (cm)	No. of bunches with nuts	Qty. of water (cm)	Husk (%)
I	116.00	295.00	4.70	105.50	62.00	35.00	28.00	7.50	4.94	2.50	56.50	59.67
II	140.75	366.25	5.28	105.25	80.50	50.00	32.50	5.00	6.38	3.05	187.50	53.82
III	122.00	260.00	5.30	95.00	60.00	33.00	26.00	9.00	12.00	7.00	70.00	79.57
IV	147.93	340.40	5.21	114.53	87.80	48.40	36.80	8.20	8.02	3.34	86.90	65.98
Mean	131.67	315.41	5.12	105.07	72.58	41.60	30.83	7.43	7.84	3.97	100.23	64.76
S.D	15.12	47.24	0.28	7.98	13.72	8.84	4.82	1.73	3.05	2.05	59.50	11.05

Table 4d. Latent vectors and latent roots of selected characters in the final clustering procedure

Sl. No.	Character	PC 1	PC 2	PC 3
1	Collar girth (cm)	0.347*	0.422	0.166
2	Length of leaf bearing portion (cm)	0.195	-0.073	0.317
3	Breadth of leaflet (cm)	0.217	0.085	-0.108
4	Length of leaflet (cm)	-0.165	0.065	0.718
5	Length of inflorescence (cm)	-0.306*	-0.013	-0.277
6	Length of stalk (cm)	0.541*	0.075	-0.111
7	No. of spikelets	-0.147	0.528	0.197
8	Husk thickness (cm) up	-0.265	-0.062	-0.276
9	Husk thickness (cm) mid.	-0.389*	-0.084	0.185
10	No. of bunches with nuts	-0.322 *	0.178	-0.030
11	Qty. of water	0.059	0.223	-0.268
12	Husk %	-0.173	0.655	-0.184
	Eigen root	4.996	2.976	1.666
	% variation	41.39	24.80	13.88
	% cumulative variation	41.39	66.19	80.07

* Collar girth, length of inflorescence, length of stalk, husk thickness (mid.) and number of bunches with nuts were found to be important in divergence.

Table 5. Edapho-climatic factors at collection sites:

Sl. No.	Site / soil-climate	Rebena farm	Konark	Sakhigopal
1.	Maximum temperature (°C)	33-35	33	35-37
2.	Minimum temperature (°C)	28	26	27
3.	Rel. Humidity (%)	80	70-80	85-95
4.	Soil type	Sandy	Sandy	Sandy loam
5.	Altitude (m > msl)	3	3	9
6.	Rainfall (mm)	1500	800	1500
7.	Longitude	86°E	86°E	86°E
8.	Latitude	20°N	20°N	20°N

scores in this PC were recorded in accessions of peculiar shape i.e. Gol (Round shape), Tinisera (Triangular) and Jahaji (Boat shape). Brown color of nuts appears in crosses between Chowghat Orange Dwarf and West Coast Tall (Green). Recently a brown dwarf has been reported from Sri Lanka (Peries, 1996). Brown petiole color in coconut is governed by two dominant alleles (R-G-) (Bourdeix, 1988).

Odissi Giant formed single accession cluster indicating the uniqueness of the accession. This had longest distance with the cluster having Bana and Narangi. Though located near the gardens of cultivated coconut palms it also possesses the typical wild type characters of huge husk, large fruit size. It seems to be an atavistic mutation. The uniqueness of Bana is the large volume of tendernut water it holds and that of Narangi is the pink colour of husk and fruit it produces. These three divergent types (Bana, Narangi and Odissi Giant) could be utilised in future for utilization in breeding programs. During recent cyclone that hit the region severely took toll of many humans and perennial plants. This effort conserved most of coconut diversity of the state which otherwise would have been vanished.

Earlier biometrics analysis of Papua New Guinea accessions of coconut using UPGMA by Ovasuru (1993) resulted in placing Rabul Red Dwarf and Markham as single accession clusters. Spicata is a mutant form of coconut having unbranched inflorescences. It is also known as spikeless due to the absence of spikelets. The trait is governed by dominant allele in translocation heterozygous state (Ss) over normal inflorescence (ss). Spicata was found to be divergent along with two other Talls using principal component analysis of morphological data in our investigations at CPCRI. In this study, they found that the leaflet of true spicata palms was always lower than that of normal palms. Spicata with Rennel Tall and Polynesian Tall were found to be divergent among the 10 talls and 10 dwarfs analysed using molecular markers (SSRs) (Rivera *et al.*, 1999)

Kumaran *et al.*, (2000) could get Coco Gra Tall, a makapuno type, as a single accession cluster. They found the characters contributing to divergence as fruit weight, length of inflorescence, length and breadth of leaflet etc., The lethal recessive gene action controlling makapuno trait has already been reported in coconut (Torres, 1937). Ashburner *et al.*, (1997 a) recorded RAPD data and fruit component data of Pacific region coconut populations. They found the fruit characters to be more conservative than DNA. Rennel Tall was found to be a divergent accession based on their studies. It is a large fruited type with desirable fruit composition. In this study we found that the large fruited Odissi Giant having undesirable fruit composition (high husk percentage) to be a divergent accession. Zizumbo-Villareal and Pineo(1998) could classify the Mexican coconut populations mainly based on fruit weight. Harries (1978) reviewing the global fruit component data records, found fruit weight and husk percentage as the two most important characters in classifying coconut populations.

We have used three sets of data relating to vegetative, reproductive and fruit components. Among these fruit component characters were helpful in divergence. This agrees with the earlier work by Harries (1978) who could classify the entire global coconut genotypes based fruit characters. When we used the selected characters recording high scores in each set of data, PC1, PC 2 and PC3 could explain nearly 80 % of variation. When analyzed by principal component analysis, we find the major role of length of inflorescence, length of stalk, and husk thickness. The important characters such as collar girth, husk thickness and inflorescence length as reported by earlier workers as well as in the present work could be used in future to enrich the gene banks with truly divergent genotypes.

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