EFFECT OF MANAGEMENT PRACTICES ON THE INCIDENCE AND INTENSITY OF GREY BLIGHT DISEASE OF COCONUT

By

N. ANUPAMA

Thesis

Submitted in partial fulfilment of the

Requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

Department of Plant Pathology

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM

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DECLARATION

I hereby declare that this thesis entitled "**Effect of management practices on the incidence and intensity of grey blight disease of coconut**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellayani,

N. ANUPAMA

CERTIFICATE

Certified that this thesis entitled "Effect of management practices on the incidence and intensity of grey blight disease of coconut" is a record of research work done independently by Miss. N. Anupama under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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N. ANUPAMA

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INTRODUCTION

INTRODUCTION

Coconut (*Cocos nucifera* L) is a most important palm species of the humid tropics. Its cultivation extends over most of the islands and coasts of the tropics. India stands second in area and production of coconut in the world with an estimated area of 1.6 million hectares and an employment potential for over 10 million people. Kerala, Tamil Nadu and Karnataka account for the major area and production of coconut in the country. The productivity of coconut is 33 nuts/palm/year in Kerala against 44 nuts/palm/year in Karnataka and 55 nuts/palm/year in Tamil Nadu.

Analysing the reason for the low productivity, the International Symposium on Coconut Research and Development held at Kasaragod in November 1991 was of the view that lack of adequate management of nutrients, water, diseases and pests were the prime reason for low productivity. Pests and diseases play a pivotal role in the low productivity of coconut in Kerala. The major diseases affecting coconut palm are Bud rot, Basal stem rot, Stem bleeding, Leaf rot and Grey blight. However, Grey blight caused by *Pestalotiopsis palmarum* (Cooke) Stey has gained substantial importance due to its significant damage in certain pockets of the state. Ever since Cooke in 1875 reported the role of *P. palmarum* in decaying the leaves of *C. nucifera* in Bengal,

there have been moderate attention given to the problem of *Pestalotiopsis* mediated leaf spot of different economically important crops.

Grey leaf blight is not a major concern in Kerala with regard to reduction in yield. Yet, great damage is done to the leaves which are valuable material for thatching. However, severe outbreak of the disease, especially during the monsoon, has been a regular feature of the coconut palms at Coconut Research Station, Balaramapuram. Whereas the nearby cultivator's field are free from this disease. This raises doubt to the influence of fertilizer and spacing on the disease incidence. A perusal of literature revealed only scattered information on the morphology, pathogenicity and host range of the pathogen on crops like *C. nucifera*, *Manilkara hexandra* (root stock of sapota) *Achras sapota*, *Mangifera indica*, *Psidium guajava* etc. Very little knowledge has been generated on the influence of spacing and fertilizer application on the incidence of grey leaf blight. In the above context, the present study was taken up with the following objectives.

1. Isolation of the organism associated with the disease from endemic areas of Kayamkulam (Allapuzha District), Vellayani and at Balaramapuram (Thiruvananthapuram District).

2. Study of the symptomatology and etiology.

3. Study of the morphological and physiological characters of the causal organism.

4. Study of the host range of the pathogen.

5. Study of the influence of plant nutrition on the intensity of the disease.

6. Study of the influence of spacing and fertilizer on the intensity of the disease.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 Organisms associated with grey blight disease in coconut, their discovery, nomenclature and host range studies

2.1.1 *Pestalotiopsis palmarum*

The genus *Pestalotia* was named by de Notaris in 1839. The word is latinized from Pestalozza, the Italian Botanist after whom the genus was named. Cooke (1875) reported *Pestalotia palmarum* on decaying leaves of *Cocos nucifera* from Demerara and Bengal. *Pestalotia psidii* was first reported by Patouillard (1892) in the fruits of *Psidium pomiferum*. Burkill (1902) reported *P. palmarum* on the leaves of *Phoenix sylvestris* from Bombay. Butler (1918) reported *Pestalotia* sp. on *Mangifera indica* from India. Butler (1906) reported the fungus on *Cocos nucifera* and Sen (1907) recorded it from *Areca catechu*. Hennings (1908) recorded the fungus on mango leaves from Congo and named it *P. mangiferae* and also reported *Pestalotia sapotae* on the leaves of *Achras sapota* from Brazil. Chibber in 1912 first reported *P. psidi* from India. Wright (1925) recorded *P. palmarum* on the leaves of rubber in the nursery. Bertus (1927) made cross-inoculation studies with *P. theae* and *P. palmarum* and reported that the former species could attack injured leaves of tea and coconut, while the latter could infect injured coconut leaves only.

Guba (1929, 1932) made a monographic study of the genus *Pestalotia*. Uppal *et al*. (1935) reported *P. funerea* var. *mangiferae*. Narasimhan (1939) reported *P. psidii* on guava fruits from Mysore; but could not obtain infection on artificial inoculation. Mundkur and Kheswalla (1942) reported *P. mangiferae* and the fungus *P. sapotae* was reported from mature sapota fruits kept in cold storage.

Chowdhury (1946) conducted inoculation experiments with *P. palmarum* and found that the fungus could infect the leaves of *Borassus flabellifer*, *Areca catechu*, *Cocos nucifera* and *Phoenix sylvestris*. The inoculations were successful only through injury. Steyaert (1949) suggested an amended description for the genus *Pestalotia* in which he included only a single representative, viz., *P. pezoides*. Two new genera namely *Truncatella* and *Pestalotiopsis* were created by him for including the remaining species. Servazzi (1954) however rejected the proposal for creation of the above two genera and preferred to retain the generic name *Pestalotia*. Galluci - Rangone (1954) considered that the genus *Pestalotiopsis* was superfluous and retained the name as *Pestalotia*.

Tandon (1955) from his studies on phytopathogenicity of *P. mangiferae* concluded that the organism was a weak parasite capable of infecting only injured leaves. Agrawal and Ganguli (1959) reported that *Pestalotiopsis versicolor* causing leafspot

of *Anogeissus latifolia* could infect the leaves of *Psidium guajava* on artificial inoculation. Agnihothrulu (1962) reported the natural occurrence of *P. palmarum* on tea leaves. Bilgrami (1963) reported *Pestalotiopsis funerea* isolated from leaf spot on *Eucalyptus globulus* was able to infect the leaves of a number of plants including *Psidium guajava* and *Mangifera indica*. Tandon and Srivastava (1963) obtained infection on guava fruits with *Pestalotia cruenta* causing fruit rot of *Emblica officinalis* by artificial inoculation.

Srivastava *et al*. (1964) in their studies on fungal disease of tropical fruits recorded a leaf spot and fruit rot of *A. sapota* caused by *P. sapotae* which was proved pathogenic to the fruits on artificial inoculation. Dube and Bilgrami (1966) after conducting a study of 57 isolates included in the genera *Pestalotiopsis* and *Pestalotia* causing leaf spot on a variety of plant species concluded that all those isolates could be included in the original genus *Pestalotia*.

Anandaraj *et al*. (1992) reported a new leaf spot caused by the combined infection of *Cylindroclaidum quinquiseptatum* and *Pestalotia* sp. from *Pimenta dioica*. Ashok kumar (1992) reported that *P. mangiferae* could infect grape vine.

Karunakaran *et al*. (1993) reported grey blight of *Cinnamomum verum* caused by *Pestalotiopsis palmarum*. Naseema and Sulochana (1993) isolated *P. palmarum* from the infected leaves of

nutmeg. Rawal (1993) reported *P. psidii* from fruit rot affected guava. Thakur and Sugha (1994) reported *P. theae* from different tea cultivars. Varma and Kapur (1995) reported the leaf and shoot blight, caused by *P. psidii* on guava.

2.1.2 *Curvularia* sp.

Subramanian (1953) reported *Curvularia* sp. from the leaves of *C. nucifera*. Johnston (1959) described the etiology and symptametology of leaf spot of oil palm seedling caused by *Curvularia maculans* in detail. Chan (1974) reported *Curvularia maculans* from coconut. A *Curvularia* sp. has been reported to occur in leaf rot disease complex by Srinivasan and Gunasekharan (1995).

2.2 Studies on chemical control of disease in coconut

2.2.1 *Pestolotiopsis palmarum*

Wilson and Peethambaran (1971) reported that Cuman (ziram) and Dithane Z-78 checked the mycelial growth of *P. palmarum in vitro*. Rao *et al*. (1975) reported that Bordeaux mixture and Fytolan were most effective for the control of leaf blight.

Das and Mahanta (1989) found that Bavistin, Hexathir and Tecto-60 completely inhibited the growth of *P. palmarum*.

Metha *et al*. (1990) reported that 0.2 per cent carbendazim was most effective followed by thiophanate, methyl, zineb, and mancozeb for the control of date palm leaf spot. Panconesi *et al*. (1995) reported that copper oxychloride 400 g a.i/ha and mancozeb 120 g a.i/ha were most effective fungicides for the control of *P. funerea*.

2.2.2 *Curvularia* sp.

Heath (1958) reported that leaf blight of oil palm caused by *Curvularia* sp. was controlled by spraying with copper fungicide. Coleman (1958) showed that for controlling seedling blight of oil palm caused by *Curvularia* sp. captan gave best control. Turner (1967) reported that copper oxychloride and Dithane M - 45 were effective against *C. eragrostidis* attacking the oil palm seedling. Grewal and Payak (1978) in their studies on the control of *Curvularia* leaf spot of maize caused by *C. graminicola* were sensitive to Bavistin (carbendazim). Difolatan 80 W (captafol), Captan and Dithane M-45 (Mancozeb). Jin *et al*. (1994) reported that mancozeb gave 69.8 per cent control of the leaf spot of oil palm caused by *Curvularia* sp.

2.3 Incidence of grey blight disease in coconut in relation to the nutrient status

Studies on the grey blight disease of coconut with reference to the nutrient content in the plant and soil are reviewed hereunder.

2.3.1 Plant content of nutrients and its relationship with disease incidence in coconut

Grey blight or leaf spot disease caused by *P. palmarum* (Cooke) Stey is of common occurrence in all coconut growing areas of the world.

Pryor (1940) reported that increasing nitrogen supply in the nutrient solution increased the severity of the club root of crucifers. Salgado (1942) reported that heavy manuring followed by drought might be one of the reasons for the stem bleeding. Walker and Hooker (1945) studied the relationship between nutrition and *Fusarium oxysporum*, *F. conglutinus* and found that the omission of potassium from the nutrition increased the disease ratings for cabbage yellows.

Cooke (1950) found that magnesium aids the transport of phosphorus within the coconut plant and the deficiency of magnesium reflect in terms of phosphorus deficiency in the tissues. Menon *et al.* (1950) reported that the leaves show suboptimal level of potassium were very susceptible to the attack by *P. palmarum*. Menon and Nair (1951) and Radha *et al.* (1961) reported that potassic fertilizer increases the resistance of the palm against leaf rot disease of coconut.

At least fifteen species of *Pestalotiopsis* occur in oil palm throughout the world as per the repot of Stylert 1953 and

Turner 1971. They studied about the natural occurrence, survival of the species, host nutrition, exudation in relation to spore germination, penetration and lesion development. The relationship between leaf magnesium levels and occurrence of *Pestalotiopsis* leaf spot in oil palm (*Elaeis guineensis*) has been recognised for many years. (Bull 1954) and would appear to provide excellent opportunity for detail study of a weak pathogen which can become aggressive when there exists a suitable nutrient status.

Krackenberger and Peterson (1954) in a review pointed out a positive correlation between the phosphorus and magnesium contents of the coconut palm. Francis (1977) reported that an increase in potassium content caused a decrease in the magnesium and manganese content in leaf tissues. This decrease in magnesium and manganese contents resulted in an increase in severity of grey blight of coconut.

2.3.2 Effect of soil nutrient status / nutrient management in relation to disease incidence in coconut

Menon *et al*. (1950) showed that the leaves of coconut palm which showed sub-optimal levels of potassium were very susceptible to the attack by *P. palmarum*. Child (1950) found that omission of potassium from soil lead in causing foliage yellowing due to the fungus *Pestalotia*. Menon and Pandalai (1958) and Briton Jones (1940) reported that the application of

balanced fertilizer, adequate shade, spraying with Bordeaux mixture will reduce the disease intensity of leaf blight of coconut.

George and Samraj (1966) reported that one of the main factors of the high incidence of leaf rot disease is due to the deficiency of boron. Robertson *et al*. (1968) recorded many species of *Pestalotiopsis* from oil palm through out the world and the invasion appears to be associated with magnesium deficiency. Tisdale and Nelson (1970) reported that one of the problems arises with magnesium is that the ratio of exchangeable potassium to exchangeable magnesium is too wide in many soils. The problem is further aggravated by continuous application of potassic fertiliser without considering the magnesium levels.

Turner (1971) reported that, in Malaysia and Indonesia seedlings raised on peat soil were very prone to nursery leaf spot, which was mainly due to the imbalance of nutrients. UmarAkbar *et al*. (1971) showed that the deficiency of magnesium and nitrogen was the real cause of *Ganoderma* infection in *Elaeis guineensis*.

Vijayan and Natarajan (1975) reported that the higher doses of N, P, K found to aggravate the infection of root (wilt) disease particularly when applied to diseased plants.

Rajalekshmi *et al*. (1975) reported that in case of leaf spot disease of rubber, high disease intensity was noticed in

presence of nitrogen and low disease incidence in the absence of nitrogen. Application of phosphorus partially reduces the adverse effect of nitrogen and application of potassium along with nitrogen increases the disease severity. Potty and Radhakrishnan (1977) reported that the stem bleeding disease of coconut is increased in the absence of nitrogen. The incidence of disease increased with higher doses of phosphorus while the interaction effect of potassium and nitrogen reduces the incidence of disease.

Bhaskaran *et al*. (1978) reported that the severity of Thanjavur wilt of coconut increased with heavy dose of N and K but phosphorus shows lesser degree in the intensity. Alonzo and Palmer (1980) reported that the application of sea water or sea weed salt reduces the leaf spot in coconut seedlings.

Abad *et al*. (1978) reported that pre bearing and bearing plants applied with potassium chloride develops considerable resistance against leaf blight disease. Bhaskaran and Ramanathan (1983) reported that *P. palmarum* is considered as a weak pathogen causing severe disease only in palm that are deficit in potash.

Narayanaswamy (1983) reported that heavy doses of N, P, K fertilization increases the incidence of wilt disease of coconut. Srivastava and Singh (1983) reported that the influence of spacing on boll rot of cotton is minimum at widest spacing and

maximum in the lesser spacing. Mathai *et al*. (1984) reported that the deficiency of calcium, magnesium and zinc predisposes the palm to infection by root (wilt) pathogen.

Rathinam (1984) reported that Thanjavur wilt of coconut is decreased with application of 0.35, 0.25 and 0.45 kg N, P_2O_5 and K_2O/palm/year. He also reported that the disease intensity was highest in palms that received molybdenum. Mathai (1986) studied the nutritional relation of arecanut yellow leaf disease and shows that iron content of diseased palms are higher than healthy. The Fe:Mn ratio is high in diseased than healthy ones.

Suhag and Khera (1986) reported that a proper and judicious incorporation of N and Zn in the over all management of guava orchards will go a long way to mitigating the spread of guava wilt. Jagadish kumar and Gupta (1986) reported that in case of apple scab high nitrogen increases the susceptibility, high potash increases the resistance to biotic disease and phosphorus is variable. Rajagopalan *et al*. (1987) showed that the diseased palm shows significant improvement under well managed condition but management with ash and salt with no irrigation improves disease severity. Nambiar *et al*. (1987) reported that the application of balanced fertilizer, proper drainage and plant protection measures will decrease the intensity of Thanjavur wilt of coconut.

2.4 Studies on optimum leaf nutrient status for economising yield level

Soil analysis have been extensively used as a method of predicting the mineral requirement of crop. However, this technique has its own limitation due to the multiplicity of soil factors that influence the availability of soil nutrition towards the root absorption. Very often an assessment of the soil available nutrients do not give an index for this possible uptake pattern of the crop. At present tissue analysis has been widely adopted as a diagnostic tool for predicting the nutrient requirement of the palm largely due to pioneering work of IRHO scientists, West Africa.

Foliar analysis for nutritional assay gained importance during the late forties of this century. The studies conducted by Manciot *et al*. (1979a and b) and the result obtained by Magat (1979a and b) have sufficiently illustrated that the leaf analysis is an every time tool for predicting the fertiliser requirement of coconut palm.

Nethsinghe (1963) reported that a fall of nutrients below 0.2% may result in deficiency symptom in coconut. Bachy (1963) has cited that for optimal growth and yield, sum of potassium, calcium and magnesium should be 2.7 per cent on dry weight basis, 67-70 per cent of this should be potassium. Felizendo *et al*. (1963) reported a low level of magnesisum in

leaves. A concentration of 0.25 - 0.3 per cent of magnesium is sufficient for the coconut palm. Pillai and Davis (1963) studied the removal of nutrients from soil by coconut palm and reported that the foliar nutrient content of a healthy WCT palm to be 1.4 per cent N 0.16 per cent phosphorus and 1.00 per cent K on dry matter basis. Prevot and Ollagnier (1963) suggested the critical levels (in 14th leaf) as 1.80 per cent N 0.10 per cent P and 0.45 per cent K.

Fremond (1964) reported that the critical value of calcium in leaf suggested by IRHO was 0.5 per cent. However, values higher or lower than these levels have been widely reported on healthy palm without any adverse effect on yield or foliar condition. Fremond *et al*. (1966) reviewing the results of 20 years of research on coconut carried out by IRHO in different countries fixed the critical level of foliar nitrogen, phosphorus, potassium, calcium and magnesium as 1.8 - 2.0, 0.12, 0.8 - 1.0, 0.5 and 0.3 per cent respectively on dry matter basis.

Nethsinghe (1966) indicated that for young palms the optimum foliar content of N 2.2 per cent, phosphorus 0.4 per cent and potassium 0.2 per cent on dry matter basis. Indirakutty and Pandalai (1968) made an attempt to categorise palm of WCT into 3 different yield groups ie. low yielders, medium yielders and high yielders. The corresponding NPK content on the leaves are given below.

	N	P	K
Low yielders	1.64	0.12	0.81
Medium yielders	1.76	0.13	0.11
High yielders	1.86	0.14	1.30

The average value of foliar calcium content obtained was 0.28 per cent on dry matter basis. Cecil (1969) reported that NPK count of 14th frond of healthy palm of high productivity were 1.3, 0.198 and 1.23 per cent and also reported a high value of Ca 0.48 per cent and Mg 0.29 per cent on dry matter basis. Smith (1969) suggested as N:K ratio of 2.25 where foliar level of N was less than the critical level 1.8 per cent.

Kanapathy (1971) reported a leaf nutrient concentration of 0.5 per cent to 0.3 per cent Ca was found optimum for talls, semitalls as well as dwarf. Suggested tentative optimal levels of 1.8 per cent N 0.12 per cent P and 0.8 - 1.11 per cent K for talls 1.8 - 2.0 per cent N 0.2 per cent P and 0.8 - 0.9 per cent K for semitalls and 1.9 - 2.0 per cent N 0.2 per cent P and 0.75 - 1.0 per cent K for dwarf.

Martin and Prioux (1972) have reported that the application of potassium increases with nitrogen and magnesium levels in the leaves of oil palm and they concluded that phosphorus should be the pivot of fertilizer formulae in the crop.

Kamala devi *et al*. (1973) found significant increase in the leaf nitrogen content (1.4 to 1.55 per cent) due to the fertilization (1 kg N 1 kg P_2O_5 and 1 kg K_2O/palm) but it did not reach the critical level of 1.8 per cent suggested by IRHO. The phosphorus status in the leaf was never to critical level. The leaf status of K was very low in unfertilized plots. The calcium level in the leaf did not show much variation while there was significant variation in the case of Mg between medium and high level of fertilization.

Thomas (1973) from his observation on low and high yielding group of coconut palm in Tanzania found that (1) high yielding palm recorded high N level in the leaf than low yielding group, however both were less than the critical level of 1.8 - 2.0 per cent, (2) the result of phosphorus in leaf varied. However, it is higher than the critical level of 0.12 per cent, (3) foliar K was high in low yielding group of palms and K levels in low as well as high yielding groups were higher than the critical level and 4) high yielding group has high calcium content but lower than the critical level of 0.5 and the foliar magnesium was high in low yielding group.

Ramanadan and Pillai (1974) reported that the foliar N and K were significantly higher in manured plots as compared to unmanured plots, leaf P and Mg was less in manured plots and leaf Ca did not show any significant difference. Wahid *et al*. (1974) suggested the critical level of K 0.8 - 1.0 per cent was found to

hold good in coconut. Pillai *et al*. (1975) reported the mean value of leaf nutrient as N 1.82 per cent, P 0.13 per cent, K 1.08 per cent of dry matter basis.

Abraham (1978) reported the application of fertilizer significantly increased the leaf nutrients. Palms in fertilized plots recorded the N content as 1.54 per cent and P 0.14 per cent. Application of K fertilizers increases the leaf K level to 1.17 per cent. The leaf Mg content was found to decrease with fertilization.

Magat (1979a&b) has suggested the critical level of potassium in frond 14 was 0.8 - 1.0 per cent on dry matter basis which is same as suggested by IRHO, also obtained the results showing that the calcium levels in frond 14 ranges from 0.14 - 0.42 per cent and magnesium ranges from 0.16 - 0.48 per cent with an average of 0.29 per cent. Manicot *et al*. (1979) an interesting observation by these workers was that prolonged use of potassium fertilizers especially at higher rate may depress foliar magnesium content and induce Mg deficiency condition in the palm, they also reported that palm which contained below 0.2 per cent of Mg in their leaves showed highly significant response to the application of Mg and the foliar concentration was also improved. These workers also reported the Ca levels of 0.3 - 0.4 per cent of dry matter in leaf 14 as satisfactory.

Manicot *et al*. (1980) showed that a drop in nitrogen level below 1.13 per cent in leaf tissue develop deficiency symptom. The critical level suggested by them for nitrogen was 1.5 - 2.0 per cent of frond 14. Cecil (1984) reported that the increasing rate of nitrogen will increase the N levels. The foliar analysis shows the value of 1.8 - 2 and they suggested that the recomendation of 500 g N/tree is sufficient. Phosphorus application increases P levels, higher levels of potassium increases the K content of the leaves to 0.8 - 1.0 per cent. Addition of calcium increases the Ca level to 0.3 - 0.4 per cent. They also reported that NPK had no effect on leaf Mg and Mg content of the leaf is 0.2 per cent in the absence of magnesium fertilizer.

Jose *et al*. (1985) reported higher levels of micronutrients except boron in leaves of coconut palms. Loganathan and Atputharaja (1986) estimated the concentration of nutrients from 14th frond of the leaf and reported that the N content was 1.9 - 2.1, P 0.11 - 0.13, K 1.2 - 1.5 and Mg were 0.25 - 0.30 per cent. Biddappa *et al*. (1987) reported that the amount of leaf phosphorus, K, Ca and Mg are affected by several other metals like Al, Pb etc.

Ollaginer *et al*. (1987) studied about the influence of climate and soil and potassium critical level in oil palm in Indonesia and they revealed that the response of potassium is

strong under high water deficit condition and weak when irrigation is given. For an identical potassium concentration level in the leaf, the response which can be expected from the KCl application depends on water supply, the potassium critical level also depends on type of soil, particularly the clay minerals, the absorbing complex and the exchanging cation balance. Cecil (1988) suggested that the quantitative requirement of coconut for Ca and Mg are much higher than P. He also presented the critical value of calcium at the 14th frond is 0.3 per cent and magnesium is a limiting nutrient and the foliar level is about 0.2 per cent.

Khan *et al*. (1988) studied about the effect of mineral nutrition on coconut and they reported that the N nutrition did not reach sufficiency levels elsewhere and the available P status of 15 ppm in coconut plots kept P at sufficiency levels. P fertilizers did not increase the P content of the leaf. Doubling the levels had no effect on the levels of nutrients. Changes in K levels of leaves had antagonistic effect on leaf Mg and Na. They concluded that the palm receiving potassium might need additional amount of Mg. Wahid and Kamalam (1988) studied the nutrient distribution in crown of healthy and root (wilt) affected plants and reported that the disease affected palm registered a high level of nutrients in the foliage than the healthy palm except for phosphorus and calcium. They studied about the nutrient distribution pattern in coconut and indicated

that NPK and Mg are relatively more mobile in palm than Ca, S and Mn. Perhaps this may be the reason for the decrease of levels of the former nutrient with the age of the leaves.

2.5 Studies on the effect of different substrates on growth and sporulation of the causal organisms

The growth and size of the spores of certain fungi is known to be influenced by the substrate on which they are produced.

Dosdall (1923) working with *Helminthosporium sativum* stated that difference in length were found between spores produced on different substrates. Chowdhury (1944) found that average length of *Cercospora sesami* was greatest on sesamum stems and least on Dox agar while average width was same on Dox and oatmeal agar media and slightly more on sesamum stems. Chowdhury (1946) reported that maximum spore size of *Pestalotia palmarum* was obtained when produced on artificial cultural media.

Patel *et al*. (1950) noted that the conidial size of *Pestalotia psidii* varied according to the substrate on which they are produced. Large conidia were produced on lima bean meal and Richard's agar as compared to those produced on gram meal and oat meal agar. Kulkarni and Patel (1956) noted that the spores of *Pyricularia setariae*, from *Setaria italica* were larger than on oat meal, *Setaria italica* leaf decoction with dextrose and

Eleusine coracan leaf decoction agar media, than on the host lesions. Increase in length occured on potato dextrose agar. *Setaria italica* leaf decoction with out dextrose and rice decoction agar media and increase in length accompanied by significant decrease in breadth on Brown's agar.

Agrawal and Ganguli (1959) reported that the spore of *P. vesicolor* produced on its host plant, *Anogeissus latifolia* were smaller than those produced on artificial media. Rangaswami and Sambandan (1960) found that the spore size of *Alternaria melongenae* was significantly less in pure culture than on natural host. Rangaswamy and Pandurangan (1962) - reported significant increase in conidial size of *Helminthosporium oryzae* and *H. turcicum* grown on potato dextrose agar medium.

Gopalan (1963) found that the conidia of *Corynespora cassicola* produced in culture were more slender and shorter than those produced on leaves kept in moist chamber. Verma (1967) reported that the spore of *Alternaria sesamicola* on the natural host were smaller than those on artificial media while the spores of *A. gomphrenae* and *A. tenuis* showed marked reduction in length when cultured on artificial media.

Das *et al*. (1985) studied about the carbon and nitrogen source on the growth and sporulation of *P. palmarum*. The results revealed that the carbon source tried were significantly superior to control in promoting the growth of the fungus. The fungi

would neither grow nor sporulate in the absence of any carbon source. Sucrose was significantly superior followed by mannitol, glucose, lactose. They also observed that the fungi also fails to sporulate in the absence of nitrogen. Peptone was the best source followed by ammonium oxalate. Hedge *et al*. (1992) reported dextrose and sucrose were best carbon sucrose for *Colletotrichum gloeosporioides* from *Areca catechu* and tyrosine, peptone and tryptophan were the best nitrogen sources.

2.6 Effect of temperature on the growth of the organisms

Temperature is an important factor which influence the growth of the organism. The severity of infection caused by *Corticium sasakii* differed even with the same temperature range, on different plants like rice, maize, bean reported by Hashioka (1948). Mishra and Chaudhary (1989) studied the effect of temperature and pH on the growth and sporulation of *P. mangiferae* and found that the growth and sporulation on Richard's medium were best at 25 - 30°C and at pH 5.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Survey on the occurrence of fungi causing grey leaf blight of coconut

A detailed survey on the occurrence of leaf blight disease of coconut on the coconut palms at the Coconut Research Station, Balaramapuram, Instructional Farm, Vellayani and Rice Research Station, Kayamkulam was carried out during the months June-July and September-October in 1994 and 1995. The common varieties cultivated in this area are WCT, TxD, TxYD and Komadan. The details of samples collected for the study are given below.

Location	Number of samples collected June-July (1994)	August-September (1995)
1. Coconut Research Station, Balaramapuram	10	10
2. Instructional Farm, Vellayani	10	10
3. Rice Research Station, Kayamkulam	10	10

A survey was also made on the different fungal pathogens infecting the different intercrops in the above coconut gardens selected for the study. Details of the intercrops in each location are given below.

Location	Intercrops
1. Coconut Research Station, Balaramapuram	Clove, Banana, Pepper, Mango
2. Instructional Farm, Vellayani	Clove, nutmeg, mango, pepper, guava, cinnamon
3. Rice Research Station, Kayamkulam	Banana

3.2 Symptomatology

The specific pattern of the incidence of the grey leaf blight disease and the symptom observed on the leaves were described in each case.

3.3 Isolation of the pathogen

3.3.1 Isolation of fungi from coconut leaves

Leaf samples of coconut showing disease symptoms were collected from the above regions for isolation of fungal pathogens.

The infected parts of the dried leaf samples were cut into small bits and washed thoroughly in distilled water and surface sterilized by dipping in 0.1 per cent mercuric chloride solution for one to three minutes. The leaf bits were then washed in three changes of sterile distilled water. The pieces were then plated on potato dextrose agar (PDA) medium in

petridishes and incubated at room temperature (28±2°C) for seven days. When the fungal growth was visible, mycelial bits were subcultured and transferred to PDA slants and were identified.

3.3.2 Isolation of different fungi from the intercrops in coconut gardens

Leaf samples of intercrops showing disease symptoms were collected from the above regions for the isolation of the pathogen. The pathogens were isolated following the same procedure as that used for the isolation from the coconut leaves.

3.4 Pathogenicity of the isolates from coconut palm

Artificial inoculation using the pathogen isolated was done with and without injury on the leaflets of the frond. Injury of the leaf surface was made by scraping the surface and also by pin prick. Inoculation was done with mycelial bits from an eight day old culture grown in potato dextrose agar medium. Culture bits were placed on the plant surface and then covered with moist cotton wool and kept covered inside a polythene bag. A swab of cotton wool soaked in water was placed inside the bag to ensure high humidity. The cotton swab was removed two days after incubation. Once the leaf spot started growing up, the organisms were again isolated from those areas and maintained in PDA for further studies.

3.5 Morphological studies

Morphological studies of the two pathogens *Pestalotiopsis palmarum* (Cooke) Stey and *Curvularia* sp. isolated from diseased coconut leaves were carried out.

3.6 Physiological studies

The cultural characters on solid and liquid media of the isolates were studied.

3.6.1 Growth and Sporulation on different solid media

Solid media viz., carrot agar, Czapek's (Dox) agar, Host leaf extract agar, potato dextrose agar and Richard's agar were used for culturing the fungal isolates for studying the growth and sporulation pattern. The composition of the media were given in Appendix I. The different media were prepared and sterilized by autoclaving at 1.05 kg/cm^2 for 20 minutes. The sterilized media were poured into sterilized petridishes in triplicate at the rate of 15 ml per each dish and allowed to solidify. Circular mycelial discs of 5 mm diameter were cut using a sterile cork borer from an actively growing culture of the respective fungi and placed centrally in the petridishes. The plates were then incubated at room temperature (28$\pm$2°C). Measurement of the radial growth of the mycelium was taken from the 4th day onwards.

3.6.2 Growth in different liquid media

Liquid culture of carrot extract medium, Czapek's medium, host leaf extract medium, potato dextrose medium, and Richard's medium were used for this study. Three replications were maintained for the study. 50 ml of the media was taken in 250 ml conical flask and sterilized. The flasks were inoculated with mycelial disc of 5 mm diameter cut from an actively growing culture of the fungi and incubated at room temperature (28±2°C). After 12 days incubation the culture was filtered through a previously weighed Whatman No. 1 filter paper and the dry weight of the biomass was determined. Three replications were maintained for each isolate.

3.6.3 Effect of different carbon sources on the growth of the isolates

For this study, Czapek's medium enriched with different carbon compounds such as dextrose, inositol, lactose and starch were used. Control flask were also maintained. 100 ml of each medium was taken in 250 ml conical flask and sterilized. The flasks were inoculated with mycelial disc from an actively growing culture of the respective fungi and incubated at room temperature (28±2°C). After 12 days of incubation the culture was filtered through previously weighed Whatman No.1 filter paper and the dry weight of the biomass was determined. Three replications were maintained.

3.6.4 Effect of different nitrogen source on the growth of the isolates

Czapek's medium was taken as the base medium. Sodium nitrate which is the nitrogen source in Czapek's medium was substituted with, ammonium nitrate, asparagine, potassium nitrate and peptone. 100 ml of each medium was taken in 250 ml conical flask and sterilized. The flasks were inoculated with mycelial disc from an actively growing 8 day old culture of the respective fungus and incubated at room temperature (28±2°C). After 12 days of incubation the culture was filtered through a previously weighed Whatman No.1 filter paper and dry weight of the biomass was determined. Three replications of each isolate were maintained.

3.6.5 Effect of different temperatures on the growth of the isolates

For this purpose the fungi were grown in potato dextrose medium and Czapek's medium and incubated at three temperature ranges such as 25±2°C, 28±2°C and 35±2°C.

The liquid media prepared in conical flasks as described earlier were inoculated with mycelial disc of 5 mm diameter cut from an actively growing culture of the test fungi and incubated at the required temperature. After 7 days of incubation, the dry weight of the biomass of the isolates was

determined. For each treatment three replications were maintained.

3.7 Host range studies of the pathogen

To study the host range of the pathogen, the following plants were artificially inoculated with the isolates and the symptoms developed were observed and recorded. Inoculation was carried out with culture bits on detached leaves with and without injury kept in petridishes. The inoculated leaves were covered with polythene paper to maintain high humidity.

1. Arecanut - *Areca catechu* L.
2. Banana - *Musa paradisiaca* L.
3. Cinnamon - *Cinnamomum zeylanicum* Blume.
4. Clove - *Eugenia caryophyllata* Thumb.
5. Cocoa - *Theobroma cocao* L.
6. Guava - *Psidium guajava* L.
7. Jack - *Artocarpus hetrophyllus* Lank
8. Mango - *Mangifera indica* L.
9. Nutmeg - *Myristica fragrans* Houtt.
10. Pepper - *Piper nigrum* L.
11. Sapota - *Achras sapota* L.
12. Tapioca - *Manihot esculenta* Crantz.

3.8 *In vitro* evaluation of the fungicides against the isolates

The following five fungicides were tested for the *in vitro* effect on the fungi isolated

Generic name	Trade name	Chemical name	Concentration of the commercial product (ppm)
Bordeaux mixture		Copper sulphate lime mixture	500 1000 1500
Carbendazim	Bavistin	Methyl-2-benzimidazol Carbamate	2000 2500 3000
Mancozeb	Indofil-M-45	Manganese ethylene bis dithiocarbamate and zinc ions	1000 2000 3000
Captafol	Foltaf	Cis-N (1,1,2.2 tetra chloro ethyl thio)-4-cyclohexane 1,2 dicar-boximide	500 2000 3500
Copper oxychloride	Fytolan		2000 3500 4500

Poisoned food technique by Zentmeyer (1955) was employed for this study.

The required quantity of fungicides was weighed out and added to 100 ml of sterilized potato dextrose agar medium, mixed well and poured into sterilized petridishes at the rate of 15 ml per dish. After solidification, the plates were inoculated with 5 mm disc cut from an actively growing culture of respective

fungi. Control dishes consisting of PDA without any fungicide were also maintained. The dishes were then incubated at room temperature (28±2°C) and observed daily for the growth of the fungi. Observations were taken when the mycelial growth was completely covered in the control dishes. The per cent inhibition over control was calculated using the following formula

$$I = \frac{C - T}{C} \times 100$$

where I - Per cent inhibition

C - Radial growth in control

T = Radial growth in treatment

3.9 Influence of N, P and K on the intensity of grey leaf blight disease of coconut

3.9.1 Field experiment

This aspect was studied using the coconut palms in the spacing cum manurial trial on going at the Coconut Research Station, Balaramapuram. Details of the experiment are given below.

Lay out	-	Factorial RBD
Treatments	-	9
Replications	-	3

T_1 - Spacing 5 x 5m (S_1) with $N_0P_0K_0$ (M_0)

T_2 - Spacing 5 x 5m (S_1) with $N_1P_1K_1$ (M_1)

T_3 - Spacing 5 x 5m (S_1) with $N_2P_2K_2$ (M_2)

T_4 - Spacing 7.5 x 7.5m (S_2) with $N_0P_0K_0$ (M_0)

T_5 - Spacing 7.5 x 7.5m (S_2) with $N_1P_1K_1$ (M_1)

T_6 - Spacing 7.5 x 7.5m (S_2) with $N_2P_2K_2$ (M_2)

T_7 - Spacing 10 x 10m (S_3) with $N_0P_0K_0$ (M_0)

T_8 - Spacing 10 x 10m (S_3) with $N_1P_1K_1$ (M_1)

T_9 - Spacing 10 x 10m (S_3) with $N_2P_2K_2$ (M_2)

Fertilizer levels

N_0 - 0 Nitrogen

N_1 - 340 g N/tree/year

N_2 - 680 g N/tree/year

P_0 - 0 Phosphorus

P_1 - 225 g P_2O_5/tree/year

P_2 - 450 g P_2O_5/tree/year

K_0 - 0 Potash

K_1 - 450 g K_2O/tree/year

K_2 - 900 g K_2O/tree/year

3.9.2 Disease incidence and intensity in relation to nutrient status

One tree, from each treatment combination was taken for observing the disease intensity at bimonthly intervals starting

from February 1995 for a period of one year. Based on the intensity of disease, the leaflets on the frond were grouped into five categories as detailed below and disease index calculated.

Grade 1 - One or two minute yellow spots encircled by a greyish band. 10 per cent of the leaf area were affected but no necrotic lesions on the leaves were found.

Grade 3 - 11-30 per cent of leaf area showed minute yellow specks encircled by a greyish band.

Grade 5 - 30-50 per cent leaf area showed symptoms. Gradually the centre of the spots turned greyish white and were often surrounded by a brown band.

Grade 7 - 51-70 per cent leaf area were affected. Spots enlarged and many lesions coalesced and blighting of the leaves occurred. On the upper surface of the spots globose, spherical or ovoid black fruting bodies of the organisms can be seen.

Grade 9 - Above 70 per cent leaf area were affected and showed blighted patches. Fruting bodies of the organism can be seen on the spots. Tip of the leaflet show severe symptom of blighting.

Disease index was calculated using the formula

$$DI = \frac{\text{Sum of grades of each leaf} \times 100}{\text{Total No. of leaves assessed} \times \text{maximum score}}$$

3.10 Chemical analysis of plant samples

3.10.1 Preparation of plant samples

The leaf samples were collected from the 14th frond (Jose *et al*. 1985). The leaves were cleaned and dried in a hot air oven at 60±5°C for 48 hrs. The samples were powdered and composite samples were kept in brown paper cover for further analysis.

3.10.2 Estimation of N, P, K, Ca and Mg

The total N content of the samples was determined by micro kjeldhal digestion and distillation method (Jackson, 1973). For the determination of P, K, Ca and Mg, the triple acid extract (HNO_3, H_2SO_4, $HClO_4$) of the plant material was made use of. Phosphorus was determined by Vanado-molybdo phosphoric yellow colour method (Jackson, 1973). The yellow colour was red in a Klett Summerson photoelectric colorimeter using a blue filter. Potassium was determined by using an EEL flame photometer (Jackson, 1973). Calcium and magnesium were estimated using Atomic absorption spectrophotometer (Perkin-Elmer model 1982).

RESULTS

4. RESULT

4.1 Survey on the occurrence of fungi causing grey leaf blight of coconut

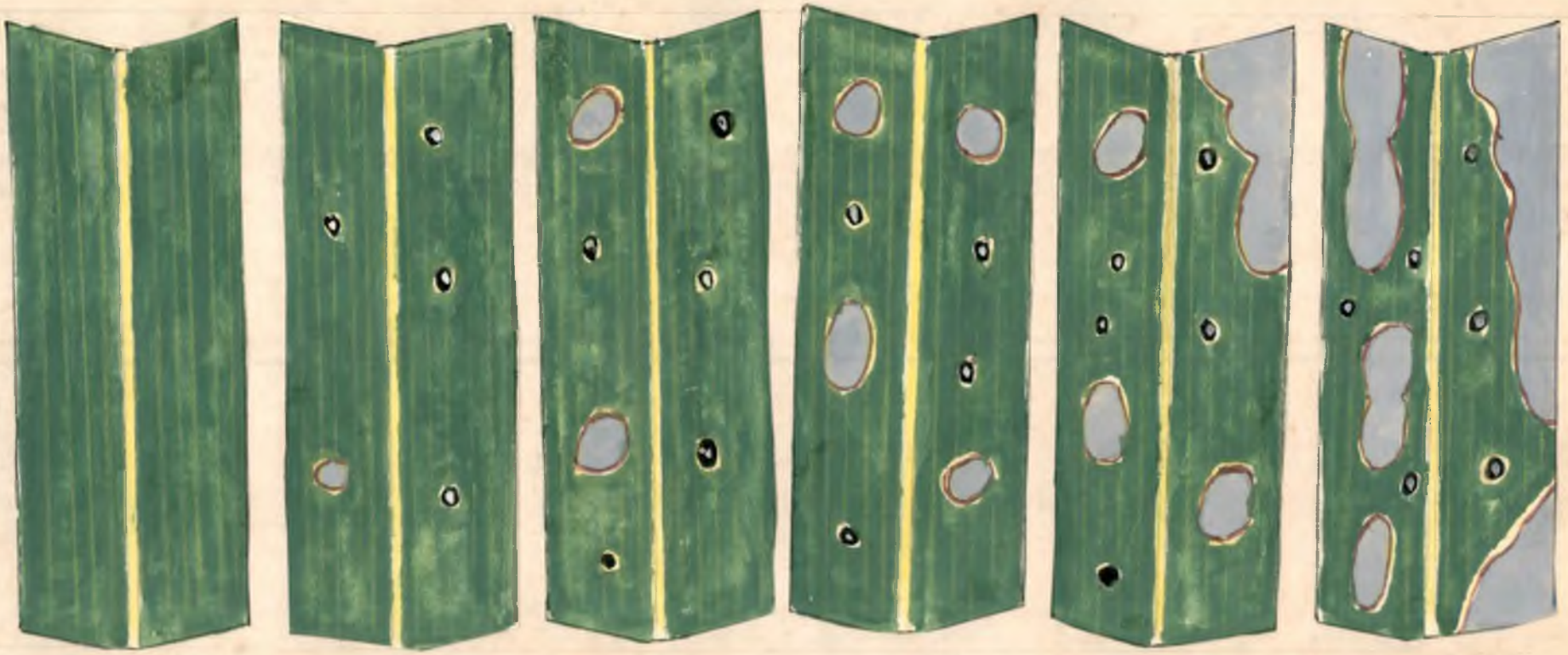
Isolation and identification of the fungal pathogen revealed that *Pestalotiopsis palmarum* (Cooke) Stey was the major pathogen causing grey leaf blight of coconut in all the three areas. In all the palms, the disease was more in the outer whorl of the fronds compared to inner younger leaves. The incidence and spread of the disease was high in the samples collected during both the seasons (Table 1).

4.2 Symptomatology

4.2.1 Leaf spot caused by *Pestalotiopsis palmarum* (Cooke) Stey

The initial symptoms become manifest on the leaves of the outer whorl in the form of minute yellow specks on the leaflets, which gradually become oval in shape and encircled by a greyish band. The centre of the spots subsequently turn greyish white and the band darkens which in turn is surrounded by a 'halo' of yellowish green tissue. The lesions, were usually large and irregularly margined and have raised edges. In the upper surface of the leaves, the black pycnidia of the fungus appear as black minute specks. The leaves in the advanced stages of the disease present a blighted appearance. In certain areas

Coconut leaves affected by *P. palmarum*



STAGES

the significant symptom of the disease is drying up of the leaves from tip downwards, the progress of infection begin from the older leaves to younger. In the advanced stage several of the spots coalesce into irregular grey necrotic patches resulting in marginal necrosis. The worst affected palms present the appearance of severe drought affected trees. The leaflets show a burnt or blighted appearance and on close examination, minute black spots were seen on the burnt surface. In certain cases the infected leaflets may appear either at the base of the petiole or along the whole length of the rachis. Diseased as well as healthy leaflets in many instances appear intermingled on the rachis (Fig. 1 and Plate 1).

4.2.2 Leaf spot caused by *P. palmarum* and *Curvularia* sp.

In some case *Curvularia* is also found to be associated with *Pestalotia* and their can be called a combined infection. The initial symptom were visible on the outer whorl in the form of minute yellow specks and small circular yellow spots on the leaf lets. Gradually the specks became ovel in shape, encircled by dar grey band and the circular yellow spots rapidly expanded to became light brown colour. The centre of the spots turn dark grey and the spots gradually dries up giving a sunken impression.

In the upper surface of the leaves the black pycnidia of *P. palmarum* and spores of *Curvularia* appeared as minute specks, in the case of combined infection. The lesion in the

Plate 1.

Leaf blight caused by *P. palmarum* on coconut

Plate 2.

Leaf blight caused by *Pestalotiopsis*. sp. on mango

plate 1

1711998

plate 2

advanced stages, present a blighted appearance. In the advanced stage, several of the spots coalesce into irregular grey necrotic patches usually marginal necrosis. The leaflet show a burned appearance as in the case of infection by *P. palmarum* alone.

4.3 Isolation of the pathogen

4.3.1 Isolation of fungi from coconut leaves

The following fungi were isolated from three different locations namely Coconut Research Station, Balaramapuram, Instructional Farm, Vellayani and Rice Research Station, Kayamkulam as mentioned under 3.3. The details are presented in Table 1.

Table 1 Fungi isolated from the diseased leaf samples of coconut palms

Location	Organisms isolated			
	1994		1995	
	June-July	Sep. - Oct.	June-July	Sep.-Oct.
1. Coconut Research Station, Balaramapuram	*Pestalotiopsis palmarum* (Cooke) Stey	*P. palmarum* (Cooke) Stey *Curvularia* sp.	*P. palmarum* (Cooke) Stey	*P. palmarum* (Cooke) Stey
2. Instructional Farm, Vellayani	*P. palmarum* (Cooke) Stey	*P. palmarum* (Cooke) Stey	*P. palmarum* (Cooke) Stey	*P. palmarum* (Cooke) Stey
3. Rice Research Station, Kayamkulam	*P. palmarum* (Cooke) Stey	*P.palmarum* (Cooke) Stey	*P. palmarum* (Cooke) Stey	

Plate 3.

Leaf blight caused by *Pestalotiopsis*. sp. on clove

Plate 4.

Leaf blight caused by *Pestalotiopsis*. sp. on cinnamon

plate 3

171198

plate 4

4.3.2 Isolation of different fungi from the intercrops in coconut garden

The following microorganisms were isolated from the different locations, namely Coconut Research Station, Balaramapuram, Instructional Farm, Vellayani and Rice Research Station, Kayamkulam as mentioned under 3.3. The details are presented in Table 2 (Plate 2 - 6).

Isolation of *Pestalotiopsis* sp from intercrops like cinnamon, clove, guava, mango, nutmeg and sapota were morphologically and culturally similar to *P. palmarum* isolated from coconut and were cross infective.

Table 2 Fungi isolated from the intercrops of coconut

Location	Crops	1994		1995	
		June-July	September-October	June-July	September-October
Coconut Research Station, Balaramapuram	Banana	*Colletotrichum* sp.	-	*Colletotrichum* sp.	*Colletotrichum* sp.
	Cinnamon	*Colletotrichum* sp.	*Colletotrichum* sp.	*Pestalotiopsis* sp.	*Colletotrichum* sp.
	Mango	-	*Colletotrichum* sp.	*Colletotrichum* sp. *Pestalotiopsis* sp.	*Colletotrichum* sp.
	Pepper	*Phytophthora* sp. *Fusarium* sp.	*Phytophthora* sp. *Colletotrichum* sp.	*Colletotrichum* sp.	*Rhizopus* sp. *Colletotrichum* sp.
Instructional Farm, Vellayani	Cinnamon	*Colletotrichum* sp.	-	*Pestalotiopsis* sp.	-
	Clove	*Colletotrichum* sp.	*Pestalotiopsis* sp.	-	*Pestalotiopsis* sp.
	Guava	-	-	*Pestalotiopsis* sp.	-
	Mango	-	*Colletotrichum* sp.	-	*Pestalotiopsis* sp.
	Nutmeg	*Colletotrichum* sp.	-	*Colletotrichum* sp. *Pestalotiopsis* sp.	-
	Pepper	*Phytophthora* sp.	*Colletotrichum* sp.	*Colletotrichum* sp.	-
Rice Research Station, Kayamkulam	Banana	*Colletotrichum* sp.	-	*Colletotrichum* sp.	-

Plate 5.

Leaf blight caused by *Pestalotiopsis*. sp. on nutmeg

Plate 6.

Leaf blight caused by *Pestalotiopsis*. sp. on sapota

plate 5

plate 6

4.4 Pathogenicity of the isolates from coconut palm

The pathogens isolated under 3.3 are given in (Table 1). On artificial inoculation on fresh coconut leaf bits produced the symptoms of leaf blight disease and were confirmed to be *Pestalotiopsis palmarum* (Cooke) Stey and *Curvularia* sp.

Artificial inoculation studies conducted under laboratory conditions showed that both the pathogens could infect older leaves more easily than younger ones. In majority of the cases, the injured leaves showed the symptom of disease development earlier than the uninjured leaves. Successful infection occurred when the leaves were inoculated with mycelial bits. The initial symptom appeared after 6-7 days after inoculation. It took 12-14 days to develop a typical symptom. The symptoms produced by each pathogen are described below.

4.4.1 *P. palm*

Symptom were developed very slowly in older leaves without injury. The leaves with injury showed symptoms easily. The symptom started as dark brown spots with yellow halo and enlarged upto 1 mm diameter.

4.4.2 *Curvularia* sp.

Symptom were developed as dark brown coloured ashy spots on younger leaves and gradually the size enlarged and coalesced to form large spots similar to the grey leaf spots.

4.5 Morphological studies

4.5.1 *Pestalotiopsis palmarum* (Cooke) Stey

White cottony growth of the mycelium and black coloured fruiting body appeared on mycelial mat after 4-5 days of inoculation. Colonies reached 4.5 - 5 cm diameter in four days. The spores were five celled. Intermediate cells were coloured and upper two cells were opaque, and lowest coloured cell olivaceous, constricted at the dividing septa. Conidia measured 29.37 x 6.9 um. Taxonomically this fungus belongs to the class Deuteromycotina and order melenconiales of the family melenconiaceae.

4.5.2 *Curvularia* sp.

The colour of the colony in the potato dextrose agar was creamy and turned darker later. Mycelium was septate, profusely branched and unbranched conidiophores. Conida measured 18 to 32 x 9 to 15 um. Conidia were boat shaped and generally three celled. End cells were pale in colour. This fungus comes under the class Deuteromycotina and order moniliales and the family dematiaceae.

4.6 Physiological studies

4.6.1 Growth and sporulation on different solid media

The mean radial growth and culturál characters of thè two pathogens grown in different solid media are presented below.

4.6.1.1 *Pestalotiopsis palmarum* (Cooke) Stey

After seven days of growth in different media the colony diameter was compared. Statistical analysis showed that there was significant difference among treatments. In potato dextrose agar, maximum growth was recorded (8.12 cm) Growth on carrot agar was found to be equally good which was statistically on par with that in PDA. However growth in Czapek's agar recorded 6.72 cm which was statistically inferior to that of PDA. Host leaf extract agar and Richard's agar produced the least growth of 6.18 cm. The data are presented in Table 3 and Fig. 2.

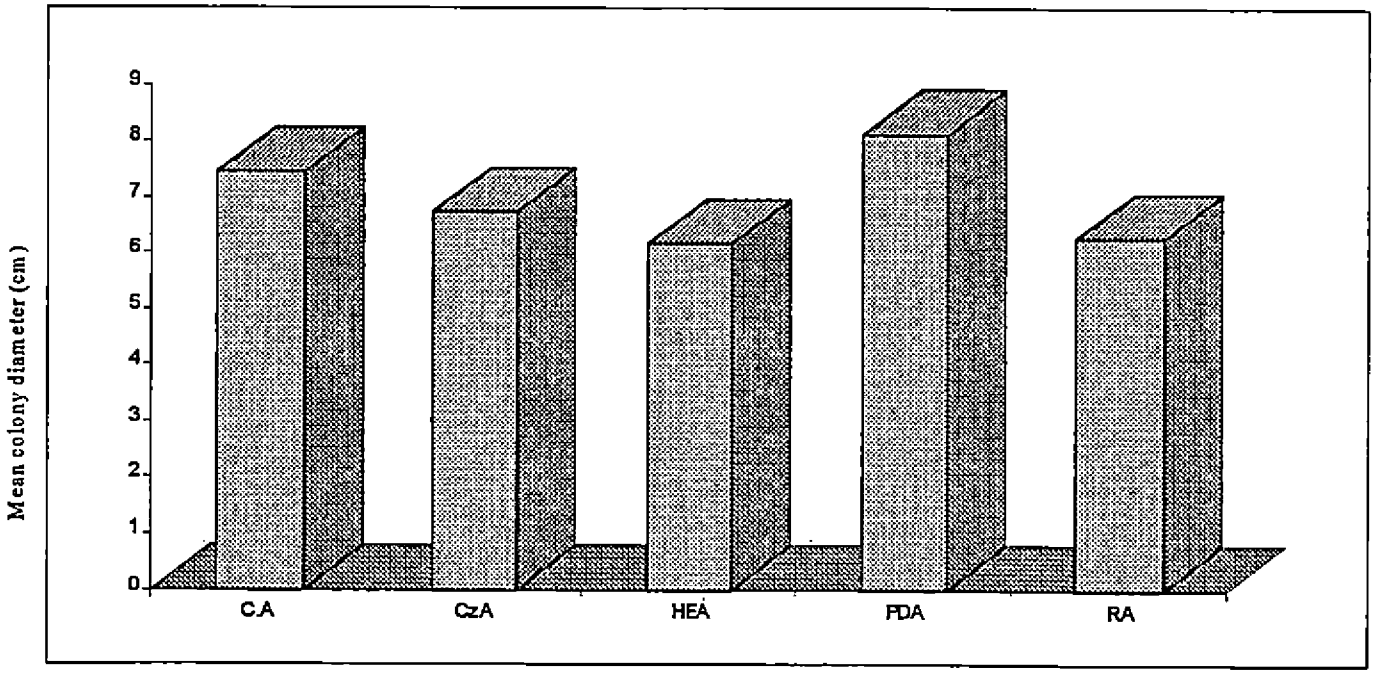
Among the different media tested on the sporulation of the fungus potato dextorse agar was found to be the best in which the sporulation started from the 5th day followed by carrot agar. Moderate sporulation was recorded in Richard's agar and Czapek's agar the fungus failed to sporulate in host leaf extract agar.

Table 3 Growth and sproulation of *P. palmarum* in different solid media

Medium	Mean colony diameter on the seventh day in cm	Colony characters
Carrot agar	7.46 (2.72)	Mycelium was thick and white in colour at first and turned cream in colour as it became s older. Sporulation started on the 6th day.
Czapek's (Dox) agar	6.72 (2.59)	Mycelium cottony and light yellow in colour. Zonation faintly seen. Moderate sporulation was occurred.
Host leaf extract agar	6.18 (2.49)	Abundant growth was absent. Mycelium was light yellow in colour, zonation was not visible, sporulation was absent.
Potato dextrose agar	8.12 (2.89)	Mycelium was cottony white in colour and turned pale yellow as it became older. Colony with distinct zonation. Sporulation started on 5th day.
Richard's agar	6.20 (2.49)	Mycelium cottony white and turned yellow on again, zonation faintly seen, sporulation was moderate.
CD (0.05)	0.264	Average of 3 replications

(Figures in parenthesis indicate transformed value)

Fig. Growth of *Pestalotia palmarum* on different solid media



CA - Carrot agar
CzA - Czapek's agar
HEA - Host leaf extract agar
PDA - Potato dextrose agar
RA - Richard's agar

4.6.1.2 Growth of *Pestalotiopsis* sp. from different intercrops in different solid media

The mean colony diameter of *Pestalotiopsis* sp from different intercrops of coconut garden were studied after seven days. The results were presented in Table 4. From the study it was found that the growth of *Pestalotiopsis* sp from clove and nutmeg, potato dextrose agar, carrot agar and Czapek's agar were equally effective. Thoguh the growth character of *Pestalotiopsis* from cinnamon, mango and sapota were not statistically different, variation in trend occurred, potato dextrose agar supported the growth of the organism followed by carrot agar. In all the cases host leaf extract agar and Richard's agar produced the least growth.

Table 4 Growth of *Pestalotiopsis* sp. from intercrop in different solid media (Mean colony diameter in cm)

Media	Cinnnamon	Clove	Mango	Nutmeg	Sapota
Carrot agar	8.21 (2.86)	8.21 (2.86)	7.82 (2.79)	7.80 (2.79)	7.51 (2.73)
Czapek's (Dox) agar	7.84 (2.79)	7.65 (2.75)	7.41 (2.72)	7.03 (2.70)	7.51 (2.73)
Host leaf extract agar	6.71 (2.59)	7.31 (2.70)	6.73 (2.59)	6.94 (2.63)	6.03 (2.45)
Potato dextrose agar	8.43 (2.89)	8.65 (2.93)	8.22 (2.86)	8.13 (2.85)	8.11 (2.85)
Richard's agar	7.42 (2.72)	7.30 (2.70	5.09 (2.43)	7.26 (2.68)	5.52 (2.68)
CD (0.05)	-	0.19	-	0.15	-

Average of three replications
(Figures in parenthesis indicate transformed values)

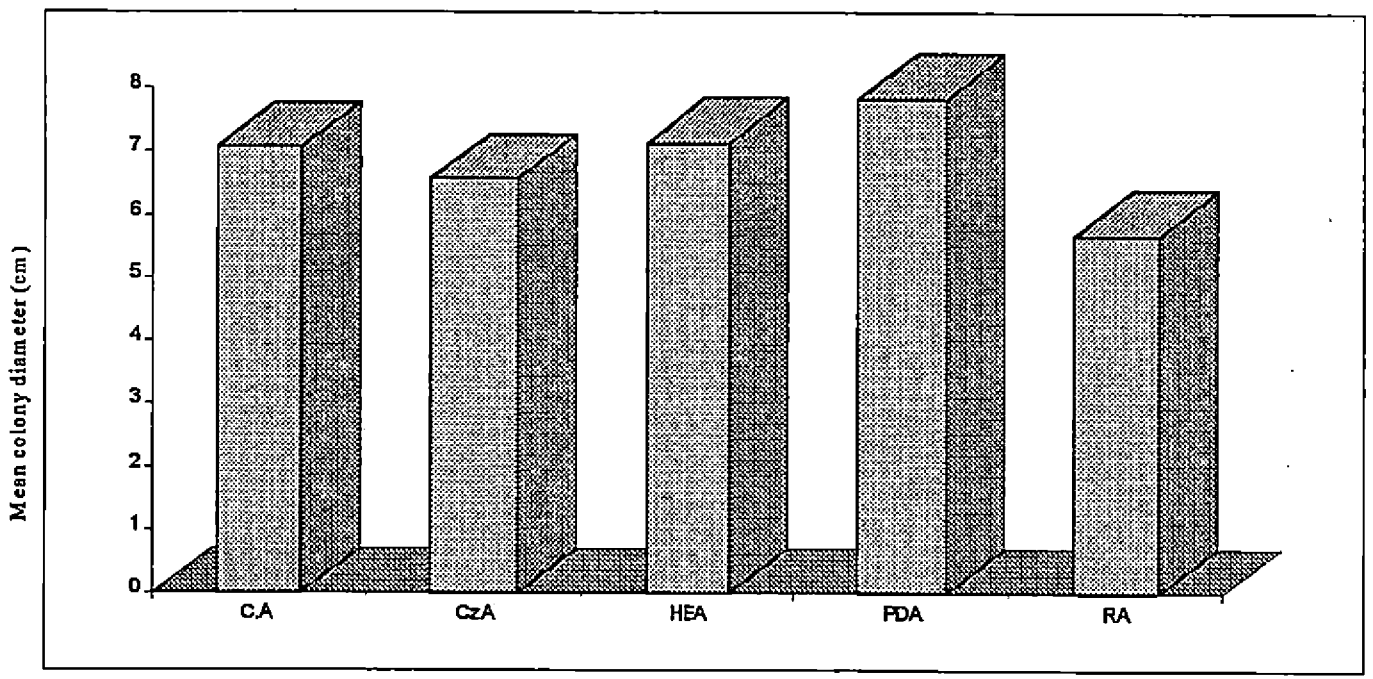
Table 5 Growth and sproulation of *Curvularia* sp. from coconut on different solid media

Medium	Mean colony diameter on the seventh day in cm	Colony characters
Carrot agar	7.06 (2.72)	Thick black mycelial growth was observed initially it was creamy and finally turned dark. Sporulation was good.
Crapek's (Dox) agar	6.56 (2.86)	Thick black mycelial growth was observed initially was creamy and finally turned dark. Sporulation was good.
Host leaf extract agar	7.14 (2.67)	Thick black mycelial growth was observed initially it was creamy and finally turned dark. Moderate sporulation was noticed.
Potato dextrose agar	7.84 (2.79)	Thick black mycelial growth was observed initially it was creamy and finally turned dark. Good sporulation was noticed.
Richard's agar	5.68 (2.36)	Only a feeble growtn of the mycelium was observed.

Average of 3 replications

(Figures in parenthesis indicate transformed value)

Fig. Growth of *Curvularia* sp on different solid media



CA - Carrot agar
CzA - Czapek's agar
HEA - Host leaf extract agar
PDA - Potato dextrose agar
RA - Richard's agar

4.6.1.3 *Curvularia* sp.

Five solid media were tested for the growth and sporulation of the organism and the results are presented in Table 5 Fig. 3.

Though the growth characters in the different media was not significantly different, there was variation in trends observed. Among the media potato dextrose medium was found to be the best (7.84 cm). Richards medium was the least effective (5.68 cm) (Table 5) (Fig. 3). Among the five media good sporulation of the fungus was observed in potato dextrose agar, carrot agar and Czapek's agar. Moderate sporulation was observed in other two media.

4.6.2 Growth in different liquid media

The mean dry weight of the mycelium was taken as the measure of growth of organism in liquid media.

4.6.2.1 *P. palmarum* (Cooke) Stey

The result on the growth of the organims of the five liquid media tested were presented in Table 6 and 10 Fig. 4 and it was found that potato dextrose medium was the best giving a mycelial weight of 0.59 g. The effect was statistically superior to other media also. The least effective one was found to be the host leaf extract medium with a mycelial weight of only 0.12g.

4.6.2.2 *Curvularia* sp.

Mycelial weight produced in the five liquid media tested showed significant difference between each other. Potato dextrose medium was found to be most effective, giving a mycelial weight of 0.36 g. The effect of Czapek's medium (0.26 g), Richard's medium (0.29 g) and Carrot medium (0.31 g) were on par. The least effective was the host leaf extract (0.13 g). The data are tabulated and presented in Table 6 and Fig. 4.

Table 6 Growth of *P. palmarum* and *Curvularia* sp. in different liquid media.

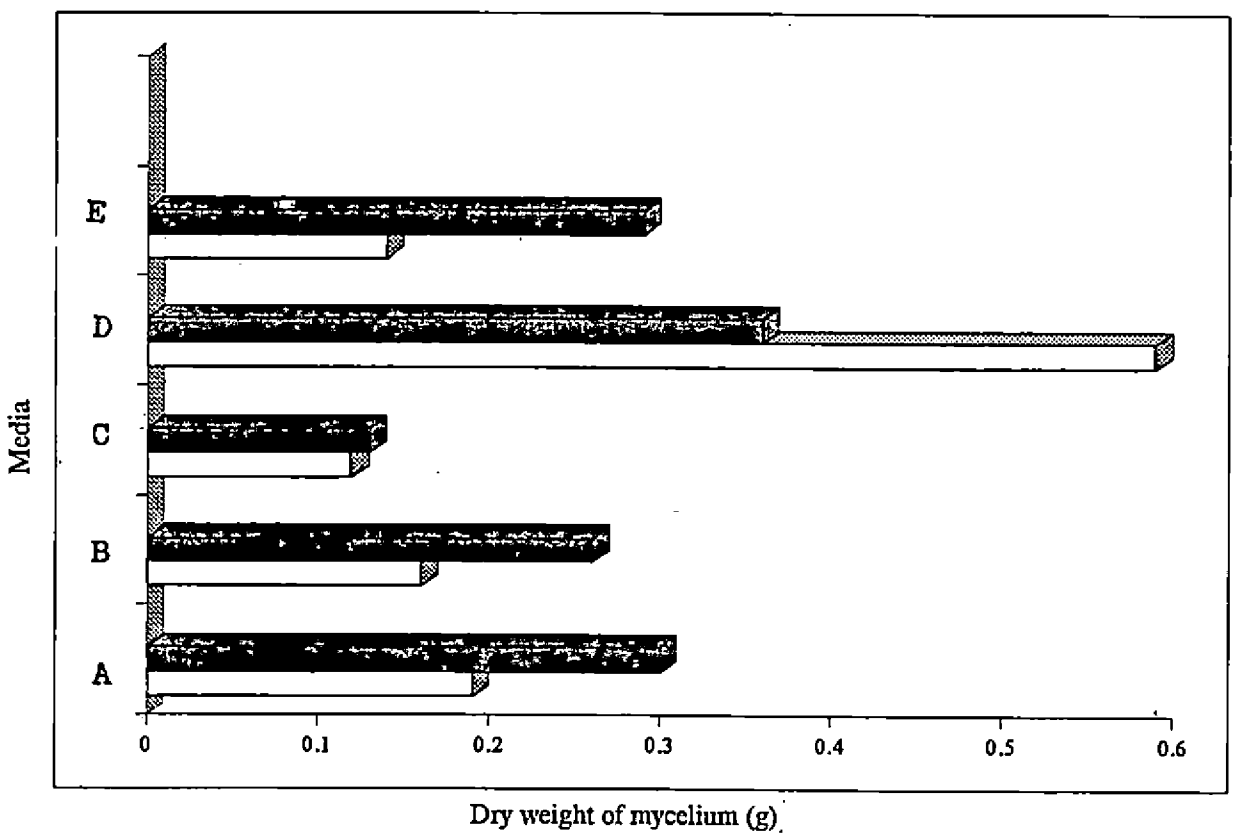
Treatments	*P. palmarum*	*Curvularia* sp.
1. Carrot extract medium	0.19 (0.44)	0.3 (0.55)
2. Crapek's medium	0.16 (0.4)	0.26 (0.51)
3. Host leaf extract	0.12 (0.35)	0.13 (0.37)
4. Potato dextrose medium	0.59 (0.77)	0.36 (0.6)
5. Richard's medium	0.14 (0.38)	0.29 (0.54)
CD (0.05)	0.07	0.11

Average of 3 replications
(Figures in parenthesis shows transformed values)

4.6.3 Effect of different carbon sources on the growth of the isolates

The mean dry weight of the mycelium produced in media with each type of carbon source was taken as the index of the growth.

Fig. 4. Growth of P. palmarum and Curvularia sp. in different liquid media



A - Carrot extract

B - Czapek's medium

C - Host leaf extract medium

D - Potato dextrose medium

E - Richard's medium

4.6.3.1 *P. palmarum* (Cooke) Stey

The effect of different carbon sources in the medium on the growth of *P. palmarum* was statistically significant. The results were presented in Table 7 and Fig. 5 showed that dextrose (0.52 g) and starch (0.51g) were found to be equally effective on the growth of the organism. The least effective carbon source was lactose (0.24g).

4.6.3.2 *Curvularia* sp

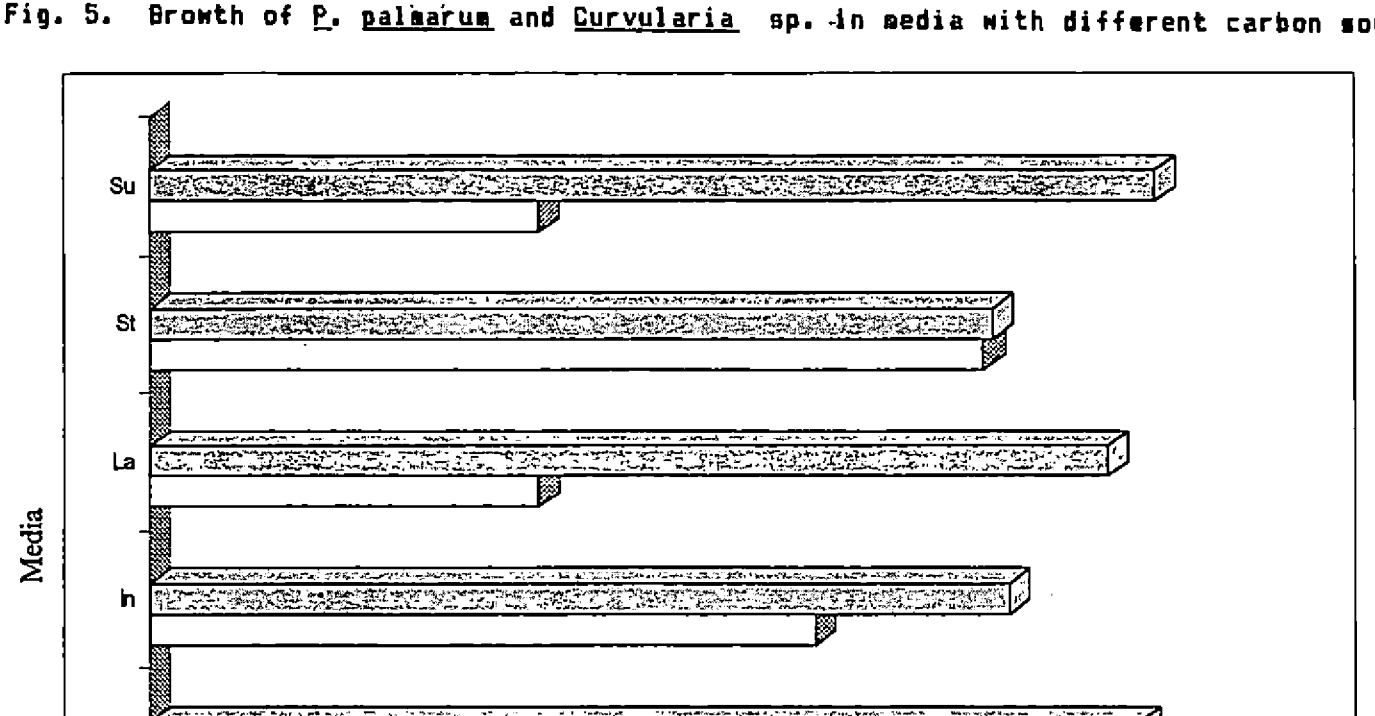
The data are presented in Table 7 and Fig. 5. All the treatments are superior than control. The effect of sucrose (0.62 g) dextrose (0.61 g) and lactose (0.59 g) were on par showing that they act similarly on the growth of the organism. The effect of the rest of the media were more or less similar.

Table 7 Growth of *P. palmarum* and *Curvularia* sp. in media with different carbon sources

Treatments	Mean dry weight of mycelium after 12 days in gram	
	P. palmarum	*Curvularia* sp.
1. Dextrose	0.52	0.61
2. Inositol	0.41	0.53
3. Lactose	0.24	0.59
4. Starch	0.51	0.52
5. Sucrose	0.34	0.62
6. Control	0.17	0.14
CD (0.05)	0.01	0.03

Average of three replications

Fig. 5. Growth of P. palmarum and Curvularia sp. in media with different carbon source



Dx - Dextrose
In - Inositol
La - Lactose
St - Starch
Su - Sucrose

Pestalotia palmarum

Curvularia sp

4.6.4 Effect of different nitrogen sources on the growth of the isolates

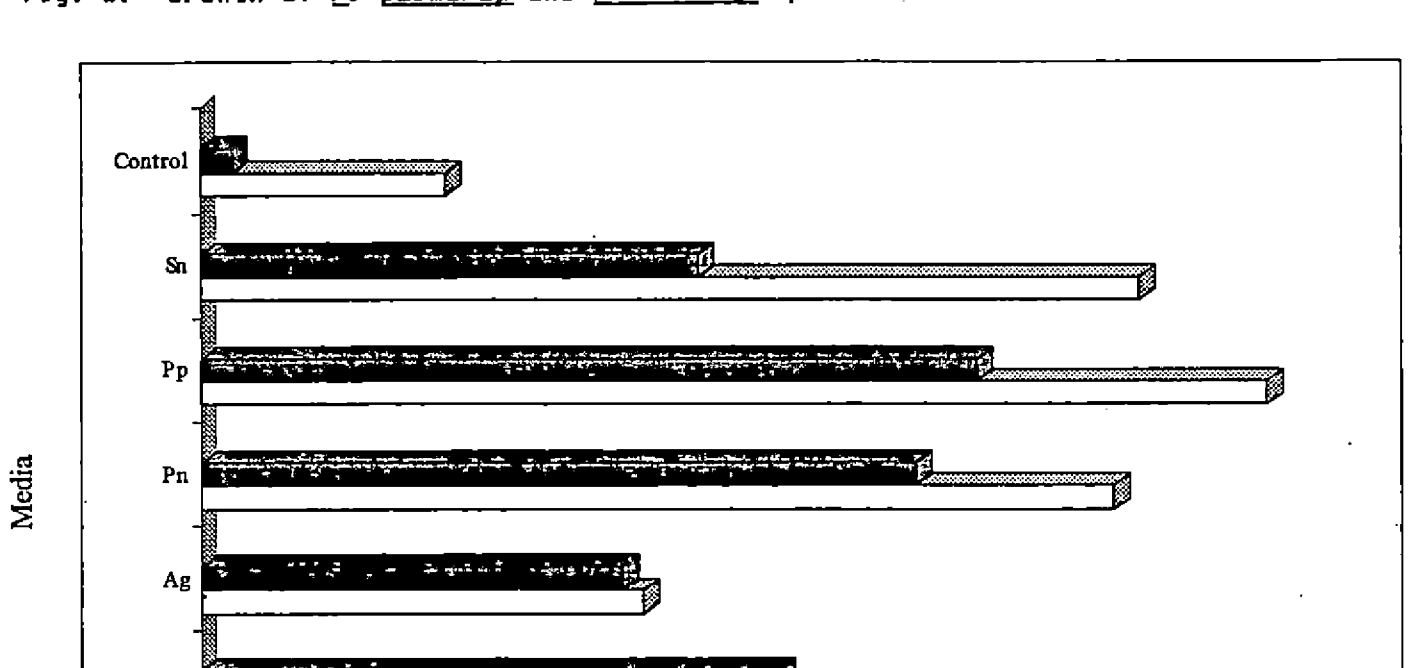
4.6.4.1 *P. palmarum*

The effect of all the treatments are superior than control. The data are tabulated and presented in Table 8 and Fig. 6. The result showed that effect of potassium nitrate (0.36 g) sodium nitrate (0.37 g) and peptone (0.42g) were on par. The least effective was asparagine producing a mycelial weight only 0.17g.

4.6.4.2 *Curvularia* sp.

All the treatments are superior than control. The effect of potassium nitrate (0.28 g) and peptone (0.31 g) were on par, and the effect of all the other three sources of nitrogen was more or less similar. Mean dry weight obtained are presented in Table 8 and Fig. 6.

Fig. 6. Growth of P. palmarup and Curvularia sp. in media with different nitrogen source



An - Ammonium nitrate
Ag - Asparagine
Pn - Potassium nitrate
Pp - Peptone
Sn - Sodium nitrate

Pestalotia palmarum

Curvularia sp

Table 8 Growth of *P. palmarum* and *Curvularia* sp on media with different nitrogen source

Treatments	Mean dry weight of mycelium after 12 day in gram	
	P.palmarum	*Curvularia* sp
1. Ammonium nitrate	0.19	0.23
2. Asparagine	0.17	0.17
3. Potassium nitrate	0.36	0.28
4. Peptone	0.42	0.31
5. Sodium nitrate	0.37	0.19
6. Control	0.09	0.01
CD (0.05)	0.06	0.06

Average of 3 replications

4.6.5 Effect of different temperatures on the growth of the isolates

4.6.5.1 Potato dextrose medium

In this medium, in case of *P. palmarum* maximum growth was noticed at 25°C with a mycelial weight of 0.131 g and was lower at 35°C with a value of 0.124 g. In case of *Curvularia* sp maximum growth was recorded at 35°C with a mycelial weight of 0.127 g and a decrease in temperature indicated a reduction in growth. The results are presented in Table 9.

Table 9 Growth of *P. palmarum* and *Curvularia* sp. on potato dextrose medium at different temperatures

Name of isolate	Temperature	Mean dry weight (g) after 7 days
1. *P. palmarum*	25±2°C	0.134
	28±2°C	0.127
	35±2°C	0.124
2. *Curvularia* sp	25±2°C	0.123
	28±2°C	0.123
	35±2°C	0.129
CD (0.05)	0.005	

Average of three replications

4.6.5.2 Czapek's medium

In the case of *P. palmarum* the maximum growth was obtained at 25°C with a value of 0.126 g followed by growth at room temperature. In case of *Curvularia* sp the maximum growth was noticed at a temperature of 35°C (0.115 g) and 25°C (0.103 g). The mean dry weight at different temperatures are presented in Table 10.

Table 10 Growth of *P. palmarum* and *Curvularia* sp in Czepek's medium at different temperature

Name of isolate	Temperature	Mean dry weight (g) after 7 days
1. *P. palmarum*	25±2°C	0.126
	28±2°C	0.109
	35±2°C	0.101
2. *Curvularia* sp	25±2°C	0.101
	28±2°C	0.103
	35±2°C	0.115
CD (0.05)	0.136	

Average of three replications

4.7 Host Range studies of the pathogen

The results of the study conducted on twelve plants (intercrop) showed that nutmeg, clove, mango, sapota, guava, arecanut and cinnamon were able to produce disease symptom with *P. palmarum*. *Curvularia* sp. was not able to produce disease symptom on any of the plants tested. The results are presented in Table 11.

Table 11 Host range studies of the pathogens

Host plant	*P. palmarum*	*Curvularia* sp
Arecanut	+	-
Banana	-	-
Cinnamon	+	-
Clove	+	-
Cocoa	-	-
Guava	+	-
Jack	-	-
Mango	+	-
Nutmeg	+	-
Sapota	+	-
Tapioca	-	-
Pepper	-	-

\- No infection
\+ Infection

4.8 *In vitro* evaluation of fungicides against the isolates

4.8.1 *P. palmarum*

Among the different fungicides tested Bordeaux mixture 1000 ppm and 1500 ppm and carbendazim at all the three concentrations (2000 ppm, 2500 ppm, 3000 ppm), Mancozeb 2000 ppm, 3000 ppm gave complete control (Plate 7 and 8). Captafol 4500 ppm gave only 75 per cent control and copper oxychloride 3500 ppm gave 84.1 per cent control (Plate 9 and 10). The per cent inhibition data of the different fungicides are presented in Table 12.

4.8.2 *Curvularia* sp.

Bordeaux mixture 1000 ppm and 1500 ppm as well as Mancozeb 1000 ppm, 2000 ppm and 3000 ppm were found to be equally effective and gave complete control of the organism (Plate 11 and 12). Copper oxychloride 4500 ppm was effective and gave 88.9 per cent control and captafol gave 79 per cent control with 3500 ppm. The least effective was carbendazim which gave 39 per cent control at the highest concentration of 3000 ppm (Plate 13 and 14). The data are presented in Table 12.

Plate 7.

Effect of carbendazim on the growth of *P. palmarum*

A - 2000 ppm

B - 2500 ppm

C - 3000 ppm

Plate 8.

Effet of mancozeb on the growth of *P. palmarum*

A - 1000 ppm

B - 2000 ppm

C - 3000 ppm

plate 7

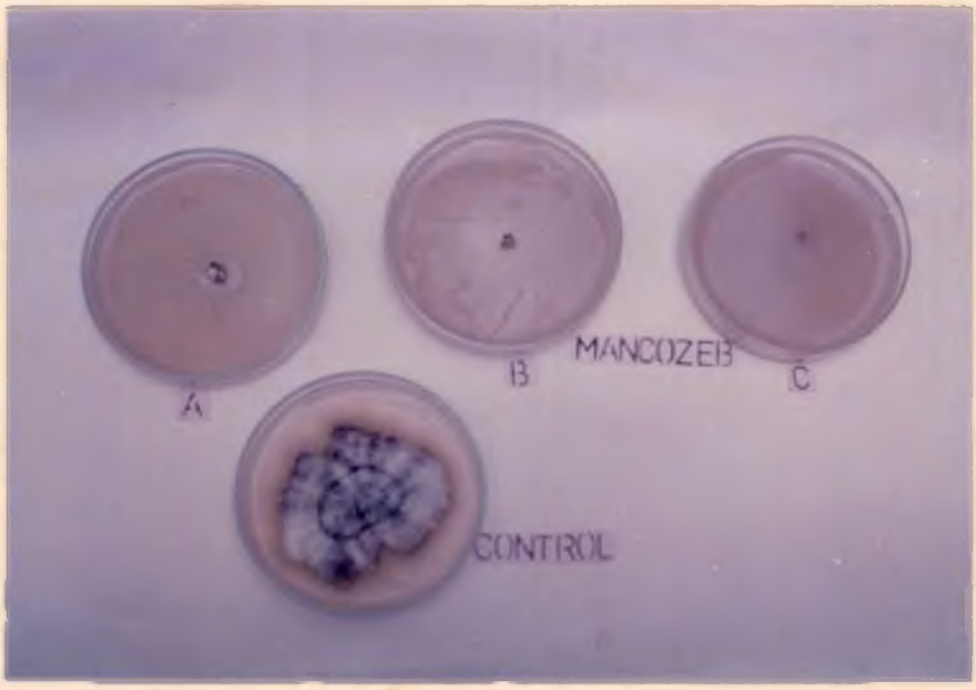


plate 8

Plate 9.

Effect of captafol on the growth of *P. palmarum*

A - 500 ppm

B - 2000 ppm

C - 3500 ppm

Plate 10.

Effect of copper oxychloride on the growth of *P. palmarum*.

A - 2000 ppm

B - 3500 ppm

C - 4500 ppm

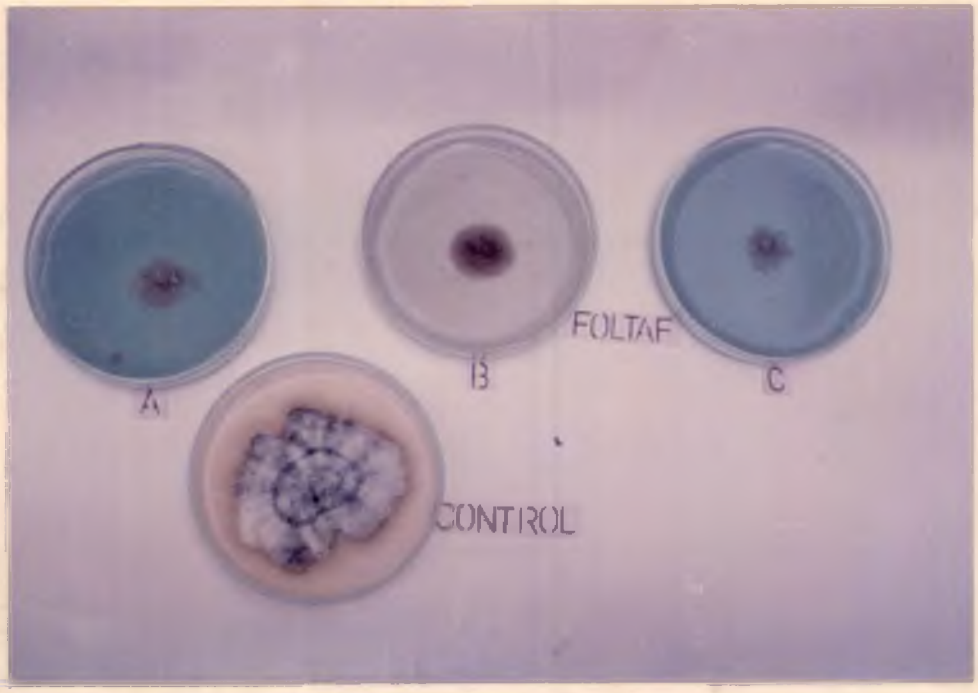


plate 9

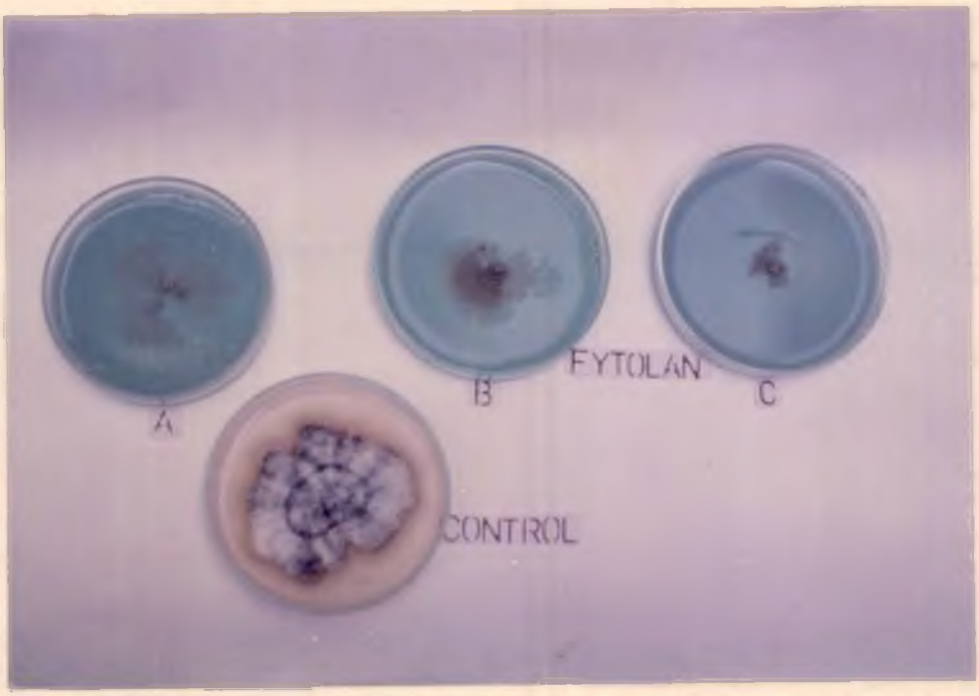


plate 10

Table 12 *In vitro* effect of fungicides on the pathogens

Generic name of fungicide	Concentration ppm	% inhibition over control (Mean value)	
		P. palmarum	*Curvularia* sp
Bordeaux mixture	500	79.3	75
	1000	100	100
	1500	100	100
Carbendazim	2000	100	34.8
	2500	100	36.9
	3000	100	39.3
Mancozeb	1000	89.3	100
	2000	100	100
	3000	100	100
Captafol	500	73.7	24.4
	2000	75.9	88.1
	3500	84.1	79.9
Copper oxychloride	2000	50.7	69.6
	3500	57.7	85.6
	4500	75.9	88.9

Plate 11.

Effect of carbendazim on the growth of *Curvularia* sp.

A - 2000 ppm

B - 2500 ppm

C - 3000 ppm

Plate 12.

Effect of mancozeb on the growth of *Curvularia* sp.

A - 1000 ppm

B - 2000 ppm

C - 3000 ppm

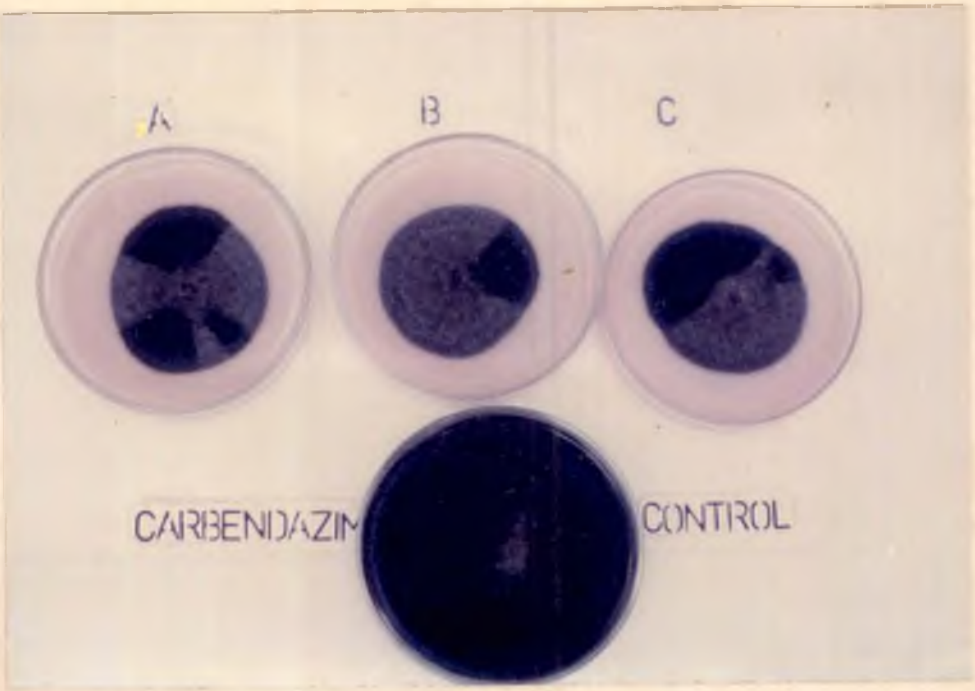


plate 11

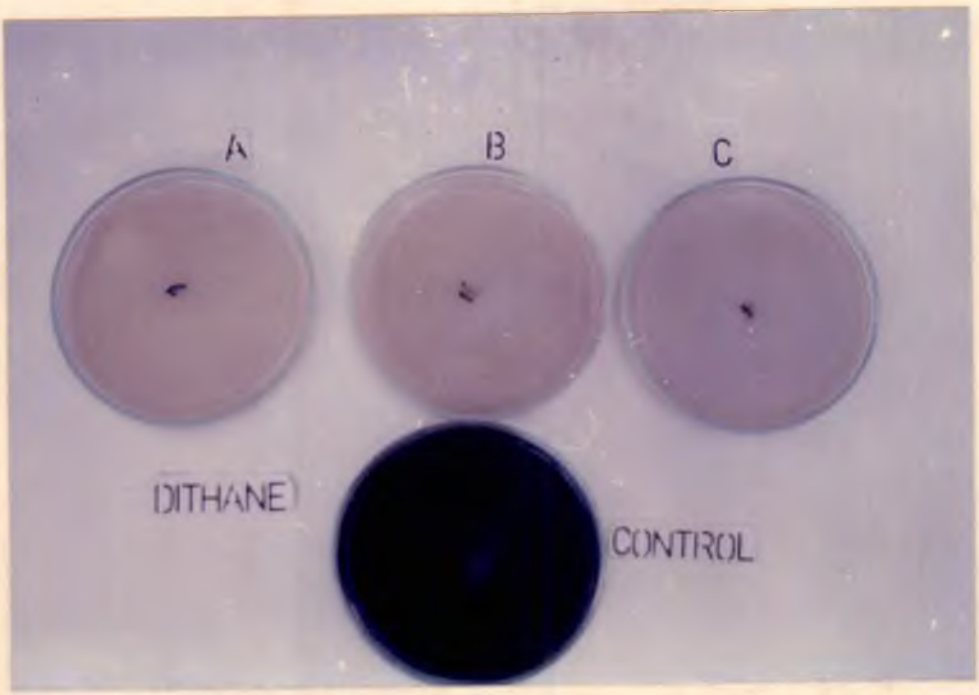


plate 12

Plate 13.

Effect of captafol on the growth of *Curvularia* sp.

A - 500 ppm

B - 2000 ppm

C - 3500 ppm

Plate 14.

Effect of copper oxychloride on the growth of *Curvularia* sp.

A - 2000 ppm

B - 3500 ppm

C - 4500 ppm

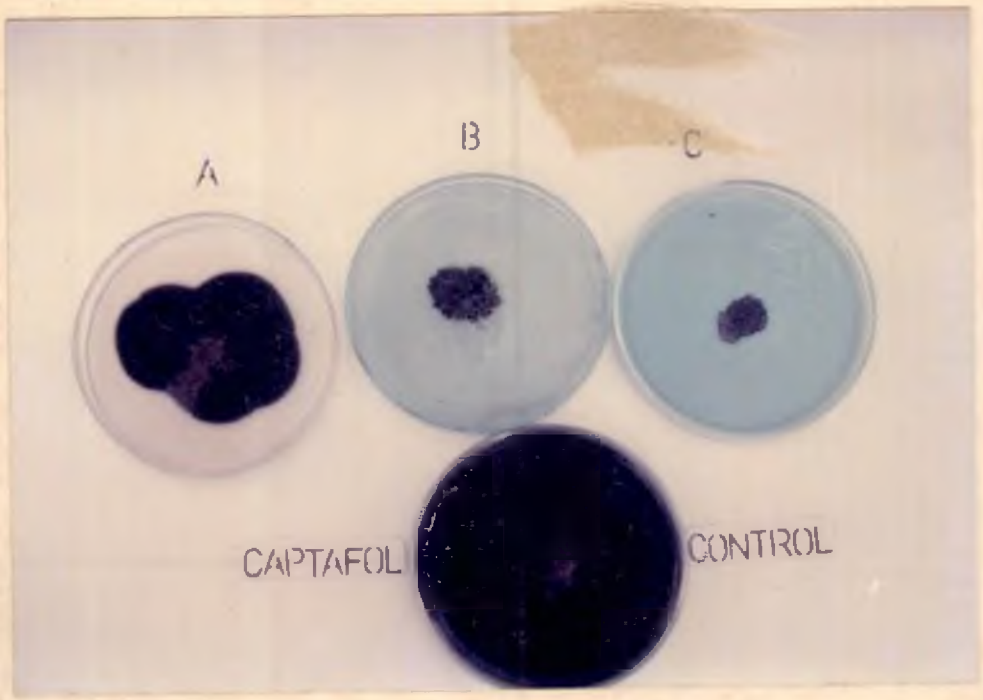


plate 13

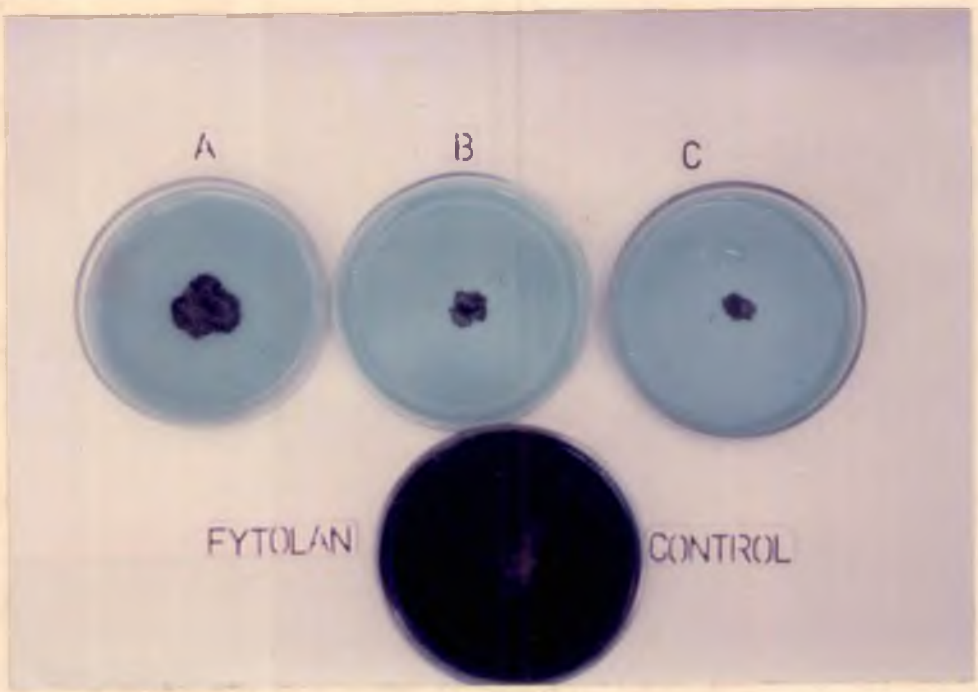


plate 14

4.9 Influence of N, P and K on the intensity of leaf blight disease of coconut

4.9.1 Bimonthly studies for a period of 12 months

Bimonthly studies for a period of 12 months viz. February, April, June, August, October and December 1995 were carried out and the results arre presented in Table 13-18.

From the first observation (February) it was seen that there was significant difference in the intensity of disease with respect to various spacings. Disease intensity was high in the 5 x 5 m^2 plots (41.024%) and significantly low in widely spaced (10 x 10 m^2) plots (15.264%). Unfertilized plots recorded maximum disease and was significantly low in the fertilized plots. However, no interaction was observed between manuring and spacing with respect to the intensity of disease (Table 13).

The results from the 2nd observation (April) showed that closer spacing resulted in high intensity of disease (37.405%) and significantly low in wider spacing (12.552%). No significant difference in disease intensity was observed in treated plots, but was high in control plots (Table No. 14).

In the third observation (June) low disease intensity was seen in 10x10 m^2 plots (16.184%). Highly fertilized plots showed lesser disease intensity (15.57%). But a significant

interaction between spacing and manuring was observed during this period. In 5 x 5 m^2 spaced palms M_1 manured and control plots showed high incidence of disease. In 7.5 x 7.5 m^2 spaced palms no significant difference was seen between M_1 and M_2 levels of fertilizer whereas disease intensity was significantly low in M_2 treated plots spaced at 10 x 10 m^2 (Table 15).

From the 4th observation (August) it was found that significant interaction was observed. Differential response was observed with different spacings for various levels of manuring. In 7.5 x 7.5 m^2 spaced plots M_1 and M_2 treated palms exhibited more or less similar intensity while in 5 x 5 m^2 and 10 x 10 m^2 plots, M_2 fertilized palms recorded lesser incidence than M1 (Table 16).

In the 5th observation (October) 5 x 5 m^2 and 7.5 x 7.5 m^2 spaced palms disease intensity was not significantly different at M_1 and M_2 manured palm, while in 10 x 10 m^2 spaced palm intensity was low in M_2 treated palms (Table 17).

In the 6th observation (December) interaction was observed. Under 5 x 5m^2 and 7.5 x 7.5 m^2 spacings M_1 and M_2 treated palms showed similar disease intensity. In 10 x 10 m^2 spaced palms disease intensity was significantly lower than M_2 treated palms (Table 18).

4.9.2 Disease intensity for a period of 12 months (Pooled data)

The disease intensity over a period of 12 months as seen from pooled analysis revealed inconsistent behaviour of the treatments over the period of observation. There was significant interaction between periods of observation and treatments as revealed from results already presented (Table 19).

Table 13 Influence of NPK and different spacing on the intensity of leaf blight of coconut during February

	Intensity of disease			
	M0	M1	M2	Mean
S_1	51.531 (7.178)	37.685 (6.139)	34.179 (5.897)	41.024 (6.405)
S_2	39.140 (6.256)	27.359 (5.230)	21.430 (4.624)	28.658 (5.372)
S_3	25.878 (5.087)	12.507 (5.536)	9.595 (3.097)	15.264 (3.907)
Mean	38.068 (6.174)	24.641 (4.964)	20.621 (4.541)	

CD (0.05) for comparing spacing 0.289
CD (0.05) for comparing spacing manuring 0.501
(Figures in parenthesis show transformed values)

S_1 - 5 x 5m
S_2 - 7.5 x 7.5m
S_3 - 10 x 10m

M_0 - $N_0P_0K_0$
M_1 - $N_1P_1K_1$
N_2 - $N_2P_2K_2$

Table 14 Influence of NPK and different spacing on the intensity of leaf blight of coconut during April

	Intensity of disease			
	M0	M1	M2	Mean
S_1	48.052 (6.932)	32.581 (5.708)	32.581 (5.708)	37.405 (6.116)
S_2	32.014 (5.832)	25.878 (5.087)	21.467 (4.633)	26.873 (5.184)
S_3	20.727 (4.552)	9.595 (3.097)	8.880 (2.979)	12.552 (3.543)
Mean	33.315 (5.772)	21.446 (4.631)	19.71 (4.440)	

CD (0.05) for comparing spacing 0.217
CD (0.05) for comparing spacing manuring 0.375
(Figures in parenthesis shows transformed values)

Table 15 Influence of NPK and different spacing on the intensity of leaf blight of coconut during June

	Intensity of disease			
	M0	M1	M2	Mean
S_1	55.493 (7.449)	52.569 (7.251)	40.709 (6.380)	50.013 (7.027)
S_2	45.155 (6.719)	31.841 (5.642)	30.357 (5.509)	35.485 (5.975)
S_3	27.358 (5.230)	13.987 (3.740)	9.595 (3.097)	16.184 (4.023)
Mean	41.740 (6.461)	30.735 (5.544)	15.570 (3.946)	

CD (0.05) for comparing spacing 0.191
CD (0.05) for comparing spacing manuring 0.332
(Figures in parenthesis shows transformed values)

Table 16 Influence of NPK and different spacing on the intensity of leaf blight of coconut during August

	Intensity of disease			
	M0	M1	M2	Mean
S_1	54.049 (7.351)	39.225 (6.203)	34.779 (5.897)	42.302 (6.504)
S_2	34.779 (5.897)	29.614 (5.441)	25.880 (5.374)	31.360 (5.571)
S_3	22.910 (4.786)	12.507 (3.536)	8.88 (2.979)	14.197 (3.768)
Mean	36.144 (6.012)	25.806 (5.080)	22.562 (4.750)	

CD (0.05) for comparing spacing 0.174
CD (0.05) for comparing spacing manuring 0.302
(Figures in parenthesis shows transformed values)

Table 17 Influence of NPK and different spacing on the intensity of leaf blight of coconut during October

	Intensity of disease			
	M0	M1	M2	Mean
S_1	54.049 (7.351)	43.675 (6.608)	43.675 (6.608)	47.004 (6.856)
S_2	45.155 (6.719)	31.841 (5.642)	30.357 (5.509)	35.485 (5.957)
S_3	29.614 (5.441)	15.55 (3.943)	11.11 (3.33)	17.969 (4.239)
Mean	42.302 (6.504)	29.138 (5.398)	26.532 (5.151)	

CD (0.05) for comparing spacing 0.141
CD (0.05) for comparing spacing manuring 0.245
(Figures in parenthesis shows transformed values)

Table 18 Influence of NPK and different spacing on the intensity of leaf blight of coconut during December

	Intensity of disease			
	M0	M1	M2	Mean
S_1	54.049	39.225	39.225	43.903
	(7.351)	(6.263)	(6.263)	(6.626)
S_2	43.675	29.614	28.88	33.732
	(6.608)	(5.441)	(5.374)	(5.008)
S_3	30.357	13.987	10.338	17.264
	(5.509)	(3.740)	(3.215)	(4.155)
Mean	42.107 (6.489)	26.501 (5.140)	24.509 (4.650)	

CD (0.05) for comparing spacing 0.201
CD (0.05) for comparing spacing manuring 0.349
(Figures in parenthesis shows transformed values)

Table 19 Intensity of disease for a period of 12 months (Pooled data)

Treatments	February	April	June	August	October	December
S_1M_0	51..531 (7.178)	48.052 (6.932)	55.493 (7.449)	54.049 (7.351)	54.049 (7.351)	54.049 (7.351)
S_1M_1	37.685 (6.139)	32.581 (5.708)	52.569 (7.251)	39.225 (6.203)	43.675 (6.608)	39.225 (6.263)
S_1M_2	34.179 (5.897)	32.581 (5.708)	(40.709 (6.380)	34.779 (5.897)	43.675 (6.608)	39.225 (6.263)
S_2M_0	39.140 (6.256)	32.014 (5.832)	45.155 (6.719)	34.779 (5.897)	45.155 (6.719)	43.675 (6.608)
S_2M_1	27.359 (5.130)	25.878 (5.087)	31.841 (5.642)	29.614 (5.441)	31.841 (5.642)	29.614 (5.441)
S_2M_2	21.130 (4.624)	21.467 (4.633)	30.357 (5.509)	25.800 (5.374)	30.357 (5.509)	28.880 (5.374)
S_3M_0	25.878 (5.087)	20.727 (4.552)	27.358 (5.230)	22.910 (4.786)	29.614 (5.441)	30.357 (5.509)
S_3M_1	12.507 (5.536)	9.595 (3.079)	13.987 (3.740)	12.507 (3.536)	15.550 (3.943)	13.987 (3.740)
S_3M_2	9.595	8.880	9.595	8.880	11.110	10.338
CD (0.05)	0.204					

4.9.3 Correlation of disease intensity and yield

The studies indicated a significant negative correlation between disease and yield, that is, as the disease intensity increased there was a reduction in the yield of coconuts. In February (0.653%) and December (0.513%) the results were highly significant but not high indicating a lesser influence of the disease in controlling the yield.

Table 20 Correlation of disease intensity and yield

Months	Correlation values
February	-0.653**
April	-0.042*
June	-0.460*
August	-0.318*
October	-0.421*
December	-0.513**

'r' values (0.01) - 0.380%
(0.05) - 0.486%

4.10 Chemical analysis of leaf samples

4.10.1 Nitrogen

The leaf nitrogen content was not influenced by the variation in spacing or its interaction with levels of fertilizers. The result of chemical analysis of leaf samples were presented in Table 21. It was observed that variation in fertilizer application influenced the leaf N content. The higher dose (M_2) of fertilizer (N_2, P_2, K_2) resulted in a significant increase in leaf N with a value of 1.577. The nitrogen content in leaves receiving first level (M_1) of fertilizer was on par with the palms which did not receiving any fertilizer.

4.10.2 Phosphorus

The phosphorus content of the leaf was not influenced by variation in spacing or its interaction with manuring. There was no significant difference between P content of leaves in the lowest dose and highest dose of phosphorus applied.

4.10.3 Potassium

The content of leaf potassium was also not influenced by the variation in spacing or its interaction with levels of fertilizer.

4.10.4 Calcium

The calcium content was found to be influenced by the spacing and manuring. But it was not influenced by the interaction effects. The treatments varied significantly in maintaining Ca content. The Ca content was high in the palms which received the lowest dose of fertilizers. The various levels of N, P and K did not influence the Ca content. There was no variation in calcium content of leaf tissues from 5x5 M spacing (closest) and 10x10 M spacing (widest spacing).

4.10.5 Magnesium

The magnesium content also was influenced by different levels of fertilizer and spacing. But was not influenced by there interaction effect. The magnesium content was high in the palms with the lowest level of fertilizers. The various levels of N, P and K did not influence the Mg content in leaves.

The correlation studies carried out to study the influence of leaf nutrients to leaf blight disease revealed that the leaf nutrient levels did not significantly affect the leaf blight disease.

Table 21 Leaf nutrient content (%) mean values

Treatment	N	P	K	Ca	Mg
S_1	1.312	0.139	0.538	0.269	0.182
S_2	1.501	0.146	0.571	0.256	0.162
S_3	1.152	0.137	0.541	0.286	0.187
CD (0.05)	-	-	-	0.017	0.015
M_0	1.054	0.122	0.481	0.306	0.203
M_1	1.333	0.144	0.564	0.252	0.171
M_2	1.577	0.156	0.604	0.252	0.157
CD (0.05)	0.391	-	-	0.017	0.015
S_1M_0	1.005	0.125	0.483	0.292	0.211
S_1M_1	1.351	0.140	0.541	0.241	0.183
S_1M_2	1.679	0.152	0.592	0.274	0.165
S_2M_0	1.175	1.125	0.493	0.293	0.194
S_2M_1	1.507	1.153	0.611	0.252	0.173
S_2M_2	1.819	1.161	0.621	0.225	0.132
S_3M_0	0.982	1.116	0.473	0.334	0.212
S_3M_1	1.141	1.138	0.553	0.263	0.174
S_3M_2	1.334	1.157	0.621	0.263	0.173
SE values	0.228	0.019	0.083	0.010	0.008

DISCUSSION

DISCUSSION

Grey leaf blight is a devastating disease of coconut palm which has been assuming great importance in recent years. A survey was conducted to study the epidemiology and spread of the disease in the major coconut growing areas of southern Kerala viz. Kayamkulam in Allappuzha district, Vellayani and Balaramapuram in Thiruvananthapuram district.

The study revealed that *Pestalotiopsis palmarum* was found to be associated with the disease in all the regions. However, in the leaf samples taken from Balaramapuram and Vellayani *Curvularia* sp. also was found along with *P. palmarum*. The susceptibility of plant parts to infection vary with stage of development. It was found in the present study, that the older leaves were more susceptible to infection than younger leaves. This may be probably due to the difference in the nutritional status of the leaves. The content of phenols drastically decline with maturity in many of the crop plants which contribute to their susceptibility to pathogen. (Hwang, 1983). *Curvularia* sp have been reported to a leaf spot disease in coconut (Subramanian, 1953, Chan 1974). A *Curvularia* sp. has also been found to occur in leaf rot disease complex also (Srinivasan and Gunasekharan 1995).

The pathogenicity of the isolates was proved by artificial inoculation on host plant. Slight injury was found to be necessary for successful infection. Bertus (1927) made cross inoculation studies with *P. theae* and *P. palmarum* and reported that the former species could attack injured leaves of tea and coconut while the latter could infect injured coconut leaves only. Chowdhury (1946) also found that the fungus *P. palmarum* could infect the injured leaves of *Borassus flabellifer*, *Areca catechu*, *Cocos nucifera* and *Phoenix sylvestris*.

The growth and sporulation of the fungus was influenced by different media and by different carbon and nitrogen sources. Potato dextrose agar and carrot agar were found to be the best medium for supporting the growth and sporulation of *P. palmarum*. Potato dextrose broth was assessed as the best liquid medium. Chowdhary (1946) reported that the maximum spore size of *P. palmarum* was obtained when cultured on artificial medium. Variations in the growth and spore size of certain fungi are influenced by different substrates and has been reported by number of workers (Varma 1967). Rangaswamy and Sambadan (1960), Kulkarni and Patel (1956). Patel *et al*. (1950) noticed that the conidial size of *P. psidii* varied according to the substrate on which they are produced.

Carbon and nitrogen sources are not only essential substrate for growth of pathogen, but also important for certain

metabolic process. Pathogens generally show increased preference for carbon and nitrogen source. *P. palmarum* was found to grow well in media contain certain carbon sources like dextrose and starch. *P. sapotae* and *P. versicolor* were found to prefer glucose as the efficient source of carbon and energy (Agarwal and Agnihotri, 1970). The nitrogen source like potassium nitrate, sodium nitrate and peptone were also found to promote the growth of *P. palmarum*. However in case of *Curvularia* sp. sucrose, dextorse and lactose were found to be the best carbon source and potassium nitrate and peptone were the nitrogen sources. Singh and Tandon (1970) reported that *Curvularia* sp. prefer fructose, manose and galactose as good carbon source for promoting growth. Das *et al*. (1985) to assess the best carbon and nitrogen sources for the growth and sporulation of *P. palmarum*, it was also observed that the fungi could neither grow nor sporulate in the absence of any carbon source, and sucrose was significantly superior to manitol, glucose and lactose. It was also revealed that the fungi failed to sporulate in the absence of nitrogen. Peptone was identified as the best nitrogen source.

From the study conducted to find out the host range of *P. palmarum* it was observed that mango, guava, arecanut, clove, cinnamon and nutmeg were the collateral hosts for the pathogen. Butler (1904) reported *Pestalotia* sp. on *Mangifera indica* from India. Sen (1907) recorded *P. palmarum* from *A. catechu*. Naseema and Sulochana (1993) isolated *P. palmarum* from the infected

leaves of nutmeg. Karunakaran *et al*. (1993) reported grey blight of *Cinnamomum verum* caused by *P. palmarum*. Rawal (1993) reported *P. psidii* from fruit rot affected guava. Varma and Kapur (1995) reported the leaf and shoot blight caused by *P. psidii* on guava.

Grey leaf blight can be controlled to a great extent by the use of fungicides. However, efficient control needs a careful selection of fungicides and correct dosage. Among the fungicides tested for the *in vitro* efficacy against the pathogens, Bordeaux mixture emerged as best giving complete control of both the test organisms at a concentration of 1000 ppm. Mancozeb at 2000 ppm was also equally effective. Menon and Pandalai (1958) and Das and Mahanta (1985) reported that grey leaf blight affected palms may be treated with Bordeaux mixture or other copper fungicides or carbamate containing zinc/Mn at fortnightly intervals. Rao *et al*. (1975) reported that Bordeaux mixture (1000 ppm) and Fytolan were effective for the control of leaf blight of coconut.

In this study other copper based fungicide like copper oxychloride was not found effective in suppressing both *P. palmarum* and *Curvularia* sp. Systemic fungicide, carbendazim could produce significant inhibition of *P. palmarum* at all the doses tried, but failed to produce any impact on *Curvularia* sp. Heath (1958) reported that copper fungicide are effective for controlling *Curvularia* sp. From the study Turner (1967) reported

that copper oxychloride and Dithane M-45 were effective in controlling leaf blight of oil palm caused by *C. eragrostidis* Jin *et al.* (1994) reported that Mancozeb gave significant control of the disease caused by *Curvularia* sp. on oil palm leaf spot.

Fertilizers are applied to maintain the yield and nutritional quality of the crops (Huber 1978). Couch (1973) reported that the relationship between levels of nutrients is the determining factor in disease development. Spacing and fertilizer application plays an important role in regulating plant diseases. Increased spacing increases air circulation, temperature and light and lower the humidity around the plants. Balanced application of fertilizers especially P and K promote tissue maturation, increases plant hardness and reduces disease incidence in many cases (Maloy, 1992).

In an attempt to study the influence of spacing and manuring on disease intensity of coconut palms it was observed that there was significant difference in the intensity of *Pestalotiopsis* leaf spot in palms receiving different levels of fertilizer. This may also be due to the influence of different components of climate on the host and the pathogen. There was significant variation in the intensity of leaf spot caused by *Pestalotiopsis* sp. on coconut palms with variation in spacing. Disease intensity was high in closely spaced plots ($5x5m^2$) and was low in widely spaced plots ($10x10m^2$). This may be due to

variation in sunlight which may cause a suitable microclimate for the growth of the fungi. It was also revealed that the plots which did not receive fertilizer and with closer spacing, recorded maximum disease intensity. The disease intensity was low in M_2 level of fertilizer and in widely spaced plots. Francis (1977) reported that maximum disease intensity was recorded in the palms which received a higher level of fertilizers ($N_2P_2K_2$). Pooled analysis of one year data revealed an inconsistent behaviour of treatment over the period.

Pryor (1940) reported that increasing nitrogen supply in the nutrient solution increased the severity of club root of crucifers. Salgado (1942) reported that heavy manuring followed by drought was one of the reason for the severity of stem bleeding. It was revealed that omission of potassium from the nutrient schedule increased the disease ratings for cabbage yellows caused by *Fusarium oxysporum* (Walker and Hooker 1945).

Menon and Nair (1951) and Radha *et al*. (1961) reported that potassic fertilizers increases the resistance of the palm against leaf rot of coconut. Earlier workers showed that inadequacy of the dose of potassium was the real factor that predisposed the palms to the attack by *Pestalotia palmarum*. Menon *et al*. (1950) observed that the coconut palms which were insufficiently supplied with potassium were susceptible to attack by *P. palmarum*.

The chemical analysis of leaves of coconut palms from the experimental area at Coconut Research Station, Balaramapuram revealed that the leaf nitrogen was not influenced by the variation in spacing or its interaction with levels of fertilizers. The higher dose of fertilizer (M_2) resulted in a significant increase in leaf N with a value of 1.577. The highest level of application of N fertilizer (680 g N/Palm/year) increased the leaf N content to 1.58 per cent compared to 1.31 per cent in the plots which received no nitrogen. This level was significantly higher than the N in palms which were not treated with N. Even with the highest level of N applied, the level of N in the leaves did not reach the level suggested by IRHO (1.8% - 2.0%) for producing maximum yield. Kamala Devi *et al*. (1973) found significant increase in the leaf nitrogen content (1.4% - 1.55%) by the application of 1kg N/palm. Pillai *et al*. (1975) reported the average value of N was 1.82 per cent in coconut leaf. Abraham (1978) reported that the application of fertilizer significantly increased the level of leaf N from 1.06 per cent in unfertilised palm to 1.44 per cent in palm receiving medium level of fertilization.

Miles and Thomas (1925) conducted investigation on the effect of varying quantities of nitrogen, potash as well as balanced fertilizers, on the percentage of infection of potato late blight caused by *Phytophthora infestans* and other diseases caused by *R. solani* and *Colletotrichum tubifium* and found that

application of nitrogenous manure upto 3.5 cwt had no effect on disease incidence but an excess quantity over this favoured disease. Further trials on this line showed that increased application of potash reduced the disease. Anonymous (1981) reported that nutrient imbalance rather than absolute amounts of each nutrient favours disease development in the palms.

Balakrishnan and Nair (1985) found that application of slow release nitrogen by utilising neam coated urea and an enhanced rate of potash application were found to have profound effect in reducing the severity of sheath blight and sheath rot of rice.

No change has occurred on leaf P content with variation in P levels. The P level of leaves ranged from 0.12 per cent in unfertilized palms to 0.15 per cent in palm with the highest level of P fertilizer. There seems to be no need for applying higher dose of phosphorus because even with the lower level of P application, the foliar content reached the critical mark of 0.12 suggested by IRHO for higher yield. Pillai *et al*. (1975) reported that the mean value of P content in palms is 0.13 per cent. Loganathan and Atputharaja (1986) reported the leaf P content was 0.11 - 0.13 per cent in the 14^{th} frond of coconut leaf.

Various reports showed that the imbalance of nutrients is the fundamental cause of many diseases in plants.

Gallasch (1974) showed the effect of nutrition on the incidence of *Drechslera incurvata* leaf spot of coconut. The severity of *D. incurvata* leaf spot disease on coconut seedling was related to the level of nitrogen applied. Addition of nitrogenous fertilizers increased the susceptibility of seedlings to the disease while potassium and phosphorus fertilizers decreased it.

The K content of leaf did not reach the level of 0.8 - 1.0 per cent suggested by IRHO even with the application of 900 g K/palm. But the K level was significantly higher in fertilized plots (0.60%) than the unfertilized plots (0.46%). Prevot and Ollaginier (1963) suggested that the critical level of K in 14th frond is 0-45 per cent.

The application of varying doses of NPK has not affected the Ca content of the palm. The calcium content ranged from 0.26% to 0.28% in the palms which received the highest level of NPK. This value was lower than the value suggested by IRHO. Magat (1979) reported that the calcium level of the 14th frond ranges from 0.14% to 0.42%. George and Samraj (1966) suggested boron deficiency as a factor responsible for the disease development since coconut palms affected by leaf rot responded favourably to boric acid application.

The magnesium levels were also not influenced by the various doses of NPK fertilizers. The magnesium content was high in leaves in the control plots. This study revealed that the

magnesium content was low in leaves of palms which showed high disease intensity. The result is in confirmation with the findings of Francis (1977). Monciot *et al*. (1979) reported that prolonged use of potassium fertilizers especially at higher rate may depress the foliar magnesium content. Lognathan and Atputharaja (1986) reported the Mg content of frond 14 as 0.25 - 0.3%.

Abad and Magad (1978) opined that the disease incidence indicated poor nutritional status of affected palms. Imbalanced nutrition such as potash deficiency or too much nitrogen caused the seedlings to be more susceptible.

Alonzo and Palomar (1980) reported that potassium deficiency increased the blight disease in coconut palm. Pillai *et al*. (1975) observed that no regular pattern was apparent in the content of Mg when the diseased and healthy palms were compared. They also worked out the K/Mg ratio in the healthy and diseased palms, and observed that unfavourable cation balance of Ca and Mg may affect the entire physiological process of the palms leading to the development of more advanced symptoms of disease.

Francis (1977) revealed that an increase in potassium level resulted in a decreased magnesium and manganese content in the leaf tissues. Based on the findings of Robertson *et al*. (1968), Tisdale and Nelson (1970), UmarAkbar *et al*. (1971) it may

be assumed that the grey leaf blight of coconut caused by *P. palmarum* may be at due to the lower content of magnesium and manganese in leaf tissues. Cecil (1988) in his studies on the coconut (wilt) disease showed that the calcium and magnesium content of the healthy palms were significantly higher than these of apparently healthy or diseased palms.

Correlation analysis of the data on nutrients levels in palms with disease incidence has revealed that the levels of nutrients did not significantly affect the incidence or intensity of the grey blight disease in coconut palm in the Coconut Research Station, Balarampauram. Knowledge of host nutrition to disease development provides a basis of modifying current agricultural practices to reduce disease severity and should be considered an important cultural weapon in our arsenal for controlling disease in an integrated crop production system (Huber and Army 1985).

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SUMMARY

SUMMARY

Grey blight disease of coconut caused by *Pestalotiopsis palmarum* (Cooke) Stey is a widely distributed disease in Southern Kerala.

In the present study, a detailed survey on the occurrence of grey leaf blight of coconut in Thiruvananthapuram (Coconut Research Station, Balaramapuram and Instructional Farm, Vellayani) and Allappuzha districts (Rice Research Station, Kayamkulam) was carried out. The isolation and identification of the pathogens from the samples collected revealed that *P palmarum* (Cooke) Stey was the major pathogen causing grey leaf blight in all the areas. The disease symptom appeared as minute yellow specks encircled by a greyish band on the leaflet which coalesced into irregular grey necrotic patches. In rare cases a combined infection of *P. palmarum* and *Curvularia* sp also cause similar but severe symptoms.

Physiological study carried out revealed that *P. palmarum* and *Curvularia* sp prefer potato dextrose agar medium for its growth. Among the different liquid media tested potato dextrose medium was the best liquid medium for the growth of the organism.

The growth of the organism was influenced by different carbon and nitrogen sources. Among the different carbon source tested dextrose and starch were found to be best for the growth of *P. palmarum*. The organism *Curvularia* sp. gives a better growth with sucroses, dextrose and starch. Among the different nitrogen sources used potassium nitrate, sodium nitrite and peptone seems to be the best for *P. palmarum*. For *Curvularia* sp., potassium nitrate and peptone were found to be the best.

P. palmarum grows well at 25°C in both the media tested. In case of *Curvularia* sp. 35°C is found to be the ideal temperature for the growth. The results of the host range studies revealed that *P. palmarum* can infect intercrops in coconut gardens like arecanut, clove, guava, mango, nutmeg, sapota and cinnamon.

The *in vitro* evaluation of fungicides on *P. palmarum* revealed that Bordeaux mixture (1000 ppm) and Bavistin (2000 ppm) was found to be best for inhibiting the growth of the organism. For controlling *Curvularia* sp Bordeaux mixture (1000 ppm) and Dithane M-45 (1000 ppm) were found to be very effective.

An investigation carried out at Coconut Research Station, Balaramapuram for 1 year viz. February, April, June, August, October and December of 1995 to study the effect of spacing and manuring on the intensity of grey blight (spacing cum

manurial trial at the station). The result revealed that disease intensity was maximum at S_0M_0 (5x5m^2 spacing and no fertilizer) and was minimum at S_2M_2 (10x10 m^2 spacing and $N_2P_2K_2$ level of fertilizer). Therefore it may be concluded that the intensity of the disease in coconut palms can be controlled by applying NPK at 680 g N, 450 g P_2O_5 and 900 g. K_2O g/palm/year and by planting at a wider spacing.

Chemical analysis of leaf samples revealed that higher dose of N fertilizer increased the leaf nitrogen content. In case of phosphorous and potassium it was not influenced by spacing or its interaction with manuring. The calcium content was high in palms receiving lowest level of fertilizer and various levels of N, P and K did not affect the Ca and Mg content of the leaves.

APPENDICES

APPENDIX - I

Composition of the cultural media used

1. Carrot Agar

Carrot	-	200 g
Agar	-	20 g
Distilled water	-	1000 ml

2. Czapek's (Dox) Agar

Magnesium sulphate	-	0.5 g
Potassium chloride	-	1.5 g
Potassium dihydrogen ortho phosphate	-	1 g
Ferrous sulphate	-	0.01 g
Sodium nitrate	-	2.00 g
Sucrose	-	30.00 g
Agar	-	20 g
Distilled water	-	1000 ml

3. Host leaf extract Agar

Coconut leaves	-	200 g
Agar	-	20 g
Distilled water	-	1000 ml

4. Potato dextrose agar

Pealed and sliced potato	-	200 g
Dextrose	-	20 g
Agar	-	20 g
Distilled water	-	1000 ml

5. Richards Agar

Potassium nitrate	-	10 g
Potassium dihydrogen ortho phosphate	-	5 g
Magnesium sulphate	-	2.5 g
Ferric chloride	-	0.02 g
Sucrose	-	50 g
Agar	-	20 g
Distilled water	-	1000 ml
pH	-	6.6 - 7.2

APPENDIX - II

1. Correlation Matrix - Disease intensity and yield

1.0000											
0.9632	1.0000										
0.9428	0.9378	1.0000									
0.9404	0.9592	0.9485	10000								
0.9823	0.9718	0.9664	0.9565	10000							
0.9720	0.9741	0.9538	0.9501	0.9804	1.0000						
-0.6530	-0.5881	-0.5968	-0.5892	-0.6322	-0.6803	1.0000					
-0.4421	-0.4122	-0.3454	-0.3528	-0.3653	-0.3978	0.6805	1.0000				
-0.5800	-0.5469	-0.4607	-0.4626	-0.5360	-0.5731	0.6578	0.6250	1.0000			
-0.4619	-0.3978	-0.3421	-0.3182	-0.4004	-0.4214	0.6424	0.6298	0.6555	1.0000		
-0.4692	-0.4051	-0.3460	-0.3299	-0.4211	-0.4493	0.6655	0.5565	0.4713	0.7374	1.0000	
-0.5100	-0.5146	-0.4265	-0.4549	-0.4751	-0.5132	0.5800	0.6125	0.6005	0.2488	0.4291	1.0000

2. Leaf nutrient content (%) mean values

Treatment	N	P	K	Ca	Mg
S_1M_0	1.005	0.125	0.483	0.292	0.211
$S_{1M}{}^1$	1.351	0.140	0.541	0.241	0.183
S_1M_2	1.579	0.152	0.592	0.274	0.165
S_2M_0	1.175	1.125	0.493	0.293	0.194
S_2M_1	1.507	1.153	0.611	0.252	0.173
S_2M_2	1.819	1.161	0.621	0.225	0.132
S_3M_0	0.982	1.116	0.473	0.334	0.212
S_3M_1	1.141	1.138	0.553	0.263	0.174
S_3M_2	1.334	1.157	0.621	0.263	0.173
SE values	0.228	0.019	0.083	0.010	0.008

EFFECT OF MANAGEMENT PRACTICES ON THE INCIDENCE AND INTENSITY OF GREY BLIGHT DISEASE OF COCONUT

By

N. ANUPAMA

ABSTRACT OF THE THESIS

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ABSTRACT

From a detailed survey on the occurrence of leaf blight disease of coconut in Thiruvananthapuram (Coconut Research Station, Balaramapuram and Instructional Farm, Vellayani) and Alappuzha Districts (Rice Research Station, Kayamkulam) it was revealed that *Pestalotiopsis palmarum* (Cooke) Stey was the major pathogen causing grey leaf blight of coconut in both the areas. *Curvularia* sp. were also found to be contribute to this disease. Of the various media tested, best growth of *P. palmarum* was seen in potato dextrose agar and broth. Among the various carbon sources tested dextrose, starch and inositol were equally effective for the growth of *P. palmarum* and for *Curvularia* sp., Sucrose, dextrose and starch were the best carbon sources.

A temperature of 25°C and 35°C was found to be optimum for the growth of *P. palmarum* and *Curvularia* sp respectively. Arecanut, cinnamon, clove, guava, mango, nutmeg and sapota intercropped with coconut in the three locations were found to be host of the pathogen *P. palmarum*. *In vitro* evaluation of fungicides revealed that Bordeaux mixture (1000 ppm) and Bavistin (2000 ppm) were superior in inhibiting the growth of *P. palmarum* on the other hand *Bordeaux mixture* (1000 ppm) and Dithane M-45 (1000 ppm) effectively inhibited the growth of *Curvularia* sp.

Monitoring of the disease intensity over a period of 12 months has shown that grey leaf blight intensity was high in palms planted at closer spacing and which received no fertilizers. The disease intensity was minimum in palms with wider spacing and with higher level of fertiliser ($N_2P_2K_2$). In general higher level of fertilizers and wider spacing may be considered as a management practice for controlling the incidence and intensity of the grey blight diseases in coconut palm in South Kerala.