VIRULENCE, VARIATION AND SURVIVAL OF *COLLETOTRICHUM FALCATUM* WENT IN KERALA

BY

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THESIS

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requirement for the degree
DOCTOR OF PHILOSOPHY
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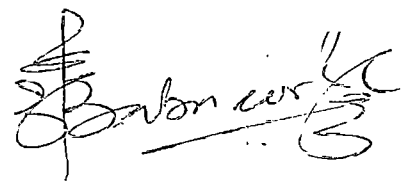
DECLARATION

I hereby declare that this thesis entitled "Virulence, variation and survival of Colletotrichum falcatum Went in Kerala" 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 to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.



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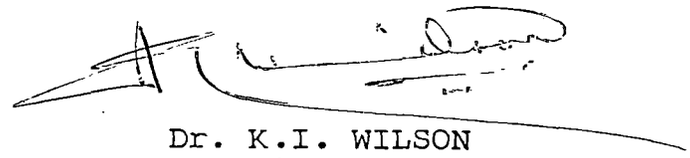

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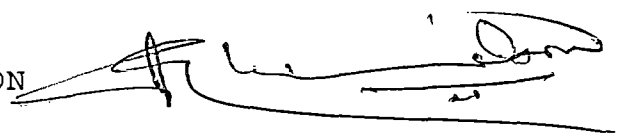
Dr. K.I. WILSON 

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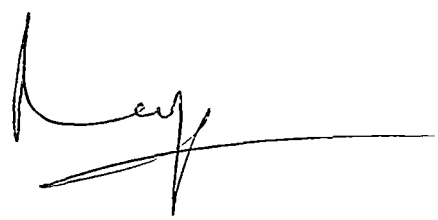
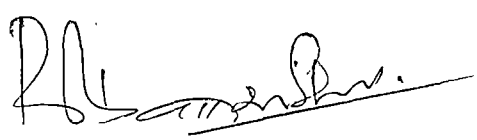
1. Dr. K.M. Rajan 

2. Dr. S. Balakrishnan 

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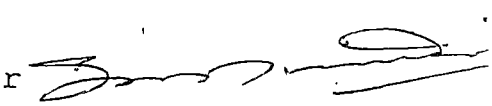
4. Prof. S. Sukumaran Nair 

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(BABU GEORGE)

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INTRODUCTION

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Red rot caused by Colletotrichum falcatum Went is one of the oldest known diseases of sugarcane. The disease was first reported from Jawa in 1893 and had badly affected the sugarcane cultivation in several countries. In India, the disease was first reported by Barber in 1901. Eventhough, red rot was prevalent in almost all the sugarcane tracts of India, Kerala has been free from the disease till its occurrence was noticed in 1983 in the sugarcane fields in Thiruvalla region coming under the command area of Travancore Sugars & Chemicals Ltd. (Pumpa Sugar Factory) which has nearly 4000 ha of land under this crop. The disease appeared in a devastating form in subsequent years, affecting almost all the commonly cultivated varieties in the region. The spread of the disease was further triggered by the flooding of sugarcane fields with river water during the South-West monsoon. This eventually led to the non-availability of sufficient quantities of canes required for the Pumpa Sugar Factory. Adding to the calamity, a variety Co.7704 recommended for cultivation in the area due to its moderately resistant reaction to red rot infection (Mathew et al, 1987) was found infected, in further observations. This suggested the possibility

for the presence of virulent strains capable of infecting varieties hitherto resistant to the disease.

Detailed investigation was, therefore, undertaken to study the isolate of the fungus from different varieties of sugarcane cultivated at different locations of the region so as to identify the virulent strains if any, of the pathogen and to test the reaction of different varieties against most virulent isolate and to study the role of infected plant debris, river water, collateral hosts, if any, for the incidence and spread of the disease in the region.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Red rot is one of the oldest known diseases of sugarcane and is world wide in distribution. The disease causes serious losses and has been called 'cancer' of sugarcane due to its far reaching influence on the economics of sugar production in several countries (Abbott and Hughes, 1961). This disease has been mainly responsible for the deterioration of several promising commercial varieties and continues to be a threat in the USA, Australia, Taiwan, Bangladesh, India etc (Edgerton, 1959; Agnihotri and Singh, 1977).

Went (1893) described a disease of sugarcane in Indonesia and called it 'rood snot' or 'red smut'. The pathogen was isolated and named as Colletotrichum falcatum. Howard (1903) conclusively proved by inoculation tests that Colletotrichum falcatum Went was responsible for the disease. Barber (1901) reported a severe outbreak of the disease in India in the Godavari delta of Andhra Pradesh. Butler (1906) critically studied the devastating disease in relation to the causal organism and its portals of entry into the cane stalk and proposed the name 'red rot' for the disease, which was later accepted by the world over.

Although the disease has caused and is causing, appreciable damage to crops in Rajasthan, Punjab, Haryana,

Uttar Pradesh, Bihar, West Bengal and Orissa, it is particularly rampant in Eastern Uttar Pradesh and Northern Bihar. These places have become 'hot spots' for the disease as epidemics frequently occur in these regions and have occurred during 1939-40 in Co.213; 1946-47 in Co.213, Co.312, Co.453, Bo.11, Bo.17 and Bo.54; 1964-65 in Bo.10 and Bo.11; 1968-69 in Co.997, Cos.562 and Bo.3. Outbreaks in Co.419 and Co.658 in Andhra Pradesh, Tamil Nadu and Pondicherry indicated that virulent races of the pathogen have got their foothold in these areas also (Rafay, 1955; Kirtikar and Singh, 1955; Lewin et al, 1976a; Agnihotri and Singh, 1977). Peethambaran and Wilson (1970) recorded C. falcatum on sugarcane in Thiruvalla and Vennikulam areas in Kerala. However, the disease was not at all significant in the past. Nair et al, (1984) reported epiphytotic occurrence of red rot in high yielding varieties like Co.997 and Co.449 cultivated in the Pumba river factory zone in Thiruvalla.

The red rot pathogen

Red rot is mostly caused by the imperfect stage described as Colletotrichum falcatum Went. The perfect stage was first reported by Carvajal and Edgerton (1944) from USA, who identified it as Physalospora tucumanensis described by Spegazzini from Argentina in 1896. Chona and Srivastava (1952) reported the production of ascigerous

stage in culture under laboratory conditions. Later, Chona and Bajaj (1953) and Misra (1957) observed perithecial production on leaf lamina, midrib and leaf sheath of dry foliage in nature. Arx and Muller (1954) placed the fungus in the genus Glomerella and the perfect stage is now known as Glomerella tucumanensis (Speg.) Arx and Muller.

Nutritional requirements of C. falcatum

Ramakrishnan (1941) reported that C. falcatum grew luxuriantly on sucrose and glucose. Joly and Gambogi (1957) observed that maltose formed the best source of carbon for C. falcatum. Manocha (1965) reported that the light type isolates of C. falcatum grew best on media containing sucrose, glucose, fructose etc., while the dark isolates showed thrifty growth on media containing starch and sorbitol. Singh (1966) stated that sucrose was the best carbon source for the conidial germination of light type isolates, followed by xylose, fructose, lactose, glucose, starch, galactose, rhamnose, raffinose and glycogen. On the other hand, starch appeared better for the dark type ones followed by lactose, sucrose, fructose, raffinose, glucose, xylose and galactose.

Ramakrishnan (1941, 1947) reported that asparagine, potassium nitrate and peptone were very well utilized by

C. falcatum while, growth was poor in ammonium sulphate and urea. Singh (1966) reported that potassium nitrate among inorganic sources, casein and peptone among organic ones stimulated the conidial germination in six isolates of C. falcatum. Ahmed (1973) reported that inorganic nitrogen compounds like potassium nitrate, sodium nitrate and calcium nitrate supported good growth of C. falcatum while ammonium phosphate, potassium nitrate and sodium nitrate supported good sporulation.

Singh (1966) reported that in C. falcatum, different amino acids like arginine, dl-aspartic acid and dl-valine stimulated the conidial germination of all the six isolates studied. Ahmed (1973) observed that glycine, dl-tyrosine, dl-serine, dl-phenylalanine and dl-cystine were very good sources for the sporulation of C. falcatum.

Srinivasan and Vijayalakshmi (1960) studied the thiamine and biotin requirements of two strains of C. falcatum. They reported that the strains of the fungus generally showed deficiency for thiamine and biotin. Ghouse and Khan (1963) reported that certain isolates of C. falcatum were partially deficient for thamine, biotin and pyridoxine but not for inositol. Chatrath and Bajaj (1964) studied the dark and light type isolates of C. falcatum and reported that the dark isolate was deficient for thiamine while the light type was deficient for biotin.

Singh (1966) reported that thiamine induced better stimulation of the light type isolates of C. falcatum while thiamine and riboflavin had greater effect on the dark types.

Studies conducted by Ramakrishnan (1941) and Ahmed and Divinagracia (1974) revealed that C. falcatum could grow over a wide pH range, the optimum being between 5.5 and 6.5.

Variation in red rot pathogen

Physiologic specialisation in C. falcatum was first demonstrated by Edgerton and Moreland (1920). They opined that differences in strains were perhaps responsible for the divergent results reported regarding the mode of infection in young plants raised from diseased seed pieces in India and the USA. Earlier workers distinguished two distinct types of isolates of the pathogen viz., dark and light (Abbott, 1935; Mundkur, 1946).

Some workers differentiated isolates/strains/races of red rot pathogen based on colony characters and conidial measurements. Chona and Hingorani (1950) observed that for isolate 29, the conidial size was 27.1 μ x 4.99 μ and for isolate 29-D the size was 20.3 μ x 4.92 μ. Rafay and Singh (1957) reported that strain D had a length and breadth of 21.0 μ x 6.3 μ and strain I had 24.2 μ x 3.1 μ.

Singh and Rana (1968) observed the morphological characters of three isolates viz., isolate R-158 with average length and breadth of 26.6 µ x 4.12 µ; isolate R-135 with 23.2 µ x 5.0 µ and isolate R-141 with 22.0 µ x 6.1 µ. Gupta et al (1980) noticed a new biotype R-183 having a spore size ranging from 33.0 - 37.4 µ in length and 4.4 - 4.95 µ in width. Verma et al (1984) noted another new biotype R-196, the conidial measurements of which ranged from 13.4 - 29.5 µ in length and 3.8 - 4.9 µ in width.

The collections of isolates of C. falcatum over several years indicated the appearance of new strains with marked virulence on different cultivars. (Rafay, 1950, 1953; Pandey and Sakal, 1974). The strains isolated upto 1957 were classified (Rafay and Padmanabhan, 1941; Rafay and Singh, 1957) into several types viz., A, B, C, D, E, F, G, H, I and S-244. Kirtikar (1959) designated isolates as R-115, 103, 117, 121 and 123 etc. Prakasam and Reddy (1961) identified a light race from Bobbili. Later, several workers viz., Sarkar and Chattopadhyay (1960); Srinivasan (1962); Chona and Srivastava (1960); Kirtikar et al (1965) and Sharma (1970) described several isolates mostly as light and dark types. Chirbat et al (1980) reported cultural and morphological variations in different isolates of the pathogen.

Satyanarayana and Rao (1984) reported two strains in Andhra Pradesh. Alexander and Rao (1972), after examining a large number of varieties and their reactions at different endemic locations in India, came to the conclusion that resistance to 'D' strain which was commonly used in testing programmes was not uniform and reaction at each of the endemic location was different. After examining large number of isolates from endemic locations, Alexander et al (1979) classified the isolates of India into four Major Pathotypes (MP) for particular endemic zones as follows:

	Resistant Genotypes
Endemic zone I (Tamil Nadu area) MP-I	Co.6866, Co.62198
Endemic zone II (Coastal Andhra Pradesh) MP-II	Co.975, Co.6907, Co.62101
Endemic zone III (Eastern Uttar Pradesh and North Bihar) MP-III	Bo.90, Bo.91, Bo.102 Bo.104, Cos.767
Endemic zone IV (Western Uttar Pradesh pockets of Haryana and Punjab) MP-IV	Co.6914, Co.7314 CoJ.58, Co.62399

Mathew et al (1987) identified a hitherto unreported strain of red rot pathogen from Kerala, based on colony characters and reaction on standard differential hosts. This was subsequently designated as MP-V of Endemic zone V (Kerala) with resistant genotypes, Co.7704 and Co.6907 (Alexander, 1988a).

Entry of the pathogen into sugarcane stalks

Went (1893) stated that the place of attachment of the leaf sheath at the node was permeable to natural infection by the fungus. Howard (1903) made inoculations at the leaf bases and obtained infection in some cases. Edgerton (1959), Singh and Budhraja (1964) and Srinivasan and Alexander (1966) also reported that the pathogen gained entry through the leaf scar.

Atkinson and Edgerton (1937) opined that infection of sugarcane stalk occurred when conidia lodged between the leaf sheath and stalk. They observed that numerous appressoria developed within two days of inoculation on the inner surface of leaf sheath and outer surface of stalk. Fine infection threads from the appressoria penetrated the tissues and produced conspicous lesions on leaf sheath, similar to those occuring in nature. Field experiments conducted by Steib and Chilton (1951) indicated that the fungus first developed behind the

leaf sheath as it pulled away from the stalk and then spread and finally infected nodal tissues.

Butler and Khan (1913) obtained infection through adventitious root eyes and injured buds in inoculated canes. Freize (1930) stated that C. falcatum penetrated through the rudimentary roots. Abbott (1938) reported that infection of the growing canes occurred in some varieties through the root primordia, but was limited largely to certain highly susceptible varieties like P.O.J. 213 and 2714. Chona (1950) reported that infection took place, chiefly through leaf scar, root primordia and growth ring but seldom through buds. Srinivasan and Alexander (1966) also noted penetration of the fungus by the formation of appressoria at the growth ring. According to Singh and Budhraja (1964) and Singh et al (1977), the pathogen entered the stalk through roots also. Bhansali and Singh (1981) studied red rot development in young plants using ^{32}P tagged C. falcatum and noted 60-80% disease incidence when the pathogen was applied at the root primordia and bud regions of Co.312 sugarcane setts.

Chilton et al (1947) observed red rot infection on the scales covering the buds. Steib (1949) reported that buds with infected scales developed red rot under favourable conditions. Steib and Chilton (1951) and

Srinivasan and Alexander (1966) observed that scales of young buds were more prone to acquire dormant infection than the older ones.

Lewton-Brain (1908), Edgerton (1911), Abbott (1938) and Wiehe (1944) have implicated the role of borer holes in accentuating red rot incidence. Edgerton (1911) observed that 50 per cent of the Diatraea saccharalis infested plants were badly infected with red rot in the USA. Butler and Khan (1913) did not get any positive correlation between borer holes and red rot incidence. Chona (1950) reported that red rot infection in certain varieties took place through growth cracks. Edgerton (1959) also made similar observations in variety Co.290.

Singh (1967) observed spread of red rot from leaf sheath to leaf midrib in green house grown sugarcane plants. When leaf sheath without injury was inoculated by spore suspension, sheath symptoms appeared in 48 hours and lesions on midribs developed in six days, with more lesions appearing thereafter. Agnihotri and Budhraja (1974) and Sandhu et al (1974) reported that the isolates of C. falcatum from midrib lesions were less virulent than stalk isolates and did not present a serious threat to cane cultivation. Lewin et al (1978) noted a type of midrib lesion in highly susceptible varieties, Co.658

and C.7058 which was a continuation of stem lesion extending into the midribs. They further noted that isolates from such lesions were quite similar to the stalk isolates, in all respects. Agnihotri (1983) reported that the preponderance of virulent midrib isolates was more in endemic areas and that such isolates caused infection on second or third leaf, developed acervuli on both sides of the midrib and continued infection right upto the leaf sheath. Such infections often led to top rot and under congenial atmospheric conditions the pathogen invaded the stalk and caused extensive damage.

Transmission of the disease

According to Butler and Khan (1913), Chona (1950), Mehta and Sinha (1957), Rafay and Singh (1959) and Agnihotri *et al* (1979), sett transmission could be considered as the most common method of transmission of the disease. Raciborski (1897) demonstrated that the mycelium of *C. falcatum* passed from the sett to the emerging shoot. This was confirmed by several workers (Butler, 1906; Kulkarni, 1911; Butler and Khan, 1913; Chona, 1950; Agnihotri *et al*, 1979). On the other hand, Lewton-Brain (1908); Edgerton (1911) and Singh (1969) reported that no mycelial connection existed between the

young shoots and the seedcane. Steib (1949) and Singh (1969) reported that young shoots got infection from the dormant mycelium present in the bud scales. They noted that when the bud sprouted, the dormant mycelium became active and kept pace with the emerging shoot.

Agnihotri et al (1979) reported that when setts having both internal and nodal infections were planted, the loss in stand in different varieties varied from 33.7 to 100 per cent. Such setts also provided inoculum for the secondary spread of the disease. Singh et al (1983) reported poor emergence of lateral buds due to red rot infection when setts were inoculated at the nodes and internodes with ^{32}P labelled culture of C. falcatum.

Chona and Padwick (1942), Chona (1950), Kirtikar and Singh (1955) and Agnihotri et al (1979) reported that asexual and sexual structures like conidia, setae, chlamydospores, ascospores etc produced on decaying canes and/or debris caused infection to healthy setts planted in soil. Various degrees of red rot infection evidenced by reduction in germination of setts and disease development in the shoot have been noticed in soil containing infected debris (Singh, 1981).

Rafay (1955) reported that in places where ratoons were maintained, red rot incidence increased considerably in the field. Singh and Singh (1983) reported that in the first ratoon crop taken in a red rot affected field, 15.5 to 23.1 per cent shoots became infected. Alexander (1984) observed transmission of red rot from plant crop to ratoons in the case of susceptible varieties. There was no transmission of red rot in ratoons of resistant genotypes.

Resistance of sugarcane to red rot

Edgerton (1959) recognised two types of resistance to red rot in sugarcane, (i) morphological and (ii) physiological. According to him sugarcane cultivars differed appreciably among themselves with regard to the thickness of epidermis, cuticle and rind, relative abundance of vascular bundles in the stalk just below the rind, thickness of bundle sheath and of the scales protecting the bud. These structures conspicuously affected the infection process and prolification of the mycelium. Two types of modifications namely, the presence of heavily lignified sclerenchyma and low sugar in nodal tissues, acted as strong barrier against transnodal extension of primary red rot lesions and the presence of cross walls or septa in the xylem vessels of vascular

bundles restricted the migration of conidia and prevented development of secondary lesions.

Physiological resistance to red rot is perhaps the most important type of resistance. Abbott (1938) conducted preliminary experiments to study the phenolic compounds in the internodes of sugarcane varieties resistant and susceptible to red rot and observed that the former contained significantly higher quantities of phenolic compounds. Physiological investigations conducted by Evans (1941) indicated that the reaction of sugarcane to invasion by C. falcatum was associated with the amount of aminophenol of the tyrosine type in the resistant variety. Dufrenoy (1942) showed that compounds like pyridoxin contributed to the resistance of sugarcane to red rot disease. At the margins of red rot lesions in the nodal region, greater amount of pyridoxin was present than in the healthy nodal portions. Edgerton and Carvajal (1944) studied the host parasite relationship in red rot of sugarcane. They concluded that the reaction of protoplasm to the advancing mycelium involved many complex biological and chemical problems, which decided resistance/susceptibility of the host. In advance of the invading mycelium, protoplasm changed in colour and a gummy dark red material oozed out of the cells and filled the intercellular spaces. The zone

adjacent to the advancing mycelium became red due to the elaboration of a soluble dye, which was absorbed by the cell walls. The growth of the advancing mycelium was stopped or at least checked temporarily at the red zone. The natural resistance of a variety depended on the rapidity of development of red zone around infected areas. The red zone was formed quickly in resistant varieties and more slowly in susceptible varieties. Parthasarathi and Vijayasaradhy (1958) suggested that higher phenolic content in S. spontaneum and Co.285 might be of special physiological significance in the hardy nature and disease resistant character of these varieties. Rao et al (1968); Wilson and Srivastava (1969); Verma et al (1971) and Sharma et al (1982) also, demonstrated that resistance against red rot was linked with the amount of total phenols present in different varieties. Singh et al (1976) pointed out that there was no positive correlation between the total phenols in sugarcane varieties and the degree of resistance against C. falcatum.

Lewin et al (1976b) conducted trials to screen clones for field resistance to red rot in Tamil Nadu. Of the 23 varieties tested, eleven were completely free from the disease. Commercial clones viz., Co.449, Co.6304, CoC.671, C.62198, Clones 65221, 66085 and 68075 were very promising among the group tested.

Beniwal et al (1979) reported the reaction of 134 clones against red rot in Haryana. They found that ten clones namely, S.34-69, S.41-69, S.626-75, S.950-75, S.1239-75, S.1244-75, Co.1148, Co.6905, Co.7108 and Co.7314 were resistant to red rot. Of the remaining clones, 43 were graded as moderately resistant, 21 moderately susceptible, 18 susceptible and 42 highly susceptible.

Gupta (1980) screened fourteen varieties and observed that only four, CoS.770, CoS.771, CoS.802 and CoS.820 were moderately resistant to red rot. Natarajan and Muthuswamy (1981) studied the reaction of fiftynine promising clones of which 17 were highly resistant, 2 resistant, 5 moderately resistant, 14 moderately susceptible and the remaining were either susceptible or highly susceptible. The highly resistant clones included C.69107, C.69113, C.69071, C.68166, C.7039, C.69109, C.68071 and C.1742. Sattar et al (1982) tested red rot resistance of 60 clones and reported that twelve clones viz., Co.997, Co.6907, CoC.773, CoA.7701, CoA.11, MS.68/47, CoR.8001, 65.A.66, 77.R.50, 78.R.2, 78.R.28 and 78.R.33 were resistant. Among 62 cultivars tested against the most virulent "Simta" isolate, none of them was found highly resistant to the pathogen (Jhamaria et al, 1985). However, 11 cultivars viz., Co.1007, Co.6803, Co.7301, Co.7307, Co.7322, Co.7517,

Co.7609, Co.7610, Co.7615, Co.7622 and Co.7648 were resistant and 15 were moderately resistant.

Lal (1986) screened fifty sugarcane cultivars at the Indian Institute of Sugarcane Research, Lucknow against red rot infection and reported two varieties viz., CoS.8214 and CoS.8312 as resistant and three varieties viz., Co.312, Co.997 and Co.1148 as highly susceptible.

Biswas (1987) studied eighteen varieties in West Bengal and observed two of them, Co.1148 and U.P.I. as resistant to red rot. Kalaimani et al (1987) in varietal evaluation tests against red rot disease studied the reaction of 569 clones during the years 1976-85. Among the common varieties tested, Co.62198 was highly resistant, Co.419 and Co.6907 were resistant while Co.449 and Co.658 were highly susceptible to the disease.

Evaluation of sugarcane varieties against a new strain of red rot pathogen from Kerala conducted by Mathew et al (1987) revealed that out of 156 varieties tested, 33 were resistant and 46 were moderately resistant. Among the commercial varieties, Co.6907 and Co.7717 were resistant, Co.7704 moderately resistant, Co.1148, Co.62175 and Co.62198 moderately susceptible while, Co.997 was highly susceptible to the disease.

Alexander (1988b) while summarising the results of varietal screening tests conducted at different co-ordinating centres reported eighteen varieties including Bo.91, Co.1148 as moderately resistant at Anakkapalli Centre. At Uchani Centre at Hissar, twelve varieties including CoS.767 were resistant while at the Jhallunder Centre, twenty two varieties including Bo.91, Co.975, Co.1158, Co.7704 and CoS.802 were moderately resistant when tested by the plug method.

Serological differentiation

Serological techniques are now being used as a tool for studying the antigenic relationship and for the differentiation of species, strains and physiological races of certain phytopathogenic fungi.

Burrell et al (1966) demonstrated the usefulness of serological technique for differentiating species of Phytophthora. Genus and species - specific antisera were utilised for the identification of three relatively distinct species of Phytophthora viz., P. cactorum (Lebort and Cohn) schroet, P. cinnamomi Rands, and P. erythroseptica Fethyb. by means of immunodiffusion and indirect immunofluorescence tests. Morton and Dukes (1966) differentiated race 1 and race 2 of Fusarium oxysporum f. sp. lycopersici by serological method.

They further (1967) demonstrated distinct serological differences between the genera Phytophthora and Pythium by means of immunodiffusion tests, but could not demonstrate differences between Phytophthora parasitica Dast. and P. parasitica var. nicotianae Tucker. Kalyanasundaram et al (1967) showed relationship between Fusarium oxysporum f.sp. vasinfectum and F. oxysporum f. sp. cubense and the lack of relationship between these species and Sclerotium rolfsii, through immunodiffusion studies using antisera produced in rabbits, rats and guinea pigs. Hegde et al (1968) utilized serological tests for differentiating physiologic races of Colletotrichum lindemuthianum and were able to arrange nine isolates of the fungus into four distinct groups. Five species of Colletotrichum viz., C. atramentarium, C. capsici, C. curvatum, C. falcatum and C. gloeosporioides showed strong antigenic relationship with C. lindemuthianum. Merz et al (1969) conducted serological comparison of six heterothallic species of Phytophthora and showed that Phytophthora cinnamomi was serologically distinct, whereas two serological groups were evident among five closely related species when tested with antiserum to P. arecae. Kalyanasundaram and Charudattan (1969) conducted serological comparison of three strains of the genus Fusarium and found that two pathogenic strains of F. oxysporum f.sp.vasinfectum from cotton were closely related while, non pathogenic

strain showed marked differences. Serological studies conducted by Renard and Mayer (1969) with saprophytic strains of Fusarium oxysporum and F. oxysporum f.sp. elacidis revealed great variability in the antigenic constitution of extracts of strains within a phenotype or within a pathogenic forma. All the strains studied appeared to belong to one serological group. Kaiser and Gupta (1976) conducted serological and electrophoretic studies employing three formae specialis of Fusarium oxysporum and found some preciptin lines and a few protein bands to be common to the species. Adams and Butler (1979) studied the serological relationship of sixty four isolates of Rhizoctonia solani. The serologic groups corresponded with the anastomosis groups with the exception of AG-2 types 1 and 2, which were serologically indistinguishable. Kryweinczyk and Dorworth (1980) investigated the serological relationship of some fungi of the genus Pythium and found P. aphanidermatum and P. butleri to be identical but different from other species. Hornok (1980) compared serological relationship of thirteen species of Fusarium. Fitzell et al (1980) conducted serological studies of verticillium spp. and the results indicated that Verticillium dahliae had extremely close serological affinities with V. alboatrum while V. tricerpus showed less and V. nigrescens had very little antigenic resemblance

to V. dahliae. Balasubramanian and Kalyanasundaram (1981) conducted antigenic analysis of mycelial extracts of an American and an Indian strain of Fusarium vasinfectum. Although, the two strains were geographically distant, these were serologically closer. Cristinzio (1982) observed serological differentiation of Phytophthora capsici with other species. Anilkumar and Singh (1987) serologically differentiated Neovossia indica and N. horrida but could not differentiate five isolates of N. horrida.

Collateral hosts of C. falcatum

Abbott (1938) reported that Colletotrichum isolates from Johnson grass and sorghum produced red rot symptoms when introduced into sugarcane stalks. Le Beau et al (1951), however, noted that C. falcatum isolates were rarely pathogenic to sorghum. The red rot pathogen produced perfect stage under field conditions on the foliage of Leptochloa filiformis in Louisiana (Carvajal and Edgerton, 1944) and on Miscanthus species in Taiwan (Wang, 1950). Ramakrishnan (1949) reported C. falcatum var. arundinis causing leaf spot of Arundo donax L. in Coimbatore. Experiments conducted by Rafay (1953) showed that Sorghum vulgare, S. halapense, Saccharum robustum, Saccharum spontaneum, Erianthus munja and

Saccharum fusca were able to serve as collateral hosts of red rot organism in descending order of susceptibility. Edgerton (1959) reported Sorghum vulgare, S. halapense and Saccharum spontaneum as collateral hosts of C. falcatum.

Survival of the pathogen in soil

Chona and Nariani (1952) reported that C. falcatum could grow in the soil and produce abundant acervuli. They found that the fungus failed to survive beyond three to four months in the soil. Singh et al (1977) studied the survival of the fungus by burying pieces of infected sugarcane tissues in different depths of soil. They noticed that the pathogen survived for sixtythree days in winter and thirtyfour days in autumn and opined that the longer survival of the pathogen during winter was due to the slower activity of decomposing microbes as compared to that in autumn. Singh and Singh (1982) reported that incubation of C. falcatum conidia in soil using the buried slide technique showed production of appressoria even upto 40 days indicating a long survival of the pathogen in soil. Singh (1983) was able to isolate the pathogen upto two months after burial of infected debris in the soil. Waraitch (1983) observed that C. falcatum could be isolated from infected plant debris buried in soil upto sixty and seventyfive days respectively under nonflooded and flooded conditions respectively

Survival of the pathogen in irrigation water

Chona (1950) obtained high incidence of red rot infection through irrigation water. Kirtikar and Singh (1955) reported that spores of C. falcatum applied through irrigation water thrice at an interval of fifteen days could cause upto 24.6 per cent infection in sugarcane crop planted with healthy setts. Results of experiments conducted by Lal and Singh (1986) showed that red rot fungus present in stagnant water could cause reddening of the pith upto thirty days and lesions at the nodal portion upto sixty days.

MATERIALS AND METHODS

MATERIALS AND METHODS

Survey and collection of diseased specimens

Red rot affected sugarcane fields in and around Thiruvalla including the command area of Travancore Sugars and Chemicals Ltd., Pulikeezhu were surveyed and diseased specimens of different cane varieties were collected during the cropping seasons of 1984 and 1985.

Isolation of the causal organism

Diseased specimens collected from different locations and from different varieties were brought to the laboratory and the causal organism, Colletotrichum falcatum Went was isolated on potato dextrose agar medium. The isolates were purified by single spore method (Riker and Riker, 1936) and their pathogenicity proved, by inoculating the internodes of sugarcane variety Co.997 by the standard plug method (Chona, 1954). Stock cultures were maintained on oat agar slants and stored in the freezer of a refrigerator, after waxing the cotton plug (Alexander, 1982). Subculturing was done regularly at monthly intervals. The isolates were passed through a susceptible host (Co.997) once a year and reisolated to keep up the virulence.

Size of conidia

Measurements of conidia collected from 10-day-old cultures maintained at 28°±2°C were taken in sterile distilled water, under high power of the microscope. One hundred conidia from ten different slide preparations were measured for each isolate.

Growth and sporulation on culture media

Growth characters and sporulation of different isolates were studied on the following culture media in petridishes at room temperature, 28°±2°C.

1. Richards' agar

Potassium nitrate	10.00 g
Potassium dihydrogen phosphate	5.00 g
Magnesium sulphate	2.50 g
Ferric chloride	0.02 g
Sucrose	50.00 g
Agar	20.00 g
Distilled water	1000.00 ml

2. Coon's agar

Sucrose	7.20 g
Dextrose	3.60 g
Magnesium sulphate	1.23 g
Potassium dihydrogen phosphate	2.72 g
Potassium nitrate	2.02 g
Agar	20.00 g
Distilled water	1000.00 ml

3. Czapek's agar

Sodium nitrate	2.00 g
Dipotassium phosphate	1.00 g
Magnesium sulphate	0.50 g
Potassium chloride	0.50 g
Ferrous sulphate	0.01 g
Sucrose	30.00 g
Agar	20.00 g
Distilled water	1000.00 ml

4. Potato dextrose agar

Potato	200.00 g
Dextrose	20.00 g
Agar	20.00 g
Distilled water	1000.00 ml

5. Oat agar

Oat meal	40.00 g
Agar	20.00 g
Distilled water	1000.00 ml

Radial measurement of growth was recorded when the culture in any one of the petridishes reached the edge.

Ten 5 mm discs were cut out from each petridish having ten day old culture of each of the isolates. The discs from each petridish were transferred to ten ml of sterile water in a test tube. After vigorous shaking, one drop of the spore suspension was transferred to a glass slide and a cover slip was placed over it. The number of spores was counted in ten microscopic fields under low power and the intensity of sporulation was graded as - no sporulation, + 1-20 spores, ++ 20-40 spore +++ 40-60 spores, ++++ 60-80 spores and +++++ more than 80 spores.

Effect of different nutrients and hydrogen ion concentration on growth and sporulation

Czapek's solution was used to study the growth and sporulation with different carbon and

nitrogen sources and hydrogen ion concentration. Fifty ml medium in 250 ml flask was used for each treatment. In the case of nutrients, the pH of the medium was adjusted to 7.0 before sterilization. Three replications were maintained for each treatment. After inoculation by the culture of the fungus, the flasks were incubated at room temperature ($28^{o}\pm2^{o}C$) for 15 days.

The culture flasks were vigorously shaken and one drop of the spore suspension from each flask was placed on a glass slide. The intensity of sporulation was graded as mentioned above.

The mycelial growth from each flask was transferred to a previously weighed filter paper (Watman No.1) disc placed in buchner funnel. The mycelial mat was washed with distilled water and then dried in an oven at $60^{o}C$ till constant weight was obtained. Weight of filter paper with mycelial mat was recorded and the dry weight of mycelium was calculated from the same.

A. Utilization of carbon sources

The carbon sources employed for this study included glucose, fructose, maltose, lactose, mannitol, sucrose, starch and cellulose. The sucrose in Czapek's solution

was replaced by other carbon sources so as to supply the amount of carbon equivalent to 30 g of sucrose. Czapek's solution without carbon source served as control.

B. Utilization of nitrogen sources

1. Inorganic nitrogen

Ammonium chloride, ammonium sulphate, ammonium oxalate, sodium nitrate, sodium nitrite, ammonium nitrate, potassium nitrate, magnesium nitrate and calcium nitrate were used as sources of inorganic nitrogen.

Sodium nitrate in Czapek's solution was replaced by other nitrogen sources so as to supply the amount of nitrogen equivalent to 2 g of sodium nitrate. Czapek's solution without nitrogen served as control.

2. Amino nitrogen

Cystine, leucine, arginine, threonine, glycine and tyrosine were added to Czapek's solution at the rate of 500 ppm in place of sodium nitrate. Czapek's solution without nitrogen served as control.

C. Hydrogen ion concentration

Czapek's solution was adjusted to various pH values ranging from 4-10 using 1 N HCl or 1 N NaOH before sterilization.

Reaction of sugarcane varieties to different methods of inoculation

Five sugarcane varieties viz., Co.785, Co.7704, Co.997, Co.62175 and Co.449 were raised in thirty cm diameter earthen pots. When the canes were five to six months old and developed six to seven internodes, these were inoculated by the plug, nodal and whorl methods (given below) with three isolates of the pathogen during the month of September. Five canes were inoculated by each method and in each variety.

1. Plug method

Standing, healthy canes were inoculated by the 'standard' plug method (Chona, 1954). The third exposed internode from bottom was surface sterilized by wiping with a swab of cotton dipped in rectified spirit. A hole, two cm deep was made in the middle of the internode by means of a sterile 5 mm, steel cork borer. Three drops of the spore suspension (containing 30 to 40 spores per microscopic field under low power) prepared from ten day old cultures were carefully poured into the hole by means of a sterile pipette and the plug replaced in the cavity. The point of inoculation was sealed with plastic/modelling clay.

2. Nodal method

Standing canes were inoculated by pouring one ml of the spore suspension into the cavity between the leaf sheath and stem (Rana and Gupta, 1968). The node supporting the lowermost intact leaf sheath was inoculated in each case.

3. Whorl method

One ml of the spore suspension was poured into the funnel of the leaf whorl by means of a pipette (Alexander, 1982).

Observations were recorded two months after inoculation.

In the plug method, the canes were split open longitudinally along the point of inoculation and the condition of the top, nodal transgression, lesion width and white spot/s in the lesion were recorded as detailed below and the extent/severity of infection was graded using a 0-9 scale (Sri nivasan and Bhat, 1961).

I. Condition of top - Green(G), Yellow(Y), Dry(D) (Plate 1.1.)

II. Width of lesion

Width of lesion in the internode above the inoculated one was noted and assigned the score 1, 2 or 3,

based on the area covered in respect to the width of the cane.

III. Occurrence and nature of white spots (Plate 1.2.)

0 = white spot absent

1 = white spot small in size

2 = white spot upto half the width of the cane

3 = white spot large and more than half the width of the cane

IV. Nodal transgression

The spread of infection from above the inoculated internode was recorded and assigned the score as 1, 2 or 3, based on the number of nodes crossed.

The scores obtained in the above three aspects (II, III and IV) were considered to assign the reaction of cane varieties to different grades in the 0-9 scale as given below.

0.0 to 2.0 = R (Resistant)

2.1 to 4.0 = MR (Moderately Resistant)

4.1 to 6.0 = MS (Moderately Susceptible)

6.1 to 8.0 = S (Susceptible)

8.1 to 9.0 = HS (Highly Susceptible) (Plate 1-A & B)

In nodal and whorl methods of inoculation, presence of mid rib lesions and infection at the

Plate 1

Symptoms of red rot in sugarcane

1.1. Yellowing of leaves and drying of canes

1.2. Typical red rot lesion with characteristic white spot

1.1

Plate 1

1.2

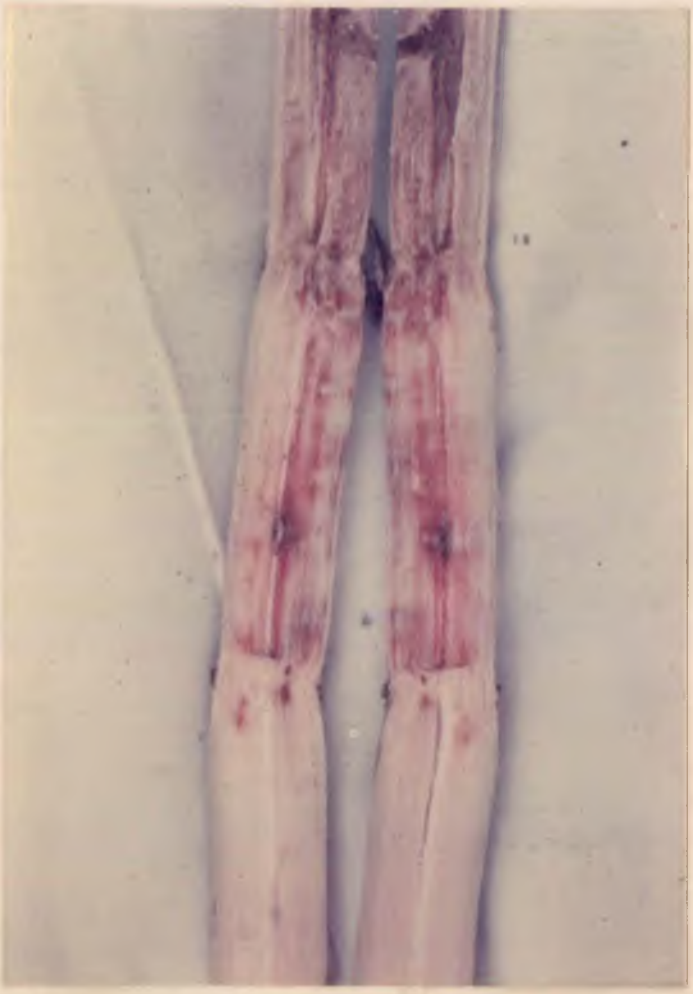


Plate 1-A

Grades of red rot reaction in sugarcane

R - Resistant

MR - Moderately Resistant

Plate 1-A

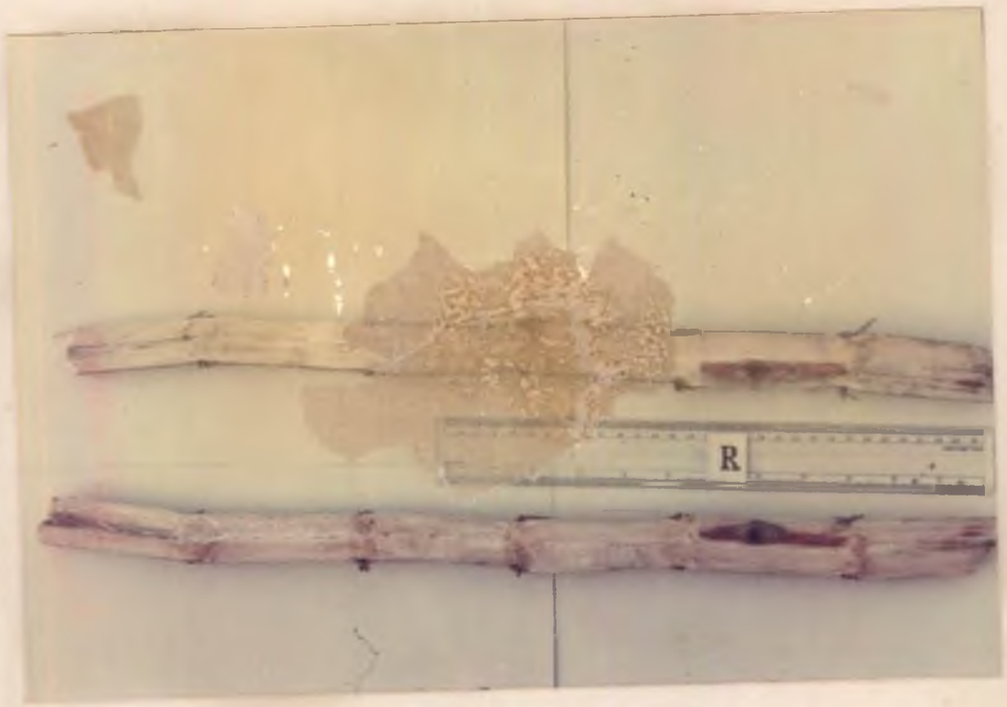


Plate 1-B

Grades of red rot reaction in sugarcane

MS - Moderately Susceptible

S - Susceptible

HS - Highly Susceptible

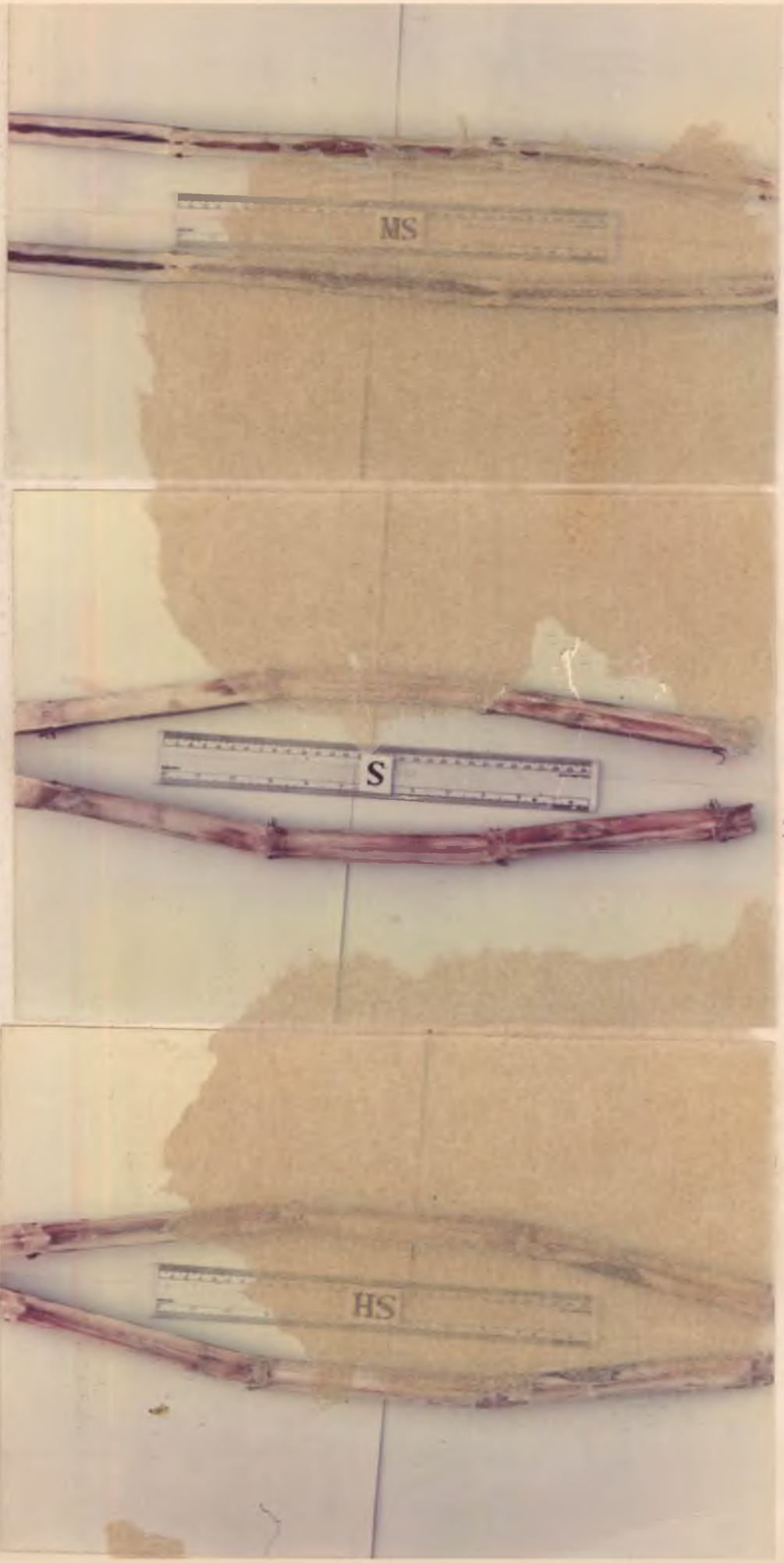


Plate 1-B

nodes (in nodal method) and spindle infection characterised by yellowing/drying of the spindle leaf due to infection (in whorl method) were recorded.

Comparative virulence of different isolates of the pathogen

Three-budded setts of thirteen differential varieties (obtained from Sugarcane Breeding Institute, Coimbatore, through Dr.K.C. Alexander, Senior Pathologist) were planted in the farm attached to the Sugarcane Research Station, Thiruvalla during the cropping seasons of 1986 and 1987.

Five canes of each variety were inoculated with each of the eleven isolates of the pathogen, by the plug method (described earlier), during the month of September. Observations were recorded two months after inoculation. The names of differential varieties and their reaction to Major Pathotypes of C. falcatum are given in page No. 36.

Evaluation of different sugarcane varieties and clones against infection by C. falcatum in Kerala

Two hundred varieties/clones available at the Sugarcane Research Station, Thiruvalla were planted

Variety	Reaction to Major Pathotypes*				
	I	II	III	IV	V
Bo.91	-	-	Resistant	-	-
Cos.767	-	-	Resistant	-	-
Co.975	-	Resistant	-	-	-
Co.1158	-	-	-	Moderately Resistant	-
Cos.802	-	-	Resistant	-	-
Co.62399	-	-	-	Resistant	-
Co.1148	-	-	Resistant	-	-
Co.7704	-	-	-	-	Resistant
Co.6907	-	Resistant	-	-	Resistant
Co.62198	Resistant	-	-	-	-
Co.62101	-	Resistant	-	-	-
Co.62175	-	-	-	-	Moderately susceptible
Co.997	-	Susceptible	-	-	Susceptible

*Alexander, 1988

during the cropping seasons of 1985, 1986 and 1987. Ten, three-budded setts of each variety/clone were planted in a row of three metres. Ten canes in each variety/clone were inoculated with a virulent isolate (I) of the pathogen during the month of September by the plug method. Observations were taken two months after inoculation.

Serological studies

A. Preparation of antigen

The different isolates of Colletotrichum falcatum from Kerala and a new isolate (from Karnal) infecting Co.1148, obtained from Sugarcane Breeding Institute, Coimbatore were grown for fifteen days in 250 ml flasks containing fifty ml of Czapek's solution in each. The mycelial growth was then transferred into Buchner funnel and the culture filtrate was removed under suction. The fungal mat was then washed with phosphate buffer solution to remove the traces of nutrient medium and then dried in a vacuum desiccator.

Two grams of dried mycelium of each isolate was macerated by means of ice cold pestle and mortar after adding a pinch of acid-washed sand and three ml of chilled 0.1 m phosphate buffer solution. After grinding well,

a further quantity of ten ml buffer solution was added to the mortar. The homogenate was strained through muslin cloth and centrifuged at 10,000 rpm for 15 min at 4°C in 'HIMAG' refrigerated centrifuge model HCR 20 BA. The supernatent (antigen) was collected, dispensed into small screw-capped vials and stored in the freezer of a refrigerator. These antigen preparations were used for agglutination and immunogel diffusion tests.

B. Preparation of antiserum

The antigens from isolate I and the new isolate from Karnal were used for preparing antiserum. Healthy rabbits weighing 1.5 - 2.0 kg were used for immunization with the antigens. Approximately two ml of blood sample was drawn from the marginal vein of ear of each rabbit and the serum was collected and preserved as normal check. Emulsion of antigen and fruends complete adjuvant was prepared by vigorously mixing equal quantities of both. Two rabbits were given intramuscular injection on the thigh with two ml of the emulsion from each isolate. The rabbits were given three more injections likewise at weekly intervals with one ml of the antigen alone at each time. One week after the fourth injection,

a trial bleeding was done from the marginal ear vein, inorder to test the titre of the antiserum (Vincent, 1970).

Three days later, bleeding was again done through the marginal vein of the ear. A total quantity of 100 ml blood was collected in a medium sized beaker from each rabbit. The beaker was left undisturbed for 1 h at 37°C, for proper clotting and separation of the serum. The beakers were then held at 4°C overnight to facilitate the extrusion of the serum from the clotted blood. The serum was then drawn out and centrifuged at 3000 rpm for ten minutes to remove the residual cells. Sodium azide at 0.025% concentration was then added as a preservative to the serum and stored at -5°C in the freezer.

C. Determination of titre

The titre of the antiserum was tested by the tube agglutination test described by Vincent (1970). Two fold serial dilutions starting from 1:50 to an end dilution of 1:6400 were prepared by mixing the serum with appropriate quantities of 0.1 m phosphate buffer saline. To each 0.5 ml of diluted antiserum taken in agglutination tubes, 0.5 ml of antigen (used for immunizing rabbit) was added. The tubes containing the antibody-antigen mixture were placed in agglutination racks,

shaken well and then incubated for two hours in a water bath maintained at 52°C, and afterwards overnight in a refrigerator for reading the antibody titre. Antigen + saline and antiserum + saline served as control.

D. Antigen-antibody cross reaction

Cross reaction of antisera prepared against the two isolates of the fungus with the antigen of other isolates was studied by conducting the following tests.

a. Tube agglutination

The antisera (of isolate I and new isolate from Karnal) diluted as described in 'determination of titre' were dispensed in agglutination tubes, 0.5 ml in each and an equal quantity of antigen of each of the isolates was added, mixed well by shaking and incubated in a waterbath for two hours at 54°C. Antiserum + saline and antigen + saline similarly treated served as control. Observations were taken after keeping the tubes overnight in a refrigerator.

b. Slide agglutination

One drop from each dilution of the antisera (of isolate I and new isolate from Karnal) was taken on a glass slide and a drop of the antigen was gently placed

by the side and both drops were mixed well with an inoculation needle. The slide was observed for agglutination directly and also under the low power of a microscope. Antiserum + saline and antigen + saline served as control. The test was conducted with the antigen of all the isolates under study.

c. Immunogel diffusion

Immunogel diffusion test was conducted following the technique described by Vincent (1970), with slight modification.

A clear glass slide was precoated with two per cent difco agar in distilled water. Agarose at 0.85 per cent concentration prepared in normal saline after adding 0.025 per cent, sodium azide (as preservative) was poured over the slide to a thickness of 4 mm and stored in refrigerator in a plastic box. Wells, four mm in diameter and five mm between each other were made in the agarose on the slide in an hexogonal form by means of a cork borer. The central well was filled with the antiserum and the two opposite wells were filled with the homologous antigen. The other four wells were filled with the antigens of different (four) isolates. All the antigens were tested in a similar way. The slides were placed in large sized humid petridish and kept on laboratory benches.

After 24 hours, the slides were observed for the presence of precipitation bands.

Search for collateral hosts

The common weeds in and around sugarcane fields were observed for infection by red rot pathogen and in suspected cases the tissues were kept for isolation in oat agar medium. (APPENDIX-II) Healthy, young weed plants were inoculated with spore suspension prepared from ten to twelve day old cultures of the fungus and placed under humid chamber for 72 hours. These plants were then kept under shade and observed for infection upto ten days after inoculation.

Search for ascigerous stage

Red rot affected fields were regularly inspected to find out whether the ascigerous stage of the pathogen was produced on infected plants or on the plant debris lying in the soil, during different months of the year. Old cultures of the fungus on different media were also examined for the presence of ascigerous structures. Attempts were also made to find out whether perithecial production could be obtained on autoclaved leaf pieces of sugarcane as described by Chona et al (1961).

Spread of the disease to ratoon crop

Disease affected sugarcane clumps of Co.997, a highly susceptible variety in the field were marked

and the intensity of infection was noted down. After harvesting the canes, the infected stumps were uprooted and planted in thirty cm diameter earthen pots. These were grouped into three categories: 1) severely affected clumps with complete drying of the canes, 2) clumps with partially affected canes, 3) clumps with healthy canes. Ten stumps were planted in each category. The pots planted with the stumps were placed in an elevated, disease-free area of the farm. The ratoon crop produced by such stumps were examined for red rot incidence, six months after planting.

Survival of the pathogen in soil

Red rot affected canes of variety Co.997 were chopped into small pieces and placed in thirty cm diameter earthen pots filled with field soil. The pieces were placed at depths of zero, five, ten and fifteen cm (fifteen pieces at each depth), during the month of January. Three pots were used for each treatment.

At intervals of two weeks, five cane pieces were taken out, cut into smaller bits after peeling off the rind and kept for isolation in oat agar medium containing Dicrysticin-S at 500 mg/1 (Singh et al, 1977). Observations for the growth of C. falcatum if any were recorded daily starting from the second day upto ten days.

Survival of the pathogen in river water

The possibility and extent of survival of the propagules of the pathogen, in river water was studied as follows:

Water from the Manimala river by the side of Sugarcane Research Station, Thiruvalla was collected in one litre flasks. Mycelium and spores of C. falcatum scraped out from 10 day old petridish cultures were mixed with the river water and stored in the farm office. River water alone was also stored similarly.

One to two metre long, cut canes of variety Co.997 were inoculated in the middle internode with the river water mixed with the fungus, by the standard plug method, at intervals of two weeks. Five canes were inoculated each time. River water alone was poured into the cavity of the canes which served as control. After dipping the cut ends in molten wax, the canes were wrapped with gunny bag and stored in farm office.

The canes in each set were split open longitudinall and observed for red rot infection, two weeks after inoculation. The tissues from the inoculated node were also cut into small pieces and kept for isolation of the pathogen in oat agar medium.

RESULTS

RESULTS

Isolates of the causal organism

Eleven isolates of the red rot pathogen, Colletotrichum falcatum Went from different varieties and localities were maintained on oat agar medium. The details are given in Table 1. In regard to growth characters of the different isolates, there was very little difference noticeable when grown on this medium. All the isolates grew well with the production of whitish subaerial mycelium and good sporulation evidenced by the appearance of pinkish spore masses.

Size of conidia

Length and breadth of conidia produced by the different isolates on oat agar medium are given in Table 2.

Isolates I and XI produced comparatively longer conidia (27.88 µm and 27.54 µm) than most of the other isolates. Conidial length of isolates II, III, IV, VI, VII and VIII was significantly shorter than the above isolates. Isolate VII had the shortest conidial length (19.72 µm). It was, however, noticed that the conidia produced by isolate VII had maximum breadth (5.10 µm)

Table 1. Isolates of *Colletotrichum falcatum* Went from different locations

Isolate number	Variety from which isolated	Place of collection	Colony character on oat agar medium
I	Co 449	Valanjavattom	Mycelium sub-aerial white with good sporulation
II	Co 997	Eramallikkara	Mycelium dense white with good sporulation
III	Co 419	Kallungal	Mycelium cottony white with good sporulation
IV	Co 997	Kallungal	Mycelium cottony white with good sporulation
V	Co 449	Parumala	Mycelium fluffy white with good sporulation
VI	Co 997	Parumala	Mycelium fluffy white with good sporulation
VII	Co 997	Muthoor	Mycelium cottany white with good sporulation
VIII	Co 997	Valanjavattom	Mycelium sub-aerial white with good sporulation
IX	Co 785	Kallungal	Mycelium dense white with good sporulation
X	Co 997	Kuttoor	Mycelium fluffy white with good sporulation
XI	Co 997	Thiruvampady	Mycelium sub-aerial white with good sporulation

Table 2. Conidial measurements of different isolates of Colletotrichum falcatum Went

Isolate number	Length (µm)		Breadth (µm)	
	Range	Mean	Range	Mean
I	27.2 - 30.6	27.88	3.4 - 6.8	4.76
II	20.4 - 23.8	22.44	3.4	3.40
III	17.0 - 27.2	24.48	3.4 - 6.8	4.42
IV	17.0 - 23.8	20.74	3.4 - 6.8	3.74
V	20.4 - 30.6	25.84	3.4	3.40
VI	23.8 - 27.2	24.48	3.4 - 6.8	4.08
VII	17.0 - 23.8	19.72	3.4 - 6.8	5.10
VIII	20.4 - 23.8	22.78	3.4 - 6.8	4.08
IX	23.8 - 30.6	26.86	3.4	3.40
X	20.4 - 30.6	25.50	3.4 - 6.8	4.76
XI	23.8 - 30.6	27.54	3.4	3.40
C.D.(0.01)		2.13		1.10

while those of isolates II, V, IX and XI had the minimum (3.4 µm) which was significantly lower than that of isolate VII.

Growth and sporulation on culture media

Good mycelial growth of all the isolates was obtained on oat agar and potato dextrose agar media. Maximum radial growth (9.0 cm) was obtained on oat agar by isolate III. Growth on Coon's agar and Richards' agar was rather poor. The least radial growth was noticed on Richards' agar by isolate V (4.12 cm). Potato dextrose agar favoured slightly more fluffy growth in all the isolates. Measurements of radial growth on different culture media are given in Table 3. The radial growth on oat agar and potato dextrose agar media was significantly wider than that on the other media tested.

The data regarding sporulation of different isolates on the culture media are presented in Table 4. Maximum sporulation of most of the isolates was obtained on oat agar medium. Potato dextrose agar also favoured good sporulation. Coon's agar and Richards' agar did not favour good sporulation by any of the isolates.

Table 3. Effect of different culture media on the growth of different isolates of *Colletotrichum falcatum* Went

Medium	Radial growth of isolates in cm											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Mean
Richards' agar	5.09 (2.25)	5.16 (2.27)	4.93 (2.22)	4.59 (2.14)	4.12 (2.03)	4.59 (2.14)	4.83 (2.19)	5.25 (2.29)	5.10 (2.25)	5.35 (2.31)	4.23 (2.05)	4.79 (2.19)
Coon's agar	4.58 (2.14)	4.83 (2.19)	4.26 (2.06)	4.99 (2.03)	4.31 (2.07)	5.12 (2.06)	4.85 (2.00)	4.83 (2.79)	5.06 (2.26)	5.13 (2.26)	5.23 (2.30)	4.84 (2.20)
Czapek's agar	6.06 (2.46)	5.86 (2.42)	5.32 (2.30)	6.46 (2.54)	5.61 (2.38)	6.38 (2.52)	6.23 (2.49)	6.60 (2.58)	5.32 (2.30)	6.39 (2.52)	6.03 (2.45)	6.00 (2.45)
Potato Dextrose agar	8.43 (2.90)	8.49 (2.91)	8.66 (2.94)	8.16 (2.85)	8.49 (2.91)	8.76 (2.96)	8.09 (2.84)	8.29 (2.88)	8.76 (2.96)	7.99 (2.82)	8.56 (2.92)	8.41 (2.90)
Oat agar	8.69 (2.94)	8.86 (2.97)	9.00 (3.00)	8.83 (2.97)	8.76 (2.96)	8.79 (2.96)	8.59 (2.93)	8.34 (2.98)	6.76 (2.60)	8.93 (2.98)	8.66 (2.94)	8.58 (2.93)
Mean	6.45 (2.54)	6.50 (2.55)	6.25 (2.50)	6.50 (2.55)	6.10 (2.47)	6.60 (2.57)	6.40 (2.53)	6.65 (2.58)	6.10 (2.47)	6.65 (2.58)	6.40 (2.53)	

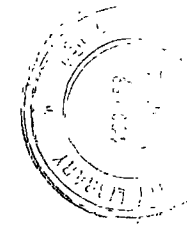
Figures in parentheses are transformed values.

C.D. (0.01) Source - 0.03
Isolate - 0.05
Source x isolates - 0.12

Table 4. Effect of different culture media on the sporulation of different isolates of Colletotrichum falcatum Went

Medium	Intensity of sporulation in isolates										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Richard's agar	++	+	++	+	++	-	++	+	-	-	+
Coon's agar	+	+	++	+	-	-	++	+	-	+	++
Czapek's agar	++	++	+++	+	++	+	++	++	+++	++	++
Potato Dextrose agar	+++	+++	++++	+++	+++	++	+++	+++	+++	+++	+++
Oat agar	++++	+++++	++++	+++++	+++	+++	++++	++++	+++	+++	+++

Effect of different nutrients and hydrogen ion concentration on growth and sporulation



A. Carbon

Effect of various carbon sources on the growth of different isolates is presented in Table 5.

Fructose, mannitol and sucrose supported very good growth of all the isolates. The difference between these carbon sources was not significant. Maximum mycelial growth of isolates I, VIII, IX, X and XI was obtained in fructose. Isolate I produced 435.94 mg, closely followed by isolate VIII with 426.11 mg of dry mycelium, in fructose. In sucrose, maximum growth was obtained by isolates IV, VII and IX. In the case of isolate V, growth in maltose and mannitol was found to be almost similar. For isolate VII, lactose and sucrose supported more or less similar amount of growth. In isolate IX, fructose and sucrose were almost similar in supporting growth. Starch and cellulose were comparatively poor for the growth of all the isolates. The least mycelial growth (50.90 mg) was obtained in cellulose by isolate IV.

In regard to sporulation, glucose, mannitol and sucrose were found to be good for all the isolates. Glucose and mannitol supported maximum sporulation in

Table 5. Effect of carbon sources on the mycelial growth of different isolates of Colletotrichum falcatum Went

Carbon source	Dry weight of mycelium (mg) of isolates											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Mean
Glucose	270.00 (16.43)	181.90 (13.48)	318.22 (17.83)	166.93 (12.92)	338.55 (18.39)	338.18 (18.38)	224.74 (14.99)	219.59 (14.81)	345.18 (18.57)	284.96 (16.88)	246.65 (15.70)	263.08 (16.22
Fructose	435.94 (20.87)	227.46 (15.08)	367.50 (19.17)	338.55 (18.39)	319.99 (17.88)	260.07 (16.12)	300.51 (17.33)	426.11 (20.64)	364.97 (19.10)	373.91 (19.33)	265.53 (16.29)	331.24 (18.20
Maltose	316.46 (17.78)	359.00 (18.94)	360.37 (18.98)	260.89 (16.15)	391.96 (19.79)	375.95 (19.38)	297.89 (17.25)	296.84 (17.22)	287.10 (16.94)	247.95 (15.74)	131.80 (11.48)	297.21 (17.24)
Lactose	155.91 (12.48)	290.49 (17.04)	379.70 (19.48)	331.67 (18.21)	278.09 (16.67)	272.37 (16.50)	316.59 (17.79)	371.98 (19.28)	250.00 (15.81)	355.47 (18.85)	194.03 (13.92)	285.94 (16.91)
Mannitol	364.29 (19.08)	344.16 (18.55)	339.02 (18.41)	369.93 (19.23)	390.97 (19.77)	335.91 (18.32)	286.61 (16.92)	384.88 (19.61)	313.99 (17.72)	353.56 (18.80)	192.88 (13.88)	331.60 (18.21)
Sucrose	380.99 (19.51)	330.44 (18.17)	304.15 (17.44)	410.54 (20.26)	358.28 (18.92)	216.54 (14.71)	317.12 (17.80)	386.39 (19.65)	363.09 (19.05)	346.86 (18.62)	167.40 (12.93)	321.12 (17.92)
Starch	265.63 (16.29)	116.48 (10.79)	168.56 (12.98)	152.88 (12.36)	162.32 (12.74)	249.93 (15.80)	269.81 (16.42)	172.40 (13.13)	222.18 (14.90)	170.12 (13.04)	119.74 (10.94)	184.41 (13.58)
Cellulose	190.32 (13.79)	105.99 (10.29)	156.49 (12.51)	50.90 (7.13)	129.89 (11.39)	152.99 (12.36)	164.42 (12.82)	121.62 (11.02)	216.17 (14.70)	94.95 (9.74)	101.34 (10.06)	130.87 (11.44)
Control	64.06 (8.00)	32.56 (5.70)	60.83 (7.79)	21.38 (4.62)	41.09 (6.41)	31.65 (5.62)	25.11 (5.01)	30.68 (5.53)	42.58 (6.52)	29.24 (5.40)	20.65 (4.54)	35.04 (5.92)
Mean	256.96 (16.03)	202.49 (14.23)	257.92 (16.06)	206.20 (14.36)	248.69 (15.77)	232.56 (15.25)	229.52 (15.15)	245.23 (15.66)	253.44 (15.92)	229.82 (15.16)	148.59 (12.19)	

Figures in parentheses are transformed values.

C.D.(0.01) Source - 0.63
Isolate - 0.70
Isolate x source - 2.10

isolate I whereas, glucose, mannitol and sucrose supported best sporulation in isolate II. Glucose was found to be the best source of carbon for sporulation by isolates III, VII, VIII, IX, X and XI. Cellulose was found to be very poor for the sporulation of all the isolates. The results are presented in Table 6.

B. Nitrogen

1. Inorganic nitrogen

The effect of various inorganic nitrogen sources on the growth of different isolates is presented in Table 7.

Sodium nitrate supported fairly good growth of all the isolates. Isolate I and XI produced maximum mycelial growth (307.66 mg and 338.80 mg) in the presence of sodium nitrate. Maximum growth of isolate IX (387.47 mg) was obtained in ammonium chloride. Ammonium sulphate was found to be the best for isolates II, III and VIII. However, sodium nitrate was on par with ammonium sulphate in the case of isolate VIII. Ammonium oxalate supported maximum mycelial growth of isolate VI and X (409.34 mg and 389.94 mg). Best growth of isolate IV was obtained in sodium nitrite. Ammonium nitrate supported best growth of isolate VII (333.96 mg) while

Table 6. Effect of carbon sources on the sporulation of different isolates of Colletotrichum falcatum Went

Carbon source	Intensity of sporulation in isolates										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Glucose	+++++	+++++	+++++	++++	++++	++++	+++++	+++++	+++++	+++++	+++++
Fructose	+++	+++	+++	++	+++	+++	++	++	++	+++	+++
Maltose	++++	+++	++++	++++	++++	++++	++++	+++	+++	++++	++++
Lactose	++++	++++	+++	+++	++++	++++	++++	++++	++++	+++	+++
Mannitol	+++++	+++++	+++	++++	++++	++++	+++	++++	++++	++++	++++
Sucrose	++++	+++++	++++	++++	++++	++++	++++	+++	+++	++++	++++
Starch	+++	++	++	+++	+++	+++	++	++	+	++	+++
Cellulose	+	+	+	+	++	++	+	++	-	+	+
Control	-	-	+	-	-	-	+	-	-	-	-

Table 7. Effect of nitrogen sources on the mycelial growth of different isolates of Colletotrichum falcatum Went

Nitrogen source	Dry weight of mycelium (mg) of isolates											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Mean
Ammonium chloride	242.62 (15.57)	172.95 (13.15)	303.99 (17.43)	185.96 (13.63)	242.72 (15.57)	337.45 (19.42)	268.17 (16.37)	204.20 (14.29)	387.47 (19.68)	264.95 (16.27)	212.59 (14.58)	256.00 (16.00)
Ammonium sulphate	161.85 (12.72)	220.95 (14.86)	322.31 (17.95)	190.60 (13.80)	260.38 (16.13)	264.78 (16.27)	176.84 (13.29)	363.91 (19.07)	275.18 (16.58)	263.37 (16.22)	298.11 (17.26)	250.58 (15.83)
Ammonium oxalate	218.52 (14.78)	184.59 (13.58)	257.96 (16.06)	115.80 (10.76)	154.50 (12.43)	409.34 (20.23)	291.86 (17.08)	175.20 (13.23)	303.44 (17.41)	389.94 (19.74)	312.27 (17.67)	247.11 (15.72)
Sodium nitrate	307.66 (17.54)	159.87 (12.64)	229.65 (15.15)	230.75 (15.19)	248.20 (15.75)	396.29 (19.90)	237.59 (15.41)	364.53 (19.09)	164.98 (12.84)	384.88 (19.61)	338.80 (18.40)	272.25 (16.50)
Sodium nitrite	283.32 (16.83)	205.65 (14.34)	167.98 (12.96)	260.87 (16.15)	207.63 (14.40)	184.60 (13.58)	195.41 (13.97)	289.94 (17.02)	80.81 (8.98)	131.90 (11.48)	207.62 (14.40)	210.54 (14.51)
Ammonium nitrate	205.97 (14.35)	196.26 (14.00)	171.78 (13.10)	219.05 (14.80)	207.59 (14.40)	251.87 (15.87)	333.96 (18.27)	222.56 (14.91)	251.87 (15.87)	239.50 (15.47)	187.93 (13.70)	224.40 (14.98)
Potassium nitrate	266.73 (16.33)	214.93 (14.66)	180.94 (13.45)	174.29 (13.20)	192.73 (13.88)	283.97 (16.85)	219.07 (14.80)	259.61 (16.11)	242.00 (15.55)	330.96 (18.19)	318.04 (17.83)	241.18 (15.53)
Magnesium nitrate	230.31 (15.17)	153.11 (12.37)	224.59 (14.98)	224.49 (14.98)	326.23 (18.06)	261.30 (16.16)	246.49 (15.70)	293.52 (17.13)	242.74 (15.58)	362.12 (19.02)	115.46 (10.74)	238.39 (15.44)
Calcium nitrate	253.91 (15.93)	173.85 (13.18)	255.60 (15.98)	197.18 (14.04)	207.05 (14.38)	182.11 (13.49)	318.72 (17.85)	167.44 (12.94)	258.77 (16.08)	273.03 (16.52)	314.66 (17.73)	233.47 (15.28)
Control	72.39 (8.50)	40.64 (6.37)	46.04 (6.78)	91.85 (9.58)	61.85 (7.86)	73.86 (8.59)	61.32 (7.83)	84.61 (9.91)	73.19 (8.55)	64.29 (8.01)	39.96 (6.32)	63.36 (7.96
Mean	256.96 (16.03)	202.49 (14.23)	257.92 (16.06)	206.20 (14.36)	248.69 (15.77)	232.56 (15.25)	229.52 (15.15)	245.23 (15.66)	253.44 (15.92)	229.82 (15.16)	148.59 (12.19)	

Figures in parentheses are transformed values.

C.D.(0.01) Source - 0.45
Isolate - 0.47
Isolate x source- 1.51

maximum mycelial growth of isolate V was obtained in magnesium nitrate (326.23 mg). Least mycelial growth (80.81 mg) was noticed in sodium nitrite, by isolate IX.

Ammonium chloride and sodium nitrate favoured very good sporulation by all the isolates. Maximum sporulation of isolate I was obtained in ammonium chloride and sodium nitrate. Best sporulation of isolates II, III, VII and X was obtained in the presence of sodium nitrate. Ammonium chloride and sodium nitrate were equally good in supporting sporulation by isolates VIII, IX and XI. Isolate V exhibited maximum sporulation in the presence of ammonium chloride. Calcium nitrate was found to be a poor source of nitrogen for the sporulation of all the isolates tested. The data are presented in Table 8.

2. Amino nitrogen

The effect of various amino nitrogen sources on the growth of different isolates is given in Table 9.

Tyrosine was found to be a very good source of amino nitrogen for most of the isolates. This was found to be the best for the mycelial growth of isolates V, VII and IX. Leucine was the best for the mycelial growth (224.53 mg) of isolate I. Maximum mycelial growth of

Table 8. Effect of nitrogen sources on the sporulation of different isolates of Colletotrichum falcatum Went

Nitrogen source	Intensity of sporulation in isolates										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Ammonium chloride	++++	+++	+++	+++	++++	+++	+++	++++	++++	+++	++++
Ammonium sulphate	+++	++	++	+++	+++	++	++	++	++	+++	+++
Ammonium oxalate	+++	++	++	+	+	++	++	+++	++	+++	++
Sodium nitrate	++++	++++	++++	+++	+++	+++	++++	++++	++++	++++	++++
Sodium nitrite	+++	++	+++	++	++	++	+++	+++	+++	+	+++
Ammonium nitrate	+++	++	++	+++	+++	++	++	++	+++	++	+++
Potassium nitrate	++	+++	++	++	++	++	++	++	+	++	++
Magnesium nitrate	++	++	+++	++	+++	+++	++	+++	++	++	+++
Calcium nitrate	+	+	++	-	-	+	+	-	+	-	-
Control	-	-	-	-	-	-	-	-	-	-	-

Table 9. Effect of amino nitrogen sources on the mycelial growth of different isolates of Colletotrichum falcatum Went

mino acid source	Dry weight of mycelium (mg) of isolates											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Mean
Cystine	173.62 (13.17)	82.32 (9.07)	102.65 (10.13)	181.88 (13.48)	110.11 (10.49)	169.09 (13.00)	149.86 (12.24)	66.29 (8.14)	143.17 (11.96)	190.65 (13.80)	153.98 (12.40)	135.25 (11.63)
Leucine	224.53 (14.98)	107.87 (10.38)	92.87 (9.63)	162.29 (12.73)	173.70 (13.17)	180.30 (13.42)	172.92 (13.15)	61.52 (7.84)	172.29 (13.12)	157.57 (12.55)	162.32 (12.74)	147.86 (12.16)
Arginine	154.50 (12.43)	86.64 (9.30)	79.49 (8.91)	149.32 (12.21)	170.31 (13.05)	212.84 (14.58)	137.92 (11.74)	75.58 (8.69)	140.30 (11.84)	143.25 (11.96)	135.28 (11.63)	132.02 (11.49)
Threonine	199.81 (14.13)	81.10 (9.00)	117.30 (10.83)	172.84 (13.14)	114.14 (10.68)	228.08 (15.10)	159.99 (12.64)	85.28 (9.23)	205.31 (14.32)	168.64 (12.98)	178.86 (13.37)	151.53 (12.31)
Glycine	217.35 (14.74)	83.32 (9.12)	73.19 (8.55)	218.28 (14.77)	156.15 (12.49)	194.89 (13.96)	172.98 (13.15)	72.95 (8.54)	197.08 (14.03)	203.95 (14.28)	205.51 (14.33)	157.25 (12.54)
Tyrosine	222.24 (14.90)	72.90 (8.53)	88.64 (9.41)	207.70 (14.41)	209.72 (14.48)	211.56 (14.54)	189.65 (13.77)	80.66 (8.98)	214.22 (14.63)	191.87 (13.85)	168.92 (12.99)	163.07 (12.77)
Control	72.39 (8.50)	40.64 (6.37)	46.04 (6.78)	91.85 (9.58)	61.85 (7.86)	73.86 (8.59)	61.32 (7.83)	84.61 (9.99)	73.19 (8.55)	64.29 (8.01)	39.96 (6.32)	63.36 (7.96)
Mean	175.82 (13.26)	77.96 (8.83)	84.27 (9.18)	166.41 (12.90)	138.06 (11.75)	177.15 (13.31)	145.68 (12.07)	74.99 (8.66)	159.76 (12.64)	156.00 (12.49)	143.28 (11.97)	

Figures in parentheses are transformed values

C.D.(0.01) Source - 0.34
Isolate - 0.43
Isolate X Source - 1.14

isolates IV, X and XI was obtained with glycine. Maximum growth of isolate VI (228.08 mg) was obtained with threonine.

Arginine, glycine and tyrosine supported very good sporulation by all the isolates. Cystine also favoured good sporulation by most of the isolates. Leucine was found to be very poor for the sporulation of all the isolates. Maximum sporulation of isolate I was obtained with tyrosine. The results are presented in Table 10.

C. Hydrogen ion concentration

The effect of hydrogen ion concentration on the growth of different isolates is presented in Table 11.

Maximum mycelial growth of all isolates except isolate X was obtained at pH 7.0. In the case of isolate X best growth was obtained at pH 8.0. At pH 7.0, isolate VI and XI produced 270.91 and 270.23 mg of dry mycelium respectively, being significantly higher than that produced by all the other isolates. Production of mycelium was reduced at higher and lower pH.

Best sporulation of all the isolates was obtained at pH 7.0. Fairly good sporulation was obtained at pH 5.0, 6.0 and 8.0. Sporulation was almost nil at pH 10.0. The data are presented in Table 12.

Table 10. Effect of amino nitrogen sources on the sporulation of different isolates of Colletotrichum falcatum Went

Amino nitrogen source	Intensity of sporulation in isolates										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Cystine	++++	+++	+++	+++	+++	+++	+++	++++	+++	++++	+++
Leucine	+	-	-	-	+	-	-	+	+	+	-
Arginine	++++	++++	++++	++++	++++	++++	+++	++++	+++	+++	++++
Threonine	++	++	+++	++	+++	+++	++	++	++	++	++
Glycine	++++	+++	+++	++++	++++	+++	++++	+++	++++	+++	++
Tyrosine	+++++	++++	++++	+++	++++	++++	++++	++++	+++	+++	+++
Control	-	-	-	-	-	-	-	-	-	-	-

Table 11. Effect of hydrogen ion concentration on the mycelial growth of different isolates of Colletotrichum falcatum Went

Hydrogen ion concentration (pH)	Dry weight of mycelium (mg) of isolates											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Mean
4.0	83.99 (9.16)	77.96 (8.83)	52.97 (7.27)	71.32 (8.44)	62.94 (7.93)	70.66 (8.40)	74.17 (8.61)	77.25 (8.78)	83.29 (9.12)	62.48 (7.90)	97.16 (9.85)	73.44 (8.57)
5.0	126.18 (11.23)	124.65 (11.16)	59.32 (7.70)	134.62 (11.60)	87.85 (9.37)	180.91 (13.45)	85.95 (9.27)	66.65 (8.16)	115.95 (10.76)	75.97 (8.71)	189.71 (13.77)	109.62 (10.47)
6.0	188.94 (13.74)	233.30 (15.27)	80.30 (8.96)	172.18 (13.12)	140.35 (11.84)	212.61 (14.58)	71.33 (8.44)	93.57 (9.67)	117.30 (10.83)	128.44 (11.33)	229.31 (15.14)	145.92 (12.08)
7.0	206.99 (14.38)	234.94 (15.32)	76.28 (8.73)	211.19 (14.53)	168.76 (12.99)	270.91 (16.45)	103.06 (10.15)	144.36 (12.01)	161.79 (12.71)	174.25 (13.20)	270.23 (16.43)	178.48 (13.36)
8.0	170.19 (13.04)	204.29 (14.29)	71.31 (8.44)	155.61 (12.47)	138.82 (11.78)	174.17 (13.19)	73.97 (8.60)	104.57 (10.22)	88.94 (9.43)	188.93 (13.74)	217.89 (14.76)	139.47 (11.81)
9.0	144.29 (12.01)	142.71 (11.94)	67.99 (8.24)	118.90 (10.90)	129.96 (11.40)	153.18 (12.37)	83.83 (9.15)	81.64 (9.13)	133.20 (11.54)	127.38 (11.28)	174.60 (13.21)	121.22 (11.01)
10.0	114.27 (10.68)	128.44 (11.33)	67.62 (8.22)	108.65 (10.42)	135.32 (11.63)	139.64 (11.81)	78.96 (8.88)	85.93 (9.26)	103.58 (10.17)	136.32 (11.67)	109.11 (10.44)	108.36 (10.41)
Mean	144.96 (12.04)	158.50 (12.59)	67.56 (8.22)	135.48 (11.64)	120.78 (10.99)	166.15 (12.89)	81.18 (9.01)	91.96 (9.59)	113.42 (10.65)	123.65 (11.12)	178.75 (13.37)	

Figures in parentheses are transformed values.

C.D.(0.01) Source - 0.21
Isolate - 0.26
Source x Isolate - 0.70

Table 12. Effect of hydrogen ion concentrations on the sporulation of different isolates of Colletotrichum falcatum Went

Hydrogen ion concentration (pH)	Intensity of sporulation in isolates										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
4	++	+	++	++	++	+	++	++	++	+	++
5	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
6	++++	+++	++++	+++	+++	+++	+++	+++	+++	+++	+++
7	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
8	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
9	++	++	+	+	+	++	+	++	++	++	++
10	+	+	-	-	-	+	+	-	+	+	+

Reaction of sugarcane varieties to different methods of inoculation

When five commonly cultivated varieties of sugarcane were tested by three methods of inoculation, for their reaction to three isolates of the pathogen, it was noticed that isolate I was more virulent than the other two, when tested by the plug method. The data are presented in Table 13-A and B and Plate 2-A and B. All the five varieties were found susceptible to infection by isolate I whereas, varieties Co.785 and Co.7704 were resistant to isolates II and III.

In the nodal as well as whorl methods of inoculation, isolate I could cause infection in all the varieties except Co.7704. Isolate II caused infection in Co.997, Co.62175 and Co.449 by the nodal method and only Co.997 by the whorl method. Isolate III infected all the varieties except Co.7704 by nodal method and only Co.997 and Co.449 by the whorl method. The data are presented in Table 13-A.

The above results indicated that isolate I was more pathogenic than the other two isolates tested.

Comparative virulence of different isolates of the pathoge

Inoculation of thirteen differential varieties with eleven isolates of the pathogen revealed that there was

Table 13-A. Comparative reaction of five sugarcane varieties to infection by three isolates of Colletotrichum falcatum Went by the plug, nodal and whorl methods of inoculation

Isolate	Variety	Plug method	Nodal method	Whorl method
I	Co.785	MS	++	+
	Co.7704	MS	-	-
	Co.997	S	+++	++
	Co.62175	MS	++	+
	Co.449	MS	++	+
II	Co.785	R	-	-
	Co.7704	R	-	-
	Co.997	S	++	+
	Co.62175	MS	+	-
	Co.449	HS	+	-
III	Co.785	MR	+	-
	Co.7704	MR	-	-
	Co.997	HS	++	+
	Co.62175	S	+	-
	Co.449	HS	+	+

\- absent ++ moderate
\+ low +++ severe

Table 13-B. Evaluation of five varieties of sugarcane against infection by three isolates of Colletotrichum falcatum Went by the plug method

Isolate number	Variety	Mean width of Lesion	Mean width of White spot	Nodal trans-gression	Condition of top	Pith lesion	Colour of lesion	Total	Grade
I	Co.785	2.0	1.4	1.8	D	+	Black	5.2	MS
	Co.7704	1.6	0.4	2.8	G	-	Red	4.8	MS
	Co.997	3.0	1.8	3.0	D	-	Red	7.8	S
	Co.62175	2.4	0.4	3.0	G	-	Red	5.8	MS
	Co.449	2.2	1.6	2.0	G	-	Red	5.8	MS
II	Co.785	0.2	0.0	0.4	G	+	Black	0.6	R
	Co.7704	1.2	0.0	0.2	G	-	Red	1.4	R
	Co.997	2.6	1.8	2.4	D	-	Red	6.6	S
	Co.62175	2.4	0.2	2.6	D	-	Red	5.2	MS
	Co.449	2.8	2.8	2.8	D	+	Black	8.4	HS
III	Co.785	1.4	0.8	1.6	G	+	Black	3.8	MR
	Co.7704	1.4	0.4	2.0	G	+	Black	3.8	MR
	Co.997	3.0	2.6	3.0	D	-	Red	8.6	HS
	Co.62175	2.2	0.8	3.0	D	+	Black	6.0	S
	Co.449	3.0	2.8	2.8	D	+	Black	8.6	HS

G = Green + = Present MS = Moderately Susceptible R = Resistant
D = Dry - = Absent MR = Moderately Resistant S = Susceptible
HS = Highly Susceptible

Plate 2-A

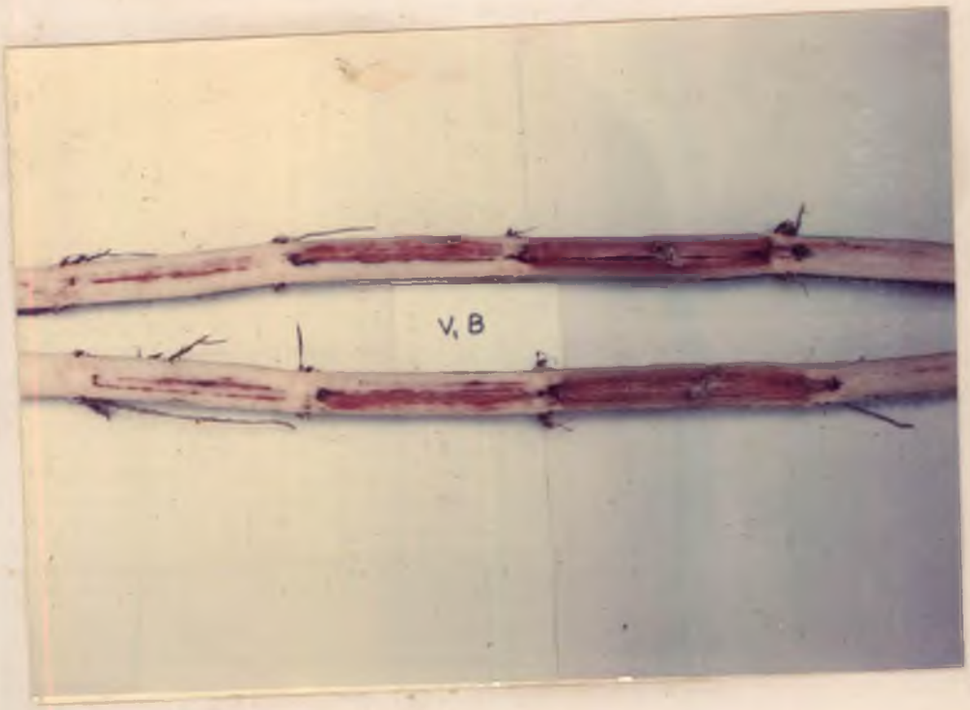
Reaction of sugarcane varieties commonly cultivated in Kerala against infection by *Colletotrichum falcatum* - Isolate I

V_1 - Co.785

V_2 - Co.7704

B - *C. falcatum* (Isolate I)

Plate 2-A



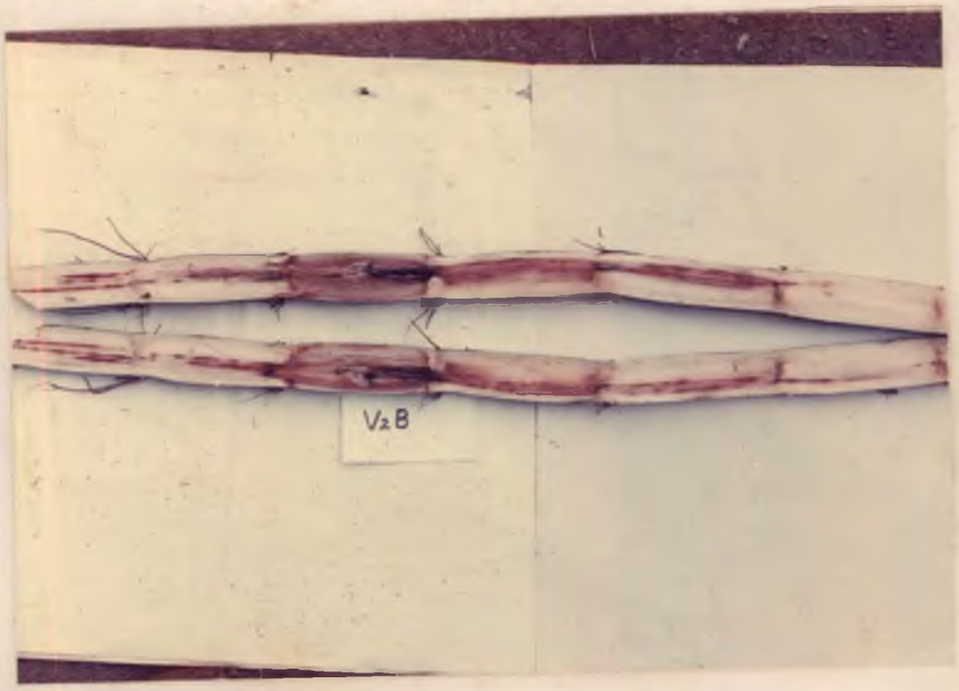


Plate 2-B

Reaction of sugarcane varieties commonly cultivated in Kerala against infection by *Colletotrichum falcatum* - Isolate I

V_3 - Co.997

V_4 - Co.62175

V_5 - Co.449

B - *C. falcatum* (Isolate I)

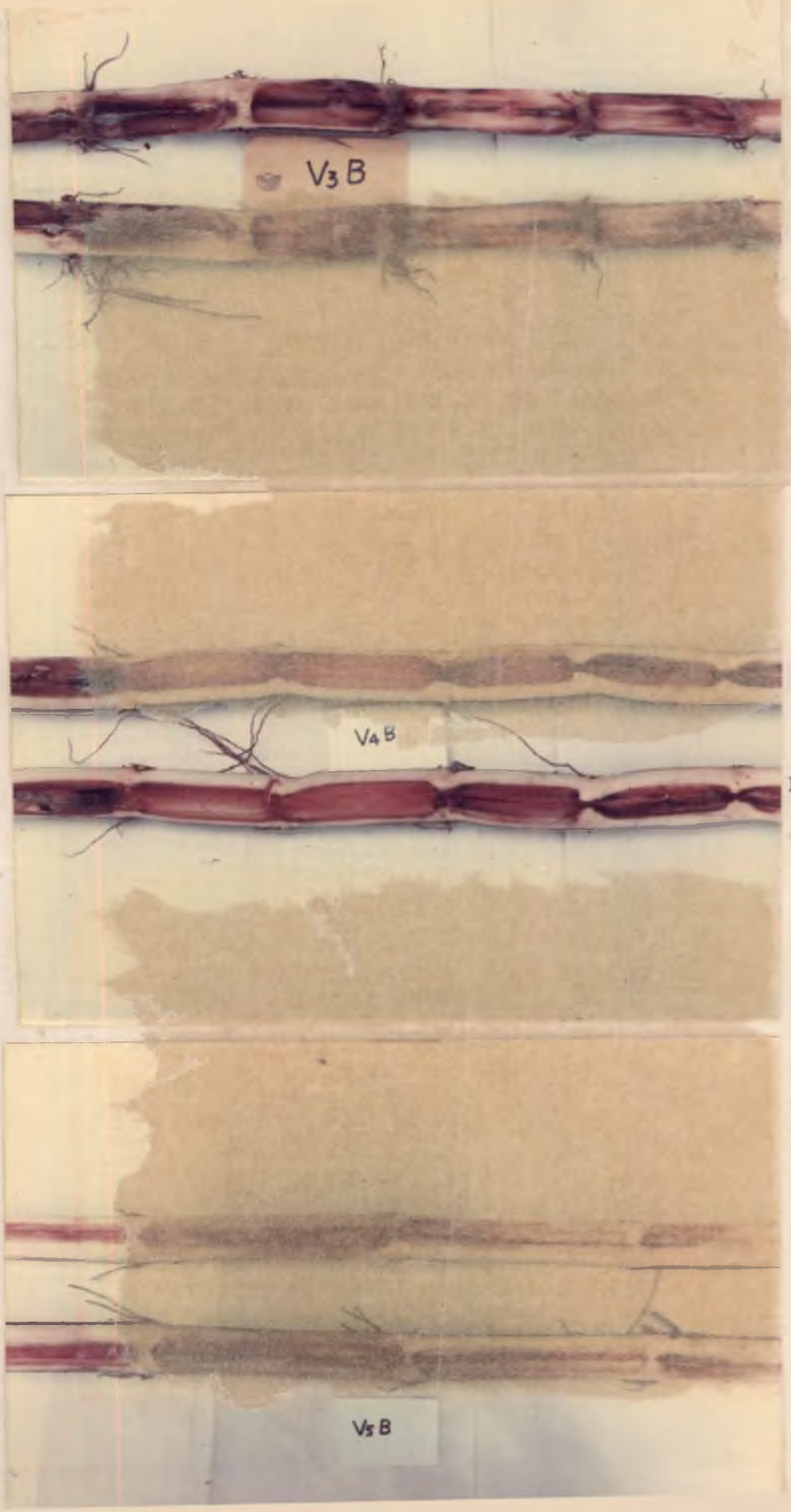


Plate 2-B

considerable variation in the reaction of the different varieties to infection by different isolates of the pathogen. Five varieties viz., Bo.91, Co.975, CoS.802, Co.62399 and Co.6907 were found to be resistant/moderately resistant to isolate I while the remaining eight varieties were susceptible. Eight varieties were resistant/moderatel resistant and five varieties susceptible to isolate VI. Nine varieties were resistant and four varieties susceptibl to isolate VII and X. Ten varieties were resistant and three varieties susceptible to isolate III, V, VIII and XI. Eleven varieties were resistant and two susceptible to isolate II and IV. In the case of isolate IX all except one variety showed resistant reaction. The results are presented in Table 14-A and B and Plates 3 to 13.

The results indicated that isolate I was comparatively more virulent than the other ten isolates studied.

Evaluation of different sugarcane varieties/clones against infection by isolate I

The reaction of different varieties of sugarcane to infection by isolate I of C. falcatum is presented in Table 15.

It was noticed that 10 varieties were resistant, 85 moderately resistant, 86 moderately susceptible,

Table 14-A. Reaction of differential varieties of sugarcane to infection by different isolates of Colletotrichum falcatum Went

Isolate	Variety	Mean lesion width		Mean white spot		Mean nodal transgression		Mean total	Pith lesion		Colour of lesion		Condition of top		Grade
		A	B	A	B	A	B		A	B	A	B	A	B	
I	Bo.91	0.6	2.0	0.0	0.2	1.2	2.2	3.1	-	-	R	R	G	G	MR
	Co.975	1.0	1.2	0.2	0.0	1.2	2.0	2.8	-	-	R	R	G	G	R
	CoS.767	2.0	2.4	1.0	2.4	1.0	2.6	5.7	-	-	R	R	G	G	MS
	Co.1158	1.6	2.4	0.4	1.0	1.8	2.8	5.0	-	-	R	R	G	G	MS
	CoS.802	0.7	1.4	0.2	0.0	1.0	1.6	2.4	-	-	R	R	G	G	MR
	Co.62399	1.2	1.2	0.5	0.4	1.2	1.6	3.0	-	-	R	R	G	G	MR
	Co.1148	2.0	2.2	1.2	0.4	2.0	2.8	5.3	-	-	R	R	G	G	MS
	Co.7704	2.0	2.0	1.4	1.2	1.6	2.2	5.2	-	-	R	R	G	G	MS
	Co.6907	1.8	1.4	0.6	0.0	1.4	2.0	3.6	-	-	R	R	G	G	MR
	Co.62198	2.4	1.6	1.2	0.2	2.0	2.0	4.7	-	-	R	R	G	G	MS
	Co.62101	1.5	2.6	0.5	0.4	2.2	2.2	4.7	-	-	R	R	G	G	MS
	Co.62175	2.0	2.4	1.0	1.6	2.0	2.6	5.8	-	-	R	R	G	G	MS
	Co.997	2.4	2.8	2.2	2.4	2.6	3.0	7.7	-	-	R	R	G	D	S
II	Bo.91	0.8	1.6	0.4	0.2	1.2	2.0	3.1	-	+	R	B	G	G	MR
	Co.975	0.7	0.8	0.2	0.0	1.0	1.2	2.0	-	-	R	R	G	G	R
	CoS.767	1.0	1.8	0.5	0.8	2.5	2.0	4.3	-	-	R	R	G	G	MS
	Co.1158	1.2	1.4	0.6	0.4	1.2	1.8	3.3	-	-	R	R	G	G	MR
	CoS.802	1.0	0.8	0.2	0.0	2.0	1.4	2.7	+	-	R	B	G	G	MR
	Co.62399	1.7	1.8	1.0	0.2	1.2	1.6	3.7	+	-	R	B	G	G	MR
	Co.1148	1.6	1.8	0.0	0.2	2.0	2.4	4.0	+	-	R	B	G	G	MR
	Co.7704	1.2	1.8	0.0	0.2	1.8	2.2	3.6	-	-	R	R	G	G	MR
	Co.6907	1.8	1.4	0.6	0.0	2.0	1.6	3.7	+	+	B	B	G	G	MR
	Co.62198	1.2	1.2	0.0	0.2	2.0	1.6	3.1	-	-	R	R	G	G	MR
	Co.62101	1.6	1.8	0.8	0.4	1.4	1.8	3.9	-	-	R	R	G	G	MR
	Co.62175	1.2	1.8	0.6	0.6	1.8	2.0	4.0	-	-	R	R	G	G	MR
	Co.997	3.0	3.0	2.4	3.0	1.8	3.0	8.1	-	-	R	R	D	D	HS
III	Bo.91	1.0	1.6	0.0	0.4	1.2	1.4	2.8	-	-	R	R	G	G	MR
	Co.975	1.2	1.6	1.0	0.4	2.0	1.2	3.7	-	-	R	R	G	G	MR
	CoS.767	2.4	2.0	1.2	0.6	2.6	2.2	5.5	-	-	R	R	G	G	MS
	Co.1158	2.2	2.0	0.2	0.4	1.6	1.4	3.9	-	-	R	R	G	G	MR
	CoS.802	1.2	1.2	0.2	0.0	0.8	1.4	2.9	-	-	R	R	G	G	MR
	Co.62399	1.4	1.2	0.4	0.2	1.6	1.4	3.1	-	-	R	R	G	G	MR
	Co.1148	1.6	1.4	0.6	0.2	1.6	1.4	3.4	-	-	R	R	G	G	MR
	Co.7704	1.4	1.2	0.0	0.2	1.4	1.4	2.8	-	-	R	R	G	G	MR
	Co.6907	1.8	1.4	0.6	0.0	1.8	1.4	3.5	+	-	B	R	G	G	MR
	Co.62198	1.4	1.2	0.0	0.0	1.8	1.4	2.9	+	-	B	R	G	G	MR
	Co.62101	1.4	1.6	0.2	0.0	1.6	1.4	3.1	+	-	B	R	G	G	MR
	Co.62175	2.0	2.2	0.8	0.6	2.2	2.0	4.6	-	-	R	R	G	G	MS
	Co.997	3.0	3.0	2.4	2.6	2.6	2.8	8.2	-	-	R	R	D	D	HS

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Table 14-A Contd....

Isolate	Variety	Mean lesion width		Mean white spot		Mean nodal transgression		Mean total	Pith lesion		Colour of lesion		Condition of top		Grad
		A	B	A	B	A	B		A	B	A	B	A	B	
IV	Bo.91	0.7	1.2	0.0	0.0	1.0	1.4	2.1	-	-	R	R	G	G	MR
	Co.975	1.0	1.4	0.0	0.0	1.2	1.4	2.5	-	-	R	R	G	G	MR
	CoS.767	1.2	1.6	0.2	0.0	1.7	1.4	3.0	-	-	R	R	G	G	MR
	Co.1158	0.6	1.2	0.0	0.2	0.6	1.2	1.9	-	-	R	R	G	G	R
	CoS.802	1.7	1.2	0.0	0.0	0.7	1.6	2.6	-	-	R	R	G	G	MR
	Co.62399	0.5	1.4	0.0	0.2	0.7	1.2	2.0	-	-	R	R	G	G	R
	Co.1148	1.6	1.2	1.0	0.0	1.8	1.2	3.4	-	-	R	R	G	G	MR
	Co.7704	0.2	0.6	0.0	0.0	0.2	0.6	0.8	-	-	R	R	G	G	R
	Co.6907	1.0	1.2	0.2	0.0	1.2	1.6	2.6	+	+	B	B	G	G	MR
	Co.62198	1.2	0.8	0.0	0.0	1.2	1.6	2.4	+	-	R	R	G	G	MR
	Co.62101	1.6	0.8	0.4	0.0	1.8	1.0	2.8	+	-	B	R	G	G	MR
	Co.62175	2.2	2.2	0.4	0.4	2.0	2.6	4.9	-	-	R	R	G	G	MS
	Co.997	3.0	3.0	2.6	3.0	3.0	3.0	8.8	-	-	R	R	D	D	HS
V	Bo.91	0.6	1.4	0.0	0.0	0.6	1.2	1.9	-	-	R	R	G	G	R
	Co.975	1.0	1.0	0.0	0.0	1.2	1.2	2.2	-	-	R	R	G	G	MR
	CoS.767	1.5	1.6	0.2	0.0	2.2	1.8	3.6	+	-	B	R	G	G	MR
	Co.1158	0.8	0.8	0.0	0.0	0.8	1.0	1.7	-	-	R	R	G	G	R
	CoS.802	0.7	1.4	0.0	0.0	0.7	1.0	1.9	-	-	R	R	G	G	R
	Co.62399	1.3	1.4	0.0	0.0	2.3	2.2	3.6	-	-	R	R	G	G	MR
	Co.1148	1.6	1.4	0.2	0.0	1.2	2.0	3.2	-	-	R	R	G	G	MR
	Co.7704	0.6	1.0	0.0	0.0	0.6	0.8	1.4	-	-	R	R	G	G	R
	Co.6907	1.0	1.6	0.2	0.4	1.0	2.0	3.1	-	-	R	R	G	G	MR
	Co.62198	2.2	1.8	1.3	0.8	1.3	2.0	4.2	-	-	R	R	G	G	MS
	Co.62101	1.2	1.2	0.4	0.2	1.2	1.0	2.6	-	-	R	R	G	G	MR
	Co.62175	2.0	1.8	1.2	0.2	2.2	2.2	4.4	-	-	R	R	G	G	MS
	Co.997	3.0	3.0	2.3	3.0	2.3	3.0	8.3	-	-	R	R	G	D	HS
VI	Bo.91	1.2	1.6	0.2	0.0	1.6	1.6	3.1	-	-	R	R	G	G	MR
	Co.975	1.5	1.2	0.0	0.0	1.5	1.6	2.9	-	-	R	R	G	G	MR
	CoS.767	1.5	2.2	0.5	0.2	2.2	2.2	4.4	-	-	R	R	Y	G	MS
	Co.1158	2.5	1.4	1.0	0.2	2.5	1.6	4.6	-	-	R	R	G	G	MS
	CoS.802	1.0	1.0	0.2	0.0	2.2	1.2	2.8	-	-	R	R	G	G	MR
	Co.62399	1.2	1.2	0.2	0.2	1.0	1.0	2.4	-	-	R	R	G	G	MR
	Co.1148	2.6	1.6	1.0	0.2	2.4	1.8	4.8	-	-	R	R	G	G	MS
	Co.7704	1.2	1.2	0.6	0.0	1.2	1.4	2.8	-	-	R	R	G	G	MR
	Co.6907	1.8	1.4	0.6	0.0	1.8	1.2	3.4	+	-	B	R	G	G	MR
	Co.62198	1.5	1.2	1.0	0.0	1.5	1.4	3.3	-	-	R	R	G	G	MR
	Co.62101	1.8	1.6	0.4	0.0	1.6	1.8	3.7	-	-	R	R	G	G	MR
	Co.62175	1.8	1.6	0.6	0.6	2.0	2.2	4.4	-	-	R	R	G	G	MS
	Co.997	3.0	2.6	2.6	1.6	3.0	2.8	7.8	-	-	R	R	D	G	S

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Table 14-A Contd....

Isolate	Variety	Mean lesion width		Mean white spot		Mean nodal transgression		Mean total	Pith lesion		Colour of lesion		Condition of top		Grade
		A	B	A	B	A	B		A	B	A	B	A	B	
VII	Bo.91	1.5	1.4	0.5	0.2	1.5	1.6	3.3	-	-	R	R	G	G	MR
	Co.975	1.2	1.0	0.2	0.0	1.5	0.8	2.3	-	-	R	R	G	G	MR
	CoS.767	1.2	1.0	0.2	0.0	1.7	1.6	2.8	-	-	R	R	G	G	MR
	Co.1158	1.6	2.0	0.6	0.4	1.2	2.4	4.1	-	-	R	R	G	G	MS
	CoS.802	1.2	1.0	0.7	0.0	1.2	1.0	2.5	-	-	R	R	G	G	MR
	Co.62399	1.5	1.2	0.5	0.0	0.7	2.6	3.2	-	-	R	R	G	G	MR
	Co.1148	1.8	1.4	0.6	0.2	2.0	1.4	3.7	-	-	R	R	G	G	MR
	Co.7704	2.0	1.0	0.5	0.0	0.6	1.4	2.7	-	-	R	R	G	G	MR
	Co.6907	2.0	1.0	1.2	0.2	2.2	2.0	4.3	+	+	B	B	G	G	MS
	Co.62198	1.4	1.6	0.2	0.0	1.2	1.2	2.8	-	-	R	R	G	G	MR
	Co.62101	1.4	1.6	0.2	0.0	1.6	1.2	3.0	-	-	R	R	G	G	MR
	Co.62175	2.2	2.0	0.8	0.4	2.2	2.0	4.8	-	-	R	R	G	G	MS
	Co.997	3.0	3.0	2.2	2.4	2.5	3.0	8.0	-	-	R	R	D	G	HS
VIII	Bo.91	0.8	1.2	0.0	0.0	0.6	1.6	2.1	-	-	R	R	G	G	MR
	Co.975	0.8	1.4	0.2	0.0	1.0	1.8	2.6	-	-	R	R	G	G	MR
	CoS.767	2.2	2.0	0.2	0.2	1.7	1.6	3.9	-	-	R	R	G	G	MR
	Co.1158	1.8	1.2	0.4	0.0	2.0	1.8	3.6	-	-	R	R	G	G	MR
	CoS.802	1.0	1.6	0.4	0.0	1.8	1.4	3.1	-	-	R	R	G	G	MR
	Co.62399	1.3	1.2	0.3	0.0	1.6	0.8	3.1	-	-	R	R	G	G	MR
	Co.1148	2.0	1.2	1.0	0.0	2.5	1.2	3.9	-	-	R	R	G	G	MR
	Co.7704	1.8	1.6	0.6	0.0	1.4	2.0	3.5	-	-	R	R	G	G	MR
	Co.6907	1.6	1.8	0.4	0.4	1.8	1.8	3.6	+	-	B	R	G	G	MR
	Co.62198	1.8	0.8	1.0	0.0	2.2	1.0	3.4	-	-	R	R	G	G	MR
	Co.62101	2.6	1.4	1.8	0.2	1.8	1.2	4.5	-	-	R	R	G	G	MS
	Co.62175	2.2	2.2	1.0	0.4	2.8	2.2	5.4	-	-	R	R	G	G	MS
	Co.997	3.0	3.0	2.8	1.0	3.0	3.0	7.8	-	-	R	R	D	D	S
IX	Bo.91	1.2	1.2	0.4	0.0	0.8	1.4	2.5	-	-	R	R	G	G	MR
	Co.975	1.0	1.0	0.2	0.0	1.2	1.0	2.2	-	-	R	R	G	G	MR
	CoS.767	1.2	1.2	0.2	0.0	1.2	1.2	2.5	-	-	R	R	G	G	MR
	Co.1158	1.5	1.8	0.0	0.2	1.1	1.2	2.9	-	-	R	R	G	G	MR
	CoS.802	1.0	1.2	0.0	0.0	1.0	1.0	2.1	-	-	R	R	G	G	MR
	Co.62399	1.2	1.2	0.5	0.0	1.2	1.6	2.8	-	-	R	R	G	G	MR
	Co.1148	2.4	1.4	1.0	0.4	2.0	0.8	4.0	-	-	R	R	G	G	MR
	Co.7704	1.6	1.0	0.4	0.0	1.4	1.0	2.7	-	-	R	R	G	G	MR
	Co.6907	1.2	1.8	0.2	0.4	2.2	1.4	3.6	+	+	B	B	G	G	MR
	Co.62198	1.2	1.4	0.2	0.0	1.4	1.2	2.7	-	+	R	B	G	G	MR
	Co.62101	1.2	1.4	0.6	0.2	1.2	1.4	3.0	-	-	R	R	G	G	MR
	Co.62175	1.6	1.8	0.6	0.4	1.8	1.0	3.6	-	-	R	R	G	G	MR
	Co.997	2.6	2.8	1.8	2.0	2.0	3.0	7.1	-	-	R	R	G	G	S

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Table 14-A Contd....

Isolate	Variety	Mean lesion width		Mean white spot		Mean nodal transgression		Mean total	Pith lesion		Colour of lesion		Condition of top		Grade
		A	B	A	B	A	B		A	B	A	B	A	B	
X	Bo.91	0.8	0.8	0.0	0.0	1.6	1.2	2.2	-	-	R	R	G	G	MR
	Co.975	1.0	1.4	0.6	0.0	1.0	1.4	2.7	-	-	R	R	G	G	MR
	CoS.767	1.5	1.2	1.0	0.4	2.2	1.6	3.9	-	-	R	R	G	G	MR
	Co.1158	1.5	1.6	0.4	0.4	1.4	1.6	3.4	-	-	R	R	G	G	MR
	CoS.802	0.8	1.0	0.0	0.4	1.4	1.6	2.6	-	-	R	R	G	G	MR
	Co.62399	1.0	1.2	0.0	0.4	1.0	1.2	2.4	-	-	R	R	G	G	MR
	Co.1148	1.4	1.6	0.4	0.2	1.4	1.4	3.2	-	-	R	R	G	G	MR
	Co.7704	1.8	1.8	1.2	0.0	2.0	1.4	4.1	-	-	R	R	G	G	MS
	Co.6907	1.2	1.6	0.2	0.0	1.2	1.2	2.7	+	+	B	B	G	G	MR
	Co.62198	1.5	1.2	0.2	0.0	1.7	1.6	3.1	+	-	B	R	G	G	MR
	Co.62101	1.6	1.2	1.6	0.2	2.2	1.6	4.9	-	-	R	R	G	G	MS
	Co.62175	2.0	2.6	1.6	1.4	1.5	3.0	6.0	-	-	R	R	G	G	S
	Co.997	2.8	3.0	2.4	2.2	2.6	2.8	7.9	-	-	R	R	G	G	S

XI	Bo.91	1.0	1.2	0.2	0.0	1.0	1.6	2.5	-	-	R	R	G	G	MR
	Co.975	1.0	1.0	0.0	0.0	1.0	1.2	2.1	-	-	R	R	G	G	MR
	CoS.767	2.0	0.6	1.2	0.0	2.0	0.0	2.6	-	-	R	R	G	G	MR
	Co.1158	1.6	1.6	0.6	0.2	1.6	0.6	3.1	-	-	R	R	G	G	MR
	CoS.802	0.6	0.6	0.0	0.0	1.8	0.6	1.9	-	-	R	R	G	G	R
	Co.62399	1.0	0.8	0.0	0.0	1.2	1.0	2.0	-	+	R	B	G	G	R
	Co.1148	1.4	0.4	1.2	0.2	1.6	1.0	2.9	-	-	R	R	G	G	MR
	Co.7704	1.4	1.4	1.2	0.0	1.4	1.0	3.2	-	-	R	R	G	G	MR
	Co.6907	1.0	1.2	0.2	0.2	1.4	1.0	2.5	+	+	B	B	G	G	MR
	Co.62198	1.8	1.6	0.8	0.2	2.2	2.2	4.4	-	-	R	R	G	G	MS
	Co.62101	2.0	1.8	0.8	0.0	1.2	1.6	3.5	-	-	R	B	G	G	MR
	Co.62175	1.8	2.8	1.0	0.4	2.0	2.8	5.9	-	-	R	R	G	G	MS
	Co.997	2.8	3.0	1.8	2.2	1.6	3.0	7.2	-	-	R	R	G	G	S

A - 1986 - Absent R - Red G - Green R - Resistant

B - 1987 + Present B - Black D - Dry S - Susceptible

MS - Moderately Susceptible MR - Moderately Resistant HS - Highly Susceptible

Table 14-B. Comparative virulence of different isolates of Colletotrichum falcatum Went to differential varieties of sugarcane

Varieties	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Bo.91	MR	MR	MR	MR	R	MR	MR	MR	MR	MR	MR
Co.975	R	R	MR	MR	MR	MR	MR	MR	MR	MR	MR
CoS.767	MS	MS	MS	MR	MR	MS	MR	MR	MR	MR	MR
Co.1158	MS	MR	MR	R	R	MS	MS	MR	MR	MR	MR
CoS.802	MR	MR	MR	MR	R	MR	MR	MR	MR	MR	R
Co.62399	MR	MR	MR	R	MR	MR	MR	MR	MR	MR	R
Co.1148	MS	MR	MR	MR	MR	MS	MR	MR	MR	MR	MR
Co.7704	MS	MR	MR	R	R	MR	MR	MR	MR	MS	MR
Co.6907	MR	MR	MR	MR	MR	MR	MS	MR	MR	MR	MR
Co.62198	MS	MR	MR	MR	MS	MR	MR	MR	MR	MR	MS
Co.62101	MS	MR	MR	MR	MR	MR	MR	MS	MR	MS	MR
Co.62175	MS	MR	MS	MS	MS	MS	MS	MS	MR	S	MS
Co.997	S	HS	HS	HS	HS	S	HS	S	S	S	S

Plate 4

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate II

Plate 4

Plate 3

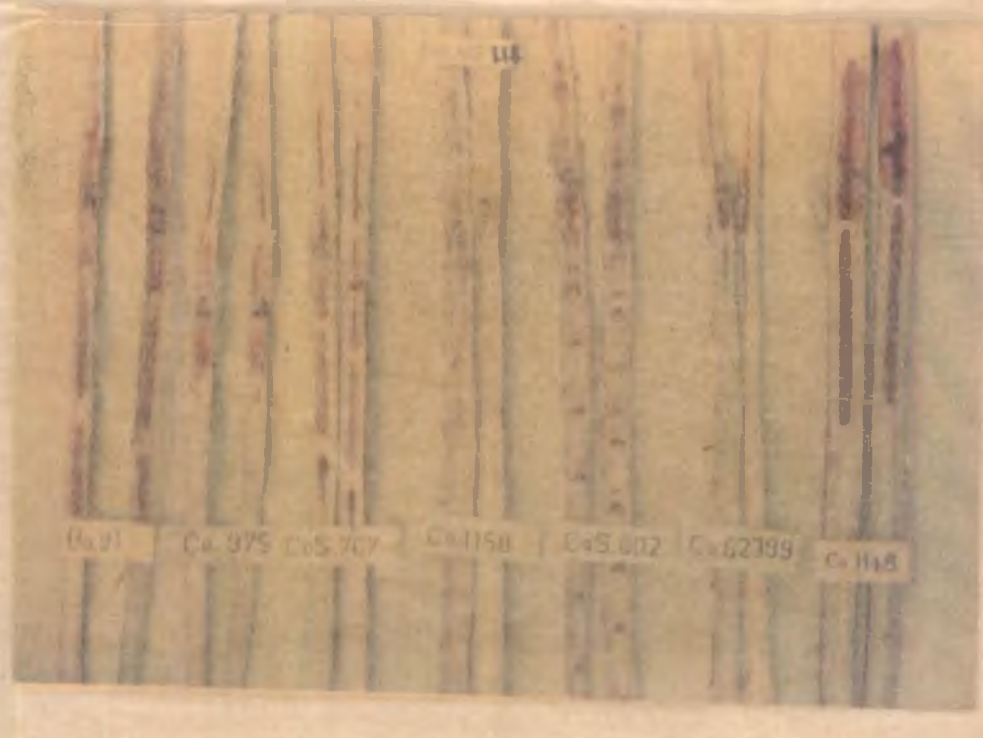
Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate I

Plate 3

Plate 5

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate III

Plate 5



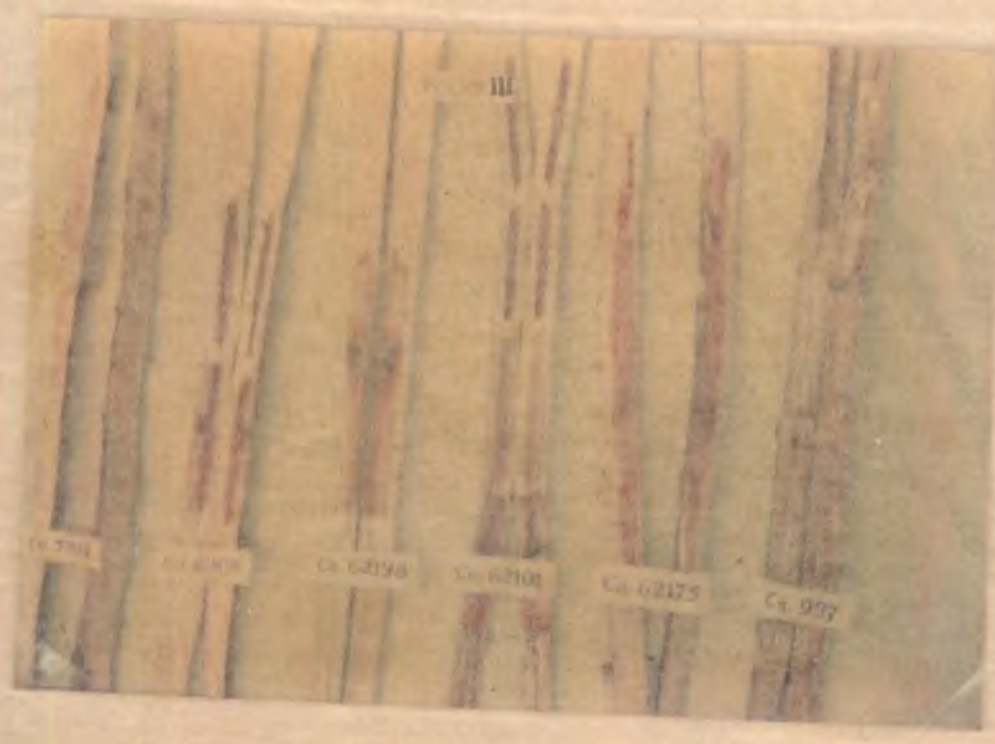
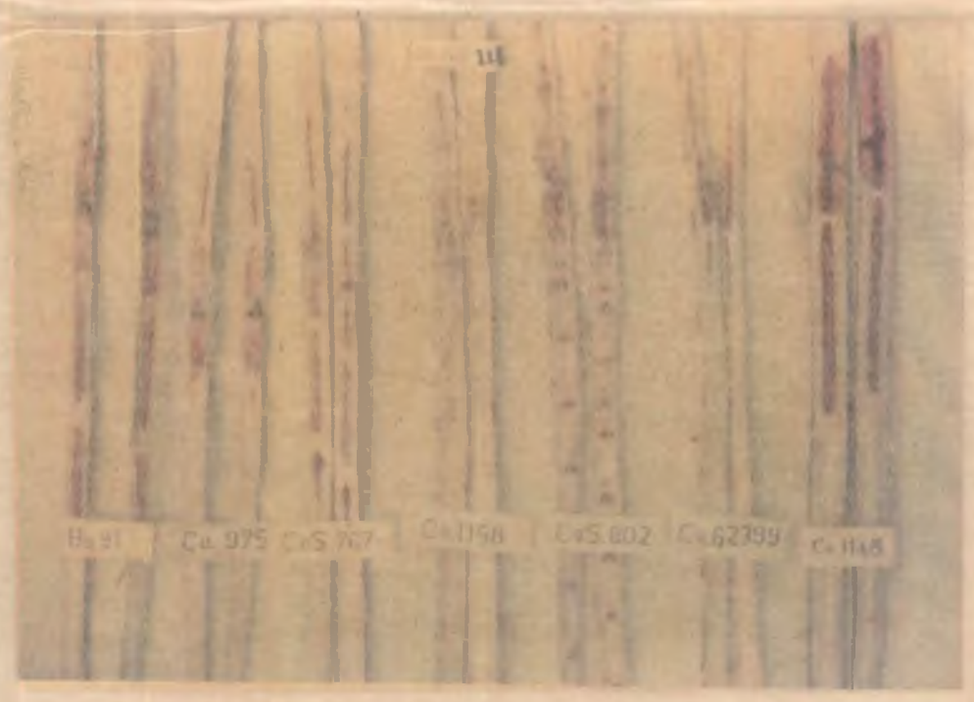


Plate 5



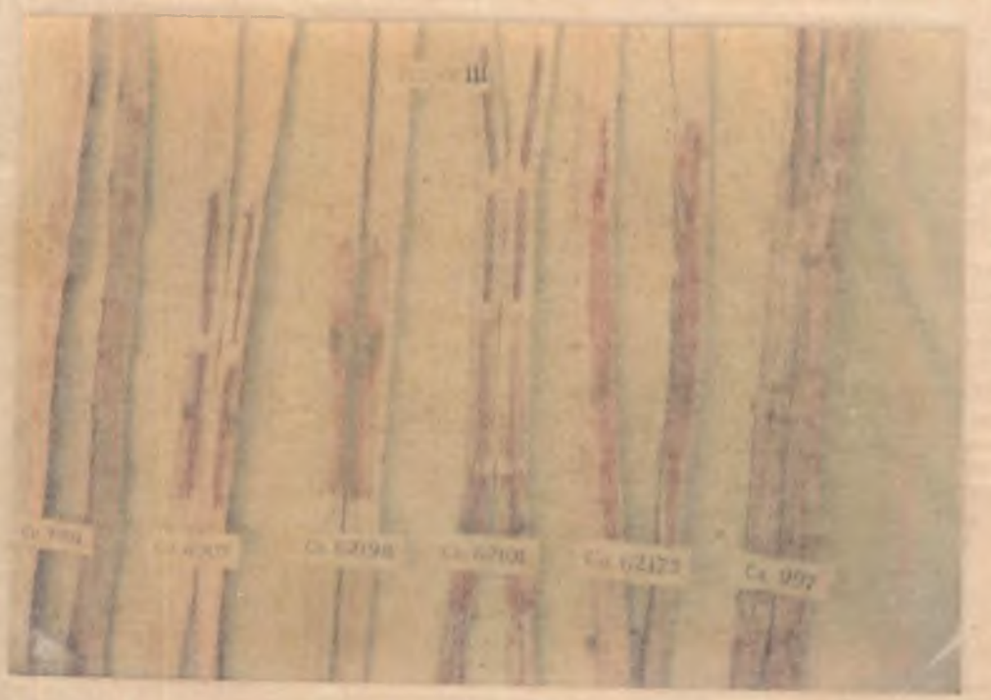


Plate 6

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate IV

Plate 6

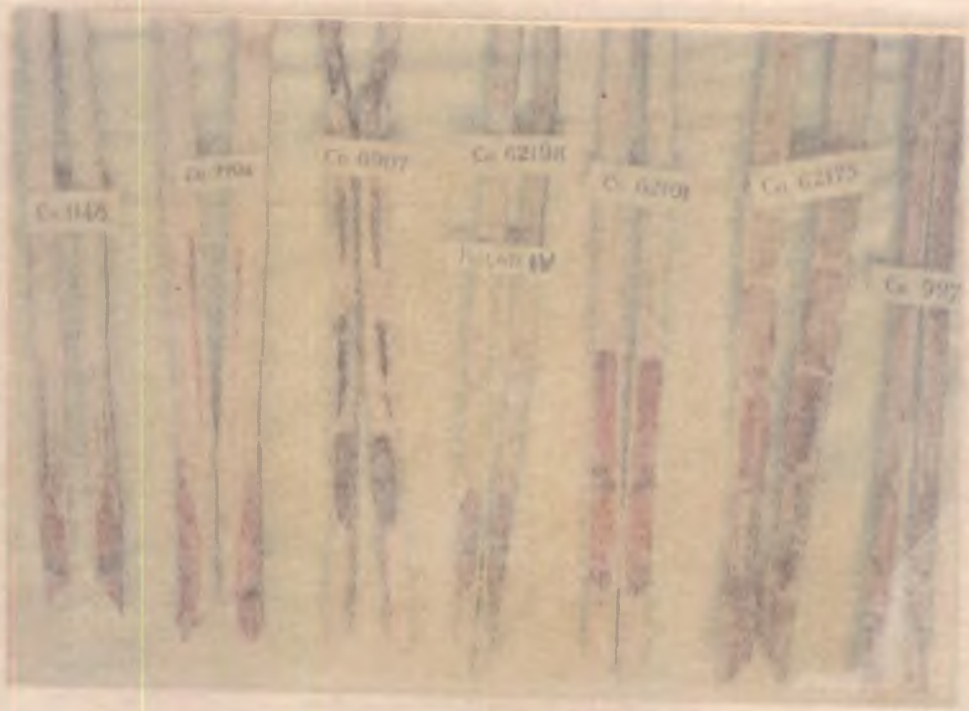


Plate 7

Reaction of differential varieties against infection by *Colletotrichum falcatum* - Isolate V

Plate 7

Plate 8

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate VI

Plate 8


Co.31
Co. 975
CoS. 767
Co.1158
CoS. 802
Co.62399
Co 1148


Co 7704
Co 6907
Co 62198
Co 62173
Co 997

Plate 9

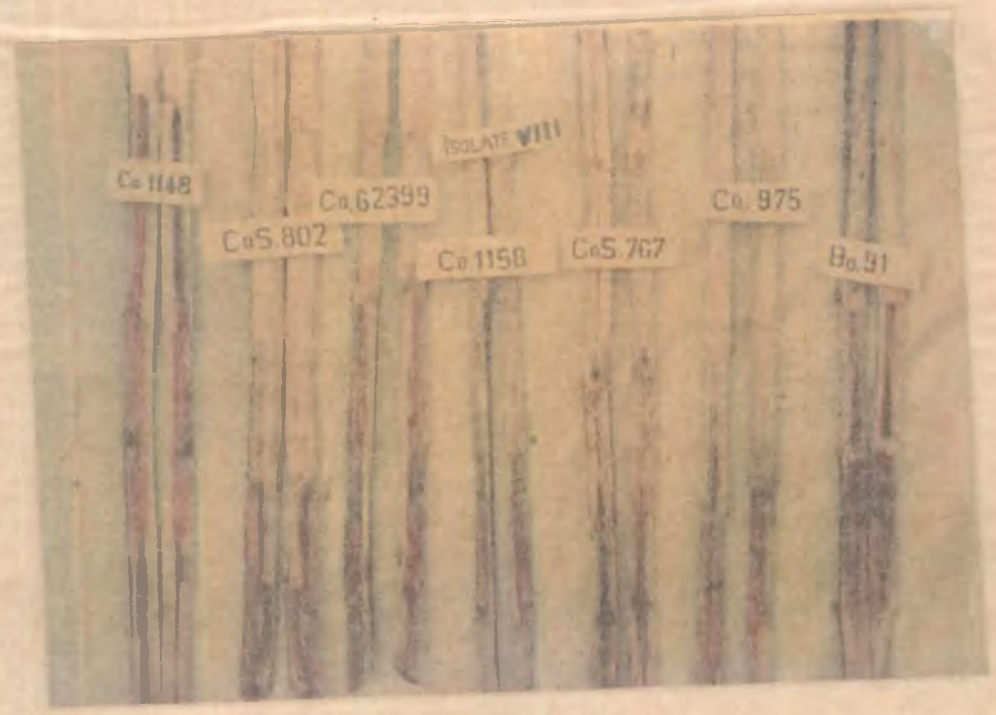
Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate VII

Plate 9

Plate 10

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate VIII

Plate 10


Co 1148
Co.62399
CoS.802
ISOLATE VIII
Co.1158
CoS.767
Co. 975
Bo.91


Co. 997
Co. 62373
ISOLATE VIII
Co. 62198
Co 6207

Plate 11

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate IX

Plate 11


Co 1148
CoS. 802
Co. 62399
ISOLATE IX
Co 1158
CoS. 707
Co. 975
Be 91

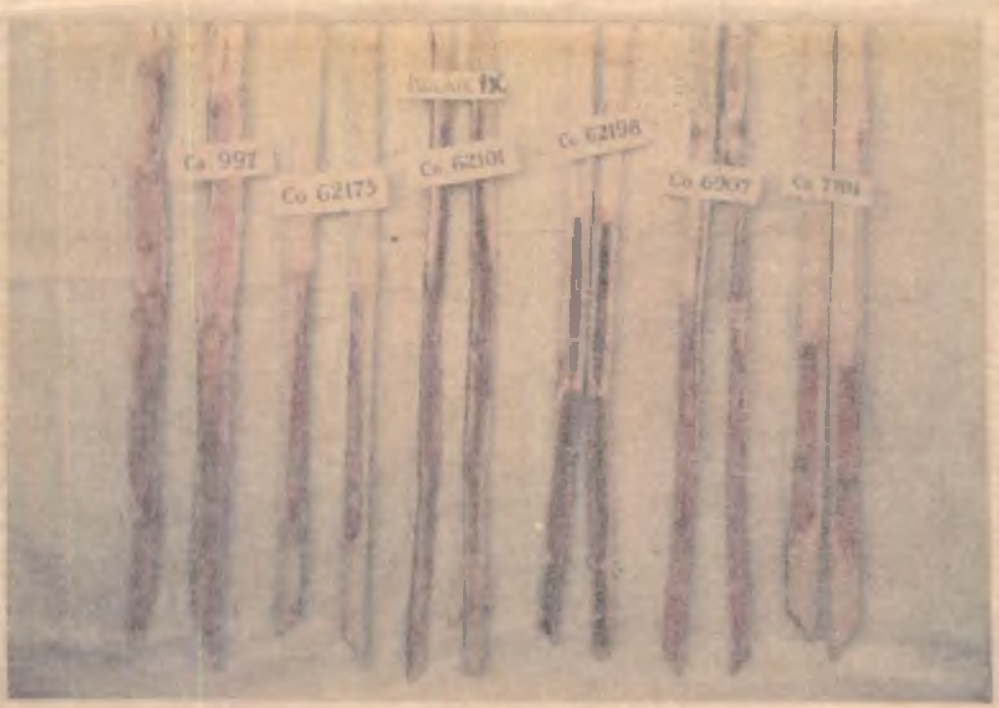

Co. 997
Co 62175
ISOLATE IX
Co. 62108
Co. 62198
Co 6007
Co 7804

Plate 12

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate X

Plate 12


Co. 997
Co 62173
Co. 62101
Co. 62138
Co 6907

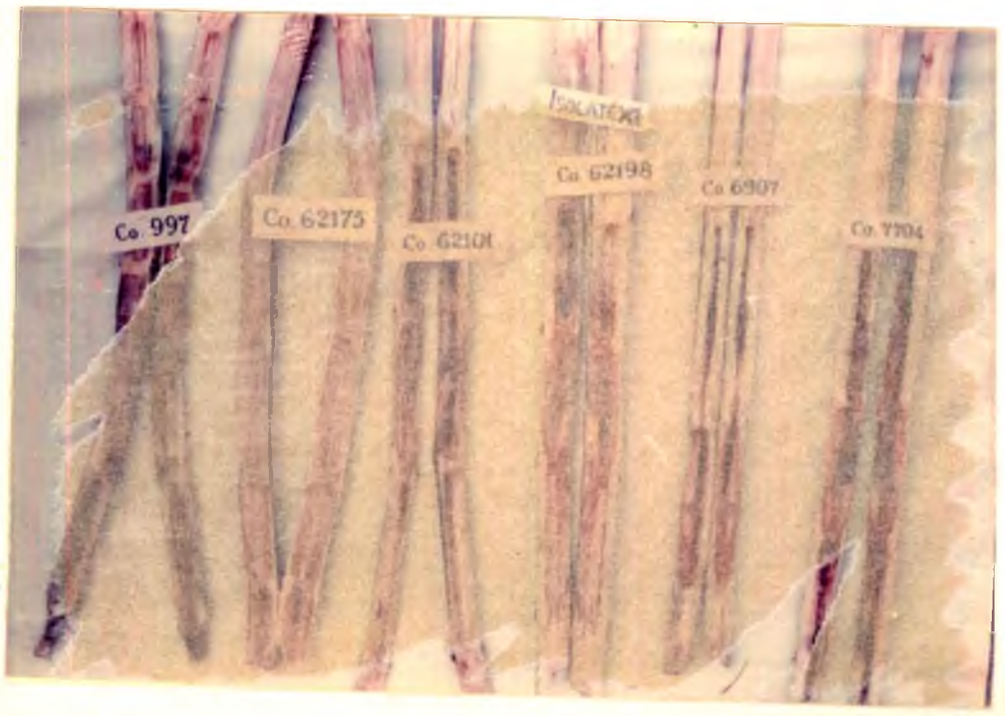

Co 975
Co S.802
Co 62393

Plate 13

Reaction of differential varieties against infection by Colletotrichum falcatum - Isolate XI

Plate 13


Co 62399
CoS 802
Co 1158
CoS 707
Co 975
Co 91


Co 997
Co 62173
Co 6210
Co 62198
Co 6907
Co 7704

14 susceptible and 5 highly susceptible to the isolate I of the pathogen.

Most of the commonly cultivated varieties of Thiruvalla region like Co.997, Co.449, Co.419, Co.785 and Co.62175 were either moderately susceptible or highly susceptible (Co.997) to the isolate. Among the two varieties viz., Co.7704 and Co.6907 recently recommended for cultivation in the area (Mathew et al, 1987), Co.7704 was found moderately susceptible to the isolate under study.

A comparison of the reaction of different varieties to isolate I with that reported by Mathew et al, 1987, subsequently designated as major pathotype-V is presented in Table 16.

It will be noticed that, out of the 21 varieties resistant to the MP-V, eleven were moderately resistant and eight were moderately susceptible to the present isolate I. Similarly, out of the twenty five varieties moderately resistant to MP-V, twelve were moderately susceptible, one was highly susceptible and one was resistant to isolate I.

These observations clearly indicated that marked differences existed between the two isolates in respect to their pathogenicity to different sugarcane varieties.

Table 15. Reaction of different sugarcane varieties to infection by Colletotrichum falcatum - Isolate I

Sl. No.	Variety	Mean lesion width			Mean white spot			Mean nodal transgression			Mean total	Pith lesion			Colour of lesion			Condition of top			Grade
		A	B	C	A	B	C	A	B	C		A	B	C	A	B	C	A	B	C	
1	CoC.774	2.0	1.7	2.8	0.0	0.7	1.0	3.0	2.0	3.0	5.40	+	+	+	B	B	R	G	G	D	MS
2	CoC.775	2.0	1.6	2.8	0.0	0.7	1.0	3.0	1.9	2.4	5.13	+	-	-	B	R	R	G	G	G	MS
3	CoC.778	3.0	1.7	1.8	2.0	0.1	0.2	2.0	2.0	1.4	4.73	-	-	-	R	R	R	G	G	G	MS
4	Co.685	1.0	1.2	2.0	0.0	0.3	0.3	1.0	0.7	1.0	2.50	+	-	-	B	R	R	G	G	G	MR
5	B.37172	3.0	1.7	2.2	1.0	1.0	0.6	3.0	2.2	2.6	5.77	-	-	-	R	R	R	G	G	G	MS
6	Co.7717	1.0	1.6	1.8	0.0	0.3	0.8	1.0	2.1	1.6	3.40	-	-	-	R	R	R	G	G	G	MR
7	IC.225	3.0	3.0	3.0	3.0	2.8	2.0	3.0	3.0	3.0	8.60	-	-	-	R	R	R	D	D	D	HS
8	Co.1307	3.0	1.4	3.0	2.0	0.7	1.0	3.0	1.7	1.8	5.87	+	-	-	B	R	R	G	G	G	MS
9	CoA.7602	1.0	2.0	1.0	0.0	0.6	0.0	1.0	2.1	1.0	2.90	-	-	-	B	R	R	G	G	G	MR
10	Co.6304	2.0	2.2	1.8	0.0	0.6	0.4	3.0	2.3	2.0	4.77	+	-	-	B	R	R	G	G	G	MS
11	CoC.779	1.0	1.5	1.8	0.0	0.7	0.0	1.0	1.7	1.2	2.97	+	-	-	B	R	R	G	G	G	MR
12	Co.419	2.0	1.2	2.0	2.0	0.4	0.4	3.0	1.3	1.6	4.63	+	-	-	B	R	R	G	G	G	MS
13	Co.771	2.0	1.0	2.2	1.0	0.4	0.2	3.0	0.9	2.0	4.23	+	-	-	B	R	R	G	G	G	MS
14	Co.1305	1.0	1.6	2.5	0.0	0.8	0.5	3.0	1.4	2.2	4.00	+	-	-	B	R	R	G	G	D	MR
15	Co.62198	1.0	1.3	1.6	0.0	0.4	0.0	1.0	1.8	1.2	2.77	+	-	-	B	R	R	G	G	G	MR
16	Co.1340	1.0	1.8	1.8	0.0	0.6	0.2	2.0	2.0	2.0	3.80	-	-	-	R	R	R	G	G	G	MR
17	KHS.3296	1.0	1.0	2.2	0.0	0.4	0.0	2.0	1.0	1.8	3.13	+	-	+	B	R	D	G	G	G	MR
18	Co.997	3.0	2.7	3.0	3.0	1.6	3.0	3.0	2.3	3.0	8.20	-	-	-	R	R	R	D	G	D	HS
19	MS.6347	1.0	0.9	2.1	0.0	0.5	0.2	1.0	0.8	2.3	2.93	+	-	-	B	R	R	G	G	G	MR
20	CoC.773	1.0	2.0	2.0	1.0	0.7	0.8	2.0	2.1	1.8	4.47	+	-	-	R	R	R	G	G	G	MS
21	T.67172	2.0	0.8	2.0	2.0	0.3	0.7	3.0	1.1	2.0	4.63	+	-	-	B	R	R	G	G	G	MS
22	Co.62175	1.0	0.8	2.5	1.0	0.3	1.0	2.0	0.8	2.2	4.53	-	-	-	R	R	R	G	G	G	MS
23	CoC.671	2.0	1.1	2.2	1.0	0.7	0.6	3.0	2.0	2.8	5.13	+	-	-	B	R	R	G	G	G	MS
24	Co.449	1.0	2.1	2.1	1.0	0.5	0.7	2.0	2.3	2.4	4.70	-	-	-	R	R	R	G	G	G	MS
25	CoC.777	2.0	1.4	2.2	1.0	0.6	0.0	2.0	1.4	1.4	4.00	-	-	-	R	R	R	G	G	G	MR
26	Co.453	0.0	1.1	1.4	0.0	0.2	0.2	0.0	1.0	1.5	1.80	-	-	-	B	R	R	G	G	G	R
27	CoM.7125	2.0	1.9	1.8	1.0	0.8	0.2	2.0	2.5	1.8	4.67	+	+	-	B	R	R	G	G	G	MS
28	CoM.7114	2.0	1.3	2.3	2.0	1.0	0.6	3.0	2.1	2.6	5.63	+	-	-	B	R	R	G	G	G	MS
29	Co.7219	2.0	1.2	2.0	1.0	0.6	1.2	1.0	1.2	1.8	4.00	+	-	-	B	R	R	G	G	G	MR
30	Co.62101	2.0	0.9	3.0	2.0	0.3	2.5	3.0	1.0	3.0	5.90	+	-	-	B	R	R	G	G	D	MS
31	Co.8332	3.0	1.6	2.5	2.0	0.3	1.8	3.0	1.8	2.5	6.17	-	+	-	R	B	R	G	G	G	S
32	Co.8334	1.0	2.0	2.5	1.0	0.7	0.7	2.0	2.5	3.0	4.97	-	-	-	R	R	R	G	G	G	MS
33	Co.8329	1.0	2.0	1.8	0.0	0.6	0.8	3.0	1.7	2.2	4.37	+	-	-	B	R	R	G	G	G	MS
34	Co.8327	1.0	1.7	2.6	1.0	0.8	1.2	2.0	2.1	2.6	5.00	-	-	-	R	R	R	G	G	G	MS
35	Co.8341	1.0	3.8	3.0	1.0	0.1	1.6	3.0	0.8	3.0	5.73	-	-	-	R	R	R	G	G	G	MS
36	Co.8307	3.0	1.7	2.2	2.0	0.5	0.3	3.0	2.5	2.6	5.93	-	-	-	R	R	R	G	G	G	MS
37	Co.8303	1.0	1.8	2.1	0.0	0.5	0.7	1.0	2.2	2.2	3.83	-	-	-	R	R	R	G	G	G	MR
38	Co.8306	1.0	1.3	2.2	0.0	0.2	1.0	1.0	1.7	2.0	3.47	-	-	-	R	R	R	G	G	G	MR
39	Co.8367	1.0	1.3	2.4	0.0	0.3	0.4	1.0	1.9	2.3	3.53	-	-	-	R	R	R	G	G	G	MR
40	Co.8302	1.0	2.2	3.0	0.0	0.2	1.1	1.0	2.8	2.7	4.67	-	-	-	R	R	R	G	G	G	MS
41	Co.8314	2.0	1.6	2.2	1.0	0.6	0.4	3.0	1.7	2.4	4.00	+	-	-	B	R	R	G	G	G	MS
42	Co.8342	1.0	2.1	2.7	0.0	0.6	2.1	1.0	2.5	3.0	5.00	-	-	-	B	R	R	G	G	D	MS
43	Co.8326	1.0	1.8	2.4	1.0	0.1	1.8	1.0	2.0	2.4	4.83	+	-	-	R	R	R	G	G	G	MS
44	Co.8311	1.0	1.3	2.1	1.0	0.4	0.6	2.0	1.7	1.8	3.97	+	-	-	R	R	R	G	G	G	MR
45	Co.8310	1.0	1.5	1.4	0.0	0.2	0.0	1.0	1.9	1.6	2.70	-	-	-	R	R	R	G	G	G	MR
46	Co.8312	1.0	1.6	2.8	1.0	0.6	2.0	3.0	1.5	3.0	5.50	+	-	-	B	R	R	G	G	D	MS
47	Co.8325	2.0	1.1	2.0	2.0	0.4	0.4	3.0	1.3	2.0	4.73	-	-	-	R	R	R	G	G	G	MS
48	Co.8340	1.0	1.5	1.8	0.0	0.2	0.0	1.0	1.9	1.6	3.00	-	-	-	R	R	R	G	G	G	MR
49	Co.8353	1.0	0.6	1.0	0.0	0.6	0.0	2.0	0.6	1.2	2.33	+	-	-	B	R	R	G	G	G	MR
50	Co.8331	1.0	1.0	2.0	1.0	0.5	0.8	1.0	2.0	2.2	3.83	+	+	-	B	B	R	G	G	G	MR

Contd. Page No. 74.

Table 15 Contd....

Sl. No.	Variety	Mean lesion width			Mean white spot			Mean nodal transgression			Mean total	Pith lesion			Colour of lesion			Condition of top			Grade
		A	B	C	A	B	C	A	B	C		A	B	C	A	B	C	A	B	C	
51	Co.8304	1.0	0.6	2.2	0.0	0.1	0.2	3.0	0.6	2.4	3.37	+	-	-	B	R	R	G	G	G	MR
52	Co.8313	1.0	1.8	2.7	0.0	0.6	2.0	1.0	2.5	2.7	5.43	-	-	-	R	R	R	G	G	G	MS
53	Co.8360	3.0	2.2	2.0	2.0	1.2	0.3	2.0	2.4	2.6	5.90	+	-	-	B	R	R	G	G	G	MS
54	Co.8352	1.0	2.1	2.7	0.0	0.3	0.7	1.0	2.1	2.7	3.97	+	+	-	R	B	R	G	G	G	MR
55	Co.8356	2.0	1.3	1.8	1.0	0.6	0.8	3.0	2.6	1.6	4.90	+	+	-	B	B	R	G	G	G	MS
56	Co.8368	1.0	1.5	1.5	0.0	1.0	0.1	2.0	1.5	1.3	3.30	-	-	-	R	R	R	G	G	G	MR
57	Co.8309	1.0	1.2	2.1	0.0	0.2	1.0	1.0	1.0	2.6	3.37	-	-	-	R	R	R	G	G	G	MR
58	Co.8355	1.0	1.5	1.8	1.0	0.4	0.8	3.0	2.7	1.6	4.60	+	+	-	B	B	R	G	G	G	MS
59	Co.8362	1.0	1.8	1.6	0.0	0.8	0.0	3.0	3.0	1.6	4.27	+	-	-	B	R	R	G	G	G	MS
60	Co.8315	3.0	2.3	2.0	3.0	0.6	0.2	3.0	2.8	2.6	6.50	+	-	-	R	R	R	G	G	G	S
61	Co.7506	1.0	1.3	1.6	0.0	0.1	0.7	1.0	0.1	1.5	2.50	+	-	-	R	R	R	G	G	G	MR
62	Co.7634	1.0	1.6	1.0	1.0	0.5	0.0	2.0	1.9	1.0	3.67	-	-	-	R	R	R	G	G	G	MR
63	Co.7527	1.0	1.7	1.5	0.0	1.0	0.2	1.0	2.3	1.5	3.40	+	-	-	B	R	R	G	G	G	MR
64	CoA.7601	1.0	2.3	1.6	0.0	0.7	0.4	3.0	2.8	1.4	4.40	+	-	+	B	R	B	G	G	G	MS
65	Co.1148	1.0	2.4	2.2	0.0	0.8	0.7	2.0	2.8	2.7	4.87	+	-	-	R	R	R	G	G	G	MS
66	Co.995	3.0	2.8	3.0	3.0	2.8	1.8	3.0	3.0	3.0	8.47	+	-	-	R	R	R	D	D	D	HS
67	Co.6407	1.0	1.7	2.0	0.0	0.1	1.2	2.0	2.7	2.6	4.43	+	+	-	B	B	R	G	G	G	MS
68	Co.785	2.0	1.4	2.6	1.0	0.6	2.0	2.0	1.4	2.8	5.27	+	-	-	B	R	R	G	G	G	MS
69	Co.8003	1.0	0.7	1.2	0.0	0.9	0.0	1.0	0.0	1.0	1.93	-	-	-	R	R	R	G	G	G	R
70	Co.7704	2.0	1.1	2.0	1.0	0.1	1.2	2.0	1.5	2.6	4.50	-	-	-		R	R	G	G	G	MS
71	Co.458	1.0	1.6	1.1	0.0	0.1	0.1	1.0	1.9	1.8	2.87	-	-	-	R	R	R	G	G	G	MR
72	Co.62174	1.0	1.4	1.2	0.0	0.6	0.4	2.0	1.8	1.6	3.33	+	-	-	B	R	R	G	G	G	MR
73	Co.8014	1.0	1.3	1.6	0.0	0.4	0.6	1.0	1.6	2.0	3.10	-	-	-	R	R	R	G	G	G	MR
74	Co.8006	1.0	1.4	2.0	0.0	0.3	0.8	2.0	1.8	1.7	3.67	+	+	-	R	R	R	G	G	G	MR
75	Co.8009	2.0	2.0	1.6	3.0	1.7	0.3	3.0	2.6	2.0	6.07	-	-	-	R	R	R	G	G	G	S
76	Co.8002	3.0	3.0	2.6	3.0	3.0	0.6	3.0	3.0	2.6	7.93	-	-	-	R	R	R	G	G	G	S
77	IA.1367	1.0	0.7	1.0	0.0	0.9	0.0	1.0	0.0	1.0	1.87	+	-	-	B	R	R	G	G	G	R
78	Co.8004	1.0	2.1	1.7	0.0	0.8	0.5	3.0	2.5	1.5	4.37	-	+	-	R	B	R	G	G	G	MS
79	Co.6772	1.0	1.4	1.6	0.0	0.2	0.0	2.0	1.9	1.4	3.17	+	-	-	B	R	R	G	G	G	MR
80	Co.740	1.0	1.3	1.5	0.0	0.3	0.3	2.0	1.8	1.3	3.17	+	-	-	B	R	R	G	G	G	MR
81	Co.6907	2.0	2.1	1.5	0.0	0.2	0.1	1.0	2.3	1.6	3.60	+	-	+	B	R	B	G	G	G	MR
82	Co.6806	1.0	1.4	2.0	0.0	0.2	0.8	3.0	1.9	2.8	4.37	-	-	-	R	R	R	G	G	G	MS
83	Co.8011	1.0	1.7	1.4	0.0	0.8	0.0	1.0	2.8	2.0	3.57	-	+	-	R	B	R	G	G	G	MR
84	Co.8010	1.0	1.0	2.0	0.0	0.0	0.0	1.0	1.4	2.4	2.93	-	-	-	R	R	R	G	G	G	MR
85	Co.8012	1.0	1.5	1.8	1.0	0.5	0.8	1.0	2.0	1.6	3.74	-	-	-	B	R	R	G	G	G	MR
86	Co.8015	1.0	1.5	1.5	0.0	0.7	0.0	1.0	2.2	1.3	3.07	-	-	-	R	R	R	G	G	G	MR
87	Co.8013	1.0	1.0	2.2	0.0	0.0	1.0	2.0	1.5	2.4	3.70	-	-	-	R	R	R	G	G	G	MR
88	Co.8005	1.0	2.0	1.6	1.0	1.4	0.0	2.0	2.0	1.4	4.13	-	-	-	R	R	R	G	G	G	MS
89	Co.8007	1.0	1.5	2.0	0.0	0.6	0.7	2.0	2.6	2.0	4.13	-	-	-	R	R	R	G	G	G	MS
90	Co.8008	1.0	1.8	1.8	0.0	0.5	0.6	2.0	2.0	1.6	3.77	-	-	-	R	R	R	G	G	G	MR
91	Co.8001	2.0	1.9	1.6	1.0	1.1	0.0	3.0	2.2	2.3	5.03	+	-	+	R	R	B	G	G	G	MS
92	Co.8361	2.0	1.8	2.8	2.0	0.7	2.0	2.0	2.8	3.0	6.37	-	-	-	R	R	R	G	G	G	S
93	Co.8366	3.0	2.1	2.2	2.0	1.2	0.0	3.0	2.6	2.0	6.03	+	+	-	B	B	R	G	G	G	S
94	Co.8363	2.0	2.2	3.0	0.0	1.7	2.4	3.0	2.5	3.0	6.60	+	-	-	B	R	R	G	G	D	S
95	Co.8346	2.0	1.7	1.4	1.0	0.5	0.4	2.0	2.7	2.6	4.77	-	+	+	R	B	B	G	G	G	MS
96	TS.1	0.0	1.8	1.8	0.0	1.0	0.6	0.0	2.7	2.2	3.30	-	-	-	R	R	R	G	G	G	MR
97	Co.8321	2.0	1.8	1.6	1.0	1.0	0.4	2.0	2.2	1.6	4.47	+	-	+	B	R	R	G	G	G	MS
98	Co.8348	1.0	1.4	1.2	1.0	0.3	3.0	1.8	2.2	1.8	4.57	+	-	-	B	R	R	G	G	G	MS
99	Co.8350	1.0	1.8	1.6	0.0	0.8	3.0	1.4	2.0	1.4	4.33	-	-	-	R	R	R	G	G	G	MS
100	Co.8317	1.0	1.7	1.6	0.0	0.6	3.0	1.8	2.1	1.8	4.53	-	-	-	R	R	R	G	G	G	MS

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Table 16. Comparative evaluation of sugarcane varieties against infection by two isolates of Colletotrichum falcatum Went from Kerala

Variety/ culture	Reaction to		Variety/ culture	Reaction to	
	Isolate of MP V Mathew et al,1987	Isolate of the present study		Isolate of MP V Mathew et al,1987	Isolate of t present stud
Co.6907	R	MR	Co.8123	MR	MR
Cul.74/84	R	MS	Co.8131	MR	MS
Cul.76/84	R	MS	Co.8135	MR	MS
Co.7717	R	MR	Co.8138	MR	MS
Co.8001	R	MS	Co.8143	MR	R
Co.8003	R	R	T.67172	MR	MS
Co.8004	R	MS	KMS.1185	MR	MS
Co.8008	R	MR	Co.419	MS	MS
Co.8018	R	MR	CoC.671	MS	MS
Co.8021	R	MR	CoC.775	MS	MS
Co.8102	R	MR	CoC.778	MS	MS
Co.8105	R	MS	Co.1148	MS	MS
Co.8115	R	MR	Co.6407	MS	MS
Co.8117	R	MR	Co.62175	MS	MS
Co.8152	R	MS	CoA.7601	MS	MS
Co.8153	R	MS	Cul.74/52	MS	MS
3.37172	R	MS	Co.8007	MS	MS
CHS.3296	R	MR	Co.8015	MS	MS
3.87	R	MR	Co.8025	MS	S
3.99	R	MR	Co.8104	MS	S
3.105	R	R	Co.8108	MS	MS
Co.785	MR	MS	Co.8111	MS	MS
Co.1307	MR	MS	Co.8118	MS	MS
Co.7506	MR	MR	Co.8129	MS	MS
Co.7634	MR	MR	Co.8131	MS	MS
Co.7704	MR	MS	Co.8133	MS	MS
CoM.7712	MR	MS	Co.8134	MS	MS
Cul.76/17	MR	MS	Co.8146	MS	MS
Co.8005	MR	MS	KMS.1412	MS	MS
Co.8010	MR	MR	Co.449	S	MS
Co.8011	MR	MR	Co.8009	S	S
Co.8013	MR	MR	CoM.1391	S	S
Co.8014	MR	MR	Cul.74/45	HS	S
Co.8019	MR	MR	Co.995	HS	HS
Co.8022	MR	MR	Co.997	HS	HS
Co.8023	MR	MR	Co.8002	HS	S
Co.8103	MR	HS	Co.8020	HS	S
Co.8118	MR	MS	IC.225	HS	HS
Co.8121	MR	MR			

MS - Moderately Susceptible
MR - Moderately Resistant
HS - Highly Susceptible
R - Resistant
S - Susceptible

Table 15 Contd....

Sl. No.	Variety	Mean lesion width			Mean white spot			Mean nodal transgression			Mean total	Pith lesion			Colour of lesion			Condition of top			Grade
		A	B	C	A	B	C	A	B	C		A	B	C	A	B	C	A	B	C	
101	Co.8357	1.0	1.1	1.0	0.0	0.2	0.2	1.0	1.6	1.4	2.50	-	-	-	R	R	R	G	G	G	MR
102	Co.8316	1.0	1.2	1.0	0.0	0.3	0.2	2.0	0.9	1.0	2.53	-	-	-	B	R	R	G	G	G	MR
103	Co.8354	1.0	1.1	1.2	0.0	0.2	0.4	1.0	1.2	1.4	2.50	+	-	-	B	R	R	G	G	G	MR
104	Co.8334	1.0	1.2	1.0	0.0	0.5	0.4	1.0	1.4	1.6	2.70	+	-	-	B	R	R	G	G	G	MR
105	Co.8336	2.0	1.1	1.4	1.0	0.2	0.2	3.0	1.5	2.2	4.20	+	-	-	B	R	R	G	G	G	MS
106	Co.8358	1.0	1.6	1.0	0.0	0.4	0.0	1.0	2.3	2.0	3.10	-	-	-	R	R	R	G	G	G	MR
107	Co.8320	1.0	1.0	1.2	0.0	0.2	0.4	1.0	1.2	1.4	2.47	+	-	-	R	R	R	G	G	G	MR
108	Co.8345	1.0	2.0	1.6	0.0	0.5	0.4	3.0	1.5	2.4	4.13	+	-	-	B	R	R	G	G	G	MS
109	S.33	1.0	1.6	1.0	0.0	0.5	0.0	3.0	2.0	1.3	3.47	+	-	-	B	R	R	G	G	G	MR
110	Co.8017	1.0	1.4	1.3	0.0	0.0	0.0	3.0	2.4	2.3	3.80	+	-	+	B	R	B	G	G	G	MR
111	Jawa	1.0	1.5	1.8	0.0	0.3	0.6	1.0	2.6	2.6	3.80	-	-	-	B	R	R	G	G	G	MR
112	Co.8016	2.0	1.0	1.8	1.0	0.2	0.2	2.0	1.4	2.8	4.13	-	-	-	R	R	R	G	G	G	MS
113	Co.8018	1.0	1.3	1.3	0.0	0.1	0.0	2.0	2.3	1.3	3.10	+	-	-	B	R	R	G	G	G	MR
114	Co.8105	2.0	1.8	2.3	1.0	0.6	1.1	2.0	1.8	2.3	4.97	+	-	-	R	R	R	G	G	G	MS
115	S.105	1.0	0.6	1.0	0.0	0.0	0.0	1.0	0.8	1.0	1.80	+	+	-	B	B	R	G	G	G	R
116	KMS.881	3.0	1.1	1.3	2.0	0.2	0.0	2.0	1.5	1.5	4.20	+	-	-	B	R	R	G	G	G	MS
117	Co.527	1.0	2.1	1.5	0.0	1.1	0.0	1.0	2.1	1.5	3.40	-	-	-	B	R	R	G	G	G	MR
118	S.87	1.0	1.3	1.6	0.0	0.5	0.0	1.0	1.8	1.0	2.33	-	-	-	B	R	R	G	G	G	MR
119	Co.8023	1.0	1.1	1.0	0.0	0.0	0.0	1.0	1.1	1.0	2.07	+	-	-	B	R	R	G	G	G	MR
120	Co.8019	2.0	1.0	1.8	1.0	0.2	0.3	2.0	1.8	1.3	3.80	+	+	-	B	B	R	G	G	G	MR
121	Co.8101	2.0	1.1	1.0	1.0	0.1	0.0	2.0	1.5	1.1	3.27	+	-	-	B	R	R	G	G	G	MR
122	KMS.1412	1.0	1.5	2.3	0.0	0.5	1.3	2.0	2.5	2.3	4.47	-	-	-	R	R	R	G	G	G	MS
123	KMS.1185	2.0	2.5	1.6	1.0	0.3	0.3	3.0	2.7	1.3	4.90	+	-	-	B	R	R	G	G	G	MS
124	KMS.1381	1.0	1.8	1.6	0.0	0.3	0.3	3.0	2.0	1.3	3.77	+	-	-	B	R	R	G	G	G	MR
125	Co.8021	1.0	1.6	1.2	0.0	0.3	0.0	1.0	2.8	1.5	3.20	-	+	-	R	B	R	G	G	G	MR
126	Co.8022	2.0	1.3	1.1	1.0	0.3	0.0	2.0	1.0	1.0	3.23	+	-	-	B	R	R	G	G	G	MR
127	Co.8020	2.0	3.0	3.0	1.0	2.0	2.3	3.0	3.0	3.0	7.43	+	-	-	B	R	R	G	G	G	S
128	Co.8025	1.0	1.5	2.2	0.0	0.1	0.2	1.0	2.0	1.8	3.27	-	-	-	R	R	R	G	G	G	MR
129	S.77	2.0	2.2	1.6	0.0	0.4	0.4	2.0	2.4	2.4	4.47	+	-	-	B	R	R	G	G	G	MS
130	F.1-2	1.0	1.5	1.6	0.0	0.1	0.0	1.0	1.5	1.4	2.70	-	-	-	R	R	R	G	G	G	MR
131	S.99	1.0	1.6	2.0	0.0	0.3	0.2	1.0	2.1	2.2	3.47	-	-	-	R	R	R	G	G	G	MR
132	Co.8024	1.0	1.2	1.5	0.0	0.2	0.0	2.0	2.0	1.6	3.17	+	-	-	B	R	R	G	G	G	MR
133	Co.8102	1.0	1.5	2.0	0.0	0.3	0.4	2.0	1.5	1.8	3.50	+	-	-	B	R	R	G	G	G	MR
134	Co.8104	2.0	2.0	2.8	1.0	0.3	1.6	3.0	3.0	2.8	6.17	+	-	-	B	R	R	G	G	D	S
135	Co.8103	3.0	3.0	3.0	3.0	2.6	3.0	3.0	3.0	3:0	8.87	+	-	-	R	R	R	D	D	D	HS
136	Co.8106	2.0	1.5	1.6	1.0	0.3	0.1	2.0	1.5	1.1	3.70	+	-	-	B	R	R	G	G	G	MR
137	KMS.1391	2.0	2.1	2.6	2.0	1.6	0.6	3.0	2.8	2.6	6.63	-	-	-	R	R	R	G	G	G	S
138	Co.8127	2.0	1.8	2.6	1.0	0.1	1.2	2.0	2.6	3.0	5.43	+	-	-	B	R	R	G	G	G	MS
139	Co.8128	1.0	1.1	1.5	0.0	0.0	0.1	1.0	1.6	1.3	2.53	+	-	-	R	R	R	G	G	G	MR
140	Co.8125	1.0	1.6	2.6	0.0	0.6	0.4	2.0	2.3	2.6	7.17	-	-	-	R	R	R	G	G	G	S
141	Co.8112	1.0	1.6	1.6	0.0	0.1	0.2	2.0	1.5	1.4	3.13	+	+	-	B	B	R	G	G	G	MR
142	Co.8111	1.0	3.0	2.0	0.0	2.3	0.0	3.0	2.8	2.0	5.37	+	-	+	B	R	B	G	G	G	MS
143	Co.8110	1.0	1.8	2.2	0.0	0.3	0.2	2.0	2.1	1.2	3.60	-	-	-	R	R	R	G	G	G	MR
144	Co.8108	1.0	2.8	1.5	0.0	1.5	0.0	1.0	3.0	1.7	4.17	+	-	-	B	R	R	G	G	G	MS
145	Co.8109	1.0	1.6	1.8	1.0	0.1	0.0	2.0	1.5	1.2	3.40	+	+	-	B	B	R	G	G	G	MR
146	Co.8107	3.0	2.0	1.6	3.0	1.2	0.0	3.0	2.5	1.6	5.87	-	-	+	R	R	B	G	G	G	MS
147	Co.8113	2.0	1.8	2.6	1.0	0.3	1.2	3.0	2.1	2.8	5.60	-	-	-	R	R	R	G	G	G	MS
148	Co.8117	1.0	1.1	1.4	0.0	0.3	0.0	1.0	1.5	1.0	2.43	-	-	-	R	R	R	G	G	G	MR
149	Co.8118	2.0	1.1	2.4	1.0	0.0	0.8	3.0	2.0	2.0	4.77	+	-	-	B	R	R	G	G	G	MS
150	Co.8114	2.0	1.0	1.6	1.0	0.3	0.0	3.0	1.1	1.6	3.87	+	-	+	B	R	B	G	G	G	MR

Table 15 Contd....

Sl. No.	Variety	Mean lesion width			Mean white spot			Mean nodal transgression			Mean total	Pith lesion			Colour of lesion			Condition of top			Grad
		A	B	C	A	B	C	A	B	C		A	B	C	A	B	C	A	B	C	
151	Co.8115	1.0	1.1	3.0	0.0	0.0	0.0	1.0	1.6	3.0	3.57	+	-	-	B	R	R	G	G	G	MR
152	Co.8129	2.0	2.0	1.7	1.0	0.5	0.5	3.0	2.5	2.5	5.23	+	+	-	B	B	R	G	G	G	MS
153	Co,8133	2.0	1.6	2.2	1.0	0.6	1.2	2.0	2.0	2.2	4.93	+	-	-	B	R	R	G	G	G	MS
154	Co.8122	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	2.00	+	-	-	B	R	R	G	G	G	R
155	Co.8123	2.0	1.3	1.0	1.0	0.1	0.0	3.0	1.1	1.0	3.50	+	-	-	B	R	R	G	G	G	MR
156	Co.8131	2.0	1.4	1.4	1.0	0.2	0.0	3.0	2.4	1.0	4.13	+	-	-	B	R	R	G	G	G	MS
157	Co.8121	1.0	1.6	1.0	0.0	0.0	0.0	3.0	2.4	1.0	3.33	+	-	-	B	R	R	G	G	G	MR
158	Co.8130	1.0	1.4	1.8	0.0	0.2	0.4	2.0	2.2	1.6	3.53	-	-	-	R	R	R	G	G	G	MR
159	Co.8120	1.0	0.8	1.3	0.0	0.0	0.0	3.0	1.3	1.0	2.80	-	-	-	R	R	R	G	G	G	MR
160	Cul.76	1.0	1.6	1.0	0.0	0.6	0.0	1.0	2.1	1.0	2.77	-	-	-	R	R	R	G	G	G	MR
161	Cul.17	3.0	1.6	2.0	2.0	0.8	1.3	1.0	1.8	1.3	4.93	-	-	-	R	R	R	G	G	G	MS
162	Cul.36	2.0	1.8	2.5	0.0	1.3	1.0	3.0	1.8	1.5	5.30	+	-	-	B	R	R	G	G	G	MS
163	Cul.79	2.0	2.0	3.0	1.0	0.8	2.0	3.0	2.6	2.3	6.23	+	-	-	B	R	R	G	G	G	S
164	Cul.83	0.0	0.6	1.6	0.0	0.0	0.3	0.0	0.6	1.3	1.47	-	-	-	R	R	R	G	G	G	R
165	Cul.117	0.0	1.6	1.7	0.0	0.8	0.0	2.0	1.8	1.5	3.13	-	-	-	R	R	R	G	G	G	MR
166	Cul.82	2.0	1.8	1.4	2.0	1.0	0.0	3.0	2.5	1.2	4.97	-	-	-	B	R	R	G	G	G	MS
167	CoM.7129	2.0	2.1	1.6	2.0	1.3	0.0	3.0	2.5	1.0	5.17	+	-	-	B	R	R	G	G	G	MS
168	CoM.7704	1.0	2.1	2.0	0.0	0.6	0.6	2.0	2.5	2.0	4.27	-	-	-	R	R	R	G	G	G	MS
169	Cul.76/59	1.0	2.3	1.5	2.0	1.8	0.0	3.0	2.8	2.0	5.47	-	-	-	R	R	R	G	G	G	MS
170	CoM.7712	2.0	1.8	2.3	1.0	0.3	1.3	3.0	2.0	1.6	5.10	+	-	-	R	R	R	G	G	G	MS
171	Cul.76/84	2.0	2.0	1.3	1.0	1.5	0.0	3.0	2.8	1.3	4.97	-	-	-	R	R	R	G	G	G	MS
172	Cul.76/59	1.0	1.1	2.5	0.0	0.1	1.2	1.0	1.5	2.7	3.87	-	-	+	R	R	B	G	G	D	MR
173	Cul.74/84	2.0	2.3	2.3	1.0	0.6	1.0	2.0	2.8	2.0	5.33	+	+	-	R	B	R	G	G	G	MS
174	Cul.76/17	2.0	2.3	2.7	1.0	1.1	1.7	2.0	1.6	2.7	5.70	+	+	-	B	B	R	G	G	D	MS
175	Cul.74/52	2.0	2.0	2.0	1.0	0.6	0.5	3.0	2.8	2.2	5.37	+	+	-	B	B	R	G	G	G	MS
176	Co.8152	1.0	2.3	2.0	0.0	1.0	0.4	2.0	2.6	2.2	4.50	-	-	-	R	R	R	G	G	G	MS
177	Co.8135	2.0	2.3	2.0	1.0	1.5	0.3	2.0	2.8	1.6	5.17	+	-	-	B	R	R	G	G	G	MS
178	Co.8134	2.0	2.0	2.0	1.0	0.6	0.0	3.0	2.6	2.0	5.07	-	-	-	R	R	R	G	G	G	MS
179	Cul.74/45	3.0	3.0	2.0	3.0	3.0	0.0	3.0	3.0	2.0	7.33	-	-	-	R	R	R	D	D	G	S
180	Co.8153	1.0	1.8	3.0	0.0	0.6	2.2	3.0	2.3	3-0	5.63	+	-	-	B	R	R	G	G	D	MS
181	Co.8148	1.0	1.0	2.0	0.0	0.0	0.0	1.0	1.6	1.0	2.53	+	+	-	B	B	R	G	G	G	MR
182	Co.8138	1.0	2.0	2.0	0.0	1.0	0.0	2.0	2.5	2.0	4.17	-	+	-	R	B	R	G	G	G	MS
183	Co.8147	1.0	2.2	1.3	0.0	1.4	0.0	1.0	2.2	1.0	3.37	+	+	-	B	B	R	G	G	G	MR
184	Co.8142	1.0	1.5	2.3	0.0	0.5	1.3	1.0	1.5	2.6	3.90	-	+	-	R	R	R	G	G	G	MR
185	Co.8143	0.0	0.8	2.2	0.0	0.0	0.0	0.0	0.8	2.2	2.00	-	-	-	R	R	R	G	G	G	R
186	Co.8146	2.0	2.8	1.7	1.0	1.3	0.7	3.0	2.8	2.0	5.67	+	+	-	B	B	R	G	D	G	MS
187	Cul.32	1.0	1.2	0.8	0.0	0.0	0.0	1.0	1.0	1.0	2.00	+	-	-	B	R	R	G	G	G	R
188	Cul.52	2.0	1.4	1.7	0.0	0.0	0.7	3.0	2.6	2.0	4.47	+	-	-	B	R	R	G	G	G	MS
189	Cul.153	2.0	1.8	2.0	1.0	0.4	0.0	3.0	3.0	2.0	5.07	-	-	-	R	R	R	G	G	G	MS
190	Cul.176	2.0	1.8	1.8	0.0	0.6	0.4	3.0	3.0	3.0	5.20	+	+	-	B	B	R	G	G	G	MS
191	Cul.81	2.0	3.0	2.3	3.0	1.8	1.3	3.0	3.0	2.6	7.33	-	-	-	R	R	R	D	D	D	S
192	Cul.202	3.0	2.4	3.0	3.0	1.2	3.0	3.0	3.0	3.0	8.20	-	-	-	R	R	R	D	D	D	HS
193	Cul.84	3.0	1.0	1.0	0.0	0.2	0.0	1.0	1.0	1.6	2.07	-	-	-	R	R	R	G	G	G	MR
194	Cul.9	1.0	1.2	1.3	0.0	0.2	0.0	3.0	2.8	1.0	3.50	-	-	-	R	R	R	G	G	G	MR
195	Cul.109	1.0	1.0	1.0	0.0	0.0	0.2	1.0	1.4	1.0	2.20	-	-	-	R	R	R	G	G	G	MR
196	Cul.1	1.0	0.8	2.0	0.0	0.2	0.3	2.0	1.0	1.6	2.97	-	-	-	R	R	R	G	G	G	MR
197	Cul.168	1.0	1.6	1.7	0.0	0.4	0.7	3.0	2.6	2.0	4.33	+	-	+	B	R	B	G	G	G	MS
198	Cul.53	1.0	0.8	1.0	0.0	0.0	0.2	1.0	1.0	1.0	2.00	-	-	-	R	R	R	G	G	G	R
199	Cul.227	2.0	2.0	1.8	1.0	0.6	0.4	3.0	2.4	3.0	5.40	+	+	+	B	R	B	G	G	G	MS
200	Cul.79	1.0	1.0	0.8	0.0	0.0	0.0	1.0	0.6	1.0	1.80	-	-	-	R	R	R	G	G	G	R

A - 1985 MS - Moderately Susceptible R - Red D - Dry - Absebt

B - 1986 MR - Moderately Resistant B - Black R - Resistant + Present

C - 1987 HS - Highly Susceptible G - Green S - Susceptible

Table 16. Comparative evaluation of sugarcane varieties against infection by two isolates of Colletotrichum falcatum Went from Kerala

Variety/ culture	Reaction to		Variety/ culture	Reaction to	
	Isolate of MP V Mathew et al,1987	Isolate of the present study		Isolate of MP V Mathew et al,1987	Isolate of t present stud
Co.6907	R	MR	Co.8123	MR	MR
Cul.74/84	R	MS	Co.8131	MR	MS
Cul.76/84	R	MS	Co.8135	MR	MS
Co.7717	R	MR	Co.8138	MR	MS
Co.8001	R	MS	Co.8143	MR	R
Co.8003	R	R	T.67172	MR	MS
Co.8004	R	MS	KMS.1185	MR	MS
Co.8008	R	MR	Co.419	MS	MS
Co.8018	R	MR	CoC.671	MS	MS
Co.8021	R	MR	CoC.775	MS	MS
Co.8102	R	MR	CoC.778	MS	MS
Co.8105	R	MS	Co.1148	MS	MS
Co.8115	R	MR	Co.6407	MS	MS
Co.8117	R	MR	Co.62175	MS	MS
Co.8152	R	MS	CoA.7601	MS	MS
Co.8153	R	MS	Cul.74/52	MS	MS
3.37172	R	MS	Co.8007	MS	MS
KHS.3296	R	MR	Co.8015	MS	MS
S.87	R	MR	Co.8025	MS	S
S.99	R	MR	Co.8104	MS	S
S.105	R	R	Co.8108	MS	MS
Co.785	MR	MS	Co.8111	MS	MS
Co.1307	MR	MS	Co.8118	MS	MS
Co.7506	MR	MR	Co.8129	MS	MS
Co.7634	MR	MR	Co.8131	MS	MS
Co.7704	MR	MS	Co.8133	MS	MS
CoM.7712	MR	MS	Co.8134	MS	MS
Cul.76/17	MR	MS	Co.8146	MS	MS
Co.8005	MR	MS	KMS.1412	MS	MS
Co.8010	MR	MR	Co.449	S	MS
Co.8011	MR	MR	Co.8009	S	S
Co.8013	MR	MR	CoM.1391	S	S
Co.8014	MR	MR	Cul.74/45	HS	S
Co.8019	MR	MR	Co.995	HS	HS
Co.8022	MR	MR	Co.997	HS	HS
Co.8023	MR	MR	Co.8002	HS	S
Co.8103	MR	HS	Co.8020	HS	S
Co.8118	MR	MS	IC.225	HS	HS
Co.8121	MR	MR			

MS - Moderately Susceptible

MR - Moderately Resistant

HS - Highly Susceptible

R - Resistant

S - Susceptible

Serological studies

Determination of titre

The titre of antisera developed against isolate I and the new isolate from Karnal was tested with homologous antigens used for immunising rabbits. Details of the titre values are given in Table 17.

Clear and distinct agglutination was noticed up to 1600 dilution for both antisera when tested by the tube as well as slide agglutination methods. At 3200 dilution, however, the agglutination was not clear. The titre of antisera was therefore recorded at 1600 for both the isolates. Plate 14.

Cross reaction of antisera with different antigens

The serological relationship between isolate I and the new isolate from Karnal as well as with isolates II to XI (heterologous antigens) was studied by means of tube and slide agglutination tests. The cross reaction titre of the antisera with heterologous antigens is presented in Table 18.

It was noticed that there was no difference in the titre values obtained in the tube and slide agglutination tests. The antiserum developed against isolate I gave agglutination at 800 dilution with isolates II, IV and VI;

Table 17. Titre of antisera by agglutination tests (Tube & slide)

Antiserum used	Dilution of antiserum						
	100	200	400	800	1600	3200	6400
Isolate I	+	+	+	+	(+)	±	-
Karnal isolate	+	+	+	+	(+)	±	-

+ Agglutination positive

- Agglutination negative

± Not clear

(+) Titre

Table 18. Cross reaction of two antisera against different isolates of Colletotrichum falcatum Went

Antiserum used	Antigen of (isolate)											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Karnal isolate
Isolate I	1600	800	200	800	200	800	400	200	100	400	200	200
Karnal isolate	200	400	400	100	800	400	100	100	100	200	200	1600

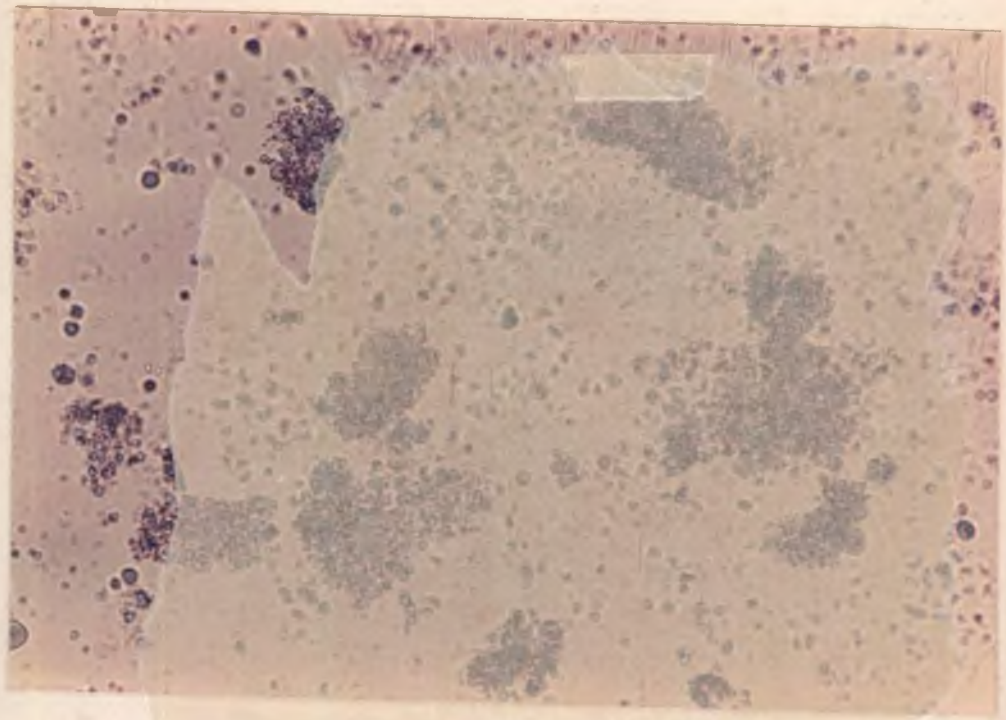
Plate 14

Antigen-antiserum cross reaction in *Colletotrichum falcatum* - Isolate I by slide agglutination test

A. Photomicrograph of precipitate at 100 titre

B. Photomicrograph of precipitate at 1600 titre

Plate 14



A

B

at 400 with VII and X; at 200 with III, V, VIII, XI and Karnal isolate and at 100 with isolate IX. In the case of antiserum developed against Karnal isolate, agglutination was noticed at 800 dilution with isolate V; at 400 with II, III and VI; at 200 with I, X and XI and at 100 with isolates IV, VII, VIII and IX.

The results indicated that isolates II to XI and the one from Karnal are not identical to isolate I, as there was no agglutination at 1600 dilution. However, isolates II, IV and VI possessed partial relationships with isolate I, because these isolates developed agglutination at 800 dilution of the antiserum.

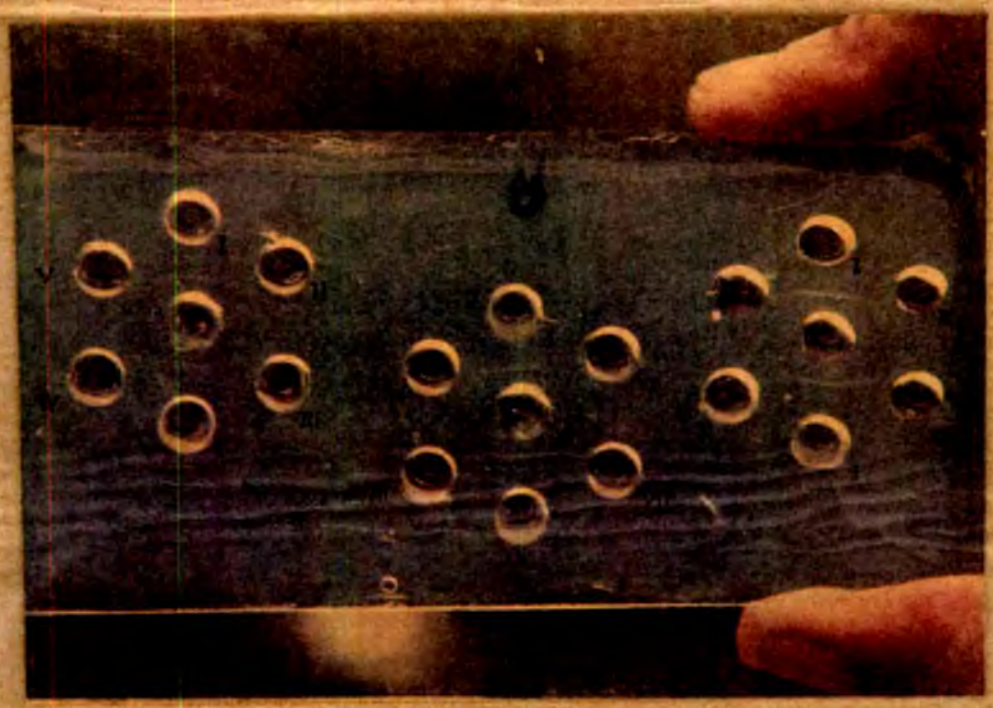
When tested with the antiserum against Karnal isolate, only isolate V showed partial relationship, giving agglutination at 800 dilution.

When the antigen-antibody cross reaction was tested by the immunogel diffusion technique it was noticed that no definite cross reaction band developed with the antigen of any of the isolates. A clear and definite band was formed with homologous antigens (Plate 15). In the case of heterologous antigens, only very weak and indefinite bands could be observed, indicating that there was no definite cross reaction with the antisera tested.

Plate 15

Immunogel diffusion reaction between antisera of isolate I and antigens of isolate II to XI and Karnal isolate of Colletotrichum falcatum Went

Plate 15



Collateral hosts of the pathogen

Out of the common weed plants in sugarcane fields observed for infection by the red rot pathogen, none was found to harbour the organism in nature. Artificial inoculations also revealed that those plants could not be infected by the red rot pathogen.

Ascigerous stage of the pathogen

Inspection of disease affected sugarcane fields as well as infected plant debris lying in the soil during different periods of the year did not reveal the presence of ascigerous stage of the pathogen. Also, the fungus did not produce ascigerous stage in culture medium as well as in autoclaved leaf pieces of sugarcane, in the laboratory.

Spread of the disease to ratoon crop

When infected stumps of variety Co.997 were planted and allowed to ratoon, it was noticed that the canes produced from all severely affected stumps (category 1) became infected. One or more shoots arising from such stumps contracted the disease as evidenced by infection originating at the base. In some stumps, one or two shoots showed yellowing and drying at the time of observation. The canes produced from

partially affected stumps and those from healthy stumps (categories 2 and 3) were free from the disease, thereby showing that the disease could be transmitted to the ratoon crop from severely affected stumps. The results are presented in Table 19.

Survival of the pathogen in soil

When the viability of the pathogen on infected sugarcane pieces buried at different depths of soil was tested at different periods, it was noticed that the pathogen was able to survive up to eight weeks at five cm and ten cm depths of soil.

During the second and fourth weeks, the fungus could be isolated from infected pieces buried at all depths of soil, but during the sixth week the pathogen could not be isolated from cane pieces placed on the surface of the soil. The data are presented in Table 20.

Survival of the pathogen in river water

The pathogen was found to survive in river water up to four weeks, as evidenced by the symptoms developed in inoculated cut canes. The results are presented in Table 21. The pathogen could be isolated from the inoculated canes. The canes kept as control did not yield the pathogen.

Table 19. Spread of red rot disease to ratoon crop

Category of stump planted	Development of red rot in ratoon
Severely affected clumps showing complete drying of canes	+
Clumps with partially affected canes	-
Clumps with healthy canes	-

\+ Red rot appeared in ratoon crop

\- Red rot did not appear in ratoon crop

Table 20. Survival of *Colletotrichum falcatum* Went at different depths of soil

Period	Number of pieces plated	Number of pieces yielding the fungus in different depths (cm)			
		0	5	10	15
Second week	20	8	14	17	12
Fourth week	20	4	16	9	8
Sixth week	20	0	11	5	3
Eighth week	20	0	6	5	0
Tenth week	20	0	0	0	0
Twelth week	20	0	0	0	0

Table 21. Survival of Colletotrichum falcatum Went in river water

Period of storage	Presence of redrot symptoms	Recovery of pathogen from canes inoculated	
		Treatment	Control
On the day of storage	Redrot symptoms developed	+	-
Two weeks	-do-	+	-
Four weeks	-do-	+	-
Six weeks	Slight red discoloration noticed	-	-
Eight weeks	-do-	-	-
Ten weeks	-do-	-	-

\+ Presence of the pathogen

\- Absence of the pathogen

Treatment : Mycelium and conidia of C. falcatum mixed in river water

Control : River water alone

DISCUSSION

DISCUSSION

Eleven isolates of Colletotrichum falcatum Went obtained from four common sugarcane varieties cultivated at seven different localities in Thiruvalla region including the command area of Travancore Sugars & Chemicals Ltd. (Pumpa Sugar Factory), were employed in the present investigation.

All the isolates belonged to the 'light type' in respect to mycelial characters (Abbott, 1938; Chona and Srivastava, 1960) with very good sporulation on most of the culture media. In regard to the size of conidia, isolates I and XI produced comparatively longer conidia than most of the other isolates. Isolate VII had the shortest conidia but had maximum breadth as compared to others. Chona and Srivastava (1960) reported that the conidia of light type, highly sporulating, virulent isolates of C. falcatum were longer than the dark type isolates. Singh and Rana (1968) and Gupta et al (1980) also noted that the conidia of virulent isolates were larger than the other isolates studied. Verma et al (1984), however, reported that a new virulent biotype of C. falcatum had shorter conidia than two less virulent isolates. Virulence of the isolate cannot, therefore, be correlated with the size of conidia.

Maximum mycelial growth and best sporulation of all isolates were obtained at pH 7.0. A pH range between 5.5 to 6.5 has been reported to be optimum for the growth and sporulation of different isolates of C. falcatum (Ramakrishnan, 1941; Sarkar, 1960; Ahmed and Divinagracia, 1974).

When three isolates of the pathogen obtained from three varieties at different localities were tested against five varieties commonly cultivated in Thiruvalla region, it was noticed that isolate I (from Co.449 at Valanjavattom) was more virulent than the other two. All the five varieties (including Co.7704 reported as moderately resistant and recommended for cultivation in the area by Mathew et al, 1987) were found susceptible to isolate I. In the case of isolates II and III, Co.785 and Co.7704 were resistant/moderately resistant.

In the experiment to study the comparative virulence of different isolates against differential varieties of sugarcane, it was noticed that here again isolate I was more virulent than the other 10 isolates tested. Of the thirteen differential varieties, one was resistant, four moderately resistant, seven moderately susceptible and one susceptible to isolate I. Thus, only five varieties showed resistant reaction to this isolate. The number of varieties resistant/moderately resistant to the other isolates ranged from eight to twelve.

Oat agar and potato dextrose agar media supported good growth and sporulation in most of the isolates. Oat agar has been reported to be an excellent medium for the growth and sporulation of different isolates of C. falcatum (Abbott, 1938; Prakasam and Reddy, 1961; Singh and Rana, 1968).

Among the carbon sources tested, fructose, mannito and sucrose supported very good growth of all the isolates Sucrose has been reported to encourage good growth of the light type isolates of C. falcatum (Manocha, 1965; Agnihotri, 1983). Glucose, mannitol and sucrose supported abundant sporulation by all the isolates.

Sodium nitrate among inorganic nitrogen sources favoured fairly good growth and sporulation of all the isolates. However, the isolates differed widely in regard to their utilization of other inorganic nitrogen sources (Ramakrishnan, 1941; Manocha, 1965). Sodium nitrate has been reported to favour good growth and sporulation by different isolates of C. falcatum (Ahmed, 1973).

Among the organic nitrogen sources tested, tyrosine was generally found good for growth as well as sporulation of majority of the isolates. Ahmed (1973) reported dl-tyrosine as one of the sources of amino nitrogen favouring good sporulation of C. falcatum.

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Singh and Rana (1968) studied the comparative virulence of three isolates (R-158, R-135 and R-141) of the red rot pathogen on ten sugarcane varieties at Gorakhpur, Uttar Pradesh and found that isolate R-158 was more virulent than the other two, mainly based on its ability to infect two predominant varieties of the region viz., Bo.3 and Bo.17 which were resistant to the other two isolates. Gupta et al (1980) inoculated ten sugarcane varieties with three isolates (R-117, R-135 and R-183) at Shajahanpur, Uttar Pradesh and noted that R-183 was distinct from the other two, due to its virulence to Co.213, Co.331 and Bo.47 which were moderate resistant to the other two isolates. Singh et al (1984) studied the reaction of 12 varieties to five isolates (R-191, R-195, R-200, CoS-770 and Co-1148) at Shajahanpur and reported isolate R-200 as highly pathogenic, because of its virulence to seven out of the twelve varieties tested. Only three to five varieties were susceptible to the other isolates. Khirbat et al (1980) tested the virulence of five isolates (RH-1, RH-2, RH-3, RR-4, RJ-5) at Haryana against 14 varieties of sugarcane and noted that RH-3 could be considered as a new strain in the North Indian sugar belt because of the susceptible reaction of varieties CoL.9 and Co.62399 to this isolate. The variety Co.1148 was, however, resistant to this isolate. Later, Satyavir et al (1984) reported a new

isolate pathogenic to Co.1148 at Haryana. Virk and Satyavir (1986) and Prakasam and Alexander (1986) considered this new isolate as a specific pathotype from Haryana.

When 200 varieties/clones of sugarcane were tested in the field for three years, for their reaction against infection by isolate I, it was noticed that 10 varieties were resistant, 85 moderately resistant, 86 moderately susceptible, 14 susceptible and 5 highly susceptible on artificial inoculation. The susceptible varieties included those commonly cultivated in Thiruvalla region like, Co.997, Co.449, Co.419, Co.785 and Co.62175. Of these, Co.785 has been reported as moderately resistant by Mathew et al (1987). Among the two varieties, Co.7704 and Co.6907, recently recommended for cultivation in the area due to their resistant reaction and desirable agronomic qualities (Mathew et al, 1987), Co.7704 was found moderately susceptible during the present study.

Further, a comparison of the reaction of different varieties obtained by Mathew et al (1987) with that obtained for isolate I during the present study, revealed that out of 21 varieties reported as resistant to MP-V, 11 were moderately resistant and 8 were moderately susceptible to isolate I. Also, of the 25 varieties moderately resistant to MP-V, 12 were moderately susceptible and one highly

susceptible to isolate I; one variety was resistant. These observations clearly indicated that marked differences existed between isolate I employed in the present investigation and the isolate (MP-V) reported by Mathew et al (1987) in respect to their pathogenicity to different varieties of sugarcane.

Singh et al (1984) also made similar observations based on their studies on the pathogenic variability in isolates of C. falcatum in Uttar Pradesh. Alexander (1988) while summarising the results of experiments conducted for standardization of methods for the identification of pathotypes, under the All India Co-ordinated Research Project on Sugarcane, concluded that, the red rot isolates collected from different endemic zones varied in their virulence within that zone. He, further stated that there were evidences of the existence of two major pathotypes in Haryana isolates and perhaps three major pathotypes in Andhra collections.

Based on virulence to larger number of cane varieties (including Co.785 and Co.7704)than that of the stra reported earlier (Mathew et al, 1987), it is proposed to consider isolate I of the present study as a new pathotype from Kerala.

Studies on the serological relationship between isolate I, Karnal isolate and the other 10 isolates

(II to XI) of the present study revealed that these isolates are not identical. Eventhough all the isolates except the one from Karnal were from the same region, no definite relationship could be noticed between isolate I and the others in both agglutination and immunogel diffusion tests. Gooding (1966) reported various difficulties in testing relationship between fungal isolates through serological methods. These included (1) quantitative variation in common antigens in fungal cultures (2) artifacts resulting from extraction techniques and non-specific precipitations and (3) qualitative and quantitative changes in the antigen during the life cycle of the organism. Balasubramanian and Kalyanasundaram (1981) stressed the importance of age of cultures for the preparation of antigen and antiserum for serological comparison of different strains/isolates of fungi. Based on studies on the antigens of different strains of Fusarium vasinfectum, they opined that "no strain comparison is complete without determining the optimum age level for antigenic comparison, which may be specific for individual fungal species". It is therefore, felt that a more definite and clear picture of the antigenic relationship between the different isolates of Colletotrichum falcatum could be obtained by using cultures of optimum age for antigenic comparisons and by adopting more exacting and advanced serological techniques.

Attempts to find out the collateral hosts of the pathogen, if any, among the common weeds in sugarcane fields were not successful. None of the plants exhibited infection in nature or through artificial inoculation.

Ascigerous stage of the pathogen was not observed on infected plant parts, either in the laboratory or in the field. Perithecial structures were not produced in culture medium and on autoclaved leaf pieces inoculated with the fungus.

Studies on the effect of ratooning on the survival and spread of the pathogen revealed that the disease could be transmitted to the ratoon crop from severely affected stumps of a susceptible variety, whereas canes from partially affected and healthy stumps were free from the disease. Rafay (1955) reported increased incidence of red rot in places where ratoons were maintained. Alexander (1984) reported that most of the susceptible genotypes which were disease-affected in the plant crop developed the disease in ratoon and concluded that red rot infection could spread from plant crop to ratoon.

When infected sugarcane pieces were buried at different depths of soil, the pathogen was found viable up to eight weeks (from January to March) at five and 10 cm depths. Survival of C. falcatum on infected plant debris in the field from 60 to 75 days has been reported by other

investigators (Singh et al, 1977; Waraitch, 1983). Since sugarcane in Thiruvalla region is planted within 30 to 45 days from harvest of the previous crop, the pathogen is able to survive on infected plant debris and cause infection to the newly planted crop, year after year.

Experiment on the survival of the pathogen in river water, clearly indicated that the propagules of the fungus were able to survive up to four weeks in the water collected from Manimala river. Waraitch (1983) reported that C. falcatum could be isolated up to 75 days from infected plant debris in artificially flooded sugarcane fields. Flooding the fields with river water during South-West monsoon period when the crop will be sufficiently grown and vulnerable to infection, is a common event in the Thiruvalla region. The flood water often stays in the field for a number of days. This is likely to cause extensive spread of red rot if the crop in any one field in the region is affected by the disease.

The foregoing discussion clearly indicates that in addition to using disease-free setts for planting, removal and destruction of infected plant debris lying in the field after harvest, avoiding or stopping ratooning in infected fields, cultivation of varieties

resistant or moderately resistant to the existing strains of the pathogen and keeping constant watch for detecting virulent strains are extremely essential for the prevention and control of the incidence and spread of red rot disease in the Thiruvalla sugarcane tract.

SUMMARY

SUMMARY

Eleven 'light type' isolates of Colletotrichum falcatum Went obtained from four common sugarcane varieties cultivated at different localities in Thiruvalla region were employed in the present study.

The conidia of isolates I and XI were comparatively longer than most of the other isolates. Isolate VII produced the shortest conidia but had maximum breadth as compared to others.

Good mycelial growth of all the isolates was obtained on oat agar and potato dextrose agar media. Maximum radial growth was obtained on oat agar by isolate III. Maximum sporulation of most of the isolates was obtained on oat agar medium.

Fructose, mannitol and sucrose supported very good growth of all the isolates. Glucose, mannitol and sucrose gave abundant sporulation by all the isolates. Sodium nitrate favoured fairly good growth and sporulation of all the isolates. Tyrosine was found to be a good source of amino nitrogen for the growth and sporulation of most of the isolates.

Maximum mycelial growth and best sporulation of all the isolates were obtained when grown at pH 7.0.

When three isolates from different varieties at different localities were tested against five commonly cultivated varieties it was noticed that isolate I (from Co.449 at Valanjavattom) was more virulent than the other two. Isolate I was more virulent than the other 10 isolates when tested against 13 differential varieties of sugarcane.

When the reaction of 200 varieties/clones were tested in the field, it was noticed that 10 varieties were resistant, 85 moderately resistant, 86 moderately susceptible, 14 susceptible and 5 highly susceptible, on artificial inoculation. The susceptible varieties included Co.997, Co.449, Co.419, Co.785 and Co.62175, commonly cultivated in the region and also Co.7704 recently recommended for cultivation.

Based on virulence to largernumber of varieties than that of the strain reported earlier (1987), isolate I of the present study is considered as a new pathotype from Kerala.

Serological studies conducted by means of test tube and slide agglutination and immunogel diffusion techniques revealed that isolate I was not identical with the other 10 isolates, as well as the one from Karnal.

Common weeds in sugarcane fields in Thiruvalla region were not found to act as collateral hosts of the pathogen. Ascigerous stage of the fungus could not be obtained on infected plant parts, in culture medium or on autoclaved leaf pieces.

The disease could be transmitted to the ratoon crop from severely affected stumps of a susceptible variety, whereas canes from partially affected and healthy stumps were free from the disease.

The pathogen was found viable upto eight weeks (from January to March) on infected sugarcane pieces buried at 5 and 10 cm depths in the soil. Propagules of the fungus were able to survive up to four weeks in the water collected from Manimala river.

The results indicated that removal and destruction of plant debris, stopping ratooning in infected fields, cultivation of varieties resistant or moderately resistant to the existing strain/s of the pathogen and vigilant inspection of fields for detecting virulent strains of the pathogen are essential for the prevention and control of the disease.

REFERENCE

REFERENCES

Abbott, E.V. (1935). Physiologic specialisation in Colletrotichum falcatum. Proc. Intern. Soc. Sugarcane Technol. 5th Congress. pp.730-736.

* Abbott, E.V. (1938). Red rot of sugarcane. Tech. Bull. USDA, 641, pp.96.

Abbott, E.V., and Hughes, C.G. (1961). Red Rot. In sugarcane diseases of the world, Ed. Martin, J.P., Abbott, E.V., Hughes, C.G. Elsevier Publishing Company, Amsterdam. pp.259-287.

Adams, G.G. Jr. and Butler, E.E. (1979). Serological relationships among anastomosis groups of Rhizoctonia solani. Phytopathology 69 : 629-633.

Agnihotri, V.P. (1983). Diseases of sugarcane. Oxford and IBH Publishing Co., New Delhi. pp.363.

Agnihotri, V.P. and Budhraja, T.R. (1974). Pathogenic potentialities of mid rib isolates of Colletotrichum falcatum in inciting stalk rot of sugarcane. Sugarcane Pathol. Newsl. 11/12 : 19-21.

Agnihotri, V.P., Budhraja, T.R. and Singh, K. (1979). Role of diseased sett and soil and the annual recurrence of red rot in sugarcane. Intern. Sugar 82 : 263-265.

Agnihotri, V.P. and Singh, K. (1977). Seed-piece transmissible diseases of sugarcane and their chemical control. Sugar News. 2 : 90-95.

Ahamed, H.U. (1973). Nitrogen utilisation of highly and weakly virulent isolates of Colletotrichum falcatum Went. Mycopath. et. Mycol. Appl. 50 : 323-327.

* Ahmed, H.U. and Divinagracia, G.G. (1974). Growth and sporulation of Colletotrichum falcatum at different temperatures, pH and light conditions. Philippines Agriculturist 57 : 379-382.

Alexander, K.C. (1982). Assessment of disease resistance in breeding programmes for production of commercial varieties. Proceedings of the working group meeting of sugarcane Breeders and Pathologists. Nov.29 - Dec. 4, 1982 held at Sugarcane Breeding Institute, Coimbatore.

Alexander, K.C. (1984). Testing of sugarcane varieties for comparative resistance to red rot in ratoon of inoculated plant crop. Technical Report on Plant Diseases. All India Co-ordinated Research Project on Sugarcane. 1984-85.

Alexander, K.C. (1988a). Breeding for resistance to red rot and smut diseases of sugarcane. Paper presented at the XIV Workshop in All India Co-ordinated Research Project on Sugarcane at Bangalore, Oct.3-6.

Alexander, K.C. (1988b). Standardization of methods for identification of pathotypes in red rot disease. Technical Report on Plant Diseases. All India Co-ordinated Research Project on Sugarcane. 1987-88.

Alexander, K.C., Kandasami, P.A., Rao, R.T.C., Raj, M.D. and Rao, M.M. (1979). A new approach to genetics defence against red rot disease of sugar cane. Indian Sugar 28 : 695-696.

Alexander, K.C. and Rao, M.M. (1972). Comparative evaluation of genotypes in different centres in India for red rot and smut. Proc. Diamond Jubilee Symp. Sug. Cane Breed. Inst., Coimbatore.

Anilkumar and Singh, R.A. (1987). Serological differentiation between Neovossia indica and N. horrida. Indian Phytopath. 40 : 114-115.

*Arx, J.A., Von and Muller, E. (1954). Die Gattungen der Amerosporen Pyrenomyceton. Beitr. Kryptogamenfl. Schweig 11 : 195-196.

*Atkinson, R.S. and Edgerton, C.W. (1937). Possible migration of spores of red rot fungus in cane stalks. La. Agri. Expt. Sta. Bull. 228 : 8-10.

Balasubramanian, R. and Kalyanasundaram, R.(1981). A Serological Study of Mycelial and culture filtrate antigens of strains of Fusarium vasinfectum. Kavaka 9 : 7-20.

*Barber, C.A. (1901). Sugarcane diseases in Godawari and Ganjam Districts, Madras Dept. Land Records and Agri. Bull. 512 : 181-194.

Beniwal, M.S., Behl, K.L. and Satyavir (1979). Screening of sugarcane clones for resistance to red rot. Sugarcane Pathol. Newsl. 22 : 42-44.

Bhansali, R.R. and Singh, N. (1981). Infection sites and systemic movement of ^{32}P labelled red rot pathogen in sugarcane mother setts and settlings. Annual Report 1981. Indian Institute of Sugarcane Research, Lucknow, India.

Biswas, A. (1987). Testing of sugarcane varieties for red rot disease resistance in West Bengal. Proceedings of the 50th Annual convention of the Sugar Technologists Association of India, New Delhi. 1-3 Nov.1987.

Burrell, R.G., Clayton, C.W., Gallegly, M.E. and Lilly, V.G. (1966). Factors affecting the antigenicity of the mycelium of three species of Phytophthora. Phytopathology 56 : 422-426.

*Butler, E.J. (1906). Fungus diseases of sugarcane in Bengal. Mem. Dept. Agri. India. Bot. Ser. 1 : 2-24.

*Butler, E.J. and Khan, A.H. (1913). Red rot of sugarcane. Mem. Dept. Agri. India. Bot. Ser. 6 : 151-178.

Carvajal, F. and Edgerton, C.W. (1944). The perfect stage of Colletotrichum falcatum. Phytopathology 34 : 206-213

Chatrath, M.S. and Bajaj, B.S. (1964). Studies on the physiology and pathogenicity of virulent strain of Colletotrichum falcatum. Indian J. Sugarcane Res. and Dev. 8 : 288-292.

*Chilton, S.J.P., Steib, R. and Mills, P.J. (1947). Red rot of Sugarcane. Abstract in Sugar. 43-50.

Chona, B.L. (1950). Studies on the diseases of sugarcane in India III. Sources and modes of red rot infection. Indian J. Agri. Sci. 20 : 363-385.

Chona, B.L. (1954). Relative resistance of sugarcane varieties to red rot. Indian J. Agri. Sci. 24 : 301-315.

Chona, B.L. and Bajaj, B.S. (1953). Occurrence in nature of Physalospora tucumanensis Speg. the perfect stage of sugarcane red rot organism in India. Indian Phytopath. 6 : 63-65.

Chona, B.L., Bajaj, B.S., Agarwal, H.O. and Sreenivasan, T.V. (1961). A note on the factors influencing perithecial production in Glomerella tucumanensis (Speg.) Arx and Muller. All India Conf. Sugarcane Res. & Dev. Workers 4 : 624-626.

Chona, B.L. and Hingorani, M.K. (1950). Mutation in Colletotrichum falcatum Went, the causal organism of sugarcane red rot. Phytopathology 40 : 221-227.

Chona, B.L. and Nariani, T.K. (1952). Investigations on the survival of Colletotrichum falcatum in soil. Indian Phytopath. 5 : 152-157.

Chona, B.L. and Padwick, G.W. (1942). More light on the red rot epidemic. Indian Fmg. 3 : 70-73.

Chona, B.L. and Srivastava, D.N. (1952). The perithecial stage of Colletotrichum falcatum Went in India. Indian Phytopath. 5 : 158-160.

Chona, B.L. and Srivastava, D.N. (1960). Variations in Colletotrichum falcatum Went, the causal organism of red rot of sugarcane. Indian Phytopath. 13 : 58-65.

*Cristinzio, G. (1982). Possible serological differentiation of Phytophthora capsici. Annales dilla Facottadi surize Agrasic dilla Universita digli studidi Napoli portici 16 : 118-124.

*Dufrenoy, J. (1942). The occurrence of pyridoxine (Vitamin B6) in sugarcane tissues. Proc. La. Acad. Sci. 73 : 13-16.

*Edgerton, C.W. (1911). The red rot of sugarcane. La. Agri. Expt. Sta. Bull. 133. pp.24.

Edgerton, C.W. (1959). Sugarcane and its diseases, Louisiana State University Press. La., U.S.A.

Edgerton, C.W. and Carvajal, F. (1944). Host parasite relations in red rot of sugarcane. Phytopathology 34 : 827-837.

*Edgerton, C.W. and Moreland, C.C. (1920). Effect of fungi on the germination of sugarcane. La. Agri. Expt. Sta. Bull. 169. pp.40.

*Evans, H. (1941). New light on red rot disease of sugarcane. Rep. Mauritius Sugarcane Res. Sta. 12 : 25-26.

Fitzell, R., Fahy, P.C. and Evans, G. (1980). Serological studies in some Australian isolates of Verticillium species Aust. J. Biol. Sci. 33 : 115-124.

Freire, F.W. (1930). Cane diseases and plaques in Brazil. Facts about Sugar. 25 : 613-614.

Ghouse, A.K.M. and Khan, A.M. (1963). Vitamin requirements of Colletotrichum spp. on graminaceous hosts. Indian J. Expl. Biol. 1 : 217-220.

Gooding, G.V. Jr. (1966). Preparation of macromolecular antigens from Fomes annosus. Phytopathology 56 : 1310-1311.

Gupta, S.C. (1980). Importance of varietal screening against red rot disease of sugarcane. Indian Phytopath 33 : 388-390.

Gupta, S.C., Singh, M.P. and Upadhaya, V.C. (1980). A new biotype of Colletotrichum falcatum Went. Curr. Sci. 49 : 600-601.

Hegde, R.K., Sachichidananda, J., Chenulu, V.V. and Munjal, R.L. (1968). Serology in the differentiation of Physiologic races of Colletotrichum lindemuthiarum (Sace. & Magn). Bri. & Car. and determination of varietal resistance to disease. Indian J. Expl. Biol. 6 : 166-167.

Hornok, L. (1980). Serotaxonomy of Fusarium species of the sections Gibbosum and Discolor. Trans. Br. Mycol. Soc. 74 : 73-78.

Howard, A. (1903). On some diseases in West Indies. Ann. Bot. 17 : 373-411.

Jhamaria, S.L., Ghemawat, M.S. and Amarjeet Kaur (1985). Screening of sugarcane varieties for red rot resistance. Indian Sugar 34 : 717-718.

*Joly, S. and Gambogi, P. (1957). Brief notes and some investigations on the biology of Colletotrichum falcatum Went, the cause of red rot of sugarcane. Rept. Ann. Fac. Agri. Pisa. N.S. 18. pp.22.

Kaiser, S.A.K. and Gupta, P.K.S. (1976). Serological and electrophoretic studies of three formae specialis of Fusarium oxysporum. Trans. Br. Mycol. Sco. 67 : 33-37.

Kalaimani, T., Padmanabhan, D., Ponniah, S. and Natarajan, S. (1987). Evaluation of sugarcane varieties/clones for tissue resistance to red rot caused by Colletotrichum falcatum Went. Co-operative Sugar 19 : 95-98.

Kalyanasundaram, R. and Charudattan, R. (1969). Serological studies in the genus Fusarium. A comparison of strains. Phytopath. Z. 64 : 28-31.

Kalyanasundaram, R., Desai, V.B. and Sirsi, M. (1967). Serological studies in the genus Fusarium. Phytopath. Z. 59 : 39-45.

Khirbat, S.K., Satyavir and Beniwal, M.S. (1980). Physical and Pathological variability in sugarcane red rot pathogen C. falcatum in Haryana. Indian Phytopath. 33 : 296-299.

Kirtikar (1959). Physiological specialisation in red rot pathogen. Indian Sugar 8 : 797-799.

Kirtikar, Rana, O.S. and Gupta, S.C. (1965). An intermediate type virulent isolate of Colletotrichum falcatum Went in eastern tract of Uttar Pradesh. Indian Sugar 15 : 161-163.

Kirtikar and Singh, D.R. (1955). Recurrence of red rot epidemics in Uttar Pradesh. Proc. of the Second Biennial Conference of Sugarcane Research and Development Workers in the Indian Union, Jullunder, February, 1954.

Krywienczyk, J. and Dorworth, C.E. (1980). Serological relationships of some fungi of the genus Pythium. Can. J. Bot. 58 : 1412-17.

※Kulkarni, G.S. (1911). Preliminary study of the red rot of sugarcane in Bombay Presidency. Dept. Agric. Bombay Bull. 44 : 1-8.

Lal, R. (1986). Testing of sugarcane varieties/genotypes for red rot resitance. Annual Report 1986. Indian Institute of Sugarcane Research, Lucknow. pp.39-56.

Lal, R. and Singh, N. (1986). Viability of red rot pathogen under water logged condition. Annual Report 1986. Indian Institute of Sugarcane Research, Lucknow, India. pp.39-56.

※Le Beau, F.J., Stokes, I.E. and Cobman, O.H. (1951). Anthracnose and red rot of sorghum. U.S. Dept. Agri. Bull. 1035 : 22.

Lewin, H.D., Muthusamy, S. and Sanjeevi, P.S. (1978). Role of midrib lesion isolates of Glomerella tucumanensis in causing red rot in sugarcane. Sugarcane Pathol. Newsl. 20 : 13-16.

Lewin, H.D., Natarajan, S. and Rajan, S.D. (1976a). Occurrence of red rot (Physalospora tucumanensis Speg.) of sugarcane in Tamil Nadu. Farm Sci. 3 : 15-17.

Lewin, H.D., Natarajan, S. and Rajam, S.D. (1976b). Screening of sugarcane clones for field resistance to red rot (Physalospra tucumanensis Speg.) Sugarcane Pathol. Newsl. 17 : 20-22.

※Lewton-Brain, L. (1908). Red rot of sugarcane stem, Expt. Sta. Hawalian Sugar Planters' Assoc. Div. Path and Physiol. Bull. 8. pp.44.

Manocha, M.S. (1965). Effect of different carbon and nitrogen sources on growth and sporulation of Colletotrichum falcatum Went isolates. Indian J. Microbiol. 5 : 21-26.

Mathew, A.V., Potty, N.N., Suman Susan Varghese, Nari, S.S. and Alexander, K.C. (1987). Evaluation of sugarcane varieties against a new strain of red rot pathogen. The Indian Sugar Crops Journal. 13 : 4-5.

Mehta, P.P. and Sinha, R.N. (1957). Sources of red rot infection - some observations in North Bihar. Indian Sugar 7 : 337-339.

Merz, W.G., Burrell, R.G. and Gallegly, M.E. (1969). A serological comparison of six heterothallic species of Phytophthora. Phytopathology 59 : 367-370.

Misra, A.P. (1957). Outbreaks and new records. FAO Plant Protec. Bull. 5 : 145-146.

Morton, D.J. and Dukes, D.D. (1966). Serological differentiation of race 1 from race 2 of Fusarium oxysporum f. sp. lycopersici. Plant Dis. Reptr. 50: 444-445.

Morton, D.J. and Dukes, P.D. (1967). Serological differentiation of Pythium aphanidermatum from Phytophthora parasitica var. nicotianae and Phytophthora parasitica, Nature. 213 : 923.

Mundkur, B.B. (1946). Report of the Imperial Mycologist. Sci. Rept. Agri. Res. Institute, New Delhi.

Nair, S.S., Potti, N.N., Mathew, A.V., Alexander, K.C. and Singh, K. (1984). Red rot and other important seed piece transmissible diseases of sugarcane in Kerala. Indian Sugar 33 : 815-816.

Natarajan, S. and Muthusamy, S. (1981). Screening of sugarcane clones for resistance to red rot. Sugarcane Pathol. Newsl. 26 : 33-34.

Pandey, L.N. and Sakal, R. (1974). New pathogenic strain of Glomerella tucumanensis (Speg.) Arx and Muller in Uttar Pradesh. Indian Sugar 24 : 707-709.

Parthasarathi, K. and Vijayasaradhy, M. (1958). On the phenolic content of sugarcane and spontaneum Juices. Curr. Sci. 27 : 218-219.

Pethambaran, C.K. and Wilson, K.I. (1970). Fungal flora of Kerala II. Agric. Res. J. Kerala 8 : 126-128.

Prakasam, N. and Alexander, K.C. (1986). Testing of sugarcane varieties for comparative resistance to red rot. Annual Report Sugarcane Breeding Institute. 1986-1987

Prakasam, P. and Reddy, V.T.C. (1961). Occurrence of a light race of C. falcatum Went in Andhra Pradesh Sci. and Cult. 27 : 250-251.

*Raciborski (1897). De Bestrijding van het Rood-snot. Arch. Java Suikerindus 5 : 1133-1135.

Rafay, S.A. (1950). Another strain of Physalospora tucumanensis. Curr. Sci. 19 : 385-386.

Rafay, S.A. (1953). Pathogenicity, spread and reversion of Physalospora tucumanensis. Proc. Indian Acad. Sci. 38 : 99-100.

Rafay, S.A. (1955). Control of cane diseases. Proc. Second Biennial conference of sugarcane Research and Development Workers in the Indian Union, Jullunder, February 1954.

Rafay, S.A. and Padmanabhan, S.Y. (1941). Strains of Colletotrichum falcatum Went. Curr. Sci. 10 : 25-26.

Rafay, S.A. and Singh, V.B. (1957). A new strain of Glomerella tucumanensis. Curr. Sci. 26 : 19-20.

Rafay, S.A. and Singh, V.B. (1959). Primary and secondary infection of red rot. All India Conf. Sugarcane Res. & Dev. Workers 3. pp.333-335.

Ramakrishnan, T.S. (1941). Studies on the genus Colletotrichum II. Physiological studies on C. falcatum Went. Proc. Indian Acad. Sci. 14 : 395-411.

Ramakrishnan, T.S. (1947). Studies on the genus Colletotrichum III. Proc. Indian Acad. Sci. Sec. B. 25 : 15-27.

Ramakrishnan, T.S. (1949). Studies on the genus Colletotrichum Part IV. Leaf spot of Arundo donax L. caused by Colletotrichum falcatum Went var. arundinis var. nov. Proc. Indian Acad. Sci. Sect. B. 29 : 289-294.

Rana, O.S. and Gupta, S.C. (1968). An easy method of screening out red rot susceptible varieties at initial stages of multiplication. Indian Sugar 18 : 447-452.

Rao, K.C., Krishnamurthy, T.N., Lalitha, E. and Rajalakshmi (1968). Phenols in relation to resistance of sugarcane varieties to red rot. Curr. Sci. 37 : 532.

Renard, J.L. and Mayer, J.A. (1969). Serological study of saprophytic strains of Fusarium oxysporum and F. oxysporum f.sp. Glaeidis. Trans. Br. Mycol. Soc. 53 : 455-461.

Riker, A.J. and Riker, R.S. (1936). Introduction to research on plant diseases. John S. Swift Co., Inc. New York. pp. 117.

Sandhu, S.S., Mohan, V.K. and Singh, K. (1974). Role of mid-rib lesions in the epidermiology of red rot caused by Colletotrichum falcatum Went in Punjab. Indian Sugar 24 : 391-395.

Sarkar, A. (1960). Comparative studies of two races of Colletotrichum falcatum Went. Sci. & Cult. 26 : 83-84.

Sarkar, A. and Chattopadhyay, S.B. (1960). A perithecia forming isolate of Colletotrichum sp. from sugarcane. Ind. J. Agric. Sci. 30 : 162-164.

Sattar, M.A., Rao, R.P. and Rao, N.P. (1982). Screening sugarcane clones for resistance to red rot disease, Sugarcane Pathol. Newsl. 28 : 11-14.

Satyanarayana, Y. and Rao, M.A. (1984). The red rot causal organism. Sugarcane 3 : 6.

Satyavir, Beniwal, M.S., Virk, K.S. and Maheshwari, S.K. (1984). Breakdown on red rot resistance in sugarcane cultivar Co.1148. Indian Phytopath. 37 : 407.

Sharma, M.N. (1970). Occurrence of a new strain of P. tucumanensis Speg. in Nizamabad district of Andhra Pradesh. Sci. and Cult. 36 : 52-54.

Sharma, K.P., Batta, S.K. and Kanwar, R.S. (1982). Phenolic contents in red rot resistant and susceptible varieties of sugarcane. Journal of Research, Punjab Agri. University 19 : 21-25.

Singh, G.R. (1967). Spread of red rot in the leaves of sugarcane plant. Indian Phytopath. 20 : 220-225.

Singh, G.R. (1969). Red rot infection and its development in young sugarcane plants. Proc. Inter Soc. Sugarcane Technol., 13th Congress. pp.1243-1250.

Singh, G.P. and Rana, O.S. (1968). A new strain of Glomerella tucumanensis red rot pathogen in U.P. Indian Sugar 18 : 537-540.

Singh, K., Bhansali, R.R., Singh, N., Ghosh, A.K. and Srivastava, A.K. (1983). Infection sites and movement of C. falcatum in sugarcane setts and settlings. Journal of Nuclear Agriculture and Biology. 12 : 62-64.

Singh, K. and Budhraja, T.R. (1964). Method of inoculating sugarcane for red rot. Plant Dis. Reptr. 48 : 991-993.

Singh, K., Budhraja, T.R. and Agnihotri, V.P. (1977). Survival of Colletotrichum falcatum in soil, its portals of entry and role of inoculum density in causing infection. Intern. Sug. J. 79 : 43-44.

Singh, K., Singh, R.P. and Agnihotri, V.P. (1976). Phenolics in relation to sugarcane resistance against red rot disease. Sugarcane Pathol. Newsl. 15/16 : 37-41.

Singh, M.P., Upadhyay, U.C., Verma, K.P. and Singh, H.V. (1984). Pathogenic variability in red rot isolates of sugarcane in U.P. Indian Sugar 33 : 669-671.

Singh, N. (1981). Role of naturally infected debris in red rot development. Annual Report 1981. Indian Institute of Sugarcane Research, Lucknow, India. pp. 54.76.

Singh, N. (1983). Longevity of red rot pathogen in soil. Annual Report 1983. Indian Institute of Sugarcane Research, Lucknow, India. pp.92-117.

Singh, N. and Singh, K. (1982). Formation of resting structures by the C. falcatum Went in soil. Curr. Sci. 51 : 102-104.

Singh, N. and Singh, K. (1983). Build up of red rot in ratoon. Annual Report 1983. Indian Institute of Sugarcane Research, Lucknow, India. pp.92-117.

Singh, P. (1966). Studies on the effect of certain nutrients on the conidial germination in Colletotrichum falcatum. Indian Phytopath. 19 : 30-37.

Srinivasan, K.V. (1962). Some observations on variation in red rot pathogen, G. tucumanensis Speg. Proc. Intern. Soc. Sug. Tech. Mauritius II : 795-802.

Srinivasan, K.V. and Alexander, K.C. (1966). A study of mode of nodal infection and occurrence of dormant infections of red rot. Proc. All India Conf. Sugarcane Res. & Dev. Workers 5 : 676-684.

Srinivasan, K.V. and Bhat, N.R. (1961). Red rot of sugarcane criteria for grading resistance. Jour. Indian Bot. Soc. 11 : 566-577.

Srinivasan, K.V. and Vijayalakshmi, U. (1960). Thiamine and biotin requirements of two strains of Glomerella tucumanensis (Speg.) Arx and Muller. Curr. Sci. 29 : 103-104.

Steib, R.J. (1949). Studies on penetration and infection of sugarcane stalks by Physalospora tucumanensis Speg. Phytopathology 39 : 23.

Steib, R.J. and Chilton, S.J.P. (1951). Infection of sugarcane stalks by red rot fungus, Physalospora tucumanensis Speg. Phytopathology 41 : 522-526.

※ Verma, A.K., Jaiswal, S.P., Bajaj, K.L. and Bhatia, I.S. (1971). A study of polyphenols in sugarcane in relation to red rot disease present in the stem of sugarcane varieties. Sugar y Azucar. 66 : 11-13.

Verma, K.P., Srivastava, C.M. and Singh, R. (1984). R.196 - a new biotype of Colletotrichum falcatum Went. The Indian Sugarcrops Journal 10 : 26.

Vincent, J.M. (1970). A manual for the practical study of the Root Nodule Bacteria. Blackwell Scientific Publication. Oxford and Edinburgh. pp.25-40.

Virk, K.S. and Satyavir (1986). Plant Diseases. Tech. Report All India Co-ord. Res. Project on Sugarcane. 1985-86. p.24.

*Wang, S.C. (1950). Studies of Physalospora tucumanensis Speg. Proc. Intern. Soc. Sugarcane Technol. 7th congress. pp.513-516.

Waraitch, K.S. (1983). Survival of C. falcatum in soil and its role in the initiation of red rot of sugarcane. Indian Phytopath. 36 : 199.

*Went, F.A.F.C. (1893). Het rood snot. Arch. Jora-Suikerind. 1 : 265-282.

*Wiehe, P.O. (1944). Red rot and M 134/32. Rev. Agri. Maurices 23 : 242-243.

Wilson, K.I. and Srivastava, D.N. (1969). Chromatographic detection of chlorogenic acid and a histochemical test for phenols in nodal tissues of sugarcane. Indian Phytopath. 22 : 306-308.

* Originals not seen

APPENDICES

APPENDIX I

Abstract of Analysis of Variance Tables

Sl. No.	Source	df	MSS	
			Conidial Length	Conidial Breadth
1.	Table 2			
	Treatment	10	73.06**	4.03**
	Error	99	5.89	1.57
2.	Table 3			
	Isolate	10	0.023**	
	Source of media	4	4.330**	
	Source x isolate	40	0.022**	
	Error	110	0.006	
3.	Table 5			
	Isolate	10	35.09**	
	Source of carbon	8	562.10**	
	Source x isolate	80	8.82**	
	Error	198	1.73	
4.	Table 7			
	Isolate	10	27.61**	
	Source of nitrogen	9	199.06**	
	Source x isolate	90	12.80**	
	Error	220	0.89	
5.	Table 9			
	Isolate	10	66.88**	
	Source of amino nitrogen	6	89.66**	
	Source x isolate	60	3.44**	
	Error	154	0.49	

**Significant at 1% level

APPENDIX II

List of weeds artificially inoculated with *Colletotrichum falcatum* Went.

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1. *Cynadon dactylon* (L.C. Rich) Pers.
2. *Cyperus iria* L.
3. *Cyperus rotundus* L.
4. *Echinochloa colonum* (L.) Link
5. *Echinochloa crus-galli* (L.) Beauv.
6. *Euphorbia hirta* L.
7. *Marsilea quadrifolia* L.
8. *Panicum repens* L.
9. *Phyllanthus niruri* L.
10. *Solanum nigrum* L.

VIRULENCE, VARIATION AND SURVIVAL OF *COLLETOTRICHUM FALCATUM* WENT IN KERALA

BY

BABU GEORGE M.Sc. (Ag.)

ABSTRACT OF A THESIS

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ABSTRACT

Eleven 'light type' isolates of Colletotrichum falcatum Went from four common sugarcane varieties cultivated at different locations in Thiruvalla region were employed in the present study.

The conidia of isolates I and XI were longer than most of the other isolates. Isolate VII produced shorter but broader conidia than the other isolates. Oat meal and potato dextrose agar media were found very good for the growth of all the isolates. Maximum sporulation of most of the isolates was obtained in oat agar medium.

Fructose, mannitol and sucrose supported very good growth of all the isolates. Abundant sporulation was obtained in the presence of glucose, mannitol and sucrose. Sodium nitrate favoured fairly good growth and sporulation of all the isolates. Tyrosine used as amino nitrogen source aided good growth and sporulation by most of the isolates. Maximum mycelial growth and best sporulation of all the isolates were obtained when grown at pH 7.0.

Isolate I was found to be more virulent than the other 10 isolates when tested against 13 differential varieties of sugarcane. One hundred and five varieties

were susceptible and ninety five were resistant to isolate I of the pathogen when tested in the field. The susceptible varieties included Co.997, Co.449, Co.419, Co.785 and Co.62175 commonly cultivated in the region and Co.7704 recently recommended for cultivation.

Serological studies indicated that isolate I was not identical to the other 10 isolates and the one from Karnal.

The disease could be transmitted to the ratoon crop from severely affected stumps of a susceptible variety. The pathogen remained viable up to 8 weeks on infected sugarcane pieces buried at five and ten cm depths in soil. The propagules of the fungus were able to survive up to four weeks in water collected from Manimala river.