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Incidence and Severity of Anthracnose in Mango Fruits and its Control with Plant Extracts in South West Nigeria

[1]Charles Awa Onyeani and [2]N.A. Amusa

[1]Post-Entry Quarantine Station, Nigeria Agricultural Quarantine Service, Moor Plantation, Ibadan, Oyo State, Nigeria

[2]Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria

Corresponding Author: Charles Awa Onyeani, Post-Entry Quarantine Station, Nigeria Agricultural Quarantine Service, Moor Plantation, Ibadan, Oyo State, Nigeria

ABSTRACT

Anthracnose fruit rot is the most devastating fungal disease limiting the production and marketing of fresh mango fruits in Nigeria. This study investigated the incidence and severity of anthracnose in mango and its control with plant extracts. A systematic field survey of mango fruit anthracnose was carried out in four locations (Agege, Ayetoro, Ibadan and Ogbomosho) in Southwest Nigeria which fall along mango production belt. The efficacy of botanicals: *Annona squamosa*, *Azadirachta indica* and *Vernonia amygdalina* and synthetic fungicide (Benomyl) in the control of mango anthracnose were evaluated. Data generated from the studies were analyzed using Duncan multiple range test and Pearson's correlation coefficient, respectively at 5% probability. The results showed that 60% of mango trees surveyed were found to be infected with anthracnose and over 34% of fruits produced on those trees were severely infected. Ogbomosho recorded relatively higher percent occurrence (45.9%) and severity (38.1%) of anthracnose. Thirty percent and ten percent concentration levels of *Annona squamosa* were observed to be highly significant in reducing the incidence of anthracnose when compared with benomyl. Anthracnose disease especially at the postharvest stage is a threat to production and marketing of fresh mango fruits in South West Nigeria.

Key words: Fungal disease, *Colletotrichum gloeosporioides*, botanicals, systematic survey, postharvest

INTRODUCTION

Mango (*Mangifera indica* Linn) dietary contributions in the diet of most people in Nigeria rank above that of citrus fruits and it is the second largest consumed fruit after bananas (Onyeani *et al*., 2012). The economic value of fresh mango fruits to most households especially in the rural areas of Nigeria cannot be over estimated as most families depend greatly on the income they make from mango for their livelihood. However, mango production and marketing especially export of fresh mango fruits from the country is to a very large extent limited due to post harvest rotting of fruits associated with anthracnose disease caused by the fungus *Colletotrichum gloeosporioides* and over 30% of harvestable fruits are lost annually because of fruit abortions and abscission caused by this disease (Onyeani *et al*., 2012).

There is no mango variety or cultivar including those found in Nigeria that has been documented to be completely resistant to anthracnose disease (Tarnowski and Ploetz, 2008;

Pandey *et al.*, 2012), production of anthracnose free mango fruits therefore rely heavily on the use of fungicide as earlier reported by Dodd *et al.* (1997) and Ploetz (1999). But, the use of fungicides has reduced drastically due to development of resistance by fungal pathogens and public perception that fungicides have harmful effect on human health and the environment (Sun *et al.*, 2008).

Nevertheless, mango production remain one of the horticultural sectors which if well harnessed and provided for with the necessary logistics, can easily become a major foreign exchange earner for Nigeria and in turn will improve the lots of many households in the country. This may not be achievable unless the menace of anthracnose is tackled.

In the last few decades, the efficacy of plant extracts have been found by several workers including Lapkin *et al.* (2006) to be effective as plant disease control materials capable of replacing synthetic pesticides without any harmful effects on both man and the environment. Three promising sources of botanicals might turn out to be of great use in the management options against this disease pathogen.

This study therefore was undertaken with the aim of evaluating the incidence and severity of anthracnose infection in mango and identifying suitable botanicals that could be used for future management of this disease in Nigeria.

MATERIALS AND METHODS

This study was conducted in Agege, Ayetoro, Ibadan and Ogbomosho in the South West region of Nigeria.

Assessment of incidence and severity of mango fruit anthracnose: Survey and sampling of mango fruits in four locations (Agege, Ayetoro, Ibadan and Ogbomosho) was carried out following Masyahit *et al.* (2009) method. Fifteen mango trees in each location were randomly selected. On each tree, five on-tree ripened mango fruits were picked and examined for anthracnose lesions. Fruit anthracnose was assessed using the standards for the assessment of fruit anthracnose of mango proposed by Akhtar and Alam (2002). Disease incidence (percentage of diseased fruits) and disease severity (percentage of area affected on the fruit on average) was then obtained using the following formula:

$$\text{Disease Incidence (DI)} = \frac{X}{N} \times 100$$

where, X = Numbers of infected fruits and N = Total number of fruit sampled.

$$\text{Disease Severity (DS)} = \frac{\Sigma(a+b)}{N} \times \frac{100}{Z}$$

where, $\Sigma(a + b)$ = Sum of symptomatic fruits and their corresponding score scale, N = Total number of fruits sampled and Z = Highest score scale. Five is the highest disease rating.

Evaluation of botanicals as anthracnose control materials: Three indigenous plants (*Annona squamosa, Azadirachta indica* and *Vernonia amygdalina*) were selected and used in the study based on the fungicidal background previously reported in literature.

Preparation of plant extracts: Aqueous plant extract was prepared by sun-drying for 2 days and grinding separately 100 g of fresh leaves of each of the selected plants in a blender following

Abd El-Khair and Haggag (2007) method. Resultant extract solution was filtered through two layers of cheesecloth and different concentrations prepared by diluting 1 part of the plant extract into 9 part of sterile distilled water.

Alcohol plant extract was prepared by air-drying and grinding 100 g of leaves of each plant to powder state and subjected to cold extraction with 95% alcohol for 8 days following Khan *et al.* (2004). The solution was filtered through two layers of cheese cloth and different concentration levels were prepared as describe above.

Anthracnose disease pathogen: Laboratory studies were conducted on lesions on mango leaves, panicles and fruits collected from orchards and home gardens surveyed in each location. The lesions were carefully excised and sterilized before incubation at room temperature for 5 days following Amusa *et al.* (2005) isolation procedures. Isolated colonies were sub-cultured onto fresh potato dextrose agar media to obtain pure cultures which were identified based on conidia and colony morphology as described by Dugan (2006) and Mordue (1971). Single spore isolates of *Colletotrichum gloeosporioides* were cultured on potato dextrose agar slants in Bijour bottles, stored in a refrigerator and were sub-cultured in Petri dishes and incubated at temperature ranging from 28-30°C for 7 days following Sangeetha and Rawal (2009) method before use.

Pathogenicity test: Six healthy freshly harvested green matured mango fruits were surface sterilized by swabbing with 70% alcohol and later with 1% NaOCl solution. The fruits were inoculated with spore suspension of *Colletotrichum gloeosporioides* prepared following the procedure of Sivakumar *et al.* (1997). Isolation and re-isolation of pathogens from fruits that showed symptoms of anthracnose after 5 days of incubation was carried out following Koch's postulate for proof of pathogenicity as described by Schumann and D'Arcy (2006).

Effect of plant extracts on mycelial growth of anthracnose fungus: The effect of the plant extracts on the linear mycelial growth was evaluated using hole-plate diffusion method of Deans and Ritchie (1987). Petri dishes containing 15 mL of potato dextrose agar each were inoculated with 5 mm disc of fungal pathogen at the center surrounded by 3 wells of 1 cm each in diameter at a distance of 1 cm from the fungal pathogen. Each well was added with 100 μL of aqueous or alcohol extracted plant extracts. Three plates were used for each plant extract as replicates and sterile water was used for control. Inoculated plates were incubated at 25-30°C until mycelial growth of the fungal pathogen covered the surface of the agar medium in control treatment. The antifungal activity of each plant extract was measured by measuring the mycelial growth of the pathogen on PDA with measuring rule and the percentage of linear growth reduction of fungal pathogen in relation to the control was calculated using the following formula:

$$\text{Linear growth reduction (\%)} = \frac{\text{Growth in control-Growth in treatment}}{\text{Growth in control}} \times 100$$

Effect of botanicals on anthracnose fungi spore germination: Spore suspension (0.1 mL) of fungal pathogen was sprayed with hand sprayer over films of plant extract added to dried clean slides following Abd El-Khair and Haggag (2007) slide technique. Control was prepared and spread as a film of distilled water. Three slides were used as replicates for each plant extract. Each slide was placed on glass rod in Petri dish under moistened conditions and incubated for 24 h at 25°C.

Using 4 microscopic fields (x = 10×40) for each replicate, spore germination percentages were calculated using the following formula:

$$\text{Spore germination (\%)} = \frac{\text{Spore germination number}}{\text{Total spores number}} \times 100$$

Effect of botanicals on incidence and severity of mango fruit anthracnose: One hundred and fifty green matured mango fruits were randomly collected from the sampling areas. The fruits were mixed together and later subdivided into 10 parts of 15 fruits each with each fruit representing a replicate. Each part containing 15 numbered fruits was treated separately with botanicals (water or alcohol extraction) and fungicide (benomyl). One part was treated with sterile distilled water to serve as control.

For botanicals, the fruits were soaked in aqueous or alcohol plant extract for 30 min and air-dried. Benomyl 50% w/w at 100 g/100 L of water was sprayed over the fruits and completely covered with sterilized paper towel while in the case of control treatment; the fruits were thoroughly washed and soaked in sterile distilled water for 30 min and air dried.

The treated fruits for each treatment were arranged in separate boxes laid out in a completely randomized design layout and allowed to ripen for 16 days under humid condition. The fruits were individually examined for anthracnose lesions every other day beginning from the sixth day after treatment when ripening has commenced until the sixteenth day. Anthracnose incidence and severity was assessed and calculated as described above.

Statistical analysis: Data collected were subjected to one-way analysis of variance (One-way ANOVA) using Statistical Package for Social Sciences (SPSS) 14.0 version. Means were separated using Duncan multiple range tests at 5% level of significance.

RESULTS

Incidence and severity of fruit anthracnose in the study areas: Sixty percent of the 60 trees assessed had ripened fruits with anthracnose symptoms on them. Mango samples from Ogbomosho recorded highest disease incidence of 45.9% and severity of 38.1% (Fig. 1). There were no

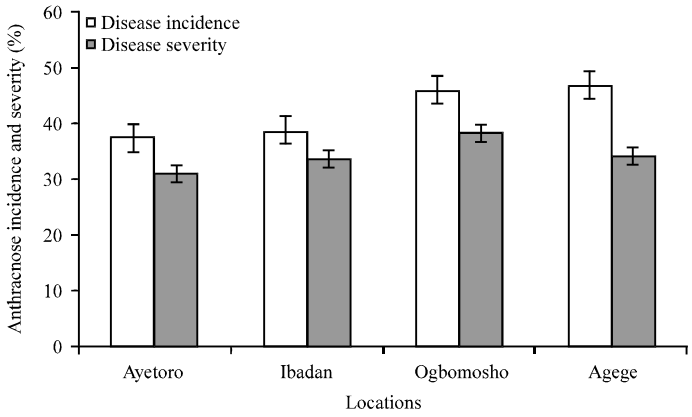

Fig. 1: Mango fruit anthracnose incidence and severity in different mango growing areas in Southwestern Nigeria

significant differences between mango samples from Ibadan and Ayetoro with 38.67 and 37.33% anthracnose incidence, respectively. Similarly, disease incidence correlated positively (r = 0.96, r = 0.99, r = 0.98, r = 0.99) with disease severity in mango fruits from Ayetoro, Ibadan, Ogbomosho and Agege, respectively (Fig. 2).

Effect of aqueous and alcoholic plant extracts on mycelial growth and spore germination of anthracnose fungus: Aqueous and alcohol extracts of both *Azadirachta indica* and *Vernonia amygdalina* significantly reduced mycelial growth and spore germination of *Colletotrichum gloeosporioides* (Table 1). Alcohol extract of *Vernonia amygdalina* was significantly more effective in mycelial growth reduction of the pathogen than other extracts. It reduced radial growth of mycelia to 3.0 cm^2 representing 62.5% reduction and spore germination to 127.33 spores mL^{-1} representing 66.1% reduction when compared with the mycelial growth and spore germination in the control treatment.

Table 1: Effect of plant extracts on *in-vitro* mycelial growth and spore germination of *Colletotrichum gloeosporioides*

Plant extracts	Mycelial growth diameter (cm)	Decrease over control (%)	Spore germination (mL^{-1})	Decrease over control (%)
Sterile distilled water (Control)	8.0^{a}	-	375.67^{a}	-
Benomyl	0.0^{e}	-100.00	27.67^{d}	-92.63
Annona squamosa				
Aqueous extract	8.1^{a}	+1.25	382.60^{a}	+1.84
Alcohol extract	6.3^{b}	-21.25	298.33^{c}	-20.57
Azadirachta indica				
Aqueous extract	3.5^{cd}	-56.25	134.30^{e}	-64.25
Alcohol extract	4.2^{cd}	-47.50	158.67^{b}	-57.76
Vernonia amygdalina				
Aqueous extract	4.5^{c}	-43.75	173.67^{c}	-53.77
Alcohol extract	3.0^{d}	-62.50	127.33^{c}	-66.11

Means with same letter are not significantly different at 5% probability by Duncan multiple range test, values with positive or negative signs represent percentage differences in performance of treatments below or above control

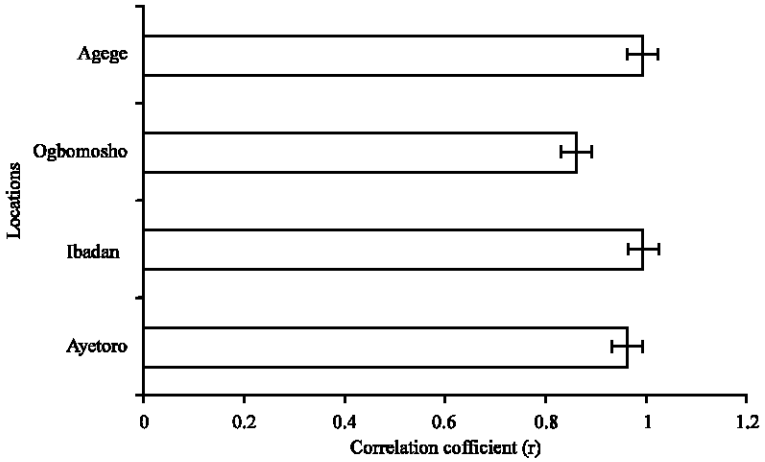

Fig. 2: Correlation coefficient between anthracnose incidence and severity in the study areas

Aqueous extract of *Azadirachta indica* also significantly reduced radial mycelial growth to 3.5 cm^2 representing 56.25% reduction and spore germination to 134.30 spores mL^{-1}, representing 64.25% reduction. Alcohol extract of *Azadirachta indica* and aqueous extract of *Vernonia amygdalina* reduced mycelial growth to 4.2 cm^2 (47.5%) and 4.5 cm^2 (43.75%) centimeter and spore germination to 158.67 spores mL^{-1} (57.76%) and 173.67 spores mL^{-1} (53.77%), respectively. Benomyl was most effective in the reduction of mycelial growth recording no growth representing 100% mycelial growth reduction. Similarly, in spore germination benomyl recorded the lowest germination of 27.67 spores mL^{-1}, representing 92.6% reductions.

Effect of aqueous and alcoholic plant extracts on fruit anthracnose incidence: Effect of treatment of fruits with aqueous and alcoholic plant extracts shows that anthracnose disease incidences increased as number of days of treatment increased. Comparatively, disease incidences after 6 days of treatment were lowest while after 16 days of treatment were highest (Table 2). Similarly, there were significant variations in the effect of the extracts on different mango varieties. On Alphonso variety, no control material was able to inhibit anthracnose lesion development below 66.67% recorded by benomyl. After 16 days of ripening, 30% (aqueous extract) and 10% (alcohol extract) concentration levels of *Annona squamosa* significantly reduced anthracnose on Ogbomosho variety, respectively to 26.67%.

Table 2: Anthracnose disease incidence percentage on mango fruits six days after treatment with aqueous and alcohol plant extracts

	Aqueous plant extract			Alcohol plant extract		
Treatments	Alphonso	Julie	Ogbomosho	Alphonso	Julie	Ogbomosho
Sterile distilled water	20.00^{g}	73.33^{a}	33.33^{d}	20.00^{f}	73.33^{a}	33.33^{a}
Benomyl	6.67^{i}	0.00^{j}	0.00^{j}	6.67^{h}	0.00^{e}	0.00^{d}
Hot water	0.00^{j}	0.00^{j}	0.00^{j}	0.00^{i}	0.00^{e}	0.00^{d}
Annona squamosa						
Crude	100.00^{a}	53.33^{c}	26.67^{e}	73.33^{c}	40.00^{b}	0.00^{d}
40% concentration	40.00^{f}	33.33^{f}	20.00^{f}	80.00^{b}	26.67^{d}	20.00^{b}
30% concentration	40.00^{f}	33.33^{f}	13.33^{g}	60.00^{d}	40.00^{b}	0.00^{d}
20% concentration	46.67^{e}	46.67^{d}	53.33^{a}	73.33^{c}	33.33^{c}	0.00^{d}
10% concentration	53.33^{d}	73.33^{a}	46.67^{b}	73.33^{c}	40.00^{b}	6.67^{c}
Azadirachta indicla						
Crude	13.33^{h}	66.67^{b}	6.67^{h}	80.00^{b}	26.67^{d}	0.00^{d}
40% concentration	0.00^{j}	40.00^{e}	33.33^{d}	80.00^{b}	0.00^{e}	0.00^{d}
40% concentration	53.33^{d}	13.33^{i}	0.00^{j}	86.67^{a}	0.00^{e}	6.67^{c}
20% concentration	73.33^{b}	0.00^{j}	20.00^{f}	13.33^{g}	0.00^{e}	0.00^{d}
10% concentration	66.67^{c}	0.00^{j}	40.00^{c}	13.33^{g}	0.00^{e}	6.67^{c}
Vernonia amygdalina						
Crude	0.00^{j}	26.67^{g}	13.33^{g}	40.00^{e}	40.00^{b}	0.00^{d}
40% concentration	6.67^{i}	20.00^{h}	6.67^{h}	80.00^{b}	0.00^{e}	6.67^{c}
30% concentration	40.00^{f}	0.00^{j}	0.00^{j}	73.33^{c}	0.00^{e}	0.00^{d}
20% concentration	53.33^{d}	0.00^{j}	20.00^{f}	6.67^{h}	0.00^{e}	6.67^{c}
10% concentration	46.67^{e}	0.00^{j}	20.00^{f}	0.00^{i}	0.00^{e}	0.00^{d}

Means with same letter are not significantly different at 5% probability by Duncan multiple range test. Values are mean values of 15 replications

Table 3: Anthracnose disease incidence percentage on mango fruits sixteen days after treatment with aqueous and alcohol plant extracts

	Aqueous plant extract			Alcohol plant extract		
Treatments	Alphonso	Julie	Ogbomosho	Alphonso	Julie	Ogbomosho
Sterile distilled water	93.33^{b}	100.00^{a}	100.00^{a}	93.33^{b}	100.00^{a}	100.00^{a}
Benomyl	66.67^{f}	40.00^{j}	33.33^{h}	66.67^{d}	40.00^{j}	33.33^{i}
Hot water	93.33^{b}	53.33^{h}	60.00^{g}	93.33^{b}	53.33^{i}	60.00^{f}
Annona squamosa						
Crude	100.00^{a}	93.33^{b}	60.00^{g}	93.33^{b}	73.33^{d}	73.33^{d}
40% concentration	80.00^{d}	80.00^{d}	60.00^{g}	100.00^{a}	53.33^{i}	73.33^{d}
30% concentration	80.00^{d}	86.67^{c}	26.67^{i}	86.67^{c}	53.33^{i}	60.00^{f}
20% concentration	80.00^{d}	100.00^{a}	80.00^{d}	93.33^{b}	66.67^{e}	66.67^{e}
10% concentration	86.67^{c}	100.00^{a}	86.67^{c}	93.33^{b}	60.00^{f}	26.67^{j}
Azadirachta indica						
Crude	73.33^{e}	93.33^{b}	93.33^{b}	86.67^{c}	53.33^{i}	66.67^{e}
40% concentration	93.33^{b}	60.00^{g}	100.00^{a}	86.67^{c}	73.33^{d}	60.00^{f}
30% concentration	73.33^{e}	66.67^{f}	73.33^{e}	86.67^{c}	73.33^{d}	40.00^{h}
20% concentration	80.00^{d}	73.33^{e}	66.67^{f}	100.00^{a}	66.67^{e}	66.67^{e}
10% concentration	80.00^{d}	80.00^{d}	73.33^{e}	86.67^{c}	93.33^{b}	93.33^{b}
Vernonia amygdalina						
Crude	66.67^{f}	86.67^{c}	100.00^{a}	86.67^{c}	66.67^{e}	40.00^{h}
40% concentration	80.00^{dc}	86.67^{c}	60.00^{g}	86.67^{c}	73.33^{d}	40.00^{h}
30% concentration	66.67^{f}	73.33^{e}	80.00^{d}	93.33^{b}	73.33^{d}	46.67^{g}
20% concentration	80.00^{dc}	73.33^{e}	60.00^{g}	93.33^{b}	66.67^{e}	93.33^{b}
10% concentration	80.00^{dc}	73.33^{e}	80.00^{d}	86.67^{c}	80.00^{c}	86.67^{c}

Means with same letter are not significantly different at 5% probability by Duncan multiple range test. Values are mean values of 15 replications

Effect of aqueous and alcoholic plant extracts on fruit anthracnose severity: The effect of treatment of fruits with aqueous and alcoholic plant extracts on anthracnose disease severity followed the same trend with disease incidence. Severity equally increased as number of days of treatment increased. After 6 days of treatment, disease severity was lowest in all the treatments while after 16 days of treatment they were highest (Table 3).

On Alphonso mango fruits, 40% aqueous *Azadirachta indica* extract and crude aqueous extract of *Vernonia amygdalina* treatments recorded lowest disease of 20% while crude aqueous extract of *Annona squamosa* recorded the highest (72%) disease severity after six days of treatment. No treatment was effective in reducing anthracnose disease severity on Alphonso mango fruits at the end of the study period. Benomyl only reduced disease severity to approximately 45% while all other treatments recorded between 49 and 93% disease severity (Table 4).

The trend was slightly different on Ogbomosho mangoes treated with aqueous and alcoholic extracts. *Annona squamosa* 30% aqueous extract concentration and 30% alcoholic extract of *Vernonia amygdalina* recorded 30.67% severity each. These followed closely to the severity record of 28% recorded in benomyl treatment while the highest severity of 76% was recorded in the control treatment (Table 5).

Table 4: Anthracnose disease severity percentage on mango fruits six days after treatment with aqueous and alcohol plant extracts

	Aqueous plant extract			Alcohol plant extract		
Treatments	Alphonso	Julie	Ogbomosho	Alphonso	Julie	Ogbomosho
Sterile distilled water	24.00^{i}	38.67^{c}	26.67^{f}	24.00^{m}	38.67^{a}	26.67^{a}
Benomyl	21.33^{k}	20.00^{j}	20.00^{j}	21.33^{o}	20.00^{h}	20.00^{e}
Hot water	20.00^{l}	20.00^{j}	20.00^{j}	20.00^{p}	20.00^{h}	20.00^{e}
Annona squamosa						
Crude	72.00^{a}	38.67^{c}	33.33^{b}	49.33^{f}	32.00^{d}	20.00^{e}
40% concentration	30.67^{h}	28.00^{f}	29.33^{d}	58.67^{b}	25.33^{g}	24.00^{b}
30% concentration	32.00^{g}	30.67^{e}	28.00^{f}	38.67^{j}	37.33^{b}	20.00^{e}
20% concentration	33.33^{f}	40.00^{b}	38.67^{a}	41.33^{h}	33.33^{c}	20.00^{e}
10% concentration	34.67^{e}	48.00^{a}	33.33^{b}	40.00^{i}	30.67^{e}	21.33^{d}
Azadirachta indica						
Crude	22.67^{j}	37.33^{d}	21.33^{h}	50.67^{e}	26.67^{f}	20.00^{e}
40% concentration	20.00^{l}	30.67^{e}	30.67^{c}	52.00^{d}	20.00^{h}	20.00^{e}
30% concentration	34.67^{e}	24.00^{h}	20.00^{j}	62.67^{a}	20.00^{h}	21.33^{d}
20% concentration	42.67^{b}	20.00^{j}	26.67^{f}	22.67^{n}	20.00^{h}	20.00^{e}
10% concentration	40.00^{c}	20.00^{j}	38.67^{a}	25.33^{l}	20.00^{h}	21.33^{d}
Vernonia amygdalina						
Crude	20.00^{l}	26.67^{g}	22.67^{g}	30.67^{k}	30.67^{e}	20.00^{e}
40% concentration	21.33^{k}	24.00^{h}	21.33^{h}	48.00^{g}	20.00^{h}	22.67^{c}
30% concentration	37.33^{d}	20.00^{j}	20.00^{j}	53.33^{c}	20.00^{h}	20.00^{e}
20% concentration	37.33^{d}	20.00^{j}	29.33^{d}	21.33^{o}	20.00^{h}	21.33^{d}
10% concentration	34.67^{e}	20.00^{j}	30.67^{c}	20.00^{p}	20.00^{h}	20.00^{e}

Means in a column with same letter are not significantly different at 5% probability by Duncan multiple range test. Values are means of 15 replications

DISCUSSION

Based on the results of this study, the observation on mango trees (Leaves, stem, panicles and fruits) on the field and fruits in storage, colony and conidia morphology of the fungal isolates in the laboratory that conform to the symptoms of anthracnose and characteristics of anthracnose pathogen documented in literature (Iram and Ahmad, 2013; Pandey *et al*., 2012; Pitkethley and Conde, 2007; Ploetz, 1994; Dugan, 2006; Mordue, 1971) and the result of pathogenicity test conducted suggests that anthracnose disease is prevalent in Southwestern Nigeria.

Several reports have shown that production of anthracnose free mango fruits rely heavily on the use of fungicides. Nevertheless, the use of fungicides has reduced drastically due to development of resistance by fungal pathogens and public perception that fungicides have harmful effect on human health and the environment. This study confirmed the efficacy of fungicide (benomyl) in the control of anthracnose. The inability of any of the control materials (botanicals and synthetic fungicides) tested in this study to prevent or reduce significantly the development of anthracnose lesions in Alphonso variety probably suggest the virulence of the *Colletotrichum gloeosporioides* strains recovered from the variety or the development of resistance by the strains. It is also possible that the control materials could have served as source of nutrient for the fungus. The slight significant difference between fruits treated with benomyl and those untreated do not suggest benomyl as having had any significant effect in the control of postharvest loss of Alphonso mango fruits.

Table 5: Anthracnose disease severity percentage on mango fruits sixteen days after treatment with aqueous and alcohol plant extracts

	Aqueous plant extract			Alcohol plant extract		
Treatments	Alphonso	Julie	Ogbomosho	Alphonso	Julie	Ogbomosho
Sterile distilled water	49.33^{j}	90.67^{b}	76.00^{c}	49.33^{m}	90.67^{a}	76.00^{a}
Benomyl	45.33^{l}	32.00^{n}	28.00^{o}	45.33^{n}	32.00^{o}	28.00^{o}
Hot water	81.33^{b}	30.67^{o}	44.00^{l}	81.33^{d}	30.67^{p}	44.00^{h}
Annona squamosa						
Crude	93.33^{a}	86.67^{c}	58.67^{g}	86.67^{b}	53.33^{d}	50.67^{d}
40% concentration	70.67^{e}	68.00^{g}	57.33^{h}	84.00^{c}	44.00^{h}	48.00^{e}
30% concentration	66.67^{f}	82.67^{f}	30.67^{n}	74.67^{i}	42.67^{k}	44.00^{h}
20% concentration	70.67^{e}	84.00^{e}	70.67^{d}	72.00^{k}	48.00^{h}	42.67^{i}
10% concentration	66.67^{f}	96.00^{a}	66.67^{e}	78.60^{f}	50.67^{f}	32.00^{m}
Azadirachta indica						
Crude	49.33^{j}	86.67^{c}	70.67^{d}	84.00^{c}	45.33^{i}	45.33^{g}
40% concentration	50.67^{i}	56.00^{i}	86.67^{b}	80.00^{e}	57.33^{c}	38.67^{j}
30% concentration	64.00^{g}	49.33^{l}	30.67^{n}	76.00^{h}	44.00^{j}	33.33^{l}
20% concentration	73.33^{d}	53.33^{j}	58.67^{g}	90.67^{a}	45.33^{i}	46.67^{f}
10% concentration	76.00^{c}	61.33^{h}	54.67^{j}	73.33^{j}	61.33^{b}	54.67^{c}
Vernonia amygdalina						
Crude	46.67^{k}	85.33^{d}	82.67^{a}	77.33^{g}	49.33^{g}	32.00^{m}
40% concentration	41.33^{m}	61.33^{h}	41.33^{m}	78.67^{f}	52.00^{e}	34.67^{k}
30% concentration	56.00^{h}	50.67^{k}	56.00^{i}	74.67^{i}	37.33^{n}	30.67^{m}
20% concentration	76.00^{c}	48.00^{m}	49.33^{k}	70.67^{l}	38.67^{m}	76.00^{a}
10% concentration	66.67^{f}	49.33^{l}	61.33^{f}	70.67^{l}	41.33^{l}	70.67^{b}

Means in a column with same letter are not significantly different at 5% probability by Duncan multiple range test. Values are means of 15 replications

The significant differences obtained between control treatment and all the botanicals in anthracnose disease incidence and severity notwithstanding, control treatment was slightly superior to all the treatments in some instances. This result could be in agreement with the reports of Korsten (1995), Osuinde *et al.* (2001), Janisiewicz and Korsten (2002) on the decreased efficiencies of fungicides due to development of resistance by fungi pathogens worldwide. The result of this study further indicated that on Julie and Ogbomosho mango varieties, anthracnose incidence was less when both cultivars were treated with aqueous and alcohol extracts of *Annona squamosa, Azadirachta indica* and *Vernonia amygdalina.* Anthracnose incidence was lesser in fruits treated with some of *Annona squamosa* concentrations than it was in those treated with benomyl an indication of the potential of the extract in suppressing anthracnose disease infection. Pandey *et al.* (2012) found *Azadirachta indica* very effective in the reduction of radial growth of *Colletotrichum gloeosporioides.* Similar result was obtained in this study with *Azadirachta indica* and *Vernonia amygdalina* in the inhibition of radial mycelial growth and sporulation of the pathogen.

Anthracnose disease especially at the post harvest stage has been implicated to pose serious threat to production and marketing of fresh mango fruits in Southwestern Nigeria. There were significant differences between benomyl (a synthetic fungicide) and other control materials used in this study. Benomyl was consistently more effective than the other materials. Most plant extracts used in the study, rather than reduce anthracnose incidence and severity enhanced the growth of

the fungus. This was evident in their inability to reduce fruit anthracnose incidence and severity below what were obtained in the control treatments. This suggests that synthetic fungicide use remain the surest means of controlling anthracnose on mango fruits. However, the limited successes recorded in the control of the disease in this study, using the available control materials, emphasizes the need and importance of further search and development of effective and safe alternative control strategies.

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