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In vitro evaluation of aqueous leaf and peel extracts of *Musa* species for low-input management of fungal leaf spots of sweet potato (*Ipomea batatas* Linn.)

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ABSTRACT

Sweet potatoes are important food staples in tropical sub-Saharan Africa. Orange flesh sweet potato (OFSP) varieties are especially important for combating vitamin A deficiencies and nutrition-induced blindness. Fungal leaf spots are one of the many challenges constraining its production in Umudike, Southeast, Nigeria. The aims of this experiment were to isolate the causal fungi of leaf spots of OFSP and to attempt their control using aqueous extracts of banana peels, plantain peels and plantain leaf *in vitro*. Mycotic agents isolated from infected plant were *Verticillium longisporum, Rhizoctonia solani, Penicillium chrysogenum* and *Aspergillus niger*. Pathogenicity test conducted on the organisms revealed that the first three pecies were actively pathogenic, with infected sweet potato showing irregular brown spots/blights surrounded by chlorotic hallo around leaf veins and margins of the laminae; while *A. niger* showed weak infection of the plant. In the laboratory, four concentrations (10%, 25%, 50% and 75%) of ripe and unripe plantain peels, ripe and unripe banana peels, and senescent and new plantain leaves, griseovid® (a standard antifungal) and control (sterile water) were evaluated *in vitro* for inhibition of mycelial elongation of the test myco-pathogens associated with the leaf spot disease of the crop. The experiment was laid out as 3 x 4 x 8 factorial in CRD with 3 replications. The botanicals significantly ($P \leq 0.05$) and differentially retarded radial growth of the fungus over the control in a dose-dependent manner. However, the fungitoxicity of the botanicals were inferior but compared favourably with the standard antifungal griseofulvin (griseovid®). Exploiting the potency of these readily available, cost effective and eco-friendly agro-wastes against these fungal pathogens causing leaf blight of sweet potato will not only reduce the hazards and pollution challenges associated with use of synthetic pesticides but also increase food production in developing countries where synthetic fungicides are expensive and out of reach of low-input farmers.

Keywords: Sweet potato, Leaf spot disease, *Musa* spp., Plant extracts, Agro-wastes

ABSTRAK

Evaluasi in vitro ekstrak air daun dan kulit spesies Musa untuk manajemen input rendah bercak daun jamur ubi jalar (*Ipomea batatas Linn.)*

Ubi jalar adalah makanan pokok penting di Afrika sub-Sahara tropis. Varietas ubi jalar daging jeruk (OFSP) sangat penting untuk memerangi kekurangan vitamin A dan kebutaan akibat nutrisi. Bercak daun jamur adalah salah satu dari banyak tantangan yang menghambat produksinya di Umudike, Tenggara, Nigeria. Penelitian ini bertujuan untuk mengisolasi jamur penyebab bercak daun OFSP dan mencoba pengendaliannya menggunakan ekstrak air kulit pisang, kulit pisang raja dan daun pisang raja secara in vitro. Agen mikotik yang diisolasi dari tanaman terinfeksi adalah *Verticillium longisporum, Rhizoctonia solani, Penicillium chrysogenum* dan *Aspergillus niger*. Uji patogenisitas yang dilakukan terhadap organisme mengungkapkan bahwa tiga spesies pertama aktif patogen, dengan ubi jalar yang terinfeksi menunjukkan bercak/blight coklat yang tidak teratur dikelilingi oleh hallo klorotik di sekitar urat daun dan tepi lamina; sedangkan A. *niger* menunjukkan infeksi yang lemah pada tanaman. Di laboratorium, empat konsentrasi (10%, 25%, 50% dan 75%) kulit pisang raja matang dan mentah, kulit pisang matang dan mentah, dan daun pisang tua dan baru, griseovid® (antijamur standar) dan kontrol (steril). air) dievaluasi in vitro untuk penghambatan pemanjangan miselium dari miko-patogen uji yang terkait dengan penyakit bercak daun pada tanaman. Percobaan disusun sebagai faktorial 3 x 4 x 8 dalam CRD dengan 3 ulangan. Tumbuhan secara signifikan ($P \leq 0{,}05$) dan secara berbeda memperlambat pertumbuhan radial jamur di atas kontrol dengan cara yang bergantung pada dosis. Namun, fungitoksisitas tumbuhan lebih rendah tetapi lebih baik dibandingkan dengan griseofulvin antijamur standar (griseovid®). Memanfaatkan potensi limbah pertanian yang tersedia, hemat biaya dan ramah lingkungan ini terhadap patogen jamur penyebab hawar daun ubi jalar tidak hanya akan mengurangi bahaya dan tantangan polusi yang terkait dengan penggunaan pestisida sintetis tetapi juga meningkatkan produksi pangan di negara berkembang. di mana fungisida sintetis mahal dan tidak terjangkau oleh petani dengan input rendah.

Kata Kunci: Ubi jalar, Penyakit bercak daun, Musa spp., Ekstrak tumbuhan, Limbah pertanian

INTRODUCTION

Orange Fleshed Sweet potato (OFSP) (*Ipomea batatas* Linn.) is one of the staple foods that has potentials for providing sustainable source of Vitamin A for people living with vitamin A deficiency (VAD) in Nigeria. It is highly nutritious being rich in beta-carotene (vitamin A precursor) whose concentration is correlated by the degree of intensity of orange colour of the root. The root is often consumed as a vegetable (boiled, fried or roasted) or processed in different

forms to enhance the household intake as food (Maru *et al*., 2018; Anyaegbulam *et al*., 2019). OFSP contains natural sugars that are gradually released into the bloodstream to ensure a balanced source of energy, thereby reducing fatigue and weight gain. It is a powerful antioxidant that helps in prevention of cancer, and vitamin A related retinal and sight complications in public health (Enyiukwu *et al*., 2020).

In spite of its importance and steady increase in consumption levels, the production of OFSP has been faced with a number of challenges especially attack by pathogenic organisms both in the field and storage (Enyiukwu *et al*., 2014; Okigbo & Omodamiro, 2006). Several fungal pathogens have been implicated to incite diseases on the aerial parts of sweet potato such as *Alternaria* spp. (Alternaria leaf spot and stem blight), *Cercospora* spp. (Cercospora leaf spot), *Sphaceloma batatas* (Leaf and stem rot), *Helminsthoporium* spp. (Heminsthoporium leaf spot), and *Fusarium denticulatum* (chlorotic leaf distortion)(CABI, 2008; Enyiukwu *et al*., 2021). Attack by these pathogens on the aerial or vegetative parts of the crop has negatively impacted its food and vine production (Ames, 1997; Vinayaka *et al*., 2012; Enyiukwu *et al*., 2021).

In order to curb the effects of these phyto-pathogens on the crop, synthetic fungicides such as mancoxeb, thiophenate-methyl, benomyl etc. have been employed. However, the attendant ecological and mammalian toxicities from inappropriate or excessive application of broadspectrum biocides have spurred search for less toxic compounds (Amadioha & Kenkwo, 2019; Enyiukwu *et al*., 2021). Antifungal potentials of some plant materials against fungal pathogens causing plant diseases both in the field and storage have been reported by some workers (Amadioha, 2006, 2012; Amadioha & Enyiukwu, 2019; Amadioha & Kenkwo, 2019). Okorondu *et al.* (2012) reported the antifungal properties of the peel and stalk extracts of plantain (*M. paradisiaca*). Different species of *Musa* have been reported to contain bioactive compounds such as apigenin glycosides, myricetin glycoside, naringenin glycosides, dopamine, *N*-acetyl serotonin, and rutin (Egbonu *et al*., 2017; Shadrach *et al*., 2020).

Generally, there is dearth of information on the fungal pathogens causing leaf spot diseases of OFSP varieties on one hand; and on the other hand, little or no information is available on their control using readily available agro-wastes such as peels and leaves of plantains and bananas in the humid Umudike, Southeast Nigeria. The use of agricultural wastes in the control of fungal pathogens causing diseases of OFSP in the field and storage will not only reduce the ecological and public health problems associated with synthetic pesticides, but is environmentally non-disruptive, cost effective for low-input farmers and holds great potentials to increase food production. Therefore, the aims of this paper were to isolate and identify fungal pathogens associated with leaf spot diseases of OFSP; and assess the fungitoxic attributes of aqueous extracts of peels and leaves of plantains and bananas (*Musa* species) in the control of fungal pathogens causing leaf spot diseases of OFSP in the humid Umudike area of Southeast, Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the Department of Plant Health Management Laboratory and greenhouse of the Michael Okpara University of Agriculture, Umudike (MOUAU) Umudike, Abia State, Nigeria. The soil type of the study area was sandy loam (77% sand, 13% clay), mean annual rainfall, ambient temperature, relative humidity and elevation were 2439 mm, 28±2^{o}C, 85± 2% and 122 meters above sea level respectively.

Source of materials

The potato vines (Var: Mothers' Delight) were sourced from national Roots Crop Research Institute (NRCRI), Umudike. The vines were cut at 15 cm with 4-5 nodes and planted in micro-plots to multiply them. The agro-waste materials (ripe and unripe plantain peels, ripe banana peels) were collected from fruit vendors at Ndoru market in Ikwuano council area of Abia State, Nigeria; while the plantain leaves were collected at a plantation in the University neighborhood and authenticated at the Department of Botany of the University.

Preparation of culture medium

Dehydrated potato dextrose (PDA) (Oxoid™ ThermoScientific Product, England, UK) was prepared by reconstituting 39.5 g of dehydrated PDA powder in 1000 ml of sterile distilled water contained in a 2L flat-bottomed conical flask, to which 250 mg chloramphenicol was added, stirred vigorously, and covered with a foiled non-absorbent cotton wool and thereafter autoclaved at 15 Psi for 15 minutes (Enyiukwu *et al*., 2021).

Isolation and identification of pathogens

The infected sweet potato leaves (petioles and laminae) with typical leaf spot disease symptoms were collected from the field and placed in clean brown envelops and taken to laboratory. The infected leaves were washed in 5% sodium hypochlorite solution for one minute and then rinsed thrice in several changes of sterile distilled water (Amadioha, 2003; Enyiukwu *et al*., 2021). They were allowed to dry on sterile filter paper to remove water droplets and then cut into small pieces (3 mm). Three pieces were placed in a Petri dish containing solidified sterilized molten Potato Dextrose Agar. The inoculated Petri plates were incubated at 27^{o}C and observed daily for mycelia growth. Different fungal colonies were each isolated and sub-cultured to obtain pure cultures (Amadioha, 2003; Enyiukwu *et al*., 2021). Microscopic

examination was carried out on each of the isolates to ascertain their characteristic features and then identified according to Barnet & Hunter (1999).

Pathogenicity test

The pathogenicity test of the fungal isolates was conducted in the Plant Health Management Department greenhouse, Michael Okpara University of Agriculture Umudike, Abia state, Nigeria. Polythene bags (30×15×0.3 cm) were each filled with 10 kg of heat-sterilized loam soil from the University Research Farm. OFSP vine (20 cm) was planted at 45^0 to the horizontal in each bag. The greenhouse temperature and relative humidity stood at about 27±2^{o}C and 85±2% for 4 weeks; before the relatively disease-free test seedlings were separately spray-inoculated with spore suspension (1.5×10^5 spores/ml of distilled water) prepared from seven-day old cultures of each isolate; or supernatant of mycelial/sclerotial suspension in the case of *R. solani* from 10-day old culture of the pathogen (Amadioha *et. al.*, 2019). Those fungal isolates that caused typical disease symptoms on the OFSP seedlings (Figure 1) were identified as pathogens and used subsequently for the experiment.

Figure 1**.** From left to right**:** *Verticillium longisporum, Rhizoctonia solani* and *Penicillium chrysogenum* infecting OFSP during pathogenicity test.

Preparation of plant extracts

The plant materials (senescent and new plantain leaves, ripe and unripe plantain peels and ripe and unripe banana peels) were washed thoroughly in tap water, rinsed in three changes of sterile distilled water. The plant materials where then prepared by weighing out 10 g, 25 g, 50 g and 75 g of each specimen and then separately pulverized them using an electric blender (Model: Waring UK, CB15V), while griesovid® (a standard antifungal - griseofulvin) (prepared by mixing 10 ml of the antifungal in 1 liter of sterile distilled water) was applied at 10 ml/L. Each pulverized test plant specimen was soaked in 100 ml of sterile distilled water in 250 ml conical flask, stirred vigorously and allowed to stand for 8 hours with its mouth was covered with a foiled stopper. Thereafter they were strained separately through 4-folds of sterile cheese cloth to obtain filtrates of 10%, 25%, 50% and 75% concentrations of the aqueous plant extracts and kept in sterile vials in the refrigerator at 4 degrees centigrade until required.

***In vitro* experiment**

One (1) ml suspension of each of the plant extracts was mixed separately with cooled molten PDA contained in Petri dishes by gentle swirling motion and allowed to solidify. A disc (3mm) diameter cut with a cork borer from 7-day old pure culture of each pathogen was transferred aseptically to the center of the solidified PDA–Extracts medium in Petri dishes that had been marked at the bottom with two perpendicular lines through the center. The Petri dishes (9 cm diameter) were incubated at 27^o C for 7 days. The control was set up likewise but consisted of 1ml of sterile water or griesovid. Growth of the pathogen was measured daily with a meter rule along the perpendicular lines for one week after incubation. The experiment was a 3 x 4 x 5 (3 pathogens, 4 extract concentrations and 7 extracts) factorial experiment in a completely randomized design (CRD) with 3 replications and was repeated twice. The fungitoxicity of the extracts was determined as a percentage of mycelial growth inhibition, calculated according to the formula by Amadioha (2003) as:

$$\text{Growth inhibition (\%)} = \frac{x}{y} \text{ x } 100$$

Where:

x = Average diameter of colony with control.

y = Average diameter of colony with treatment.

Statistical analysis

All data are means of triplicate determinations and were analysed using analysis of variance (ANOVA) as contained in the general linear model procedure in SAS System (2008) version. Means were separated and compared using Fisher's LSD at 0.05% level of significance.

RESULTS

Result presented in Table 1 showed that 75% (0.2) and 50% (0.3) concentrations of the ripe banana peels extracts compared favourably with (the standard

antifungal) griseovid® (0.1%) in reducing the mycelial growth of *V. longisporum* when compared with 10% (0.9%) and 25% (0.4) respectively. Also, 75% (0.8) concentration of ripe banana peels extracts significantly ($p \leq 0.05$) reduced the mycelial growth of *R. solani* when compared with 10% (39.0), 25% (38.0) and 50% (37.0) of the same extract against *P. chrysogenum* as shown in the result. This result could be due to the presence or concentration of the active compounds contained in the ripe banana peels which inhibited growth and development of these pathogens. This result further revealed that the higher the concentration of the plant extracts assayed, the more effective it reduced the mycelial growth of the assayed pathogens.

Table 1. Effects of aqueous extract of ripe banana peels and griseovid® on the radial growth of the test pathogens in culture.

Fungal isolates	Fungal isolates and concentration (%) of extracts of ripe banana peels Concentrations (%)					
	10	25	50	75	Griseovid*	sterile water
V. longisporum	0.9	0.4	0.3	0.2	0.1	0.9
P. chrysogenum	39.0	38.0	37.0	30.0	10.0	40.0
R. solani	16.0	11.0	10.0	0.8	0.1	12.0

**Data are means of triplicate determinations, * Concentration = 10ml/L
LSD (0.05) – isolate = 0.49
LSD (0.05) – concentration = 0.70
LSD (0.05) – isolate x concentration = 1.21

In Table 2 below, 75(0.3) and 50% (0.4) of senescent chlorotic plantain leaf extracts was highly effective against the radial growth of *V. longisporum* and *R. solani* when compared with 10% (40.0), 20% (40.0), 50% (38.0) and 75% (38.0) of the same extract against *P. chrysogenum*. However, griseovid® (the standard antifungal) significantly ($p \leq 0.05$) reduced the mycelial growth of the three test fungi unlike the sterile water control (40.0) which encouraged the growth of *P. chrysogenum*. This result could be due to enzymes or compounds released by the pathogen in culture which probably hydrolyzed or inhibited the active principle of the test botanical and thereby suppressed the fungitoxicity of the test plant extracts (Enyiukwu *et al*., 2016; Prakash *et al*., 2017).

Table 2. Effects of aqueous extracts of yellowish plantain leaves and griseovid on radial growth of the test pathogens in culture.

Fungal isolates	Fungal Isolates and Concentration (%) of extracts of plantain leaf Concentrations (%)					
	10	25	50	75	*Griseovid	Control (sterile water)
V. longisporum	0.9	0.6	0.4	0.3	0.1	0.9
P. chrysogenum	40.0	40.0	38.0	38.0	0.5	40.0
R. solani	11.0	0.9	0.40	0.3	0.1	11.0

**Data are triplicate determinations, *Concentration = 10ml/L
LSD (0.05) – isolate = 0.3
LSD (0.05) – concentration = 0.43
LSD (0.05) – isolate x concentration = 0.75

Result in Table 3 below also revealed that 75% (0.2, 0.2) and 50% (0.3, 0.3) concentrations of the unripe plantain peels extracts similarly controlled effectively the mycelial growth of *V. longisporum* and *R. solani* when compared with 10% (37.0) and 75% (38.0) concentrations against *P. chrysogenum*. Also, the griseovid significantly ($p \leq 0.05$) reduced the mycelial growth of *V. longisporum* (0.1) and *R. solani* (0.1) in culture respectively. This result also showed that the higher the concentration of the plant extracts evaluated, the more effective they inhibited the mycelial growth of the test fungi. Also, the active compounds present in the plant material studied could have played a significant role in suppressing the growth of *V. longisporum* and *R. solani*.

The result presented in Table 4 also showed that 75% concentration of the unripe banana peels gave the highest (%) percentage inhibition against *R. solani* (78%) and *V. longisporum* (77%) and this favorably compared with griseovid 99% and 78%

against the same fungal pathogens as shown in the result. However, there was a wide contrast between the percentage (%) inhibition recorded with 10% (0%) extract of the unripe banana peels against *V. longisporum* and 10% (2), 25% (5), and 50% (7) which significantly ($p \geq 0.05$) increased the mycelial growth of *P. chrysogenum* in culture. Therefore, the result indicated that 75% concentrations of the ripe banana peels could be highly effective against *V. longisporum* and *R. solani* spores and similarly competed with the synthetic fungicide (griseovid) on the same fungi.

Table 3. Effect of aqueous extract of the unripe plantain peels and griseovid on the radial growth of the test pathogens in culture.

Fungal isolates	Fungal isolates and Concentration (%) of extracts of unripe plantain peels Concentrations (%)					
	10	25	50	75	Griseovid	Control (sterile water)
V. longisporum	0.5	0.4	0.5	0.2	0.1	0.7
P. chrysogenum	39.0	39.0	38.0	38.0	10.0	4.0
R. solani	10.0	0.5	0.3	0.2	0.1	10.0

**Data are means of triplicate determinations, *Concentration = 10ml/L
LSD (0.05) – isolate = 0.37
LSD (0.05) – concentration = 0.53
LSD (0.05) – isolate x concentration = 0.91

Table 4. Effects of different concentrations of aqueous extract of unripe banana peels and griseovid on radial growth of the test pathogens in culture

Fungal isolates	Fungal isolates and Concentration (%) of extract of ripe plantain peels Concentrations (%)					
	10	25	50	75	Griseovid	Sterile water
V. longisporum	1.01	55.56	66.67	77.78	88.89	0.93
P. chrysogenum	2.50	5.00	7.50	25.00	75.00	1.50
R. solani	25.00	8.33	16.67	93.33	93.33	2.07

**Data are means of triplicate determinations, *Concentration = 10ml/L
LSD (0.05) – isolate = 0.42
LSD (0.05) – concentration = 0.66
LSD (0.05) – isolate x concentration = 1.21

The result shown in Table 5 revealed that amongst the three fungal pathogens studied, 10% (0), 25% (0) and 50% (5) 75% (5) concentrations of fresh plantain leaves similarly were the most effective extracts to support the mycelial growth of *P. chrysogenum* in culture. This result however could be due to the percentage (%) concentration of the active principle present in the plant material and probably as a result of the fungal pathogens tested. Furthermore, the fresh plantain leaves compared favorably with the synthetic fungicide (griseovid) at 25% (91), 50% (76) and 75% (97) in supporting the mycelial growth of *R. solani* as shown in the result below.

The result in Table 6 also showed the same trend as the ripe plantain peels at 10% (2), 25% (2), 50% (5) and 75% (5) concentrations similarly increased the radial mycelial growth of *P. chrysogenum*, followed by 25% (95), 50 (97%) and 75%(98) concentrations which on the contrary inhibited effectively the mycelial growth of *R. solani* in culture. However, the griseovid which is the synthetic fungicide significantly ($p \leq 0.05$) inhibited the radial growth of the three fungal pathogens tested. The result therefore revealed that the unriped plantain leaves which compared favorably with griseovid against *R. solani* at 25%, 50%, and 75% showed no potency against the mycelial growth *P. chrysogenum* irrespective of the different concentrations of the extracts from the ripe plantain peels assayed.

Table 5. Effect of different concentrations of aqueous extracts of fresh plantain leaves and griseovid on the radial growth of the test pathogens in culture.

Fungal isolates	Fungal isolates and Concentration (%) of extracts of plantain leaves Concentrations (%)					
	10	25	50	75	Griseovid	Sterile water
V. longisporum	11.10	33.33	55.56	66.67	88.89	0.12
P. chrysogenum	09.00	14.06	5.00	5.00	98.75	0.67
R. solani	15.08	91.82	96.67	97.27	99.10	1.03

**Data are means of triplicate determinations, *Concentration = 10ml/L
LSD (0.05) – isolate = 1.04
LSD (0.05) – concentration = 0.91
LSD (0.05) – isolate x concentration = 1.32

Table 6. Effect of different concentrations of aqueous extracts of ripe plantain peels and griseovid on radial growth of the test pathogens in culture.

Fungal isolates	Fungal isolates and Concentration (%) of extracts of ripe plantain peels Concentrations (%)					
	10	25	50	75	Griseovid	Sterile water
V. longisporum	28.57	40.86	57.14	71.43	85.71	0.20
P. chrysogenum	2.50	2.50	5.00	5.00	75.00	1.33
R. solani	1.09	91.82	97.00	98.00	99.00	0.62

**Data are means of triplicate determinations, *Concentration = 10ml/L
LSD (0.05) – isolate = 0.29
LSD (0.05) – concentration = 0.41
LSD (0.05) – isolate x concentration = 0.70

DISCUSSION

The study showed that four (4) out of five (5) pathogens isolated from the aerial parts of the three improved sweet potato varieties assayed were all pathogenic, with *V. longisporum, P. chrysogenum* and *R. solani* being more virulent than *A. niger*. These pathogens may have penetrated into the host plants' organs through natural openings such as leaf stomata or lenticels of their roots in the soil. Several works by many researchers have reported that *V. longisporum, P. chrysogenum* and *R. solani* conveniently incited leaf spot, and leaf blight diseases in plants such leafy vegetables, succulent roots and tuber crops (Ilondu *et al*., 2013).

Leaf spot attacks on affected crops usually result in leaf defoliations, which translates to disruption in the photosynthetic process, serious qualitative foliage losses and up to 25-43% direct losses in biomass accumulation and yield of crops (Walluyah *et al*., 2000). Sizeable leaf defoliations attendant from attacks of these pathogens on the test crop varieties during pathogenesis supports these reports. *R. solani* causing necrotic lesions of leaves, stem rot of near-ground sweet potato vine is an aggressive species. It attacks the whole vine (leaves, petioles and stem) of susceptible sweet potato varieties at an early stage and through all the crop cycle causing girdling of the stem to severe necrotic spots which results into wilt or die back of the terminal portion of the vine (Alajo, 2000; Huang *et al*., 2017; Ekhuruele & Nsobundu, 2020).

Also, Berlenger & Powelson (2005) reported that during warm weather *V. longisporum* (a fungus that grows on a variety of plants) can cause premature foliar chlorosis beginning from the lower leaves of sweet potato vines, necrosis and vascular discolouration in stems and roots resulting to wilting. Findings in this study showed that these fungi are pathogenic to OFSP thus consistent with views of the previous workers.

Results from this study also revealed that 50% and 75% concentrations of ripe aqueous banana peels extracts reduced effectively the mycelial growth of *V. longisporium* and *R. solani* and moderately inhibited *P. chrysogenum* (Table 1). This therefore agrees with the views of many workers. Previous works by Okigbo & Nmeka (2009) and Amadioha *et al.* (2000) reported that bio-fungicides of plant origin have been successfully used to control fungal diseases in vegetables, roots and tuber crops. Banana peels is a cheap and effective natural antagonist against certain growth, reproductive structures and development of certain pathogenic fungi such as *A. flavus, A. niger and Penicillium sp*. (Prakash *et al*., 2017). Differences in targets sites of the fungitoxic compounds of the test extracts on the pathogens or differences in potentials to incapacitate certain fungal growth promoting and/or chitin enhancing enzymes may explain the differentials susceptibility of the pathogens to the extract (Enyiukwu *et al*., 2016).

The result also showed that aqueous fresh leaf extracts of plantain in a similar showed strong toxicity against the mycelial growth of *V. longisporum* and *R. solani* and compared favorably with the synthetic fungicide. This view is supported by Enyiukwu *et al.* (2021) where aqueous extracts of some tropical flora effectively frustrated the onslaught of *Alternaria alternata* in the field. In a parallel study, Osman *et al.* (2011) also found that *R. solani* was successfully controlled using some agricultural wastes in soybean (*Glycine max* L.). Several workers reported that most tropical medicinal plants contain fungitoxic phenolic ingredients which help inhibit penetration and maceration of target host crops by preventing production or inactivation certain enzymes or compromising certain cell organelles such as the mitochondria and cell membranes of fungal pathogens (Mendes *et al*., 2013; Enyiukwu and Awurum, 2013; Enyiukwu *et al*., 2016; Telles *et al*., 2017).

The result of this study further showed that 75% (0.2, 0.2) and 50% (0.3, 0.3) concentrations of unripe plantain peels also showed strong antagonism against the mycelial growth of *V. longisporum* and *R.solani*. This, thus suggests that plantain and banana peels may contain similar bioactive antioxidant antimicrobial and fungal growth compromising compounds such as rutins, tannins, flavonoids, alkaloids, terpenoids, saponins, glucosides and phenolics (Enyiukwu & Awurum, 2013). Lindo *et al*. (2016) reported that globally fruit peels are agricultural wastes discarded as useless materials, and thus poses serious environmental management problems. Fruits peels including plantain and bananas contain many bioactive compounds like rutins,

tannins, flavonoids, alkaloid, terpenoids, glucosides etc. which have antioxidant, antimicrobial and antifungal principles (Prakash *et al*., 2017).

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Results of pathogenicity studies from this study showed that *V. longisporum, R. solani,* and *P. chrysogenum* were strongly pathogenic to OFSP. However, *A. niger* was mildly pathogenic to the crop. The result of antifungal evaluation of the test botanicals in this study showed that aqueous extracts of banana peels (ripe and unripe), plantain leaves (old and new) and plantain peels (ripe and unripe) possess active phytochemicals and differentially inhibited the growth of *V. longisporum, R. solani, P. chrysogenum* causing the leaf spot of test sweet potato variety in culture. However, the efficacy of the extracts differed with concentration and type of pathogen. Though griesovid (griseofulvin) out-performed the botanicals, however, the effects of the later were comparable to it; and thus they could be used in low-input farmsteads for control of leaf spot diseases of sweet potato.

RECOMMENDATIONS

Further research is required especially in the area of extracting the active principle present in the test extracts and testing them individually on the test pathogens or their target organelles to assess the activity and/or synergistic roles of each principle as well as their mechanism of action against the target pathogen.

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