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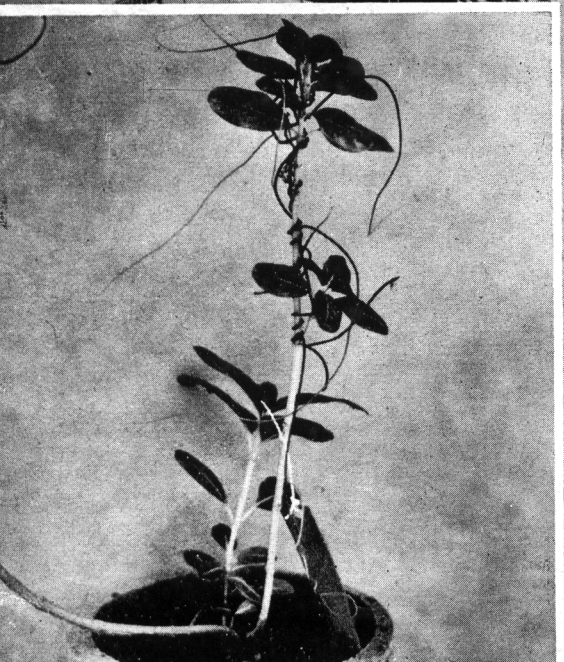
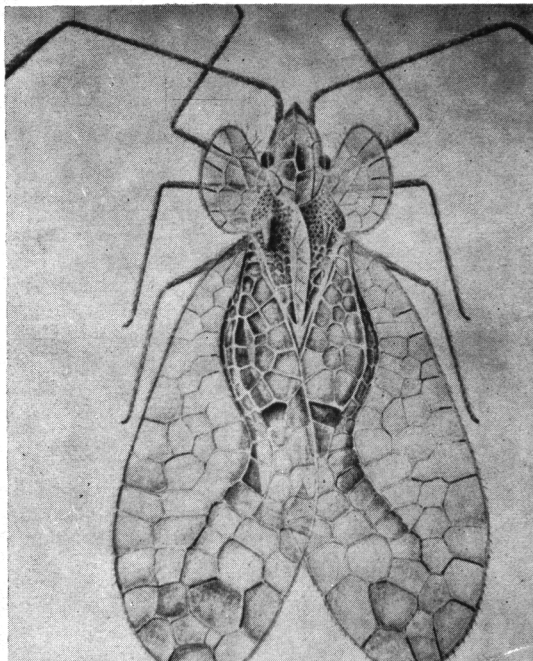
Central Plantation Crops Research Institute
Kasaragod 670 124, Kerala, India

COCONUT ROOT (WILT) DISEASE

Present Status of Research and Management





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1. Introduction

The root (wilt) disease of coconut is non-lethal, but debilitating, characterised by the abnormal bending or ribbing of the leaflets. Yellowing of the older leaves and drying of the margins of leaflets are the other associated symptoms of the disease. Shedding of buttons and immature nuts and reduction in the number and size of leaves are often observed. In several cases root (wilt) diseased palms are found to be affected by leaf-rot also. The disease is reported to have made its appearance a century ago, after the great floods of 1882. Eventhough research on this malady was initiated in 1948, co-ordinated research programmes with multi-disciplinary bias were drawn up and implemented only from 1970 after the establishment of the Central Plantation Crops Research Institute, when scientific efforts acquired better direction and new dimensions. Since then considerable information has been gathered on various aspects of the malady.

The disease is currently prevalent in the districts of Trivandrum, Quilon, Pathanamthitta, Alleppey, Idukki, Kottayam, Ernakulam and Trichur and has affected about 32 per cent of the palm population. A survey conducted during 1984-85 revealed that the disease incidence and intensity varied considerably in different districts, the highest incidence being in Kottayam (75.6%) and the lowest in Trivandrum (1.5%) (Fig. 1). The annual reduction in the yield has been estimated to be 968 million nuts in addition to the loss in the number and quality of leaf, copra weight and oil content (Table 1). The survey also revealed the occurrence of diseased palms in some isolated pockets in the northern parts of Kerala far away from the diseased tract and also in the adjoining districts of Tamil Nadu. The results of the survey are summarised in Table 1.

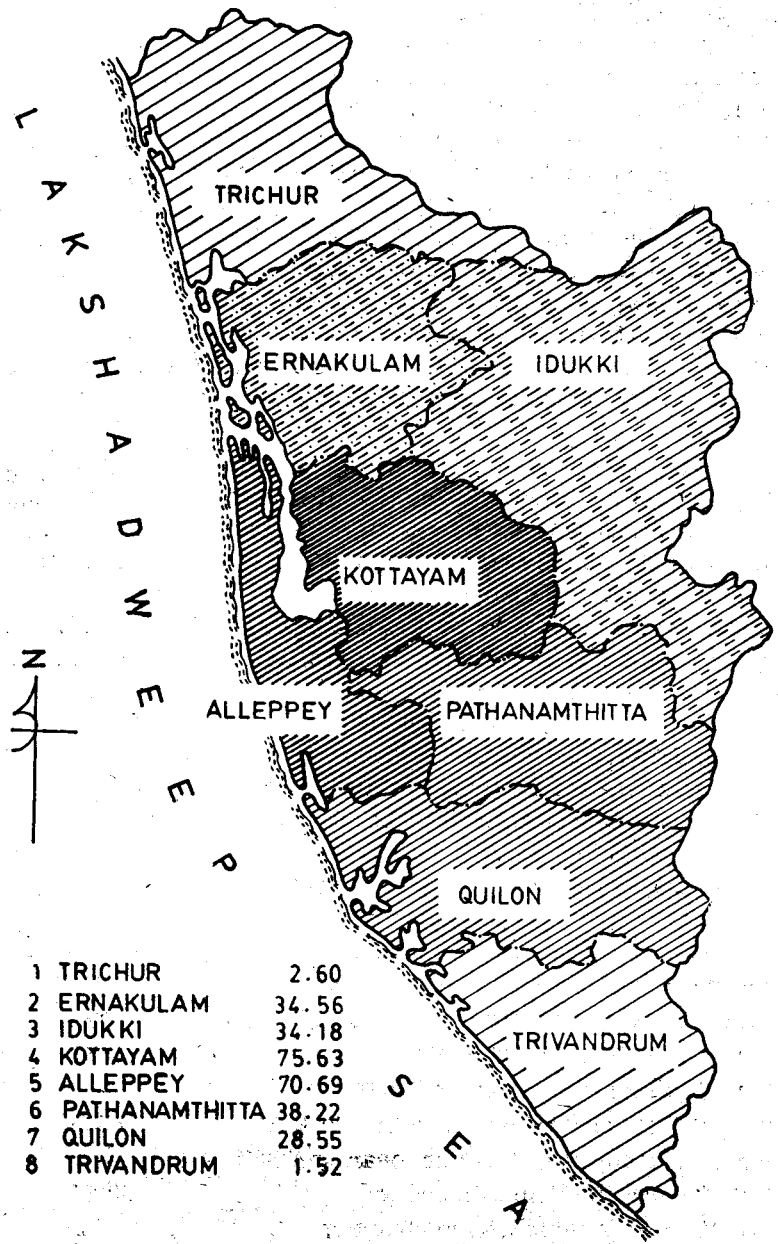
Table 1. *Area and production loss due to root (wilt) disease in Kerala*

	1976	1984
Total area under coconut in Kerala ('000 ha)	693*	674*
Root (wilt) affected area (8 districts) ('000 ha)	412*	410*
Total number of palms-bearing ('000)	60837	59188*
Total number of palms-non bearing ('000)	–	32358*
Total number of diseased palms-bearing ('000)	18535	24209
Total number of diseased palms-non bearing ('000)	–	5422
Percentage of disease incidence-bearing	30.47	40.90
Percentage of disease incidence-non bearing	NA	16.7
Annual loss of nuts (million)	340	968

* Directorate of Economics and Statistics, Government of Kerala, Trivandrum

FIG. 1.

INTENSITY OF INCIDENCE OF COCONUT ROOT (WILT) DISEASE IN THE CONTIGUOUSLY AFFECTED DISTRICTS OF KERALA STATE



2. Present status of research

2.1 Etiology

Extensive nutritional studies have ruled out any physiological and nutrient disorder to be the primary causes of the malady. Though several biotic agents have been found associated with the disease, the weightage is currently in favour of the phloem restricted submicroscopic mycoplasma-like organisms (MLO).

2.1.1 Electron microscopy

Electron microscopic examination of ultrathin sections from the apical meristem, root tips, rachillae, unopened inflorescence, petiole and tender leaves revealed the presence of typical mycoplasma-like organisms in the sieve tubes of all the disease affected palms, while they were totally absent in the tissues of disease-free palms. Constant association of MLO with root (wilt) affected palms was observed in all the samples examined from diverse locations.

2.1.2 Light microscopy

Suitable light microscopic staining techniques for the detection of MLO have been standardised. Fluorescent microscopy using fluorochromes like BAPI and HOECHST 33258 was promising. Use of these dyes has resulted in an increase in fluorescence in the sieve tubes of diseased palms. Similarly Dienes' stain gave a distinct blue colouration to phloem tissues of the disease-affected palms. These observations are significant, since identification of MLO in plant tissues by electron microscopy is laborious and time consuming.

2.1.3 Transmission

Mycoplasmal agents causing diseases in plants are reported to be transmitted by different means *viz.*, grafting, through insects, bridging plants like dodder etc. in the case of coconut root (wilt) disease, work on insects and dodder transmission was undertaken.

2.1.3.1 Insects

A systematic cataloguing of all insects visiting the disease - affected coconut palms resulted in the identification of one leaf hopper *(Sophonia greeni)* and one plant hopper *(Proutista moesta)* along with lace bug *(Stephanitis typica)* an insect constantly associated with the coconut palms in the contiguously root (wilt) affected tract. Both the lace bug and leaf hopper feed and breed on coconut leaflet. However, the immature forms of the plant hopper were not observed on coconut foliage. These hoppers are conventional phloem feeders and mycoplasmal plant diseases are normally transmitted by such insects. Lace bug, by virtue of possessing a long stylet, is capable of reaching inner tissues of the leaf and as such, is a potential suspect in transmission. It feeds through the stomata on chlorophyllous tissues. Electron microscopic examination of

the lace bug which had sufficient acquisition and incubation periods on diseased coconut palms revealed the presence of structures resembling MLOs in the salivary glands and brain tissues. Such bodies are absent in lace bugs collected from the disease-free areas.

2.1.3.2 Dodder

An accession of dodder colonising coconuts collected from Lakshadweep was maintained under controlled conditions. Transmission of MLOs from a young diseased coconut palm to periwinkle (*Catharanthus roseus*), which is a universally accepted mycoplasmal indicator host plant, was accomplished through dodder established on the diseased palms by bridging to periwinkle. The test plant periwinkle developed characteristic interveinal yellowing. Electron microscopic studies showed the presence of MLOs both in the vegetative vector dodder and test plant periwinkle. Healthy periwinkle plants and the control plants did not show such bodies. Dodder was subsequently bridged from a set of primary infected periwinkle plants to a secondary set of healthy periwinkle plants. Characteristic symptoms were observed in the secondary set of plants with the presence of MLOs in the mid vein phloem cells under the electron microscope. Transmission of the MLOs to healthy coconut palms for establishing Koch's postulate is in progress.

2.1.4 Antibiotic therapy

MLOs are sensitive to oxytetracycline group of antibiotics. Remission of symptoms of mycoplasmal diseases is normally observed in plants treated with this antibiotic. In order to undertake large scale trials, an efficient pneumatic pressure injector for introducing the antibiotic in a reasonably short period with minimum injury to the trunk of the palm was developed. The efficiency of the procedure has been determined on the basis of uptake, translocation and persistence of the chemical in the foliage by bioassay using the bacterium *Bacillus cereus* as test organism. Injections at different levels of the palm trunk indicated that the bole region below the ground level is the ideal site for administering the antibiotic. Elaborate field trials with various concentrations of the antibiotic are in progress.

2.1.5 Diagnostic studies

For the implementation of any phytosanitary programme in containing and controlling the disease, it is essential that diseased palms are identified in the field with certainty. With this in view a serodiagnostic test was developed. Physiological studies revealed that the stomatal regulation is significantly impaired in disease affected palms resulting in greater loss of water compared to apparently disease-free palms. A linear relationship was observed between the disease index and the rate of transpiration. The possibility of using this rapid sensitive parameter as a diagnostic aid has been attempted and comparisons made with the serodiagnostic test and visual symptoms. The data

collected so far have revealed that the tests are complementary in detecting incipient infection in palms and in about 75 per cent of the cases tested the infection could be detected before the onset of clear visual symptoms.

2.2 Disease eradication trials

With the objective of containing the disease within the contiguously infected tract, a programme of eradication of the diseased palms followed by surveillance was started from 1971 onwards in Shencottah of Tamil Nadu and areas north of Karuvannur river in Trichur district, which is the northern boundary of the diseased tract. The results are given in Table 2.

Table 2. *Effect of eradication of diseased palms on recurrence of disease*

State, District and Village	Year of eradication	Number of Gardens	Number of Palms	Recurrence in 1984 Gardens	Recurrence in 1984 Palms
Tamilnadu					
Shencottah	1971	1	3	Nil	Nil
Kerala					
Trichur Dist.					
1. Nadathara	1973	1	1	Nil	Nil
2. Varandarappalli	1979	78	175	5	8
3. Amballur	1979	43	66	Nil	Nil
4. Kellur	1979	5	9	Nil	Nil
5. Arattupuzha	1979	2	9	Nil	Nil
6. Inchemudi	1979	2	3	Nil	Nil
7. Kurumbilavu	1979	5	8	Nil	Nil
8. Keezhupallikare	1979	17	24	Nil	Nil
9. Urakam	1979	4	9	Nil	Nil
10. Nemmenikkare	1981	13	37	Nil	Nil
11. Vellachira	1981	2	2	Nil	Nil
Palghat Dist.	1980–82	11	27	Nil	Nil
Malappuram Dist.	1980–82	3	3	Nil	Nil
Kozhikode Dist.	1980–82	30	48	Nil	Nil

It will be seen from the table that the recurrence of disease was observed only in Varandarappally village where the initial disease intensity was high.

These observations clearly indicate the advantage of eradication of root (wilt) affected palms in isolated and mildly affected areas. The disease could be eliminated from such areas if this phytosanitary measure is adopted.

A large scale demonstration on the eradication of root (wilt) disease affected palms and management of the gardens was in operation in one ward of Varandarappalli village jointly by CPCRI, Department of Agriculture, Kerala

State, FACT, Indian Overseas Bank, Service Co-operative Bank and Varandarappalli panchayat since 1979. The entire area could be kept free of disease and yield doubled from its original mean yield of about 28 nuts/palm/year over a period of five years.

2.3 Management experiments

The root (wilt) disease is only debilitating but not lethal and as such the health and yield of palms can be maintained through the adoption of integrated management practices consisting of balanced fertilizers, addition of organic matter, raising green manure crops in the basin and incorporation, weed control, leaf rot control and recycling organic matter. In general, apparently healthy palms and those in the early stage of disease respond better to management practices. Results of these trials are given below:

2.3.1 Mixed farming

Cultivation of fodder crops in the interspace of diseased coconut plantation and maintenance of milch cows enabled recycling of cattle manure and other organic wastes in the plantation. This resulted in an increase of nut yield by 26.1 per cent over a period of five years (1971–75). The follow-up experiment during the next five years (1976–80) confirmed the beneficial impact of such mixed farming system. In addition, there was a significant increase in soil fertility as evidenced by higher values of soil organic carbon, exchangeable calcium, magnesium, and potash with enhanced soil microbial activity.

2.3.2 Inter and mixed cropping

Cultivation of tapioca, elephant foot yam and yam for a period of three years in the interspaces of palms in the disease affected gardens increased the nut yield by 4.96, 15.57 and 8.07 per cent, respectively. In plots intercropped with elephant foot yam and yam, a slight improvement in the condition of the diseased palms was also noticed. Similar trials carried out in farmers' fields did not reveal any adverse effect either on the disease index or yield of the palms.

Mixed cropping with cocoa under single and double hedge system increased the yield of coconut by 27.1 and 35.0 per cent, respectively without any deterioration in the disease intensity of the palms, under rainfed conditions. In a similar experiment, conducted in farmer's field for a period of five years under irrigated conditions with the recommended dose of fertilizers to both the crops, the yield of coconut increased from an average of 17.6 to 46.0 nuts per palm per year.

2.3.3 Basin management

Eight species of leguminous green manure crops were raised in coconut basins in a farmers' field to evaluate their efficiency in enriching soil organic matter and biological activity. Highest green matter yield of

43.4 kg, was obtained from *Pueraria phaseoloides*. It also had a beneficial influence on the microbial activity in the coconut basins.

2.3.4 Nutrient requirement for WCT and CDO × WCT palms

In a freshly replanted plot, application of magnesium sulphate at the rate of 500 g MgO per palm per year along with 500, 300, 1000 g, N, P_2O_5 and K_2O, respectively from seedling stage increased the vegetative growth of palms and reduced the yellowing of leaves. The yield of nuts increased by about 40% in the early bearing period. The mean cumulative yields of the WCT palms upto 12 years from the time of planting with and without the application of magnesium were 310.8 and 220.4 nuts, respectively per palm.

CDO × WCT hybrids under good management with a fertilizer dose of 500, 300,1000 g N, P_2O_5 and K_2O, respectively and 500 g MgO per palm per year yielded higher number of nuts compared to WCT palms of identical age in the early years of production. The application of magnesium increased the cumulative yield of CDO × WCT hybrids from 463.5 to 658.8 nuts per palm.

In the management experiments carried out in cultivators' fields regular application of fertilizers and organic manures at the recommended dose increased the yield of nuts from 24.7 to 38.2 per palm within a period of 2 years. (Table 3).

Table 3. *Response due to management practices on the yield of coconut in cultivators' fields (rainfed)*

Disease index	No. of palms observed		Yield at start of expt. nuts per palm 1982	Present yield (Estimated for 1984) nuts per palm	Response % increase
	1982	1984			
Apparently healthy (10%)	114	90	29.1	49.3	69.4
Disease early (11–50%)	66	82	18.9	30.2	59.8
Disease advanced (50%)	9	12	8.5	9.4	10.6
Total	188	184	4643.6	7028.8	51.4
General mean			24.7	38.2	

2.3.5 Water management

Studies conducted in the farmers' fields have shown that irrigation of the palms with 250 litres of water per palm per week during January to May with normal application of fertilizers and plant protection measures has resulted in overall improvement of the condition of palms with an increased nut production ranging from 64 to 200 per cent. The palms in the advanced stages of the disease did not respond to the management practices.

2.3.6 Plant protection

Regular spraying with fungicides significantly reduced the incidence of leaf rot disease which is normally found superimposed on root (wilt) affected palms, causing considerable loss in yield. In a sequential spraying with Bordeaux mixture (1.0%), Dithane M-45 (0.3%) and Fytolan (0.5%) carried out on 1610 leaf rot affected palms, the incidence could be brought down to 220 palms during the period from December 1982 to January 1984.

2.4 Varietal reaction to disease

In two separate blocks of CPCRI Regional Station, Kayangulam WCT and CDO × WCT hybrids were planted after total removal of all the palms. Observations recorded indicated that the disease incidence was lower (41.1%) and the nut yield more in CDO × WCT compared to WCT (62.2%) at twelfth year. The trend was similar from fourth to eleventh year after planting. (Table 4).

Table 4. *Comparative performance of CDO × WCT and WCT in root (wilt) affected area with respect to yield and disease incidence*

Year of planting	Disease incidence %		Nut yield/palm	
	CDO × WCT	WCT	CDO × WCT	WCT
4th year	1.8	2.2	–	–
5 ,,	3.6	4.3	55.9	–
6 ,,	5.0	8.8	100.9	–
7 ,,	5.0	22.5	75.9	16.8
8 ,,	8.9	29.3	91.1	39.6
9 ,,	22.1	35.5	105.0	49.4
10 ,,	22.8	42.6	61.9	44.8
11 ,,	40.9	50.7	103.4	62.9
12 ,,	41.1	62.2	26.6*	52.1
Cumulative yield/palm upto the 12th year			620.7	265.6

* Mean yield in 1984 after the unprecedented drought in 1982-83

A varietal screening programme to evaluate the yield potential and resistance/tolerance to root (wilt) disease has been in progress since 1972 in the institute farm and in cultivators, fields with 45 cultivars and 62 hybrid combinations.

3. Strategy for containing and managing the disease

3.1 For mildly affected areas

The incidence of the disease in Trivandrum and Trichur districts is only 1.52 and 2.6 per cent, respectively, while it is sporadic in Palghat, Malappuram Kozhikode, Wynad and Cannanore and the neighbouring state of Tamil Nadu. It is possible to eradicate the disease from these areas through removal of the

diseased palms followed by active surveillance. It would thus, be possible to salvage an area of 0.13 million hectares of coconut plantation in Trichur and Trivandrum districts by the total removal of about 0.608 million diseased palms. By a similar action to remove a few thousand root (wilt) affected palms, the entire Tamil Nadu State can also be kept free of the disease. If the eradication is taken up in a phased manner it should be on contiguous area basis from north to south in Trichur District and south to north in Trivandrum District. This will help in bringing down the zone of disease incidence to a geographical area of six southern districts alone in Kerala. The suggested plan of action can be as detailed below :

1) All the disease affected palms in the two districts of Trivandrum and Trichur districts of Kerala and also in Tamil Nadu will be sprayed with 0.01% endosulfan to reduce the vector population and will be cut and removed within a month after spraying. Removal may be taken up in the months of September–October so as to have six months gap before replanting. The planting may be done in May–June. 2) The diseased palms will be removed along with bole and the pits burnt with all the leaves and roots and kept ready for planting 4) The planting may be taken up preferably with CDO × WCT or WCT × CDO hybrid or high yielding talls. 4) The seedlings planted will be sprayed with endosulfan 0.01% and monocrotophos 0.01% alternatively, one in March–April and other in Sept.-October for about three years with a view to keep away the insect vectors 5) Manage the gardens after eradication of diseased palms with adequate manuring and irrigation, wherever possible. Raising inter and mixed crops for increasing the income may also be adopted.

3.2 For the highly diseased contiguous areas

Investigations show that young palms affected before or at flowering stage may not flower at all or flower much later, yielding very few nuts. Under the circumstances, all such palms alongwith those in advanced stage of disease should be removed after spraying them with an insecticide so as to prevent the spread of the insects carrying the pathogen.

The operational strategy for the highly diseased and contiguous areas would be the following :

1. Eradication of 13 million diseased coconut palms which are in the early age of bearing irrespective of the disease intensity and those in advanced stage of the disease. All the palms in the proposed area of replanting may be sprayed with endosulfan 0.01% to kill the insects and palms cut and removed within a month of spraying.

2. Replanting the gaps wherever required with CDO × WCT or WCT × CDO or high yielding local talls so as to maintain a palm population of 175/ha.

3. Continue the spraying of all the planted seedlings with insecticides for three years with endosulfan 0.01% and monocrotophos 0.01% alternatively.

4. Manage the replanted area with adequate fertilizer application and irrigation wherever possible. Grow green manure crops in the basin and appropriate inter and mixed crops.

4. Future thrust

Based on the lead obtained so far from EM studies and also dodder transmission using Periwinkle, it is fairly clear that MLOs are the causative organisms. Successful culturing of MLO is essential for screening of different coconut germplasm for resistance/tolerance. Work in this direction has been initiated. The already available technology of tissue culturing of coconut will be made use of for *in-vitro* screening for locating resistant lines when once the MLO is brought into culture. Perfection of diagnostic tests will enable large scale use of this tool in the field for efficient eradication of diseased palms and successfully containing the disease. Hot spot survey to identify the disease tolerant/resistant palms and using them for future breeding programmes will be another priority area of research.