

Prevalence of *Colletotrichum* spp. Infecting Fruits in Southern Ethiopia

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Abstract: *Colletotrichum* is an important fungal genus infecting several crops including avocado, papaya and banana. The current study was conducted to i) assess the incidence and severity of anthracnose of in avocado and papaya fields of southern Ethiopia; ii) identify the *Colletotrichum* species infecting both crops. For this purpose, field surveys were carried out in Wolaita, Wondo Genet and Ziway fruits with and without visible symptoms of anthracnose were collected; isolates were identified to a species level and characterized based on their phenotypic features. Results of the field surveys revealed the prevalence of anthracnose in all the locations. However, both disease incidence and severity varied markedly across the locations. Both incidence and severity of avocado and papaya anthracnose were found to be highest in Wondo Genet (45 and 22% for avocado and 39.7 and 22% for papaya, respectively) followed by Wolaita (32.4 and 16.8% for avocado and 36 and 16.6% for papaya, respectively). However, both anthracnose incidence and severity were lowest at 23.99% on avocado and 31.8% papaya and 13.33% on avocado and 13.67% on papaya, respectively, in Ziway. Mean monthly and annual rainfall positively and significantly ($p < 0.05$) correlated with both incidence and severity of anthracnose. Based on morphological features, *Colletotrichum* isolates from both avocado and papaya fruits were identified as *C. gloeosporioides*. The associated *Colletotrichum* isolates grew optimally at 25°C (39.55mm/two days and 39.26mm/two days for isolates from avocado and papaya, respectively) and 30°C, which resulted in growth of isolates at a rate of 39.37mm/two days and 40.3 mm/two days for isolates from avocado and papaya, respectively. Conidial germination was significantly and positively correlated with temperature for both avocado ($r = 0.559$) and papaya ($r = 0.562$) isolates.

Key words: Anthracnose • Quiescent infection • *Colletotrichum* • *Persea americana* • *Carica papaya*

INTRODUCTION

Ethiopia possesses diverse agro-ecological zones, suitable for grow several fruit crops [1]. The major tropical fruits produced in Ethiopia are banana, avocado, mango, orange and papayas, which are mainly, cultivated in the Rift Valley region [2]. These fruits are typically cultivated to supplement household income from their main crops and are considered important to human health because they supply essential nutrients including vitamins, minerals and other necessary compounds such as antioxidants [3-4]. However, the shelf-life of most tropical and subtropical fruit crops is limited by their high susceptibility to postharvest diseases particularly those caused by *Colletotrichum* spp [5]. Other constraining factors include low production and productivity, lack of

adequate pest control, poor soil fertility management practices, lack of attention to product quality and prevention of physical damage, as well as the lack of storage and packaging facilities [6-8]. *Colletotrichum* is a large genus of ascomycete fungi to which the major pathogens of fruit crops causing economically important losses in temperate, subtropical and tropical regions of the world belong, which causes anthracnose in a wide range of hosts including cereals, legumes, vegetables and fruits [9]. Anthracnose caused by *Colletotrichum* species is characterized by sunken necrotic tissue, where orange conidial masses are produced. Anthracnose diseases appear in both developing and mature plant tissues giving rise to two distinct types of diseases i.e. those affecting developing fruit in the field (pre-harvest) and those damaging mature fruit during storage (post-harvest).

The ability to cause latent or quiescent infections has grouped *Colletotrichum* among the most important post-harvest pathogens in the globe [10-11]. *Colletotrichum* infects fruits throughout the period of fruit growth but remains quiescent for weeks or months while the fruit is immature. Quiescent infection appears to be a fungal response to adverse physiological conditions temporarily imposed by the host [11]. Environmental conditions have also their own contribution for *Colletotrichum* infection [12]. Control of anthracnose is primarily by fungicides, applied both before and after harvest. But in most countries the use of fungicides is becoming increasingly restricted particularly in the case of those fungicides applied postharvest [13]. Southern Ethiopia produces large amount of papaya, mango, banana, avocado and other fruits for local consumption and sells to other parts of the country. *Colletotrichum* species are known to infect fruits including avocado and papaya and cause both pre- and post-harvest anthracnose. However, infection may remain quiescent for some time during fruit development and appear in storage or while the fruits are sold on markets. Nevertheless, the awareness of farmers on protection of fruits from infection during growth in the field and postharvest care during gathering, transportation and storage is little or lacking in many instances. The main objective of this study was to assess prevalence of *Colletotrichum* spp. infecting fruits in Southern Ethiopia and give appropriate recommendations for effective management of anthracnose and future research.

MATERIALS AND METHODS

Description of The Study Areas: The study was conducted from in three locations found in southern part of Ethiopia: Wolayta, Wondo Genet and Ziway. Wolayta is located at 6°40'-7°58' N latitude and 37°14'-37°56' E longitudes and 390km South of Addis Ababa and 170km from Hawassa. Altitude of the area varies from 1000 and 2900m.a.s.l. Average annual temperature and rain fall range from 16°C to 20°C and 800mm to 1300mm, respectively [14]. Wondo Genet is situated 263 km South of Addis Ababa and 13km southeast from Shashemene in West Arsi Zone of Oromia Regional State and about 38km from Hawassa town. It is situated between 38°37'-38°42'E longitude and 7°02'-7°07'N latitude and an altitude of 1600-2500 m.a.s.l. Annual rainfall ranges from 700 to 1400 mm. Ziway is a town located 160km South of Addis Ababa in the Misraq Shewa zone of the Oromia region of Ethiopia at latitude and longitude of 7°56'N 38°43'E, respectively,

with an elevation of 1643m.a.s.l. and the mean annual temperature is 19.98°C. Annual rain fall ranges from 600 to 800mm/year and the economy of the town is based on fishing and horticulture [15].

Survey of Anthracnose on Avocado and Papaya: Field surveys were conducted in the aforementioned locations (Wolayta, Wondo Genet and Ziway) to gather information on the incidence and severity of anthracnose in the study areas. A total of 60 avocado and papaya fields (15-25 per location) were surveyed randomly in the three locations. Ten avocado and papaya fruits were collected from each of the three fruit trees for assessment of anthracnose incidence as the percentage of avocado and papaya fruits in the field showing visible symptoms out of 30 collected fruits from each type of fruit at each farm of the selected locality. On the other hand, anthracnose severity was assessed as the average fruit area covered by the symptom of anthracnose among the collected fruits infected with anthracnose in each farm. In addition, up to 10 avocado and papaya fruits without visible anthracnose symptoms were collected from each field making the total fruits collected 300. Besides the altitude, latitude and longitude of each field were recorded during field surveys and weather data of the three locations were obtained from the National Meteorological Agency, Hawassa branch. Pathogen Isolation and Species Identification: *Colletotrichum* isolates were isolated from 5mm pieces of tissues that were surface sterilized with 70% ethanol for 1min and rinsed in three series of sterilized distilled water and dried on sterilized filter paper. The surface sterilized tissues were plated on potato dextrose agar (PDA) and incubated at 25±2°C for seven days. At the end of the 7th day of incubation typical *Colletotrichum* conidia's were visible on the culture plates. The total number of isolates isolated from asymptomatic fruits is 187 (93 from avocado and 94 isolates from papaya).

The morphological features used in the identification process included conidia shape, colony colour described using the degree of pigmentation of the colonies, edge morphology (colony margin) and presence /absence of sectoring (concentric ring) after five days of incubation at 25°C.

Characterization of *Colletotrichum* Isolates Infecting Avocado and Papaya: Pure cultures of *Colletotrichum* isolates isolated from both avocado and papaya and representing different species and geographic origins were characterized in terms of colony morphology, growth rate and conidial shape. Pure cultures of isolates were

transferred to PDA and incubated at 25°C in the dark. After seven days of incubation, 5mm of mycelia plugs was taken from the actively growing edges of the colonies, transferred to the centre of fresh PDA plates and incubated under dark at three temperature conditions (20, 25 and 30°C). The experiment has completely randomized design with three replications.

Conidial Germination: Suspensions of conidia from 30 randomly selected avocado and papaya isolate (10 from each location) were transferred to ELISA plates in 100ml sterilized distilled water for incubation at different temperature (20, 25 and 30 °C) in three replicates. After 48hr and 96hr of incubation, 5ml of the conidial suspension was taken, mounted on a slide and then the conidia were examined under light microscope. The number of germinated conidia from the total conidia was counted at 40X magnification and changed the percentage of conidial germination was determined as proportion of germinating conidia per sample. Finally the mean percentage germinated conidia per isolate-temperature condition was used for statistical analysis using the SAS software (SAS 9.1). Besides, correlation analysis was done to assess the impact of temperature on conidial germination of *Colletotrichum*.

Data Analysis: The collected data on incidence and severity, Radial growth, Colony color and margin and Growth rate were subjected to statistical analysis using the SAS software. Correlation analysis was done to see the impact of temperature on the growth rate of the isolates.

RESULTS AND DISCUSSION

Field Assessment of Anthracnose: Survey results revealed the incidence of anthracnose on both Avocado and papaya across the three locations (Table 2). However, both disease incidence and severity varied significantly ($p < 0.05$) among the survey locations. The highest incidence and severity of anthracnose were recorded at Wondo genet (Incidence: 45% on avocado and 39.7% on papaya; Severity: 22% on avocado and 22% on papaya), followed by Wolayta (32.4% and 36% incidence on avocado and papaya, respectively; and severity of 16.8% and 16.4% on avocado and papaya, respectively). Both anthracnose incidence and severity were the lowest at Ziway (23.99% on avocado and 31.8% papaya and 13.33% on avocado and 13.67% on papaya, respectively, in Ziway). The lowest anthracnose incidence and severity in Ziway could be attributed to the effective application of fungicides in the government fruit farm. Furthermore, lower rain fall in Ziway could be probably the cause for low incidence and severity of anthracnose in the location. This was in agreement with [16-18], who reported variations in anthracnose incidence in other parts of the world.

Correlation Analysis: Incidence of avocado anthracnose had a positive and significant correlation with monthly and annual rain fall ($r = 0.675$ and $r = 0.666$, respectively) (Table 3). Besides, disease severity had also significant positive correlation with monthly and annual rain fall ($r = 0.545$ and $r = 0.535$, respectively). These results suggest the significant impact of rainfall on avocado anthracnose.

Table 1: Number of *Colletotrichum* isolates from avocado and papaya collected from the three location and GPS data

Location	Fruits and No of isolates			Altitude	Latitude	Longitude
	Avocado	Papaya	Banana			
Wolayta	33	36		1731-1754m	N 07°03.720' - N 07°42.222'	E037°42.193' - E 037°47.497'
Wondo Genet	35	30		1713-1733m	N 06°59.340' - N 07°03.653'	E038°34.485' - E 038°36.701'
Ziway	25	28		1646-1649m	N 07°56.426' - N 07°57.399'	E038°42.245' - E 038°43.130'

Table 2: Incidence and and severity of avocado and papaya at different survey locations of southern Ethiopia

Locations	Avocado		Papaya	
	Incidence(%)	Severity (%)	Incidence (%)	Severity (%)
Wolayta	32.4±6.84 ^b	16.80±4.30 ^b	36±6.52 ^b	16.4±4.69 ^b
Wondo genet	45.0±5.87 ^a	22.0±4.41 ^a	39.7±5.06 ^a	22±4.97 ^a
Ziway	23.99±5.80 ^c	13.33±3.09 ^c	31.8±5.89 ^c	13.67±3.52 ^b
CV (%)	13.96	19.66	14.84	24.58
LSD(0.05)	3.14	2.26	3.49	2.81

Means in a column followed by the same letter are not significantly different at $p < 0.05$

Table 3: Pearson correlation result for field survey incidence and severity of the two fruit type with rainfall

Fruit	Disease parameter	Monthly rain fall	Annual rain fall
Avocado	Incidence	0.675****	0.666****
	Severity	0.545****	0.535****
Papaya	Incidence	0.341**	0.426***
	Severity	0.532****	0.469****

Significant at $P<0.01$, *Significant at $P<0.001$, **** significant at $P<0.0001$.

Table 4: Colony characteristics of isolates found from avocado

		Colony color				
Location	Isolate no	Upper surface	Reverse side	Concentric ring	Margin	Conidial shape
Wolayta	1,10	Gray Cottony	Dark gray	Present	Regular	Cylindrical conidia with both ends obtuse
	2,11	Gray cottony	Gray center and dark margin	Absent	Regular	Cylindrical conidia with both ends obtuse
	3,13	gray cottony	Dark gray	Present	Irregular	cylindrical conidia with obtuse ends
	4,12	gray cottony	Dark gray	Absent	Regular	Cylindrical conidia with pointed and obtuse end
	6-9,14-15	White cottony	Dark gray	Absent	Regular	Cylindrical conidia with both ends obtuse
Wondo-genet	17,21,23,29	White cottony	Gray	Present	Regular	Cylindrical conidia with both ends obtuse
	18, 20	White cottony	Dark gray	Absent	Regular	Cylindrical conidia with both ends obtuse
	19, 24-25,30	White cottony	White gray	Absent	Regular	Cylindrical conidia with both ends obtuse
	26,28	Gray cottony	Dark gray	Present	Irregular	Cylindrical conidia with pointed and obtuse ends
	16,22,27	Gray cottony	Dark gray	Absent	Regular	Cylindrical conidia with both ends obtuse
Ziway	31,38-39,41,45	White cottony	Gray	Present	Regular	Cylindrical conidia with obtuse ends
	32,35-36,40	Gray cottony	Dark gray	Absent	Regular	Cylindrical conidia with both ends obtuse
	33,43,44	White cottony	Gray	Absent	Irregular	Cylindrical conidia with obtuse and pointed ends
	34,37,42	White cottony	Gray	Absent	Regular	Cylindrical conidia with both ends obtuse

There was a relatively lower and yet significantly positive correlation between the incidence of anthracnose on papaya and monthly and annual rain fall ($r=0.341$ and $r=0.426$, respectively). Further to this, anthracnose severity on papaya had also significantly positive correlation with both monthly and annual rain fall ($r=0.532$ and $r=0.469$, respectively) further confirming the influence of rain fall on the development of papaya anthracnose. Correlation analysis was not done for temperature since temperature of Wondo Genet location was not found from meteorological agency.

Species Identification and Morphological Characterization: A total of 69, 65 and 53 isolated of *Colletotrichum* were isolated from fruits in Wolayta, Wondo Genet and Ziway locations, respectively. The isolates were identified to a species level on the basis of their morphological features as described by [19].

Grouping of the *Colletotrichum* Isolates Based on Morphological Characters: Forty-five isolated from avocado and 45 from papaya (15 at each location) were randomly chosen for morphological analysis (species

identification). The morphological groupings of isolates used in the current study are presented in Tables 4 and 5. Isolates from avocado from Wondo Genet and Wolayta were classified into five morphological groups each while those from Ziway were categorized into four groups (Table 4). Majority of the isolates showed diverse upper and reverse side colony characteristics from white cottony to gray and to dark gray despite cylindrical conidia with the majority having both ends obtuse and some with one obtuse and other pointed end. In addition, the majority of the isolates have regular margin and without concentric ring. Besides, the isolates were found to grow faster, which is the characteristics of *C. gloeosporioides* unlike that of *C. acutatum* [6]. The conidial shape, the colony color and growth rate of the tested isolates indicated that the *Colletotrichum* spp. infecting avocado in southern Ethiopia were *C. gloeosporioides* since the morphological characteristics is typical of *C. gloeosporioides* since all of them displayed the description of [19]. The morphological characteristics in the current study also confirmed that there is intra-species diversity among *Colletotrichum* isolates in southern Ethiopia.

Table 5: Colony characteristics of isolates found from papaya

Location	Isolate no	Colony color		Concentric ring	Margin	Conidial shape
		Upper surface	Reverse side			
Wolayta	1,2,6,9,11,14,15	Gray cottony	Dark gray	Absent	Regular	Cylindrical conidia with both ends obtuse
	3,5,8,12,13	White cottony	Gray	Absent	Regular	Cylindrical conidia with both ends obtuse
	4,7,10	White cottony	Gray	Present	Regular	Cylindrical conidia with obtuse and pointed ends
Wondo	1718,23,24,28,29	Gray cottony	Dark gray	Present	Regular	Cylindrical conidia with obtuse ends
Genet	19,20-22	White cottony	Gray	Absent	Regular	Cylindrical conidia with both ends obtuse
	16,25,27	White cottony	Gray	Present	Irregular	Cylindrical conidia with obtuse ends
	26,30	Gray cottony	Centrally gray and dark gray edge	Present	Regular	Cylindrical conidia with obtuse ends
Ziway	31,32,44	White cottony	Gray	Absent	Regular	Cylindrical conidia with obtuse ends
	35,37,38,40	White cottony	Gray	Present	Regular	Cylindrical conidia with both ends obtuse
	36,43,45	Gray cottony	Dark gray	Absent	Regular	Cylindrical conidia with obtuse ends
	33,39, 41,42	White cottony	Gray	Present	Irregular	Cylindrical conidia with obtuse ends
	34	White cottony	Dark gray	Present	Regular	Cylindrical conidia with obtuse and pointed ends

Three, four and five groups of *Colletotrichum* were isolated from papaya from Wolayta, Wondo Genet and Ziway, respectively (Table 5). The *Colletotrichum* isolates showed diverse upper and reverse side colony characteristics from white cottony to gray and to dark gray colony color. In addition, the majority of the isolates have regular margin and almost half of the isolates have concentric ring. However, there was no much difference between shapes of conidia of different isolates in which all of them displayed the description of [10, 19] as being both ends round (majority) or pointed at one end and rounded at the other end. Besides, the isolates were found to have higher growth rate, which is the characteristics of *C. gloeosporioides* unlike that of *C. acutatum* (Table 5). The colony color, shapes of conidia's and growth rate of the isolates were typical of *C. gloeosporioides*. The morphological characteristics in the current study also confirmed that there is intra-species diversity among *Colletotrichum* isolates in southern Ethiopia.

Effect of Temperature on Growth Rate of *Colletotrichum*

Isolates: There was significant variation ($p < 0.05$) in growth rate of isolates collected from the three locations (Tables 6). For avocado isolates the maximum mean growth rate at different temperatures ranged from 37.3mm at 20°C to 39.6mm at 25°C. This was in agreement with another study by this another study [20], who reported temperature range from 25-30°C as favorable for good growth of *C. gloeosporioides* isolates. In addition, the growth rate of avocado isolates had a positively significant correlation with incubation temperature ($r = 0.403$, $p < 0.0001$). Mean growth rate of *Colletotrichum* isolates of papaya increases with temperature and

temperature of 25°C and 30°C were found to be most favorable in supporting the growth of isolates. On the other hand, temperature of 20°C resulted in significantly the lowest growth rate (37.7mm/48hr). A positively significant correlation ($r = 0.582$, $p < 0.0001$) was also established between growth rate of isolates and incubation temperature agreeing with the results obtained for isolates from avocado. Differences in growth rates of *Colletotrichum* isolates grown at the same temperature may be an indication for presence of intra-specific variation between different groups of *C. gloeosporioides* [21] has reported that maximum growth of *C. gloeosporioides* was observed at 30°C and good growth was supported by temperature ranging from 20 to 30 °C whereas least growth of isolates from papaya was recorded at 10°C(22) also confirmed that a temperature of 25 and 30°C to be favorable for growth of *C. gloeosporioides*.

Conidial Germination: Conidial germination was quantified at the second and fourth days after plating, using microscope. Mean conidial germination of *Colletotrichum* isolates from avocado ranged between 39% at 20°C and 48% at 30°C suggesting a linear increase in conidial germination with incubation temperature [8]. Likewise mean conidial germination of *Colletotrichum* isolates from papaya increases with the smallest (37.4%) and the fastest (46.6%) obtained at temperatures of 20 and 30°C [9]. Incubation temperature of 25°C had a more or less similar effect (45.30% conidial germination) on conidial germination as that 30°C. But results also indicated significant variations in conidial germination of the tested isolates incubated at the same temperature

Table 6: Mean growth rate/48hr of isolates of avocado at different temperature and at different location

Location	20°C	25°C	30°C
Wolayta	37.38±1.64 ^{ab}	39.73±1.97 ^a	40±1.88 ^a
Wondo genet	36.93±1.59 ^b	39.11±2.0 ^a	39.0±2.03 ^b
Ziway	37.58±1.41 ^a	39.8±1.9 ^a	39.1±1.68 ^b
CV (%)	3.29	3.60	4.12
LSD(0.05)	0.51	0.60	0.68

Means in a column followed by the same letter are not significantly different at $p < 0.05$.

Table 7: Mean growth rate/48 hr of isolates of papaya at different temperature and at different Location

Location	20°C	25°C	30°C
Wolayta	37.33±2.05 ^b	39.38±1.92 ^a	41.4±1.66 ^a
Wondo genet	38.62±1.89 ^a	38.95±1.57 ^a	40.35±1.3 ^b
Ziway	37.4±2.1 ^b	39.44±1.84 ^a	39.13±1.81 ^c
CV (%)	4.46	3.94	3.45
LSD (0.05)	0.71	0.65	0.58

Means in a column followed by the same letter are not significantly different at $p < 0.05$.

Table 8: Conidial germination of *Colletotrichum* isolates of avocado and papaya at different temperatures

Location	Avocado			Papaya		
	20°C	25°C	30°C	20°C	25°C	30°C
Wolayta	37.38±1.64 ^{ab}	39.73±1.97 ^a	40±1.88 ^a	37.33±2.05 ^b	39.38±1.92 ^a	41.4±1.66 ^a
Wondo genet	36.93±1.59 ^b	39.11±2.0 ^a	39.0±2.03 ^b	38.62±1.89 ^a	38.95±1.57 ^a	40.35±1.3 ^b
Ziway	37.58±1.41 ^a	39.8±1.9 ^a	39.1±1.68 ^b	37.4±2.1 ^b	39.44±1.84 ^a	39.13±1.81 ^c
CV (%)	3.29	3.60	4.12	4.46	3.94	3.45
LSD(0.05)	0.51	0.60	0.68	0.71	0.65	0.58

Means in a column followed by the same letter are not significantly different at $p < 0.05$

regardless of host of origin (Tables 8). This result in agreed with [23] reported that temperature ranging from 25-30°C favored good sporulation of *C. gloeosporioides*. Correlation analysis between conidial germination and incubation temperature revealed significantly ($p < 0.0001$) positive impact of the latter on the former ($r = 0.559$ for avocado isolates and $r = 0.562$ for isolates from papaya).

CONCLUSION AND RECOMMENDATIONS

The assessment conducted during field surveys showed that the disease anthracnose is prevalent on both avocado and papaya in all the surveyed locations. Nevertheless, both disease incidence and severity varied significantly across the locations. Besides, weather variables particularly rain fall was found playing higher role for anthracnose development. This suggested healthy avocado and papaya fruits from the field may harbor the pathogen to storage houses, which may further become possible cause for post harvest loss of avocado and papaya fruits by in southern Ethiopia. The morphological characteristics of *Colletotrichum* isolates found from avocado and papaya fruits including colony color, concentric ring, margin and conidial shapes indicated that the *Colletotrichum* spp. infecting avocado and papaya in southern Ethiopia was *Colletotrichum gloeosporioides*. The results of the morphological analysis suggest a high degree of similarity in terms of conidial shape and colony color. On the other hand, there was intra-species diversity among *Colletotrichum*

infecting avocado and papaya fruits in southern Ethiopia in terms of growth rate and conidial germination at different incubation temperatures. In addition, temperatures of 25 and 30°C are found to be favorable for growth rate and conidial germination of *Colletotrichum* isolated from the avocado and papaya fruits in southern Ethiopia. So this indicated that temperature played an important role on mycelia growth and conidial germination.

Recommendations:

- Field survey results indicated that *Colloettrichum* infection is a common problem on avocado and papaya in southern Ethiopia. So due attention should be given to effective management of anthracnose. However, most of the farmers that produce these fruit crops in the region are small scale subsistence farmers and thus the cost effectiveness of control measures should be considered to ensure adoption by farmers. Fruits are eaten fresh and hence emphasis in controlling fruit diseases including anthracnose must be given on non-chemical options as much as possible. Integrating disease management strategies (preharvest and post harvest) like spraying of fungicide, using resistant variety of the fruits, maintenance of tree hygiene, storing fruit at low temperature and controlled ripening may also play an important role in controlling the disease in an efficient, cost effective and sustainable manner.

- In general harvesting fruits during or soon after rain must be avoided, trees and fruits must be allowed to dry before harvesting and during harvesting and those with visible anthracnose symptoms should be removed to avoid cross infection the fruit by *Colletotrichum* spp. Besides, care should be taken during transportation of fruits to the market to prevent fruits from anthracnose damage.
- Studies conducted on quiescent anthracnose are important for effective prevention and control of *Colletotrichum*. So due attention should be given to study quiescent infection of fruits for controlling anthracnose and to reduce post harvest loss of avocado and papaya fruits in southern Ethiopia.
- Temperature studies indicated that *Colletotrichum* will grow preferably at temperature of 25°C and 30°C. So fruits should be stored at low temperature to hinder growth of *Colletotrichum*. However, further studies are needed to determine the most optimum temperatures for the growth and development of the fungus.

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