9

VARIETAL RESISTANCE

P.M. JACOB, R.V. NAIR and T.S.S. RAWTHER

Evidences for the involvement of Phytoplasma in the etiology of the root (wilt)disease of coconut have been presented in Chapter 3.5 of this publication. As the disease cannot be controlled by conventional plant protection measures, development of resistant/tolerant genotypes is an ideal solution to this malady.

Studies on identifying coconut genotypes resistant/tolerant to root (wilt) disease were initiated by Varghese in 1934. He surveyed about 10 sq. km in and around Kayangulam, a highly root (wilt) affected area and could not locate genotypes resistant to root (wilt) disease.

Trials conducted at CPCRI Kayangulam during 1951 to 1968 have shown that open-pollinated progenies of healthy palms from disease endemic areas had higher yields and lesser disease incidence than the progenies from disease affected palms (Menon *et al.*,1981).

Attempts to screen the available coconut cultivars were made as early as 1961 at CPCRI Kayangulam. The cultivars tested were Andaman Ordinary, Andaman Giant, Cochin China, Ceylon tall, Laccadive Dwarf, Laccadive Ordinary, New Guinea, Philippines, Strait Settlement Apricot, Strait Settlement Green, St. Vincent and Spicata. All these cultivars evaluated in the field developed typical symptoms of root (wilt) disease (Menon *et al.*, 1981).

Rawther and Pillai (1972) reported that natural cross dwarf coconuts (NCD hybrids) exhibited higher tolerance to the disease as compared to West Coast Tall (WCT) cultivar. These hybrids also gave higher yield in spite of contracting the disease. However, the survey had some limitations on account of insufficient number of hybrid population in the field.

Large scale field experiments were undertaken during 1972 in CPCRI Kayangulam and also in cultivators' gardens in different soil types in 63 villages of Alappuzha, Kollam and Kottayam districts. Under this programme, one year old open pollinated progenies of 36 cultivars and 43 hybrid combinations were planted in gardens that had 40 to 70 percent incidence of root (wilt) disease. The data collected from these experiments revealed that all the cultivars and hybrids contracted the disease irrespective of the soil type. However, the percentage of incidence was comparatively high in alluvial and reclaimed soil types (Table 33).

Analysis of the data collected for ten years from 21 cultivars and 15 hybrid combinations along with WCT as control, planted in CPCRI Kayangulam in a replicated trial during 1972, revealed that none of the cultivars and hybrids has tolerance to root

Table 33. Percentage of incidence of root (wilt) disease in cultivars/ hybrids planted in different soil types during 1972

Sl. No.	Cultivar/ hybrid	Sandy loam	Laterite	Alluvial	Reclaimed
1.	WCT	34.0	22.0	50.0	52.0
2.	COD	22.0	9.5	26.0	47.5
3.	CODxWCT	38.7	31.0	45.5	51.7
4.	WCTx COD	27.2	36.0	53.1	71.0
5.	WCTx Gangabondam	30.5	25.0	60.0	53.6

(wilt) disease. The percentage of disease incidence ranged from 33.3 to 100 (Table 34). The average annual yield was maximum in WCT x COD hybrid (52.5 nuts per palm) though the disease incidence was as high as 91.6%, followed by Java Giant x KGD with 43 nuts and 83.3% disease incidence and Laccadive Ordinary with 40 nuts and 58.3% disease incidence in the sixteenth year of planting.

Information gathered from the screening experiments laid out during 1972 in cultivators'' gardens (sandy loam soil) indicated that the hybrid combination CODx WCT had the average yield of 80.1 nuts/palm/year with 50% disease incidence, followed by WCT x COD with 70.3 nuts and 94% disease incidence and WCTx Gangabondam with 52.5 nuts and 87.5% disease incidence compared to 70 nuts and 37.5 % disease incidence in West Coast Tall.

New trials involving 27 cultivars, 10 hybrid combinations, F_2 (OP) of DxT and TxD, progenies of elite palm, high yielding WCT and prepotent WCT, were laid out in cultivators', gardens during 1982. Among these, 27 cultivars were planted in 5 locations and the remaining in 8 locations. Data collected from the above trials have shown that among the 27 cultivars, all except Kenthali have taken up the disease and the disease index ranged from 7.1% to 55.6%. All the ten hybrid combinations, F_2 (OP) of TxD and DxT, progenies of elite palm, prepotent and high yielding WCT were affected by the disease ranging from 12.5 percent to 66.7 percent at the fifth year of planting. Of the two hybrid combinations and the three cultivars planted during 1983, MYD contracted the maximum disease incidence (48.3%), followed by Laccadive Ordinary (33.3%) and the minimum by COD x WCT (2.6%) as compared to WCT (6.9%) at the fourth year of planting.

Twenty four exotic accessions collected in 1981 from South Pacific Ocean islands have been planted at the World Coconut Germplasm Centre at Sipighat in Andamans, with the main objectives of producing *inter se* and selfed seed nuts; and also making crosses using pollen collected from them on disease free palms located in the hotspot areas in South Kerala. These seed nuts will

Table 34. Reaction of coconut cultivars and hybrids to root (wilt) disease

Trial No.1 Year of planting: 1972; Location: CPCRI Kayangulam

Sl. No.		No. of palms	Percentage of disease incidence	Annual yield of nuts
a)	**Cultivars**			
1.	Andaman Giant	12	100.0	4.5
2.	Andaman Ordinary	12	33.3	18.4
3.	B.S.I.	12	100.0	9.7
4.	Car Nicobar	12	92.0	22.1
5.	Chowghat Orange Dwarf	12	66.6	30.7
6.	Cochin China	12	50.0	14.4
7.	F.M.S.	12	33.3	18.7
8.	Gangabondam	12	92.0	13.3
9.	Java Giant	12	92.0	25.4
10.	Jamaica	12	66.6	24.1
11.	Kulasekharam Green Dwarf	12	66.6	22.0
12.	Kulasekharam Orange Dwarf	12	66.6	24.1
13.	Laccadive Micro	12	75.0	36.7
14.	Laccadive Ordinary	12	58.3	40.0
15.	M2 irradiated	12	100.0	28.2
16.	Malayan Green Dwarf	12	83.0	31.4
17.	Malayan Orange Dwarf	12	66.6	15.4
18.	Malayan Yellow Dwarf	12	100.0	29.2
19.	Philippines Ordinary	12	41.6	21.9
20.	SS Apricot	12	92.0	19.9
21.	SS Green	12	83.3	14.1
22.	West Coast Tall	36	61.0	29.0
b)	**Hybrids**			
1.	COD x WCT	12	100.0	32.8
2.	Fiji x Gangabondam	12	66.6	16.4
3.	Fiji x SS Green	12	75.0	31.1
4.	Jamaica x Gangabondam	12	75.0	12.2
5.	Java Giant x KGD	12	83.3	43.0
6.	Java Giant x KOD	12	83.3	29.5
7.	Java Giant x KOD	12	33.3	38.2
8.	KGD x Java Giant	12	50.0	35.0
9.	KOD x Java Giant	12	75.0	37.0
10.	KYD x Java Giant	12	83.3	35.5
11.	Laccadive Ordinary x San Ramon	12	66.6	11.7
12.	San Ramon x Gangabondam	12	66.6	13.1
13.	WCT x COD	12	91.6	52.5
14.	WCT x Gangabondam	12	91.6	24.4
15.	WCT x MYD	12	66.6	13.1

be planted in 'hot spot' areas for screening for resistance/tolerance to root (wilt) disease.

A large scale screening trial with three replications was initiated in 1985, in the Kayangulam Kayal farm, 16 km from CPCRI involving 33 Talls, 6 Dwarfs and 9 hybrid combinations with plot size of 16 seedlings have been laid out. The cultivars and hybrids were monitored regularly for their reaction to root (wilt) disease. The first symptom was noticed 30 months after planting. Of the 17 cultivars and five hybrids planted during 1985, twelve cultivars and all the five hybrids have been affected by the disease with the disease incidence ranging from 2.3 to 11.6%, the maximum being recorded in WCTx Gangabondam hybrid. Among the 10 cultivars and four hybrids planted during 1986, Markham Tall and Fiji Tall contracted the disease with an index of 2.1 and 2.3 percent, respectively. The trial had to be unfortunately discontinued.

The elite palms identified in the diseased tract (Iyer *et al.*, 1979) were monitored for their yield and reaction to root (wilt) disease (see back cover). Among the 9 elite palms under observation, three have been affected by root (wilt) disease [Thazhava, Champakulam and Krishnapuram (Kappil)] and their yield level ranged from 96 to 156 nuts per palm per year (Anon., 1988). All the open pollinated progenies of these elite palms planted in CPCRI Kayangulam during 1980, have contracted the disease ranging from 40% to 100%. However, the progenies of Thazhava palm showed their superiority over the others in yield with an annual average yield of 100 nuts in the eighth year of planting.

As an initial step towards breeding for resistance/ tolerance to root (wilt) disease, an intensive survey covering the heavily root (wilt) affected areas (hot spots) of Kottayam, Alappuzha, Pathanamthitta and Kollam districts of Kerala, was initiated during 1985 to identify disease free and high yielding palms (Anon., 1986). Occurence of high yielding palms among the heavily diseased palms was reported as early as 1953 by Davis. The survey was further intensified during 1988. Chowghat Green Dwarf (CGD) which was reported to show maximum field tolerance (over 90%) to root (wilt) disease (Anon, 1972) was also included in the survey. The criteria for the selection of West Coast Tall (WCT) and Chowghat Green Dwarf (CGD) mother palms were as follows :

WEST COAT TALL (WCT)

1. They should yield 80 or more nuts per palm per year
2. They should be regular bearers, the bunches being well supported by the petioles
3. They should be free from all diseases and pests
4. They should show negative reaction to root (wilt) disease in the sero-diagnostic tests
5. They should be 35 or more years of age
6. They should be surrounded by 80% or more root (wilt) affected palms preferably in the advanced stages of disease

7. They should have all typical characters of WCT confirmed by the progeny test to make sure that no hybrid palm is selected as mother palm

CHOWGHAT GREEN DWARF (CGD)

1. Annual yield should be over 100 nuts per palm per year
2. Age of the palm should be 20 years or more
3. Should be serologically negative to root (wilt) disease
4. Should be free from all diseases and pests
5. Should posses all the typical characters of CGD with regard to stem, crown, leaf, nut and inflorescence
6. Should be surrounded by 80% or more root (wilt) affected palms preferably in the advanced stages of disease

A total number of 187 mother palms were selected and employed in the crossing programme (Table 35).

Hybridization involving disease-free elite WCT and CGD mother palms in hot spots of Kottayam, Alappuzha, Pathanamthitta and Kollam districts was carried out in the following cross combinations for generating progenies to study their reaction to root (wilt) disease (Nair *et al.*, 1996).

1. WCT x WCT (*inter se*)
2. WCT x WCT (Mixed pollen)
3. WCT selfed
4. WCT x CGD (TxD)
5. CGD x CGD (*inter se*/selfing)
6. CGD x WCT (DxT)

Artificially pollinated seedling progenies of different cross combinations mentioned above were underplanted since 1991 in different blocks at CPCRI Regional Station, Kayangulam, where more than 80% of the existing palms were affected by root (wilt) disease. A total of 2423 artificially pollinated progenies raised by crossing the disease free elite WCT and CGD mother palms in hotspots have been planted so far, from 1991 to 1997 as shown in Table 36.

Observations on the first batch of 31 CGDxWCT hybrid progenies planted during 1991 at CPCRI Regional Station at Kayangulam revealed that the palms have an yield potential of over 100 nuts per palm per year in the fifth year of planting and came to flowering in 30 to 40 months after planting. The copra content was 215 g/nut. Characteristic symptoms of the root (wilt) disease were noticed only in 5 palms in the eighth year of planting (16%).

On the other hand, the performance of 50 CGDxWCT hybrid progenies brought from a disease-free area (Kasaragod) and planted in 1990 at Kayangulam revealed that the percentage of disease incidence was 60 in the fifth year of planting itself (Fig. 26). This has highlighted the scope of developing the CGDxWCT hybrid from the disease-free CGD and WCT palms in disease endemic areas, as the ideal planting material.

The *inter se* crossed and selfed progenies of WCT from disease-free elite mother palms in hotspots are also being evaluated. The first batch of progenies planted during 1992 are in the initial stages of flowering. Preliminary indications show that the root (wilt) disease incidence is nearly 30% as compared to 50% in the progenies raised from open pollinated seednuts from the mother palms under crossing. This clearly

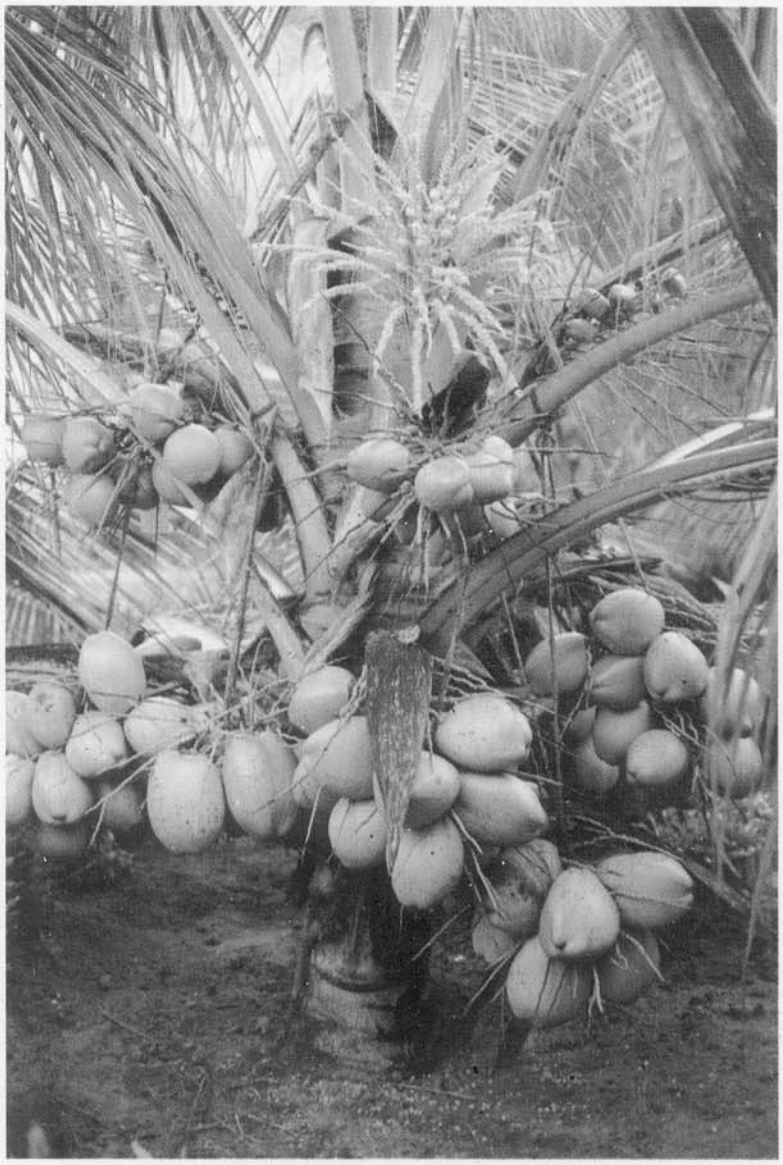

Fig. 26. CGD x WCT hybrid

Table 35 : Yearwise details of mother palms under artificial pollination in hotspots

	No. of mother palms employed in the crossing programme		
	WCT	CGD	Total
1988-89	25	–	25
1989-90	30	6	36
1990-91	32	–	32
1991-92	40	8	48
1992-93	67	10	77
1993-94	104	5	109
1994-95	95	30	125
1995-96	85	20	105
1996-97	76	111	187

Table 36 : Details of seedlings planted at CPCRI farms at Kayangulam for screening

Year	Block	WCTxWCT			WCTxCGD	WCT	CGDxWCT	CGDxCGD	Total
		B.P.	M.P.	Self	TxD	O.P.	DxT	DxD	
1991	4	74	-	-	-	-	31	-	105
1992	1,4	286	172	79	-	20	14	20	591
1993	4, 6,'7	86	206	46	-	124	-	24	486
1994	3,5,6,11	105	390	53	-	47	88	24	707
1995	3,4,5	257	-	15	23	40	15	-	350
1996	2,3	37	-	77	26	36	44	-	220
1997	6,7	166	-	-	65	-	-	-	231
	Total	1011	768	270	114	267	192	68	2690

B.P. - Biparental, M.P. - Mixed pollen, O.P. - Open pollinated

demonstrated the better performance of the artificially pollinated progenies over the open pollinated progenies in the disease endemic areas.

Seed gardens one each at CPCRI Research Centre, Kannara (Thrissur district) and Coconut Development Board Farm at Neriamangalam (Ernakulam district) have been established for large scale production of disease tolerant planting materials such as WCT x WCT, WCT x CGD and CGD x WCT hybrids for distribution to farmers in the disease endemic districts in Kerala State. Details of the planting are given in Table 37.

Breeding for resistance/ tolerance to coconut root (wilt) disease initiated in 1987-88 is showing encouraging results and indicates the possibility of evolving resistant/ tolerant high yielding CGDxWCT and WCTxWCT hybrids for combating the root (wilt) disease problem.

Table 37 : Details of seedlings planted for establishing seed gardens

Location	Year of start	No. of seedlings planted			Total
		WCT X WCT	WCT selfed	CGD X CGD *inter se*/selfed	
CPCRI (RC) Farm, Kannara	1995	350	200	250	800
CDB Farm, Neriamangalam	1996	250	_	100	350
Grand Total		600	200	350	1150

REFERENCES

ANONYMOUS, 1972. Annual Report for 1971. Central Plantation Crops Research Institute, Kasaragod, pp. 212

ANONYMOUS, 1986. Annual Report for 1986. Central Plantation Crops Research Institute, Kasaragod, pp. 205.

ANONYMOUS, 1988. Annual Report for 1987. Central Plantation Crops Research Institute, Kasaragod, pp. 174.

DAVIS, T.A. 1953. Breeding in coconut for disease resistance. *Indian Coconut J.* **6** (3) : 95-100

IYER, R.D., RAO, E.V.V.B. and GOVINDANKUTTY, M.P. 1979. Super yielders in coconut. *Indian Fmg.* **28** (10) : 3-5.

MENON, K.S., THOMMEN, K.J. and SUKUMARAN, A.S. 1981. Varietal resistance studies. In : *Review of Research on Coconut Root (wilt) disease.* Central Plantation Crops Research Institute, Kayangulam. pp. 78-82 (Mimeo).

NAIR, M.K., KOSHY, P.K., JACOB, P.M., RAO, E.V.V.B., NAMPOOTHIRI, K.U.K. and IYER, R.D. 1996. A root (wilt) resistant coconut hybrid and strategy for resistance breeding. *Indian Coconut. J.* **27** (1) : 2-5.

RAWTHER, T.S.S. and PILLAI, R.V. 1972. Note on field observations on the reaction of coconut varieties to root (wilt). *Indian J. Agric. Sci.* **42**: 747-749.

VARGHESE, M.K. 1934. *Disease of coconut palm.* Supdt., Govt. Press, Trivandrum. pp. 105.