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DISCUSSION: The discussion should be the inference drawn from the results as indicated in the previous section. Furthermore, implications and consequences of the results reported here should be backed up with previous relevant and recent literatures from past workers on the subject matter. Comparative analyses should be drawn from the inference in relation to previous works.

CONCLUSION: The contribution to scientific knowledge and suggestions for further research in line with the study could be indicated here.

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PRESIDENTIAL ADDRESS BY PROFESSOR D.B. OLUFOLAJI

The Nigerian Society for Plant Protection has come of age, ranking with notable National and International scientific Societies worldwide. As its concern for agriculture remains paramount in its agenda, the mission and vision of the Society remains undaunted towards its goals at all times. Since food production is inevitable to mankind and other animals survival, the protection of our plants therefore is an issue that must not be taken lightly.

The clarion call to all the stakeholders in agriculture, both public and private sectors alike should still be very dear to them if we have the collective duty to feed the teeming world population.

Our inputs are very important to achieve this goal. Since a sick plant cannot give the best in terms of growth, development and yield, our duty is to keep these plants healthy for our benefit and survival on earth. If our inputs in terms of fertilizers, good seeds and sound farming systems are alright, if the appropriate pest and disease control measures are not put in place, the farm produce will suffer great setbacks on the farm.

However, management of the agro-ecosystems should be handled with caution since an attempt to completely eliminate the pests and pathogens will alter the ecosystem and could be detrimental to the well-being of the animals which rely on the agro-ecosystem for their survival.

I call on members in various establishments to carry out meaningful research and attend both local and international conferences regularly in order to raise the standard in our areas of research. This will also assist us in widening our scope of knowledge. Let me also inform you as I have done before that our Society is a registered member of "International Society of Plant Pathology". I implore you to join some of these related International Societies: American Phytopathological Society, British Society for Plant Pathology among others.

Thanks for the opportunity you have given us to serve you.

Prof. D.B. Olufolaji
(National President)
BRIEF FROM THE EDITOR-IN-CHIEF

This edition is a follow up to the previous efforts made to ensure the regular turnout of Nigerian Journal of Crop Protection (NJPP). The 27th Volume is aimed for presentation at the 39th Annual conference holding at the Ladoke Akintola University, Ogbomosho.

Articles in this volume cut across the different disciplines of crop protection and the selection has been purely on the basis of merit and timeliness in the return of reviewed manuscripts.

Efforts will be geared towards production of the second edition of this volume before the end of the year. Therefore, members and non-members are encouraged to keep up the tempo of sending in articles for review as well as working on reviewed manuscripts. It is important though, to emphasise the need for the necessary peer review of articles before they are sent to the Editor-in-chief. This will no doubt reduce the time and effort deployed to the review of manuscripts.

I hereby appreciate the efforts of Associate Editors notably Dr. Joseph Abiodun of Landmark University, Omu-Aran, Kwara State and Dr. Tim Olabiyi of LAUTECH, Ogbomosho. I also acknowledge the consistent and selfless contributions of the Secretary, NSPP Dr. J.J. Atungwu towards the successful production of this volume. The President, NSPP, Prof. D.B. Olufolaji’s encouragement is also duly acknowledged.

I thank you all for the opportunity given to me to serve.

Prof. O.A. Enikuomehin
Editor-in-chief
A SURVEY OF INCIDENCE, SEVERITY AND CONTROL OF SOME PESTS AND DISEASES OF WHITE YAM IN ABUJA, NIGERIA  
(Yam Pest, Diseases and Control in Abuja)

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SUMMARY
The incidence, severity and control of some pests and diseases of yam in the Federal Capital Territory (FCT) Abuja, Nigeria were investigated. A total of 120 farms and stores in three villages each from five Area Councils of Abuja were assessed and visually rated between February and October, 2012. Questionnaires were also administered to the 120 farmers to obtain information on the method of control of pests and diseases of yam on the field and in their stores. On yam farms and in barns, the mean incidence of termites was 11.6% and that for rodents was 19.84%. Incidence of yam beetles was 10.85% while that of scale insect was 37.8%. Cercospora leaf spots mean incidence was 33.0%. The incidence of yam tuber Meloidogyne gall disease was 23.4% and more prevalent on meckusa cultivar especially those cultivated on poorly drained soils. The disease index of yam tuber gall was variety-dependent. Up to 55.0% of farmers treated their yam sets before planting. The outcome of this study provides basic information for integrated control strategy of pest and diseases of yam in the FCT, Abuja.

 Keywords: Abuja-Nigeria, Dioscorea rotundata, Disease Index, Incidence, Severity, Agricultural Pests.

WHITE yam (Dioscorea rotundata Poir) is a major food crop contributing to food security and poverty alleviation in Nigeria. Nigeria is the largest producer of yam in the world with an annual production of 36.72 million metric tons in 2007 (24). White yam is unique among food crops in relation to the prestige it enjoys and the central role it plays in the socio-economic life of the people of southern and central Nigeria (20).

In spite of the increase in yam production, pest damage and disease infection have constituted major constraints to increased yam output (29). It is estimated that agricultural pests destroy about 50% of yam annually (7). The field and store pests reduce productivity, quality and thus the profitability of yam industry. The socio-economic consequences include low farm income and consequently, increased hunger, poverty, malnutrition and loss of Gross Domestic Product (GDP). In West Africa, the yam nematode, Scutellonema bradys, is a major causal agent of dry rot (4). Economic insect pests of yam include the beetle (Heterolygus meles), termites (Amitermes spp.), aphids (Aphis spp.). Others are scale insects, mealy bugs, grasshoppers, mites, whiteflies, leaf hoppers and weevils (41). Important economic diseases of yam include anthracnose, blight, Cercospora leaf spot, mosaic and tuber rot (3).
Pest identification and monitoring which are among the tools of Integrated Pest and Disease Management (IPDM) keep track of the pests and their potential damage. These tools provide knowledge about the current pests and crop situation and are helpful in selecting the best possible combinations of the pest management methods. They could also help in reducing the need for pesticide usage, and ensure that the appropriate pesticides are used. The point at which pests and disease will become an economic threat is critical to guide future pest and disease control decisions (15).

There have been several reports on the distribution and incidence of pests and pathogens in Nigeria (8, 9, 10). There is, however, a dearth of information on the incidence, severity and the use of IPDM tool on pests and diseases of tuber crops in the FCT Abuja. This study was aimed at determining the incidence, severity and control measures of pests and diseases of yam in Abuja, Nigeria with emphasis on the disease severity index of tuber gall disease of white yam.

MATERIALS AND METHODS

Study area

The study was carried out in the Federal Capital Territory (FCT), Abuja, Nigeria situated between Lat. 9° 40' N and Long. 7° 29' E with a total land area of 713 km². The study area covered five out of six Area Councils namely, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali. The study was carried out between February and October, 2012.

Sampling method and data collection

Three villages were selected randomly from each Area Council and ten yam farms and stores per Area Council were visited for the study. A total of 120 questionnaires were
also administered to the farmers to obtain information on how they control the pest and diseases on yam on the field and in the store. Five farmers each out of the respondents from each Area Council were individually interviewed and when necessary with the help of an interpreter.

Pest and disease incidence and severity were visually rated on at least three spots in a farmer’s field or store visited by random sampling. Percentage incidence was expressed, as the number of infected yam stand over the total number of yam stands sampled. Severity was expressed as the total area of the yam part tissue affected over the total area of the plant tissue. The general formulae used for estimations are:

\[
\text{disease incidence} = \frac{\text{number of diseased plant} \times 100}{\text{total number of sampled plant}}
\]

\[
\text{disease severity} = \frac{\text{total area infected}}{\text{total area}}
\]

\[
\text{disease severity index} = \sum_{i=1}^{n} \frac{\text{grade} \times \text{area infected}}{\text{total area}}
\]

where:

- \( x \) = number of plants (entries) in each grade in each replication
- \( 0 - n \) = Grades of injury/disease as per disease rating scale (5).

**Specific visual severity score/rating for yam pests diseases**

A severity scale of 1-5 was used where: 1= No damage /infection, 2= Slight damage /infection, 3= Moderate damage /infection, 4= Extensive damage /infection and 5= Very extensive damage /infection.

**Grasshopper damage rating**

Grasshopper severity was estimated using the visual rating scale of 1-5 per individual plant. Where, 1 = 0 = 20% of foliage consumed, 2 = 21 – 40% of foliage consumed, 3 = 41 – 60% of foliage consumed, 4 = 61 – 80% of foliage consumed and 5 = 81- 100% of foliage consumed as given by Capinera (8) and (25).

Data on plant damage was collected from the two middle rows per plot.

**Termite damage**

The tubers were examined for the presence of emergence holes, frass, webbings and dusts indicating termite feeding. The damage was graded using a rating scale of Erlinda et al. (12) as follows: 1 = no infestation; 2 = 1 - 10% of the tubers infested; 3 = 11 - 25% of the tubers infested; 4 = 26 - 50% of the tubers infested and 5 = > 50% of the tubers infested.

**Scale insect and mealy bug damage**

The scale insect incidence was assessed by counting the number of individual plants infested in each replication as given by Mshai et al. (24) with suitable modifications. The damage rating was based on the percentage infestation of the surface area to the total surface area of the tubers. The scale insect damage severity index was worked out using the formula of Hoda et al.(17).

**Yam mosaic disease (YMD) rating**

Disease severity on plants was assessed by rating the symptom expressed on six topmost leaves of one shoot per plant in line with ITA (8). The rating method was based on a score of 1-5 where: 1 = no symptoms observed; 2 = mild chlorotic pattern over entire leaflets or mild distortion only at base of leaflets with the rest of the leaflets appearing green and healthy; 3 = conspicuous mosaic pattern throughout leaf, narrowing and distortion of lower one-third of leaflets; 4 = severe mosaic, distortion of two-thirds of leaflets and general reduction of leaf size; and 5 = severe mosaic, distortion of four-fifth of leaves, twisted and misshapen leaves.
Cercospora leaf spot, blight and anthracnose diseases of yam

The modified rating of Fokunang et al. (7), Enikuomehin et al. (11) and Krishnambika et al. (23) were adopted as follows: 1 = No disease (No trace of infection) 2 = Trace infection (Small lesions on lower leaves); 3 = Slight infection (Small lesions on upper and/or lower leaves); 4 = Moderate infection (Advanced lesions on upper and/or lower leaves, with or without new infections on pediole); and 5 = Severe infection (Advanced lesions on upper and lower leaves, buds and pedioles). Advanced lesion was characterised by a dark to dark-brown spot with a whitish to straw-coloured or perforated center.

Yam tuber Meloidogyne gall disease

The percentage incidence of yam tuber Meloidogyne gall disease on farmer’s field and store was determined as follows: % incidence = No of galled yam tubers/Total no of yam tubers examined x 100. Infectivity was determined as Gall Index (G.I.) on individual tubers using the following key based on Ogara and Bina (31) and Taylor and Sasser (39): 0 = No galls, 1 = 1-2 galls, 2 = 3-10 galls, 3 = 11-30 galls 4 = 31-100 galls and 5 = more than 100 galls. The mean gall index was collected for each of the locations.

Tuber rot disease assessment

Incidence was recorded as percent of plants showing tuber rot, while disease severity was based on visual rating scales in line with 1 to 5 rating scale of Yusuf and Okusanya (44) which is as follows: 1 = clean, 2 = slight, 3 = moderate and 4 = severe; 5 = very severe by considering the surface area and depth of rot.

Statistical Analysis

The observations on the pest and disease incidence/severity of diseases were made based on the mean of three replications. The data collected were subjected to descriptive statistics and figuratively shown by pie and bar charts. The Analysis of Variance was computed and separation of treatment means was carried with a statistical package SPSS statistics version 17.0. All probabilities were appreciated at the 5% confidence level.

RESULTS

The primary occupation of the traditional inhabitants of Abuja is farming, trading and public service.

Prevalence of yam cultivars in the Federal Capital Territory, Abuja, Nigeria

As shown in Table 1, Mecakusa cultivar was the most cultivated white yam in the FCT, Abuja. This was followed by Dammicha while Lagos was only prevalent in Gwagwalada area. The farmers interviewed traced the Mecakusa’s popularity to its high yield potential and ability to thrive well in low nutrient soil.

<table>
<thead>
<tr>
<th>Area Council</th>
<th>White Yam Cultivars</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ame</td>
<td>Akuki</td>
</tr>
<tr>
<td>Abuja</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Municipal</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bwari</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gwagwalada</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Kuje</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Kwali</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

* = present, - = absent.
Incidence of pests and diseases of yam in Federal Capital Territory, Abuja

Fig. 2 shows that mosaic virus disease had the highest mean incidence in the FCT area councils (Table 2). Grasshopper incidence in yam field was significantly lower ($p < 0.05$) in Bwari and Kuje than in other area councils. Grasshopper infestation varied from slight to moderate in one area council to another and from one yam field to another.

### Table 2: Mean Incidence and Severity of termite and grasshoppers in yam fields in the FCT - Abuja, Nigeria

<table>
<thead>
<tr>
<th>Area council</th>
<th>Incidence (%)</th>
<th>Severity class</th>
<th>Incidence (%)</th>
<th>Severity class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abuja municipal</td>
<td>10.0b</td>
<td>Slight damage</td>
<td>30.0c</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>Bwari</td>
<td>0.0d</td>
<td>No damage</td>
<td>25.0d</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Gwagwalada</td>
<td>20.0a</td>
<td>Moderate damage</td>
<td>48.0b</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Kuje</td>
<td>10.0b</td>
<td>Slight damage</td>
<td>25.5d</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Kwali</td>
<td>6.0e</td>
<td>Slight damage</td>
<td>56.5a</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>Mean (FCT)</td>
<td>11.6</td>
<td></td>
<td>37.0</td>
<td></td>
</tr>
</tbody>
</table>

Means with the same letters along the column are not significantly different ($p > 0.05$) as analyzed by DMRT.
Incidence of yam beetle and scale insect
Yam beetle incidence in FCT-Abuja was significantly different ($p = 0.05$) from one area council to another. Kwali area council recorded the highest incidence (18%) while Bwari recorded the least incidence of 10%. Yam beetle severity varied from slight damage in Abuja municipal, Bwari and Gwagwalada area councils to moderate damage in Kwali (Table 3). Incidence of scale insect in yam stores in FCT-Abuja was significantly higher ($p < 0.05$) in Abuja municipal than other area councils. There was no significant difference ($p > 0.05$) in the scale insect incidence in Gwagwalada and Kwali ($p > 0.05$). Abuja municipal recorded severe case of yam damage by scale insect. Scale insect infestation was observed in yam stores in most of the surveyed area with the exception of Kuje.

Table 3: Mean Incidence and Severity of yam beetle and scale insect on yam in the Federal Capital Territory, Abuja

<table>
<thead>
<tr>
<th>Area council</th>
<th>Yam beetle</th>
<th>Scale insect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incidence (%)</td>
<td>Severity class</td>
</tr>
<tr>
<td>Abuja municipal</td>
<td>7.3c</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Bwari</td>
<td>2.0d</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Gwagwalada</td>
<td>14.0b</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Kuje</td>
<td>10.0c</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Kwali</td>
<td>18.0a</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>Mean (FCT)</td>
<td>10.26</td>
<td></td>
</tr>
</tbody>
</table>

Means with the same letters along the column are not significantly different ($p > 0.05$) as analyzed by DMRT.

Incidence and severity of rodent and Cercospora leaf spot disease
Incidence of rodent in yam field in Kuje was significantly ($p < 0.05$) higher than in other area councils. Rodent severity of damage in yam field and store varied from slight damage in Abuja municipal and Bwari area council to moderate damage in Gwagwalada, Kuje, and Kwali (Table 4). On Kuje yam field, Cercospora leaf spot incidence was significantly higher ($p < 0.05$) than other area councils. Kwali area council recorded the least incidence (28.2%) and with slight infection.

Table 4: Mean Incidence and Severity of infestation of rodents and Cercospora leaf spot on yam fields in the FCT Abuja

<table>
<thead>
<tr>
<th>Area council</th>
<th>Rodent</th>
<th>Leaf spot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incidence (%)</td>
<td>Severity class</td>
</tr>
<tr>
<td>Abuja municipal</td>
<td>20.0c</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Bwari</td>
<td>10.0d</td>
<td>Slight damage</td>
</tr>
<tr>
<td>Gwagwalada</td>
<td>10.0d</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>Kuje</td>
<td>35.2a</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>Kwali</td>
<td>24.0b</td>
<td>Moderate damage</td>
</tr>
<tr>
<td>Mean (FCT)</td>
<td>19.84</td>
<td></td>
</tr>
</tbody>
</table>

Means with the same letters along the column are not significantly different ($p > 0.05$) as analyzed by DMRT.

Incidence of tuber rots and mosaic virus diseases
Yam tuber rot was observed in all the surveyed area councils in FCT-Abuja with a mean incidence of 32.5% (Table 5). There was a significant difference ($p < 0.05$) in the incidence of yam mosaic diseases in one
area council and the other. The symptoms observed on the yam leaves varied from vein banding, curling, mottling, green-spotting to flecking.

Table 5: Incidence and severity of tuber rot and mosaic disease in yam fields in the FCT

<table>
<thead>
<tr>
<th>Area council</th>
<th>Tuber rot</th>
<th>Yam mosaic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incidence (%)</td>
<td>Severity class</td>
</tr>
<tr>
<td>Abuja municipal</td>
<td>40.0a</td>
<td>Moderate infection</td>
</tr>
<tr>
<td>Bwari</td>
<td>30.5d</td>
<td>Moderate infection</td>
</tr>
<tr>
<td>Gwagwalada</td>
<td>20.0e</td>
<td>Slight infection</td>
</tr>
<tr>
<td>Kuje</td>
<td>37.0b</td>
<td>Moderate infection</td>
</tr>
<tr>
<td>Kwali</td>
<td>35.0e</td>
<td>Slight infection</td>
</tr>
<tr>
<td>Mean (FCT)</td>
<td>32.5</td>
<td></td>
</tr>
</tbody>
</table>

Data is a means of three replicates. Means with the same letters along the column are not significantly different ($p < 0.05$) as analyzed by DMRT.

Incidence of bacterial blight, anthracnose and yam tuber *Meloidogyne* gall diseases

Incidence of bacterial blight disease in the yam fields in Kwali area council was significantly higher than in other area councils. Severity of infection was moderate in Kwali but slight in Abuja municipal and Gwagwalada (Table 6). Incidence of yam anthracnose disease was significantly higher than other area councils, while Gwagwalada recorded the lowest disease incidence (20%). Severity of damage by anthracnose was slight in all the area councils where the disease occurred. Yam tuber *Meloidogyne* gall disease was observed in all the area councils. Severity of infection was however slight in all the area except in Gwagwalada where it was moderate.

Table 6: Mean Incidence and Severity of bacterial blight and anthracnose in yam fields in the FCT

<table>
<thead>
<tr>
<th>Area council</th>
<th>Bacterial blight</th>
<th>Anthracnose</th>
<th>Yam tuber gall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incidence (%)</td>
<td>Severity class</td>
<td>Incidence (%)</td>
</tr>
<tr>
<td>Abuja municipal</td>
<td>12.0b</td>
<td>Slight infection</td>
<td>26.7b</td>
</tr>
<tr>
<td>Bwari</td>
<td>0.0d</td>
<td>No infection</td>
<td>22.5c</td>
</tr>
<tr>
<td>Gwagwalada</td>
<td>10.0e</td>
<td>Slight infection</td>
<td>20.0d</td>
</tr>
<tr>
<td>Kuje</td>
<td>0.0d</td>
<td>No infection</td>
<td>0.0c</td>
</tr>
<tr>
<td>Kwali</td>
<td>33.0a</td>
<td>Moderate infection</td>
<td>30.0a</td>
</tr>
<tr>
<td>Mean (FCT)</td>
<td>11.0</td>
<td></td>
<td>20.0</td>
</tr>
</tbody>
</table>

Means with the same letters along the column are not significantly different ($p < 0.05$) as analyzed by DMRT.

Yam *Meloidogyne* gall disease index in two major yam cultivars in Abuja

The severity index of tuber gall disease of three local yam cultivars in barns in Gwagwalada was quantified and disease index computed. Table 7 indicates that, *mekakusa* cultivar had highest tuber gall disease index of 0.18 (Table 7).
Table 7: Yam *Meloidogyne* gall Disease Index of the three major yam cultivars in Abuja

<table>
<thead>
<tr>
<th>Disease scale</th>
<th>White yam varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Mecakusa</em></td>
</tr>
<tr>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Disease index</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Twenty randomly selected samples per cultivar were involved.

The status of pest and diseases control by yam farmers in Abuja

Only 0.25% of the farmers adopted minisett innovation (Table 8). Considerable number of farmers (65%) intercropped their yam with maize. Many farmers (55%) indicated that dipping of yam seeds in insecticide/fungicide solution before planting is a control measure for tuber rot. Nine percent (9%) of the farmers avoided planting and storage of damaged/rotten yams. Up to 60% of the farmers were not aware of the foliage diseases of yams and only 10% of them adopt a control measure. The major problem faced by most FCT farmers were their inability to detect the presence of disease, differentiate between disease symptoms and lack of knowledge on modern management methods.

Table 8: Control methods of pests and diseases of yam by the FCT Farmers

<table>
<thead>
<tr>
<th>Control Method</th>
<th>% Usage by yam farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cultural</strong></td>
<td></td>
</tr>
<tr>
<td>1. Burning of infected debris</td>
<td>90</td>
</tr>
<tr>
<td>2. Crop rotation</td>
<td>50</td>
</tr>
<tr>
<td>3. Mixed cropping</td>
<td>65 (maize)</td>
</tr>
<tr>
<td>4. Heat therapy</td>
<td>0</td>
</tr>
<tr>
<td>5. Rousking out infected plant</td>
<td>25</td>
</tr>
<tr>
<td>6. Appropriate planting and harvesting dates</td>
<td>40 (market condition)</td>
</tr>
<tr>
<td>7. Hand picking</td>
<td>7</td>
</tr>
<tr>
<td>8. Avoidance of damaged/rotten yams for planting/storing</td>
<td>9</td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
</tr>
<tr>
<td>1. Installation of traps</td>
<td>20</td>
</tr>
<tr>
<td><strong>Biological control</strong></td>
<td></td>
</tr>
<tr>
<td>1. Use resistant/improved cultivars</td>
<td>0.25 (minisett)</td>
</tr>
<tr>
<td>2. Use conservation of natural enemies of pests such as insect predators, parasitoids, pathogens and weed feeders/use of biocontrol agent</td>
<td>0</td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td></td>
</tr>
<tr>
<td>1. Dipping of stem cuttings/yam set in nemacur</td>
<td>55</td>
</tr>
<tr>
<td>2. Use of nematicide like carbofuran</td>
<td>45</td>
</tr>
<tr>
<td>3. Wood ash or locally dry gin for seed treatment</td>
<td>9.5</td>
</tr>
<tr>
<td>4. Botanical pesticides for seed treatment</td>
<td>12</td>
</tr>
<tr>
<td>5. Application of potash fertilizer</td>
<td>10</td>
</tr>
</tbody>
</table>
DISCUSSION
The popularity of a particular yam cultivar in an area council could be a function of its yield potential, storability and palatability. *Mecakusa* yam cultivar is often referred to as the king of yam because of the relatively giant tubers it produces. However, it was confirmed to be highly susceptible to *Meloidogyne* tuber gall disease. Some farmers preferred *Dannicha* because it can store better, is less susceptible to gall and rot pathogens and more palatable when cooked, fried and/or pounded. Determining the incidence, severity and prevailing control measures in any agro-ecosystems is necessary for the formulation of a good pest management strategy. IITA (18) reported that yam damage by termites is most severe when there is moisture stress particularly in the savanna belt and grass hoppers damage is most serious during the dry season starting from the end of rains in September. Modder (28) reported that hatched population of grasshoppers attack crops when preferred herbaceous food plant becomes scarce. Grasshoppers' incidence was higher in yam than in adjacent cassava farms. This might be due to some anti-nutritional factors such as cyanogenetic glucosides content of the adjacent cassava cultivars (21). Keckunou (22) reported that the increased impact of the grasshopper currently observed today in the fields, compared to what existed in the recent past is as a result of deforestation and increase in herbaceous fallow instead of forest and shrubby fallows. Bernays (6) recommended host plant resistance could be adopted as an alternative means to the control of grasshoppers instead of using synthetic insecticides. Ijon (19) and Tobih (42) reported a higher beetle occurrence in the upper Niger Delta than the 10.86% incidence observed in the survey. Scale insect has been a problematic insect pest of yam tubers in the FCT. Salako et al. (37) reported that neem extract significantly reduced this insect pest in stored yam tubers. On the incidence of yam rots, Amusa and Baiyewu (2) reported that when infected tissues become soft, ramified by the fungal mycelium and turn brown and become soft, it is termed soft rot. Fungi associated with soft rot of yam are *Rhizopus* spp., *Sclerotia rolfsii* and *Rhizoctonia solani* and *Armillariella mellea*. On the hand, wet rot is characterized by the oozing of whitish fluid out of the tissue when pressed. This symptom is usually associated with the bacterium *Erwinia carotovora*. In case of dry rot, the infected tissues become hard and dry. This is when tubers are infected with *Penicillium oxalicum*, *P. cyclopium*, *Aspergillus niger*, *A. tamari* and *Botryodiplodia theobromae* (13). Onyeka (35) reported that tuber rot is prevalent on farms where rainfall is high and the soil is poorly drained. Morse et al. (27) reported that most of the yam rot induced by fungi in specialized barns in Kogi State, Nigeria were predisposed to insect attack by mainly mealybug (*Pseudococcus citri*) and scale insect (*Aspidiella hartii*) during storage. Further he said that treatment of yam tuber sets with fungicides such as Benlate, Captan, Actelic 2% dust has been found to be effective in reducing fungal yam rot. Ogundana (33) recommended *Tecto*® (Thiabendazole), locally made dry gins or wood ash before storage as they are known to have little or no mammalian toxicity (31).

In other to control bacterial blight in yam, it has been reported that Integrated control strategies should comprise of improved cultural methods, crop sanitation, resistant cultivars and quarantine measures to prevent introduction of highly aggressive strains to areas with low or no infection. Further crop rotation could completely break the life cycle of the pathogen, and
burying or burning of infected debris, can provide some control, especially under dry conditions, when the pathogen may survive in crop residues for up to 5 months (13). LITA, (18) added that the application of potash fertilizer could reduce blight disease severity.

On the incidence of tuber Meloidogyne gall disease, Ogara and Bina (31) reported the disease to be prevalent in Nasarawa State which is adjacent to Abuja. Fallowing, planting of healthy materials and destruction of infected crop cultivars are good control measures. The use of crop rotation and nematocide such as carbofuran granular at planting and dipping of seed pieces in nemacron are appropriate for reducing the inocula (38). For soil-borne diseases, the site on which yam sett is to be cultivated is often recommended for prior soil testing for the presence of the pathogen.

None of the Abuja farmers employed natural enemies of pests or bio control agents. Anjorin (3) recently reported that inconsistent field efficacy, questionable cost-effectiveness, high specificity of most bioagents, ecological instability and biocompatibility of the biocontrol agent with other Integrated Disease Management strategies are some of the constraints militating against its adoption.

The adoption of yam minisett technology for yam propagation is not yet popular among Abuja farmers. This might be due to the fact that it is capital intensive and time consuming. From the report of (43) on the factors influencing adoption of yam minisett technology in South eastern Nigeria, the estimated coefficient of awareness level was positive (0.570) and was significant at 1%. Awareness exercise should therefore be continued in the FCT so as to carry every farmer along in yam propagation by yam minisett technology. Otoo (36) cautioned that if not done properly the sets could rot and all investment wasted and thus advised farmers to allow the cut surfaces to be cured with insecticide, fungicide or wood ash treatment. McGee (26) and Cook (9) however recommended the use of clean heat sanitized tuber propagules as an excellent plant health management strategy. Ogbede et al. (32) reported that neem application at 30 tons/ha suppressed termites incidence and severity. More than half of the farmers intercropped their yam with maize. This was not with an intention of controlling pest or disease on their farm but to generate income. Cercospora leaf spot occurred in all the surveyed area councils in FCT-Abuja. If the severity is below the economic injury level, (35) and (40) recommended the use of copper fungicide (Copper oxychloride), Benomyl as a systemic fungicide and Rovral TS as a combination of systemic (Carbendazim) and non-systemic (Iprodion) fungicide showed significant effect in controlling the disease under field condition. Roguing-off of infected plants during the early stage could reduce secondary spread.

CONCLUSION

On yam farms and barns in the FCT, Abuja, the mean incidence of termites was 11.6% and that of rodents was 19.84%. Cercospora leaf spots disease mean incidence was 33.0% while that of scale insect was as high as 37.8%. The incidence of yam tuber Meloidogyne gall disease was 23.4% and was more prevalent on mecakusa cultivar especially when cultivated on poorly drained soils. The disease index of yam tuber gall was variety-dependent. Up to 55.0% of farmers treated their yam sets before planting. The use of agricultural extension agents for the education of farmers on modern control strategies of pest
and diseases of tuber crops should be resuscitated. Government should adequately provide farmers with subsidized and less hazardous insecticides, nematicides and fungicides and environment-friendly botanicals. Crop disease clinics should be introduced in each area councils of the FCT Abuja for farmers, extension agents and crop marketers to patronize. Further investigation into the influence of pests and diseases on various yam cultivars is imperative.

LITERATURE CITED


COMBINED EFFECT OF NPK FERTILIZER AND ARBUCULAR MYCORRHIZAL FUNGI (*Glomus mosseae*) ON THE INFESTATION OF THREE RICE (*Oryza sativa*) VARIETIES BY *Striga hermonthica*

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**SUMMARY**

Screen house experiment was conducted in 2008 and repeated in 2009 to evaluate the combination of NPK fertilizer and Arbuscular Mycorrhizal fungus (AMF), *Glomus mosseae*, for the management of *Striga hermonthica* in three rice (*Oryza sativa* L.) varieties. The treatments were laid out in split-split plot arrangement fitted into a randomized complete block design with three replicates. The main treatments consisted of two Striga resistant rice varieties, FARO 40 and WAB 56-50 as well as a susceptible variety, FARO 45. The sub treatments consisted of soil inoculations with Striga or the AMF, each alone and Striga mixed with AMF as well as no inoculation control. The three sub-sub treatments were made up of NPK (15-15-15) compound fertilizer rates at 100 kgN - 50 kgP₂O₅ - 50 kgK₂O/ha, 50 kgN - 25 kgP₂O₅ - 25 kg K₂O/ha and 0 kgN - 0 kgP₂O₅ - 0 kgK₂O/ha. The results revealed that rice varieties FARO 40 and WAB 56-50 exhibited high and moderate resistance to *S. hermonthica* respectively as reflected in high crop vigour score and shoot dry matter production; low reaction syndrome score and support for shoot emergence count of Striga as well as delay in emergence on rice compared to the susceptible FARO 45. Inoculation with mixture of AMF and Striga significantly (p < 0.05) improved rice growth parameters, delayed the emergence and reduced the emergence of Striga shoot on rice by up to 45% compared to Striga alone. Fertilizer application also mitigated the parasitism of Striga on rice, resulting in improved crop growth, reduced damage and emergence of Striga on the crop. Host x inoculation, host x fertilizer, and fertilizer x inoculation interactions, were significant (p < 0.05) on various rice and Striga parameters. Integration of AMF, host plant resistance and fertilizer application is an easily adoptable package that should be evaluated for sustainable Striga management in upland rice.

**Keywords:** *Glomus mosseae, Striga hermonthica, fertilizers, Rice*
RICE, a major staple food for approximately half of the world's population, had an estimated cultivated area of about 6.8 million hectares and total production of about 21.6 million tonnes in sub-Saharan Africa (SSA) in 2006 (12). One of the major constraints to the production of upland rice in SSA is weed infestation, especially that of parasitic *Striga* spp. Among these is *S. hermonthica*, which occurs in 80% of the cultivated lands in the Nigerian savanna. It infests several cereal crops, including upland rice as it is the most ubiquitous *Striga* spp. (28, 20). Isah et al. (24) reported yield loss of about 59% in susceptible rice variety, FARO 45 in the Southern Guinea Savanna of Nigeria. Host-plant resistance has been identified as a major sustainable component for the management of *S hermonthica* in various cereal hosts, especially rice (28, 26). In Nigeria, two varieties of upland rice, FARO 40 and WAB 56-50, have earlier been reported to consistently support low emergence of *S. hermonthica*, exhibited low damage by the parasite and produced acceptable grain yield in pot and field experiments over years (3, 24, 25). Application of high doses of N fertilizer was reported to reduce the incidence of Striga, decreased shoot count of the weed and its dry matter (9), reduced infestation and increased host cereal grain yield in Nigeria (31). The suppressive effect of N on Striga, especially at high rate, include reduction in Striga seed germination, inhibition of seedling attachment (10) subsequent development hence parasitism by the high concentration in host crop (30), alteration of balance of growth factors of the host in favour of shoots hence starvation of the parasite (33), accumulation of ammonium and nitrate ions to toxic levels (22) and higher transpiration rate in *Striga* than the host plant (17). Conversely, Yoneyama et al. (39) reported that nutrient deficiency could increase strigolactone production in potential host leading to high *Striga* seed germination hence infestation. Major constraints to the adoption of mineral fertilizer are cost, unavailability in adequate quantity and in time as well as long-term adverse effect on the health and physico-chemical properties of soil. The control of *Striga* is difficult to achieve because of its high fecundity (6), viability of the seed in the soil over several years, lack of seed germination in the absence of chemical stimulant from a suitable plant, close association with and aggressive growth on the host after attachment as well as vigorous growth after emergence (21). An integrated approach involving various components has therefore been suggested for a sustainable control of *Striga* in various host crops (28). The development of components for the new strategies should focus on initial subterranean stages, seed germination and haustorial initiation in the host parasite interaction (21). Ahonsi et al. (4) had suggested biological control involving the use of soil microorganism as a component of the integrated management system if it gave demonstrable yield within the season, because of the low-cost and accessibility to resource-poor SSA farmers. Among soil microorganisms, Arbuscular
Mycorrhizal Fungi (AMF) has been found essential components of sustainable soil-plant systems (36). AMF inoculation has been reported to reduce Striga shoot emergence on sorghum despite reduction in plant growth and dry matter production of the host crop plants (4). Several mechanisms suggested for decreased damage of AMF host by soil-borne pathogens and possibly hemi-parasites included increased nutritional status of the host plant, changes in quality and quantity - accumulation of phenolics in the endoderm (15) and lignifications of the root cell of the endodermis (11), root exudates, competition for colonization sites and mobilization of plants defence mechanism (7).

The objective of this study was to evaluate the integration of host plant resistance and compound inorganic fertilizer with AMF inoculation for the management of S. hermonthica infection in upland rice under the screen house condition.

MATERIALS AND METHODS

The experiments were conducted in the screen house of Niger State College of Agriculture, Mokwa (09°18'N; 05°04'E) in the Southern Guinea Savanna agro-ecological zone of Nigeria from October to December in 2008 and January to March in 2009. The experiment was laid out in a split-split plot arrangement in a randomized complete block design with three replicates. The three rice varieties, FARO 40, WAB 56-50 and FARO 45, constituted the main plot treatments while the subplot treatments were inoculation of the soil with Striga or G. mossae (AMF), each alone, and Striga mixed with AMF as well as no inoculation control. The sub-sub treatments consisted of application fertilizer at the respective N, P, O, and K rates of 100-50-50 kg/ha and 50-25-25 kg/ha as well as no fertilizer control. The rice varieties, FARO 40 and WAB 56-50, are Striga resistant varieties while variety FARO 45 is susceptible to Striga (23). The sandy loam soil (0.44% total N, 9.99 mg/kg available P and 0.29 cmol/kg exchangeable) which was collected from the crop farm was sieved to remove stones and debris before it was used to fill the pots. The pots inoculated with Striga were initially filled with sieved soil to two-third depth and later with soil/Striga seed mixture to the brim, to give evenly distributed approximately 3000 germinable Striga seeds per pot, following procedure of Kim (27). Glomus inoculation in the appropriate pots was done by spreading the inoculum on soil surface before mixing and covering up with soil. Fifty gramme (50 g) of the AMF inoculum, collected from International Institute of Tropical Agriculture, Ibadan Nigeria and multiplied at the Federal University of Agriculture, Abeokuta, Nigeria, was applied to each pot. The AM inoculum contains spores and hyphae of the fungus and root of fragments of rice as host.

Three rice seeds (surface sterilized in 1 % NaOCl for 15 mins) were sown in each pot. The soils were maintained at field capacity during the first week of the treatment and thereafter given 10 ml
water every 48 hours. The seedlings were later thinned down to two per pot at two weeks after planting. Fertilizer was split-applied using compound NPK 15-15-15 at half dose of N and full doses of \( P_2O_5 \) and \( K_2O \) at 3 WAP, while the remaining half of N was applied as urea at 6 WAP. Weeds, other than Striga were hand-pulled regularly from each pot when observed. Data were collected on the plant height, crop vigour and reaction to Striga scores as well as Striga shoot count all at 6, 9 and 12 WAP. Days to first Striga emergence and shoot dry weights of rice and Striga at 12 WAP, when the experiment was terminated, were also recorded. The data collected were subjected to Mixed Model Analysis of Variance and treatment means separated using Duncan’s Multiple Range Test where \( F \) values were significant at 5% level of probability. The discrete data were transformed using square root transformation.

RESULTS AND DISCUSSION

The results of the two screen house experiments conducted in 2009 and 2010 are presented in Tables 1 to 5. The rice varieties differed significantly \( (p < 0.05) \) in plant height, crop vigour score, crop reaction score and support for Striga shoot emergence count all at 6, 9 and 12 WAP as well as days to first Striga emergence; and Striga and crop dry shoot weights at 12 WAP. FARO 40 consistently had taller plants than FARO 45 (Table 1) while crop vigour score of rice varieties followed the order FARO 40 > WAB 56-50 > FARO 45 (Table 2). Crop reaction score of rice (Table 3) and the shoot count (Table 4) and weight of Striga on rice (Table 5) however followed a reverse trend to that of vigour score. First emergence of Striga (Table 5) was significantly delayed on FARO 40 by 6.4 and 7.0 compared to WAB 56-50 and FARO 45, respectively while

<table>
<thead>
<tr>
<th>Source Host (Rice)</th>
<th>Plant height at 6 WAP</th>
<th>Plant height at 9 WAP</th>
<th>Plant height at 12 WAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2009</td>
<td>Combined</td>
</tr>
<tr>
<td>FARO 40</td>
<td>15.6a</td>
<td>18.6</td>
<td>15.8a</td>
</tr>
<tr>
<td>WAB 56 - 50</td>
<td>13.3b</td>
<td>18.1</td>
<td>15.7ab</td>
</tr>
<tr>
<td>FARO 45</td>
<td>12.5c</td>
<td>17.6</td>
<td>15.2b</td>
</tr>
<tr>
<td>SE + (0.65%)</td>
<td>0.03</td>
<td>m</td>
<td>0.18</td>
</tr>
<tr>
<td>Inoculation (I)</td>
<td>13.1c</td>
<td>18.4a</td>
<td>15.8a</td>
</tr>
<tr>
<td>Striga</td>
<td>11.9d</td>
<td>16.6b</td>
<td>14.3c</td>
</tr>
<tr>
<td>Glomus</td>
<td>13.3b</td>
<td>18.3a</td>
<td>15.8b</td>
</tr>
<tr>
<td>Control</td>
<td>14.4a</td>
<td>18.5c</td>
<td>16.5a</td>
</tr>
<tr>
<td>SE + (0.65%)</td>
<td>0.02</td>
<td>0.41</td>
<td>0.20</td>
</tr>
<tr>
<td>Fertilizer (F)</td>
<td>100kg N - 50kg</td>
<td>13.2a</td>
<td>18.7a</td>
</tr>
<tr>
<td>P2O5 - 50kg K2O</td>
<td>13.2a</td>
<td>18.1a</td>
<td>15.6a</td>
</tr>
<tr>
<td>50 - 25 - 25</td>
<td>13.2a</td>
<td>18.1a</td>
<td>15.6a</td>
</tr>
<tr>
<td>No fertilizer</td>
<td>13.1b</td>
<td>17.1b</td>
<td>15.1b</td>
</tr>
<tr>
<td>SE + (0.65%)</td>
<td>0.01</td>
<td>0.25</td>
<td>0.18</td>
</tr>
<tr>
<td>H x F</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>I x F</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>H x I x F</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
</tbody>
</table>

*Means with the same alphabets along the columns are not significantly different from one another at \( p < 0.05 \) (DMRT)

\(^{2}\) (WA) Weeks After Planting

\(^{*}\)significant at 1% level of probability
crop shoot dry weight followed the order WAB 56-50 > FARO 40 > FARO 45 (Table 5).

Earlier reports by Adagba et al. (3) and Isah and Lagoke (25) have reported the consistent exhibition of resistance to Striga by rice varieties FARO 40 and WAB 56-50. The results on crop reaction score and various crop growth parameters, including plant height,
vigour score and dry matter production as well as support for Striga shoot emergence were also consistent with those observed earlier for the two rice varieties, even when different ecotypes of *S. hermonthica* were used to infect the crop (25). Some of the reasons suggested for reduced growth and productivity in the susceptible varieties, include early and copious production of germination
stimulant-strigolactone (35), uninhibited attachment to host plant root through haustoria (16) diversion of nutrients and assimilates from the host plant to the parasite (18), disruption of hormonal balance of host plant in favour of stress, hence growth inhibition (34) as well as production of phytotoxins that could further disrupt physiological processes in the host plant (37). The higher level of resistance exhibited by FARO 40 compared with WAB 56-50 as indicated in various growth parameters such as crop vigour score and reaction to Striga as well as support for low Striga shoot emergence corroborates earlier report of Adagba et al. (3). The delay of Striga emergence on FARO 40 compared with WAB 56-50 further emphasizes the superiority of FARO 40 over WAB 56-50 in resistance to Striga. This was probably due to delay in the germination of seeds, seedling attachment and subsequent development of the established plants of Striga on the host plant as a result of inadequate production of appropriate relevant chemical stimulants that initiate and promote these processes in parasitism (5, 18).

Inoculation and fertilizer application had significant (p < 0.05) effects on plant height (Table 1), crop vigour score (Table 2), crop reaction score (Table 3), shoot emergence count (Table 4) and dry weight of Striga shoot, days to Striga emergence on rice and crop shoot dry weight (Table 5). Inoculation with Striga alone resulted in shorter plants (Table 2) and lower plant vigour (Table 2) of rice compared with other inoculation treatments including the control. Inoculation with AMF alone and Striga/AMF mixture however resulted in more vigorous plants at 6 and 9 WAP than the control. Rice plants inoculated with Striga alone had higher crop reaction score than the other inoculation treatments including Striga/AMF mixture (Table 3). Inoculation with the mixture significantly reduced Striga shoot emergence count on rice by 49.3, 48.7 and 45.3% at 6, 9 and 12 WAP, respectively compared to Striga alone (Table 4). Striga shoot dry weight was similarly reduced on rice by 42.1% in the pots inoculated with the mixture (Table 4). Lendzemo et al. (29) and Orthira et al. (32) corroborated similar results on sorghum and maize, respectively.

In this study, Striga/AMF mixture induced crop reaction score comparable to that of plants inoculated with AMF alone at 6 to 12 WAP and higher than that of the control at 6 and 9 WAP. This indicates that the symbiotic association of AMF was greater on rice than parasitism of Striga. Torelli et al. (38) and Press et al. (34) reported that AMF colonization increased root IAA, hence compensating for the hormonal imbalance. This could well explain the delayed and reduced emergence of Striga on AMF colonised rice in this study. The two rates of fertilizer significantly (p < 0.05) increased rice plant height compared with the control at all stages while the heights of rice plants actually increased significantly with the rates of fertilizer used in this study at 12 WAP, possibly due to decline in inherent
soil fertility (Table 1). Crop vigour score (Table 2) and shoot dry weight of rice (Table 5) also increased significantly (p < 0.05) with fertilizer rate while a reverse trend was observed for crop reaction syndrome score (Table 3), Striga shoot count (Table 4) and dry weight on rice (Table 5). High rate of fertilizer delayed Striga emergence on rice compared with the low rate and no fertilizer control (Table 5). Earlier reports have confirmed that soil fertility, especially nitrogen stimulates host growth, while causing reduction in seed germination, seedling attachment, subsequent development and emergence of Striga on rice plants (1). However for effective reduction of Striga parasitism, simultaneous application of P and N is desirable rather than P alone (13).

**Host x inoculation interaction**

The interaction of rice varieties x inoculation was significant (p<0.05) on plant height and crop reaction score of rice at 9 and 12 WAP (Tables 1 and 3); crop vigour score and Striga shoot emergence count at 6, 9 and 12 WAP (Tables 2 and 4), days to first Striga emergence as well as shoot dry weights of Striga and crop (Table 5).

Mineral and organic mobilization for enhanced plant uptake, which consequently resulted in improved plant growth, had been attributed to AMF inoculation (8). It has been suggested that the AMF mycelium, which serves as an extension of the host plant root and the link with the soil nutrient reserve, facilitates nutrient extraction and absorption from the soil. The mutualistic biological relationship was also reported to affect water relation, hormonal balance and root colonization by other micro organism leading to the improvement of food plant health hence growth (14). In this study, it was possible that the mobilization of nutrient by AMF which increased nutrient availability at the early stage, enhanced rice growth at 6 and 9 WAP. Orthira et al. (32) also observed that in the absence of Striga, AMF colonization increased nitrogen content in Striga-susceptible maize cultivar while it increased N in both susceptible and tolerant maize cultivars.

**Inoculation x fertilizer**

The interaction of inoculation x fertilizer was significant (p < 0.05) on rice plant height at 9 and 12 WAP (Table 1), crop vigour score and crop reaction score at 6, 9 and 12 WAP (Table 2 and 3), Striga shoot count at 12 WAP (Table 4), days to first emergence and crop shoot dry weight (Table 5).

It is obvious that fertilizer application further enhanced the effect of AMF in reducing the symptoms of Striga parasitism on rice as reflected in improved crop vigour, plant height, reduction of emergence count and crop reaction score to Striga. Gworgwor and Weber (19) indicated that Striga seed germination, seedling attachment and parasitism on sorghum plants were reduced by the presence of nutrients P and N. The complimentary effect of fertilizer and AMF in reducing Striga parasitism on host crop was only possible when both N and P were simultaneously applied as it was done in this study (19).
Host x fertilizer interaction
Significant (p < 0.05) host x fertilizer application was observed on plant height at 6, 9 and 12 WAP (Table 1), crop vigour score at 9 and 12 WAP (Table 2), crop reaction score at 6, 9 and 12 WAP (Table 3), Striga shoot count pot at 9 and 12 WAP (Table 4) and days to Striga emergence and crop dry shoot weight (Table 5). The delay and reduction of Striga emergence on host plants by fertilizer is consistent with earlier reports on the differential effect of fertilizer on varieties of sorghum (19) and rice (2). This emphasises the need for combination of various components for the development of sustainable management of Striga in appropriate cereal host, rice in this case. There is however a need to relate N, P and K nutrient uptake by host to its reaction to Striga parasitism at various stages of crop growth, as part of the effort to develop a sustainable integrated management strategy for Striga in upland rice production.

CONCLUSION
In Africa, the crop production systems may be improved by introducing management strategies which are environment friendly. In this study, the three control components evaluated: host-plant resistance, AMF inoculation, and fertilizer application have each exclusively reduced Striga parasitism on rice. Their combinations have also had additive effects in enhancing the levels of reduction of Striga parasitism on the host crop. AMF obviously reduced Striga damage and improved plant growth when applied in mixture with the parasite. Glomus mossea which is a biological resource is readily available in the savannah and can be rapidly multiplied for use with very low cost to the farmer. Resistance varieties which constitute the most important component is cheap and readily adopted by farmers. However, nutrient which is also essential can be supplied in organic and inorganic forms. This study concludes that a integration of host plant resistance with AMF and adequate fertilizer application can constitute sustainable Striga management option.

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EFFECT OF SOME TROPICAL PLANT EXTRACTS ON MYCELIAL GROWTH AND SPORULATION OF Fusarium graminearum, CAUSAL AGENT OF Fusarium Head Blight (FHB) OF WHEAT (Triticum aestivum L.)

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SUMMARY

Extracts derived from leaves and stems of seven tropical plants were tested for their abilities to inhibit mycelial growth and sporulation densities of Fusarium graminearum, the causal agent of FHB. Mycelial growth of F. graminearum was significantly (p ≤ 0.05) reduced by hot water extract of V. amydalina (98%), S. torvum (97%), A. occidentales (85.9%) and A. indica (81.3%) stem. Similarly mycelial growth was significantly reduced by hot water leaf extract of M. oleifera (86.3%) and cold water leaf extract of O. gratissimum (75.9%). Sporulation density of F. graminearum was significantly (p ≤ 0.05) reduced by cold water leaf extract of V. amydalina (94.5%), M. oleifera (90.7%), O. gratissimum (74.6%) and C. odorata (70.9%). Sporulation density was also significantly (p ≤ 0.05) reduced by cold water stem extracts of A. indica (99.3%) and A. occidentale (93.8%). This study showed the potentials of extracts of some plants parts to control F. graminearum on wheat.

Keywords: Wheat, Fusarium graminearum, sporulation density, Plant extracts, Fusarium head blight.

WHEAT is generally grown for food for humans, but lesser quality wheat and the nutrient-dense by-products of flour refining are used for animal feed (12). With the importance of wheat, it is plagued by an array of diseases one of which is Fusarium head blight (FHB). Fusarium head blight or scab is one of the most destructive diseases in humid and semi-humid areas (1). The disease is caused by a number of Fusarium species, mainly F. graminearum (teleomorph Gibberella zeae), F. culmorum and F. avenaceum (teleomorph G. avenacea) (2,20). The disease causes substantial yield losses as a result of a diminished number of grains per spike and reduced grain weight. The infected grains are of low quality with damaged starch granules and storage proteins (4). Outbreaks of FHB in wheat and other grains generally occur all over the world.

Attempts have been made to develop wheat resistant varieties particularly to Fusarium species and many other control measures have also been used to check this fungal disease (3). These include improved cultural practices on the farm and chemical control using fungicides and were then found to be effective against leaf spot when tested. However, most of these fungicides are not available to peasant farmers because of high cost and they require skilled labour and thereby adding to the cost of production. The yield obtained by their use may not be sufficient to justify cost of production (13). Similarly, most of these fungicides are toxic to humans and non-target organisms. The pathogen also has potential to build up
resistance to the fungicides when resistant varieties are planted in endemic areas. These constraints have stimulated studies on the development of safer, cheaper, and effective control measures against head blight. This has brought about the introduction of the use of natural plant extracts in the control of this disease, which may not have any side effect on the agro-ecosystem, readily available and require little or no skill for its application (9). In order to combat pest and pathogen attacks, plants have over the years developed a number of protective mechanisms such as repellent pesticidal action (21). Aqueous extracts of some plants are known to have fungicidal properties in roots, leaves and other parts of plants which when present in sufficient concentration exerts toxic effect on the plant pathogens (7). This study evaluated the effect of hot and cold water extracts of some tropical plants on growth and sporulation of F. graminearum which is the major pathogen of FHB disease.

MATERIALS AND METHODS
Collection of plant samples and isolation of F. graminearum

sickle-shaped to almost straight, thick walled, 5 to 6 - septeate with a tapered apical cell and a distinctly foot-shaped basal cell. Chlamydospore formation varies, and its formation in the macroconidia, microconidia are absent. However, on the PDA, colonies grow rapidly and produce relatively large amounts of dense mycelia that vary from white to pale orange to yellow in color.

Collection of Plant Materials
Leaves and stems of Solanum torvum (Sw.), Vernonia amygdalina (Del.), Ocimum gratissimum (L.), Azadirachta indica(Juss), Moringa oleifera (Lam.), Anacardium occidentales (L.), and Chromolaena odorata (L.) were collected from within the Federal University of Agriculture, Abeokuta in February, 2012.

Preparation of hot water extracts
Fresh leaves and stem bark of the test plants were obtained and surfaced-sterilized (2 % NaOCI for 2 min), thoroughly washed in five changes of distilled water and were air dried at room temperature (28 ± 2°C) for 3 weeks (leaf) and 5 weeks (stem bark). The air-dried plant parts were milled into powder
Preparation of cold water preparation
For cold water extraction, blended and weighed plant parts were soaked in 100 ml of distilled water for 2 hr to produce 25%, 50% and 75% extract concentrations as described above before being sieved. The supernatant were exposed to ultra-violet radiation for 5 hr. One millimeter of each extract supernatant was then added with 9 ml of molten PDA (22). The Petri plates were gently swirled to ensure even distribution of the extracts. The agar-extract mixture was allowed to solidify.

Evaluation of Fungitoxic effect of plant extracts on mycelial growth and sporulation density of Fusarium graminearum
Media amended with plant extracts were inoculated with mycelial strand (2 mm diameter) taken from the advancing edges of 10 day-old cultures of F. graminearum. The factorial set of treatments consisting of two plant parts (leaf and stem bark) of each of the seven plants and a control (where no extract was added) were arranged in a completely randomized design replicated three times and the inoculated media were incubated at room temperature (28 ± 2°C). The diameter of the fungal colony was measured using a meter rule along two diagonal lines drawn on the reverse side of each Petri dish seven days after inoculation. Sporulation density was determined by adding 10ml sterile distilled water to each petri dish and gently scraping with a sterile glass rod to dislodge the spores. The spore suspensions obtained was filtered through sterile cheesecloth into a sterile 50 ml glass beaker and homogenized by manual shaking. The spores were then counted using a haemocytometer. The percentage inhibition of mycelial growth and sporulation density by each extract were computed using the formula.

\[ I = 100 \times \frac{(C - T)}{C} \]

Where
\( I \) = percentage inhibition
\( C \) = growth of fungus
\( T \) = growth of fungus in the treatment

(24)
The percentage reduction (S) or stimulation (S) of sporulation by each extract was determined using the following formula,

\[ S = \frac{(S1 - S2) \times 100}{S1} \]

Where;
\( S \) = Percentage of reduction in sporulation;
\( S1 \) = Sporulation on the untreated medium (control);
\( S2 \) = Sporulation on the treated medium.

\[ S = \frac{(S2 - S1) \times 100}{S2} \]

Where;
\( S \) = Percentage of stimulation in sporulation;
\( S2 \) = Sporulation on treated medium; and
\( S1 \) = Sporulation in untreated medium.

Statistical analysis.
Data were subjected to a one way analysis of variance (ANOVA). Mean differences between treatments or concentration levels of the extract were separated by Duncan Multiple Range Test (P ≤ 0.05).

RESULTS
Inhibition of mycelial growth of Fusarium graminearum by cold water extract (stems and leaves) of test plants
Cold water extracts of all test plants reduced mycelial growth of F. graminearum. However, Chromolaena odorata exerted the least mycelial growth reduction of F. graminearum (Table 1). Fungitoxicity of plant extracts against F. graminearum increased as concentration increased irrespective of the plant parts. Moringa
oleifera leaf induced the highest (85 %) mycelial growth reduction, followed by Solanum torvum leaf (82.5 %). However, the efficacy of the test plants on the mycelial growth of F. graminearum was not significantly (p<0.05) different from one another (Table 1).

Table 1: Inhibition of mycelial growth of Fusarium graminearum by varying concentrations of cold water extract (leaf and stem) of some tropical Plants

<table>
<thead>
<tr>
<th>Treatment (Plant extract)</th>
<th>25g/ml</th>
<th>50g/ml</th>
<th>70g/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stem</td>
<td>Leaf</td>
<td>t-test</td>
</tr>
<tr>
<td>Solanum torvum</td>
<td>57.6b±0.03a</td>
<td>50.9±0.15b</td>
<td>11.3*</td>
</tr>
<tr>
<td>Virusia amygadina</td>
<td>61.8±0.1b</td>
<td>59.6±0.12c</td>
<td>1.68NS</td>
</tr>
<tr>
<td>Oxalum graminicinum</td>
<td>66.6±0.09d</td>
<td>49.1±0.09d</td>
<td>8.08*</td>
</tr>
<tr>
<td>Acanthosicyos indica</td>
<td>64.6±0.12c</td>
<td>65.9±0.12d</td>
<td>0.03NS</td>
</tr>
<tr>
<td>Anacardium occidentale</td>
<td>52.4±0.08b</td>
<td>46.3±0.15d</td>
<td>12.3a</td>
</tr>
<tr>
<td>Mangifera olivera</td>
<td>75.6±0.06b</td>
<td>65.0±0.09d</td>
<td>8.00*</td>
</tr>
<tr>
<td>Chrysanthemun sukure</td>
<td>17.4±0.03c</td>
<td>20.9±0.09c</td>
<td>20.00NS</td>
</tr>
</tbody>
</table>

Data obtained at 5 days after inoculation
* = Significant at (P ≤ 0.05), NS not significant
Each value represents mean ± standard error at (P<0.05) Duncan's multiple range tests

Inhibition of mycelial growth of Fusarium graminearum by hotwater extracts (leaf and stem) of test Plants

The four plant extracts showed a relatively high fungitoxic effect of 50 % and above on the mycelial growth of F. graminearum regardless of the concentration levels. At 70g/ml concentration, V. amygadina stem and leaf induced the highest (98.8 %) mycelial growth reduction followed by S. torvum leaf (97.9 %), M. oleifera leaf (86.3 %) and A. indica (81.3 %). However, the ability of A. occidentale leaf to reduce the mycelial growth of F. graminearum at 25 g/ml was below 50 % but at 70 g/ml, mycelial reduction potential was 85.9 % (Table 2).

Table 2: Inhibition of mycelial growth of Fusarium graminearum by varying concentrations of hot water extracts (leaf and stem) of some tropical Plants

<table>
<thead>
<tr>
<th>Treatment (Plant extract)</th>
<th>25g/ml</th>
<th>30g/ml</th>
<th>70g/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stem</td>
<td>Leaf</td>
<td>t-test</td>
</tr>
<tr>
<td>Solanum torvum</td>
<td>51±0.1b</td>
<td>79.1±0.83d</td>
<td>1.66NS</td>
</tr>
<tr>
<td>Virusia amygadina</td>
<td>94±0.03b</td>
<td>97.9±0.01d</td>
<td>20.00</td>
</tr>
<tr>
<td>Oxalum graminicinum</td>
<td>0.0±0.38a</td>
<td>22.4±0.35b</td>
<td>5.50a</td>
</tr>
<tr>
<td>Acanthosicyos indica</td>
<td>58±0.03b</td>
<td>55.4±0.18b</td>
<td>1.61NS</td>
</tr>
<tr>
<td>Anacardium occidentale</td>
<td>47±0.05b</td>
<td>61.6±0.27b</td>
<td>7.20c</td>
</tr>
<tr>
<td>Mangifera olivera</td>
<td>80±0.06a</td>
<td>68.8±0.40c</td>
<td>4.04NS</td>
</tr>
<tr>
<td>Chrysanthemum sukure</td>
<td>14±0.03b</td>
<td>5.0±0.10c</td>
<td>8.31c</td>
</tr>
</tbody>
</table>

Data obtained at 7 days after inoculation
* = Significant at (P ≤ 0.05), NS not significant
Each value represents mean ± standard error at (P<0.05) Duncan's multiple range tests