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Evaluation of Some Plant Extracts on the Control of Storage Rot Diseases of Yam (*Dioscorea Rotundata* Poir.)

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Abstract
This study involved the evaluation of the efficacy of some plant extracts on the control of storage rot diseases of yam (*Dioscorea rotundata*) especially caused by *Aspergillus niger, Fusarium oxysporium*, *Rhizopus stolonifer and yeast.* Fungitoxic activities of ethanol extract of seven plant leaves namely; *Chromolaena odorata, Asminia triloba, Vernonia amygdalina, Ocimum gratissimum, Azadirachta indica, Psidium guajava, and Cymbopogon citrates* were tested in potato dextrose agar (PDA) medium to determine their efficacy on organisms isolated from the tubers. Completely Randomized Design (CRD) with three replications was adopted. Results of the analysis of variance test revealed that all the plant extracts investigated possessed anti-fungal inhibitory properties that can be utilized as post-harvest control to suppress rot-causing fungi of yam in storage. The ethanol extract of *Azadirachta indica* was most fungitoxic on *Aspergillus spp,* and *Fusarium spp* while *Ocimum gratissimum* was more potent on the inhibition of *Rhizopus spp.* Pathogenicity test carried out on healthy-looking yam tubers inoculated with fungal isolates authenticated the efficacy of *A. indica, V. amygdalina, A. triloba and O. gratissimum* as potential extracts that can be effectively applied to control the growth of rot pathogens of yam tubers in storage. *Azardirachta indica* is the most potent, readily available in large quantities and therefore recommended for use in the storage of yam tubers. These plant-based extracts offers cheaper means of protection that is easily accessible to local farmers who may not be literate enough to handle synthetic chemicals even if they are able to afford them. Proximate analysis of diseased tubers (*D. rotundata*) showed that moisture content ranged from 65.71-68.90 %, Ash 0.93-1.15 %, Crude fibre 0.81-3.02, Crude protein 1.13-2.03, Fat 0.35-1.01 %, NFE (CHO) 25.59=29.81 %, Nitrogen 0.81-0.33 %, and Carbon 12.45-22.06 % respectively

Keywords: *Dioscorea*, fungi inhibition, mycelia growth, pathogens, plant leaves extract, rot diseases.

1. Introduction

Yam (*Dioscorea rotundata*) belongs to the *Order Dioscoreales*, family, *Dioscoreaceae* and *genus Dioscorea.* Yam species include *Dioscorea rotundata* (white yam) *Dioscorea dumentorum* (bitter yam), *Dioscorea cayanensis* (yellow yam), *Discorea alata* (water yam), *Dioscorea esculenta* (Chinese yam), *Dioscorea bulbifera* (aerial yam). Yam is among the most important groups of staple foods in tropical world (Okigbo & Ogbonnaya, 2006, Taiga, 2002, Adelusi & Lawanson, 1987). Importance of yam lies in its usage as main food supplying carbohydrate. It is also a major source of mineral such as calcium, phosphorus, iron, and vitamins namely; riboflavin, thiamine and vitamins B and C. The world's total production of yam is about 30 million tons per annum out of which Nigeria alone produces 22 million tons (FAO, 2005). 25 % average total yam yield is lost to some diseases and pests that follow the crop after harvest to the store causing severe post-harvest damages to the stored tubers (FAO, 1998). Losses due to rots affect availability of yam, the quantity and quality, the revenue of farmers and traders as well as the nation's food security.

2. Materials and Methods

Yam tubers used for this study were collected from the National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria while plant-leaf extracts were obtained from the plants in Genetic Resource Unit of the Department of Crop Science and Technology, Federal University of Technology Owerri, Imo State, Nigeria. The state Owerri is located on Latitude 5° 30' 01" N and Longitude 7° 01' 44" E in the tropical rainforest region of Nigeria. The plants include *Cymbopogon citrates* (Lemon grass), *Ocimum gratissimum* (Nchuanwu), *Chromolaena odorata* (Elizabeth plant), *Psidium guajava* (Guava), *Asiminia triloba* (Pawpaw leaves), *Vernonia amygdalina* (Bitter leaf), and *Azadirachta indica* (Neem). The experiment was carried out at the Research Laboratory of the Department of Crop Science and Technology, and the study was accomplished in four experiments as follows:

2.1 Pathogenicity Studies

200 g of sliced and peeled potato was boiled in one litre of distilled water for 30 minutes, filtered through cheese cloth, saving effluent, which is potato infusion. This was mixed with 20 g of agar - agar powder and 20 g of glucose D and mixed with decant from the boiled potato. It was autoclaved for 15 minutes at 121 ^{0}C. Portions of 20 to 25 ml were dispensed into sterile 15 x 100 mm Petri-dishes; pH 5.6 ± 0.2 medium was used. The medium had final concentration of 20 g/l. Diseased tubers of yam were collected from (NRCRI), Umudike for this test.

2.2 Physical Identification of the Diseases that Infected the Yams in Storage

Physical investigation of seven infected yam tubers was conducted by virtual assessment.

2.3 Isolation of Fungal Species from Rotten Yam Tubers

Pieces of diseased tissues cut from the periphery of rotten yam tubers with a sterilized knife were surface-sterilized in 5 % sodium hypochlorite solution for 5 minutes. The surface-sterilized diseased tissues were washed three times using sterile distilled water and allowed to dry in a sterile Lamina Flow Chamber. The dried diseased tissues were placed on a potato dextrose agar (PDA) medium (Manufacturer: Mearek). Five days after incubation, mycelia that grew from the plated yam tissues were sub-cultured into fresh PDA. Further sub-culturing was carried out until pure cultures of single species isolates were obtained. From these pure cultures, inocula of the different fungal species isolates were obtained for the pathogenicity tests.

2.4 Identification of Fungal Isolates

Various pathogens were identified and isolated based on their colonies and characteristics. The characteristics of fungal isolates from rotten yam tubers such as pigment production, colony texture, spore or conidia-producing structures and spore shapes were documented. The characteristics were observed from fungal growth for five days. Spore and mycelium were viewed using a compound microscope. Their characteristics was studied and used in identifying the fungal organism to the species level, following the standards described by Mathur & Kongsdal, (2003) and Barnett and Hunter, (1972). The micro-organisms seen and identified from the slides were; *Aspergillus spp., Fusarium spp., Rhizopus spp. and Helminthosporium spp.* identified under the microscope. *Aspergillus niger* on the surface is black and white or yellow underneath. It is the most common specie of the genus *Aspergillus* causing the disease called *"black mold* on certain fruits. *Aspergillus niger* has conical heads of dark-brown to black colour with condia brown and rough walled radiate and biserate with metulae. *Fusarium spp* usually grows in crops before harvest and grow only at high air levels. Mycotoxins are therefore usually produced before or immediately after harvest. *Fusarium oxysporium* colonies are differentiated from other species of *Fusarium* by their pink colour. (Dhingra and Sinclair, 1985). *Rhizopus spp* are characterized by the presence of stolons and pigmented rhizoids which are first white to grey or yellowish brown. Sporangia develop from nodes that are relatively small and pear-shaped.

2.5 Pathogenicity Test

The method of Okigbo and Ikediugwu (2000) was used for the pathogenicity test. Cylindrical cores of 1 cm deep were removed from various spots of each yam tuber sample with 5mm core-drill that was sterilized by dipping in ethanol followed by flaming. The different plant extracts were first introduced into the holes before inoculation with the identified pathogens. One week old pure cultures of the fungal isolates obtained from the yam tubers produced on PDA were the source of inocula for the studies. The five-millimeter diameter core-drill was used to cut plugs from the one week old cultures of the isolates to be tested. These fungal plugs were put in the holes created in the yam tubers after which the removed yam tuber discs were used to plug the holes. Melted candle wax from burning candle was used to seal the edges of the replaced yam discs. This process prevented any external influence on the positioned inocula. Each fungal isolate was replicated seven times (on seven different yam tubers). Control was set up in the sterile core-drill which was used to remove five-millimeter diameter tuber tissue. This disc was used to plug the hole and its edges sealed with melted wax. In the control, no fungal organism/plant extract was placed in the hole. These activities were carried out inside a sterile hood.

2.6 Study on Control of Yam Tuber Diseases in Storage with Plant Extracts

2.6.1. Preparation of Leaf Extracts:

The ethanol extraction method was used for the preparation of the botanical extracts. The efficacies of the botanical extracts were tested for their fungicidal activity in controlling yam tuber post-harvest diseases.

2.6.2. Anti-fungal Activity of Plant

Ethanol extraction method was used to assess the anti-fungal activity of the plant extracts.. The inhibiting effects of the plant extracts were thereafter, observed after five (5) days by weighing the difference between the initial and final weights and calculated thus, using Koch's Postulate:

$$\text{Percentage inhibition} = \frac{Wi - Wo}{Wo} \times \frac{100}{1}$$

where,
Wo = weight before treatment
Wi = weight after treatment

2.6.3. Biochemical Analysis

The following biochemical compositions of the diseased yam tubers were determined: water, ash, fat, protein, fibre, ether extracts (fat) and carbon content using proximate analysis procedure according to AOAC, (1990). For example:

i. $$\% N = \frac{\text{Crude protein}}{6.25}$$

ii. NFE(CHO) = Ash + Crude fibre + Crude protein + Ether extracts(Fat) + Moisture

3. Results

Table 1 contains the percentage inhibition of *Aspergillus spp* by the plant extracts. *A. indica* leaf extract recorded the highest level of inhibition of *Aspergillus spp* (46.87 %) followed by *O. viride* (49.93 %), *V. amygdalina*, (50.38 %) and *A. triloba (*54.36 %). From the result, it is evident that, *A. indica, O. gratissimum, V. amygdalina* and *A. triloba* proved more effective in the suppression of *Aspergillus spp* while *C. citrates,* (65.11 %), *C. odorata* (65.17 %) and *P. guajava* (65.63) were less effective in suppressing the growth of *Aspergillus spp.*

Table 1. Effects of the Plant Extracts on the Percentage Inhibition of *Aspergillus niger* Isolated from Diseased Yam Tubers

Plant extract	Initial weight (g)	Final weight (g)	Weight difference (g)	Inhibition (%)
C. odorata	7.23	20.76	13.53	65.17
A. triloba	7.23	15.84	8.61	54.36
V. amygdalina	7.23	14.57	7.34	50.38
O. gratissimum	7.23	14.44	7.21	49.93
A. indica	7.23	13.61	6.38	46.87
P. guajava	7.23	21.04	13.81	65.63
C. citrates	7.23	20.73	13.5	65.11

Table 2 shows the percentage inhibition of *F. oxysporium* by the plant extracts. Again *A. indica* (50.07 %) *recorded* the highest level of inhibition of *F. oxysporium*. This was followed by *A .triloba* (52.28 %), *V. amygdalina* (*50.38 %)* and *O. gratissimum* (56.90 %). *C. odorata, P. guajava* and *C. citrates,* had the least inhibition levels recording, (60.36, 61.03 and 64.25 %), respectively. *Azadirachta indica, A. triloba, V. amygdalina* and *O. gratissimum,* proved more effective in the suppression of *F. oxysporium* while *Chromolaena odorata* (60.36 %), *Psidium guajava* (61.03 %) and *Cymbopogon citrates,* (65.25 %) were less fungitoxic to the growth of *F. oxysporium.*

Table 2. Effects of the Plant Extracts on the Percentage Inhibition on F*usarium Oxysporium I*solated from Diseased Yam Tubers

Plant leaf extract	Initial weight (g)	Final eight (g)	Weight difference (g)	Inhibition (%)
C. odorata	7.23	18.24	11.01	60.36
A. triloba	7.23	15.15	7.92	52.28
V. amaygdalina	7.23	14.57	7.34	50.38
O. gratissimum	7.23	14.48	7.25	50.07
A. indica	7.23	16.76	9.54	56.90
P. guajava	7.23	18.55	11.32	61.03
C. citrates	7.23	20.28	13.03	64.25
Mean	7.23	16.86	9.63	56.47
Standard deviation	0.00	2.25	2.24	5.66

Results presented in Table 3 showed that ethanol extracts of *O. gratissimum, A. triloba, V. amygdalina* and *A. indica* all proved to be fungitoxic on *Rhizopus spp* when used to inhibit their growth in culture. This was closely followed by *A. triloba.* However, *C. odorata* had the lowest percentage inhibition on the organism.

Table 3. Effects of the Plant Extracts on the Percentage Inhibition on *Rhizopus stolonifer* Extracted from the Diseased Yam Tubers.

Plant leaf extracts	Initial weight (g)	Final weight (g)	Weight difference (g)	Inhibition (g)
C. odorata	7.23	19.90	12.17	63.66
A. triloba	7.23	13.41	6.18	46.10
V. amygdalina	7.23	15.88	8.65	54.46
A. indica	7.23	16.74	9.51	56.80
O. gratissimum	7.23	12.52	5.29	42.24
P. guajava	7.23	19.40	12.17	62.76
C. citrates	7.23	18.14	10.91	60.14
Mean	7.23	16.57	9.27	55.17
Standard deviation	0.00	2.84	2.75	8.24

Results presented in Table 4 on comparison of the percentage inhibition of the plant extracts on the microorganisms identified indicated that *A. odorata* recorded the highest inhibitory capacity irrespective of the organism present followed by *O. gratissimum, V. amygdalina* and *A. triloba* in all organisms as they had more inhibiting properties by having more adverse effect on the growth of the organisms and therefore were more effective in the control of rot diseases of yam tubers. On the other hand, *C. citrates, C. odorota,* and *P. guajava* recorded low inhibitory effects irrespective of the organism.

Although, ethanol extracts of *A. indica* proved more fungitoxic in controlling the growth of both *Aspergillus spp* and *Fusarium spp*, *O. gratissimum* proved most fungitoxic on *Rhizopus spp* than the rest of the plant extracts. Results also showed that the ethanol extracts of *V. amygdalina* and *A. triloba* were effective in controlling the growth of *Aspergillus spp, Fusarium spp* and *Rhizopus spp.* Comparison of the efficacy of the various extracts under this investigation shows that *O. gratissimum* was most effective in the control of *Rhizopus spp.*

Table 4. Comparison of the Percentage Inhibition of the Plant Extracts on the Micro-organisms Identified

Plant extract (Leaf)	*A. niger* (%)	*F. Oxysporium* (%)	*R. stolonifer* (%)
C. Odorata	65.17	60.36	63.66
A. triloba	54.36	52.28	46.10
V. Amygdalina	50.38	50.38	54.46
A. indica	46.87	50.07	56.80
O. gratissimum	49.93	56.90	42.24
P. guajava	65.63	61.03	62.76
C. Citrates	65.11	64.25	60.14
Mean	56.78	56.47	55.17
Standard deviation	8.27	5.66	8.24

Table 5 shows the result of the proximate analysis to determine the moisture, ash, crude fibre, crude protein, ether extracts (fat), NFE (CHO), nitrogen (%) and carbon (%) contents. The moisture content of diseased yam samples ranged from 65.71 to 68.90 % , ash content 0.93 to 1.15 %, crude fibre 0.81 to 3.02 %, crude protein 1.13 to 2.03 %, ether extract (fat) 0.35 to 1.01 %, NFE (CHO) 25.59 to 29.81 %, Nitrogen 0.18 to 0.33 % and carbon 12.45 to 22.05 %.

Table 5. Proximate Analysis of the Diseased Yam Tubers before Isolation of the Micro-organisms

Yam tuber samples	Moisture content	Ash	Crude fibre	Crude protein	Ether extract (fat)	NFE(CHO)	% Nitrogen	% Carbon
A	68.59	0.93	0.81	1.51	0.35	27.81	0.24	22.06
B	68.90	0.96	2.33	1.13	1.08	25.59	0.18	21.39
C	65.71	0.84	1.18	1.57	0.88	29.81	0.25	18.14
D	66.57	1.05	1.06	1.71	0.58	29.05	0.27	19.95
E	67.30	0.97	0.80	1.53	0.88	28.53	0.24	20.19
F	65.82	1.15	2.18	2.03	1.01	27.81	0.33	12.45
G	66.12	1.10	3.02	1.53	0.74	27.50	0.25	15.21
Mean	67.00	1.00	1.63	1.57	0.79	28.02	0.25	18.48
Standard error	1.31	0.10	0.88	0.27	0.25	1.34	0.04	3.50

Azardirachta indica showed the highest potency level of inhibition when applied to *Aspergillus spp, Rhizopus stolonifer, Fusarium spp.* and yeast by limiting their growth to 2.0, 1.5, 2.5 and 1.5 cm, respectively. It was equally very effective in the control of *Fusarium spp* by limiting its growth to 2.5 cm.

Vernonia amygdalina was very effective in controlling the growth of yeast, *Fusarium spp, Rhizopus spp* and *Aspergillus spp* that only grew to 2.0 cm for yeast, 2.5 cm for *Fusarium spp*, and 3 cm for both *Rhizopus* and *Aspergillus spp* respectively while *O. gratissimum* was effective in inhibiting the growth of *Rhizopus spp* (2cm), *Aspergillus spp* (3.0 cm), and *Fusarium spp* (3.5 cm) but less effective in controlling the growth of yeast. *A. triloba* proved effective in limiting the growth of yeast (2 cm), *Rhizopus spp* (2.5 cm), *Fusarium spp* (3.5 cm) but less effective in the control of *Aspergillus spp. Psidium guajava, C. odorota* and *C. citrates* proved less effective in the control of the organisms under investigation.

Table 6. Average Level of Inhibition Carried out Using Depth of Spread and Penetration

	Depth of penetration of fungi (cm)			
Plant extract	*Aspergillus*	*Rhizopus*	*Fusarium*	Yeast
V. amygdalina	3.0	3.0	2.5	2.0
C. odorota	5.0	6.0	7.0	4.0
O. gratissimum	3.0	2.0	3.5	4.0
A. triloba	4.0	2.5	3.0	2.0
C. citrates	6.0	3.5	6.0	6.0
A. indica	2.0	1.5	2.5	1.5
P. guajava	5.0	4.0	4.0	4.5
Mean	4.0	3.2	4.1	3.4
Standard deviation	1.4	1.5	1.8	1.6

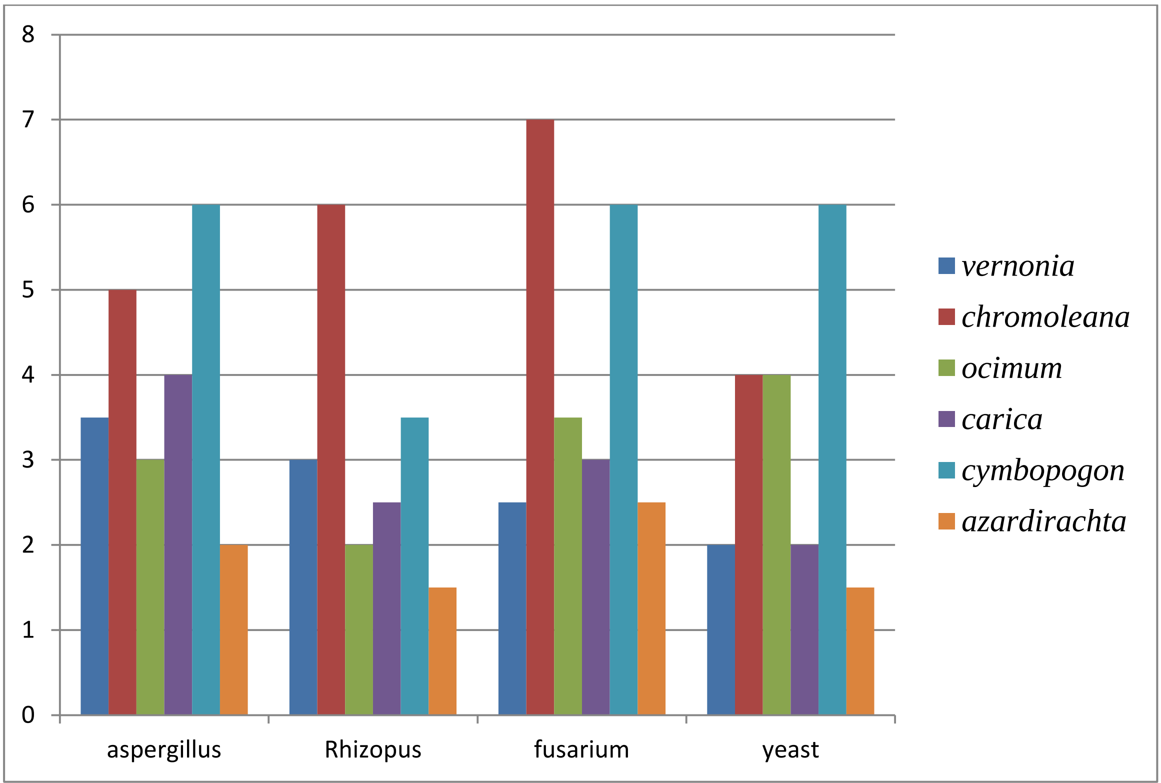

Chart 1. Levels of penetration of the organisms after treatment with plant extracts

4. Discussion

This investigation has shown that rot, at the range of 4 to 18 % was the most prevalent source of yam tuber diseases. Rot was followed by rust at 1 to 8 % while mosaic at 1 % to 4 % was less evident. Amusa & Baiyewu (1999) were able to categorize storage diseases of yam into 3 based on the symptoms of dry rot, soft rot, and wet and causal agents.

This study initially identified four pathogenic fungi - *Aspergillus spp, Fusarium spp, Rhizopus spp* and to *a lesser extent, Helminthosporium* as organisms associated with post-harvest rot of yam tubers in storage. It showed that *Aspergillus niger* was the most virulent of all the pathogens causing post-harvest rot of yams in storage. This finding is in conformity with several works that have identified microorganisms responsible for post-harvest rot of yam tubers in storage (Okigbo & Ikediegwu, 2000; Okigbo, 2002; Nahunnaro, 2008). The fungicidal activities of *Aspergillus spp, Fusarium spp* and *Rhizopus stolonifer* have also been associated with the pot-harvest rot of yams in previous studies carried out by Okigbo (2002, 2005).
The data show very clearly that *A. indica, A. triloba* and *V. amygdalina* significantly inhibited the growth of *F. oxysporium* and therefore is effective in the control of *Fusarium spp* on yam tubers in storage post-harvest. The work of Okigbo, Agbata and Echezona (2010) has earlier shown the efficacy of *Chromolaena odorata* in the control of *Fusarium oxysporium* in post-harvest rot of yam tubers in storage.

This work has demonstrated the presence of active anti-fungal properties in *O. gratissimum, A. triloba, Vernonia amygdalina* and *Azadirachta indica.* It has also shown that anti-fungal properties contained in the leaves of *O. gratissimum, A. triloba, V. amygdalina* and *A. indica* demonstrated the ability to inhibit the growth of *Rhizopus stolonifer.* The three extracts have shown significant difference in their degree of potency against the rot pathogen of *R. stolonifer.* This is in conformity with the report of Ijato, Adebiyi & Ijadnola, (2011) that *A. indica* was able to inhibit the growth of *R. stolonifer* in tomato rot.

For the control of plants pathogens, the fungicidal activities of some plant extracts have equally been reported by Amadioha (2000). Plant extracts have been successfully used in the control yam diseases and tuber crops in previous works.

O. gratissimum was effective in the control of *Aspergillus spp* and *Fusarium spp. A. indica* was very effective in the control of both *Aspergillus spp* and *Fusarium spp.* This work also shows that *O. gratissimum* reduced the mycelial growth of *Rhizopus spp* and *Aspergillus spp* effectively. *Asiminia triloba* displayed the ability to inhibit the growth of *Rhizopus spp, Fusarium spp* and *Aspergillus spp.* However, this research also proved that *P. guajava,* and *C. odorata* were ineffective against *Aspergillus spp, Rhizopus spp* and *Fusarium spp.*

Four rot pathogens were implicated during the Pathogenicity test. These were; *Aspergillus spp, Rhizopus spp, Fusarium spp* and yeast. Contrary to the initial discovery of *Helminthosporium* in some samples in this study, pathogenicity test could not find any evidence of *Helminthosporium* in the yam tuber samples used during the pathogenicity test. Rather, yeast was implicated as a causal agent of rot. *Aspergillus* was characterized by the development of visible dry-firm decaying areas on the yam tuber sample while *F. oxysporium* were compact with abundant aerial mycelium. *Rhizopus spp,* on the other hand, was characterized by water-soaked lesions areas on the tubers while the yeast was characterized by the softening of the tuber as well as the production of watery fluid that had pungent odour (Mba & Nwufo, 1987).

The pathogenicity test proved that *A. indica* was most effective in controlling the growth of *Rhizopus spp, Yeast, Aspergillus spp and Fusarium*. Its application on the yam tuber samples was able to limit the growth and penetration of the four plant pathogens implicated in the rot of yam tubers in storage,

Fusarium spp experienced the greatest growth level when it was treated with *Chromolaena odorota* plant leaf extracts when measured after three days of inoculation but had the lowest rate of growth when it was treated with both *Vernonia amygdalina* and *Azardirachta indica*. *Asminia triloba* and *Ocimum gratissimum* permitted moderate growth when applied to *Fusarium spp. Asminia triloba* was also effective in controlling the growth of yeast and *Rhizopus stolonifer.*

Cymbopogon citrates had the least effect on the growth of *Aspergillus spp*, closely followed by both *C. odorota* and *P. guajava* that allowed it to grow up to 5cm experienced level of penetration. *Cymbopogon citrates* had very moderate effect on *R. stolonifer* because it was able to limit growth to only 3.5 cm.. However, *R. stolonifer* experienced the greatest level of growth when the organism was treated with *C. odorota* plant extracts. On the other hand, *P. guajava* was also not effective in hindering the growth of *Rhizopus spp.* This observation agrees with the works done on the use of plant extracts in the control of fungal rot of yams in storage (Okigbo and Ogbonnaya, 2006). This work has demonstrated that the presence of antifungal properties in all the plant extracts varied in their ability to inhibit the growth of the organisms investigated.

This study has proved that the various plant extracts used have fungitoxic potentials although none of the extracts had total level of inhibition on the various organisms investigated.

5. Conclusions and Recommendation

This study has identified plants with inhibiting properties for the storage of yam tubers post-harvest and in addition identified post-harvest pathogens that destroy yam tubers, using alternative methods as well as the botanicals for their protection.

This investigation has shown that fungitoxic compounds present in *A. indica, O. gratissimum, V. amygdalina and A. triloba* were able to control the growth of *Aspergillus niger. Ocimum gratissimum, A. triloba* and *V. amygdalina* and proved efficacious in controlling the growth of *R. stolonifer. Azadirachta indica, V. amygdalina, A. triloba* and *O. gratissimum* were equally effective as they were able to control the growth of *Fusarium spp*

It is recommended that the leaf extracts of *Azadirachta indica, Ocimum gratissimum, Vernonia amygdalina* and *Asminia triloba* be applied in the storage of yam tubers as they showed substantial level of inhibition on the growth of *Aspergillus niger, Fusarium, Rhizopus stolonifer* and yeast organisms. They could, therefore, serve as alternatives to synthetic chemicals. Plant leaf extracts are more environmentally friendly without residual effect on both plants and man, readily available and can cut down production costs experienced by farmers.

References

Adelusi, A. A. & Lawanson, A. O. (1987). Disease included changes in carotenoid content of edible yam (*Dioscorea spp.)* infected by *Botrydiplodiaheorbromae* and *Aspergillus niger. Mycopthologia*, 98, 49-58A.

Amadioha, A. C. (2000). Fungitoxic effect of some leaf extract against *Rhizopus oryzae. Int. J. Pest Management,* 52, 311-314.

Amadioha, A. C. & Obi, V. V. (1998). Fungitoxic activity of *A. indica* and *Zylopia aethiopica* on *Collectotichu lindernuthiamum. J. Herb Species, Med. Plant,* 6, 33-34.

Amadioha, A. C. & Obi, V. V. (1999). Control of anthracnose disease of cowpea by *Cymbopogon citrates* and *Ocimum gratissimum* Acta Phytopathol. Entomol. Hungeriaca, 34(1-2), 85-89.

Amusa, N. A,. & Baiyewu, R. A. (1999).Yam diseases and its management in Nigeria. *African Journal of Biotechnology,* 2(12), 497-502.

Association of Official Analytical Chemists (AOAC, 1990). *Official Methods of Analysis of the Association of the Official Analytical Chemists*. 18th ed. Washinton DC.

Barnett, H. L. & Hunter, B .B (1972). Illustrated genera of imperfect fungi. (3rd ed.) Burgress Publishing Company, Minneapolis, 241.

Dhingra, O. D & Sinclair, J. B, (1985). Basic plant pathology methods, CRC Press, 69.

FAO, (Food and Agricultural Organization, 1998). Precautionary approach to yam management. *FAO Technical Guidelines for Diseases of Yam,* No. 2.

FAO, (2005) Food and Agricultural Organization of the United Nations, FAOSTAT Statistical Database, FAO, Rome.

Ijato, J. Y, Adebiyi, A. O & Ijadnola, J. A. (2011). Antifungal effects of four tropical plants aqueous and ethanolic extracts on postharvest rot tomato. (*Lycopericon esculenta*) in Ado-Ekiti, Nigeria. *New York Sci J*., 4(1), 64-68.

Mba, P. C. & Nwufo, M. I. (1987). Studies on the post-harvest rots of african breadfruit (*Treculia Africana*) seeds in Nigeria. *International Biodeterioration,* 24, 17-23.

Mathur, S. B & Kongsdal, O. (2003). Common laboratory seed health testing method for detecting fungi. 1st ed. International Seed Testing Association, Bassersdorf, CH-Switzerland, 425.

Nahunnaro, H. (2008). Effects of different plant extracts in the control of yam rot induced by *Rhyzopusstolonifer* on stored yam (*Dioscorea spp.*) in Yola, Adamawa State, *Nigeria. Medwell J. Agric. Sci*, 3(5), 382-387.

Okigbo, R. N. & Ikediegwu, FEO (2000). Studies on biological control of postharvest rot of yams (*Dioscorea. Spp)* with *Trchoderma viride. J. Phytopathol*, 148, 351-355

Okigbo, R. N., (2002). Mycoflora of tuber surface of white yam (*Dioscorea rotundata*) and post-harvest control of pathogens with *Bacillus subtilis. Mycopathologia,* 156(2), 81-85.

Okigbo, R. N. & Emoghere, A. O (2004). Antifungal activity of leaf extracts of some plant species on *Mycossphaerella fijiensis* Morelet, the causal organism of black sigatoka disease of Banana (*Musa acuminate*) KMITL, Sci. J., 4, 20-31.

Okigbo, R. N., (2005). Biological control of postharvest fungal rot of yams (*Dioscorea spp*) with *Bacillus subtilis. Mycopathologia*, 159, 307-314.

Okigbo, R. N. & Nmeka, I. A. (2005). Control of yam tuber with leaf extracts of *Xylopia eathiopica* and Zingiber officinate. *Afr. J. Biotechnol, 4, 804-807.*

Okigbo, R. N. & Ogbonnaya, U. O. (2006). Antifungal effects of two tropical plant leaf extracts (*Ocimum gratissimum* and *Aframomumm elegueta)* on post-harvest yam (*Dioscorea spp*) rot. *Afr. J. of Biotecinol*, 5(9), 727-731.

Okigbo, R, Agbata, C. A & Echezona A. C (2010). Effect of leaf extracts of *Azadirachta indica* and *Chromolaena odorotum* on post-harvest spoilage fungi of yam in storage. *Curr Res. J. BiolSci*, 2(1), 9-12.

Onifade, A. K. (2000). Antifungal effect of *Azadirachta indica* A. Juss extracts on Collectotricumlindemathianum. *Global J. Pure Appl. Sci*., 6(3), 423-428.

Taiga, A. (2002). Influence of temperature on yam tuber (*Dioscorea spp*) infection by rot causing fungi. Savanna Journal of Science and Agriculture, 1(1), 46-52.