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A STUDY OF THE F_1 HYBRIDS OF TALL × DWARF COCONUT AND ITS BEARING ON THE GENETICS OF DWARFNESS

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ABSTRACT

Genetic divergence using Mahalanobis' D^2 technique was studied in nine F_1 families of West Coast Tall × Dwarf Green coconut hybrids for 13 vegetative characters and yield components. Bulk F_1 populations of the same cross as well as open pollinated progenies of West Coast Tall were also studied. Individual cross combinations differed significantly for all the characters studied and could be grouped into four clusters depending on similarities of their D^2 values. Setting percentage, female flower production, length of leaf, number of leaf scars/metre, number of functioning leaves and height contributed maximum towards the total divergence. The pattern of clustering indicated that phenotypic uniformity can involve considerable genetic diversity. It was suggested that proper choice of palms even among tall and dwarf varieties of coconut may be done for the efficient exploitation of these hybrids. The polygenic nature of the character of dwarfness in coconut has been discussed and the genetic status of the offtype segregants in the dwarf explained.

INTRODUCTION

SEVERAL authors (Patel, 1937; John and Narayana, 1943; Rao and Koyamu, 1932; and Bhaskaran and Leela, 1963) have observed that the Tall × Dwarf coconut hybrids exhibit hybrid vigour. The appearance of pure dwarfs in Dwarf × Tall crosses has also been reported by Patel (1937), Liyanage (1956), Anonymous (1937) and Ninan and Satyabalan (1964). However, no reports are so far available on the genetic behaviour and divergence of Tall × Dwarf hybrids. In view of the reports from some coconut cultivators that all Tall × Dwarf hybrids do not perform equally well under field conditions, a critical study of such hybrids involving different parental combinations was felt necessary. The present investigation was therefore undertaken to study the genetic behaviour and divergence of Tall × Dwarf hybrids and to gather information on the genetics of the character of dwarfness in coconut.

MATERIALS AND METHODS

One hundred and thirty F_1 progenies of West Coast Tall × Chowghat Dwarf Green of nine families available at the Central Coconut Research Station, Nileshwar, were used in the study. They had been planted during 1934–37 and have been receiving similar management conditions. They were observed for (1) time taken for flowering in years (X_1); (2) height of the palm above the fixed mark (X_2); (3) girth at fixed mark in cm (X_3); (4) internodal distance at fixed mark in cm (X_4); (5) internodal distance below the crown in cm (X_5); (6) number of leaf scars per metre (X_6); (7) total number of functioning leaves on the crown (X_7); (8) total length of leaf including petiole in cm (X_8); (9) maximum breadth of leaf in cm (X_9); (10) number of leaflets on the right side (X_{10}); (11) number of leaflets on the left side (X_{11}); (12) mean annual female flower production (X_{12}); and (13) average setting percentage (X_{13}). Family differences were tested using the analysis of variance technique. All the D^2 values for divergence of any two families were also obtained on the basis of the above characters to study the genetic distance between families.

Bulk F_1 population of West Coast Tall × Dwarf Green hybrids available in two more locations at the Agricultural Research Station, Koothali, Kerala State (201 Nos.) and the Coconut Research Station, Veppankulam, Tamil Nadu (39 Nos.) and planted in 1964 and 1959, respectively, were also studied for the time taken for flowering, girth at fixed mark, internodal distance at fixed mark, total number of functioning leaves on the crown, total length of leaf including petiole, maximum breadth of leaf, number of leaflets on right side, and number of leaflets on left side. Similar observations were also recorded on 44 West Coast Tall and 27 Chowghat Dwarf Green plants of identical age and management conditions available at the Central Plantation Crops Research Institute, Kasaragod. Variations in the F_1 populations were studied both by visual observation and by indices of the palms arrived at on the basis of scores ranging from 0–100 allotted to each character. The score for each character was worked out using the formula $\frac{x - a}{b - a} \times 100$ where x is the observed value for the character in a given tree and a and b the minimum and maximum values for the same character in the overall population consisting of parents and hybrids. Scores for each character was added up to arrive at the index for each tree. A population of 3,053 open pollinated West Coast Tall progenies in 89 families were screened in the nursery for segregation based on visual observations.

Results and Discussion

The ANOVA for 13 characters (Table I) revealed significant differences between the families. Wilks' λ test also revealed differences between the families for the aggregate of the 13 characters. All the possible D^2 values (36 numbers) were worked out for every pair of families (Table II). The D^2 values varied from 3·396 to 25·612 showing high divergence among the families. Families 6 and 7 showed marked divergence from all the others. The distances between families 1, 2, 3, 4, and 9 were not much. Using Tocher's method (Rao, 1952), the nine families were grouped into four clusters and the spatial distribution of the clusters were worked out (Fig. 1). The intra and intercluster D^2 values are presented in Table III. The average performance of the clusters for all the characters including yield was also worked out (Table IV).

Maximum genetic divergence was observed between clusters III and IV mainly due to differences in height, girth, internodal distance, number of leaf scars/metre, number of functioning leaves, length of leaf, and setting percentage. The progenies of the family in cluster IV (Family 7) were dwarfish in nature as compared to the rest. Similarly, intercluster D^2 values between I and III, I and IV, II and III, and II and IV were also high mainly due to the differences in setting percentage, female flower production, length of leaf, number of leaf scars/metre, number of functioning leaves, and height. In contrast to this, the genetic divergence between clusters I and II was very low. Cluster IV was the shortest among the entries and was unique in its divergence as compared to the others. Since this is a cross between Tall and Dwarf the gametes of the parents might also be equally divergent from the rest. Since all the families have been derived from the same population but from distinct mother palms, the diversity observed among the families reflects the diversity existing among the talls. The phenotypic uniformity for height of the tall parent was, therefore, not related to the diversity among the families. The pattern of clustering also confirmed that phenotypic uniformity could involve considerable genetic diversity. For example, in cluster I, the families 1, 2, 3, 4, and 9 have similar height but in cluster II, they differ in height. Families 6 and 5 which are similar in height were in two different clusters, clusters III and II. The choice of characters in the case under study, therefore, appears to be appropriate for assessing divergence. They include not only yield attributes but others related to development in different growth phases of the plant.

Detection of such genetic divergence in parents through elaborate breeding experiments will take long period of time. The present study has shown that multivariate analysis could help to detect such diverse lines in a genetically heterogeneous but phenotypically similar population. The differential behaviour of F_1 hybrids of tall and dwarf observed in the field is, therefore, the effect of the genetic diversity existing in the parents. The importance of choosing proper palms even among tall and dwarf varieties is thus apparent.

Data in Table V show that the indices for Tall range from 329·12 to 629·54 and for Dwarf 167·72 to 259·91 indicating that the variation between these two varieties is discontinuous. Indices of F_1 hybrids show that in the case of palms at Nileshwar and Koothali the minimum index is either lower than the minimum of dwarf parent or is around it while those at Veppankulam have a higher value. The maximum index of the hybrids on the other hand was lower than the maximum value of the Tall. This indicates that the F_1

TABLE I

Analysis of variance of thirteen characters

Source	D.F.	Mean Sum of Squares												
		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}
Families	8	18·26*	22422†	61·12*	1·6025†	0·564†	159·25†	69·25†	2546·3†	2295·0†	229·88†	253·09†	8483·6†	697·4†
Error	121	8·33	7986	25·93	0·5779	0·069	41·35	20·09	854·0	414·6	30·98	27·9	3005·7	167·5

* Significant at P = 0·05 † Significant at P = 0·01

TABLE II

D^2 values between families based on thirteen characters

Family No.	Tree No.	1	2	3	4	5	6	7	8	9
1	I/109	..	3·907	3·396	6·430	7·303	16·723	12·374	5·639	5·029
2	VIII/158	..	..	4·081	8·615	13·853	23·398	21·131	9·224	7·131
3	I/58	..	..	..	4·587	8·269	15·178	18·078	7·275	5·442
4	I/76	..	..	..	..	7·158	16·773	16·926	12·260	7·772
5	VIII/143	..	..	..	..	..	9·814	15·670	7·028	10·059
6	VIII/110	..	..	..	..	..	..	25·612	19·046	15·173
7	I/114	..	..	..	..	..	..	..	17·055	14·989
8	VIII/78	..	..	..	..	..	..	..	..	10·758
9	VIII/23	..	..	..	..	..	..	—	..	..

TABLE III

Intra and intercluster D^2 values

Clusters	Family Nos.	I	II	III	IV
I	1, 2, 3, 4, 9	5·639	9·180	17·449	16·700
II	5, 8	..	7·028	14·430	16·362
III	6	..	..	..	25·612
IV	7	..	..	..	..

TABLE IV

Average performance of the clusters for each character

Character		Cluster I	Cluster II	Cluster III	Cluster IV
X_1—Time taken for flowering (years)	..	4·9	6·0	5·6	8·6
X_2—Height (cm)	..	573·3	605·4	635·8	438·2
X_3—Girth (cm)	..	71·2	71·0	72·2	60·8
X_4—Internodal distance—fixed mark (cm)	..	2·96	3·00	2·32	1·94
X_5—Internodal distance—below crown (cm)	..	1·43	1·14	1·28	1·06
X_6—Number of leaf scars/metre	..	37·7	34·4	35·8	47·8
X_7—Number of functioning leaves	..	26·6	25·6	24·4	19·0
X_8—Length of leaf (cm)	..	462·9	459·3	470·2	421·8
X_9—Breadth of leaf (cm)	..	188·6	184·7	152·4	181·0
X_{10}—Number of leaflets—right	..	111·8	107·0	115·2	100·6
X_{11}—Number of leaflets—left	..	112·5	106·6	113·8	101·0
X_{12}—Number of female flowers produced*	..	195·7	163·9	152·8	135·8
X_{13}—Setting percentage*	..	25·6	12·8	8·9	34·1
Yield of nuts*	..	49·7	19·1	12·2	43·2

* Mean based on three years data.

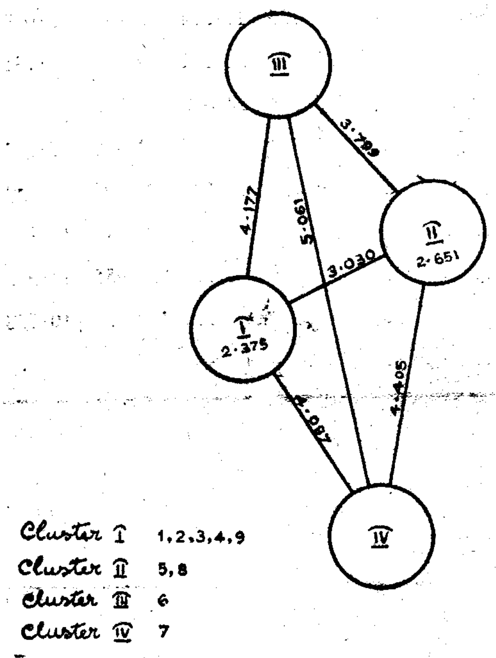

FIG. 1. Spatial Distribution of Clusters.

hybrids though intermediate are dwarfish than Tall. This was also supported from the dwarf segregants obtained in all the three centres in the F_1 population. Open pollinated progenies of seven West Coast Tall trees showed that 2·3 to 10·2% among them were dwarf segregants (Table VI).

The appearance of dwarf segregants in the F_1 hybrids of Tall × Dwarf Green and in open pollinated progenies of tall parent itself, hitherto not reported, presents interesting possibilities. In the Dwarf Green variety, Ninan and Satyabalan (1964) obtained 83·3% dwarf segregants after open pollination, 75·8% after crossing with Tall and 63·4% after selfing. They thought that the appearance of dwarf progeny in Dwarf × Tall crosses was intriguing and thought that this could be properly explained only by a better understanding of the genetics of the character dwarfness in coconut. In the present study the reciprocal cross Tall × Dwarf gave 0–60 % dwarf segregants in different cross combinations (Table VII). Even though the number of F_1 plants available in family 7 was rather low to draw any generalised conclusions, the frequency of dwarfs in the Dwarf × Tall cross and its reciprocal seemed to show considerable similarity. A more critical comparison of the reciprocals was not possible at this stage in the absence of comparable data on the segregation pattern of Dwarf × Tall crosses studied earlier. Such a comparison with larger number of parental combinations will throw more light on this aspect. This reciprocal similarity along with the dwarf segre-

TABLE V

Variation in West Coast Tall, Dwarf Green and their F_1 hybrid

Location	Variety/Hybrid	Index value		No. of dwarf segregants		Percentage of dwarfs (Visual basis)
		Mean	Range	Scores < 224·57	Visual observation	
Kasaragod	Tall	503·11	329·12–629·54	..	..	..
Kasaragod	Dwarf	224·57	167·72–259·91	..	..	..
Nileshwar	Tall × Dwarf	302·09	121·43–415·22	10	8	7·7
Koothali	Tall × Dwarf	351·47	173·13–528·17	11	9	5·5
Veppankulam	Tall × Dwarf	393·13	237·40–468·78	Nil	1	2·5

TABLE VI

Segregation of dwarf in open pollinated progenies of West Coast Tall

Sl. No.	Mother palm No.	Total No. of progenies	No. of dwarf seedlings	Percentage of dwarf segregants
1	2/174	35	2	5·7
2	41/407	36	3	8·3
3	39·3B/531	39	4	10·2
4	39·3B/558	37	2	5·4
5	40/520	34	1	2·3
6	40/364	34	1	2·3
7	27S/924	33	1	3·0
8	Others 82	3,039	Nil	Nil

TABLE VII

Segregation of dwarfs in the F_1 families of Tall × Dwarf at Nileshwar

Family No.	1	2	3	4	5	6	7	8	9
Total No. of progenies	20	16	23	31	15	5	5	6	9
No. of dwarf segregants	1	1	1	Nil	2	Nil	3	1	1
Percentage of total	5·0	6·7	4·3	..	13·3	..	60·0	16·7	11·1

gants obtained in the tall go to show that both Dwarf Green and West Coast Tall are heterozygous for dwarfness and depending upon the extent of heterozygosity of the parents involved in the cross, segregation of dwarfs in the F_1 population may vary. The dwarf segregants obtained by Patel (1937), Liyanage (1956), and Ninan and Satyabalan (1964) thus seem to be the normal segregants of a cross involving heterozygous parents for this character.

Different views have been expressed about the genetic status of the offtype progenies of Dwarfs, an understanding of which is associated with the knowledge on the genetics of the character of dwarfness in coconut. The present study has shown that there is considerable variability in Dwarf Green and Tall parents as well as in the Tall × Dwarf hybrids. The range of variation of the hybrid transgresses range of the two parents (TableV). Some of the F_1 progenies have index values lower than the minimum of the dwarf. Ninan and Satyabalan (1964) have indicated that the natural offtype progenies of dwarf mothers are almost indistiguishable from the talls and that they give dwarfish segregates in the progeny on controlled selfing. The pattern of variability of the dwarf parent and hybrid and the indistinguishable nature of the offtypes from tall and their further segregation indicate that the character of dwarfness in coconut is polygenic and that the offtypes may be tall segregants with recombined characters which can give such segregants not only hybridity but a slightly different morphological frame from the tall. Since the Tall and Dwarf palms differ in not one but series of characters, a F_1 population derived from parents heterozygous for these characters can show considerable recombination unless there is tight linkage. Data in Table IV show that recombinants have been realised in the F_1 progeny. It would thus appear that elaborate breeding experiments are now called for to assess the genetic variability in both the parents for the efficient exploitation of the hybrid vigour. Work initiated at this Institute in this direction can be expected to not only give more critical data but pave the foundation for achieving quick genetic improvement of this perennial palm.

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