Journal of Agriculture, Environmental Resources and Management
ISSN2245-1800(paper) ISSN 2245-2943(online)
8(4)1-800; **April** .2026; pp75- 84

www.saerem.com

Impact Of Botanical Applications On Leaf Distortion Disease Of Sweetpotato (*Ipomoea batatas* Lam.) In Humid South Eastern Nigeria

[1]ANONABA, N. K., [2]EFURUIBE. P. E. AND [3]OPARA, E. U

[1] Department of Crop Science, Faculty of Agriculture, University of Agriculture and Environmental Sciences Umuagwo, Imo State [2]Department of Plant Health Management, College of Crop and Soil Science, Michael Okpara University of Agriculture, Umudike [3] Department of Crop Science. Faculty of Agriculture, University of Port Harcourt
Corresponding Author's Email:katilauz@yahoo.com,; euopara22@gmail.com,

Abstract

S*weet potato is an important root crop that serves as a staple food crop to the people in the South East, it was found to be heavily threatened by leaf distortion disease. A field trial was therefore conducted during the 2024/ 2025 cropping season at the Research Farms of Michael Okpara University of Agriculture, Umudike, South Eastern Nigeria to evaluate the potential effect of plant extracts including Zingiber officinales (rhizomes), Carica papaya (seeds) and Moringa oleifera (leaves) on the control of bacterial leaf distortion of sweetpotato (Ipoemea batatas Lam.) pathogen. The main aim was to isolate the causal organisms, identify and control the pathogens that induced leaf distortion disease. The experimental design was Randomized Complete Block Design (RCBD) with three replicates. The varieties used (Umuspo 1, Umuspo 2 and Umuspo 3) were sourced from National Root Crop Research Institute, Umudike (NRCRI). Diseased sweet potato leaves were obtained randomly from the field during the cropping season and inoculated onto nutrient agar medium for isolation and identification of bacterial pathogens. Some standard morphological and biochemical tests were also conducted. The bacterial isolates obtained were sub cultured to obtain pure culture after incubation for 24hours and pathogenicity test was also conducted to determine the pathogenic nature of the causal organisms. All data obtained were subjected to analysis of variance and the means separated using Fishers significant difference at 5% probability using SASA 2009 Model. From the field experiment results showed that all the plant extracts assessed reduced disease incidence and severity significantly at 5% probability when compared with the untreated control. M. oleifera was found to be best in reducing incidence of bacterial leaf distortion (16.66%), as well as severity of leaf distortions (2.87). However, extracts of C. papaya seed had the best performance ($P \leq 0.05$) in terms of some growth parameters; vine length (144.23cm), number of leaves (270.11), stem diameter (3.54cm) and number of branches across all the sweet potato varieties tested. Data on C. papaya extracts compared favourable with those of extracts of Z. officinales on tuber yield at harvest (3.14kg). Laboratory results obtained showed that four genera of bacteria were isolated: Pseudomonas (100%), Erwinia (80%), Staphylococcus (40%) and Bacillus (20%). Pathogenicity test however proved the major organisms responsible for the leaf distortion disease of Sweet potato in Umudike were two Pseudomonas and Erwinia spp. This study proves that the extracts of Z. officinales, C. papaya and M. oleifera have the potentials to serve as biopesticides in the management of bacterial leaf distortion disease of sweet potato.*

Key Words: *Pseudomonas, Erwinia, extracts, botanicals, severity, pathogenicity.*

Introduction: Sweet potato (*Ipomoea batatas* (L)) is a tropic and creepy herbaceous, extremely versatile and delicious vegetable that possesses high nutritional value to man and animals (54). Sweet potato is traditionally used as boiled root tubers eaten with stew, boiled and pounded with either boiled or fermented cassava as fufu or boiled or pounded yam. It is used as gruel ('ogi') porridge after drying and milling as sweetening, chopped into chips, dried and boiled with beans or vegetables, and fried in vegetable oil, in addition to processing into flour for sweetening (55). However, the cultivation of sweet potato is being influenced by Bacterial spot diseases (33; 56). Root rot or stem rot caused by *Dickeya dadantii*, wilt caused by *Ralstonia solanacearum* (formerly *Pseudomonas solanacearum*) and soil rot caused by *Streptomyces ipomoea* are the three bacterial diseases reported on sweet potato (16). Bacterial stem and root rot caused by (*Dickeya dadantii)* can be economically important because it destroys plants in the field and tubers after harvest. The pathogen was earlier identified as *Erwinia chrysanthemi* which is reclassified into six new *Dickeya* species (38). The bacteria attack several hosts in different regions of the world, (27; 13; 14). *Erwinia carotovora* is a plant pathogen that brings about death of cell via the ruins of tasty fleshy plant structures by producing an osmotically delicate cell. This is gotten through the creation of Plant cell wall-degrading enzymes (8) such as extracellular

pectic enzymes and cellulase that destroys pectin and cellulose respectively. Amadioha, (5; 6) and Oladoye *et al*. (32). Direct connection of pectic and cellulolytic enzymes formed by rot pathogens have also been discovered by Willie and Dye, (1974) and later confirmed by Grimault *et al*. (22). Softening of the tissue happens during the movement of soft rot bacteria through wounds or natural openings, they feed and reproduce initially on the substance freed by the broken cells on the surface of the wound and this create increased amounts of pecteolytic enzymes that destroys pectic substance of the middle lamella (2; 9). The bacterium has the ability of surviving in the soil, so that infestation is contained between two crops. The damage is worsened during high relative humidity coupled with high temperature of about 30ºC resulting in the faster rate of reproduction these pathogen (29). Apart from these diseases, insect pests such as sweetpotato weevils, aphids and foliage feeding insects constitute major threats to sweet potato cultivation. These pests damage the stems, leaves and storage roots, thereby reducing photosynthetic efficiency and market value in addition to the damage caused by directly feeding on the crop. Some of the insects also serve as vectors for viral pathogens associated with leaf distortion symptoms in sweet potato. (Loebenstein and Thottapilly, 2009). The continuous use of synthetic pesticides for the management of sweetpotato diseases has raised concerns regarding environmental pollution, pest resistance, potential health harzards etc hence the need for alternative control options that are sustainable and environmentally friendly. Therefore, this study was designed to evaluate the impact of botanical applications as alternative to synthetic chemical on leaf distortion disease of sweetpotato in humid South Eastern Nigeria.

Materials and Methods: Field Trial The research was carried out at the College of Crop and Soil Sciences Michael Okpara University of Agriculture, Umudike Research farm.The land was mechanically cleared using tractor and prepared into ridges. The sweet potato vines were planted in the ridges at a spacing distance of 1m × 1m. The experimental design was Randomized Complete Block Design (RCBD) with three replicates.

Plant Materials: The sweet potato variety (Umuspo) used was sourced from National Root Crops Research Institute (NRCRI), Umudike. Plant extracts were sourced locally within the environment of Michael Okpara University of Agriculture, Umudike. The plant materials used were the leaves of *Moringa oleifera*, seeds of *Carica papaya* and Rhizomes of *Zingiber officinales.* These plants were selected for their potency in controlling plant diseases and pests in Nigeria (3; 30; 25).

Preparation of Plant Extracts: Freshly collected 100g of each of the plant were blended using electric blender and stored separately in sterile 1liter conical flask until when needed. A liter of distilled water was added to the blended plant materials in the conical flasks and then allowed to stand for 24 hours after which all the crude extracts were filtered using muslin cloth after stirring. The process was repeated for all the plant materials and the muslin cloth washed after used.

Application of Extracts in the Field: Plant extracts were applied at the rate of 40ml per plant leaves and at the crop base four weeks after planting and subsequent application done at 8 weeks after plant (WAP). A similar application was done using sterile water for the control.

Disease Assessments: The plants were examined for disease symptoms from two weeks after treatment (WAT) and number of plants parts infected were recorded until eighth weeks after treatment (WAT). The percentage disease incidence was determined by using the formula below;

$$\text{Percent Disease Incidence (PDI)} = \frac{\text{Number of plants infected in the sampled area}}{\text{Total number of plant assessed in the sample area}} \times \frac{100}{1}$$

$$\text{Disease severity} = \frac{\text{Sum of individual ratings}}{\text{Total number of plants examined}}$$

Assessment of disease severity on leaves was done by scoring the first four opened leaves five randomly tagged plants and rating the symptom expression on a scale of 0-6 a modified scale of Opara and Wokocha (36) where;

0 = Healthy leaf, no spot or symptom
1 = One or two spots on the leaf surface
2 = Few pots or lesions scattered on the leaf surface
3 = about 25% of the leaf surface covered with spot or lesion
4 = about 50% of the leaf covered with lesion or spot
5 = about 75% of the leaf covered with lesion or spot, the lesion coalesce or join to form large necrotic spot.
6 = more than 75% of the leaf coalesce and affected leaf surface may tear and change colour (yellow or brown)

Assessment of Growth and Yield Parameters
Data for assessment of growth and yield were collected on the following parameters;

- **Total number of leaves:** this was obtained by counting the number of leaves on each of the randomly tagged plants.
- **Vine length:** this was done by measuring from the base of plant to the tip.
- **Stem diameter:** this was obtained by measuring the circumference of the shoot base.
- **Sprout percentage:** this was done by dividing the number of vines that sprouted by the total number planted × 100
- **Number of branches:** this was done by counting all the branches.
- **Tuber Yield (kg):** harvested tubers were weighed using a 25kg scale.

Laboratory Experiments: All glass wares used for the experiment ***were*** sterilized by autoclaving at 121ºC/15psi for 15 minutes before the inoculation. The chamber was sterilized by using cotton wool soaked with 70% absolute alcohol to mop entire inoculation chamber. The culture media was prepared according to manufacturers' instructions; twenty eight grams of nutrient agar (NA) was dissolved in 1000ml of distilled water in a conical flask, it was shaken thoroughly to obtain an even mixture. The mixture was autoclaved for 30 minutes at 121ºC/15psi, allowed to cool to about 45ºC and 15ml was dispensed into sterilized Petri-dishes. The agar plates were allowed to solidified and turn upside down for the evaporation moisture to dry (44).

Pathogen Isolation: Diseased leaves were first washed under a running tap after which 12mm was cut from the advancing edge of the lesion with a sterilized scalpel. The cut sections were rinsed in three exchanges of sterile distilled water and teased apart in a drop of water inside a Petri-dish with a glass rod to form suspension. The suspension was allowed to stand for 15minutes in order for bacterial cell to multiply. The suspension was streaked onto the solidified agar plate in zigzag pattern with the aid of a flamed wire loop. The inoculated plates were incubated at 28 ± 2ºC for 24hours, after which single colonies formed were subcultured unto fresh culture media inside Petri-dishes. Subsequent sub-cultures were carried out to obtain a pure culture (44). Bacterial inoculum was prepared from 24 hours old culture by dissolving bacterial colonies formed on agar plates with sterile distilled water into McCartney bottles and adjusting the density of the inoculum to 10^8 cfu/ml using haemocytometer. (29)

Morphological test: Pathogenic organisms isolated from diseased specimens (leaves of sweet potato) were subjected to preliminary identification tests based on some morphological and biochemical tests. The colony and structural characteristics were compared with those of known existing taxa using Bergey's Manual of Determinative Bacteriology (10).

Pathogenicity test: Potted plants of *I. batatas* were raised in 10 liters perforated buckets filled with sterilized soil up to three quarter from the brim. Plants were inoculated with bacterial inoculum using a hand atomizer. The inoculum was sprayed on the leaves until runoff and the plants were kept under shade and covered with a transparent polythene bags to maintain high relative humidity (75%). The inoculated leaves were uncovered after 48hours and observed daily for symptoms of blight and leaf distortions and re-isolation made from symptomatic leaves.

Cultural and Biochemical tests for the identification of pathogen

Cultural tests: Colony colour was assessed after two days of incubation on nutrient agar medium at 30°C, motility and shape was determined by preparing a smear of the isolate and examining it under a microscope (44).

Biochemical tests: **Gram staining reaction:** The gram staining was done as a basic step to differentiate two major groups of bacteria: the gram positive and gram negative bacteria. To perform this test, a loop-full of the bacterium was spread on a glass slide and fixed by heating on a very low flame. Aqueous crystal violet solution (0.5%) was spread over the smear for 30 seconds and then washed with running tap water for one minute. It was then flooded with iodine for one minute, rinsed in tap water and decolorized with 95% ethanol until colourless. After washing, the specimen was counter stained with Safranin for about 10 seconds, washed with water, dried and observed using microscope at low power (40X). A red or pink colour stain on the slide was the basis for classification into positive or negative bacterium.

Potassium hydroxide test: This test was carried out as a preliminary test and a follow up to gram staining test. A solution of 3% potassium hydroxide (KOH) was prepared and a drop of this alkaline solution was placed on a microscope slide. A 24hours old bacterial culture was placed on this drop and mixed for 10 seconds, bacterial suspension making strands when lifted up using toothpick were considered gram negative while the production of watery suspension (absence of viscous strand when lifted up) indicated a gram positive result (7).

Catalase test: A drop of hydrogen peroxide (H_2O_2) was placed on a slide and bacterial cells were mixed with the drop. Production of gas bubbles indicates positive reaction while the absence of bubbles indicated gram negative reaction (44).

Statistical Analysis

All the data collected were statistically analyzed using SAS model (SAS, 2009) to determine Analysis of Variance (ANOVA) and the means were separated using Fishers Least Significant Difference (LSD) at 5% level probability (48).

Results and Discussion

Commom Insect Pests Associate With Sweetpotato Leaf Distortion Diseases

Insect vector	Common names	Role in Disease transmission	Common symptoms
Aphis gossypii	Cotton aphid	Transmits viral pathogens between plants	Leaf curling and distortion
Myzus Persicae	Green peach aphid	Vectors of sweetpotato virus	Chlorosis and stunted growth
B*emisia tabaci*	Whitefly	Spread viral disease during feeding	Leaf deformation and mosaic symptom
Empoasca spp	Leafhopper	May sid pathogen spread and cause feeding injury	Leaf yellowing and curling

FIELD TRIAL Effect of Plant Botanicals on yield and growth parameters after treatment with Botanicals: The result of the effects of different plant extracts against leaf distortions of sweet potato is shown in Table1. The data showed that there were significant differences ($P \leq 0.05$) in the all the crop growth parameters and yield except for number of branches. For instance, when vine length was considered, *C. papaya* recorded the highest length (71.4cm) which is significantly different from the control (37.80cm) Regarding the number of leaves *C. papaya* still had the highest number of leaves (65.67), followed by *M. oleifera* (45.00) the value though not significantly different from other extract treatments, except the untreated control which recorded the least (28.67). Result also showed that Stem diameter was highest in *C. papaya* seed extract (4.33cm); the means was significantly different from *Z. officinales* and the untreated control which recorded the least stem diameter (2.90cm) and (2.56cm) respectively. There was no significant ($P \leq 0.05$) difference between the means of *C. papaya* and *M. oleifera*. From the data there was significant ($P \leq 0.05$) difference in number of branches as *C. papaya* extract had the highest number of branches (7.00), while the means of other extracts were not significantly different from one another but all treated extracts differed ($P \leq 0.05$) from the untreated control (2.66).

M. oleifera leaf extract treated plants recorded the highest percentage sprout, (100.00) which is significantly ($P \leq 0.05$) different from *C. papaya* which had the lowest sprout percentage (73.33). The means of other extracts were statistically the similar. Effect of Plant Extracts on Disease Incidence and Severity of Sweet potato for eight weeks after treatment (WAT) The data on effect of different plant extracts on disease incidence, severity, and yield parameters of sweet potato for periods of two to eight WAT is shown in Table2 Results showed that in terms of leaf disease incidence

and severity of disease the untreated control recorded the highest disease incidence for instance at two to four WAT (48-50%), the mean obtained shows significant difference ($p \leq 0.05$) from other plant extracts. There was no significant difference in the means of *C. papaya, M. oleifera* and *Z. officinales* respectively. Disease severity was also highest in control (5.05 and 5.78 respectively at two and four WAT), which is significantly different from other extracts ($p \leq 0.05$). The effect of different plant extracts used on the control of leaf distortions, disease incidence and severity of sweet potato at the 6 WAT is also shown in Table2.

Untreated control had the highest disease incidence (66.67%) which was statistically ($P \leq 0.05$) different from the means recorded in other plant extracts including *Z. officinales* treated plants which recorded the least incidence of disease (23%). When the disease severity was considered the worst was also recorded by the control (5.17) and was significantly
($P \leq 0.05$) different from other extracts. The best effective in reducing disease severity was obtained from *Z. officinales* (3.00) as indicated in Table2.
The effect of different plant extracts used on the control of leaf distortions, disease incidence and severity at 8 WAT is also shown in Table2. Leaf Disease Incidence and Severity**:** *Z. officinales* rhizome had the least disease incidence (33.33%), while control and pawpaw had the highest disease incidence (66.75 and 64.67 %) respectively. Their means were statistically the same ($P \leq 0.05$); there was no significant ($P \leq 0.05$) difference between the means of the extracts in disease severity however, control recorded the highest disease severity (5.29) while the least disease severity was produced by *Z. officinales* (4.44).

Laboratory Tests :**Characterization of Leaf distortion Pathogen in the Laboratory** Identification and preliminary tests for the bacteria isolate was based on the description of Bergey's Manual of Determinative Bacteriology (Buchaman and Gibbons, 2004) and were summarized in Tables 3-5. The laboratory experiment revealed that two bacteria spp were isolated from the infected leaves of sweet potato: one was gram negative, motile and polar- flagellated bacterium, slander rod and non - spore forming. It also produced large opaque colonies with irregular margins (edge) and green pigmentations into the nutrient agar medium (N.A). In addition it was catalase positive, oxidase positive, and urease positive. In carbohydrate utilization test, glucose was positive, sucrose negative, lactose negative, maltose negative, mannitol positive and xylose positive. Based on these biochemical characteristics, the isolated bacterium was suspected to be *Pseudomonas* spp. The other bacterium was gram negative, motile, rod-shaped and non–spore forming. It formed smooth colonies of moderate growth with slight elevation and yellow pigments on nutrient agar (NA). In biochemical test; catalase was positive, oxidase negative, and urease positive. Carbohydrate utilization test revealed that glucose was positive, sucrose negative, lactose positive, maltose negative, mannitol positive and xyllose positive. Based on these characteristic features, the second isolated bacterium was suspected to be *Erwinia* spp. Few studies using traditional approaches reveal that many crop species can frequently be infected at the same time by more than one pathogenic species (fungi and bacteria), in many cases, a single microbe infection with another microbial species may lead to severe disease development due to synergistic interaction. Tomato pith necrosis is thus far a leading example of co–infection due to synergistic interactions among several bacterial pathogens. Overall eight bacterial species namely *Pseudomonas cichorii* (53), *P. corrugate* (43), *P. viridflava* (22), *P. mediterranea* (41), *P. flourescens* (22), *Pectobacterium atrosepticum* (26), *Pectobacterium caratovorum* (15), formally known as *Erwinia* and *Dickeya chrysanthemi* formerly *Erwinia chrysanthemi*, (4) can cause tomato pith necrosis alone or in association with other bacterial species. The severity of the disease is greatly enhanced when co-infection of one or more bacterial species occur (41).

The utilization of plant Botanicals in plant disease management has generated interest in developing countries as a result of high cost of synthetic pesticides and their attendant hazardous effects on the environment (45 and 37) Results from this study indicated that incidence and severity of leaf distortion disease of sweet potato (*Ipoemea batatas* (L) Lam) was substantially reduced by application of different plant parts used as bio-extracts or botanicals. Almost all the plant extracts used *Carica papaya* seeds, *Zingiber officinales* rhizomes and *Moringa oleifera* leaves significantly ($P \leq 0.05$) reduced severity and infection on leaves. Moreover, percentage of leaves infected as well as severity was particularly lower for bio-extracts of *Moringa oleifera*, while *Z. officinales* and *C. papaya* bio-extracts significantly reduced incidence and severity of the diseases.

This confirms earlier report that many plant products contain anti-bacterial and fungitoxic constitutes that have the potentials to control plant diseases (18; 31; 34). The genera of the bacteria isolated and their percentage of occurrence include; *Pseudomonas* (100%), *Erwinia* (80%), *Staphylococcus* (40%), *Bacillus* (20%), while genera of the fungi isolated and their percentage of occurrence include; *Aspergillus* (40%), *Fusarium* (80%), Yeast (60%), *Aternaria* (80%), *Cercospora* (80%). Oladoye *et al*. (32) identified *Staphylococcus*, *Bacillus*, *Pseudomonas* as some of the bacteria that affect sweet potato leaves and have the abilities to produce enzymes such as amylase, cellulase, zylanases, polygalacturanases (PG) and pectin – methyl esterases (PME) that are capable of degrading sweet potato tissues.

From the observation made, *Z. officinales* treated plants also performed relatively better than plants treated with

C. papaya and *M. oleifera* in terms of yield parameter, and reduction in disease incidence and severity throughout the study. Plant extract of *M. oleifera* leaves recorded the lowest performance only better than the control in terms of yield attributes, and also better than the untreated control as regards disease incidence and severity. According to Edeoga *et al.* (17) and Shukla and Singh (47), some medicinal plants contain a wide range of bioactive secondary metabolites including; alkaloids, flavonoids, tannins, saponins, phenols, phlobatamins, quinones, lecitins, polyphenols, terpenoids and polypeptides. In a review of some bio-extract plants proximate contents, Enyiukwu and Awurum (19) reported similar observation. According to Hostettman and Wolfender (23) *C. papaya* fruit and seeds possess some antihelminthic and antimoebic activities. Externally the latex (papain) is irritant, dermatogenic and vesicant. The high level of natural self defense compounds in the tree makes it highly resistant to insect and disease infestation (21). Williams (52) observed that bio-extracts of plant are systemic in action like some known bactericides and has significant effect on the pathogen leading to the bactericidal activities which in turn result to increased growth parameters and crop yield. Okigbo, (31) reported in their work that the leaf extracts of (*Moringa oleifera*) contains flavonoids, anthraquinon, alkaloids, saponins, steroids, cardial glycosides, anthocyanins, tannins and carotenoids. The antimicrobial activities of phytochemicals present in the different parts of *M. oleifera* have been reported (40;14). Similarly observations were made by several other researchers (50; 28 and 51). *Zingiber officinale* (ginger) contains gingerols and polyphenols compounds (antioxidants) which have many medicinal properties. The rhizome is effective against many diseases that affect cultivated crops. Performance of some plant extracts and pesticides in the control of bacterial spot diseases of *Solanum* was carried by Opara and Obani (35). The result of the study showed that *Z. officinale* was the most effective in controlling the disease severity when compared with other extracts and proved more superior to the untreated control (sterile water).The bactericidal effects of the plant extracts in the leaf distortion disease of *Ipoemee batata* are in agreement with the documentation of Stoll (49) which showed that they contain significant antibodies and some medicinal properties. The effectiveness of these plant extracts could also be attributed to the bioactivity of the constituents of the plant materials (5). Plant nutrients are produced in the leaf cells during photosynthesis, and are translocated downward and distributed to all the living plant cells (1). In advanced stages of some diseases, the rate of photosynthesis is not more than one- fourth the normal rate reduction of photosynthesis will result in reduction in growth and consequently in fresh and dry weight of the plant. Efforts should be geared towards reducing infestation of sweet potato leaf pathogens by encouraging those practices that prevents disease development in the field to ensure food security and sustainability. Conclusion: This research work was conducted to assess the incidence and severity of bacterial leaf distortion disease of *Ipomoea batatas* in South Eastern Nigeria, in managing the disease with Bioextracts showed that extracts from these plant materials (*Moringa* leaves, Pawpaw seeds, and Ginger rhizomes) can be used by farmers in the reduction of leaf distortion disease of sweet potato and that organic materials contain broad-spectrum of antimicrobial properties that can be utilized to prepare potential phytobactericides for controlling leaf distortion diseases of sweet potato. Based on the attendant problems associated with application of agro- chemicals with reference to pesticide residue in the ecosystem, this kind of low cost biological approach would be economically viable and ecologically friendly. In addition, these extracts can be easily prepared by farmers and plant materials accessible as *Moringa* leaves, pawpaw seeds and ginger rhizomes are readily available to farmers especially in the rural communities.

References

1.Agrios, G.N. (2005). Plant pathology, 5th edition, *Elsevier Academic Press*, Amsterdam, New York, USA, ISBN-13:9780120445653, Pp. 922.

2.Agrios, G.N. (2006). Bacterial Soft Rots.5th Edn., *Academic Press*, San Diego, 429pp.

3.Akhatar, A.H. & Ahmad, K.H (1995). Anti-ulcerogenic evaluation of the methanolic extracts of some indigenous medicinal plants of Pakistan in aspirin-ulcerated rats. *Journal of ethnopharmacology* 46:1-6

4. Vegh,A., Nemethy, Zs., Salamon, P., Mandoki, Z. & Paikovics, L.(2014). Bacterial wilt on Chrysanthemum caused by *Dickeya chrysanthemi* (syn. *Erwinia chrysanthemi*) in Hungary. *Plant Disease* 98 (7): 988

5.Amadioha, A. C. (1997). Interaction of hydrolytic enzymes produced by *Rhizoctania bataticola* during rot development. Acta phytopathologica Et Entomologica Hungarica 32(1-2): 79-87.

6.Amadioha, A. C. (2012). Reducing food losses through sustainable methods of plant disease management: an imperative for actualization of food security in Nigeria. *A paper presented at the 13th Inaugural Lecture of MOUAU, June, 2012,* 203pp.

7.Asequo, A.A. & Opara, EU., (2017). Application of some management strategies on leaf distortion and fruit diseases of watermelon (*Citrullus lanatus)* in South Eastern Nigeria. *International Journal of Research in Agriculture and Forestry*, 4 (2), 2940

8.Bell *et al.*, (2004). "Genome sequence of the entero-bacterial phytopathogen *Erwinia carotovora* p.v. *atroseptica* and characterization of virulence factors. *Proceedings of the National Academy of Sciences of USA*, 2002pp.

9.Biswas *et al.*, (2009). Effects of extracts from leaves, bark and root of *Azadirachta indica* on

10.Buchaman, R. E. & Gibbon, N.E. (2004). Bergey's Manual of Determinative Bacteriology, 8th edition, *Williams and Watkins Ltd*, UK, 304pp.

11.Clark C.A, La Bonte, D.R., Valverde, R.A., Hoy, M.W., Lotrakul, P., Kokkinos, C.

& McGregor, C. (2003). Technology to improve the quality of sweet potato seed. *Louisinia Agriculture* 46, 29-31.

12.Clark, C.A. & Moyer, J.W. (1988). Compendium of sweet potato diseases, APs Press. *The American Phytopathology Society*, St. Paul, NN, USA, 94pp.

13.Clark, C.A., Valverde, R.A., Fuentes S, Salazar L.F & Moyer J W. (2002). Research for improved management of sweet potato pests and disease: cultivar decline. *Acta horticulture* 583,103-112.

14.Cushrie, T.P. & Lamb, A.J (2009). Anti-microbial activity of flavonoids. *Int. J. Antimicrobe agents*, 43:63-74.

15.Dhanvanthari, B. N., & Dirks, V. A. (1987). Bacterial stem rot of greenhouse tomato: etiology, spatial distribution, and the effect of high humidity. *Phytopathology* 77, 1457–1463.

16.Clark, C., Holmes, G. & Ferrin, D. (2009). Major Fundgal and Bacterial Diseases. In: Loebenstein, G., Thottappilly, G. (eds). The sweet potato. *Springer, Dordrecht*. Pp 81 – 103.

17.Edeoga, H. O., Okwu, D. E., Mbaebie B. O, (2005). Phytochemical constituents of some Nigerian medicinal plants. *Afr J Biotechnol*, 4(7): 685-688.

18.Emechebe A.M.& Alabi O. (1997). Evaluation of aqueous extracts of parts of some plants for the control of cowpea diseases at Samaru. Samaru Cropping Scheme Meeting, Samaru, Zaria, Nigeria: Report on Legumes and Oil seeds Research Programme, 77 pp.

19.Enyiukwu DN & Awurum A. N, (2013). Fungitoxic principles and antifungal activity of extracts from *Carica papaya* and *Piper guineense* on *Colletotrichum destructivum*. *Cont J Biol Sc*i, 7(1):29-36.

20.Goto, M. (2012). Fundamentals of bacterial plant pathology. *Academic Press, Inc*.

21.Fahey, J.W., Zakmann, A.T. & Talalay, P. (2001). The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. *Phytochemistry* 56(1):5-51.

22.Grimault, V., Schmit, J. and Prior, P. (1992). Some characteristics involved in bacterial wilt *Pseudomonas solanacearum* resistance in tomato. *ACIAR Proc*., 45:112-119.

23.Hostettman, K. & Wolfender, J.L. (1997). "The search for biologically active secondary metabolites" Pesticide Science. Vol. 51, No. 4, pp. 471-482.

24 Lobeinstein, G., and Thottapilly, G. (2009). The Sweetpotato. Springer Science and Business Media, Dordrecht, Netherlands. Pp.522

24.Jones, J.B., Stall, R.E. & Zitter, T.A. (1997). Compendium of Tomato Diseases. The American Phytopathological Society,New York, 900pp.

25.Khanayat, B.S. & Sing, Y. (2015). Characterization of *Erwinia chrysanthemi* isolates inciting stalk rot disease of sorghum. *African Journal of Agricultural Research.* Vol. 10(22). Pp. 2309-2314.

26.Malathrakis, N. E., and Goumas, D. E. (1987). Bacterial soft rot of tomato in plastic greenhouses in Crete. *Ann. Appl. Biol.* 111, 115–123. doi: 10.1111/j.1744-7348.

27.Martin, W.J. & Dukes, P.D. (1977). A bacterial wilt and root rot of sweet potato caused by *Erwinia chrysanthemi.* Plant Disease Reporter 61, 158-161.

28.Mumuni Abudulai, Abdulai B. Salifu, Danial Opare-Atakora, Mohammed Haruna,
Inusah I.Y. Baba, Israel K. Dzomeku, Rick L. Brandenburg and David L. Jordan (2013). Field Efficacy of Neem (Azadirachta indica A. Juss) for Managing soil arthropods and cercospora leaf distortions damage for increased yield in peanut. *Plant Protect. Sci*. Vol. 49, No. 2: 65–72

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

30.Ogbonna, M.C., Nwauzor, E.C., Asumugha, G.N., Emehute, J.K.U., Korieocha, D.S.
and Anyaegbunam, H.N. (2005). Cost and return analysis for the production of sweetpotato in Nigeria: A case study of NRCRI, Umudike. *Annual Report of the National Root Crops Research Institute, Umudike*.

31.Ok igbo, RN. (2009). Variation in phytochemical properties of selected fungicidal aqueous extract of some plant leaves in Kogi State, Nigeria. *American Eurossian Journal of Sustainable Agriculture* 3(3), 407-409.

32.Oladoye, C.O.; Olaoye, O. A.; Cornnerton, I. F. (2013). Isolation and identification of bacteria associated with spoilage of sweet potatoes during postharvest storage. *Int Agric Food Sci*, 3(1):10-15

33.Orshiro, A., Kawano, S., Takushi, T., Oomi, N., Tokeshi, M & Osshiro, N. (2006). Control of soil rot of sweet potato by the incorporation of fresh aerial tissue of
Geranium camlmianum L. into the soil. *Weed Biology and Management* 6: 241244.

34.Opara, E.U. & Agugo, B.A. (2014). Control of Posthavest Rot of Sweeetpotato
(*Ipomoea batatas* Lam.) Tuber *in Vitro* and *in Vivo. Journal of Agriculture and*
Sustainability 6 (1): 50-68

35.Opara, E.U. & Obani, F.T. (2010). Performance of some plant extracts and Pesticides in the control of Bacterial spot disease of *Solanum*. *Midwell Agricultural Journal*. 5 (2): 45-49.

36.Opara, E.U & Wokocha, R.C. (2008). Efficacy of some plant extracts on the invitro and in vivo control of *Xanthomonas campestris* pv *vesicatria.Agric' Journal*, 3(3):163-170.

37.Salako, E. A. (2002). Plant protection for the Resource poor farmers. *Paper presented at the 30th annual conference of Nigeria Society of Plant Protection*, UNAAB Abeokuta. Pp.1-4.

38.Samson, R., Legrandre, J.B., Christen, R., Fisher-Le Sanx, M., Achowak, W. & Garden, L. (2005). Transfer of *pectobacterium chrysantherni* and *Brenneria paradises* to the genus dickeys gen. nov. as *Dickeya chrysanthemi* comb. Nov. and delineation of four noval species. *Dickeya dadantii sp. nov. Dickeya dieffenbachiae sp. nov. and dickey zeae sp. nov. International Journal of Systematic and Evolutionary Microbiology* 55, 1415-1427.

39.SAS Institute Inc. (2005). SAS/STAT. User's Guide, Version 6, Fourth Edition, Volume 1, *Cary, NC: SAS Institute Inc*., Cary, NC, USA

40.Sato, M., Tanaka, H., Oh-uchi, T., Fukai, T., Etoh, H. & Tamaguchi (2004). Antibacterial activity of phytochemicals isolated form *Erythrina zeyheri* against vanomycin resistant

enterococci and their combination with vancomycin. *Microbial Ecol*., 43:63-74.

41.Saygili, H., Aysan, Y., Ustun, N., Mirik, M., & Sahin, F. (2008). "Tomato pith necrosis disease caused by *Pseudomonas* species in Turkey," in *Pseudomonas Syringae Pathovars and Related Pathogens Identification, Epidemiology, and Genomics*, eds M. B. Fatmi, A. Collmer, and N.S. Iacobellis (Berlin: Springer), pp357–366

42.Saygili, H., Aysan, Y., Ustun, N., Mirik, M., & Sahin, F. (2008). "Tomato pith necrosis disease caused by *Pseudomonas* species in Turkey," in *Pseudomonas Syringae Pathovars and Related Pathogens Identification*, Epidemiology, and Genomics, eds M. B. Fatmi, A. Collmer, and N.S. Iacobellis (Berlin: Springer), pp 357–366

43 Catara, V. (2007). Pseudomonas corrugate: Plant pathogen and/ or biological resource? *Molecular Plant Pathology*, 8(3): 233 – 244.

44.Schaad, N. W (1980). Laboratory Guide for Identification of Plant Pathogenic Bacteria. *American Phytopathol.* Soc. St. Paul. Minn. 36-48.

45.Schaflutner R., Tincopa, L.R., Palomino, O., Rossel, G., Robles, R.F., Alagon, R., Rivera, C., Quispe, C., Rojas L. & Pacheco (2010). A sweet potato gene index established by de novo assembly of pyrosequencing and danger sequences and minnig for gene-based microsatellite makers BMC Cenomics DDI: 1186pp.

46.Schonfeld, J., Gelsomino, A., VanOverbeck, L.S., Gorinssen, A., Smalla, K. & Van Elsas, J.D. (2003). Effects of compost addition and stimulated solarization on the fade of *Ralstonia solanacearum* biovar 2 and indigenous bacterial in soil. *FMES microbial, Ecol*., 43:63-74.

47.Shukla, Y. & Singh, M. (2007). "Cancer preventive properties of ginger: a brief review*" Food and Chemical Toxicology*, vol. 45, no. 5, pp. 683–690.

48.Steel, R. G. & Torrie, J. H. (1997). Principles and procedures of statistics. New York:
McGraw, 1960.

49.Stoll, G. (1998). Natural Crop Protection in the Tropics and Sub-Tropics.
AGRECOL, Switzerland, pp:188

50.Thoeming G., Draeger G., & Poehling H.-M (2006): Soil application of azadirachtin and tigloyl-azadirachtol to control western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae): translocation and persistence in bean plants. Pest Management Science, 62: 759–767.

51.Tijjani, A., Adebitan, S. A., Gurama, A. U., Haruna, S. G. & Safiya, T. (2014). Effect of some selected plant extracts on Aspergillus flavus, a causal agent of fruit rot disease of tomato (Solanum lycopersicum) in Bauchi State. International Journal of Biosciences ISSN: 2220 -6655, Vol. 4, No. 12, p. 244-252.

52.Williams, Q. (2005). Control of soil borne pathogens, Bio-integral resource centre (BIRC*) Berkeley, California*. 215-220.

53.Wilkie, J. P., & Dye, D. W. (1974). *Pseudomonas cichorii* causing tomato and celery diseases in New Zealand. *N. Z. J. Agric. Res.*17, 123–130. doi: 10.1080/00288233.1974.10420990

54. Mohanraj, R. & Sivasankar, S. (2014). Sweet potato [*Ipomoea batatas* (L.) Lam] – A valuable medicinal Food: A Review. *Journal of Medicinal Food*, 17(1): 733 – 741.

55.Yang, X (2010). Rapid production of virus-free plantlets by shoot tip culture of invitro of purple sweet potato (*Ipomoea batatas* (L.) Lam), pp 211.

56.Zhang, L. Wang, Q., Liu, Q. & Wang, Q. (2009). Sweet potato in China. In: Lobenstein G., Thottappilly, G. (Eds). *The sweet potato, Springer Sciences and Business Mectia BV, Berlin*, pp. 325-358.

Table1: Effect of Plant Extracts on Growth Parameters and Yield of Sweet potato

Plant Extract	VL (cm)	NL	SD (cm)	NB	Sprout (%)	Yield (kg)
C. papaya	71.43	65.67	4.33	7.00	73.33	3.16
M. oleifera	65.00	45.00	4.20	4.00	100.00	2.36
Z. officinales	63.73 37.80	44.00 28.67	2.90	3.66 2.66	80.00 86.67	6.13 1.23
Control	42.13	30.54	2.56	2.84	24.30	2.28
LSD (P<0.5)			1.1 4			

Legend: Var = Variety, VL = Vine length, NL = Number of leaves, SD = Stem diameter, NB= Number of branches, % = Percentage, WAT = Week after treatment, C = *Carica*, M = *Moringa*, Z = *Zingiber*.

Yield weight at harvest: *Z. officinales* extract gave the highest yield at harvest (6.13kg) which was significantly (P≤0.05) different from other extracts. The lowest yield was recorded in control (1.23kg).

Table2: Effect of Plant Botanicals on Disease Incidence, Severity and Growth Parameters Eight Weeks after Treatment

Plant	2 WKS		4 WKS		6 WKS	8 WKS	Extract	DI	DS	DI	DS	DI
	DS		DI	DS								
C. papaya				2.94		3.40			4.35		4.82	
M. oleifera			26.67	3.72	23.33	3.51		26.67	3.57	40.00	4.61	
Z. officinale			13.33	2.16	13.33	3.29		23.33	3.00	33.33	4.44	
Control			48.00	5.05	50.00	5.78		66.67	5.17	66.67	5.29	
LSD(P<0.5)			20.06	1.56	23.06	1.61		24.90	1.99	31.22	1.39	
			(%)		(%)			(%)		(%)		
			16.67		23.33			30.00		64.67		

Legend: Var = Variety, VL = Vine length, NL = Number of leaves, S.D = Stem diameter, NB= Number of branches, DI = Disease incidence, DS = Disease severity, C = *Carica*, M = *Moringa*, Z = *Zingiber*

Table3: Laboratory Tests indicating incidence of fungi isolates in sweet potato leaf samples (Contaminants)

Leaf samples	***Aspergillus***	***Fusarium***	***Yeast***	***Alternaria***	***Cercospora***
1	-	+	+	+	+
2	+	+	-	-	+
3	-	+	+	+	+
4	+	-	+	+	+
5	-	+	-	+	-
Total	5	5	5	5	5
No. +ve	2	4	3	4	4
% Occurrence	40%	80%	60%	80%	80%

Legend: + = Present (isolated)
- = Absent (not isolated)

Table4: Occurrence of Bacteria Isolates in Sweet Potato Leaf Samples in Culture

Leaf samples	***Pseudomonas***	***Erwinia***	***Staphlococcus***	***Bacillus***
1	+	+	+	-
2	+	-	-	+
3	+	+	+	-
4	+	+	-	-
5	+	+	-	-
Total	5	5	5	5
No. +ve	5	4	2	1
% Occurrence	100%	80%	40%	20%

Legend: + = Present (isolated)
- = Absent (not isolated)

Table5: Morphological and Biochemical Characteristics of the Bacteria Isolates

Tests	***Pseudomonas***	*Erwinia*
Colony features	Large opaque colonies with irregular margin (edge) and green pigmentation into the medium	Smooth colonies of moderate growth with slight elevation and yellow pigment on N.A
	Slander rods	
		Rods
Cell shape and Arrangement		
Gram stain	-ve	-ve
Spore	-ve	+ve
Motility	+ve	-ve
Catalase	+ve	+ve
Oxidase	+ve	-ve
Urease	+ve	-ve
Citrate	-	+ve
Indole	-ve	-ve
MR	+ve	-ve
VP	+ve	-ve
NO_3	+ve	
Carbohydrate Utilization Glucose	+ve	+ve
Sucrose	-ve	-ve
Lactose	-ve	+ve
Maltose	-ve	-ve
Mannitol	+ve	+ve
Xyllose	+ve	+ve

+ve = Positive reaction; -ve = Negative reaction.