Trop J Nat Prod Res, August 2021; 5(8):1493-1499

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

Antifungal Potentials of Aqueous Extracts of Selected Indigenous Flora Against Leaf and Stem Blight (*Alternaria bataticola*) Disease of Sweet Potato

David N. Enyiukwu[1]*, Lwanga A. Chukwu[2], Amarachi G. Nwaogu[1], Inemesit N. Bassey[3], Juliet A. Nwaneri[4]

[1]*Department of Plant Health Management, Michael Okpara University of Agriculture,Umudike,, PMB 7267 Umuahia, Abia State, Nigeria*
[2]*Department of Agricultural Technology, Faculty of Agriculture, Akanu Ibiam Federal Polytechnic, Uwana, Afikpo, Ebonyi State, Nigeria*
[3]*Department of Botany and Ecological Studies, University of Uyo. Ikpa Road Uyo, PMB 1017 Uyo, Akwa Ibom State, Nigeria*
[4]*Minor Root Crop Programme, National Root Crops Research Institute, Umudike, KM. 8 Umuahia Ikot Ekpene Road, PMB 7006 Umuahia, Abia State, Nigeria*

ARTICLE INFO

Article history:
Received 11 June 2021
Revised 14 July 2021
Accepted 04 August 2021
Published online 02 September 2021

ABSTRACT

Leaf and stem blight (*Alternaria bataticola*) is one of the principal constraints to effective sweet potato production in many parts of the tropics. This work assessed the potentials of extracts of some indigenous plants to control the disease *in vitro* and under field conditions. The treatments comprised 20% aqueous extracts of *Stachyterpheta jamaicensis*, *Cyathula prostrata*, *Diodia scandens*, *Ageratum conyzoides and Hyptis suaveolens*, mancozeb and water (control). The experiment was set up in RCBD with 3 replicates. The results showed that all the extracts inhibited spore germination (65.08-78.71%) and radial growth (77.54-92.01%) of the pathogen *in vitro*, though these were statistically inferior (P>0.05) to 82.06 and 95.25% recorded for mancozeb respectively. The extracts of the indigenous flora also performed well in inhibiting the disease *in vivo*. Mancozeb gave the highest reduction of blight incidence (18.92%) and severity (1.18) on the treated crop, however the values (20.11-30.06%) and 1.24-2.79) of the indigenous flora extracts were significantly (P<0.05) superior to the control which had 81.35% and 7.47 for the respective test parameters. The high minimization of disease incidence and severity in mancozeb and extracts treated plots compared to the control may have accounted for the higher yield of root (6.07-10.65 tha^{-1}) and haulm (1.37-2.51 tha^{-1}) than (3.01 tha^{-1} and 0.87 tha^{-1}) obtained for the control respectively. This study showed that smallholder farmers of sweet potato can use aqueous extracts of *S. jamaicensis*, *C. prostrata* and *H. suaveolens* to keep leaf and stem blight at bay and increase the productivity of the crop.

***Keywords*:** Leaf and stem blight, *Alternaria bataticola*, Indigenous flora, Sweet potato, Plant diseases

Introduction

Sweet potato (Convulvolaceae) commonly called Louisiana yam (*Ji Obegu* in Igbo), is an important crop in the farming systems of sub-Saharan Africa.[1,2] Its origin is believed to be somewhere in Latin America; from where it spread throughout the tropical and sub-tropical worlds. The crop presents sprawling, twinning, trailing, spreading or extremely spreading growth characteristics.[3] Based on its growth pattern, the crop may be planted as a sole crop or in most cases, intercropped with other staple crops in various cropping systems; to provide soil cover, and smoother weeds in the field.[4] Nigeria, is one of the major producers of sweet potato in Africa; producing nearly 4.15 million MT of the root per annum.[5,6] Root crops are major sources of calories for natives in most developing countries of the tropics.[7] Sweet potato in particular ranks fifth in importance after rice, wheat, maize and cassava in this regard.[1,8] The root can be boiled, fried, baked or roasted; or prepared in some cases as *fufu* for human consumption.

Its leaves are used as classic leafy vegetable in several countries of Africa and Asia-Pacific.[9, 10] Appreciable amounts of protein (1.63 g), minerals, and vitamin C are present in the root. The purple and orange flesh varieties in addition contain rich amounts of anthocyanins which play active roles in fighting cancer, age-related dementia and sight defects due to vitamin A deficiency respectively.[3, 11, 12]

Farmers are faced with several constraints in its production, especially in the humid tropics.[13] These include poor yield due to use of local crop varieties and decimations by pests and diseases.[2, 3, 14] In the field, leaf and stem bight is one of the major fungal diseases attacking sweet potato foliage and vines.[15] In affected crop, the disease macerates leaf lamina and petiole as well as base or mid sections of vines. The disease is induced by a filamentous fungus *Alternaria bataticola.*[15, 16] Leaf and stem blight is widely distributed in Africa; especially in Rwanda, Ethiopia, Kenya, Uganda, South Africa and Nigeria. Blights can cause significant reductions in root and leaf yields of the crop.[17] Root losses ranging between 50-90% have been reported due to attacks of the disease in some countries;[18,19] and total crop failure in very severe outbreaks.[16] These huge losses are hinged on reductions in photosynthetic area of the affected leaves; and dissemination of toxic systemic metabolites, to slow down photosynthetic rate in areas not directly affected by the pathogen.[20,21,22] or due to clogging of water and photosyntate transport channels in vines.[23] The disease may continue as rot of roots in storage, leading to substantial maceration of tissues; and degradation of essential nutrients. In both cases, substantial losses of tuber and vegetable quality ensue.[7, 24]

Leaf and blight stem disease is thrash-borne and phyto-sanitation is key to its control.[19] Resistant varieties have been attempted also for its control but *A. bataticola* is highly variable, making such varieties to be short-lived.[15,25] Chemical treatments with broad-spectrum antifungals effectively check the disease.[19] However, outcries from environmentalists and public health practitioners, about association of

*Corresponding author. E mail: enyidave2003@gmail.com
Tel: +234-(0) 9092309790.

Citation: Enyiukwu DN, Chukwu LA, Nwaogu AG, Bassey IN, Nwaneri JA. Antifungal Potentials of Aqueous Extracts of Selected Indigenous Flora Against Leaf and Stem Blight (*Alternaria bataticola*) Disease of Sweet Potato. Trop J Nat Prod Res. 2021; 5(8):1493-1499. doi.org/10.26538/tjnpr/v5i8.27

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria.

synthetic pesticide sprays or their residues in treated crops with contamination of the food chain, allergies, birth defects, cancers, Alzheimer and Parkinson diseases, or even death in humans have made their use unattractive in agriculture.[26-29] These experts further maintain that contamination of the food chain, by pesticide residues has resulted in dwindling bio-diversity amongst aquatic, soil and terrestrial species as well as decreased nitrogen fixation in legumes.[19, 30, 31]

Given these myriads of drawbacks of man-made biocides,[29] quests for alternatives, especially bio-control agents and plant-derived pesticides, have heightened in the new millennium.[3] In ethno-botany, several tropical medicinal plants have demonstrated significant efficacies in curtailing parasitological or pathological diseases in humans.[1,32] For this reason, interests in antimicrobial potentials of phytochemicals for crop protection have increased recently.[33] Crude water extracts, organic extracts, their fractions or essential oils from many tropical higher plants,[34,35] have been screened for fungitoxic properties.[36,37] For instance, 6.5 mg/ml and 50 mg/ml of ethanol fruit extracts of *Syzygium cumini* completely inhibited mycelial growth and spore germination of *A. alternata in vitro* respectively. Similarly, aqueous extracts of *Cyathula prostata* and *Diodia scavens* and essential oil from *Hyptis marrubioides* were reported to impede the initiation, development and spread of soybean rust (*Phakospora pachyrhzi*) and southern pea anthracnose (*Colletotrichum destructivum*) too.[38, 39] These plant-based preparations amongst other advantages are comparatively less toxic to mammals, cheap, easy to find, prepare and use by subsistence farmers in sub-Saharan Africa. Moreover, development of pathogen resistance to them is grossly less likely to occur.[40]

Therefore, the purpose of this study was to assess the effects of aqueous extracts derived from *Cyathula prostrata, Stachyterpheta jamaicensis, Ageratum conyzoides, Diodia scandens* and *Hyptis suoveolens* on incidence and severity of leaf and stem blight incited by *Alternaria bataticola* on sweet potato and performance of the treated crop in typical subsistence field conditions of the humid tropics.

Materials and Methods

Experimental site and location

The experiment was conducted at a Demonstration Farm located at Ekebedi; one of the suburb communities that play host to the Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The environmental parameters of the study location include dual peak rainfall regime (July and September). About 1,247.30 mm of rainfall over a period of 150 days, temperature range of 29-33^{0}C and relative humidity spanning 76.0–84.20 % were recorded during the study months of July-November, 2019. The soil type of the area was sandy loam with organic carbon recorded at 87000 ppm, pH (water) 5.21. The geographic coordinates of the study location are latitude 5^{o}38’25.1”N, longitude 7^o.58’.43.7”E; and altitude of 130.15 meters above sea level.[41]

Sources of planting stock; collection of plant materials and their preparation

Sweet potato (Var. TIS 8164) vines obtained from the Sweet Potato Programme of the National Root Crop Research Institute (NRCRI), Umudike were used in this study. The leaves of [pasture weed (*Cyathula prostrata*), blue potter weed (*Stachyterpheta jamaicensis*), goat weed (*Ageratum conyzoides*), button weed (*Diodia scandens*) and pignut (*Hyptis suaveolens*)] were obtained from neighbouring communities of the University in April 2019. The plants were validated at the Department of Forestry, College of Natural Resources and Environmental Management (CNREM) of the University, and specimens (Voucher numbers: VIBJ 25-19) deposited at the Herbarium.

The leaves were air-dried for 20 days on the laboratory bench of the Plant Protection Laboratory of the Institute, after which they were separately enveloped, oven-dried at 40^{o}C for 15 minutes before being separately milled into powder using Thomas Wiley milling machine (Model: ED-5, USA). The respective powders of the plant leaves were separately stored in air-tight containers, and kept in dark cupboard until required. About 2kg of the different plant tissue powders was separately soaked in 10L of sterile distilled water contained in lidded transparent plastic buckets (sterilized with 70% alcohol swabs), stirred vigorously from time to time with a glass stirrer, and then allowed to stand for 8 h. Thereafter, they were separately sieved through double folds of Cheese cloth to obtain 20% concentrations of aqueous extracts of the respective plants.

Isolation and identification of the fungal pathogen

Diseased sweet potato (laminae, petioles and vines) with typical symptoms of blight were collected from a subsistence garden in the University community, enveloped and taken to the Plant Protection Laboratory of NRCRI. They were washed in tap water, cut into bits (5 mm), sterilized with 10% sodium hypochlorite for 1 minute, rinsed thrice in sterile distilled water and dried on sterile filter papers (Whatman No 1) before being plated on a moistened filter paper in Petri dishes; and incubated in the incubation chamber for 5 days, to allow the pathogens to grow. Potato dextrose agar (PDA) was prepared by reconstituting 39.5 g of dehydrated PDA in 1000 ml of sterile distilled water and autoclaved at 15 Psi for 15 minutes.[2] Bits of the organisms that grew out of the plated potato petioles and vines were aseptically transferred onto solidified PDA (20 ml) in Petri dishes and repeatedly sub-cultured until pure cultures of the organisms were obtained.[36, 42]

Pathogenicity test

Seven-day old culture of each of the fungal isolates in Petri dishes was separately scraped into 200 ml sterile distilled water in beakers, and sieved to obtain filtrates of the isolates which were adjusted to 1.0 x 10^5 spores/ml of distilled water. Sweet potato vines (TIS 8164) were planted 2 per pot of 20 kg heat-sterilized topsoil, and watered daily. At 4 weeks after planting (WAP), the seedlings (2 pots each) were separately inoculated by injecting 1 ml of the different suspensions of each of the fungal isolates at the nodes of the test seedlings using a 2 mL syringe. Six WAP, the isolate which reproduced symptoms typical of leaf and stem blight disease as observed on the sweet potato plants at the Research Farm was re-isolated from the test vine tissues; while those that failed to do the same were regarded as saprophytes and discarded. Slides of the pathogenic isolate were then prepared, mounted on the stage of a compound microscope, observed and compared for morphological and colony similarities with the original pathogen from the infected sample collected from the Research Farm and the identity of the organism identified with reference to illustrations of imperfect fungi by Barnett and Hunter.[43]

In vitro experiment

Preparation of spore suspension

The spores of the pathogen (*A. bataticola*) were collected from 8-day old culture-agar stock in Petri dishes by irrigating repeatedly into a beaker. This was sieved through 2-folds of sterile cheese cloth to remove any fragments of agar and mycelial mesh and the filtrate centrifuged for 10 minutes. Then using a haemocytometer counting slide, concentration of the spores suspension was adjusted to 1.0 x 10^5 spores/mL sterile distilled water.

Spore germination studies of Alternaria bataticola

The method of Amadioha *et al*.[7] was adopted to assess the effects of the phytochemicls on the germination of spores of *A. bataticola*. A disc (3 mm) of the fungus was placed separately in 2 mL of 20% concentration of crude aqueous extracts of the test plants or mancozebl (positive control) contained in different test tubes; centrifuged for 10 minutes, and then filtered through 2-folds of cheese cloth. A drop (0.05 mL) of the different preparations was placed separately on 3 sterile slides and incubated for spore germination at 27^{o}C for 24 h in a humid chamber. The controls were set up in like manner but consisted of sterile water or mancozeb. Further spore germination was stopped by adding one drop of lactophenol in cotton blue to each preparation on the slides. The experiment consisted of 7 treatments replicated 3 times. The whole experiment was repeated two times. The outcomes of the phytochemical treatments on germination of spores of *A. bataticola* was assessed by randomly selecting and carefully

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

examining about 100 of its spores under a microscope field (high power). The number of germinated spores for each treatment and replicate were taken. The percentage inhibition of this parameter in comparison to the controls was determined using the formula by Enyiukwu *et al.*[22] as:

$$\% \text{ Inhibition of spore germination} = \frac{(m-n)}{m} \times 100$$

Where m = average number of germinated spores of the test fungus with control
n = average number of germinated spores of the test fungus with treatment.

Radial growth studies of Alternaria bataticola
One milliliter of 20% crude aqueous extracts of the plants were smeared separately on the surface of solidified PDA contained in Petri dishes by gentle swirling motion.[3] A disc (3 mm) of the 10–day old culture of the pathogenic fungus was transferred to the center of the solidified PDA-extract medium in the Petri dishes, which had been marked underneath with two perpendicular lines intersecting at the center. The dishes were covered and incubated at 27°C for 7 days. The controls were set up in the same way but with sterile distilled water or mancozeb mixed with PDA in the dishes. The experiment consisted of 7 treatments replicated 3 times. The whole experiment was repeated twice. Seven days after incubation, the mycelia growth of *A. bataticola* along the perpendicular lines was measured with a meter rule. The toxicity of the phytochemicals to *A. bataticola* was taken as a percentage of mycelial growth inhibition and calculated by the formula adopted by Enyiukwu *et al*. [22] as:

$$\% \text{ Radial growth inhibition} = \frac{(x-y)}{x} \times 100$$

Where x = average diameter of fungal colony with control
y = average diameter of fungal colony with treatment

Field experiment
Field preparation and layout
The experimental field measuring 23 x 24 square meters was slashed and ridged by hoeing during the 2019 planting season (July-November). The field layout was randomized complete block design made up of 3 blocks of seven plots (treatments) each; giving a total of 21 experimental units. The ridges were planted with 5 cm cuttings of sweet potato (Var: TIS 8164) at a spacing of 0.5 x 1.0 m. The distance between plots and across replicates was maintained at 1 meter.

Crop establishment and treatment
Six weeks after planting, the seedlings were spray-inoculated at sunset with suspension of *A. bataticola* (1 x 10^5 spores/mL of distilled water) to run-off. They were kept moist for 7 day post inoculation by watering early and late in the evening to aid in buildup of dampness which encourages leaf and stem bight disease initiation. One week thereafter, when the sun has gone down, the plants were separately sprayed with 20% concentration of the respective plant materials; and repeated a fortnight afterwards. Records of the number of sweet potato plants that came down with leaf and stem blight were taken per treatment per replicate from 9 WAP and the percentage incidence calculated based on the formula by Enyiukwu *et al.*[22] as:

$$\% \text{ leaf and stem blight incidence} = N/T \times 100$$
Where N = number of sweet potato plants with leaf and stem blight
T = total number of sweet potato plants examined

The fungitoxicity of the plant tissue extracts was taken as a reduction of leaf and stem blight on the test plant per treatment per replicate compared to the controls; and assessed using a 10-point descriptive key adopted by Enyiukwu *et al.* [22] as:
1 = No disease
2 = less than 25% of the tissues
4 = greater than 25% but less than 50% of the lesion present
6 = greater than 50% but less than 75% of the lesion present in the tissues
8 = greater than 75% but less than 100% of the lesion present
10 = Heavy lesion on tissues, defoliation occurs (100%); and
The disease severity was calculated based on the formula adopted by Amadioha *et al.*[7] as:

$$\text{Disease severity} = \frac{\text{Sum of individual disease ratings}}{\text{Number of plants examined}}$$

Data on vine length, leaf area and number of leaves per plant, stem girth and weight of haulms and tubers of the sweet potato beginning from 10 WAP till harvest were also collected.

Statistical analysis
Analysis of variance was conducted on all the data collected from the study, using GenStat computer programme 2008 version. Means were compared using Fisher's Least Significant Difference at 5% level of probability.

Results and Discussion

All the phytochemicals in this study significantly inhibited germination of spores and radial growth of *A. bataticola* than the control experiment (Table 1). *S. jamaicensis* demonstrated the highest level of inhibition of its spore germination (78.71%), followed by *H. suaveolens* which had 73.11%, and *C. prostrata* (71.39%); whereas 65.08% inhibition effect recorded from *A. conyzoides* against conidial germination of the organism was the least. Similarly, *S. jamaicensis, H. suaveolus* and *C. prostrata* exhibited 92.01%, 90.07%, 89.17% inhibition effects against mycelial elongation of *A. bataticola* while *A. conyzoides* which had radial inhibition of 77.54% was the least. Generally, on both parameters assayed in this study, *S. jamaicensis, H. suaveolus,* and *C. prostrata* effected the highest levels of reductions on the test attributes while the least effect was recorded from *A. conyzoides*. Though mancozeb which had 82.06% and 95.25% inhibitions for spore germination and radial growth respectively, out-performed pesticides of the indigenous flora on both test parameters, however their effects especially those of *S. jamaicensis, H. suaveolus, and C. prostrata* compared ($P<0.05$) well with results obtained from it (Table 1).

Table 1: Effect of pesticides from indigenous flora on spore germination and radial growth of *Alternaria bataticola*

Treatment	Spore germination inhibition (%)	Radial growth inhibition (%)
Stachyterphyta jamaicensis	78.71 ± 0.62	92.01 ± 0.22
Cyathula prostrata	71.39 ± 0.18	89.17 ± 0.06
Diodia scandens	69.92 ± 0.04	82.06 ± 0.31
Ageratum conyzoides	65.08 ± 0.21	77.54 ± 0.09
Hyptis suaveolens	73.11 ± 0.19	90.07 ± 0.25
Mancozed	82.06 ± 0.43	95.25 ± 0.41
Control (water)	0.00 ± 0.01	0.00 ± 0.03
LSD (0.05)	0.89	1.01

*Data are means of triplicate determination from 2 separate experiments

The results of this study in the humid Southeast Nigeria, showed that *A. bataticola* is associated with leaf and stem blight of sweet potato in the area. Findings in this study (Table 1) also revealed that, all the plant extracts sufficiently impeded the germination of spores, and radial growth of the pathogen over the control experiment. Antimicrobial and antifungal activities have been ascribed to extracts of *C. prostrata, D. scandens, H. suaveolens, S. jamaicensis* and *A. conyzoides* by several workers in many studies.[44, 45, 46] A wide suite of phytochemical compounds (alkaloids, flavonoids, tannins, saponins,

phenolics, terpenids and essential oils) underpin the bioactivity of these extracts.[32, 47, 48] Plant secondary metabolites interfere; disrupt or inhibit biologically active sites of enzymes, molecules and organelles of hosts' tissues or essential processes of target pathogens.[49, 50] The observed inhibitions against spore germination and radial growth of the test fungus in this study may have been due to presence and ability of phytochemicals in the extracts to disrupt or interfere with one or more processes or enzymes of the target fungus. Findings in this study whereby extracts of the test plants strongly inhibited spore germination and radial growth of *A. batiticola* is in agreement with the reports of previous workers, who found aqueous and ethanol extracts of some tropical plants to strongly or completely inhibit these parameters in *Alternaria tenuissima* and *A. alternata in vitro*.[47, 51]

All the plant tissue extracts used in this study reduced to varying degrees, leaf and stem blight development, spread and severity on the treated sweet potato (Table 2). Plants treated with mancozeb had the lowest incidence (18.92%) and severity score (1.18) of leaf and stem blight, which were significantly higher than effects recorded for these parameters from all other treatments on the test crop. *S. jamaicensis, H. suaveolus,* and *C. prostrata,* which had disease incidences of 20.11%, 22.14% and 25.07%; and severity profiles of 1.24, 1.35 and 2.21 respectively were next in the level of reduction of the disease; being significantly (P<0.05) different from plants treated with other phyto-extracts and the control. The least reduction of the disease incidence, and severity on the test crop, was obtained from plants exposed to tissue extracts of *A. conyzoides* which had 30.06% incidence of stem and leaf bight, and severity score of tissue damage of 2.79 on a 10-point descriptive key. However, highest incidence of leaf and stem blight disease, and disease severity score (81.35% and 7.49 respectively) were obtained from plants in the control plots, and these were significantly (P>0.05) inferior from effects recorded from sweet potato plants treated with all the extracts of the indigenous plants and mancozeb (Table 2). Results presented in Table 2 showed that up to 81.50% incidence of leaf and stem blight was recorded on sweet potato in the untreated control experiment. This is consistent with findings of many workers in previous evaluations in other African countries, who reported incidence profiles ranging greater than 50% in epiphytotics due to leaf and stem blight (*A. bataticola*), in naturally infected sweet potato.[17] High ambient temperature, rainfall, humidity, overhead irrigation or free moisture on the crop have been noted to encourage development of leaf and stem blight disease on sweet potatoes.[52] Therefore, the high rainfall (1247.30 mm), humidity (76-84%) and temperature (29-33^{o}C) recorded during the months this study lasted could be the reason for the high level of incidence of the disease observed on the test crop.

The result of the study on fungitoxic effect of extracts of some indigenous flora on leaf and stem blight of sweet potato (I*pomoea batatas*) caused by *A. bataticola* showed that all the plant extracts sufficiently reduced leaf and stem blight incidence and severity. Mancozeb was significantly better in the control of the disease than the test plant extracts. However, extracts of *S. jamaicensis, H. suaveolens, C. prostrata* and *D. scadens* performed comparatively well with it. Bioactive compounds have been isolated from many tropical higher plant species, which lend antifungal properties to them.[45,46] In a fungitoxic trial against *Aspergillus sclerotiorum, Fusarium oxysporum, Penicillium corylophylum* and *Mennoiella echinata,* 10% aqueous leaf extract of *S. jamaicensis* gave 100% inhibition of all the assayed fungi; and this activity was suspected to be due to lanostane phenylacetate isolated from the plant leaf [46,53] Anti-fungal activity of *H. suaveolens* leaf oil extract against *Aspergillus* species has been reportedly linked to its terpene and tannin fractions rich in β-caryophelene, sabinene, spathulonol, γ-ellemene, eucalyptol and caffeic acid.[33,54,55] whereas the bioactivity of *A. conyzoides* is thought to hinge on the compounds precorenes I and II.[57,57] The better inhibition and reduction of the incidence, development and spread of the leaf and stem blight by *H. suaveolens* over the other plant extracts in this study may have been due to higher presence of these phytochemical compound in it than in the other test plants. This finding of fungitoxic activities of the test extracts is consistent with[46] and [58]where aqueous leaf extract of *S. jamaicensis* and *A. conyzoides* inhibited *F. oxysporum, P. corylophilum, A. sclerotiorum.*and *Botryodiplodia theobromae* by 80.74-100%. It is also congruent with[3] who reported in a similar study that *Candida albicans* was nearly 60% sensitive to extracts of *C. prostrata.* However, our observations are inconsistent with[48] and [60,61] who reported fungitoxicity of plant extracts used in their studies against *F. oxyspoum* and *C. destructivum* to be at par and superior to benomyl respectively.

The results of this study showed significant (P<0.05) treatment effects on root yield of the test crop. Plants treated with mancozeb produced the highest root yield (10.65 tha^{-1}), which did not differ statistically (P>0.05) from that of plants treated with extract of *S. jamaicensis* (10.25 tha^{-1}). However, it differed significantly (P<0.05) from plants treated with *A. conyzoides* which recorded 6.07 tha^{-1}. All the plant tissue-derived pesticides producing root yield ranging from 8.83-9.64 tha^{-1} out-performed those in the control plots, which had the least root yield of 3.01tha^{-1}. For the haulm yield, the trend is similar to that of the root yield. All the tissue extracts from the indigenous flora stimulated significantly more haulm production than the control experiment. Sweet potato plants treated with mancozeb, *S. jmaicensis, S. suaveolens* and *C. prostrata* had the highest haulm yields of 2.51, 2.48, 2.20 and 1.97 tha^{-1}, while plants in the control experiment recording 0.87 tha^{-1} represents the least of the haulm yield (Figure 1).

The superior performance of mancozeb over the fungicides from the indigenous flora in this study may be due to its ability to persist longer on the treated crop than the botanicals, whose chemical compounds are prone to heat or UV-rays degradation.[62] Mancozeb is a boadsprectrum, multi-site acting fungicide whereas terpenes and other volatile plant derived compounds such as fatty acids have been suggested to impair structural integrity of cell walls and enzymes of the energy systems.[62]

The superior antifungal activity of mancozeb over the extracts of the indigenous flora may be due to its ability to effectively inhibit biologically active sites of many enzymes, and processes of the target pathogen than disruption of cell walls or impairment of locomotor behavior of affected organisms which underscores the modes of action of these phytochemical compounds.[2, 48, 62, 63, 64] It may also be due to high antioxidant activities or anatomical aberration of target organelles or secretions of the pathogen by the plant issue extracts.[59, 65, 66]

Table 2: Effect of plant-derived pesticides on leaf and stem blight incidence and severity of treated sweet potato

Treatment	Disease Incidence (%)	Disease Severity
Stachyterphyta jamaicensis	20.11 ± 0.01	1.24 ± 002
Cyathula prostrata	25.07 ± 0.06	2.21 ± 0.01
Diodia scandens	26.07 ± 0.10	2.64 ± 0.05
Ageratum conyzoides	30.06 ± 0.04	2.79 ± 0.04
Hyptis suaveolens	22.14 ± 0.07	1.35 ± 0.02
Mancozed	18.92 ± 0.04	1.18 ± 0.01
Control (water)	81.35 ± 0.32	7.49 ± 0.28
LSD (0.05)	0.41	0.04

*Data are means of triplicate determinations from 2 separate experiments

The results of the effects of the plant materials on growth attributes (vine length, leaf area, number of leaves per plant and stem girth) of the treated crop are presented in Table 3. It shows that there were significant (P<0.05) differences in the treatment effects on the test crop. In terms of vine length, plants treated with mancozeb had the longest vine length, while those exposed to extracts of *S. jamaicensis, H. suaveolens C. prostrata, D. scandens, A. conyzoides* were significantly (P<0.05) longer than plants treated with only water in the control experiment which had the shortest vine length. Similar trends

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

were also observed for leaf area, number of leaves and stem girth in the treated crop where mancozeb, *S. jamaicensis, H. suaveolens* out-performed all the other treatments in improving the studied parameters, however plants in the control experiment exhibited the least values for these parameters (Table 3).

The ability of the plant extracts and Mancozeb to minimize incidence, size of pathogen-induced lesions and disease severity may have resulted in increased availability of photosynthetic area, as well as increased photosynthetic rate by neutralizing toxic systemic metabolites secreted by the pathogen; or by reducing clogging of the water and photosynthate channels of vines; all of which may have translated to increased performance of the test crop in terms of tuber yield, haulm yield (Figures 1) and other yield influencing parameters (Table 3); a view also held by other authors.[28, 37, 67, 68]

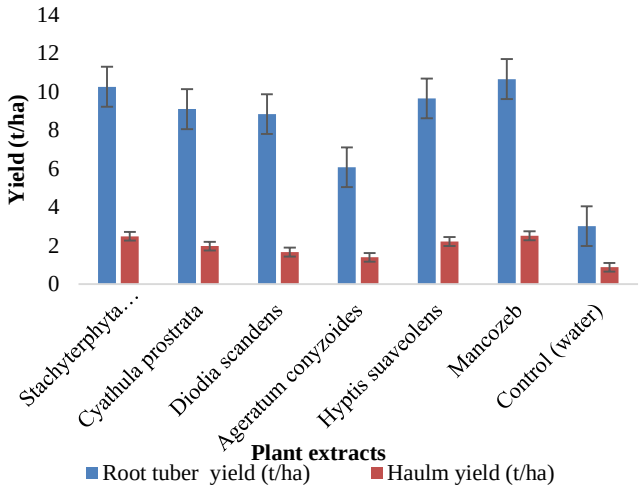

Figure 1: Effect of plant-derived pesticides on root tuber yield of the treated sweet potato

Table 3: Effects of pesticides of indigenous plants on growth attributes of the treated sweet potato

Treatment	Vine length (cm)	Leaf area (cm^2)	Number of leaves	Stem girth (cm^2)
Mancozeb	32.64 ± 0.24	42.09 ± 0.38	27.30 ± 0.91	2.04 ± 0.71
Stachyterpheta jamaicensis	33.43 ± 0.19	41.86 ± 0.28	26.60 ± 0.38	1.89 ± 0.44
Hyptis suaveolus	32.18 ± 0.33	38.94 ± 0.12	25.87 ± 1.00	2.01 ± 0.10
Cyathula prostrata	30.78 ± 0.41	38.91 ± 1.21	25.80 ± 0.50	1.68 ± 0.33
Diodia scandens	29.89 ± 0.09	37.72 ± 0.09	25.06 ± 0.49	1.71 ± 0.08
Ageratum conyzoides	29.72 ± 0.16	36.19 ± 1.05	23.87 ± 0.01	1.72 ± 0.54
Control	25.94 ± 0.33	30.16 ± 0.42	21.11 ± 1.06	1.05 ± 0.46
LSD (0.05)	1.23	0.09	1.02	0.03

*****Values are means of 3 replicates

Conclusion

This study revealed that *Alternaria bataticola* is associated with leaf and stem blight of sweet potato. It also showed that the plant extracts and mancozeb used in this study were effective in controlling the leaf and stem blight of sweet potato, both *in vitro* and in the field. Though extracts of the test plants sufficiently reduced the blight disease, they were however, slightly less effective than mancozeb. Extracts of *S. jamaicensis, H. suaveolus and C. prostrata* were the most toxic to the pathogen. This indicates therefore, that extracts of these indigenous flora contained potent fungitoxic phytochemicals which compared favourably with mancozeb in the control of leaf and stem blight of sweet potato. The use of aqueous leaf extracts of *S. jamaicensis, H. suaveolus and C. prostrata*, therefore can be adopted by farmers as cheap eco-friendly alternative (or at least complementary) control strategy of this important disease of sweet potato in smallholder farmsteads in Nigeria.

Conflict of interest

The authors declare no conflict of interests.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

References

1. Enyiukwu DN, Awurum AN, Nwaneri JA. Efficacy of plant-derived pesticides in the control of myco-induced postharvest and storage rots of tubers and agricultural products: A review. Net J Agric Sci. 2014; 2(2):30-36.
2. Nwaneri JA, Enyiukwu DN, Cyprian UEC, Nicholas JC. Response of fungal rot pathogens of sweet potato (*Ipomoea batatas* L.) in storage to aqueous extracts of some tropical plant materials and benomyl. Greener Trends Plant Pathol Entomol. 2020; 3(1):18-24.
3. Maranzu OJ. Antagonistic activities of some mycobiota against fungal rot pathogens of sweet potato in storage. Ph.D Disssetation, Michael Okpara University of Agriculture, Umudike, Nigeria. December 2020; 178p.
4. Alleman J. Evaluation of *Plectranthus esculentus* N. B. Br. As a potential vegetable crop. Ph.D Thesis, University of Pretoria, South Africa. 2002; 140p.
5. Prakash P, Prabhat K, Jaganathan D, Sheela I, Sivakumar PS. Status, performance and impact of sweet potato cultivation on farming communities of Odisha, india. A paper presented at the 10th International Conference of Agricultural Economists, July 28-August 2, 2018, Vancouver, Canada.
6. Tridge A. Sweeet potato global production and top sweet potato producing countries of the world. In: Sweet potato. Retrieved April 6, 2021. Available from: http://www.tridge.com/intelligences/sweet.potato/production...

7. Amadioha AC, Kenkwo PC, Markson AA. Fungitoxic potentials of extracts of plant origin against fungal root rot of cassava (*Manihot esculenta* Crantz) in storage. Ann Res Rev Biol. 2019; 31(1):1-9.
8. Akpaninyang F, Okpara DA, Njoku JC, Ogbologwung P, Okpara B, Akpan AE. Combinations of organic and inorganic fertilizer on root yield of orange sweet potato. Nig Agric J. 2005; 46:118-126.
9. Nielsen SS, Ohler TA, Mitchell MC. Cowpea leaves for human consumption: production, utilization and nutrient composition. In: Cowpea Research, IITA-Ibadan 1997; 126-132p.
10. Enyiukwu DN, Amadioha AC, Ononuju CC. Significance of cowpea leaves for human consumption. Greener Trends Food Sci Nutr. 2018; 1(1):001-010.
11. Tan JD, Forio EE, Estoy LS. Production and market potentials of sweet potato flakes. In: 2nd International Symposium on sweetpotato and cassava. Malaysia, June 14-17, 2005; 215-216p.
12. Ayeleso TB, Ramachela K, Mukwevho E. A review of the therapeutic potentials of sweetpotato: Phamacological activities and influence of the cultivar. Trop J Pharm Res. 2016; 15(12):27512761.
13. FAO (Food and Agricultural Organization). Human Nutrition in the developing World. FAO Food and Nutrition Series No. 29. Food and Agricultural Organization of the United Nations, Rome, Italy. 1997. 32-41p.
14. Gibson RW, Anitua V, Byamukama E, Mpembe I, Kayongo J. Control strategies for sweet potato virus diseases in Africa. Virus Res. 2003; 100(1):115-122.
15. Chalwe JM, Adebola P, Pillay M. Assessing the genetic diversity of Alternaria bataticola in South Africa using molecular markers. Asia J Appl Sci. 2017; 5(2).
16. Anginyah TJ, Nark RD, Caray EE, Njeru R. Etiology, effect of soil pH and sweet potato varietal reaction to Alternaria leaf petiole and stem blight in Kenya. Afr J Crop Sci. 2001; 9(1):287-299.
17. James WC. Crop Loss Assessment. In: Plant Pathologist Pocket Book (2nd Ed) Commomwealth Agricultural Bureaux, Farnham Royal, England, 1983; 30-143p.
18. Osiru M, Adipala E, Olanya OM, Lemaca E. Occurrences of Alternaria leaf petiole and stem blight on sweet potato in Uganda. Plant Pathol J. 2007; 6(2):112-119.
19. Jackson G. Leaf petiole and stem blight disease of sweet potato (*Alternaria bataticola*). In: African Soil Health Consortium Retrieved January 12, 2021 Available from www.africansoilhealth.cabi.org>15....
20. Meyer S, Saccardy-Adji K, Rizza E, Gevity B. Inhibition of photosynthesis by *Colletotrichum lindemuthianum* in bean leaves determined by chlorophyll imaging. Plant Cell Environ. 2001; 6(3):7-17.
21. Ilondu EM. Etiology and assessment of leaf spot disease of sweet potato (*Ipomea batatas* L) Lam. In selected farms in Nigeria. Agric Biol J Am. 2012; 4(4):474-484.
22. Enyiukwu DN, Amadioha AC, Ononuju CC. Evaluation of some pesticides of plant origin for control of anthracnose (*Colletotrichum destructivum* O'Gara) in cowpea. Asian J Agric. 2021; 5(1):004-011.
23. Asawalam EF and Adesiyan SO. 2001. Comparison of nematicidal potentials of *Azadirachta indica* and carbofuran (furadan) on growth and yield of root-knot infested okra. J Sust Agric Environ. 3(1):85-92.
24. Markson AA, Omosun G, Umunna EJ, Madunagu RE, Amadioha AC, Udo SE. Differential response of *Solanum tuberosum* L. and *Ipomea batatas* L. to three pathogens. Int J Nat Sci. 2014; 2(1):40-51.
25. Sseuwu G, Shanahan P, Ssemakula G. Genetic analysis of resistance to leaf petiole and stem blight of sweet potato in Uganda. Euph. 2016; 210:393-404.
26. BMA (British Medical Association). The BMA Guide to pesticide, chemical and health. London: Edward Press Inc.; 1992; 215p.
27. Jakoboski S. The dangers of pesticides. In: Green Science. (Online) 2011. Retrieved 2021 January 12. Available from http://www.nature.com/scitable/blog/green-science
28. Enyiukwu DN**,** Bassey IN, Nwaogu GA, Chukwu LA, Maranzu JO. Postharvest spoilage and management of fruits and vegetables: A perspective on small-holder agricultural systems of the tropics. Greener J Plant Pathol Entomol. 2020; 3(1):001-017.
29. Rifai R. UN: 200,000 die each year from pesticide poisoning. (Online) 2017. Retrieved 2021, January 12. https://www.aljazeera.com/economy/2017/3/8/un-200000-die-each-year-from-pesticide-
30. Beyound Pesticides. Impacts of pesticides on wildlife. (Online). 2016 Retrieved 2021, January 12. Available from www.beyoundpesticides.org>edia/The_dangers_of_pesticides_use....
31. DW (Defenders of Wildlife). The dangers of pesticides to wildlife A White Paper by Defenders of Wildlife. (Online) 2017. Retrieved 2020, June 13. 2020. Available from https://www.beyondpesticides.org/assets/media/documents/pesticidefreelawns/resources/DWDangers_Pesticides_Wildlife.pdf
32. Okwu DE and Njoku EE. Chemical composition and *in vitro* antifungal activity screening of leaf and seed extracts from *Afromonium meleguata* and *Monodora myristica* against *Sclerotium rolfsii* of cowpea plant. Pest Technol. 2009; 3(1):58-67.
33. Moreira ACP, Lima EO, de Souza EL. Chemical composition and antifungal activity of *Hyptis suaveolens* (L.) Poit. leaves essential oil against Aspergillus species. Braz J Microbiol. 2010; 4(1):28-33.
34. Ming LC. *Ageratum conyzoides*: A tropical source of medicinal and agricultural products. In: J. Jamick (ed). Perspectives on new crop and new uses. Alexandria: ASHS Press, 1999; 461-475p.
35. TPD (Tropical Plants Database) *Ageratum conyzoides*. (Online). 2017. Retrieved 2021, January 12. Available from https://tropical.theferns.info/viewtropical.php?id=Ageratum+conyzoides
36. Amadioha AC. Control of black rot of potato caused by *Rhizoctonia bataticola* using some plant leaf extracts. Arch Plant Pathol Plant Protect. 2004; 37:111-117.
37. Awurum AN and Nwaneri JA. Fungitoxic effect of some plant extracts on wet rot of Amaranthus induced by *Choanephora cucurbitarium.* Nig J Plant Protect. 2011; 25(2):230-236.
38. Ogu DE and Owoeye AE. *In vitro* control of anthracnose disease of cowpea (*Vigna unguiculata* L. Walp.) Caused by *Colletotrichum desttructivum* O'Gara with *Cyathula prostata* and *Diodia scandens* Sw leaf extracts. J Intercult Ethnopharmacol. 2013; 2(1):29-36.
39. Costa da Silva A, de Souza PE, Amaral DC, Zeviani WM, Brasil, JE, Pinto P. Essential oils from *Hyptis marrubiodes*, *Aloysia gratissima* and *Cordia verbenaceae* reduced the progress of Asia soybean rust. Acta Sci Agron 2014; 36(2): Doi: 10: 4025actasciagron.v36i2.17441.
40. Enyiukwu DN, Awurum AN, Ononuju CC, Nwaneri JA. Significance of characterization of secondary metabolites from higher plants in plant disease management. Int J Adv Agric Res. 2014; 2(2):30-46.
41. GPS (Global Positioning Systems) Coordinate. (Online). Retrieved 2019, June 14. Available from https://play.google.com/store/apps/details?id=com.latitudelongitude.gpscoordinates&hl=en

42. Amadioha AC. Evaluation of some plant extracts against *Colletotrichum lindemuthianum* in cowpea. Acta Phytopathol Entomol Hung. 2003; 38(3-4):259-265.
43. Barnett HL and Hunter BB. Illustrated genera of imperfect fungi (4th Ed.) Minnesota: Amer. Phytopathol Soc. 1998; 348p.
44. Ahuchaogu AA, Ogbuehi GI, Obike AI, Egedeuzo CS, Chukwu OJ, Echeme JO. GC-MS analysis of bioactive compounds from whole plant chloroform extract of *Ageratum conyzoides*. Int J Med Plants Nat Prod. 2018; 4(2):13-24.
45. Ogu GI, Madagwu EC, Eboh OJ, Ezeadila JO. Antifungal evaluation of *Diodia scandens* SW leaf extracts against some dermatophytes in Ukwuani region of Delta State, Nigeria. (Online). Retrieved 2021, January 12. Available from:www.interesjournal.org/abstract/antifungal-evaluation-of-diodia-scandens....
46. Abubacker MN, Anbumani T, Dheepan G, Chellamuthu C. Antifungal activity of leaf extract of Stachyterpheta Jamaicensis Linn. Vahl (Verbenaceae). Drug Discov Today 2014; 6(1):62-63.
47. Gupta M, Sharma S, Bhaduria R. Fungitoxic activity of fruit extracts of *Syzygium cumini* (L.) Skeels against plant pathogenic fungi *Alternaria alternata* and *Fusarium oxysporum*. Arch Phytopathol Plant Protect. 2014; 48(4):354-364.
48. Okwu DE, Awurum AN, Okonkwo JI. Phytochemical Composition and *in vitro* antifungal activity screening of extracts from Citrus plants against *Fusarium oxysporum* of Okra plant (*Hibiscus esculentus*). 8th African Crop Science Conference, El-minia, Egypt; October 27-31, 2007.
49. Cowan MM. Plant products as antimicrobial agents. Clin Microbiol Rev. 1999; 12(4):564-582.
50. Anyanwu MU and Okoye RC. Antibacterial activity of Nigerian medicinal plants. J Intercult Ethnopharmacol. 2017; 6(2):240-259.
51. Seetha RJ, Raja GRC, Ramanjaneyulu R Evaluation of certain plant extracts and antagonists against *Fusarium solani* and *Alternaria tenuissima*, the incitants of root and die-back of mulberry. Int J Industrial Entomol. 2010; 21(1): 1-5.
52. Ames T. Alternaria blight. In: Biology and ecology of *Alternaria bataticola*. (Online). 2020. Retrieved 2020, November 12. Available from: https://keys.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/Media/Html/TheProblems/DiseasesFungal/AlternariaStemBlight/Alternaria%20blight.htm.
53. Okwu DE and Offiong ON. Isolation and characterization of lanostan glycosides from leaves of *Stachyterpheta jamaicensis* Linn Vahl. Int J ChemTech Res. 2010; 1(4):1043-1047.
54. Parveen Z, Nawaz, S, Sidique S, Shahzad K. Composition and antimicrobial activity of the essential oil from leaves of *Curcuma longa* Kasur variety. Ind J Pharm Sci. 2013; 75(1):117-122.
55. Tang G, Liu X, Gong X, Lin X, Lai X, Wang D, Ji S. 2019. Studies on the chemical composition of *Hyptis suaveolens* (L.) Poit. J Serb Chem Soc. 2019; 84(1):245-252.
56. Adebayo AH, Zeng GZ, Zhang YM, Ji CJ, Akindahunsi AA, Tan NH. Toxicological evaluation of precocene II Isolated from *Ageratum conyzoides* L. (Asteraceae) in Dawley rats. Afr J Biotechnol. 2010; 9(20):2938-2944.
57. Esper RH, Gonçalez E, Felicio RC, Felicio JD Fungicidal activity and constituents of *Ageratum conyzoides* essential oil from three regions in Sao Paulo state, Brazil. Sci Comm. 2015; 82:1-4.
58. Kwemba JTK, Mbula JP, Onantshu O, Mpiana PT, Haesaent G. Antifungal activity of the strain of *Lasidiodiplodia theobromae* and phytochemical study of *Ageratum conyzoides* and *Newbodia laevis* from Kasinger region of DR Congo. Int J Pak Res. 2020; 5(4):1-10.
59. Ogu GI, Tanimowo W, Nwachukwu UP, Igaru B. Antimicrobial and phytochemical evaluation of leaf, stem bark and root extracts of *Cyathula prostrata* (L.) Blume on some human pathogens. J Compl Med Res. 2012; 1(1):35-43.
60. Amadioha AC and Obi VI. Fungitoxic activity of extracts from *Azadirachta indica* on *Colletotrichum lindemuthianum* in cowpea. J Herbs Spices Med Plants. 1998; 6(2):33-40.
61. Amadioha AC and Obi VI. Control of anthracnose disease of cowpea by *Cymbopogon citratus* and *Ocimum gratissimum.* Acta Phytopathol Entomol Hung. 1999; 34(1-2):85-89.
62. Enyiukwu DN and Awurum AN. Comparative fungitoxicity of benomyl and extracts of *Carica papaya* roots and seeds and *Piper guineense* seeds on *Colletotrichum destrucivum* O'Gara. Cont J Biol Sci. 2012; 6(1):38-42.
63. Yang C, Hamel C, Vujanovic V, Gan Y. Fungicides: mode of action and possible impact on-non target microorganisms. Int Sch Res Not. 2011; Article ID 130289
64. Enyiukwu DN, Awurum AN, Ononuju CC, Nwaneri JA. Modes of action of potential phyto-pesticides from tropical plants in plant health management. IOSR J Pharm. 2016; 6(7):01-17.
65. Dissanayake DPA, Sivaganesh S, Tissara MHA. Handunneti SM, Arawwawala LDAM. Comparative antioxidant properties of *Cyathula prostrata* Linn. and *Achyranthes aspera* Linn. grown in Si Lanka. Res Rev Insights 2018; 2(3):1-3.
66. Ajuogu PK, Eze R, Nodu MB, Nwachukwu CU, Mgbere OO. The influence of graded level of *Cyathula prostrata* (L.) Blume on sperm quality characteristics on Adult New Zealand bucks. Trans Anim Sci. 2020; 4(2):1134-1139.
67. Awurum AN and Ogbonna MJ. Field trial on the efficacy of some plant extracts in the control of wet rot of *Amaranthus cruenta* L. induced by *Choanephora cucurbitarium*. Cont J Agron. 2013; 7(1):10-17.
68. Awurum AN, Enyiukwu DN, Odoemena VK. Influence of plant-gleaned compounds on the initiation and development of fungal diseases of onion (*Allium cepa* L.) in the field. J Biol Agric Healthcare 2016; 6(9):1-80.