

## Development of varieties of coconut (*cocos nucifera* L) resistant/ tolerant to root (wilt) disease

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### Abstract

Breeding for resistance to Root (wilt) disease is being implemented since 1987. Studies revealed that Chowghat Green Dwarf (CGD) variety has higher level of resistance to root (wilt) when compared to the other varieties. In the disease-hot spots, in the midst of heavily disease-affected palms, disease-free palms of West Coast Tall (WCT), CGD and Chowghat Orange Dwarf (COD) are found and these elite palms constituted the base material for the breeding programme. Currently 69 WCT, 85 CGD and 25 COD palms, located in farmers' plot are included in the crossing programme. A total of 2725 progenies of various crosses, planted since 1991, are being evaluated for yield and disease resistance. CGD X WCT hybrid planted during 1991 showed 65% disease incidence and gave a cumulative average yield of 78 nuts/palm/year. It indicates that CGD X WCT hybrids gave satisfactory yield even when they are diseased and are tolerant to root (wilt). Four seed gardens consisting of 6472 artificially pollinated seedlings of WCT, CGD and COD have been established in five locations for large-scale production of root (wilt) resistant/ tolerant planting material.

**Key words:** Coconut varieties, root (wilt) disease, resistance / tolerance

### Introduction

Coconut root (wilt) disease, reported over a century ago in Kerala is now contiguously prevalent in eight southern districts. Sparse occurrence of this disease has also been reported from the remaining six districts of Kerala and also from parts of Tamil Nadu adjoining Kerala State (Srinivasan *et al.*, 2000). According to the survey conducted during 1984, the disease causes an annual loss of 968 million nuts (Anon. 1985). In the contiguously diseased area, vast majority of palms have succumbed to the disease.

The disease is caused by phytoplasma (Solomon *et al.*, 1983a) transmitted by the lace bug *Stephanitis typica* (Mathen *et al.*, 1987) and plant hopper *Proutista moesta* (Anon. 1991). As the disease cannot be controlled by conventional plant protection measures, development of disease resistant / tolerant variety is the most practical method for the management of this malady.

One of the most important constraints for coconut production in the root (wilt) prevalent tracts is the lack of root (wilt) resistant / tolerant planting material.

Requirement for planting material in the disease-prevalent tract is estimated to be nearly 2.4 million seedlings. With the spread of the disease to more neighbouring districts, demand is expected to further increase in the coming years.

Varghese (1934) initiated studies on identifying coconut genotypes resistant / tolerant to coconut root (wilt) disease. Davis (1953) reported occurrence of high yielding palms amidst heavily diseased palms. Seedlings were raised from healthy and diseased mother palms during 1952 and were evaluated after 10 years (Anon. 1962). Studies showed that open pollinated progenies of healthy palms from disease endemic areas had higher yield and less incidence of disease than progenies from disease-affected palms. Mathai *et al.*, (1985) reported varying degree of susceptibility to both root (wilt) and leaf-rot among the seven coconut varieties tested and Andaman Ordinary was found to be the least susceptible to both root (wilt) and leaf-rot disease. Eighty-four cultivars and sixty-eight hybrid combinations were screened for resistance to root (wilt) disease and none of them had the desired level of resistance (Jacob *et al.*, 1998). Studies by Jacob *et al.*

(1998) revealed the higher level of tolerance of COD X WCT hybrids to root (wilt) disease.

A comprehensive breeding programme for evolving root (wilt) resistant / tolerant coconut varieties is being implemented at CPCRI (RS) Kayangulam since 1987 (Nair *et al.*, 1996). From an intensive survey in a large number of farmers' plots in the disease-hot spots, observations were recorded from two hundred Chowghat Green Dwarf (CGD) palms. It was found that 75% of them were disease-free indicating that this variety is having higher level of resistance to root (wilt) disease when compared to the other varieties. From a screening trial of eight exotic and two indigenous coconut varieties carried out at CPCRI (RS), Kayangulam during 1988, it was found that CGD had the highest level of resistance after six years of planting compared to the other varieties (Nair *et al.*, 2004). Thus the studies from the survey among cultivated population as well as from the screening trials confirmed the higher level of resistance of CGD to root (wilt) disease.

### Materials and Methods

#### (i) Breeding programme

Breeding for resistance to coconut root (wilt) disease was initiated primarily based on the following observations:

1. Chowghat Green Dwarf is having higher level of resistance when compared to the other varieties.
2. In the disease endemic areas, in the midst of heavily disease-affected West Coast Tall (WCT) palms, disease-free and high yielding WCT palms are found.
3. In the disease endemic areas, a number of disease-free and high yielding Chowghat Orange Dwarf (COD) palms were also found in the midst of heavily disease-affected palms. This variety gives satisfactory yield even when the palms are diseased, indicating some degree of tolerance. These were also included in the breeding programme to exploit the reported occurrence of high yield and tolerance to the disease in COD X WCT hybrids.

These disease-free palms of WCT, CGD and COD varieties, located in farmers' plots constituted the base material for the breeding programme. Selection criteria of mother palms for artificial pollination are as follows.

#### (a) Selection criteria for mother palms

1. West Coast Tall (WCT)
  1. Parental palms should yield 80 or more nuts per year.
  2. Palms should be regular bearers and absolutely free from all diseases and pests.

3. Palms should be more than 40 years old and surrounded by palms of which at least 80% are affected by the root (wilt) disease in an endemic area.
4. Tall mother palms should have typical WCT characters.
5. Palms should be negative in their reaction to the root (wilt) antiserum (Solomon *et al.*, 1983b) and the serological tests are to be repeated every year.
2. Chowghat Green Dwarf (CGD) / Chowghat Orange Dwarf (COD)
  1. Parental palms should be at least 20 years of age.
  2. Palms should preferably yield 80 nuts or more per year.
  3. Palms should show typical CGD/ COD characters with regard to stem, crown, leaf and nuts.
  4. Palms should be healthy and free from all disease and pests surrounded by palms of which at least 80% are affected by the root (wilt) disease, in an endemic area.
  5. The palms should be negative in their reaction to the root (wilt) antiserum (Solomon *et al.*, 1983b). The serological tests are to be repeated every year.

#### (ii) Crossing programme

Artificial pollination of mother palms were carried out in farmers' plots located in the hot spots of root (wilt) disease (Table 1), to produce artificially pollinated progenies which can be used either for developing a root (wilt) resistant / tolerant variety or for the production of planting material for establishing seed gardens. Disease resistant / tolerant variety to be finally evolved can be either a CGD X WCT hybrid or an improved local tall variety. The following cross combinations were carried out:

Table 1. Locations of mother palms

District	Locations
Alappuzha	Kayamkulam
	Haripad
	Mannar
	Chengannur
Pathanamthitta	Thiruvalla
	Kalloppara
	Kozhencherry
	Kumbanad
Kollam	Thazhava
	Manappally
	Karunagappally
	Kollaka
Kottayam	Changanacherry
	Vazhappally
	Vaikom
	Kottayam

1. WCT (Self/*inter-se*)
2. WCT X CGD
3. CGD (Self/*inter-se*)
4. CGD X WCT
5. COD (Self/*inter-se*)
6. COD X WCT.

Details regarding the mother palms pollinated since 1988 are given in Table 2. Details regarding number of inflorescences and buttons artificially pollinated and nuts harvested since 1988 are given in Table 3.

Table 2. Number of mother palms used for artificial pollination

Year	WCT	CGD	COD	Total
1988-89	22	3	-	25
1989-90	30	6	-	36
1990-91	24	8	-	32
1991-92	40	8	-	48
1992-93	67	10	5	82
1993-94	104	5	-	109
1994-95	95	30	-	125
1995-96	85	20	4	109
1996-97	76	111	9	196
1997-98	76	119	9	204
1998-99	69	80	10	159
1999-00	63	97	4	164
2000-01	81	104	7	192
2001-02	71	79	7	157
2002-03	63	84	23	170
2003-04	69	85	25	179

### (iii) Screening for resistance

Artificially pollinated seedlings of the above cross combinations, were under planted since 1991 in the normal spacing of 7.5 x 7.5 m in different blocks of the Regional Station where more than 80% of the existing palms were affected by root (wilt) disease (Table 4) at the time of planting. Care was taken to see that the old diseased palms were retained at least for six to seven years after under planting of the seedlings, to provide sufficient inoculum for natural infection under field conditions. Heavy incidence of root (wilt) disease was observed for under planted seedlings under field

Table 4. Seedlings planted at CPCRI (RS) Kayangulam for screening

Year	Block	WCT X WCT		WCTXCGD	WCT OP	CGDXWCT DXT	CGDXCGD DXD	CODXCOD DXD	Total
		BP	MP	Self					
1991	-	-	-	-	-	31	-	-	31
1992	1,4	286	172	79	20	-	20	20	597
1993	4,6,7	86	206	46	124	-	24	24	490
1994	3,5,6	105	390	53	47	88	24	24	731
1995	3,4,5	345	-	15	40	15	-	-	438
1996	2,3	37	-	77	36	44	-	-	220
1997	6,7	166	-	-	-	-	-	-	231
1999	3,5,8	-	-	-	-	-	-	-	35
		1025	768	270	114	267	178	68	2725

\*BP- Bi parental; MP- Mixed pollen; OP- Open pollinated

conditions and they were removed as and when they took up infection and the same pit was replanted with the new artificially pollinated seedlings for screening.

Table 3. Details regarding artificial pollination and artificially pollinated nuts

Year	No. of inflorescences	No. of buttons	No. of nuts collected
1988-89	88	2481	-
1989-90	225	4740	366
1990-91	135	3058	791
1991-92	230	3818	747
1992-93	386	7469	1300
1993-94	464	9218	1122
1994-95	546	12173	2107
1995-96	465	10401	2480
1996-97	549	13973	3115
1997-98	275	6769	3236
1998-99	523	12397	2568
1999-00	704	18499	3090
2000-01	945	18499	3090
2001-02	756	21509	4061
2002-03	575	12492	3576
2003-04	73	18456	5004

## Results and Discussion

### (i) Evaluation of progenies

Observations on 31 CGD X WCT hybrids planted during 1991 revealed that they flower in 40 to 50 months after planting (Jacob *et al.*, 1999). Disease incidence in CGD X WCT hybrids planted during 1991 and 1994, for different years are given in Tables 5 and 6. In the case of CGD X WCT hybrids planted during 1991, 65% took up disease 12 years after planting (Table 5), whereas in the case of CGD X WCT hybrids planted during 1994, 55.4% took up disease nine years after planting (Table 6). Annual progression of root (wilt) disease incidence is also given in the respective tables. Detailed yield data of healthy and diseased palms of the hybrid are given in Table 7. The disease intensity and yield of CGD X WCT

hybrids planted during 1991 are given in Table 8. It can be seen that even though majority of CGD X WCT hybrids were diseased, they have given satisfactory cumulative mean yield of 69 nuts / palms / year indicating that this hybrid is tolerant to root (wilt) disease. Besides tolerance to the disease, this hybrid has the advantage of early bearing, large sized nuts and copra combining the desirable qualities of both CGD and WCT. Observation on yield and disease-incidence in this hybrid for a few more years is required to assess the suitability for large-scale cultivation of this variety in the disease-prevalent tract.

Table 5. Disease incidence in CGD x WCT hybrids

Year of observation	Year of planting 1991		
	No. planted	No. diseased	Disease incidence (%)
1999	31	10	32.3
2000	31	15	48.4
2001	31	16	51.6
2002	31	19	61.2
2003	31	20	64.5

Table 6. Disease incidence in CGD X WCT hybrids

Year of observation	Year of planting: 1994		
	No. planted	No. diseased	Disease incidence (%)
1997	74	06	08.1
1998	74	14	18.9
1999	74	20	27.0
2000	74	26	35.1
2001	74	30	40.5
2002	74	37	50.0
2003	74	41	55.4

Table 7. Yield (nuts / palm) of CGD x WCT hybrids

Year of observation	Year of planting: 1991		
	Healthy hybrids	Diseased hybrids	Mean yield of CGD x WCT hybrids (Healthy + Diseased)
1995-96	60	45	48
1996-97	83	63	71
1997-98	58	56	57
1998-99	51	60	57
1999-00	133	82	103
2000-01	82	54	66
2001-02	95	65	78
2002-03	82	57	69
Mean	90	69	78

Progenies of various cross combinations planted in subsequent years at Kayangulam and in other locations are young and in the initial stages of flowering and it is too early to draw conclusions about their yield and

disease resistance. Yield data of these progenies at the stabilized stage (twelve years after planting) is required for making any conclusion with regard to the performance for yield and disease resistance/tolerance. It will take some more years to reach the stabilized stage and therefore they are not presented in this paper.

Promising selections, out of the artificially pollinated progenies of WCT planted at CPCRI (RS), Kayangulam, will be further selfed/ *inter se* mated to develop through recurrent selection, a high yielding and disease resistant/ tolerant WCT variety for the root (wilt) prevalent tracts. They will also be selfed/ *inter se* mated to produce next generation of progenies for establishing second cycle of seed gardens in the root (wilt) prevalent areas of Kerala to meet the urgent needs of improved planting materials.

Table 8. Disease intensity and yield of CGD X WCT hybrids

Disease Intensity	Year of planting: 1991		
	No. of palms	Avg. disease incidence	Average yield (nuts/palm/year)
DE < 20	03	13	95
DM - 21-50	07	38	50
DA > 51	05	62	63

### (ii) Establishment of seed gardens

In order to meet the acute shortage of quality planting materials in the root (wilt) prevalent tracts, efforts were made for establishing seed gardens in different districts for large-scale production of quality planting materials concurrent with the resistance-breeding programme. Towards this end, selfed/ *inter se* progenies of WCT, CGD and COD elite palms have been planted for establishing seed gardens (Nair, 2001). Seed gardens have already been established at CPCRI (RC), Kannara, CDB Farm, Neriambangalam, District Agricultural Farm, Mavelikara and State Coconut Nursery, Karunagappally in addition to the already existing seed garden at CPCRI (RS), Kayangulam. A total of 6472 seedlings spread over nearly 40 hectares have been established in the four districts located in the root (wilt) diseased tract (Table 9). These seed gardens, when they come to the full bearing stage, are expected to produce nearly 3,00,000 seedlings/ annum (@ 45 seedlings/ palm/ year), which will go a long way in meeting the heavy demand for quality planting materials in the disease-prevalent tract.

### (iii) Varietal improvement and production of planting materials

The dwarf varieties have the following important deficiencies (1) require high level of management, (2)

susceptible particularly to insect pests such as rhinoceros beetle and red palm weevil, (3) small size of nut with poor copra out turn. Therefore it is important to develop improved local tall with resistance to root (wilt) disease that can give satisfactory yield under average management. Attempts are being made at CPCRI to develop an improved local tall by incorporating the genes for resistance existing in local tall variety viz. West Coast Tall. Above studies gave the following indications.

1. Only a small gain in selection is possible in the case of resistance in one generation, even though this population may be better with regard to yield when compared to unselected seedlings.
2. Recurrent selection involving a few cycles of the following steps viz., selection, crossing and evaluation of progenies will be needed to develop an improved local tall variety with satisfactory level of resistance / tolerance to the disease. However, it will be a time consuming process.

Table 9. Details of the seed gardens established

Location	Initial year of planting	Number of seedlings planted				Total
		WCT ( <i>Inter se</i> )	WCT (Self)	CGD X CGD ( <i>Inter sel self</i> )	COD X COD ( <i>Inter sel self</i> )	
CPCRI (RS) Kayamkulam (Alappuzha)	1992	1791	285	186	35	2297
CPCRI (RC) Kannara (Trichur)	1995	655	285	250	—	1190
CDB Farm, Neriamangalam (Ernakulam)	1996	334	108	149	56	647
D A Farm Mavelikkara (Alappuzha)	1999	633	301	860	142	1936
State Coconut Nursery, Karunaga- ppally (Kollam)	2000	09	107	235	51	402
<b>Grand Total</b>		<b>3422</b>	<b>1086</b>	<b>1680</b>	<b>284</b>	<b>6472</b>

Another approach can be development of a resistant hybrid by crossing the resistant dwarf with resistant tall occasionally found in farmers plot in disease prevalent areas. These hybrids can be evaluated for their disease resistance and yield. Once these hybrids or improved local tall are recommended and accepted, their large-scale production through establishment of seed gardens can be considered.

Establishment of seed gardens by planting of artificially pollinated seedlings, produced from the resistant dwarf and tall palms is also a suitable approach, not seen to be widely adopted elsewhere. Identification of molecular markers for resistance will enable identification of palms / seedlings with genes for resistance and then subsequent exploitation through breeding. The resistant seedlings produced can be directly distributed for cultivation. Standardization of tissue culture techniques for rapid multiplication of resistant genotypes is another promising approach for the management of phytoplasmal diseases of coconut.

### Conclusion

It may not be possible to improve the high level of resistance already existing in the Chowghat Green Dwarf variety of coconut. This variety is becoming increasingly popular especially as a compound crop in house compounds in the root (wilt) prevalent tract because of its resistance to root (wilt) disease, short stature etc. The two possibilities for varietal improvement are either through development of a D X T hybrid or improved local tall cultivar with higher level of resistance as described in this paper. Though it is clear that development of resistant/tolerant variety is imperative for the successful management of root (wilt) disease, it will require long and sustained multi-disciplinary research support for the development of root (wilt) resistant variety adapted to various conditions.

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Table 2. Details of the seed hybrids established

Year of planting (years)	WCT (Self)	WCT x CDD	CDD x WCT	CDD (Self)	Number of seedlings planted
2000	20	20	20	20	80
2001	20	20	20	20	80
2002	20	20	20	20	80
2003	20	20	20	20	80
2004	20	20	20	20	80
2005	20	20	20	20	80
2006	20	20	20	20	80
2007	20	20	20	20	80
2008	20	20	20	20	80
2009	20	20	20	20	80
2010	20	20	20	20	80
2011	20	20	20	20	80
2012	20	20	20	20	80
2013	20	20	20	20	80
2014	20	20	20	20	80
2015	20	20	20	20	80
2016	20	20	20	20	80
2017	20	20	20	20	80
2018	20	20	20	20	80
2019	20	20	20	20	80
2020	20	20	20	20	80
2021	20	20	20	20	80
2022	20	20	20	20	80
2023	20	20	20	20	80
2024	20	20	20	20	80
2025	20	20	20	20	80
2026	20	20	20	20	80
2027	20	20	20	20	80
2028	20	20	20	20	80
2029	20	20	20	20	80
2030	20	20	20	20	80