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Effect of nutritional and abiotic factors on *Glomerella cingulata* causing brown blight disease in tea (*Camellia sinensis*) van 123

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The present work presented an account of the influence of nutritional and abiotic factors on different isolates of *Glomerella cingulata* causing brown blight disease of tea. The pathogen varied in its ability to utilize different carbon and nitrogen sources tested. In various culture media the PDA was effective for growth of Gc1, Gc2 and Gc4 pathogen but Gc3 grew well in oat meal agar. Chitin for Gc1, Gc4 and pectin for Gc2 and Gc3 were to be the best sources of carbon for the higher growth and most of the carbon sources induced high sporulation. Among the nitrogen sources tested, organic nitrogen glycine (Gc1, Gc3, and Gc4) and casein (Gc2) supported the maximum growth and sporulation of all isolates, whereas in case of inorganic nitrogen sources, Sodium nitrate was to be the best one followed by potassium nitrate for growth and sporulation. The amino acid sources aspartic acid provided maximum growth followed by proline. Among various vitamins taken, biotin for Gc1, Riboflavin for Gc2, Gc4 and Vitamin – C for Gc3 recorded good growth of *G. cingulata* isolates. However, most of the isolates preferred temperature range of 25ºC to 30ºC for the growth and sporulation when grown on PDA solid medium. *G. cingulata* isolates grew well at pH 5 to 6 while sporulation was better at pH 6. Day light was found to be better for all isolates except Gc3, for their growth.

Key words: Carbon, nitrogen, tea, pH, temperature, vitamin, amino acid.

Introduction

Tea is the most popular and inexpensive beverage. Tea is grown in more than 50 countries, and being a perennial crop is prone to attack by many pests and diseases. The majority of the diseases in tea are of fungal origin. More than 400 pathogens cause various diseases in tea (Chen and Chen, 1990) viz., foliage, stem and root. Among the tea diseases, brown blight caused by

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Glomerella cingulata (sexual) (STONEMAN) Spauld. et SCHRENK (*Colletotrichum gloeosporioides*-anomorph) is one of the foliar diseases in tea.

Brown blight is common in all tea districts. It's a weak parasite which is harmless unless it can gain entrance through a wound or into tissues. The two main reasons responsible for the leaf damage that predisposes foliage to the invasion of brown blight are sun scorch and hail. Blister blight and the punctures of capsid bugs are also prevalent cause of infection (Eden, 1965). The affected tissue dies and the central portion drops off. Severe infections cause defoliation, resulting in considerable damage (Rangaswami, 1972). This plant pathogenic fungus causes various diseases in other crops such as papaya, mango, strawberry, banana and avocado (Wasantha kumara *et al*., 2008).

Recently more than 40 species are accepted based on their morphology, cultural characters, and pathogenic abilities (Cannon *et al*., 2000). Struble and Keitt (1950) recognized a considerable degree of diversity within isolates of *C. gloeosporioides* and *G. cingulata* recovered from apple fruit showing bitter rot symptoms and described seven different types of *G. cingulata* based on colony colour, distribution of perithecia in culture and relative abundance of conidia. Morphological and cultural characters remain useful for defining taxa in *Colletrotrichum* at both the species and subspecies level; however, morphology alone is unlikely to resolve relationships below the species level (Buddie *et al*., 1999, Johnston, 1997). As science developed, it became obvious that many morphological features can be quite plastic and easily damage depending on the environmental conditions and not necessarily because of variations inside the genomes. This would lead to creation of numerous synonyms, as *colletrotrichum* (Von Arx, 1957), *Trichoderma* and several other fungi. There was great potential for augmentation of morphological, physiological and nutritional characteristics with molecular data for a better classification system (Wasantha kumara *et al*., 2008). Such data will allow the development of proper, objective and even automated identification techniques (Cannon *et al.* 2000). Therefore, the present work of this experiment was to study nutritional and abiotic factors influencing on different isolates of *Glomerella cingulata* causing brown blight disease in tea.

Materials and methods

Isolation of pathogens

Field surveys were conducted in tea growing zones of South India viz., Anamallais, Central Travancore, The Nilgris, Wayanad and Koppa for the isolation of brown blight disease pathogen *Glomerella cingulata*. The diseased plant parts were collected and washed in tap water and then dried by placing

them in between folds of filter papers. The Isolation of the respective pathogen was carried out *in vitro* using water agar followed by PDA. Total of three strains were isolated and they were named as Gc2, Gc3 and Gc4. The culture of the sporulating fungi was purified by single spore isolation and those of non-sporulating fungi by hyphal tip method. (The collected three isolates were compared with the UPASI plant pathology division standard strain *G. cingulata* (Gc1) (Table 1).

Influence of nutritional factors on G. cingulata

The utilization of carbon and nitrogen sources was studied by replacing the glucose and sodium nitrate in the basal medium with various nutritional sources on the media composition basis (Media composition: Sodium nitrate - 2 g, di potassium hydrogen phosphate – 0.5 g, magnesium sulphate (Hydrated) – 0.2 g, manganese sulphate (Hydrated) – 0.02 g, ferrous Sulphate (Hydrated) – 0.02 g, calcium chloride (hydrated) – 0.02 g and glucose – 5 g dissolved with 1000 ml of distilled water). 50 millilitres of the above medium dispensed in 150 ml conical flasks were sterilized and used. Flasks were inoculated with mycelial disc of 5 mm obtained from 7 days old single spore cultures of *G. cingulata* isolates and incubated at 28 ± 1ºC for ten days. They were filtered through Whatman No. 42 filter paper and the dry mycelial weight had been measured.

Standardization of media for better growth or growth response to various nutrient media

Totally Thirteen synthetic media namely, PDA, oats meal, mineral salt, Rose Bengal, Czapeks dox, malt extract, malt yeast extract, potato dextrose yeast, Richard's, yeast extract, Sabourad's, and water agar media mixed with agar were used for this study. 20 ml of Different agar medium was poured into each Petri plate under aseptic condition and inoculated with 5 mm diameter identical culture discs of different monoconidial isolates grown for seven days. The experiment was replicated thrice. The radial growth of the pathogen was measured in Days after incubation period over.

Effect of carbon and nitrogen source

Carbon and nitrogen sources tested in the study were glucose, sucrose, fructose, maltose, mannitol lactose, chitin, pectin and dextrose. In fourteen different nitrogenous compounds *viz*., ammonium nitrate (NH4NO3), potassium nitrate (KNO3), sodium nitrate (NaNO3), ammonium sulphate (NH4SO4) and ammonium chloride (inorganic nitrogen), urea, peptone, yeast

extract, glycine, casein, beef extract, aspergine, skim milk and tryptone (organic nitrogen). Suitable controls were maintained. Mineral salt medium with-out adding sodium nitrate (nitrogen source) was used as the control. Mineral salt medium without adding glucose and sodium nitrate was used as a control. Carbon sources were added to the basal medium (mineral salt medium) at 5 g of carbon and 2.0 g of sodium nitrate per litre of medium. Each flask containing different carbon and nitrogen sources was inoculated with a 5 mm mycelial disk of seven day old fungal cultures and incubated for 7 days. Radial growth and mycelial dry weight were recorded as the criteria for growth in solid and liquid media, respectively.

Amino acid and vitamin sources

Alanine (simple amino acid), serine (hydroxyl amino acid), methionine (sulphur containing amino acid), aspartic acid and glutamic acid (acidic amino acid), asparagine (amides), arginine (basic amino acid) and proline (heterocyclic amino acid) were taken as amino acid sources. The vitamins, Thiamine (B1), riboflavin (B2), pantothenic acid (B3), nicotinic acid (B5), biotin (B7), folic acid (B9) and ascorbic acid (C) were chosen for this study. Stock solutions were prepared and required quantities of the solutions were added to the medium so as to get the final concentration of 200 ppm. Stock solutions of the vitamins were filter sterilized and incorporated with the medium so as to get a concentration of 50 ppm in the medium. Amino acids and vitamins free medium served as the control. The fungal mycelial mat was harvested on 7^{th} day and recorded the dry weight.

Effect of temperature

The pathogen was subjected to treat a range of temperature condition in order to study the suitable temperature for the better growth and sporulation of the *G. cingulata*. Mineral salt agar medium was poured into Petri plate and inoculated with identical culture discs of different monoconidial isolates grown for seven days. The experiment was replicated thrice. Then, 50 ml millilitres of mineral salt broth was poured into each 150 ml conical flask and inoculated with 5 mm mycelial disc of each isolate. Inoculated Petri plates and conical flasks were incubated at 10, 20, 25, 28 (Control) and 30ºC. The colony diameter and the level of sporulation were recorded in solid medium at seven days of inoculation. Dry mycelial weight and the extent of sporulation, were recorded in the liquid cultures seven days of the incubation.

Effect of pH

The pH on the growth of *G. cingulata* isolates was also tested using both solid and liquid media having different pH levels. The Reaction of the medium was adjusted to the desired pH by adding 0.1N NaOH or 0.1N HCl (Naik *et al.*, 1988). The medium was buffered with Disodium hydrogen phosphate citric acid buffer according to the schedule of Vogel. Each flask was inoculated with each isolate using 5 mm mycelial disc in sterile conditions. Inoculated flasks were incubated at 28 ± 1ºC for seven days and the dry mycelial weight and extent of sporulation were obtained in liquid culture. Radial growth and mycelial dry weight were recorded as the criteria for growth in solid culture too.

Effect of illumination

The fungus was subjected to treat with various illumination conditions to study the suitable light source for the growth and sporulation of the fungus. Inoculated Petriplates and conical flasks containing mineral salt medium were incubated in dark light condition, fluorescent light, UV light and day light (Control). The colony diameter and the level of sporulation were recorded. Each flask was inoculated with each isolate using 5 mm mycelial disc in sterile conditions. Inoculated flasks were incubated at 28 ± 1ºC for seven days and the dry mycelial weight and extent of sporulation were obtained in liquid culture. Radial growth and mycelial dry weight were recorded as the criteria for growth in solid culture too.

Evaluation sporulation potential of g. cingulata

The extent of sporulation in all experiments was observed visually and recorded as (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation. The experimental results were statistically analysed as 2 factorial with each replicated thrice.

Results and discussions

Standardization of media for better growth or growth response to various nutrient media

Among the media tested, the growth of *G. cingulata* isolates (Gc1, Gc2 and Gc4) was higher in Potato dextrose agar followed oat meal and carrot agar. Whereas Gc3 grew better in oat meal agar than other media. Likewise

Phytophthora palmivora grow well in oat meal agar it support our findings (Turner, 1969). *Phytophthora asparagi* was found good growth in the PDA medium (Choompookaew, 1990) (Table 2).

Effect of carbon and nitrogen source

Among the different carbon sources of monosaccharides and oligosaccharides tested mycelial biomass was noticed high in the above two groups of carbon sources amended media. Chitin was most preferred carbon source by Gc1 and Gc4 for vegetative as well as reproductive growth, while for Gc2 and Gc3 pectin was the best source for vegetative and reproductive growth. The pathogen grown on chitin and pectin amended media recorded significantly higher biomass weight followed by media containing dextrose, cellulose and starch. Gc1 had significantly higher biomass growth followed by Gc3 and Gc4 isolates while Gc2 had the least mycelial growth in carbon source amended medium and it is on par with the other isolates (Tables 3 and 4).

Fructose, Mannitol and sucrose supported the isolates to produce moderate sporulation. There was less sporulation observed when those isolates were grown in a medium without any carbon source (control) (Table 5). Fungi meet their carbon requirement mainly from various organic sources, and the nature of the organism largely determines the range of substrates (Bilgrami and Verma, 1978; Steinberg, 1950). Hegde *et al*., (1990) found dextrose and sucrose as good carbon sources for the growth of *C. gloeosporioides* isolated from arecanut. Naik *et al.* (1988) reported sucrose as the better carbon source followed by glucose and dextrose for the growth of betel vine anthracnose pathogen C. *gloeosporioides*. Sangeetha (2003) observed mannitol followed by fructose and sucrose were the best carbon sources for the growth of *C. gloeosporioides* of *Mangifera indica*. Apart from these, several reports showed that sucrose was a better carbon source for various species of *Colletrotrichum* (Reddy, 2000). However, glucose has also been reported as the best carbon source for the growth of *C. gloeosporioides* in other studies (Jeffries *et al.,* 1990). There were vast differences in the utilization of carbon sources for the growth and sporulation of these isolates tested. However, in general, fructose was found to be the best carbon source in the present study both for the growth and sporulation of the *G. cingulata*. Carbon source also affects the sporulation of *C. gloeosporioides.* Sangeetha (2003) with in mango observed heavy sporulation of the *C. gloeosporioides* when maltose was used as a sole carbon source. Chaturvedi (1965) observed fructose, glucose, maltose and starch supported good sporulation of *C. gloeosporioides,* the incident of leaf spot of *Polyscias balijuriana.* Similarly, Saxena (2002) reported that sucrose was a good sporulating compound for *C. gloeosporioides* isolated from pomegranate.

Mannitol has been utilized efficiently for both growth and sporulation of *C. gloeosporioides* isolated from grapes (Manjunatha Rao and Rawal, 2002). Lactose was also reported to be a good carbon source for sporulation of *C. gloeosporioides* in (Reddy, 2000). In *G. cingulata*, maximum growth and sporulation was noticed in maltose followed by sucrose and glucose (Singh and Shankar, 1971). Glucose was found to be the best carbon source for *Colletrotrichum capsici*, which is infected the capsicum plant (Agnihotri, 1981).

Nitrogen sources

The pathogen was able to grow in a wide range of nitrogen sources. Mycelial growth of the fungus was influenced by all the nitrogen sources and was statistically on par with the control. In organic nitrogen sources three isolates like Gc1, Gc3 and Gc4 recorded maximum biomass weight when using glycine while Gc2 recorded maximum growth in the Casein amended medium followed by urea, yeast and beef extract (Tables 6 and 7). The sporulation highly observed in glycine and yeast extract but no sporulation was observed in the tryptone amended medium (Table 8). Whereas inorganic nitrogen sources, all the isolates showed growth and sporulation high in sodium nitrate followed by potassium nitrate and ammonium nitrate in both solid and liquid medium (Tables 9 and 10). The sporulation showed high in the same nutritional sources (Table 11). Nine amino acids tested, growth of all isolates was maximum in aspartic acid followed by proline (Table 12). The sporulation also highly in all the amino acid sources but some of the amino acid gave moderate sporulation (Table 13). Nitrogen is an important element for protein synthesis but all the sources of nitrogen are not equally good for the growth of the fungi. Tandon and Chandra (1962) reported that several nitrogen compounds except nitrites, had supported varying degrees of growth of *C. gloeosporioides* and the fungus could not grow on nitrites of potassium (KNO_3) or sodium (Na_2NO_3). Peptone and tyrosine were found to be a good nitrogen source for *C. gloeosporioides* isolated from arecanut (Hegde *et al.* 1990) and a poor growth was observed in the methionine amended medum. *C. gloeosporioides* of *Amomum villo sum* could utilize many nitrates and amino acids as an N source (Lai *et al.,* 1993) except ammonia, which inhibited the growth of the fungus. In another study, inorganic nitrogen sources like ammonium phosphate supported maximum growth of *C. gloeosporioides* followed by organic nitrogen sources such as urea and asparagine (Durairaj, 1956). Both, potassium nitrate and D L -methionine supported maximum growth of *C. gloeosporioides* of betel vine (Naik *et al.,* 1988). Similarly, asparagine, peptone, and potassium nitrate supported good growth of *C. falcatum* while, ammonium sulphate and urea provided poor

growth of *C. indicum* (Ramakrishnan, 1941). Certain sources of nitrogen favour the sporulation of some fungi, which are not necessarily the same as those which are favourable for the growth (Lilly and Barnett, 1951). Mishra and Mahmood (1960) found abundant sporulation of *C. capsici* on the medium containing peptone as a nitrogen source. According to Ekbote (1994), *C. gloeosporioides* of mango utilized potassium nitrate more efficiently and ammonium nitrate less efficiently for the growth and sporulation. Manjunatha Rao and Rawal (2002) reported ammonium nitrate as a better for the growth and sodium nitrate favoured better sporulation among six different nitrogen sources tested on *C. gloeosporioides* of grapevine. The current study concluded this variation in utilizing nitrogen sources for the vegetative growth and sporulation of *G. cingulata*.

Vitamins

Mycelial dry harvest of Gc2 and Gc4 were maximum in thiamine, whereas Gc1 & Gc3 grew well in biotin and ascorbic acid respectively when used as vitamin source. Growth was equally good in riboflavin and thiamine as vitamin sources (Table 14). The high sporulation was produced in the thiamine amended medium followed by ascorbic acid (Table 15). A number of researchers (Shukla and Sarkar, 1972) had submitted their findings on importance of vitamins in nutrition of fungi. Growth and sporulation of fungi have been reported that it was affected by the presence or absence of vitamins in the medium (Lilly and Barnett, 1951) Biotin supported growth in *Cercospora cruenta* (Jandaik and Kapoor, 1972), *C. gloeosporides* (Shukla, 1972). *Botryodiplodia theobromae* is highly responded to the addition of vitamins in the media, among which ascorbic acid was the best (Shukla and Sarkar, 1972) for its own growth and sporulation.

Effect of abiotic factors

Temperature

Different isolates of *G. cingulata* responded differently to various temperature regimes. The radial growth and mycelial dry harvest were maximum at temperature 25°C. Temperature below 20°C reduced the growth was reduced at above 30°C and below 20°C then there was no growth at above 35°C. The trend remained the same to all the isolates. Mean colony diameter of isolates on solid medium, was maximum at 28°C followed by 25°C and 20°C and significantly higher. Growth of Gc2 and Gc4 isolates was maximum at 25°C (Table 16). Gc1 and Gc3 isolates showed better growth on 28°C. *G.*

cingulata in liquid media among different temperature levels tested (Table 17); the maximum growth of the fungus was observed at 28°C and differed significantly with other treatments. The least mycelial growth was observed at 10°C in liquid medium. The temperature range from 20°C to 30°C was found to be favourable for the spore production of different isolates of *G. cingulata* when grown on solid medium. There was no spore production observed when these isolates were grown at 15ºC. Extent of sporulation was high in most of the isolates at 28 °C in liquid culture (Table 18). Temperature of 10°C found to be inhibitory the sporulation of those isolates. Temperature affects almost metabolic activity of the fungal organisms (Lilly and Barnett, 1951). Mathur *et al.* (1950) reported that 15-20°C favoured the conidia formation by *Colletrotrichum lindemuthianum* in culture. They further reported that the sporulation was very less at 25°C and ceased at 30°C. In another study, *in vitro* tests on growth of *C. gloeosporioides* showed that maximum growth reached after 10 days of incubation on potato dextrose broth, with optimum temperature in the range of 25-35°C (Hegde *et al.,* 1993). Estrada *et al.* (1993) reported that two mango isolates of *C. gloeosporioides* differed in their appressoria production at different temperature levels. They observed 20°C was optimum for the production of appressoria for one isolate while the other isolate required optimum temperature of 25°C. Sangeetha (2003) recorded maximum growth of different mango isolates of *C. gloeosporioides* at a temperature range of 25-30°C while good sporulation was seen at an optimum range of 25-28°C. Rajak (1983) was reported optimum temperature for the growth of *C. gloeosporioides* as 25°C however; optimum temperature of 29°C has been reported for the maximum growth of *C. gloeosporioides* by Ekbote (1994). *In vitro* studies showed that growth of *C. gloeosporioides,* the causal organism of mango anthracnose was maximum at 28 °C (Banik *et al.,* 1998). Jayasinghe and Fernando (1998) reported that slower growth at temperatures ranging from 15 to 32.5ºC along with reaction to different fungicides were shown to be one of the reliable characteristics in distinguishing *C. acutatum* from *C. gloeosporioides* isolated from rubber. Our findings are also in agreement with observation done by various scientists that the species and isolates within the genus *Colletrotrichum* respond differently in their growth and sporulation when exposed to different temperature conditions.

pH

Hydrogen ion concentration is one of the most important factors influencing the growth of the fungi. The pH of the medium determines the rate and amount of growth and many other life processes of organism (Lilly and Barnett, 1951). The pH of growing media is also influenced on the growth and

sporulation of fungi. The mycelial growth was different among isolates and different pH levels. The results indicated that the optimum pH range for all the four isolates were 5.0 – 6.5. In solid and liquid media the trend remained the same.

G. cingulata grew significantly better on medium with pH of 5.5 followed by pH 6, pH 5.0 and pH 7. The growth at pH 4 and 8.0 was similar, but not significant with the other pH levels. All pH levels tested, Gc2 grew significantly higher than the other isolates. Gc2 and Gc3 recorded maximum growth at pH 5.5 while pH 6 supported the maximum growth of Gc1 and Gc4 isolates (Tables 19 and 20). Sporulation of tested isolates differed with the level of pH of the medium. All the isolates preferred pH 6 for better sporulation. No isolate preferred pH 8 and pH 4 for the sporulation by *G. cingulata* (Table 21). Fungi can grow at a wide range of pH range from 4.0 to 8.0 most of them have an optimum 5.0 to 6.0 for most of the fungi (Sanjay, 2004). Fungi generally tolerate high acidic than alkali range of environment. Similar observations were also reported by few authors with different species of *Colletotrichum* (Naik *et al.,* 1988; Wasantha kumara *et al*., 2008).

Illumination/ Radiation

Radial growth of all the isolates was shown maximum in day light except Gc4, followed by UV light sources of incubation. Remaining light sources gave less radial growth. But this trend was not followed in liquid medium. Mycelial biomass was maximum on day light followed by UV light for GC1, GC2 and Gc3, whereas dark light condition was suitable radiation for the growth of Gc4, This was reflected in the growth of all the isolates (Table 22 and 23). The numbers of perithecia produced on solid media were more in day light followed by dark light by the isolates. But Gc4 also have best sporulation even under UV radiation. Perithecia development was observed very less under fluorescent light condition (Table 24). Leach (1962) studied the effect of irradiation on sporulation of different species of fungi and observed that most of the sporulation could be effectively induced by ultra violet radiation. The mycelial growth, sporulation and spore germination of fungi are greatly influenced by illumination / radiation sources. Most of the studies revealed that the influences of light on fungi are in relation to fungal reproduction rather than vegetative growth. Sanjay (2004) reported that day light favored the growth of *Pestalotiopsis theae* followed by fluorescent light. The growth was relatively low in UV light. On the other hand, maximum numbers of fruiting bodies were developed under UV light. UV light was essential to the formation of pycnidia in *Ascochyta mellilotion* in synthetic media (Von and Wagner, 1955). *Diaporthe phaseolorum* produced more perithecia when kept under UV light.

Conclusion

Isolates of *G. cingulata* showed variability on growth in different temperature and pH levels and to utilize different carbon and nitrogen sources due to their specific requirement. The growth of pathogen was monitored in different media concluded that PDA and oat meal agar assured better growth when compared to the other culture media tested. Chitin and pectin were found to be the best source of carbon for the growth and sporulation of this pathogen. Among the nitrogen (both organic and inorganic) sources tested, glycine, casein, sodium nitrate supported the maximum growth of the fungus followed by potassium nitrate and yeast extract, urea and beef extract contrast to this, fungus sporulated better in media containing potassium nitrate and sodium nitrate as the nitrogen source. In case of various amino acid and vitamins sources most of the isolates resulted maximum growth in aspartic acid for all the isolates followed by Proline and Biotin, Riboflavin, Vitamin C. The isolates preferred temperature range of 25 to 30ºC for the growth and sporulation. *G. cingulata* isolates grew well at pH of 5 – 6, while pH 6 was found preferred for the sporulation.

Table 1. Isolation of *G. cingulata* from different agro climatic region of south India

S. No.	Isolated locations	Code
1	Standard (UPASI)	Gc1
2	Anamallais	Gc2
3	Koppa	Gc3
4	Vandiperiyar	Gc4

Table 2. Radial Growth of *G. cingulata* in different Media

	Radial growth (mm)											
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Medium	3	5	7	3	5	7	3	5	7	3	5	7
Potato dextrose agar	17.0	25.5	41.25	19.5	30.75	39.75	19.5	25.0	39.75	18.5	25.0	40.25
Rose Bengal agar	12.2	24.75	29.25	12.7	15.75	18.0	12.2	22.5	32.25	13.0	18.5	19.0
Malt yeast extract	16.7	20.0	20.75	14.25	22.0	28.875	12.5	22.5	27.25	15.0	23.0	25.5
Potato dextrose yeast	10.0	22.25	27.75	9.5	15.75	17.25	8.0	11.25	11.5	10.0	19.0	20.0
Malt extract agar	15.25	21.75	26.5	18.75	24.75	33.75	10.0	21.75	28.0	16.25	24.75	29.5
Sabourad’	13.5	20.0	23.2	13.5	21.5	20.5	15.	16.2	17.7	14.0	20.0	25.5

s agar			5				5	5	5			
Czapeks dox Agar	5.7	5.75	25.75	5.5	5.5	30.25	7.2	7.25	29.75	6.5	6.0	28.5
Water agar	8.0	8.0	16.25	10.75	10.75	29.25	9.0	9.0	29.75	9.5	9.5	29.2
Yeast extract agar	10.5	10.5	34.5	7.0	7.0	26.0	11.5	11.25	20.75	13.0	11.5	27.5
Richard's agar	0	0	0	0	0	0	0	0	0	0	0	0
Oat meal agar	12.0	25.5	40.25	13.75	26.0	39.25	13.0	25.25	40.25	12.5	25.0	40.0
Carrot agar	12.0	23.0	35.0	15.0	27.5	37.5	11.5	26.0	33.5	12.0	24.5	34.5
Mineral salt agar	17.0	11.25	19.5	12.0	18	29.0	11.0	17.0	27.5	10.0	16.5	29.25
C.D at P=0.05	1.0	0.8	1.3	0.6	0.9	1.5	1.0	1.1	0.9	1.1	0.9	1.7

Table 3. Radial growth of *G. cingulata* in different carbon sources

	Radial Growth (mm)											
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Carbon Sources	3	5	7	3	5	7	3	5	7	3	5	7
Fructose	10.25	25.25	35.0	9.0	24.0	37.25	12.25	20.0	36.25	9.5	22.5	32.75
Mannitol	10.75	27.25	33.75	12.5	27.25	32.75	11.25	25.5	33.75	10.5	25.75	33.75
Pectin	13.25	29.75	39.5	13.0	26.5	40.0	10.75	26.0	39.75	9.0	24.25	37.25
Maltose	10.75	28.25	35.75	10.25	24.5	35.25	11.75	25.5	34.0	9.25	22.5	31.25
Cellulose	10.0	24.5	36.75	8.5	24.25	33.5	9.75	23.5	39.75	8.75	24.5	35.75
Lactose	11.25	26.0	33.0	10.0	25.25	34.75	10.0	25.5	30.25	9.25	18.5	26.5
Starch	10.0	26.5	35.75	11.75	24.5	36.0	13.25	26.5	36.0	13.25	28.75	38.75
Chitin	10.0	29.25	40.25	8.5	20.25	38.25	11.25	25.0	39.75	11.25	24.5	40.75
Dextrose	10.0	26.5	39.75	11.25	24.75	37.0	11.25	22.75	36.25	10	24.75	35.25
Sucrose	10.75	26.0	38.75	10.75	24.0	35.0	10.0	25.25	34.0	12.5	25.75	32.0
Control	4.0	12.0	16.0	3.5	11.0	17.5	4.5	11.0	17.0	4.0	10.0	16.0
C.D. at P=0.05	0.51	0.75	0.98	0.56	0.67	0.92	0.38	0.95	0.61	0.40	0.60	0.46

Table 4. Effect of various carbon sources on the growth of *G. cingulata* in liquid medium

Mycelial dry weight (mg.)												
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Carbon Sources	3	5	7	3	5	7	3	5	7	3	5	7
Fructose	78.00	147.00	287.00	124.00	234.00	425.00	96.00	178.00	376.00	86.00	159.00	330.00
Mannitol	73.00	144.67	280.00	63.00	147.00	238.00	74.00	161.00	305.00	94.00	173.00	341.00
Pectin	124.00	198.00	380.00	147.00	254.00	483.00	167.00	347.00	535.00	118.00	184.00	393.00
Maltose	85.00	157.00	308.67	94.00	165.67	347.00	83.00	168.00	334.00	68.00	134.00	262.00
Cellulose	87.00	159.00	332.00	75.00	159.00	306.00	113.00	235.00	397.00	113.00	181.00	381.00
Lactose	45.00	139.00	238.00	79.00	163.00	330.00	47.00	98.00	166.00	63.00	117.00	225.00
Starch	79.00	155.33	297.00	101.00	172.00	372.00	86.00	171.00	336.00	168.00	238.00	425.00
Chitin	234.00	402.00	646.00	126.00	247.00	463.00	118.00	245.00	482.00	181.00	305.00	497.00
Dextrose	164.00	297.00	493.00	124.00	217.00	400.00	86.00	172.33	347.00	102.00	178.00	378.00
Sucrose	89.00	168.00	346.00	92.00	164.00	332.00	78.00	165.67	326.00	85.00	156.00	296.00
Control	42.00	105.00	142.00	19.00	89.00	134.00	25.00	94.00	135.00	57.00	76.00	150.00
C.D. at P=0.05	3.52	5.33	7.27	3.44	2.41	5.51	6.21	4.97	3.32	1.78	7.85	3.36

Table 5. Sporulation of different isolates of *G. cingulata* in different carbon sources

Different Carbon Sources	Gc1	Gc2	Gc3	Gc4
Fructose	++	++	++	++
Mannitol	++	++	++	++
Pectin	+++	+++	+++	+++
Maltose	+++	+++	++	+++
Cellulose	+++	+++	+++	+++
Lactose	+++	++	+++	+++
Starch	+++	++	++	+++
Chitin	+++	+++	+++	+++
Dextrose	+++	++	+++	++
Sucrose	++	++	++	++
Control	+	+	+	+

After 7 days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 6. Radial growth of *G. cingulata* in different organic nitrogen sources

	Radial growth (mm)											
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
organic Nitrogen Sources	3	5	7	3	5	7	3	5	7	3	5	7
Urea	4.0	8.75	36.0	4.0	8.0	28.75	6.0	11.25	30.25	4.25	7.0	32.0
Casein	5.0	13.5	32.75	4.25	9.25	33.75	8.75	15.25	34.25	9.5	17.75	35.0
Aspergine	7.5	17.0	29.5	5.0	8.25	14.0	12.75	18.0	29.5	10.0	15.25	27.5
Peptone	13.5	20.25	27.75	11.75	18.25	22.5	14.0	20.25	27.5	15.5	22.5	25.0
Tryptone	15.5	22.25	16.5	10.0	17.5	19.5	10.0	19.0	22.75	13.5	20.0	21.25
Skim milk	15.5	20.5	30.5	12.75	18.75	27.5	12.75	18.0	29.25	15.25	22.25	27.0
Beef extract	15.0	21.25	32.25	9.5	16.25	30.25	15.25	20.25	16.5	15.0	20.75	35.75
Yeast extract	10.0	19.5	35.75	13.0	20.25	30.00	8.5	12.0	34.5	10.0	19.75	34.75
Glycine	13.0	20.0	36.75	9.5	16.25	32.5	11.5	18.25	36.25	10.0	17.5	39.75
Control	3.5	8.0	14.0	2.5	8.75	10.0	4.0	11.25	12.0	3.5	6.0	12.25
C.D. at P=0.05	0.94	1.29	0.99	1.08	0.89	1.39	1.13	1.38	1.16	1.18	1.2	1.52

Table 7. Effect of various organic nitrogen sources on the growth of *G. cingulata* in liquid medium

	Mycelial dry Weight (mg.)											
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
organic Nitrogen Sources	3	5	7	3	5	7	3	5	7	3	5	7
Urea	208.67	349.00	522.67	97.00	184.00	292.00	91.00	189.00	395.00	94.00	170.67	299.00
Casein	175.00	343.33	515.67	132.00	245.00	420.67	134.00	245.00	425.00	139.00	258.00	454.00
Aspergine	128.00	238.00	440.00	48.00	97.00	137.00	88.00	175.00	308.00	89.00	168.00	277.00
Peptone	124.00	235.00	423.00	73.33	144.00	215.00	71.00	168.00	230.00	73.67	135.00	250.00
Tryptone	89.00	169.00	378.00	62.00	107.00	203.00	69.00	115.00	215.00	42.00	64.00	113.00
Skim milk	163.00	319.00	506.00	76.00	166.00	287.33	80.00	171.33	278.00	79.00	160.67	260.00
Beef extract	168.00	325.00	509.67	121.00	220.33	404.00	63.00	94.00	185.00	164.00	298.00	475.00
Yeast extract	186.00	345.00	521.00	109.00	190.00	378.00	142.00	261.00	455.00	99.00	179.00	370.00
Glycine	217.00	367.00	525.00	124.00	232.00	420.67	148.00	269.00	485.00	174.00	334.00	552.00
Control	69.00	126.00	147.00	35.00	73.00	109.33	40.00	76.33	127.00	34.00	47.00	90.33
C.D. at P=0.05	6.7	7.02	5.41	5.10	6.26	6.71	6.10	3.39	5.79	5.6	5.64	7.37

Table 8. Sporulation of different isolates of *G. cingulata* in different organic nitrogen sources

Different Organic nitrogen	Gc1	Gc2	Gc3	Gc4
Urea	+++	+	++	+
Casein	_	+	+	_
Aspergine	+	+	+	++
Peptone	+	++	++	+
Tryptone	_	_	_	_
Skim milk	+	+	+	+
Beef extract	+	++	+	++
Yeast extract	+++	++	++	+++
Glycine	+++	+++	+++	+++
Control	_	_	_	_

After 7 Days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 9. Radial growth of *G. cingulata* in different inorganic nitrogen sources

Radial growth (mm)												
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Inorganic nitrogen	3	5	7	3	5	7	3	5	7	3	5	7
Ammonium sulphate	8.0	15.75	21.5	7.5	12.25	14.0	11.25	20.0	24.75	6.75	13.25	15.75
Ammonium chloride	10.0	12.5	20.75	8.0	9.5	19.25	5.75	9.75	25.0	6.50	15.25	20.5
Sodium nitrate	19.75	38.25	40.0	17.75	31.75	38.75	18.0	33.25	40.0	15.75	33.5	39.75
Potassium nitrate	18.5	37.5	39.75	19.75	36.75	38.0	18.75	36.0	39.25	17.25	35.75	39.75
Ammonium nitrate	10.0	25.5	35.75	13.5	11.25	36.0	12.5	2.6	35.5	6.0	26.75	17.75
Control	5.0	8.5	15.0	4.0	8.0	12.0	3.5	7.5	16.0	3.5	8.0	13.0
C.D. at P=0.05	0.69	0.82	0.83	0.63	1.09	0.75	1.38	1.40	1.46	1.00	0.67	1.75

Table 10. Effect of various inorganic nitrogen sources on the growth of *G. cingulata* in liquid medium

Mycelial dry weight (mg.)												
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Inorganic nitrogen	3	5	7	3	5	7	3	5	7	3	5	7
Ammonium sulphate	142.00	239.00	417.00	74.00	147.00	277.00	84.00	175.00	263.25	77.00	161.00	310.00
Ammonium chloride	96.00	168.00	363.00	76.00	169.00	333.00	105.00	187.00	372.25	112.00	183.00	378.00
Sodium nitrate	237.00	418.00	608.00	178.00	296.75	487.00	182.00	365.00	565.00	163.00	335.00	514.00
Potassium nitrate	165.00	254.00	432.00	169.00	273.00	479.00	145.00	217.00	409.00	114.00	194.00	385.00
Ammonium nitrate	158.00	247.00	424.00	138.00	263.00	353.00	119.00	215.00	399.00	93.00	177.00	358.00
Control	48.00	75.00	132.00	24.00	45.00	109.00	33.00	67.00	124.00	28.00	54.00	115.00
C.D. at P=0.05	2.69	1.33	1.87	3.08	2.85	2.69	1.73	0.50	7.42	2.95	3.15	3.75

Table 11. Sporulation of different isolates of *G. cingulata* in different inorganic nitrogen sources

Different Inorganic nitrogen	Gc1	Gc2	Gc3	Gc4
Ammonium sulphate	+	+	+	+
Ammonium chloride	+	++	+	++
Sodium nitrate	+++	+++	+++	+++
Potassium nitrate	+++	+++	+++	+++
Ammonium nitrate	++	++	++	++
Control	+	+	-	+

After 7 days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 12. Effect of various amino acid sources on the growth of *G. cingulata* in liquid medium

Mycelial dry weight (mg.)												
	Gc1			Gc2			Gc3			Gc4		
	Day after inoculation											
Amino acid Sources	3	5	7	3	5	7	3	5	7	3	5	7
Aspartic acid	198.0	415.0	606.0	215.0	428.0	609.0	231.0	445.0	625.0	248.0	470.0	656.0
Arginine	98.0	217.0	406.0	121.0	228.0	425.0	147.0	257.0	432.0	159.0	310.0	473.0
Aspargine	87.0	235.0	441.0	113.0	259.0	437.0	149.0	301.0	452.0	127.0	216.0	401.0
Proline	157.0	324.0	554.0	167.0	329.0	568.0	175.0	345.0	585.0	191.0	384.0	578.0
Glutamine	127.0	289.0	513.0	134.0	297.0	520.0	143.0	275.0	517.0	167.0	308.0	535.0
Cystine	159.0	312.0	541.0	163.0	345.0	583.0	174.0	357.0	585.0	129.0	297.0	545.0
Methionine	74.0	189.0	325.0	89.0	201.0	328.0	68.0	178.0	313.0	79.0	195.0	341.0
Alanine	68.0	190.0	312.0	88.0	210.0	342.0	76.0	198.0	321.0	89.0	194.0	332.0
Serine	114.0	218.0	386.0	86.0	197.0	335.0	97.0	171.0	325.0	135.0	198.0	395.0
Control	105.0	214.0	359.0	123.0	235.0	385.0	125.0	247.0	396.0	154.0	268.0	400.0
C.D. at P=0.05	5.3	2.1	2.3	5.4	2.4	5.8	4.3	3.3	2.8	5.9	4.8	4.3

Table13. Sporulation of different isolates of *G. cingulata* in different amino acid sources

Amino acid sources	Gc1	Gc2	Gc3	Gc4
Aspartic acid	+++	+++	+++	+++
Arginine	++	++	++	+++
Aspargine	++	++	+++	++
Proline	+++	+++	+++	+++
Glutamine	+++	+++	+++	+++
Cystine	+++	+++	+++	+++
Methionine	+	+	+	+
Alanine	+	+	+	+
Serine	++	+	+	++
Control	+	+	+	+

After 7 days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 14. Effect of various vitamin sources on the growth of *G. cingulata* in liquid medium

	Mycelial dry weight (mg.)											
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Vitamin Sources	3	5	7	3	5	7	3	5	7	3	5	7
Nicotinic acid	67.0	145.0	392.0	84.0	139.0	384.0	112.0	217.0	416.0	121.0	234.0	435.0
Pyridomine	102.0	212.0	418.0	87.0	167.0	375.0	85.0	153.0	354.0	54.0	110.0	241.0
Thiamine	123.0	249.0	486.0	119.0	237.0	479.0	108.0	232.0	468.0	99.0	218.0	448.0
Vitamin c	124.0	258.0	495.0	116.0	247.0	487.0	145.0	264.0	495.0	137.0	238.0	485.0
Biotin	162.0	348.0	563.0	91.0	164.0	395.0	67.0	145.0	325.0	45.0	124.0	277.0
vitamin A	87.0	178.0	365.0	65.0	134.0	305.0	54.0	127.0	289.0	42.0	114.0	236.0
Riboflavin	135.0	247.0	443.0	188.0	315.0	502.0	157.0	259.0	482.0	194.0	330.0	538.0
Control	47.0	185.0	359.0	39.0	179.0	355.0	79.0	167.0	345.0	105.0	198.0	378.0
C.D. at P=0.05	3.47	9.70	6.46	4.81	8.91	7.38	1.85	6.75	8.16	4.66	5.92	6.13

Table 15. Sporulation of different isolates of *G. cingulata* in different vitamin sources

Vitamin sources	Gc1	Gc2	Gc3	Gc4
Nicotinic acid	++	++	+	++
Pyridomine	+++	++	_	+
Thiamine	+++	+++	+++	+++
Vitamin c	+++	+++	+	+++
Biotin	++	++	_	+
vitamin A	++	+	+	+
Riboflavin	++	++	+	++
Control	+	+	+	+

After 7 days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 16. Radial growth of *G. cingulata* in different temperature

Radial growth (mm)												
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
temperature (°C)	3	5	7	3	5	7	3	5	7	3	5	7
10	9.0	15.0	21.0	8.0	13.0	19.0	9.0	14.0	20.0	8.0	14.0	20.0
20	13.5	25.0	35.5	16.0	28.0	37.5	16.75	30.0	38.5	19.0	31.5	39.5
25	14.5	28.5	37.25	18.25	30.5	40.0	19.75	32.0	39.5	20.75	33.0	40.5
30	12.25	22.0	33.0	16.25	28.5	35.5	17.0	30.0	35.5	19.5	28.5	34.5
35	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
Control (Room temp.)	20.0	30.0	40.0	20.75	28.0	39.0	21.25	30.0	40.0	22.0	31.5	38.5
C.D. at P=0.05	1.5	1.6	1.4	1.3	1.9	2.0	1.4	1.8	1.5	1.4	1.3	1.1

NG – No Growth

Table 17. Effect of different temperature on the growth of *G. cingulata* in liquid medium

Mycelial Dry weight (mg.)*				
temperature (°C)	Gc1	Gc2	Gc3	Gc4
10	248.00	260.00	249.00	197.00
20	393.00	380.00	436.00	517.00
25	663.00	505.00	547.00	680.00
30	447.00	405.00	489.00	431.00
35	NG	NG	NG	NG
Control (Room temp.)	499.00	435.00	602.00	490.00
C.D. at P=0.05	2.9	3.8	2.2	3.0

After 7 days incubation*, NG – No Growth

Table 18. Effect of temperature on the sporulation of different isolates of *G. cingulata*

Temperature (°C)	Gc1	Gc2	Gc3	Gc4
10	+	+	+	+
20	++	++	+	++
25	+++	+++	+++	+++
30	+++	+++	++	+++
35	NG	NG	NG	NG
Control (Room temp.)	+++	+++	++	+++

After 7 days incubation, NG – No Growth, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 19. Radial growth of *G. cingulata* in different pH sources

	Radial growth (mm)			
pH	Gc 1	Gc 2	Gc 3	Gc 4
4.0	17.50	15.00	21.00	12.00
4.5	27.75	22.75	27.00	18.75
5.0	34.75	34.50	32.00	29.75
5.5	36.75	35.25	36.25	34.50
6.0	40.00	34.50	34.75	39.08
6.5	39.50	34.00	34.50	38.67
7.0	36.25	28.50	32.75	37.50
7.5	34.75	27.00	31.50	26.50
8.0	20.75	23.50	24.33	22.00
8.5	18.25	14.75	19.33	14.00
C.D at P = 0.05	0.7	1.0	1.8	1.3

After 7 days incubation

Table 20. Effect of various pH on the growth of *G. cingulata* in liquid medium

	Mycelial dry weight (mg.)*			
pH	Gc 1	Gc 2	Gc 3	Gc 4
4.0	384.00	523.67	352.33	335.67
4.5	394.00	527.00	434.00	393.00
5.0	448.00	752.33	520.00	483.33
5.5	509.00	807.67	585.67	498.33
6.0	536.33	642.00	492.00	518.67
6.5	507.33	603.00	481.00	472.00
7.0	497.33	538.67	445.33	430.67
7.5	464.67	533.00	431.67	356.00
8.0	436.00	434.67	330.33	329.33
8.5	308.33	379.00	297.33	250.00
C.D at P = 0.05	6.8	7.1	6.4	7.8

After 7 days incubation

Table 21. Effect of pH on the sporulation of different isolates of *G. cingulata*

pH	Gc1	Gc2	Gc3	Gc4
4	+	_	_	+
4.5	+	++	++	+
5	+++	+++	++	+++
5.5	++	+++	++	+++
6	+++	+++	+++	+++
6.5	++	++	+	++
7	++	++	+	++
7.5	+	+	+	+
8	+	_	_	+
8.5	+	_	_	+

After 7 days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

Table 22. Radial growth of *G. cingulata* in different Light sources

Radial Growth (mm)												
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Light sources	3	5	7	3	5	7	3	5	7	3	5	7
Day light (Control)	20.0	30.0	40.0	20.75	28.0	39.0	21.25	30.0	40.0	22.0	31.5	38.5
Darklight	12.75	17.5	34.25	15.5	21.0	37.0	14.5	19.5	36.75	14.5	29.5	40.0
UV light	13.25	22.0	39.5	17.25	29.5	39.0	14.25	30.0	37.5	14.75	28.5	39.75
Fluorescent light	15.5	30.0	37.25	15.75	28.0	37.25	14.25	30.0	38.75	9.0	19.5	26.5
C.D. at P=0.05	0.9	2.5	1.2	0.4	1.3	1.3	0.4	1.7	1.2	1.2	1.6	1.4

Table 23. Effect of various light sources on the growth of *G. cingulata* in liquid medium (mg.)

Mycelial dry weight (mg.)												
	Gc1			Gc2			Gc3			Gc4		
	Days after inoculation											
Light sources	3	5	7	3	5	7	3	5	7	3	5	7
Day light (Control)	219.00	427.00	533.80	246.20	442.00	573.00	283.00	456.00	585.00	210.00	408.00	538.00
Darklight	162.00	318.00	477.00	141.00	307.00	496.00	178.00	349.00	548.00	234.00	437.00	565.00
UV light	198.00	400.00	526.00	231.00	421.00	548.00	250.00	435.00	557.00	227.00	417.00	545.00
Fluorescent light	189.00	324.00	515.00	214.00	374.00	502.00	266.00	448.00	569.00	167.00	344.00	513.00
C.D. at P=0.05	4.6	1.0	3.7	5.4	1.6	2.2	5.3	3.1	2.5	1.9	1.2	3.0

Table 24. Effect of different light sources on the sporulation of different isolates of *G. cingulata*

Light sources	Gc1	Gc2	Gc3	Gc4
Day light (Control)	+++	+++	+++	+++
Dark light	+++	+++	++	+++
UV light	++	++	++	+++
Fluorescent Light	+	+	+	+

After 7 days incubation, (–) no sporulation, (+) poor sporulation, (++) moderate sporulation, (+++) heavy sporulation

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References

Agnihotri, V.P. (1981). Studies on *Colletotrichum capsici* II. Carbon and Nitrogen Requirements. Phytopath Z. 42(2): 101-112.

Banik, A.K, Kaiser, S.A.K.M. and Dhua, R.S. (1998). Influence of temperature and humidity on the growth and de-velopment of *Colletotrichum gloeosporioides* and *Diplodia natalensis* causing postharvest fruit rot of mango. Advances-in-Plant Sciences 11: 51-57.

Bilgrami, K.S. and Verma, R.N. (1978). Physiology of Fungi, Vikas Publishing House Private Ltd., New Delhi, pp. 493.

Buddie, A.G., Martínez-Culebras, P., Bridge, P.D., García, M.D., Querol, A., Cannon, P.F. and Monte, E. (1999). Molecular characterization of *Colletotrichum* strains derived from strawberry. Mycol. Res. 103: 385-394.

Cannon, P.F, Bridge, P.D. and Monte, E. (2000). Linking the past, present, and future of *Colletotrichum* systemat-ics. In: *Colletotrichum:* Host Specificity, Pathology, and Host-Pathogen Interaction. (Eds.) D. Prusky, S. Freeman, and Martin B. Dickman, APS Press, St. Paul, Minnesota, pp. 1-20.

Chandra, S. and Tandon, R.N. (1962). The effect of sorbose on the utilization of different monosaccharide by certain fungi causing leaf spot diseases. *Phytopath. Z.* 45:130-138.

Chaturvedi, C. (1965). Nutritional studies on *Colletotrichum gloeospoeilieds* Penz., Mycopath. Mycol. Appl. 27: 265-272.

Chen, Z.M. and Chen, X.F. (1990). The diagnosis of tea diseases and their control (in Chinese) Shanghai. Shangahai scientific and technical publishers 9:73-88.

Choompookaew, G. (1990). Stem blight of asparagus: etiology, infection and chemical control. Bangkok (Thailand) 90: 68.

Durairaj, V. (1956). Growth of *Colletrotrichum capsici* in pure culture, J. Indian Bot. Soc. 35: 409-413.

Eden, T. (1965). Tropical agriculture series Tea. Second edition, Longmans, Green and Co Ltd. London W.I., pp. 113.

Ekbote, S.D. (1994). Studies on anthracnose of mango (*Mangifera indica* L.) caused by *Colletrotrichum gloeosporioides* (Penz.) Penz. and Sacc., MSc Thesis, Univ. Agric. Sci., Dharward, p. 101.

Estrada, A.B, Dodd, J.C. and Jeffries, P. (1993). Effects of environment on the *in vitro* growth and development of *Colletrotrichum gloeosporioides* isolated from Philippines, Acta Horticulture. 341: 360-370.

Hegde, Y.R, Hegde, R.K. and Kulkarni, S. (1990). Studies on Nutritional Requirements of *Colletotrichum gloeosporioides* (Penz.) Penz. and Sac. – A Causal Agent of Anthracnose of Arecanut, Mysore J. Agric. Sci. 24: 358-359.

Hegde, Y.R, Hegde, R.K. and Kulkarni, S. (1993). Physiological studies on *Colletotrichum gloeosporioides* (Penz) Penz and Sacc. causing anthracnose of arecanut, Karnataka J. Agric. Sci. 6: 411-412.

Jandaik, C.L. and Kapoor, J.N. (1972). Studies on vitamin requirements of *Cercospora cruenta*. Indian Phytopathology 25: 563-565.

Jayasinghe, C.K. and Fernando, T.H.P.S. (1998). Growth at different temperatures and on fungicide amended media: two characteristics to distinguish *Colletotrichum* species pathogenic to rubber. Mycopathologia. 143: 93-95.

Jeffries, P.D, odd, J.C, Jeger, M.J. and Plumbley, R.A. (1990). The biology and control of *Colletotrichum* species on tropical fruit crops. Pl. Pathol. 39: 343–366.

Johnston, P.R., and Jones, D. (1997). Relationship among *Colletotrichum* isolates from strawberry. Mycol. Res. 103: 385-394.

Lai, C.Y, Liang, J. and Wei, G. (1993). The basic biological properties of the *Colletotrichum gloeosporioides* (Penz.) Sacc. of *Amomum villosum*. Acta Phytopa-thologica Sinica. 23(4): 293-298.

Leach, C.M. (1962). Effect of light on the production *Stemphylium botryosum*. Canadian Journal of Botany 40: 151-161.

Lilly, V.G. and Barnett, H.L. (1951). Physiology of Fungi. McGraw Hill Book Company Inc., New York, pp. 464.

Manjunatha Rao, R. and Rawal, R.D. (2002). Effect of carbonand nitrogen sources for growth and sporulation of *Colletotrichum gloeosporioides* and *Gloeosporium ampelophagum* causing grapevine anthracnose, Annu. meeting and symposium on plant disease scenario in southern India, Dec. 19-21, IPS (S Zone), UAS, Bangalore, pp. 49.

Mathur, R.S, Barnett, H.L. and Lilly, V.G. (1950). Factors in-fluencing growth and sporulation of *C. lindemuthianum* in culture, Phytopathology 40:104-114.

Mishra, A.P. and Mahmood, M. (1960). Effect of carbon and nitrogen nutrition on growth and sporulation of *Colletotrichum capsici* (Syd.) Butler and Bisby, J. Indian Bot Soc. 39: 314-321.

Naik, M.K, Hiremath, P.C. and Hegde, R.K. (1988). Physiological and nutritional studies on *Colletotrichum gloeosporioides*, A causal agent of anthracnose of beetle vine, Mysore J. Agric. Sci. 22: 471-474.

Rajak, R.C. (1983). Nutritional requirement of two species of *Colletotrichum*, Acta Botanica Indica 11: 155-160.

Ramakrishnan, T.S. (1941). Studies in the genus *Colletotrichum*: III. Physiological studies on *Colletotrichum falcatum*, Proc. Indian Acad. Sci., India (B) 14: 395-411.

Rangaswami, G. (1972). Diseases of crop plants in India. Prentice – hall of India private limited New Delhi, pp. 443.

Reddy, B.P.N. (2000). Studies on morphological, cultural, and pathogenic variations among the isolates of *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc. of some subtropical fruits, M.Sc. Thesis, Univ. Agric. Sci., Bangalore, pp. 69.

Sangeetha, C.G. (2003). Studies on anthracnose of mango caused by *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc., Ph. D Thesis, Univ. Agric. Sci., Bangalore, pp. 77-156.

Sanjay, R. (2004). Studies on Pestolotiopsis spp. Affecting tea (Camellia sinensis (L). O. Kuntze) in south India. PhD Thesis, Bharathiar Univ.Coimbatire, pp. 16-19.

Saxena, A.K. (2002). Anthracnose of pomegranate – Biology of the pathogen, Epidemiology and disease control. Ph.D. Thesis, Maharshi Dayanand Sarasvathi Univ., Ajmer, Rajastan, pp. 232.

Shukla, D.S. (1972). Studies on the growth and sporulation of *Colletotrichum gloeosporioides* in relation to vitamins. Indian Phytopathology 25: 300-302.

Shukla, D.S. and Sarkar, S.K. (1972). Effect of vitamins on the growth and sporulation of *Botryodiplodia theobromae* in culture. Indian Phytopathology 25: 40-43.

Singh, R.A. and Shankar, G. (1971). Effect of physical factors and nutrition on growth and perithecial development of *Glomerella cingulata in vitro*. Indian Phytopathology 24: 728-734.

Steinberg, R.A. (1950). Growth of fungi in synthetic solutions, Bot. Rev. 16: 208-228.

Struble, F.B. and Keitt, G.W. (1950). Variability and inheritance in *Glomerella cingulata* (Stonem.) S. and V. S. from apple. Amer. Jour. Bot 37:563-576.

Turner, G.J. (1969). Leaf lesions associated with foot rot of *piper nigrum* and *piper betle* caused by *Phytopthora palminivora*. Trans. Br. Mycol. Soc. 53: 407-415.

Von Arx, J.A. (1957). Die Arten der Gattung *Colletotrichum Corda*. Journal of Phytopathology - Phytopathologische Zeitschrift 29: 413.

Von, W.H. and Wagner, F. (1955). Induction of sporulation by light in *Alternaria brassicae* var. *danci*, caused agent of wilt disease in carrot. Arch. Microbiol. 22: 307-312.

Wasantha Kumara, K.L. and Rawal, R.D. (2008). Influence of carbon, nitrogen, temperature and pH on the growth and sporulation of some Indian isolates of *C. gloeosporioides* causing anthracnose disease of papaya (*Carrica papaya* L). Tropical agriculture research and extension 11: 7-12.

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