BASAL STEM ROT OF COCONUT

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
KASARAGOD 671 124 KERALA, INDIA

Technical Bulletin No. 30

BASAL STEM ROT DISEASE OF COCONUT

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
KASARAGOD 671 124, KERALA, INDIA

Published by:

M.K. Nair
Director
Central Plantation Crops Research Institute
Kasaragod - 671 124, Kerala, India

Text by:

R. Bhaskaran
M. Rajamannar
S.N.S. Kumar

Compiled and edited by:

K.K.N. Nambiar

March, 1996

Price Rs. 10/-

Front Cover : Palm showing typical disease symptoms

Printed at:

Codeword Process & Printers,
Falnir,
Mangalore - 575 001

BASAL STEM ROT DISEASE OF COCONUT

R. Bhaskaran[1], M. Rajamannar[2] and S.N.S. Kumar[3]

Basal stem rot disease of coconut, also known as Thanjavur wilt in Tamil Nadu, *Ganoderma* wilt in Andhra Pradesh or *anabe roga* in Karnataka is the most serious disease limiting coconut production in Tamil Nadu, Karnataka and Andhra Pradesh. Ganoderma disease was first reported in palms in India by Butler (1906). Venkatarayan (1936) studied the disease which affected both coconut and arecanut in Karnataka. In Tamil Nadu the disease was first noticed in coconut palms in Thanjavur district in 1952 and hence called Thanjavur wilt. Now this disease is prevalent in all the districts of Tamil Nadu wherever coconut is grown. It is also reported from Kerala, Maharashtra, Gujarat and Orissa.

1. OCCURRENCE AND DISTRIBUTION

A survey conducted in Tamil Nadu during 1965-66 revealed that the disease was confined to the coastal areas in the State. In 1978, the disease was noticed in all the districts of Tamil Nadu and the incidence ranged from 0.6 to 4.9%. Maximum incidence of the disease was in Thanjavur district with a mean of 4.9% followed by Chengai MGR district with a mean incidence of 4.5%. In Nagai district, the incidence was very high in Muthupet block with a mean of 8.4%, but in some severely infected gardens, the incidence was as high as 31%. Observations made during 1990-'92 in V.O.C., Kanyakumari and Coimbatore districts indicated that the disease is widespread in these places also and in some of the worst affected gardens in V.O.C. district, the incidence was as high as 25%.

In Kerala, the disease has been found in sporadic form in a few gardens in Palghat district and to a lesser degree in other districts.

In Andhra Pradesh, the disease incidence is more in lighter soils in the coastal districts while in Karnataka it is widely prevalent in the *maidan* tract. In Andhra Pradesh the survey conducted in 1966 showed that the disease was prevalent in East and West Godavari, Srikakulam and Visakhapatnam districts. However, now the disease is distributed all over the State.

2. SYMPTOMATOLOGY

The disease first starts in the root system. Initially a few roots get infected and rot. The rotting proceeds towards the bole. Till this time, no external symptoms are visible. Discolouration and extensive rotting of root system are observed which are characteristic of the disease. Cortical tissues disintegrate and the stele turns brown. There is a progressive reduction in regeneration of new roots. In moderately and severely diseased palms, the root decay was more (42-75%) at 0-30 cm depth as compared to 17% below 60 cm depth.

1. Prof. of Pathology, Agrl. College & Res. Instt. (TNAU), Tiruchirappalli - 620 009, T.N.
2. Assoc. Prof., Agrl. Res. Station (APAU), Ambajipet - 533 214, A.P.
3. Sr. Scientist, CPCRI Res. Centre, Hirehalli - 572 168, Karnataka.

In the crown, leaflets of outermost whorl start showing signs of wilting. Later one or two outer whorls of leaves turn yellow. They exhibit light to moderate browning followed by drooping and drying (Front Cover). As the disease advances, the remaining leaves also droop-down in quick succession. Under prolonged infection, the outer leaves fall off one by one leaving only the spindle with a few unhealthy leaves around. The spindle leaves which emerge subsequently are reduced in size and do not unfold properly. In some cases, leaves break off near the base of the petiole. In certain cases, soft rot sets in at the base of the petiole. The affected tissues emit a bad smell and in advanced stages, the crown is blown off leaving a decapitated stem.

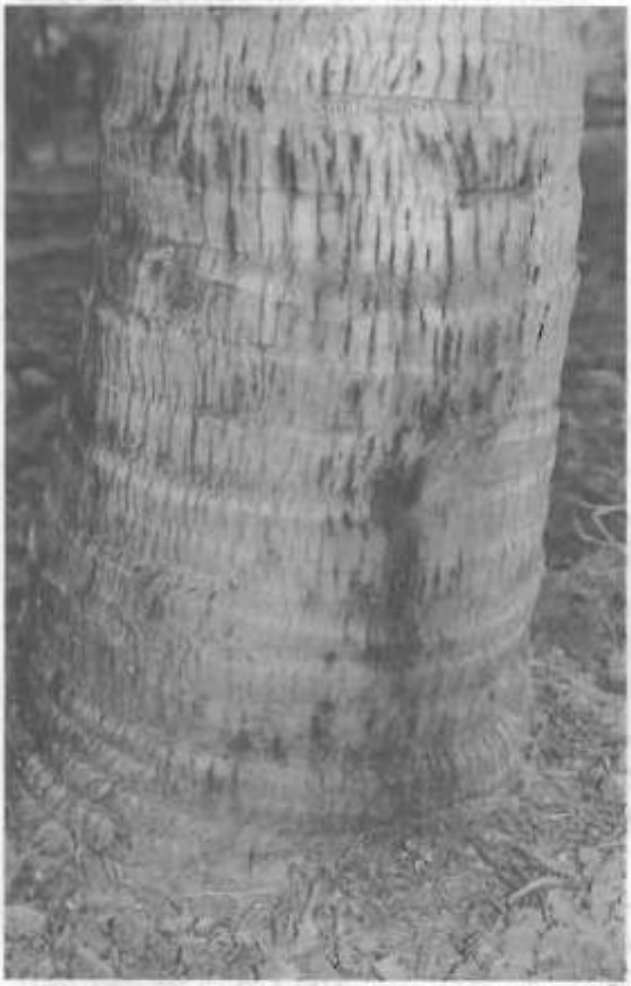

Fig. 1: Coconut trunk showing bleeding symptoms

On the stem, the symptoms first appear as exudation of reddish brown viscous fluid from its basal portion (Fig. 1). By that time the rotting would have progressed from the bole to the basal portion of stem. The bleeding patches gradually traverse upwards, reaching a maximum of 3.5 metre height as the disease progresses. The internal tissues of the affected stem turn brown in colour and this discolouration will be usually confined to the height up to which the external bleeding symptoms are visible. In advanced stages, basal portion of the stem decays completely. Occasionally, some infected palms do not show any bleeding symptom. Sporophores of the fungus, *Ganoderma lucidum*, appear at the base of the affected trunk in some palms prior to wilting or just after the death of the palm (Fig. 2).

Fig. 2: Coconut stump with sporophore of *G. lucidum*

Fig. 3a: Coconut seedling showing wilting symptoms

Fig 3b: Bole showing internal decay

In endemic areas, newly planted seedlings also contract the disease (Fig. 3a). The leaves turn pale and start drying from tip downwards. The spindle size is reduced. The bole portion and roots show extensive rotting (Fig. 3b).

Normal development of flowers and bunches is arrested with the progress of disease. In mild cases there is no button shedding. But with the progress of the disease, the leaves droop down resulting in hanging down of the subtended bunches. This leads to button shedding.

Most of the palms bear profusely just prior to and at the time of initiation of symptoms. But the yield gradually declines. In mild and moderately diseased palms, the quality of nut is not affected very much. In severely diseased palms, some of the nuts become barren. In the remaining nuts, the quality and quantity of kernel, nut water and copra vary and there is a decrease in the oil content. In final stages of the disease, only a very few normal nuts are produced.

The time taken from the initial appearance of bleeding patches on the stem to death of the palms varies from 6 to 54 months, the average being 24 months. Young trees succumb early to the disease. The scolytid beetle *Xyleborus perforans, X. testaceous* and the weevil *Diocalandra stigmaticollis* are found to infest on the bleeding patches in the moderately or severely affected palms. These insects accelerate the death of the palm.

3. ETIOLOGY

From roots of diseased palms, two species of *Ganoderma* viz., *G.applanatum* (Pers.) Pat. and *G. lucidum* (Leys.) Karst. were isolated. In the pathogenicity experiment conducted at Veppankulam with 35- year-old East Coast Tall palms, in six months after inoculation with *G. lucidum*, root rotting up to 29 per cent was noticed. Bleeding symptom in the stem was observed in five out of ten inoculated palms within 16 to 20 months after inoculation. Even in palms which showed no bleeding symptom, root rotting was observed up to 16%. In the inoculated palms, optical density (O.D.) values of root tissues observed in EDTA test were higher than those of uninoculated palms indicating that all the inoculated palms have picked up infection eventhough some of the palms have not exhibited symptoms (Table-1). From the inoculated palms, *G. lucidum* was reisolated. In coconut palms inoculated with *G. applanatum*, the fungus colonised on the surface of the root to a distance of 8-10 cm on either side of the point of inoculation and survived on the root surface for a period of six months. However no root rotting was observed one year after inoculation.

At Ambajipet, *G. applanatum* isolated from infected palm was mass multiplied on coconut stem blocks and used for pathogenicity tests. The inoculum was introduced in two layers (at 15 cm and 30 cm depths) in cement tubs containing sterilised sandy soil in which five-month-old seedlings were planted. The roots of the seedlings were longitudinally split and tied with fungus-colonised bits. The seedlings developed typical symptoms and succumbed to infection in 6-12 months.

At Hirehalli, ten coconut palms each were inoculated with *G. lucidum* using two methods viz. planting of diseased stump beside healthy palms and stem block technique. A few of the inoculated palms developed gummosis (Table-2) indicating that both the techniques can be used for pathogenicity tests.

Table 1. Root rotting and optical density values in pathogenicity experiment (Veppankulam)

Nature of palms	No. of palms showing gummosis	Root rot (%)	O.D. value in EDTA test
Inoculated (with bleeding symptom)	5*	11.7 - 29.1	0.55 - 0.72
Inoculated (no symptom)	-	2.4 - 15.8	0.11 - 0.50
Control	-	0.4 - 1.1	0.12 - 0.13

* Out of 10 palms inoculated 5 palms showed gummosis in 16-20 months after inoculation.

Table 2. Pathogenicity tests using different methods (Hirehalli)

Method of inoculation	No. of palms inoculated	No. of palms showing gummosis
Stump inoculation	10	4*
Stem block technique	10	2**

* 3 palms showed gummosis in 22-24 months and one palm in 42 months after inoculation.

** Gummosis observed in 26-28 months after inoculation.

4. THE FUNGUS

The fungus, *Ganoderma lucidum* was first described under the name *Fomes lucidus* (Leys.) Fr. It was later known under various synonyms like *Fomes amboinensis* Lam., *G. sessile* Murill, *Polyporus amboinensis* Fr. Van Overeem etc.

Aerial mycelium is hyaline, thin-walled, branched with frequent clamp connections, 1.4-2.9µ in diameter; chlamydospores formed abundantly which are slightly thick-walled, terminal or intercallary, ellipsoid, sometimes in chains, 8.8-11.8µ x 3.7-5.6µ in size; staghorn hyphae with projections present in some isolates while absent in others.

Sporophore is perennial, stipitate, usually lateral, sometimes sessile, corky, becoming woody later, usually 10-12 x 3-4 cm, but may grow up to 30 cm or more; upper surface is shiny, laccate crust, ox-blood in colour, smooth. The palisade hyphae is about 40µ long. Hymenial surface is whitish or creamish, turning brown later, pores small, round 90-250µ in diameter. Pore tubes are about 6-7 mm long, basidiospores are brown, thick-walled, minutely verrucose, truncate at one end and 8.3-10.0 x 5.8-6.7µ in size. The bracket of *G. applanatum* is sessile, laccate on top; basidiospores mostly ovate, 9.70-12.67µ x 6.79-7.76µ.

G. lucidum was found to grow best in Waksman's medium. Sporophore production was observed in saw dust medium (moist saw dust 300g, 10 per cent malt extract plus 15 ml of biotin 5 ppm) two months after inoculation. Maximum growth of the fungus occurred at pH 5.5 in culture, though the fungus was observed to grow in a wider range of pH. Glucose and peptone were found to be the best carbon and nitrogen sources for growth of the fungus.

G. lucidum is known to secrete several enzymes in culture including diastase, laccase, protease, invertase, coagulase, rennetase and oxidase. The pathogen also produces the cell wall degrading enzymes like macerating enzymes, *endo* polygalacturonase, polygalacturonase, *trans* eliminase, pectin *trans* eliminase and cellulolytic enzymes (Cl and Cx) in culture. These enzymes were detected *in vivo* also.

5. HOST RANGE

G. lucidum has got a very wide host range infecting both monocots and dicots. Besides coconut, it has been recorded on palms like *Areca catechu L.* (arecanut), *Borassus flabellifer* (palmyra) and *Elaeis guineensis* Jacq. (oil palm) and a host of other perennial trees. The prominent tree hosts are *Acacia catechu* Willd. (Black cutch), *A. melanoxylon* R. Br. (Austrialian black wood), *Albizia lebbeck* Benth. (lebbeck tree), *Cassia fistula* L. (Indian laburnum), *C. siamea* Lam. (kassod-tree), *Casurina equisetifolia* Forst. (Casuarina), *Citrus sinensis* (L.) Osbeck (sweet orange), *Dalbergia latifolia* Roxb. (rosewood), *D. sissoo* Roxb. (shisham), *Delonix regia* (Boj. ex Hook) Raf. (gulmohar), *Eucalyptus citriodora* Hook. (eucalyptus), *Ficus* spp., *Gliricidia maculata* H.B. & K., *Hevea* spp. (rubber), *Leucaena leucocephala* (Lam.) de Wit. (subabul), *Mangifera indica* L. (mango), *Melia azadirachta* L. (neem) , *Morus alba* L. (mulberry), *Pinus roxburghii* Sarg. (pine), *Pongamia pinnata* (L.)

Merr. (karanja), *Populus euramericana* (Dode) Guinier (poplar), *Ptcrocarpus marsupium* Roxb. (Indian kino), *Quercus semicarpifolia* Smith (brown oak), *Shorea robusta* Geertn. (sal), *Sterculia villosa* Roxb (udar), *Tamarindus indica* L. (tamarind) and *Vitis vinifera* L. (grapes).

6. EPIDEMIOLOGY

The disease is mostly prevalent in sandy soil and where coconut is raised under rainfed conditions. Lack of soil moisture during summer months and water stagnation during rainy season, presence of old infected stumps in the garden and non adoption of recommended cultural practices favoured the disease spread. Generally the disease incidence was more (43%) in trees in the age group of 10 to 30 years. The disease incidence was more between March and August at Veppankulam. A positive correlation was observed at Veppankulam between mean maximum soil temperature and the number of bleeding palms. It was not correwlated with minimum temperature, rainfall and relative humidity. Studies in Ambajipet also showed that soil temperature influenced disease spread since it was more during March-June when soil temperature was the highest. Further studies showed that increase in soil moisture decreased the severity of the disease. The disease incidence was low in heavy soils in Andhra Pradesh, due to retention of more moisture by this type of soils, besides the presence of high population of antagonistic microflora. The lesser disease spread during rainy season was attributed to the adverse effect of high soil moisture on the pathogen due to heavy rainfall.

The disease spreads from tree to tree mostly by root contact. From the original source of infected tree, the disease spreads in all directions. It takes about 6 to 18 months for the disease to spread to the adjacent palm. This time lag is dependent upon the soil conditions and cultural practices adopted. In the disease endemic area of Thambikkottai (Thanjavur district) in a coconut garden having 236 palms with 39 diseased ones (16.5% disease incidence), within a period of six years, the disease had spread to 188 palms (80%), of which 75 had died.

7. EARLY DIAGNOSIS OF THE DISEASE

For taking up effective control measures against the disease, it is imperative that the disease is detected in the early stage itself. Attempts have been made to use the biochemical and physiological changes in diseased palms for developing diagnostic tests.

7.1 Colorimetric methods

7.1.1 EDTA test: One gram root tissues were immersed in 10 ml of 0.3 M EDTA-disodium salt solution for one hour. The solution was filtered and optical density (O.D.) recorded at 400 nm wave length in Spectronic-20 colorimeter. The O.D. values increased with increase in disease severity. For mild type of symptoms the values ranged between 0.19 and 0.23, between 0.24 and 0.59 for moderate type and above 0.60 for severe symptoms, as against 0.02 to 0.10 for healthy palms. In apparently healthy palms, increase in O.D. value was observed at least six months before symptom expression. However, further refinement is needed to fix the critical O.D. values for symptom expression.

7.1.2 Orthophenanthroline test: Two gram root tissues were immersed in 0.1 M orthophenanthroline solution for 16 hours and O.D. values were recorded at 570 nm. The O.D. values increased with increase in disease severity in roots. The values are 0.25 for mild, 0.29 for moderate, 0.31 for severe and 0.17 for healthy root tissues. But values with leaf tissues show no pattern and hence can not be used with reliability.

7.1.3 Triphenyl tetrazolium chloride test: One gram leaf or root tissues, chopped into small pieces, were immersed in 10ml of 0.1% 2,3,5-triphenyl tetrazolium chloride (TTC) solution. The O.D. values observed after 24 hours at 460 nm, increased with increase in disease severity. Leaf tissues showed very high O.D. values when compared to root tissues (Table 3).

Table 3. Optical density values in TTC test in basal stem rot affected coconut (Veppankulam)

Samples	O.D. value at 460 nm	
	Leaf	Root
Healthy	0.14	0.08
Disease-mild	0.26	0.10
Disease-moderate	0.32	0.11
Disease-severe	0.40	0.12

7.2. Physiological methods

7.2.1 Electrolyte leakage and relative water content: The electrical conductivity was higher in root and leaf tissues of diseased palms than healthy ones. The relative water content (RWC) of leaves decreased in diseased leaves when compared to healthy ones (Table 4).

Table 4. Electrical conductivity (μ mhos/s.) and relative water content in basal stem rot affected palms (Veppankulam)

Samples	Electrical Conductivity		RWC %
	Leaf	Root	
Disease-mild	52.48	92.78	54.43
Disease-moderate	51.48	92.12	50.12
Disease-severe	59.20	112.16	48.99
Healthy	46.58	83.76	56.53
C.D. (P=0.05)	1.96	5.95	2.43

7.2.2 Transpiration rate and stomatal diffusive resistance: Transpiration rate increased in leaf tissues progressively with increase in disease severity. Stomatal diffusive resistance decreased in the diseased leaves (Table 5).

Table 5. Transpiration rate and stomatal diffusive resistance in basal stem rot affected coconut leaves (Veppankulam)

Samples	Transpiration rate ($\mu g/cm^2/s$)	Stomatal diffusive resistance (s/cm)
Disease-mild	14.14	2.02
Disease-moderate	15.06	1.98
Disease-severe	18.02	1.91
Healthy	10.08	2.51

One hundred apparently healthy palms adjacent to diseased palms were tested for transpiration rate at monthly intervals. Out of hundred palms, forty palms exhibited higher transpiration rate. Among these, twelve palms exhibited symptoms of basal stem rot disease during the next one year. Higher transpiration rate was observed at least 6 months before symptom expression. Hence this also can be employed as tool in early diagnosis.

7.3 Indicator plants

Among the hosts of the pathogen, some

plant species are highly susceptible and are infected in the field much earlier than other species of host plants. For detecting the presence of inoculum (*G. lucidum*) in coconut gardens, various plant species were tested. Subabul (*Leucaena leucocephala*) and *Glyricidia maculata* contracted natural infection under field conditions at least 6-18 months earlier than the coconut palms, and hence can be used as good indicator plants. In the glass house, 80% of subabul seedlings inoculated with *G. lucidum* culture established in sterilized coconut roots, showed drying of terminal shoot and leaves and rotting of fine roots one month after inoculation (Fig. 4). This shows that subabul may be useful as an indicator plant for basal stem rot disease under field conditions.

7.4 Serological methods: Preliminary results at Ambajipet indicated possibilities of detecting infection in apparently healthy palms in disease affected tracts using the specific antiserum developed against *G. applanatum*.

7.5 Fluorescent antibody technique: This method was developed at CPCRI Research Centre, Hirehalli. Root sections of diseased, apparently healthy and healthy coconut palms were treated with fluorescein isothiocyanate (FITC)-conjugated antiserum and incubated for 3-4 hours. After draining the unconjugated antiserum, the sections were washed with Tris hydrochloride buffer and mounted on buffered glycerine and examined under fluorescence microscope. The root sections of healthy palms showed pale green fluorescence in xylem and phloem elements

Fig. 4: Wilting of Subabul seedlings inoculated with *G. lucidum*

whereas diseased root sections had no such intense green fluorescence.

8. DISEASE INDEXING METHOD

A disease indexing method was developed at Veppankulam in 1972 for assessing the severity of the disease. In this method, the disease index may exceed 100 and there is no upper limit for disease index. Hence the method was refined later and a new disease index formula was developed in 1993 based on data collected on 922 disease affected palms at Veppankulam. Disease index (D.I.) = 23.6+17.7h+3.6r-0.6l, where h is the height in meters up to which bleeding symptom has spread in the stem, l is the number of functional leaves in the crown and r is the score for reduction in leaf size in 0 (zero) to 4 scale. Linear correlation coefficient of each variable with area of bleeding patches and step-down regression for finding out the importance and contribution of each variable for disease index were worked out. According to this formula, an index score of 15 and below can be considered as mild, 15 to 40 as moderate and above 40 as severely diseased.

9. MANAGEMENT

The results of a large number of field experiments conducted in Tamil Nadu, Karnataka, Andhra Pradesh and Kerala, have given some definite indications on the practices to be followed for managing the disease.

9.1 Phytosanitation: Palms which are dead due to severe infection of the disease and also stumps remaining in the diseased garden should be removed along with bole and root system. Often stumps and old infected palms show the presence of brackets. If strict phytosanitary measures are adopted, the inoculum in the garden can be minimised.

9.2 Cultural practices: Since the fungus has a wide host range, it is better to avoid planting susceptible host plants in the disease affected garden. Instead, planting of intercrops like banana can be taken up, since banana is a non-host of the pathogen. Cultural practices like ploughing and flood irrigation help in carrying the inoculum from the foci of infection to other areas resulting in spread of the disease. Hence, in disease affected gardens it would be better to avoid such cultural operations which aid in the spread of disease. Drip irrigation/basin irrigation may be adopted in place of flood irrigation. Isolation trenches, 1m deep and 30 cm wide, may be dug around diseased palms so that there is no contact between roots of diseased and healthy palms.

9.3 Soil moisture regime: Increased soil moisture was found to decrease disease severity. With this in mind an irrigation experiment was conducted at Veppankulam. Irrigation along with Bordeaux mixture drenching, or application of green leaves/ compost/farm yard manure + burying coconut husks in circular trench around the palm + Bordeaux mixture drenching helped in reducing the disease severity at Veppankulam.

9.4 Effect of nutrients: Trials conducted at Veppankulam from 1977 to 1982 showed that plots treated with 350, 250 and 450g N,

P_2O_5 and K_2O /palm/year respectively had low disease index (4.20) and high nut yield (72 nuts/palm/year) while higher doses of fertilizers increased the disease intensity. In the case of secondary and micronutrients, there was no consistency in results regarding their effect on reducing disease index or improving yield in Tamil Nadu.

9.5 Effect of organic manures: Annual application of 50kg farm yard manure or green leaves or 300 kg tank silt or 5 kg neem cake was found to be beneficial in arresting the disease progress at Veppankulam. However, neem cake (5 kg) when applied along with soil drenching with 1% Bordeaux mixture + Aureofungin-sol stem injection gave better disease control.

9.6 Effect of fungicides and chemicals: Trials conducted at Veppankulam during 1987 to 1991 showed that soil drenching with 40 litres of 1% Bordeaux mixture and root feeding of 1.3g Aureofungin-sol (0.6g a.i.)+0.5g copper sulphate in 100 ml of water thrice at quarterly intervals along with annual application of neem cake (5 kg) helped in arresting the disease progress considerably (Table 6). There should be at least one month interval between neem cake application and Bordeaux mixture drenching. Tridemorph can be used as an alternative choice as shown in the field trials conducted by CPCRI in Kerala (Table 7).

At Ambajipet, field trials conducted during 1992-95 showed that palms receiving tridemorph at 6ml in 20ml water/palm through root feeding (Fig. 5) recorded less disease index than other treatments.

9.7 Effect of tapping for neera on disease severity: At Veppankulam, tapping diseased palms for neera in early stage of disease was

Table 6. Effect of neem cake and fungicides on basal stem rot disease of coconut (Veppankulam)

Treatments	Disease index**		Yield increase over control (%)
	Initial (1987)	Final (1991)	
Neem cake 5 kg/palm (NC)	5.9	71.9	78
NC + Carbendazim* 2g/100 ml	6.9	139.8	30
NC + Carboxin* 2g/100 ml	5.9	159.6	43
NC + Aureofungin-sol* 0.6g ai (AF)+0.5g copper sulphate in 100 ml	5.3	45.8	176
NC + Tridemorph* 2ml/100 ml	5.8	31.3	132
NC + AF + 40 litres of 1% Bordeaux mixture (Soil drench)	7.3	35.9	197
Control	7.4	175.1	-
C.D. (P=0.05)	NS	19.5	-

* Given through root feeding

** Disease index was worked out based on the old formula developed by Vijayan and Natarajan, 1972

Table 7. Management of basal stem rot disease of coconut in Palghat Dt. Kerala (1986-89) (CPCRI, Kasaragod)

Treatment	No. of palms	Average yield of nuts/palm	
		1986	1989
Aureofungin-sol*	36	31	59
Tridemorph*	15	7	47

* Given through root feeding

Fig. 5. Root feeding with Tridemorph

found to reduce disease index in the initial 1-2 years. The yield in diseased tapped palms also showed an upward trend (Table 8).

9.8 Biofertilizers for disease management: Application of phosphobacteria (200g) with 10kg of farm yard manure per tree per year to basal stem rot affected coconut significantly reduced the disease intensity and increased the yield as compared to other treatments involving *Azospirillum* and the VAM fungus *Gigaspora calospora* (Table 9).

9.9 Antagonistic fungi: *Trichoderma harzianum* and *T. viride* were found to be antagonistic to *G. lucidumin in vitro* trests. In a field experiment initiated in 1992, *T. harzianum* applied along with neem cake or farm yard manure+Bordeaux mixture recorded lesser disease intensity and higher yield than other treatments including control (Table 10).

9.10 Intercropping: Among the intercrops tried, banana was found to be the best followed by sunhemp and turmeric (Table 11). It was found that banana rhizome extract

Table 8. Effect of tapping for neera production on basal stem rot disease of coconut(Veppankulam)

Treatments	Disease index*			Yield of nuts	
	At completion of tapping (initial)	One year after tapping	Three years after tapping	Mean	Increase over untapped diseased palms (%)
Tapped					
i)	0.92	1.18	26.54	99	35.6
ii)	3.53	4.68	38.20	66	78.1
iii)	15.86	21.00	93.92	34	36.0
Untapped (Control)					
i)	6.62	36.75	72.56	73	—
ii)	5.75	33.93	96.34	37	—
iii)	9.29	32.04	104.53	25	—

* Disease index was worked out based on the old formula developed by Vijayan and Natarajan, 1972

Table 9. Effect of biofertilizers on basal stem rot disease of coconut and nut yield (Veppankulam)

Treatments	Disease index*		Nut yield per palm*	
	1990 (Initial)	1993	1990-91	1992-93
Azospirillum Inoculum 200g	0.4	56.5	90	90
Phosphobacteria inoculum 200g	0.6	9.2	86	102
Gigaspora calospora inoculum 500g	0.1	49.8	96	89
Control	20.8	74.3	80	76
C.D (P=0.05)	2.7	4.5	NS	3

* Mean of five replications

Table 10. Effect of *Trichoderma harzianum* with different organic manures on basal stem rot intensity and nut yield (Veppankulam)

Treatments	Disease index*		Nut yield (No.)/palm*	
	1992 (Initial)	1994 (Final)	1992-93 (Initial)	1994-95 (Final)
T. harzianum with neem cake 5 kg	9.8	27.2	97	54
T.h. with FYM 50 kg	10.8	49.2	101	44
T.h. with tank silt 100 kg	54.4	62.4	83	41
T.h. with composted coir pith 50 kg	14.6	61.9	90	58
T.h. with poultry manure 10 kg	71.1	72.0	94	34
T.h. with green leaves 50 kg	8.6	23.4	88	80
T.h. with FYM + Bordeaux mixture	11.3	28.0	96	80
Control	32.9	92.9	44	7
C.D. (P=0.05)	7.8	9.6	NS	8

* Yield observed from July to June

Table 11. Effect of intercropping on basal stem rot disease and nut yield in coconut (Veppankulam)

Intercrops	Disease index*		Nut yield per palm* per year	
	1988	1990	1987-88	1989-90
Banana	0.2	0.8	83	121
Turmeric	1.0	4.6	60	76
Sunhemp	0.9	2.3	75	90
Kolingi	4.6	21.3	65	81
Desmodium	22.5	51.5	60	38
Control (no intercrop)	36.2	71.3	64	19
C.D. (P=0.05)	0.4	1.6	NS	5

gave more than 80 percent inhibition of the *in vitro* growth of *G. lucidum* (Fig. 6). Nut yield increased significantly in banana intercropped plot in a period of two years as against a sharp decrease in control plots.

9.11 Integrated management: Based on the results obtained in different centres, an integrated approach is suggested for the management of the disease.

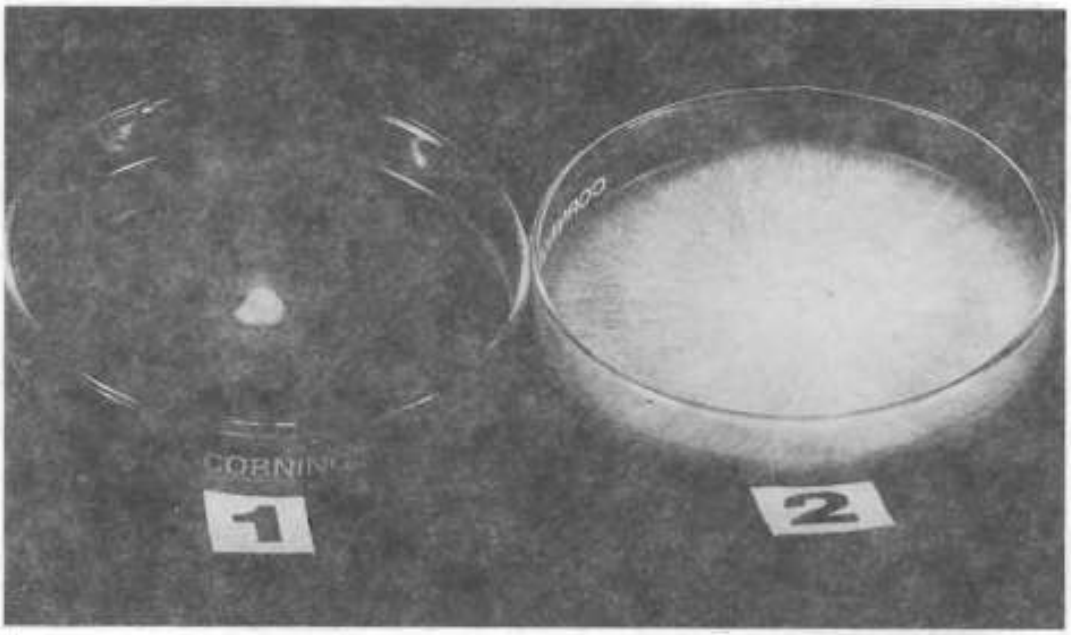

Fig. 6: Inhibition of *in vitro* growth of *G. lucidum* by banana rhizome extract

1. Removal of dead palms and stumps in the garden and destruction of the bole and roots of these palms by burning.

2. Isolation of diseased palms from healthy by digging circular trenches 1m deep and 30cm wide.

3. Adopt summer irrigation or moisture conservation by coconut husk burial in the basin. Avoid flood irrigation or ploughing in infected gardens to prevent inoculum spread. Adopt drip irrigation/basin irrigation.

4. Application of 5 kg neem cake per palm per year in addition to regular application of organics (50kg FYM or green leaves) and recommended fertilizers.

5. Raising disease tolerant intercrops like banana wherever irrigation is possible.

6. Application of phosphobacteria (200 g with 10 kg of farm yard manure per tree) every year.

7. Root feeding of 1.3 g Aureofungin-sol (0.6g ai)+0.5g of copper sulphate in 100ml of water along with soil drenching with 25-40l of 1% Bordeaux mixture thrice at quarterly intervals.

8. Tridemorph 5-10% (100ml) can also be used for root feeding as an alternative fungicide. Fungicide treatment will be effective only for palms in early stages of the disease.

9. If *Xyleborus* attack is found in the stem, the pest may be controlled by proper insecticide treatment.