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BIOACTIVE POTENCY OF MEDICINAL PLANT EXTRACTS AND SYNTHETIC CHEMICAL ON POST-HARVEST ROT PATHOGENS OF WHITE YAM (*Dioscorea rotundata* Poir) TUBER CULTIVARS

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ABSTRACT

Diseases are the major challenges facing postharvest deterioration of yam tubers by pathogens in storage. The present study was carried out at Advanced Plant Pathology Laboratory, Federal University of Agriculture, Makurdi, Nigeria to study the bioactive potency of leaves of *Azadirachta indica* A. Juss, seeds of *Piper guineense* Schumach and rhizomes of *Zingiber officinale* Rosc with the synthetic fungicide Mancozeb used as a standard for comparison on the storability of *Hembankwase*, *Pepa*, *Ogoja* and *Ghini* white yam tuber cultivars. Tubers weighing 2kg were stored for a period of five months each year for two years from December, 2015 to April, 2016 and from December, 2016 to April, 2017 to determine the biological potency of the extracts using the Decay Reduction Index (DRI) method. Mean values obtained after five months of storage in 2016 indicated that the lowest and the highest mean Decay Reduction Index of 0.45 and 0.93 respectively were recorded on *Hembankwase* when *A. indica* was used. Similar results obtained in 2017 revealed that *Z. officinale* produced the lowest and highest mean value of 0.44 and 0.72 on *Pepa* and *Ogoja* respectively. Mean values recorded in the first year of storage showed significant difference ($P \leq 0.05$) between treatments. There were only significant differences ($P \leq 0.05$) when Mancozeb and *Z. officinale* were used in the second year. Differences in means for each treatment between first and second year of storage produced significant difference ($P \leq 0.05$). It is concluded that all the plant extracts and synthetic fungicide inhibited growth of pathogens in storage and should therefore be formulated for managing storage pathogens of yam.

Keywords: Decay Reduction Index; Mancozeb; Pathogens; Postharvest; Plant extracts

INTRODUCTION

White yam (*Dioscorea rotundata* Poir) is one of the varieties of yams that is mostly cultivated on a large scale and is found to be an economically staple crop grown by millions of inhabitants of the tropical and subtropical regions of the word (FAO 2013; Nweke, 2015). Africa and indeed West Africa is reported to be the highest producer of this tuber crop with a total output of about 95% of world total output covering about 93% of the total yam production area (FAO, 2013). It has been widely reported that Nigeria is the largest producer of yam in the world, producing as much 38.92 million metric tons annually (FAO, 2008; Kleih *et al.*, 2012). Yam tubers contained high content of valuable sources of nutrients such as carbohydrate and mineral nutrients like calcium, phosphorus, iron and vitamins including riboflavin, thiamine and Vitamins B and C (Okigbo and Ogbonnaya, 2006). In spite of high output of yam tuber production, it is nonetheless susceptible to various kinds of pathogenic attack ranging from bacteria, fungi, nematodes and viruses (Okigbo *et al.*, 2010, Okigbo, *et al.*, 2015; Gwa and Richard, 2018, Gwa and Okrikata, 2019). These pathogens infect yam tubers both in the field as well as in storage which consequently result in substantial loss of quantity as well as the market value of the tubers (Amusa *et al.*, 2003). Studies conducted in different parts of the country have shown that fungi are major pathogens of yam both in the field and in storage (Amusa *et al.*, 2003; Nweke, 2015). Some of fungi pathogens causing rot of yam tubers are *Aspergillus flavus*, *A. niger*, *A. ochraceus*, *Botryodiplodia theobromae, Colletotrichum* sp., *Fusarium moniliforme*, *F. oxysporum*, *F. solani*, *Penicillium digitatum*, *P. expansum*, *P. purpurogenum*, *P. oxalicum*, *Pestalotia* sp., *Rhizopus nodosus*, *Rhizoctonia* sp (Ogunleye and Ayansola, 2014; Nweke, 2015; Okigbo *et al.*, 2015; Gwa and Richard, 2018; Gwa and Okrikata, 2019). Research conducted by Okigbo and Ikediugwu (2000) revealed that between 20 and 39.5% of stored tubers are lost to rot causing pathogens. It has also been shown that rot of yam in storage could range between 10% and 15% after three months of storage (Okigbo *et al.*, 2009b; Amaeze *et al.*, 2013) while some studies reported that rot caused by pathogens could go as high as from 17% to 49% after five months of storage (Gwa and Richard, 2018). Studies conducted by Arinze (2005) reported rot of yam tubers up to 50% under store. Most recent study conducted by Gwa and Ekefan (2021) revealed that pathogens inflicted rot in yam tubers between 6.67% and 13.33% after five months of storage for two consecutive years. There are different types of pesticides which are used in the management of plant pathogens which could be synthetic chemicals, microorganisms and plant extracts (Nduagu, 2008; Okigbo *et al.* 2015; Ekefan *et al.*, 2018; Gwa and Nwankiti, 2018a; Gwa *et al.*, 2019). Phytochemical compounds have been utilized by researchers in the management of plant pathogens on many crops such as yam, tomato, cowpea, groundnut, pepper, cassava

(Bediakao *et al.*, 2007; Padayachee and Baijnath, 2012; Shafique *et al*., 2012; Zaheer *et al.*, 2012; Sani and Gwa, 2018; Mamkaa and Gwa, 2018; Zubairu and Gwa , 2019; Chile and Gwa, 2021). These Plant products either in their refined form or crude form were reportedly recommended for the control of plant pathogens because they have been found to be cheap, easily available to farmers, highly biodegradable, little or no side effect and can as well be easily prepared by our peasant farmers (Okigbo and Nneka, 2005; Shafique and Abdul 2012). Synthetic chemicals have been found to have quick mode of action on plant pathogens but at the same time were found to have detrimental effect on our environment, crop, animals and most importantly the residual effect on the soils (Lakshmeesha *et al.*, 2013). The study evaluates the bioactive potency of some crude forms of plant extracts such as leaves of *Azadirachta indica*, seeds of *Piper guineense* and rhizomes of *Zingiber officinale* and a synthetic chemical substance, Mancozeb in the management of postharvest storage rot of local yam tubers for increase shelf life and to meet global demand for food security.

MATERIALS AND METHODS

Study area

The study was carried out at the Advanced Plant Pathology Laboratory, Federal University of Agriculture, Makurdi, Benue State, Nigeria between December, 2015 and April, 2016 and December, 2016 and April, 2017.

Source of yam tubers

Healthy *Ghini, Hembankwase, Ogoja and Pepa* white yam local cultivars were cultivated from the Federal University of Agriculture research farm for two cropping seasons between 2015 and 2016. Harvested tuber cultivars weighing 2kg were carefully washed with clean water before sterilizing them in 5% Sodium hypochlorite solution for 60 seconds. The different tuber cultivars were rinsed in three successive changes of sterile distilled and was dried under room temperature for 15 minutes before application of treatments (Gwa and Nwankiti, 2018a).

Preparation of plant extracts

Healthy leaves *Azadirachta indica,* seeds of *Piper guineense* and rhizomes of *Zingiber officinale* were purchased from different markets in Benue State and were thoroughly washed in running tap water and were air-dried before separately ground using pestle and mortar. The ground plant parts extracts were aseptically sieved to obtain fine powder. Accurate measurements of 60.0 g of each of the powdered plant were separately dissolved in 1L of sterile boiled water. The mixtures of the extracts were vigorously agitated and allowed to settle for 24 hours, after being settled for this period they were filtered through four layers of muslin cloth to give a concentration of 60.0g/L of *A. indica, P. guineense* and *Z. officinale* extracts respectively. Mancozeb which was used as the only comparative synthetic pesticide with the botanical pesticides was prepared by dissolving 4g of the chemical in 1L of sterile cold distilled water according to manufacturer's instructions to obtain a concentration of 4g/L. The efficacies of all the plant extracts and the only synthetic pesticide to inhibit the growth of the yam pathogens in storage were compared for a period of five months for two years beginning from December, 2015 to April, 2016 and from December, 2016 to April, 2017.

Determination of purity of Extract

Determinations of the purity of the extracts were carried out by streaking separately onto sterile plates of the test media Potato Dextrose Agar (PDA). The mixtures of PDA-extract were incubated at (30±5°C) for 24 hours and were carefully observed for possible growth of contaminants. The absence of any growth in the incubated plates confirmed the purity of the test extracts.

Evaluation of potency of plant extracts and synthetic pesticide on storage pathogens of white yam tuber cultivars

Efficacy of leaves of *A. indica,* seeds of *P. guineense* and rhizomes of *Z. officinale* and a chemical pesticide, Mancozeb were previously evaluated for their potency *in vitro* and found to be effective before they were tested for their ability to inhibit rot causing pathogens of white yam tuber cultivars in storage. The cultivars of the white yam tubers were sprayed using a hand sprayer with aqueous extracts *A. indica, P. guineense* and *Z. officinale* at concentration 60.0g/L while 4g/L of Mancozeb was sprayed on the yam tubers. The sprayed yam tubers were dried for 30 minutes before they were stored for a period of five months on bare floor in the store beginning from December, 2015 to April, 2016. Same procedure was from December, 2016 to April, 2017. There were seventeen (17) treatments including control (four tuber cultivars at four levels each and one control). The seventeen (17) treatments were replicated three (3) times each given a total of fifty one treatments (51). Three tubers formed a treatment which brought the total number of tubers used as 153 tuber cultivars for this experiment for each of the years. Treatments were completely randomized and control was set up in which sterile distilled water was sprayed on the yam tubers and allowed to dry (no plant extract or chemical applied). Data collected on potency of the extracts and chemical pesticide in controlling rot causing fungi were collected at monthly intervals for five months and mean value for each of the months and for each of the years was computed. The numbers of rotted and unrotted tuber cultivars in each of the treatments were recorded. The efficacy of the plant extracts and chemical fungicide in controlling yam tuber rot fungi in storage were evaluated at monthly intervals and means computed for each year. The Decay Reduction Index (DRI) method described by Amadioha (1996) was used to determine the Decay Reduction Index (DRI) which was calculated as a measure of the effectiveness of each plant extract and chemical pesticide in controlling yam tuber rot fungi in storage after six months for each of the years as stated below:

$$Decay\ Reduction\ Index\ (DRI) = \frac{\%\ decay\ in\ control - \%\ decay\ in\ treated\ tubers}{\%\ decay\ in\ control}$$

Data Analysis

Data were analyzed using Analysis of variance (ANOVA) using GenStat Discovery Edition 12 for ANOVA and means separation. Statistical F-tests were evaluated at $P\leq 0.0$ 5separated using Fisher's least significant difference (FLSD) as described by Cochran and Cox (1992).

RESULTS

Results presented in Tables 1-3 show the mean Decay Reduction Index (DRI) after six months of storage of different cultivars of local white yam tubers with some plant extracts and synthetic fungicide. The results revealed that mean DRI after six months of storage using Mancozeb to inhibit pathogens on the yam tuber cultivars under storage was least in *Hembankwase* and *Ogoja* with mean value of 0.73 compared with *Pepa* with mean highest value of 1.00. Application of *A. indica* leaf extracts on the tubers for the period of six months shows mean decay reduction index to be lowest in *Hembankwase* with mean of 0.45 while the highest mean value of 0.93 was recorded in *Pepa* yam tubers after same period of storage. Results also indicated that *P. guineense* extracts exhibited lowest level of inhibition in *Ogoja* with mean value of 0.51 while the highest value of 0.83 was recorded in *Pepa.* Application of *Z. officinale* within same period recorded lowest mean value of 0.46 in *Hembankwase* while the highest value of 0.83 was recorded in *Pepa*. Table 1shows result obtained for 2016 cropping season revealed that mean value in all the yam tuber cultivars produced significant differences *($P\leq 0.05$*) with the treatments.

Table 2 shows result obtained for 2017 storage period which reviewed that Mancozeb performed least in *Hembankwase* with Mean value of 0.60 but was highest in *Ogoja* with mean value of 0.86. Similarly, *A. indica* recorded the lowest value in *Ghini* with mean value of 0.58 while the highest of 0.66 was got in *Pepa* after five months of storage. In the same vein, *P. guineense* showed lowest inhibition in *Hembankwase* with mean value of 0.58 while the highest values of 0.64 were recorded for *Pepa* and *Ogoja* yam tuber cultivars. Result obtained using *Z. officinale* extract showed that the least Decay Reduction Index was in *Pepa* with mean value of 0.44 while the highest value of 0.72 was recorded in *Ogoja*. Results obtained in 2017 storage period reviewed that there were only significant differences *($P\leq 0.05$*) in mean value among tuber cultivars when Mancozeb and *Z. officinale* were used. Result presented in Table 3 shows the mean between the two years for all the yam tuber cultivars also showed significant differences *($P\leq 0.05$*) when the treatments were applied.

Table 1: Mean Decay Reduction Index of Mancozeb and some plant extracts on some white yam tuber cultivars after six months of storage for 2016 cropping season

Year/Yam	Plant Extracts			
Cultivars	Mancozeb	*A. indica*	*P. guinenses*	*Z. officianale*
2016				
Hembankwase	0.73 ± 0.06^{b}	0.45 ± 0.10^{b}	0.64 ± 0.05^{b}	0.46 ± 0.08^{b}
Pepa	1.00 ± 0.00^{a}	0.93 ± 0.04^{a}	0.83 ± 0.08^{a}	0.83 ± 0.11^{a}
Ogoja	0.73 ± 0.06^{b}	0.52 ± 0.08^{b}	0.51 ± 0.09^{b}	0.51 ± 0.10^{b}
Ghini	0.80 ± 0.11^{ab}	0.52 ± 0.08^{b}	0.60 ± 0.12^{b}	0.58 ± 0.11^{b}
LSD	*0.26*	*0.38*	*0.25*	*0.35*

Means in the same column with different superscript (for each section) are statistically different ($P\leq 0.05$)

Table 2: Mean Decay Reduction Index of Mancozeb and some plant extracts on some white yam tuber cultivars after six months of storage for 2017 cropping season

Year/Yam	Plant Extracts			
Cultivars	Mancozeb	*A. indica*	*P. guinenses*	*Z. officianale*
2017				
Hembankwase	0.60 ± 0.20^{b}	0.53±0.12	0.58±0.10	0.55 ± 0.09^{ab}
Pepa	0.80 ± 0.20^{ab}	0.66±0.09	0.64±0.09	0.44 ± 0.11^{b}
Ogoja	0.86 ± 0.13^{a}	0.54±0.12	0.64±0.11	0.72 ± 0.08^{a}
Ghini	0.80 ± 0.11^{ab}	0.52±0.08	0.60±0.12	0.58 ± 0.11^{ab}
LSD	*0.24*	0.17^{ns}	0.14^{ns}	*0.26*

Means in the same column with different superscript (for each section) are statistically different ($P\leq 0.05$);
ns = not significant

Table 3: Mean Decay Reduction Index of Mancozeb and some plant extracts on some white yam tuber cultivars after six months of storage for two years

Year/Yam Cultivars	Plant Extracts			
	Mancozeb	***A. indica***	***P. guinenses***	***Z. officianale***
Mean (2 years)				
Hembankwase	0.67±0.13^{b}	0.49±0.12^{b}	0.61±0.05^{ab}	0.51±0.08^{b}
Pepa	0.90±0.10^{a}	0.80±0.06^{a}	0.74±0.05^{a}	0.63±0.08^{a}
Ogoja	0.80±0.05^{a}	0.53±0.08^{b}	0.57±0.08^{b}	0.61±0.05^{ab}
Ghini	0.80±0.05^{a}	0.52±0.09^{b}	0.58±0.07^{b}	0.57±0.07^{ab}
LSD	*0.12*	*0.11*	*0.18*	*0.10*

Means in the same column with different superscript (for each section) are statistically different ($P \leq 0.05$); ns = not significant

DISCUSSION

Fungi pathogens have been known to be the major source of infection to different yam varieties while growing in the field and also when in store (Okigbo *et al.,* 2015; Gwa and Richard, 2018). Major fungi pathogens implicated as diseases causing agents in yam at different stages of growth includes *Aspergillus flavus, A. niger, A. ochraceus, Botryodiplodia theobromae, Colletotrichum sp, Curvularia eragrostide, Fusarium moniliforme, F. oxysporum, F. solan, Penicillium expensum, P. purpurogenum* and *Pestalotia sp* (Kumar *et al.,* 2007; Ogunleye and Ayansola 2014; Okigbo *et al.*, 2015; Gwa and Richard, 2018). These fungi attacked the crop and used the nutrients in the tubers as substrate for growth and development to manifest symptoms on tubers.

This study revealed that extracts of *A. indica*, *P. guineense* and *Z. officinale* as well as and Mancozeb; a synthetic fungicide all possess antimicrobial compounds that are capable of inhibiting the growth, reproduction and survival of the pathogens on yam tubers in storage. Research conducted by Biu *et al.* (2009) and Aidah *et al.* (2014) reviewed that plant materials contained secondary metabolites like alkaloids, flavonoids, terpenoids and tannins capable of inhibiting growth of different fungi pathogens. This result is similar to the work of Hycenth (2008) that inhibited the growth of *Rhizopus stolonifer* on yam tubers with leaf extracts of *A. indica.* This results also agreed with earlier studies carried out by Yeni (2011) that showed the inhibitory effect of *Z. officinale* on growth of *A. flavus*, *A. niger*, *F. oxysporum* and *F. solani* on post-harvest rot of water yam (*D. alata*) and found that the extract was potent against the growth of the rot causing fungi. A mean decay reduction index (DRI) of the extracts after five months for each year of storage on the yam cultivars showed the lowest mean value of 0.49 in *Hembankwase* using *A. indica* extract and the highest mean value of 0.80 in *Pepa* with same extract. This indicated that the extracts were able to reduce rots in the yam tubers from 49% to 80% during the five months of storage of *Hembankwase* and *Pepa* respectively. This means that a total of 51% and 20% of *Hembankwase* and *Pepa* respectively were lost to storage pathogens during the storage period.

These findings agreed with the result obtained by Gwa and Richard (2018) that reduced rot in *Ogoja* white yam tuber cultivar between 51% and 61% after five months of storage using *A. indica*, *P. guineense* and *Z. officinale*. Similarly, Gwa *et al.* (2021) inhibited rot in *hembankwase* white yam tuber cultivar to between 45% and 64% after five months of storage for two consecutive years using crude plant extracts such as *P. guinease*, *Z. officinale* and *A. indica*. According to Arinze (2005) and Okigbo *et al.,* (2009b) up to 50% of yam tubers produced in Nigeria are attacked by yam rot pathogens when stored. Similarly, Okigbo and Ikediugwu (2001) reported from 20 to 39.5% of yam tubers are lost to pathogens in storage annually. This result agreed with the findings of Okigbo *et al.* (2009a) who recorded high rot reduction of 62.80% with *A. sativum* similar to rot reduction of 80% in *Hembankwase* cultivar in this report. The result however, disagreed with Amaeze *et al.* (2013) that reported rot of yam tubers to be as low as from 10% to 15% after three months of storage. These findings have demonstrated the antimicrobial potency of these plant extracts as well as the synthetic chemical fungicide Mancozeb against storage pathogens of various cultivars of white yam tubers.

CONCLUSION

The results obtained from this study showed that *Hembankwase, Pepa, Ogoja* and *Ghini* yam tubers are susceptible to pathogens in storage. The study also revealed that extracts of *A. indica*, *P. guineense,* and *Z. officinale* may contain secondary metabolites that have the potency of inhibiting pathogenic growth in storage tubers compared with the synthetic conventional fungicide (mancozeb) which though reduced growth of pathogens during storage is considered costly, toxic to the environment due to their significant anti-pathogenic activities for the period of storage. It is therefore, recommended that these plant extracts be formulated and used by farmers in the management of plant pathogens of yam tubers in storage since they are cheap to afford, easy to prepare with little or no residual effect in the soil. This will enhance food sustainability and ensure food security with increase shelf life of the yam tubers.

CONFLICT OF INTEREST DISCLOSURE

The authors declared that there is no conflict of interest regarding the publication of this paper.

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