Cultural and morphological variations of *Colletotrichum* spp associated with anthracnose of various fruits in Cameroon

*Keuete Kamdoum E.*, 1 Tsopmbeng Noumbo G.R. 1, Kuïate J.R. 2

1Laboratory of Applied Botany, Faculty of Science, University of Dschang, Box 67 Dschang, Cameroon

2Laboratory of Microbiology and Antimicrobial Substances, Faculty of Science, University of Dschang, Box 67 Dschang, Cameroon

Abstract— The anthracnose of fruits due to *Colletotrichum* spp. is one of the principal fungal diseases which affects the production and marketing of fruits in Cameroon. Isolates of *Colletotrichum* were collected from various fruits and characterised for cultural and morphological variations. The results show that *Colletotrichum* colonies varied in the appearance of their culture ranging from fibrous, compact and cottony colonies. The colour of colonies ranged between whitish to greyish, pinkish and greyish green. AVIS1, BAIS2, MAIS1, PAIS1 and PLIS1 had an intermediate growth varying between 13.02 to 13.61 mm/day, whitish to greyish mycelium and fusiform conidia of size ranging between 19.98 x 4.17 and 21.29 x 5.14 µm. BAIS2 had the fastest growth (17.19 mm/day) with a pinkish fibrous mycelium and cylindrical or spindle-shaped conidia of 25.62 x 6.04 µm in size and a sporulation rate of $8.69 \times 10^4$. These results highlight some variations in morphocultural characteristics of *Colletotrichum* species, however molecular analyses are still going on for adequate differentiation among those isolates from different fruits.

Keywords—Anthracnose, *Colletotrichum* spp., fruits, morphocultural, variations.

I. INTRODUCTION

Anthracnose of fruits caused by the *Colletotrichum* species is one of the most important postharvest diseases of fruits. Symptoms of anthracnose include black and sunken lesions with spore masses or acervuli in the lesion. Infection on fruits usually starts during the development of the fruit but remains quiescent until the fruit ripens; symptoms often manifest during storage and marketing (Prusky and Plumbley 1992). Anthracnose becomes severe when the fruits are wounded by scratches during handling and transportation, making the fruit unmarketable. Two types of symptoms are found on fruits. The commonest is a dark-brown lesion which is slightly sunken with raised rims (Bailey et al., 1992; Agrios, 2005). This can be found on very young fruits or matured fruits in storage or transit. The lesions can enlarge on the fruit surface and eventually penetrate the fruit and infected young fruits usually drop (Nelson, 2008). The black necrotic lesions may or may not be accompanied by bright orange acervuli which are the fruiting bodies of the pathogen (Agrios, 2005). The second type of symptom is commonly referred to as tear strain symptom in which are linear necrotic regions on the fruit that may or may not be associated with superficial cracking of the fruit epidermis causing an alligator skin effect on the fruit surface (Nelson, 2008). According to Dodd et al., (1992) anthracnose causes premature fruit drop and direct reduction in quality of ripe fruits and shortening storage life time.

The disease may develop on fruits belonging to extremely varied families. For a good number of fruits, it represents the principal post-harvest disease of fungal origin as it is the case in mango, plums, pawpaw, banana and avocado (Sangeetha and Rawal, 2009; Hala and Coulibaly, 2006; COLEACP, 2011). Contamination on fruits causes necrosis and in long term, putrefaction (Prusky et al., 2000). This degrades the quality of fruit and post-harvest losses of up to 100% of the production can be recorded (COLEACP, 2008). The pathogen can infect young fruits at fruit initiation (Arauz, 2000; COLEACP, 2008) or on already developed fruits. The most significant damages on the fruits are generally expressed after harvest (Sanders and Korsten, 2003).

Differentiation between *Colletotrichum* species based on host range or host of origin may not be a reliable criterion for fungi of this genus, since taxa such as *C. gloeosporioides*, *C. dematium*, *C. acutatum*, and others infect a broad range of host plants. Some taxa appear to be restricted to host families, genus or species within those families, or even cultivars, whereas others have more extensive host ranges (Freeman et al., 1998). Identification of *Colletotrichum* spp. is therefore a fundamental criterion in the development of more control measures. Traditional identification and characterisation of *Colletotrichum* species has relied primarily on differences in morphological features such as colony colour, size and shape of conidia and appressoria, growth rate, presence or absence of...
setae, and existence of the Glomerella teleomorph (Smith and Black, 1990; Gunnell and Gubler, 1992; Sutton, 1992). Studies of these features on Colletotrichum species have not yet been conducted in Cameroon. The present preliminary are aimed at investigating on the morphocultural variation of the genus Colletotrichum isolated from five postharvest fruits sold in market in Cameroon.

II. MATERIALS AND METHODS

Isolation of Colletotrichum species from infected fruits

Pulp fragment from each fruit (avocado, banana, mango, pawpaw and plum) showing typical anthracnose symptom were thoroughly washed in tap water and separately cut into small pieces at about half a centimeter in size, showing half healthy and half diseased tissue, with the help of previously sterilized blade. The pieces were surface sterilized with 5% sodium hypochlorite solution for 5 minutes, followed by 3 changes with washings with sterilized distilled water. The surface sterilized diseased pieces were then aseptically transferred separately to Petri dishes containing 20 ml Potato Dextrose Agar (PDA) medium amended with Chloramphenicol (1 g/l) to prevent bacterial contamination and then incubated at 24 ± 2° C. After 2 to 3 days of incubation, the growing mycelium was sub-cultured on fresh PDA medium until pure cultures. In this way, the cultures of different isolates were obtained and maintained in a refrigerator at 4° C.

Morphological identification of Colletotrichum isolates was carried out based on the cultural characteristics and with the help of identification keys of mycology (Barnet and Hunter, 1972; Cannon et al., 2008; Prihastuti et al., 2009; Phoulivong et al., 2010; Su et al., 2011). A summary of Colletotrichum isolates used in this study are listed in Table 1.

Table 1: Origin of Colletotrichum spp isolates used for the study.

| Isolate code | Host fruit | Scientific Names of fruit |
|--------------|------------|--------------------------|
| AVIS1        | Avocado    | Persea americana         |
| AVIS2        | Avocado    | Persea americana         |
| BAIS1        | Banana     | Musa sapientum           |
| BAIS2        | Banana     | Musa sapientum           |
| MAIS1        | Mango      | Mangifera indica         |
| MAIS2        | Mango      | Mangifera indica         |
| PAIS1        | Pawpaw     | Carica papaya            |
| PLIS1        | Plum       | Dacryodes edulis         |

Cultural characteristics

Mycelial discs (6 mm) of 7 day old culture of Colletotrichum isolates were transferred aseptically to the center of PDA plates and incubated at 24 ± 2° C. Culture characteristics such as colony aspect and color were observed and recorded after 7 days of incubation. Colony diameter was measured in two perpendicular directions on the reverse side Petri dishsevery two days after incubation and growth rate was calculated on day 7 followed the formula of Sofi et al. (2013).

\[
\text{Growth rate} = \frac{\text{Growth observed on a particular day (mm)} - \text{Growth on previous observation (mm)}}{2}
\]

This experiment was repeated four times.

Morphological characteristics

For each isolate, a conidial suspension was prepared by carefully brushing 10 days old cultures into 20 ml of sterilized distilled water in a 90 mm Petri dish and a drop of Tween 20 was added to each plate to homogenise the suspension. Conidial suspensions obtained were filtered through a double layer of cheesecloth to remove leaf debris. Then a drop of conidial suspension from each isolate of Colletotrichum from different fruits was mounted and quantified using a haematocytometer. Afterwards, the sizes of conidia were determined by measuring 50 random conidia with a calibrated microscope (Olympus brand) at magnification 400X. The shapes of these conidia were also recorded. The experiment was repeated fourtimes.

Experimental Design and Statistical Analysis

All the experiments were conducted following a completely randomized design (CRD), and data on radial growth, growth rate and sporulation rate were analyzed using an analysis of variance (ANOVA) in SPSS software version 20.0 and mean separated with Duncan’s Multiple Range test (DMR) at a 5 % probability level.

III. RESULTS

Cultural characteristics

On the basis cultural characteristics, isolates from fruits showed different colony aspect and colour after 7 days (Fig 1). Colonies
produced by AVIS1, MAIS1, PAIS1 and PLIS1 collected respectively from avocado, mango, papaw and plums fruits varied from whitish to greyish with cottony aerial mycelium and a few bright orange masses near the inoculum point. BAIS1 and MAIS2 isolates from banana and mango produced greyish green colonies with compact mycelium. MAIS2 presented sparse white fluffy aerial mycelium. Colonies produced by BAIS2 from banana with pinkish colouration had showed fibrous mycelia. AVIS2 isolates from avocado produced greyish colonies with fibrous mycelia.

BAIS2 isolate obtained from banana, had a highest radial growth of 79.32 mm, followed by AVIS1, BAIS1, MAIS1, PAIS1 and PLIS1 that had average radial growths ranging from 54.05 to 65.27 mm while AVIS2 and MAIS2 had lowest radial growth of 38.47 to 40.06 mm (Table 2). Also, the rate of growth of isolates ranged from 7.37 to 17.19 mm/day. The rate of growth of isolate BAIS2 (17.19 mm/day) was the fastest, followed by AVIS1, BAIS1, MAIS1, PAIS1 and PLIS1 (13.41 to 13.61 mm/day). The slowest growing culture was isolated MAI2 and AVIS2 (7.37 and 7.62 mm/day).

Table.2: Cultural characteristics of Colletotrichum isolates from different fruits

| Isolates code | Aspect of colony | Colour of colony | Radial growth on the 7th day (mm) | Growth rate day 7 (mm/day) |
|---------------|-----------------|-----------------|-----------------------------------|---------------------------|
| AVIS1         | Cottony         | Whitish to greyish | 61.54 ± 2.25b                     | 13.02 ± 0.89b             |
| AVIS2         | Fibrous         | Greyish          | 38.47 ± 3.15c                     | 7.62 ± 0.74c              |
| BAIS1         | Compact         | Greyish green    | 63.81 ± 2.57b                     | 13.61 ± 0.72b             |
| BAIS2         | Fibrous         | Pinkish          | 79.32 ± 1.70a                     | 17.19 ± 0.54a             |
| MAIS1         | Cottony         | Whitish to greyish | 60.44 ± 4.63b                   | 13.47 ± 0.89b             |
| MAIS2         | Compact         | Greyish green    | 40.06 ± 4.17c                     | 7.37 ± 0.72c              |
| PAIS1         | Cottony         | Whitish to greyish | 65.27 ± 3.84b                   | 13.41 ± 0.77b             |
| PLIS1         | Cottony         | Whitish to greyish | 54.05 ± 3.51b                   | 13.14 ± 0.60b             |

*Means in columns followed by the same letter are not significantly different by Duncan’s Multiple Range test at a 5% probability level.

Morphological characteristics
Conidia produced by isolates AVIS1, BAIS1, MAIS1, PAIS1 and PLIS1 varied from fusiform with obtuse to slightly rounded ends to sometimes oblong. BAIS2 produced cylindrical conidia with obtuse to slightly rounded ends. AVIS2 and MAIS2 produced fusiform conidia with obtuse ends (oblong) with narrowing at the centre (Fig 2)
MAIS1, PAIS1 and PLIS1; (b) BAIS2; (c) AVIS2 and MAIS2.

Conidia produced by BAIS2 had biggest sizes (25.62 x 6.04 µm) and had the most abundant sporulation rate on the 10th days (13.19 x 10⁶ conidia/ml). AVIS1, BAIS1, MAIS1, PAIS1 and PLIS1 produced conidia which varied from 19.98 – 21.29 x 4.17 – 5.14 µm with sporulation rates ranging from 7.7 x 10⁶ to 9.42 x 10⁶ conidia/ml. AVIS2 and MAIS2 produced cylindrical conidia of smaller sizes which vary from 15.72 x 3.14 to 16.43 x 3.52 µm as well as sporulation rates which varied from 7.21 x 10⁶ to 7.26 x 10⁶ conidia/ml (Table 3).

| Isolate | Conidial shape | Size of conidia (µm) | Sporulation rate on day 10 (x 10⁶ conidia/ml) |
|---------|----------------|----------------------|---------------------------------------------|
| AVIS1   | Fusiform       | 20.71 x 4.65         | 9.42 ± 0.43b                                |
| BAIS1   | Fusiform       | 21.29 x 5.14         | 8.27 ± 0.62b                                |
| MAIS1   | Fusiform       | 19.91 x 4.17         | 7.50 ± 0.61bc                               |
| PAIS1   | Fusiform       | 19.98 x 4.89         | 7.81 ± 0.97bc                               |
| PLIS1   | Fusiform       | 20.43 x 4.77         | 7.70 ± 0.80bc                               |
| BAIS2   | Cylindrical    | 25.62 x 6.04         | 13.19 ± 0.47a                               |
| AVIS2   | Fusiform       | 15.72 x 3.14         | 7.21 ± 0.74c                                |
| MAIS2   | Fusiform       | 16.43 x 3.52         | 7.26 ± 0.94c                                |

*Means in columns followed by the same letter are not significantly different by Duncan’s Multiple Range test 5% at a probability level.

Dendrogram resulting from the hierarchical cluster analysis of mycelial growth rate, diameter of colonies and size of conidia of Colletotrichum spp isolates from various fruits showed three different groups; Group I (MAIS1, PAIS1, PLIS1, BAIS1 and AVIS1), group II (AVIS2 et MAIS2) and group III (BAIS2) (Fig 3).

**Fig.3: Dendrogram resulting from the hierarchical cluster analysis showing the groups formed according to the variables; mycelial growth rate, diameter of colonies and size of conidia after seven days cultivation of Colletotrichum spp from various fruits.**
IV. DISCUSSION

The results of the study indicate that *Colletotrichum* species isolated from fruits of avocado, banana, mango, pawpaw and plums show some variations in cultural and morphological characters. Based on these characteristics, *Colletotrichum* isolates were ranked into three groups; the first group made up of AVIS1, MAIS1, BAIS1, PAIS1 and PLIS1 isolates with whitish to greyish colonies and fusiform conidia, the 2nd group made up AVIS2 and MAIS2 with respectively fibrous and compact greyish green mycelia colonies and cylindrical conidia and the 3rd group (BAIS2) with pinkish mycelia and cylindrical conidia. The difference in coloration and the aspect of the isolates would be related to the fruit host, the nature of the *Colletotrichum* isolate and the environmental conditions. Identification of *Colletotrichum* species was reported to be mostly based on morphological and cultural criteria, coupled with knowledge of the host origin of the pathogen. However, many isolates of *Colletotrichum* show extensive variation in culture (Sutton, 1992; Bailey et al., 1995). Several cultural and morphological types have been observed on *Colletotrichum* species isolated from fruits of mango (Sanders and Korsten, 2003; N’Guettia et al., 2013), bananas (Cannon et al., 2008; Prihastuti et al., 2009; Su et al., 2011), pawpaw (Rampersad, 2011) and avocados (Keuete, 2014).

The mycelial growth differentiated three groups of isolates 7 days after culture. The 1st group (BAIS2) recorded a fast growth (17.19 mm/day), 2nd group (AVIS1, BAIS1, MAIS1, PAIS1 and PLIS1) recorded an average growth of 13.02 to 13.62 mm/day and the 3rd group (AVIS2 and MAIS2) recorded a slow growth (7.37 to 7.62 mm/day). The mycelial growth has been reported to be a criterion that helps to differentiate the species of *Colletotrichum* (Waller et al., 1993; Crouch et al., 2009; Liu et al., 2012). However, according to Serra et al. (2006). Although it is not a stable criterion of differentiation of *Colletotrichum* species, but it plays a significant role in variability within the species. Bailey et al. (1995) argued that many isolates of *Colletotrichum* often show extensive variation in culture and furthermore, the culture conditions, including the media, the age of culture and the temperatures used, cannot be standard between laboratories (Sutton 1992). Conidial morphology has always been emphasized over other taxonomic criteria in taxonomic investigations of the genus *Colletotrichum*. Baxter et al. (1983) used conidial shape and size as the main criteria to distinguish a number of species. According to Sutton (1992) and Bailey et al. (1995), identification of *Colletotrichum* species had been mostly based on these criteria, coupled with knowledge of the host origin of the pathogen, however, extensive variation of many isolates of *Colletotrichum* had been shown in culture.

On the basis of conidia size and shape, *Colletotrichum* isolates were divided into three groups. The first also producing fusiform shapes conidia whose sizes varied from 19.98 x 4.17 to 21.29 x 5.14 µm. These values fall within the interval described by Rivera et al. (2006) for conidia of *C. gloeosporioides*. *C. gloeosporioides* had been considered to be a group species or species complex found on a wide variety of fruits, such as apple, avocado, citrus, papaya, peach, mango and strawberry (Freeman 2000). The variation may also be attributed to the adaptation of the species to a non-specific, broad host range (Freeman et al. 1998). For *Colletotrichum* species, it is common for single hosts to become infected by a single species or for multiple hosts to be infected by a single species of the pathogen (Freeman 2000). Infection of multiple hosts by *C. musae* has been reported by Su et al. (2011).

The 2nd group consisting of AVIS2 and MAIS2 isolates was characterised by fusiform conidia with the sizes lying between 15.72 x 3.14 and 16.43 x 3.52 µm. Freeman (2002), Than et al. (2008), Peres et al. (2008) and Damm et al. (2012) observed similar shape and size of conidia on *C. acutatum*. The 3rd group made up of BAIS2 isolates had spindle-shaped conidia with the sizes of 25.62 x 6.04 µm. The grouping of *Colletotrichum* isolates into three subclades suggest that the isolates may represent a sub-population of the pathogens with distinct genetic characters. Similar results were reported by Prihastuti et al. (2009) and Waller et al. (1993) in which *C. gloeosporioides* on coffee berries showed several distinct genetic and phenotypic species. However, it is not yet known, whether these isolates are distinct or not.

V. CONCLUSION

The study highlights some variation in morphocultural characteristics of *Colletotrichum* species from various fruits, but sequence analysis are still to be carried on to confirm the existence of more than one distinct isolates since *Colletotrichum* has wide host range.

ACKNOWLEDGEMENTS

The authors are thankful to Phytopathology Laboratory, University of Dschang, Cameroon and for Providing Laboratory Facilities and grateful to Dr. M. Lekefack for the proofreading of the manuscript.

REFERENCES

[1] Agrios, G.N. 2005. Plant pathology. Fifth Edition. Elsevier Inc. 952 p.
[2] Arauz L.F., 2000. Mango Anthracnose: Economic impact and current options for integrated management. *Plant Disease* 84 (6): 600–611.
[3] Bailey, J. A., Sherriff, C. and O’Connell, R. J. 1995. Identification of specific and sub-specific diversity in *Colletotrichum*. Pp. 197-211.

[4] Bailey, J.A. and Jeger M.J., 1992. *Colletotrichum*: Biology, Pathology and Control. Wallingford, UK: CAB International, 388p.

[5] Barnett H.L. and Hunter B.B., 1972. Illustrated Genera of Imperfect Fungi. Mineapolis: Burgress Publishing Company, Minneapolis MN, 241p.

[6] Baxter A.P., Westhuizen G.C.A. and VAN DER EICKER, 2002. Survival in soil of *Colletotrichum acutatum* and *C. gloeosporioides* pathogenic on strawberry. *Plant Disease* 86: 965–970.

[7] Cannon P.F., Buddie A.G. and Bridge P.D., 2008. The typification of *Colletotrichum gloeosporioides*. *Mycotaxon* 104: 189–204.

[8] COLEACP (Comité de Liaison Europe-Afrique/Caraïbes/Pacifique), 2008. Guide de bonnes pratiques phytosanitaires pour l’avocat (*Persea americana*) issu de l’agriculture biologique en ACP. Consulté le 10 Février 2015.

[9] COLEACP (Comité de Liaison Europe-Afrique/Caraïbes/Pacifique), 2011. Guide de bonnes pratiques phytosanitaires pour : la banane, banane pomme, banane violette, mini banane, et autres bananes dites ethniques <http://www.coleACP.org/pip>. Consulté le 30 Mai 2015.

[10] Crouch J.A., Clarke B.B. and Hillman B.I., 2009. What is the value of ITS sequence data in *Colletotrichum* systematics and species diagnosis? A case study using the falcate spored graminicolous *Colletrotrichum* group. *Mycologia* 101: 648–656.

[11] Damm U., Cannon P.F., Woudenberg J.H.C. & Crous P.W., 2012. The *Colletotrichum acutatum* species complex. *Studies in Mycology* 73: 37–113.

[12] Dodd, J.C., Estrada, A. and Jeger, M.J. 1992. Epidemiology of *Colletotrichum gloeosporioides* in the tropics. Pp. 308-325.

[13] Freeman S. and Dickman M.B., 2000. *Colletotrichum*: host specificity, pathology and host pathogen interaction. St Paul USA: APS Press. 400p.

[14] Freeman S., Katan T. and Shabi E., 1998. Characterization of *Colletotrichum* Species responsible for anthracnose diseases of various fruits. *Plant Disease* 82: 596–605.

[15] Freeman S., Shaley Z. and Katan J., 2002. Survival in soil of *Colletotrichum acutatum* and *C. gloeosporioides* pathogenic on strawberry. *Plant Disease* 86: 965–970.

[16] Gunnel P.S. and Gubler D.W., 1992. Taxonomy and morphology of *Colletotrichum* species pathogenic to strawberry. *Mycologia* 84:157-165.

[17] Hala K and Coulibaly F., 2006. L’étude diagnostique de l’état sanitaire du verger manguiere et les acquis de la recherche agronomiques sur la lutte integree contre les mouches de fruits et la cochenille farineuse en Côte d’Ivoire. Rapport d’exécutin technique. Appel d’offres N° 016/ FIRCA/ Filière Mangue.

[18] Keute K.E., 2014. Inventaire des champignons post-récoltes des fruits d’avocatier et essai de lutte antifongique par l’utilisation des extraits de quelques plantes. Thèse de Master de Science en Biologie Végétale. Université de Dschang: Pp 1–79.

[19] Liu B., Louws F.J., Sutton T.B. and Correll J.C., 2012. A rapid qualitative molecular method for the identification of *Colletotrichum acutatum* and *C. gloeosporioides*. *European Journal of Plant Pathology* 132: 593–607.

[20] N’Guettia M.Y, Diallo H.A., Kouassi N. and Coulibaly F., 2013. Diversité morphologique et pathogénique des souches de *Colletotrichum sp*. responsables de l’anthracnose de la mangue en Côte d’Ivoire. *Journal of Animal & Plant Sciences* 18 (3): 2775–2784.

[21] Nelson S.C., 2008. Mango anthracnose (*Colletotrichum gloeosporioides*). Department of Plant and Environmental Protection Sciences. University of Hawai at Manoa, 48p.

[22] Peres N.A., MacKenzie S.J., Peever T.L. and Timmer L.W., 2008. Postbloom fruit drop of citrus and Key lime anthracnose are caused by distinct populations of *Colletotrichum acutatum*. *Phytopathology* 98: 345–352.

[23] Phoulivong S., Cai L., Chen H., McKenzie E.H.C., Prihastuti H., Cai L., Chen H., McKenzie E.H.C., 2009. *Colletotrichum gloeosporioides* is not a common pathogen on tropical fruits. *Fungal Diversity* 44: 33–43.

[24] Prihastuti H., Cai L., Chen H., McKenzie E.H.C., 2009. Characterization of *Colletotrichum* species associated with coffee berries in Northern Thailand. *Fungal Diversity* 39: 89–109.

[25] Prusky D., Freeman S. and Dickman M.B., 2000. *Colletotrichum*: host specificity, pathology and host pathogen interaction. St Paul USA: APS Press. 400p.

[26] Prusky, D., and Plumbley, R.A. 1992. Quiescent infections of *Colletotrichum* in tropical and subtropical fruits. Pp 289-307.

[27] Rampersad S.N., 2011. Molecular and phenotypic characterization of *Colletotrichum* species associated with anthracnose disease of papaya in Trinidad. *Plant Disease* 95: 1244–1254.

[28] Sanders G.M. and Korsten L., 2003. A comparative morphology of South African avocado and mango.
isolates of Colletotrichum gloeosporioides. Canadian Journal of Botany 81: 877–885.

[29] Sangeetha C.G. and Rawal R.D., 2009. Temperature requirement of different isolates of Colletotrichum gloeosporioides isolated from mango. American-Eurasian Journal of Scientific Research 4: 20–25.

[30] Serra I.M.R.S., Menezes M., Coelho R.S.B., Ferraz G.D.M.G., Monttroyo A.V.V. and Martins L.S.S., 2006. Morphophysiological and molecular analysis in the differentiation of Colletotrichum gloeosporioides isolats from cashew and mango trees. Anais da Academia Pernambucana de Ciência Agronômica 3: 216–241.

[31] Smith B.J. and Black L.L., 1990. Morphological, cultural and pathogenic variation among Colletotrichum species isolates from strawberry. Plant Disease 74: 69-76.

[32] Sofi T.A., Muzafar A., Beig G.H., Hassan D., Mushtaq A., Aflaq H., Ahangar F.A., Padder B.A. and Shah M.D., 2013. Cultural, morphological, pathogenic and molecular characterization of Alternaria mali associated with Alternaria leaf blotch of apple. African Journal of Biotechnology 12 (4): 370-381.

[33] Su Y.Y., Noireung P., Liu F. & Hyde K.D., 2011. Epitypification of Colletotrichum musae, the causative agent of banana anthracnose. Mycoscience 52: 376–382.

[34] Sutton B.C., 1992. The genus Glomerella and its anamorph Colletotrichum. Pp 1-26.

[35] Than P.P., Jeewon R., Hyde K.D., Pongsupasmit S., Mongkolporn O. and Taylor P.W.J., 2008. Characterization and pathogenicity of Colletotrichum species associated with anthracnose disease on chilli (Capsicum spp.) in Thailand. Plant Pathology 57: 562–572.

[36] Waller J.W., Bridge P.D., Black R. and Hakiza G. 1993. Characterization of the coffee berry disease pathogens, Colletotrichum kahawae. Mycology Research 97: 989–994.

[37] Weir B.S., Johnston P.R. and Damm U., 2012. The Colletotrichum gloeosporioides species complex. Studies in Mycology 73: 115–180.