# *Ganoderma* wilt – A Lethal disease of coconut in Tamil Nadu
# Research accomplishments and future thrust


## ABSTRACT

*Ganoderma* wilt or *Thanjavur* wilt disease is the most lethal one, is caused by the fungus *Ganoderma lucidum* (leys) Karst and it is of major limiting factor in coconut production in nine coastal districts of Tamil Nadu. The high alarming of the disease alerted the government to launch the *Ganoderma* wilt research in the state in the yesteryear. Subsequently, more than five decadal researches done on this disease that provides preliminary, applied and advanced results and outcomes that are crucial and fruitful in the disease management. The endemic nature of the disease is evident and it has been witnessed with the severe spread of the disease in the east coast region of Tamil Nadu after the attack of Gaja cyclone urges the research efforts to contain the disease. The disease incidence ranges from 6.5 % to 50% in Thanjavur district followed by Nagapattinam and Thiruvarur districts is continuously reminds the threat of the disease to the coconut farmers in this region. In this juncture, It is indispensable to highlight the significant works on documentation of disease incidence, isolation of pathogen , pathogenicity, virulence study , disease index formula development, early and rapid detection methods, epidemiology, pathophysiology, agronomical, cultural, biological chemical disease control methods ,integrated disease management strategy *etc.*, .done ,in the past and it is necessarily a boon to the current research work. Obviously, the brief review will make a corner stone and open up new discussion on the most important aspects of the disease management. This necessitates and leads the new line of research coping with the future thrusts will helpful in combating the lethal disease in the post Gaja cyclone scenario in the state.



**Keywords:** *Ganoderma* wilt, coconut, Integrated disease management, Diagnosis, biocontrol, and chemical control


## INTRODUCTION

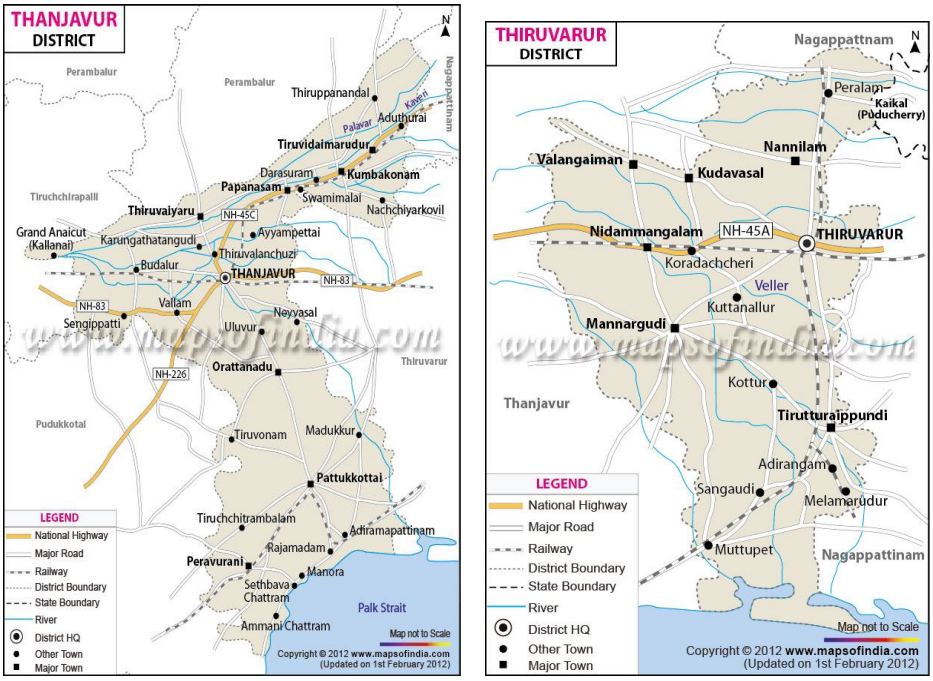
India is one of the lead producers of coconut in the world with an area of 2.15 million hectares, annual production of 21288 million nuts and productivity of 9897 nuts / ha during 2018-19 (Coconut Development Board, Kochi, India). The major limitation of the coconut production in the country is due to the occurrence of various lethal and debilitating diseases. Among the disease, *Ganoderma* wilt caused by the fungus *Ganoderma lucidum* (leys) Karst is the most lethal one, causing a considerable loss in coconut production. The disease is known as basal stem rot or Bole rot or *Ganoderma* wilt or *Thanjavur* wilt or *Anabe roga*. The disease is commonly prevalent in the coconut growing countries South Asia and Asia Pacific regions. The disease incidence is reported in the four major coconut growing states of India *viz.,* Tamil Nadu, Karnataka, Andhra Pradesh and Kerala. (Anbalagan *et.al.*,1984). In Tamil Nadu, the disease as Thanjavur wilt was first noticed in the Thanjavur district after the 1952 and 1956 cyclones (Vijayan and Natarajan 1972). The disease was reported as a major limiting factor in coastal districts of Tamil Nadu and Andhra Pradesh (Vijayan and Natarajan 1972, Srinivasulu 2001a).

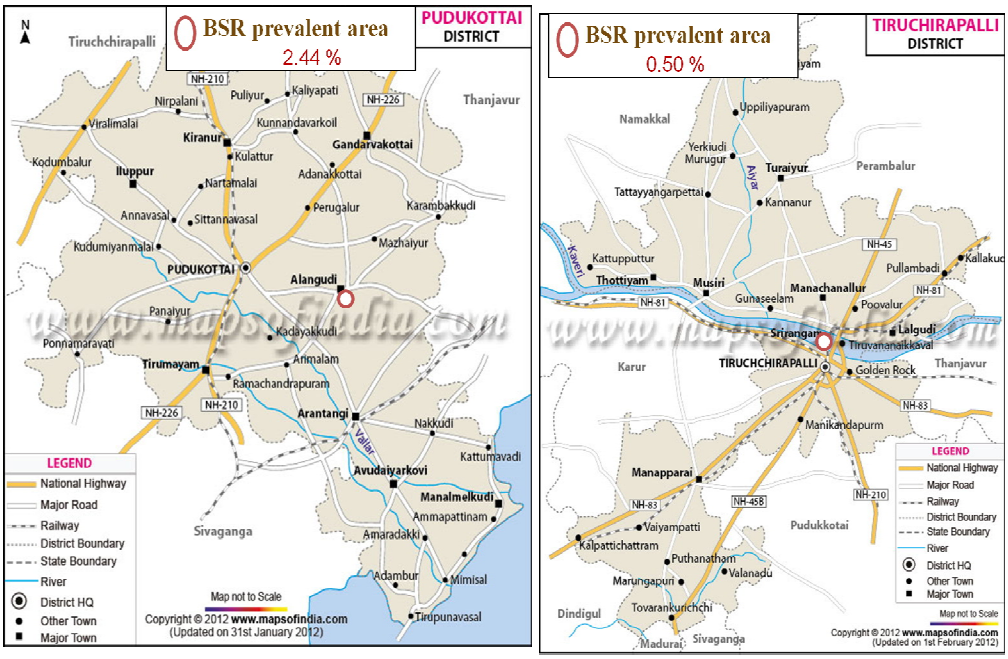
Nine coastal districts of Tamil Nadu showed the disease incidence and ranged from 0 to 46.37 per cent with a mean incidence of 3.71 per cent (Annonymons, 2005). The disease is mainly prevalent in lighter soils in the coastal districts of Andhra Pradesh and showed 100 per cent mortality of coconut palms in severely diseased gardens (Satyanarayana *et al.*, 1985, Bhaskaran and Ramanathan 1984, Papa Rao and Govinda Rao 1966, Srinivasulu *et al.* 2001a, 2002a). The disease is widely prevalent in the *maidan* tract of the southern region of Karnataka. The incidence of *Ganoderma* disease was also recorded to the extent of 10 per cent in some gardens in Palakkad district of Kerala. Surveys conducted in southern

states of India over the years revealed that the disease intensity varied in different states and maximum intensity of 50% was reported in Tamil Nadu.

Vijayan and Natarajan (1972) conducted surveys in different districts of Tamil Nadu and reported that an average disease intensity of 6.5% in coastal coconut belt of Thanjavur district and the disease maximum reached up to 50% in Thambikottai village during the survey. Bhaskaran and Ramanathan (1984) reported that disease was more in the Thanjavur district followed by the Chingelput district and the incidence ranged from 0.6 to 4.9%. In some of the severely infected gardens, more disease incidence was as high as 31.4%. Snehalatharani *et al.* 2014a assessed the severity of the basal stem rot disease and threat to coconut growers in Thanjavur, Thiruvarur and Nagapattinam districts of Tamil Nadu. The maximum mean per cent incidence of BSR was recorded as 6.5 % in Thanjavur district followed by Nagapattinam and Thiruvarur district. The more disease incidence was found during March and August (Bhaskaran and Ramanathan, 1984) and Vijayan and Natarajan (1972) observed more number of mortality of palms during summer and mostly observed that the diseased palms survived up to three years from the initial appearance of disease symptoms, In some cases, the sudden wilting of palms occurred in six months from the initial symptom and no death of palms was observed.

**Fig.(1a,1b,1c & 1d) Distribution of Basal stem rot disease in east coast region of Tamil Nadu**

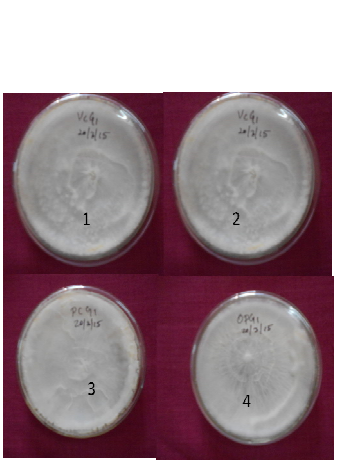





## Casual organism

The fungi *Ganoderma lucidum* and *G.applanatum* causing coconut basal stem rot disease were isolated from the roots of the diseased coconut in India. *G.lucidum* was predominately associated with the disease and its pathogenicity was established on 35 years old coconut palms in Tamil Nadu (Vijayan and Natarajan, 1972, Bhaskaran *et al.,* 1990 and Bhaskaran *et al.,* 1991). CABI Bio Science, United Kingdom made isolation studies from the disease endemic areas of Tamil Nadu also confirmed the presence of *Ganoderma spp.* in root and stem tissues of diseased coconut palm. Thirty five *Ganoderma* isolates of coconut from Andhra Pradesh, Karnataka and Tamil Nadu showed that the genetic similarity among the isolates ranged from 0 to 88.4% with RAPD PCR based clustering (Anonymous 2014). Rajendran *et al.* (2008) analyzed the laccase enzyme activity for the assessment of virulence of the *Ganoderma* isolates and cloned the partial sequence of laccase gene from highly virulent isolate.

**Fig.(2a & 2b) *Ganoderma* Isolates**




## Disease Epidemiology:

Coconut grown under rainfed conditions in sandy soils in coastal areas is prone to the disease and also the neglected plantations (Bhaskaran and Ramanathan 1984). The drought condition during summer months, water stagnation during rainy season, old infected stumps in the garden and faulty method of irrigation practices were found to favour the spread of the disease. In Tamil Nadu, the disease incidence was more between March and August and it was positively correlated with mean maximum soil temperature and negatively correlated with minimum temperature, rainfall and relative humidity (Bhaskaran *et al.* 1990, Karthikeyan *et al.* 2006b and Bhaskaran *et al*. 1985).

Almost all of the coconut genotypes in the country are susceptible to the disease. The age of the coconut trees between 10 to 30 years are more susceptible to the disease with an incidence ranged from 17-43 per cent. The Veppankulam hybrid coconuts *viz.,* VHC1, VHC2 and VHC3 were found to be attacked by the disease even at the age of 5 to 6 years. Young coconut seedlings / juvenile palms of 1-4 years old are also infected in disease endemic areas.

Soil and weather conditions are the major predisposing factors for the spread of the disease. The disease is mainly spread through infected root contact, transportation of infected soil during cultural practices and irrigation water. There is a high risk of spread of pathogen from diseased area to new areas through soil adhering on coconut seedlings.

### Disease assessment:

Bhaskaran and Karthikeyan (1994) developed a disease index formula for assessing the severity of *Ganoderma* wilt disease of coconut.
Disease index=23.6+17.7h+3.6 r-0.6 l

Where h=height in meters up to which bleeding has spread in the stem
r =reduction in leaf size in 0.4 scale
l=no. of functional leaves in the crown

An index score of below 15 can be considered as mild, 15 to 40 as moderate and above 40 are severely diseased.

### Pathophysiology

It was possible to formulate suitable disease management practices of cultural and chemical methods through the study on growth characters of pathogen and understanding the physiology of diseased palms. The growth of the fungus *G.ludicum* is possible in a wider range of pH and the maximum growth was observed at pH 5.5 in culture. Glucose and peptone were the least carbon and nitrogen sources respectively for the fungus.

### Total phenol and OD phenols

Phenol oxidizing enzymes peroxidase and polyphenol oxidase and nitrate reductase activities were reported more in leaf and root tissues of diseased palms than healthy ones. Starch, Lignin and amino nitrogen contents were less in leaf and root tissues of diseased palms as compared to healthy palms. Higher amount of proline was recorded in wilt affected palms.

## Early Diagnosis

Management practices developed for *Ganoderma* disease of coconut will be useful only if the palms are treated in the early stage of infection. By the time the visual symptoms appear in the palms, much damage might have occurred to the roots and bole region. Hence, developing methods for early diagnosis for *Ganoderma* disease will be useful in the management of the disease. Chemodiagnosis methods EDTA and TTC tests and physiological parameters EC and RWC are useful to detect the disease in coconut palms, 4-14 months before showing visual symptom found useful in disease management. (Natarajan *et al.* 1986) and Karthikeyan and Bhaskaran, 2004).

Rapid detection of *Ganoderma* disease through molecular and immunological methods was carried out by Karthikeyan *et al.,* 2006a. Karthikeyan *et al.* (2007) reported that a combination of polyclonal antibodies and PCR based methods were highly reliable, rapid and sensitive in early detection of BSR in coconut.

Roots from apparently healthy palms were tested for the infection of *Ganoderma* with ELISA test. Field evaluation was carried out with basidiocarp mycelia protein antiserum and OD values higher than 0.717 were taken as infection; this value was arrived at ELISA test. Out of 235 palms tested, 85 palms were affected. The results were further confirmed with the PCR technique exploited Gan 1 and Gan 2 primers with the application product of 167bp.

## Symptoms

Exudation of reddish brown viscous liquid from the basal portion of the stem and develop bleeding patches near the ground level is the visual symptom of the disease. Bleeding patches gradually spread vertically in a upward direction with the high disease intensity. Extensive root rotting and discoloration of roots are the first stage of internal symptoms. Production of new roots is also affected. As the disease advances, upward progression of yellowing, drooping and drying of leaves with the skirt like formation around trunk. Subsequently heavy bottom shredding, an upward extension of the stem decay and death of palm are observed. The appearance of sporophores of *G.lucidum* may be found at the base of the trunk in some palms prior to wilting or just after the death of palm. The disease development period taken from the initial appearance of bleeding patches on the stem to death of palm is from 6 to 54 months, the average being 24months.

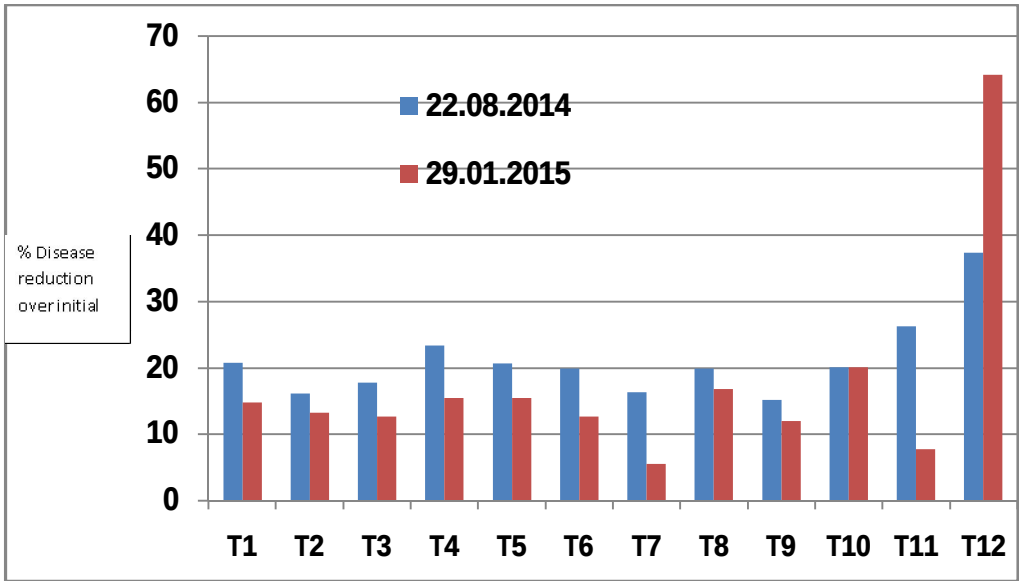
Thirumalaiswamy *et al.* (1992) reported that palms aged 10 years and older were more susceptible to the *Ganoderma* wilt disease than younger palms. Severely infected palms emit alcoholic smell and showed root rotting symptom up to 70 % (Rethinam 1984,Bhaskaran 1986, Srinivasulu and Rao 2007)**.** According to Karthikeyan *et al.* (2006a) the exudation of reddish brown from the stem that are visible only after progression of the damage of root and bole below ground level to the stem with the damage of 15 to 25%. The most probable case of infection of the disease occurred in profusely bearing palms (Vijayan and Natarajan 1972, Bhaskaran 1986 and Srinivasulu and Rao 2007).

## Disease management

Sanderson *et al. (*2000) advocated the integrated disease management system for the considerable reduction of the disease. Nambiar and Rawther (1993) reported that ploughing and flood irrigation spread the pathogen and should be avoided. According to Karthikeyan and Bhaskaran (2001) growing intercrops reduces the disease incidence, banana was very effective among many intercrops in containing the disease and increase the beneficial soil microbiota. ICAR-All India Co-ordinated Research Project on palms was instrumental in conducting field trials on cultural, chemical and biological control of *Ganoderma* wilt at different centers. Application of recommended dose of NPK 0.56N, 0.32$P_2O_5$,1.5 Kg $K_2O$ per palm per year along with 50 Kg farm yard manure and neem cake 5 Kg enhanced the soil antagonists and reduced the disease severity. Vijayan and Natarajan 1975.

Studies conducted at coconut Research Station, Veppankulam on the application of calcium sulphate and magnesium sulphate each at 500g/palm/year in disease affected gardens was found effective in the disease management and also the soil application of manganese sulphate at 227g/palm/year reduced the disease intensity. Tapping for sweet toddy in wilt affected coconut palms for a period of months reduced in disease severity and increases the nut yield. Tapped diseased palms had more phenols, starch, amino nitrogen and chlorophylls than untapped disease palms. Among the plant extracts tested, banana rhizome extract gave 86 per cent inhibition of mycelia growth of the pathogen in the laboratory. Banana intercropping in wilt affected Gardens is recommended to manage the disease (Bhaskaran *et al.,* 1989).

**Fig. 3. Management of basal stem rot disease in coconut IDM practices during 2014-2015 at CRS, Veppankulam**




| Treatments | |
|---|---|
| $T_1$-SA -125 g of *T.v* + 1.25 Kg neem cake per palm at quarterly | $T_8$- SA-125 g each of *T.v* and *Pf* + 2.5 Kg of neem cake per palm at six month interval. |
| $T_2$-SA -125 g of *T.v* + 2.5 Kg neem cake per palm at six month interval. | $T_9$-Soil application of talc based formulation of 125 g each of *T.v* and *Pf* + 5 Kg of neem cake per palm at yearly interval. |
| $T_3$-SA -125 g of *T.v* + 5 Kg neem cake per palm at yearly interval. | $T_{10}$-Root feeding of 1 ml of Hexaconazole in 100 ml water thrice in a year |
| $T_4$-SA of 125 g of *Pf*+ 1.25 Kg of neem cake per palm at quarterly interval. | $T_{11}$-Soil application of talc based formulation of 125 g each of *T.v* and *Pf* + 5 Kg of neem cake per palm at yearly interval + Root feeding of 1 ml of Hexaconazole in 100 ml water thrice in a year + Micro nutrient application @ 1 Kg /palm/year. |
| $T_5$-SA of 125 g of *Pf*+ 2.5 Kg of neem cake per palm at six month interval. | $T_{12}$-Control (without fungicide, bio-agent, micronutrient mixture) |
| $T_6$-SA of 125 g of *Pf*+ 5 Kg of neem cake per palm at yearly interval. | SA-Soil application of talc based formulation |
| $T_7$-SA 125 g each of *T.v* and *Pf* + 1.25 Kg of neem cake per palm at quarterly interval. | *T.v- Trichoderma viride*<br>*Pf- Pseudomonas fluorescens* |

**Table 1: Treatment details**

## Chemical control

Evaluation of various fungicides was tested against the pathogen *G.lucidum* under *in vitro* and *in vivo* conditions. Soil drenching with 40 litres of 1 per cent Bordeaux mixture or 0.05 per cent carboxin and root feeding of Tridemorph Aureofungin sol 1.38+0.5 g copper sulphate in 100 ml of water thrice at quarterly intervals reduce in disease severity and increase the nut yield in Tamil Nadu. Naik (2001) studied many fungicides used as root feeding and soil drenching and obtained lowest disease index.
Recent field trials conducted at CPCRI, Kasargod, India and CRS, Veppankulam revealed that root feeding with hexaconazole 2 ml in 100 ml water at quarterly intervals contained the disease incidence.

## Biological control

*In vitro evaluation of Trichoderma harzianum* and *T.viride* were found effective in showing antagonism against *G.lucidum*. Application of 500g inoculum of (sand maize medium) *T.harzianum* along with organic green leaves (50 Kg) or neem cake (5 Kg Srinivasalu *et. al.* 2004a and 2005) or farm yard manure(50 Kg) + 1 % Bordeaux mixture as soil drenching was effective in disease control under field condition (Karthikeyan *et.al.,* 2005, Karthikeyan *et.al.,* 2006).

Soil application of talc formulation of *Pseudomonas flurosence* +*Trichoderma viride* each at the rate of 200 g along with 50 Kg farm yard manure is advocated for containing the disease. (Karthikeyan *et.al.,* 2005 and Surulirajan, 2014) Soil application of Azotobactor 200 g and Azospirillum 200 g along with 10 Kg farm yard manure enhances the soil health by reducing the pathogen population. Karunanidhi *et. al.* 2007. confirmed that *Pongamia glabra*, *Azadirachta indica* and *Prosopis julifera* at 10 % concentration were found effective against basal stem rot disease in field.

All the ruling coconut genotypes including hybrids are susceptible to the disease. In breeding for disease resistance East coast Tall x wilt tolerant ECT genotypes was developed which showed resistance to wilt in disease in endemic area with higher survival rate, vigorous growth and yield. The implementation of integrated disease management against basal stem rot disease was done by Karthikeyan *et.al.,* 2006. Rajappan and Vaithiyalingam, 2009.

## Research accomplishments

1. Symptoms and epidemiology of the disease have been documented
2. *G.lucidum* and *G.applanatum* were found to be associated with the disease and their pathogenicity was established
3. Pathophysiology of diseased palm has been analyzed
4. Detailed studied have been made on growth characters of the pathogen
5. Cultural, chemical and biological methods have been developed for the disease management
6. A disease tolerant coconut genotypes has been developed
7. Chemodiagnostic physiological and molecular tests for early diagnostics of the disease have been evolved.
8. Integrated management of basal stem rot disease in coconut involving soil application of talc based formulation of 125g each of *Trichoderma viride* and *Pseudomonas fluorescens* + 1.25 Kg of neem cake per palm at quarterly interval was achieved as proven technology
9. Root feeding with Propiconalzole 25 EC @ 2 ml, Hexaconazole 5 EC@ 3 ml/100 ml of water at quarterly interval was achieved as best therapeutic treatment in combating the basal stem rot disease

10. Bio-priming of coconut seed nuts with talc formulation of *Trichoderma viride and Pseudomonas* was achieved as promising technology to obtain disease free and the increased vigour of the coconut seedlings in the nursery

### Prediction status on the spread of *Ganoderma* wilt in East Coastal region of Tamil Nadu

1. The occurrence of *Ganoderma* wilt of coconut is present wherever the coconut grown in this region
2. Gaja-Cyclone has ruined the coconut gardens and also aggravated the *Ganoderma* wilt in this region
3. Flood irrigation method is in practice in almost all the gardens of this region and those coconut gardens are more prone to *Ganoderma* wilt
4. Current monsoon rain also taken into account for more spread of the disease in this region
5. Many *Ganoderma* wilt hot spot areas like Thambikkottai, Muthupet, Thennangudi,Sanakarai, Pulichankadu,Maangadu, Vanduvancheri, Solagankudikadu have been identified through survey that also important factors for the likelihood of future spread of disease

### Future research thrust in *Ganoderma* management

- Surveillance of disease and documentation of disease hot spot areas needs to be done
- Locating disease tolerant source palm in hot spot areas and their exploitation in breeding programme should be done
- Asymptomatic palms and abnormal higher yield of diseased palms should be taken up for the detailed investigation that will expedite the diagnosis and needful management
- Development of bio-intensive integrated disease management module with the engagement of effective bio-components *viz.,* bio-consortia, mycorrhiza, bio-wastes, botanicals, soil amendments, soil conditioners etc., along with the effective fungicides have to be studied in detail.
- Exploitation of antagonistic potentials in the disease management and their enumeration needs to be studied in detail
- Exploitation of new systemic combination fungicidal molecules in the disease management to resolve the problems of fungicide resistance may be studied in detail.
- Development of Nano delivery system for combating *Ganoderma* wilt- with the use of antifungal nano-particles and effective fungicides and the development of nano-emulsion formulation of fungicide will open up new avenue in the disease management strategy
- Development of new detection methods for the early detection of the disease need further investigation to take up the preventive measures before advancement of disease

## Conclusion

Basal stem rot disease of coconut is a serious disease menace in east coast region of Tamil Nadu and shows the moderate to severe form of disease. The basic research work on this disease was attempted by various workers in the past four decades. Consequently, the control of the disease was done with the almost all possible methods. However, the early disease detection is being cumbersome and ever practically not feasible. It is concluded that new options of disease management strategy is yet to be attempted to combat the lethal disease. The new innovative approaches like disease prediction and modeling and sustainable disease controlling methods may give new impetus in dealing with the every aspect of the disease and resolve the problem of sudden wilting of palms and horizontal spreading of the disease.

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