SURVEY OF MANGO ANTHRACNOSE (*Colletotrichum gloeosporioides* (Penz.) Sacc.) IN FOUR AGRO-ECOLOGICAL ZONES OF NIGERIA

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Abstract

Assessment on incidence and severity of mango leaves and fruits anthracnose was conducted in four mango orchards during 2014 mango growing season in four agro-ecological zones in Nigeria. Ten mango varieties were assessed from the orchard of Niyya farm (Southern guinea savannah), six from the Institute for Agricultural Research (IAR), Zaria orchard (Northern guinea savannah) and five each from Yanbukar and Dabiran mango orchards (Sudan and Sahel savannah respectively). The disease incidence and severity on leaves and fruits on the surveyed orchard significantly varied (P ≤0.05). Highest incidence and severity of the disease on leaves, in Niyya orchard was recorded on variety Temo (47.20% and 55.80%) and the least was recorded on variety Dankamaru (19.20 % and 40.00 % ). Variety Peter recorded highest incidence and severity on fruits (82.00 % and 48.40 %) the least was recorded on Maya. At IAR, highest incidence and severity on leaves (37.60 % and 52.40 %) was recorded on variety Alphonso, lowest (17.00 % and 40.80 %) was obtained on variety Temo. Kanbiri had the highest incidence on fruits (18.00 %) and Binta sugar recorded higher severity on its fruits (41.20 %) and the lowest incidence and severity on fruits (11.60 % and 24.80 %) was recorded on variety Keith. In Yanbukar orchard, Bakinaku had the highest incidence and severity on leaves (40.00 % and 51.40 %) and lowest (8.80 % and 36.60 %) was recorded on variety Soto. There was no significance difference between the incidence and severity of the disease on fruits among the varieties in Yanbukar orchard. At Dabiran, variety Dangaftare had the highest incidence and severity on leaves (38.40 % and 49.40 %) and lowest (37.80 % and 10.40 %) recorded on Maijijiya. The disease parameters on fruits were higher on variety Dangaftare (42.00 % and 36.40 %) with Furdu recording the least (11.60 % and 24.00%). Based on the findings of this study, it was concluded that varieties Bakinaku and Dankamaru are moderately resistance to anthracnose on both fruits and leaves in Niyya orchard, Temo and Keith at IAR, Zaria orchard. Maijijiya and Soto varieties have shown moderately resistance to the disease at Dabiran and Yanbukar orchards respectively.

Keywords: Colletotrichum gloeosporioides; incidence; mango anthracnose; severity

Introduction

Mango (*Mangifera indica* L.) is an important fruit tree of the tropical and sub-tropical regions of the world (Shad et al. 2002). It is a fruit plant grown in abundance throughout Nigeria (Yusuf and Salau 2007). Mango is the most frequently eaten fruit in the midst of millions of people in tropical areas and the world at large (Crane and Campbell, 1994). Mango is called "The King of fruits" due to its sweetness and richness in nutrients (Vayssières et al. 2009). It is praised as "Super fruit" owing to its prospective health values (Biswas and Kumar 2011). The crop is full-grown in 87 countries of the world (Okigbo and Osuinde 2003). In Nigeria, Mango ranked the second largest eaten fruits after banana and contributes immensely to the dietary of most individuals (Awa et al. 2012; OnyeaniandAmusa 2015). Fresh mango fruits has a great economic contribution to many families of rural areas in Nigeria, where most homes depend intensely on the money they generate from selling mango for their wellbeing (OnyeaniandAmusa 2015). Anthracnose caused by *Colletotrichum gloeosporioides* is the most important field and post-harvest disease of mango in all mango-growing regions of the world (Ploetz and Prakash 1997; Chowdhury et al. 2008; Sangeethaand Rawal 2009), especially where high humidity prevails during the cropping season. *C. gloeosporioides* has been reported as one of the most significant pathogens globally that infect at least 1000 plant species including fruit trees (Phoulivong et al. 2010).
On mango tree, anthracnose symptoms occur on stem, twigs, leaves, flower clusters, and fruits as small, angular, brown to black spots that can enlarge to form extensive dead areas (Ploetz 1994). On stem and twigs, the infection is recognized as black lesions which expand up to 0.5–1.0 cm in diameter or cover entire length of twigs. The disease had been reported on mango fruits produced in the humid forest region of Nigeria (Awa et al. 2012). It also makes mango fruit rot quickly after harvest rendering it unattractive and valueless (Yusuf and Salau 2007). Post-harvest infection is economically the most significant phase of the disease worldwide (Akem 2006). In Nigeria, about 30% of mango fruits are lost every year due to fruits abscission and abortions caused by C. gloeosporioides (Awa et al. 2012; Onyeani and Amusa 2015).

Anthracnose disease of mango is considered as the major constraint to production of the crop in Nigeria (Awa et al. 2012). Apart from the report of (Osigbo and Osuinde 2003) in which C. gloeosporioides was listed as a fungal pathogen of mango and reported its occurrence in South East Nigeria and (Awa et al. 2012) who firstly reported its occurrence in South West Nigeria, literature on studies of anthracnose of mango in north western Nigeria are scarce. It is in view of the foregoing, that this study was initiated with the aim of quantifying the disease across the four agro-ecological zones of northwest Nigeria, with view of recommending the suitable varieties to be planted in the surveyed areas based on the findings.

Materials and Methods

Survey of Incidence and Severity of Mango Anthracnose

Assessment and sampling of mango anthracnose on both leaves and fruits was conducted in four orchards in 2014 mango growing season. These orchards are: Institute for Agricultural Research (IAR) (11° 04’ 00”N; 07° 42’ 00”E), in SabonGari Local Government Area (Northern Guinea Savannah), Niyaa Farm (10° 20’58”N; 07° 45’00” E) in Kachia Local Government Area (Southern Guinea savannah) both in Kaduna State; Dabiran mango orchard (13° 02’ 11”N; 8° 19’ 04”E) in Daura Local Government Area of Katsina State (Sahel Savannah) and Yanbukar Mango orchard (11° 49’ N; 8° 51’ E) in Wudil Local Government Area of Kano State (Sudan Savannah).

Source: Modified from administrative map of Nigeria.

Figure 1: Location of surveyed orchards in three state of north-western Nigeria, representing four agro-ecological zones
All the surveyed orchards are within the three states of northwestern Nigeria (Figure 1), which comprises four agro-ecological zones that vary in annual rainfall, temperature and relative humidity (Table 1).

Table 1: Average annual temperature, rainfall and relative humidity of the four agro-ecological zones of the surveyed orchards, 2014

<table>
<thead>
<tr>
<th>Agro-ecological zone</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm)</th>
<th>Relative humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Guinea Savannah</td>
<td>26.50</td>
<td>1314.0</td>
<td>80.20</td>
</tr>
<tr>
<td>Northern Guinea Savannah</td>
<td>28.20</td>
<td>1051.7</td>
<td>70.50</td>
</tr>
<tr>
<td>Sudan Savannah</td>
<td>29.80</td>
<td>657.3</td>
<td>65.65</td>
</tr>
<tr>
<td>Sahel Savannah</td>
<td>31.20</td>
<td>450.6</td>
<td>56.00</td>
</tr>
</tbody>
</table>

During the survey, infected mango fruits and leaves samples were also collected from these orchards and taken to laboratory for further studies. Ten (10) mango varieties were assessed at Niyya, six (6) assessed at IAR, Zaria while Five (5) varieties each in Dabiran and Yanbukar, were assessed. Data obtained from each orchard was analyzed separately because the varieties were not uniform across the surveyed orchards. Anthracnose disease was assessed on mango leaves and fruits in each orchard visited. For leaf assessment, 10 twigs were selected per variety per orchard from 10 plants, and on each twig five (5) leaves were randomly selected, examined and scored using a 1-8 scale described by (Masood et al. 2010), where:

1 = No visible symptom on the leaf surface  
2 = 1-10% of leaf area diseased  
3 = 11-20% of leaf area diseased  
4 = 21-30% of leaf area diseased  
5 = 31-40% of leaf area diseased  
6 = 41-50% of leaf area diseased  
7 = 51-60% of leaf area diseased  
8 = >60% of leaf area diseased

For anthracnose assessment on fruits, ten mango trees per each variety per orchard were randomly selected. On each tree, 10 matured fruits were randomly selected and scored using a 1-7 scale described by (Akhtar and Alam 2002), where:

1 = No visible symptom on the fruits  
2 = 1-10% fruit covered with lesion  
3 = 11-20% fruit covered with lesion  
4 = 21-30% fruit covered with lesion  
5 = 31-40% fruit covered with lesion  
6 = 41-50% fruit covered with lesion  
7 = >50% fruit covered with lesion

Disease severity (DS) on the leaves and fruits was calculated using the formula below:

\[ DS\% = \frac{\sum (a \times b)}{N \times Z} \times 100 \]

Where:

\( a \) = total number of assessed leaves/fruit  
\( b \) = corresponding score grade on the rating scale  
\( \Sigma (a \times b) \) = Sum of assessed leaves/fruit and their corresponding score grade  
\( N \) = total number of sampled leaves/fruit  
\( Z \) = highest disease grade

Disease incidence (DI) on the leaves and fruits was calculated using the following formula:

\[ DI\% = \frac{X}{N} \times 100 \]

Where:

\( X \) = number of infected leaves/fruits  
\( N \) = total number of leaves/fruits assessed

Isolation and Identification of the Fungal Pathogen

Samples of infected mango leaves and fruits collected from each orchard during the survey periods were brought to the Vegetable Pathology Laboratory in the Department of Crop Protection, Ahmadu Bello University, Zaria in sample bags for further studies. Small lesion (2 x 3mm) of the infected portion from both the leaves and fruits were cut using scalpel, disinfected with 1% Sodium hypochlorite (NaOCl) for three minutes, rinsed in three changes of sterile distilled water (SDW) and plated in 9 cm Petri dishes containing Potato Dextrose Agar amended with Streptomycin Sulphate (PDAs). The Petri dishes were incubated for five
days at room temperature (28 ± 2°C) fungal mycelia were sub-cultured into freshly prepared PDAs to obtain pure cultures. The cultures were identified as *Colletotrichum* spp. by cultural and microscopic examinations using identification manual (Barnett and Hunter 1998), and later confirmed as *Colletotrichum gloeosporioides* by the International Mycological Institute (IMI), Egham, Surrey, U.K with confirmation identity number as (IMI 703252). Pure cultures obtained were placed in slant bottles and kept for future use.

**Tests for Pathogenicity**

**Inoculation of fruits**

Fruit wounding technique described by (Sun et al. 2008) was used. Ten (10) green matured mango fruits (Temo variety) were, collected from the IAR orchard, Zaria, washed thoroughly under running tap water, surface sterilized using 1 % sodium hypochlorite (NaOCl). The fruits were injured slightly with pin pricks using sterilized needle. Spore suspension (0.5 ml/fruit) was sprayed over the fruits using syringe. Another ten (10) fruits sprayed with Sterile Distilled Water (SDW) after pinprick injury served as control. Inoculated fruit surface was covered with moist cotton wool and incubated at room temperature (28 ± 2°C) for five days. Disease symptoms were observed causative organism was re-isolated and compared with the original culture to confirm Koch’s postulates as described by (Onyeani and Amusa 2015; Schumann and Darcy 2006).

**Inoculation of leaves**

Mango stones sourced from Institute of Agricultural Research (IAR), Zaria were surface sterilized, planted in 20 cm diameter plastic pots filled with heat-sterilized soil and arranged on a glasshouse bench. One stone per pot was planted and watered regularly. Seedlings were arranged in completely randomized design (CRD) replicated four times. At 12 weeks after sowing (8 – 10 leaves stage) the upper axial leaf surfaces of the mango seedlings were inoculated with the conidia of *C. gloeosporioides* and other fungi associated with mango anthracnose isolated earlier using three different inoculation methods, data on lesion sizes produced by each fungi were taken daily for 7 days ( data not shown). Leaves inoculated with anthracnose causing pathogen *C. gloeosporioides* and shown its symptoms was used to confirm Koch’s postulates for pathogenicity as described by (Schumann and Darcy 2006).

**Data analysis**

Monthly temperature, rainfall and relative humidity data presented as an average over 10-15 years for each of the agro ecological location were downloaded from http://www.soilsnigeria.net. Annual mean data of the above mentioned environmental factors at each location were estimated from their mean during each month. Data collected from each orchard were analyzed separately using analysis of variance (ANOVA) with SAS. Means separated using student-Newman-Keuls (SNK) at 5% level of significance and LSD where suitable at 5% level of significance (P ≤0.05).

**Results**

**Incidence and severity of mango anthracnose in Niyya orchard**

Incidence and severity of anthracnose on mango leaves and fruits in Niyya orchard significantly varied among the ten (10) varieties surveyed. The highest disease incidence on leaves (47.20 and 44.80 %) was recorded on varieties Temo and Tommy correspondingly, followed by variety Keith (37.60 %) (Table 2). Lowest disease incidence on leaves was recorded on variety Dankamaru (19.20 %). There were also significant differences among the Mango varieties in leaves anthracnose severity. The highest disease severity (55.80 %) was recorded on variety Temo, followed by Tommy (53.40 %). Lowest severity on leaves in Niyya (40.00 %) was recorded on variety Dankamaru. (Table 1). There were also significant differences among the Mango varieties in leaves anthracnose severity. The highest disease severity (55.80 %) was recorded on variety Temo, followed by Tommy (53.40 %). Lowest severity on leaves in Niyya (40.00 %) was recorded on variety Dankamaru. (Table 1). Highest incidence (82.00 and 76.00 %) of Mango anthracnose on fruit in Niyya orchard was recorded on varieties Peter and Temo respectively, followed by variety Keith (37.60 %) (Table 2). Lowest disease incidence on leaves was recorded on variety Dankamaru (19.20 %). There were also significant differences among the Mango varieties in leaves anthracnose severity. The highest disease severity (55.80 %) was recorded on variety Temo, followed by Tommy (53.40 %). Lowest severity on leaves in Niyya (40.00 %) was recorded on variety Dankamaru. (Table 1). There were also significant differences among the varieties in Niyya. The highest severity of (48.40 %) disease severity on fruits was recorded on variety Peter, followed by Tommy (40.80 %). The least (24.00 %) was recorded on variety Dankamaru.
Table 2: Incidence and severity of Mango anthracnose in IAR, Zaria orchard

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Leaves Disease incidence (%)</th>
<th>Leaves Disease severity (%)</th>
<th>Fruits Disease incidence (%)</th>
<th>Fruits Disease severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temo</td>
<td>47.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>76.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tommy</td>
<td>44.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>53.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Keith</td>
<td>37.60&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>49.80&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>33.60&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Irwin</td>
<td>35.20&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>46.40&lt;sup&gt;d&lt;/sup&gt;</td>
<td>20.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>32.00&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Peter</td>
<td>34.40&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>49.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>82.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>48.40&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pitch</td>
<td>31.20&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>43.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
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<td>Maya</td>
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<td>45.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>22.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>24.80&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Julie</td>
<td>28.80&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>44.60&lt;sup&gt;d&lt;/sup&gt;</td>
<td>34.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>31.20&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bakinaku</td>
<td>22.40&lt;sup&gt;d&lt;/sup&gt;</td>
<td>42.60&lt;sup&gt;d&lt;/sup&gt;</td>
<td>24.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>26.40&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dankamaru</td>
<td>19.20&lt;sup&gt;d&lt;/sup&gt;</td>
<td>40.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>26.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>24.00&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>SE±</td>
<td>3.27</td>
<td>2.75</td>
<td>6.34</td>
<td>3.31</td>
</tr>
</tbody>
</table>

Means with the same superscript in a column are not significantly different at 5% level of significance (P ≤0.05) using Student- Newman-Keuls (SNK) Test.

Incidence and severity of Mango anthracnose in IAR, Zaria orchard

Incidence and severity of anthracnose on mango leaves and fruits on the six mango varieties in IAR, Zaria mango orchard were surveyed. There were no significant differences (P ≤ 0.05) on the disease incidence on leaves on varieties Alphonso, Keith and Binta sugar (37.60, 36.00 and 32.80 %) respectively (Table 3). Lowest disease incidence on leaves in the orchard was recorded on variety Temo (17.00 %). There were significant differences among the varieties in leaves anthracnose, the highest disease severity (52.40 %) was recorded on variety Alphonso, followed by Binta sugar, Keith, Pitch and Kanbiri which were statistically similar. Lowest severity on leaves at IAR orchard (40.80 %) was recorded on variety Temo (Table 3). Highest incidence (18.00 %) of anthracnose on fruits of varieties in IAR orchard was recorded on variety Kanbiri, followed by Temo (15.60 %), Pitch (15.60 %), Binta sugar (14.00 %) and Keith (11.60 %). Variety Alphonso had no fruits at the time of the survey because it is an early maturing variety therefore no disease recorded on its fruits (Table 3). There were also significant differences in disease severity among the varieties in IAR orchard. The highest severity of (41.20 %) on fruits was recorded on variety Binta sugar, followed by Kanbiri, Temo, Pitch and Keith in that order.
Table 3: Incidence and severity of mango anthracnose in IAR, Zaria orchard

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Leaves Disease incidence (%)</th>
<th>Leaves Disease severity (%)</th>
<th>Fruits Disease incidence (%)</th>
<th>Fruits Disease severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alphonso</td>
<td>37.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>52.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Keith</td>
<td>36.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46.80&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.60&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>24.80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Binta sugar</td>
<td>32.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.20&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>14.00&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>41.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pitch</td>
<td>26.40&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>45.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.60&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>24.80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kanbiri</td>
<td>17.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.40&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Temo</td>
<td>17.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.60&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>26.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD</td>
<td>11.31</td>
<td>6.11</td>
<td>10.72</td>
<td>8.01</td>
</tr>
</tbody>
</table>

Means with the same superscript in a column are not significantly different at 5% level of significance (P ≤ 0.05) using Least significance difference (LSD).

Incidence and severity of Mango anthracnose in Yanbukar orchard

Incidence and severity of anthracnose on mango leaves and fruits on the five varieties in Yanbukar orchard were surveyed. There were no significant differences (P ≤ 0.05) on disease incidence of leaves on varieties Bakinaku, Kurzunu and Dankamaru. Variety Fafaranda (16.80 %) and Soto (8.80 %) were statistically at par (Table 4). There were no significant differences (P ≤ 0.05) in severity on leaves of varieties Bakinaku, Kurzunu and Dankamaru (51.40, 46.40 and 46.00 %) respectively. The least severity on leaves (36.60 %) was recorded on variety Soto although they are statistically the same with variety Fafaranda (39.60 %). There was no significance difference on disease incidence and severity of fruits of the five varieties surveyed in Yanbukar.

Table 4: Incidence and severity of anthracnose in Yanbukar orchard

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Leaves Disease incidence (%)</th>
<th>Leaves Disease severity (%)</th>
<th>Fruits Disease incidence (%)</th>
<th>Fruits Disease severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bakinaku</td>
<td>40.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>51.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kurzunu</td>
<td>30.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>35.60&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Dankamaru</td>
<td>28.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>22.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.80&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fafaranda</td>
<td>16.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Soto</td>
<td>8.80&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.40&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD</td>
<td>10.55</td>
<td>4.96</td>
<td>19.00</td>
<td>13.82</td>
</tr>
</tbody>
</table>

Means with the same superscript in a column are not significantly different at 5% level of significance (P ≤ 0.05) using Least significance difference (LSD).

Incidence and severity of mango anthracnose in Dabiran mango orchard

Incidence and severity of anthracnose on leaves and fruits of the five varieties in Dabiran varied significantly. The highest disease incidence on leaves (38.40 %) was recorded on variety Dangafare (Table 5), and lowest on variety Maijijiya (10.40 %). Similar trend was obtained for the severity, in which highest (49.40 %) was recorded on variety Dangafare and...
least (37.80 %) was on Maijijiya. Variety Dangaftare had the highest incidence (42.00 %) on fruits while Furdu recorded the least (11.60 %), though they are statistically at par with Maijijiya, Dafsha and Bakinaku varieties. For disease severity on fruits, variety Dangaftare had the highest (36.40 %) and Bakinaku recorded the least (23.00 %).

Table 5: Incidence and severity of mango anthracnose in Dabiran orchard

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Leaves</th>
<th>Disease incidence (%)</th>
<th>Disease severity (%)</th>
<th>Fruits</th>
<th>Disease incidence (%)</th>
<th>Disease severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangaftare</td>
<td>38.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>49.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>42.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bakinaku</td>
<td>20.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dafsha</td>
<td>18.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furdu</td>
<td>15.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>38.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maijijiya</td>
<td>10.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>11.08</td>
<td>4.91</td>
<td>13.31</td>
<td>9.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means with the same superscript in a column are not significantly different at 5% level of significance (P ≤0.05) using Least significance difference (LSD).

Discussion

Anthracnose disease was recorded at all the surveyed mango orchards. From this study, the incidence and severity of anthracnose on mango leaves and fruits was significantly different at among the surveyed orchards. The results of pathogenicity test conducted on both the leaves and fresh mango fruits confirmed the prevalence of the disease in North western states across the surveyed agro-ecological areas. This is similar to the reports of (Sohiet al. 1973; Ploetz 1994; Chowdhury et al. 2008) that found anthracnose as common disease on mango. C. gloeosporioides the causal organism of anthracnose was ubiquitous and always predominant among other disease of mango (Arauz 2000). A varied amount of anthracnose disease on mango fruits was reported at Ayetoro, Ibadan, Ogbomoso and Lagos all located in the humid forest zone of South west Nigeria, recording the highest incidence at Lagos and lowest in Ogbomosho(Awa et al. 2012). The incidence and severity of anthracnose at Niyya farm mango orchard located in Southern Guinea savannah with lower temperature, higher rainfalls and relative humidity (Table 1) was higher than the other agro ecological zones. Varieties Temo and Tommy had the highest incidence and severity of anthracnose on leaves. Least incidence and severity of the disease on leaves was recorded on variety Dankamaru. This variety was believed to be brought to Nigeria from Cameroun as the name implies. Varieties Peter and Temo had the highest incidence on fruits in Niyya orchard with Irwin recording the least incidence. This agreed with an earlier screening work done in Hawaii by (Nishijima 1993), who reported varieties ‘‘Peter’’, ‘‘Tommy’’, and ‘‘Atkins’’ were more susceptible to mango anthracnose. (Sohiet al. 1973) also showed that incidence of anthracnose on fruits was positively correlated with prevailing relative humidity in the environment.

At IAR Zaria orchard, there was no significance difference between the incidence of anthracnose on leaves in varieties Alphonso, Keith and Binta sugar, the least was recorded in varieties Temo and Kanbiri. This may be attributed to the better agronomic management against possible diseases including anthracnose carried out by the institute. On fruits, Variety Binta sugar recorded the highest disease severity, no significance difference was observed between varieties Kanbiri, Temo, Pitch and Keith on their severity on fruits at IAR orchard. This is in conformity with work done in Florida by (Pernezny and Marlatt 2000) on reactions of different mango fruit to anthracnose. They reported that varieties Pitch, Julie, and Keith were moderately resistant to anthracnose, while variety Alphonso recorded lowest severity on fruits.

At the Yanbukar orchard, varieties Bakinaku and Kurzunu recorded highest incidence of anthracnose on leaves. The least incidence of the disease on mango leaves was recorded on variety Soto, although there was no significance difference on their mean with variety Fafaranda. Anthracnose severity on leaves among the varieties assessed in Yanbukar mango orchard was higher on variety Bakinaku, even though they were statistically at par with varieties...
Kurzunu and Dankamu as recorded on incidence on their leaves. Variety Soto had the least severity although there was no significance difference with the variety Fafaranda. This showed that the disease among the varieties that exist in this orchard followed the same pattern of distribution are such the incidence and severity on leaves are statistically the same with each other. There was no significance difference between the anthracnose incidence and severity on fruits in Yanbukar orchard, this showed the varieties assessed have the same status of the anthracnose. (Okigbo and Osuinde 2003) reported that the incidence and severity of anthracnose on mango varied significantly with mango orchards in south eastern Nigeria.

At Dabiran orchard, variety Dangaftare had the highest incidence and severity on its leaves. Least incidence and severity was recorded on variety Maiijiya, although they are not significantly different with Bakinaku, Dafsha and Furdu varieties. The same variety Dangaftare also recorded the highest disease incidence on fruits, while variety Furdu recorded the least. Among the varieties assessed in Dabiran mango orchard on anthracnose severity on fruits, Dangaftare had highest, followed by Maiiiya, Furdu and Bakinaku, which are statistically have the same level of severity percentage, this may be attributed to agro-ecological location of the orchard (Sahel savannah) which received the lowest annual rainfall, relative humidity than other surveyed orchards. These findings are similar to a report by (Prashanth 2007) that the incidence and severity of anthracnose on pomegranatefruits (*Punica granatum*) varied significantly with agro-climatic zones in India.

**Conclusion and recommendation**

The disease parameters of mango anthracnose caused by *Colletotrichum gloeosporioides* in the selected four orchards varied significantly with locations and varieties respectively. Our findings revealed that the brutality of the disease was higher at the areas of a low level temperatures, excessive rainfall and elevated relative humidity, and lower at location with low annual rainfall and relative humidity. Based on the findings of this study, varieties Bakinaku, Dankamaru, Maiiiya, Keith and Soto were moderately resistant to anthracnose on fruits and leaves. These varieties should therefore be recommended to be planted in the surveyed orchards and areas having the same environmental features.

### References


