International Journal of Microbiology and Mycology | IJMM |
pISSN: 2309-4796
http://www.innspub.net
Vol. 20, No. 5, p. 1-14, 2025

Open Access REVIEW PAPER

Sweet potato-rot disease caused by fungal pathogens: A review on the causal agents and management strategies

Frederick Kankam*[1], Joseph Kwowura Kwodaga[2], Fataw Yakubu Ware[2]

[1]*Department of Agricultural Biotechnology, Faculty of Agriculture, Food and Consumer Sciences, University for Development Studies, Tamale, Ghana*

[2]*Department of Crop Science, Faculty of Agriculture, Food and Consumer Sciences, University for Development Studies, Tamale, Ghana*

Keywords: *Fusarium* rot, Java black rot, Management, Control, Synergic

Publication date: May 03, 2025

Abstract

Sweet potato is one of the most cultivated root crops in the world. The crop is a potential food security crop in Sub-Saharan Africa with the ability to produce a substantial yield within three months. However, its root tubers in storage or the field are constrained with fungal root rot diseases. Notably among them are Fusarium rots, Black rots, Java black rots, Rhizopus soft rot, and Charcoal rot are known to significantly impede the long-term storage of the root tubers into lean season. The ever-increasing threat posed by the usage of synthetic chemicals in the management of these rot diseases calls for safe and environmentally friendly management strategies. This review dived into existing and current management and control strategies in the management of sweet potato root rot diseases caused by fungal pathogens. The management strategies include; good agricultural practices, curing, refrigeration, and handling methods while the control strategies comprise of chemical control, antagonistic microorganisms, secondary compounds of plants, and botanicals. Integrated disease management renders unabatedly multidisciplinary approach with synergic action on several sweet potato fungal root rot-causing pathogens in the tropics.

* **Corresponding Author:** Frederick Kankam ✉ fkankam@uds.edu.gh

Introduction

Sweet potato (*Ipomoea batatas* L. Lam) is one of the most widely cultivated root tuber crops in the world with an estimated yield production of 114 million tons per annum (Pan *et al.*, 2023). China is the major producer with about 64 % of the world's production (Alam, 2021; Pan *et al.*, 2023). In Africa, 7 million tonnes are produced annually with Uganda, Rwanda, Malawi, and Kenya producing 1. 7 million tons, 980,000, 960,000 t, and 725,000 t respectively as the top producers (Sulaiman, 2022). The storage root serves as a source of carbohydrates, vitamins, potassium, iron, calcium, and several minerals and xenobiotic phytochemicals, such as antioxidant, anticoagulant, and anti-diabetic properties (Paul *et al.*, 2021; Escobar-Puentes *et al.*, 2022;). As one of the most potential food security crops in Sub-Saharan Africa with the ability to produce a substantial yield in poor soils within three months (Low *et al.*, 2020). The tuberous roots are strongly constrained by rots caused by fungal pathogens which hinder its long-term storage. The most prominent of these diseases include; *Fusarium* rots, Java black rot, Black rot, Charcoal rot, Bacterial soft and *Rhizopus* soft rot. However, with recent emphasis on food insecurity in Sub-Saharan Africa, research scientists as well as sweet potato farmers have delved into many strategies for controlling root rot disease of the crop caused by fungal pathogens (Bodah, 2017). Synthetic chemicals remained the number one choice for managing sweet potato root rot diseases in sub-Saharan Africa. Nevertheless, 70 – 99 % of these synthetic chemicals never successfully reach their intended target (Pang *et al.*, 2021). The use of these chemicals in the environment negatively impacts soil and surface water quality, terrestrial organisms, and consumers (Fadel-Sartori *et al.*, 2020; Pang *et al.*, 2021). Due to the dangers associated with the usage of these chemicals, researchers have diverted their concerns to seeking effective and environmentally friendly management strategies in managing sweet potato root rot diseases caused by fungal pathogens (Paul *et al.*, 2020, 2021). These management strategies include; antagonistic microorganisms and the use of secondary compounds of plants and botanicals.

Major post-harvest diseases of sweet potato

Several infections may severely impact potato production, either directly or indirectly. According to Clark *et al.* (2013), diseases affecting plants brought on by biological and/or non-biological causes are a significant factor in restricting the production of high-end categories of sweet potato tubers. Tiwari *et al.* (2021a) reported in the potato production chain, fungal infections are a key limiting factor that can lead to financial losses both in the field and during transport and storage. When being harvested, transported, or stored in cold storage, newly harvested potato tubers, which contain around 70% water, are susceptible to rots, galls, and blemish diseases. These factors facilitate the postharvest losses of sweet potatoes. Many phytopathogenic *Fusarium* species threaten sweet potato production, which may cause wilt of potatoes and dry rot of tubers during storage (Bojanowski *et al.*, 2013; Tiwari *et al.*, 2021b).

Fusarium rots

In all regions where sweet potato is grown, *Fusarium* species cause the *Fusarium* dry rot disease. The distribution of these species varies depending on the season, location, and accessibility of certain potato cultivars (Tiwari *et al.*, 2020b). According to Cullen *et al.* (2005), more than 13 different *Fusarium* spp. have been identified as the root cause of *Fusarium* dry rot. Du *et al.* (2012), also reported that losses from dry rots might range from 25 to 60% during storage. The annual financial damage caused by this disease is between \$100 and \$250 million in the United States alone (https://www.ars.usda.gov). According to studies, 88% of all post-harvest losses in the Chinese province of Gansu were attributable to dry rot disease (Du *et al.*, 2012). In the Michigan state of the United States, almost 50% of sweet potato seed tubers had *Fusarium* species infections (Gachango *et al.*, 2012). Similar to this, *F. sambucinum* (FS) is described as the most aggressive fungus species causing dry rot in tubers in Europe, China, and North America (Du *et al.*, 2012). According to Gildemacher *et al.* (2009), *F. coeruleum* (Libert) is the most common fungus found in British cold storage facilities. The most frequent fungi causing dry rot in North Dakota and Michigan, respectively, are *F. graminearum* (Schwabe) and *F. oxysporum* (FO). *F. oxysporum, F. solani*, and *F. sambucinum* are often found in cold storage in tropical and subtropical areas of India (Sagar *et al.*, 2011; Tiwari *et al.*, 2021b). Necrotic wrinkled, brown to black, depressed tuber patches that diminish the dry matter and cause shrivelled flesh are signs of tuber dry rot. When stored at a temperature between 5 and 30 °C, these wrinkled patches and necrotic lesions develop mycelial growth that is creamy white, pink, or orange in colour (Bojanowski *et al.*, 2013; Elsherbiny *et al.*, 2016).

Java black rot

Botryodiplodia theobromae is the causative organism for Black Java rot of sweet potato and the most common storage disease in tropical and subtropical areas, including West Africa, Asia, and the subtropical zone of the United States (Sowley and Oduro, 2002; Ray and Edison, 2005; Ray and Tomlins, 2010). The proximal end of the root or other incision locations is typically where the rot starts to spread. The diseased tissues start out looking yellowish-brown before turning black. After six to eight weeks of storage, the afflicted roots exhibit dark patches on the outside that house numerous pycnidia while the tissues within turn yellow and eventually turn black. Roots that have deteriorated become withered, brittle, and mummified. The primary risk factor for *Botryodiplodia* infection is wounding. For *B. theobromae* to flourish, the ideal temperature and relative humidity are 25 – 35 ℃ and 85 – 90%, respectively.

Black rot

Anywhere sweet potatoes are cultivated intensively, black rot, which is caused by *Ceratocystis fimbriata* (Mohsin *et al.*, 2021), has been a concern. The pathogen causes numerous damages to sweet potato in transplanted beds, fields, and in storage. Aside from the quality loss and tuber deterioration caused by *Ceratocystis fimbriata* in storage but also gives a distinct bitter taste. The initial symptoms are usually small, circular, slightly sunken, and dark-brown spots. In the field, healthy sweet potato can be penetrated by *C. fimbriata* through the skin but preferable lateral roots, lenticels, and wounds are used (Stahr and Quesada-Ocampo, 2019). Despite efforts to eradicate the disease using fungicides such as thiabendazole on seed roots and removing transplants above the soil line, the disease still occurs mainly in the United States, New Zealand, and Japan (Stahr, 2021). Other tropical and subtropical areas including Papua New Guinea, Haiti, Peru, and Vietnam continue to view it as a significant post-harvest disease. However, sweet potato-growing Asian nations including the largest producer of sweet potato China, and Pakistan, Nepal, India have not yet detected the rot (Ray and Edison, 2005).

Rhizopus soft rot

Sweet potato storage soft root rot is caused by *Rhizopus* in many sweet potato growing regions (Penyimpanan *et al.*, 2016). The sweet potato is prone to a variety of pathogens in the field as well as in storage though *Rhizopus* soft rot is the most destructive pathogen accounting for about 2 % in storage rot before reaching the market place (Clark and Moyer, 1988; Scruggs and Quesada-Ocampo, 2016). According to Scruggs and Quesada-Ocampo (2016), *Rhizopus* soft rot mostly take advantage of natural openings and wounds that resulted from mechanical tools and pests during farming operations. It is further reported that, the susceptibility of sweet potato roots to *Rhizopus* soft rot is determinant on the type of wound and the storage time (Scruggs and Quesada-Ocampo, 2016) while Holmes and Stange (2002), reported in their study that, the disease development is conducive with bruising as compared to other type of injuries such as breaking, scraping and puncturing. It is reported that *Rhizopus* soft rot symptoms are visible between 3 to 5 months after harvest due to decreasing susceptibility within this period (Holmes and Stange, 2002). The infection of the disease on sweet potato can be reduced by curing the tubers at higher temperature and humidity as it creates suberization on the injured portions thereby serving as a barrier to the entry of the pathogen. The spores of *Rhizopus* are air-borne which makes them easier to over winter on crop debris, fruits, and vegetables as well as tools and equipment (Scruggs and Quesada-Ocampo, 2016). The distinctive characteristics of *Rhizopus* soft rot are the soft, watery, and stringy sweet potato which usually occurs around the wounded region of the infection however, (Clark, 1980) reported that 'whiskers' are the most distinguishing feature that usually arise from the periderm around the root and occur once awhile.

Charcoal rot

The fungus *Macrophomina phaseolina* is responsible for the charcoal rot on sweet potato, and it exclusively affects fleshy roots during storage (Akinbo *et al.*, 2016). Other plant components are not attacked by the fungus. It has a broad host range with ability to adapt well in warm weather conditions (Clark, 1988). The fungus produces firm rots with the tuber tissues initially giving reddish-brown and then black colour as sclerotia are produced within the tuber tissue. Starting on the root's surface, the infection spreads via the vascular ring and toward the pith. The fungus is widespread around the world and affects a variety of plant types. It is soil-borne and can exist autonomously as sclerotia or saprophytically on plant detritus. No control measures are known.

Causes of sweet potato rots

Sweet potato rots are caused by biological and environmental factors both in the field and in storage. However, the most prominent among them are as follows:

Mechanical injuries

According to reports, sweet potatoes have delicate, thin skin that is readily damaged by cuts and abrasions when being harvested, transported, or distributed. The epidermis of the roots is damaged when harvesting equipment strikes them or when they are dropped into containers (Gambari and Okinedo, 2020). If the sweet potatoes are handled harshly or stored in containers with sharp edges, they may be damaged or bruised, which might lead to microbial infection (Gambari and Okinedo, 2020). The sweet potato root's undamaged skin serves as a defence against infection penetration and moisture loss. Infections can be facilitated by mechanical injuries that serve as entrance routes for microbial pathogens. Therefore, it is important to conduct careful harvest and post-harvest management to prevent damage and promote root quality, particularly during extended storage.

Temperature

In the last decade, global temperature has risen due to the increased levels of CO_2 and other greenhouse gases (Chen and Setter, 2021). It is estimated these trends could impact crop production and food security (Jarvis *et al.*, 2012; Chen and Setter, 2021). It is reported that temperature plays a major role in lengthening the natural dormancy of potato (*Solanum tuberosum* L) as long as the storage temperatures are low (Murigi *et al.*, 2021) by managing sprout development, tuber weight loss, and tuber quality. Murigi *et al.* (2021) and Paul *et al.* (2016) reported that long-term storage can be achieved by storing potato at low temperatures

(2 – 4 ℃) as it will inhibit sprout development. However, reducing sugars (fructose and glucose) are accumulated at 2 – 4 ℃ thereby giving a sweet taste to potato tubers. It is reported that tuber maturation, cooling down, and long-term storage are the three stages of long-term storage concerning recommended temperature and humidity (Krochmal-Marczak *et al.*, 2020; Vithu *et al.*, 2020). At high temperatures though, sweet potato tubers are vulnerable to rots due to microbial attacks and become worse when tubers suffer from injuries such as cuts, bruises, insect pests etc.

Pests and diseases

Though the benefits of sweet potato are huge in Sub-Saharan Africa and the world at large, unfortunately, its production is heavily plagued with insect pests and diseases (Musa *et al.*, 2022), and microbial deterioration (Nwaneri *et al.*, 2020) in both fields and storage. Many researchers have reported that the most devastating major insect pests preventing sweet potato production in Sub-Saharan Africa are the sweet potato weevils (*Cylas puncticollis* Boheman, Coleoptera; Curculionidae) and the flea beetles (*P. cruciferae* Goeze, Coleoptera: Chrysomelidae) drastically reducing sweet potato yield (Hue and Low, 2015; Okpara *et al.*, 2021; Musa *et al.*, 2022). The major and minor insect pest infestation has been reported to reduce sweet potato yield by 20 – 75 % (Alehegne, 2007). It is reported that the adult *C. formicarius* is a notorious pest as it can destroy the petioles, vines, and crowns as well as the tubers in storage while the adult female lay their eggs underneath the vine epidermis and storage roots as well (Dongzhen *et al.*, 2020). The larvae however dig tunnels into the vines and storage roots where they deposit their faeces (Reddy *et al.*, 2014). Feeding activities of these insect pests cause the production of unwanted substances including terpenoids and phenolic compounds which give a bitter taste, inedibility, and unpleasant smell (Dongzhen *et al.*, 2020) making the storage roots unmarketable.

Sweet potato disease management

A variety of fungal diseases can affect sweet potatoes, and more than 40 pathogens are associated to cause disease infections both in the field as well as in storage in sweet potato-growing regions around the world (Hedge *et al.*, 2012). Postharvest spoilage of sweet potato root tubers is a major constraint in Ghana and extensive research has been conducted to find effective control measures for recommendation for sweet potato farmers. Physical and chemical methods have been named the two major control methods in Ghana (Sowley, 1999). However, recent research on the management of postharvest sweet potato losses has been focused on the use of botanicals that are health-wise safe and eco-friendly for all actors in the production of sweet potatoes in the tropics. Below are some of the improved methods for managing sweet potato diseases.

Good agricultural practices

With the ever-increasing human population estimated to be around 10.4 billion people by 2067 (Karavidas *et al.*, 2022) with Africa and Asia to contribute to three-quarters of this population growth (Chojnacka *et al.*, 2020), safe agronomic practices with integrated disease management could be the way forward in the 21st century for sustainable agriculture in Africa. The practice of slash and burn in most countries in West Africa in land preparation for the new farming season depletes the soil major and micronutrients depriving plants of the needed support for growth. On the United Nations Sustainable Development Goals (UN-SDGs), biological-based practices for crop production which creates an eco-friendly environment as well as long-term profitability are the priorities for irradicating malnutrition and food security (Karavidas *et al.*, 2022). For sustainable agriculture, intercropping, little or no-tillage management, and organic farming are some of the techniques that one can use to promote soil biodiversity as well as enhance the soil profile and health (Morugán-Coronado *et al.*, 2020). Reduced tillage also necessitates drastically reducing the size, power, and usage of agricultural equipment, which lowers management costs and greenhouse gas emissions (Ghimire *et al.*, 2017). High-yielding cultivars that are also resistant to biotic and abiotic stresses to sweet potatoes in the field which gives yield quality without disturbing the ecological system as well as improves nutrient uptake and water absorption from the soil could be considered as good agronomic practice. Additionally, because of its potential to increase yield and product quality as well as owing to legislative limits on soil fumigants and pesticides to battle soil-borne diseases, the use of hydroponics is becoming more and more significant in sustainable agricultural systems (Karavidas *et al.*, 2022).

Curing

To reduce storage losses, seed or marketable stocks need to be cured as soon as they are harvested. Curing entails regulating the relative humidity and temperature while supplying good aeration for several days depending on the location. For a wound to heal as quickly as possible, the curing process needs a temperature range of 27 ℃ to 32 ℃, relative humidity of 85 to 90 percent, and good ventilation to eliminate carbon dioxide from the curing region. A protective cork covering will form over the entire root surface as cuts and bruises heal.

Suberin, a waxy substance, is also deposited. To prevent moisture loss and decay-causing organisms, the cork layer and suberin serve as a barrier. Tortoe *et al.* (2014) reported on tuber crops that curing enables damaged roots and root vegetables to heal and inhibit microorganisms from attack. Substantial shrinking was decreased by approximately 1% in fresh weight of tubers after 3 days between 35 °C - 40 °C and 80% - 90% at temperature and relative humidity respectively (Demeaux and Vivier, 1984). It has been suggested that curing sweet potato roots may enhance their preservation (Tortoe *et al.*, 2014). According to reports, higher temperatures and humidity cause yam tubers to produce cork cells, which completely seal the lesions (Bautista, 1990). Cork cells are subsequently created in the cork cambium and transported into the wound sites, where they seal the wound with several layers of periderm.

This layer significantly slows down the desiccation process and guards against bacterial and fungal growth (Tortoe *et al.,* 2014). During periderm production, the metabolic reactions produce water, carbon dioxide, and heat that are released into the atmosphere as a result of starch expiration.

Refrigeration

A refrigerator slows the metabolism of pathogens, which often prevents the development of putrefaction. When the product reaches ambient temperature, putrefaction will begin again since the putrefaction organisms are rarely killed. However, this method is expensive to be carried out by peasant sweet potato farmers (Tartoura *et al.*, 2015), particularly in Ghana.

Otherwise storing root tubers at 4 – 5 ℃ and 7 – 10 ℃ are ideal temperatures for seed and fresh sweet potato for market respectively (Giri *et al.*, 2020) though undesirable sweetening in the tubers is produced due to the convection of starch into sugars caused by low temperature (Giri *et al.*, 2020).

Handling methods

Proper root tuber handling and harvesting methods are the only way to reduce mechanical damage. Tropical regions generally lack well-developed food handling practices, and it is all too common to treat fresh vegetables like inert objects. Proper packing must be prioritized, especially if the root tubers will be consumed distant from the manufacturing location. For processing and transporting root crops in the tropics, boxes or cartons are generally regarded as being significantly more suited than huge sacks (Sowley and Oduro, 2002). It is reported in Tanzania by Tomlins *et al.* (2000) and Ray and Tomlins (2010) in a survey that, 20 % and 80 % of breakages result from handling and transport of the tuberous root of sweet potato. It is further revealed by Ndanyi *et al.* (2021) that losses could range from 30 – 50 % from transporting sweet potato root tubers from farms to distant markets making them unsalable in Papua New Guinea. With the among of tuberous root losses due to poor roads in developing countries particularly in Africa, it is always mindful of the delicate skin while putting them in boxes before transport.

Sweet potato tuber decay control treatment

Chemical treatment strategies

Chemicals are still the major choice for sweet potato farmers in Ghana for managing sweet potato root tuber diseases despite their numerous dangers. The ingestion of crop products treated with synthetic chemicals has been linked to negative health impacts, including teratogenicity, allergies, and the mortality of animals, according to recent research, which has raised concerns (Nwaneri *et al.*, 2020). Typically, the tactics employed for the application of these chemicals include; fumigation, dip or drench treatments, and pre-and/or postharvest sprays. However, some of these methods are affected by the time of application on crop produce. For instance, vegetables get contaminated by viruses at the pre-harvest stage after spraying. It is often recommended for fungicides to be applied on sweet potato plants on the field (Coates and Johnson, 1997). Pre-harvest sprays often reduce the amount of surface inoculum and avoid contamination and infection during harvest and postharvest. To prevent infections from spreading throughout the postharvest handling chain, including storage, fungicides used throughout the postharvest process must suppress latent infections.

Postharvest fungicides can be applied via waxes, coatings, fumigants, treated wraps, box liners, sprays, dips, and fumigants. Frequently employed dips and sprays might be aqueous solutions, suspensions, or emulsions, depending on the substance. Fungicides such as benzimidazoles (e.g. benomyl and thiabendazole) and demethylation inhibitor fungicides (e.g. prochloraz and immazalil) are frequently used as dips or sprays. Ammonia, ozone, and carbon dioxide are among other fumigants that are employed in developed countries. A commonly used fungicide, mancozeb is categorized as a contact fungicide with preventative action. By producing a molecule containing metal-containing enzymes, especially ATP-producing enzymes, it inhibits the action of fungal enzymes. This fungicide protects fruits, vegetables, nuts, and field crops from fungal diseases, including rusted roses, apple scabs, pear scabs, leaf spots, and potato blight. Furthermore, mancozeb can also be used to treat cotton, potato, maize, safflower, sorghum, peanuts, tomatoes, flax, and cereal grains. Junaid *et al.* (2013) observed that mancozeb was the most successful in inhibiting the development of *F. solani* and *F. oxysporum*, and that zineb was also efficient at controlling *F. solani*. At the least advised dose of 500 ppm, the combination of cymoxanil + mancozeb, carbendazim + mancozeb, and tricyclazole + mancozeb was shown to be the most efficient. Despite being effective against postharvest fungal infections, fungicides primarily used to manage postharvest diseases have been extensively studied for carcinogenic and other serious health hazards (Daniel, 2014) as they can induce acute toxicity, and some can also cause chronic diseases. Ray and Ravi (2005) reported that several environmental and health problems have been connected to the use of chemical pesticides. Also, most sweet potato packing facilities employ the fungicide dicloran (Botran) as a spray or dip treatment on the packing line to reduce losses from *Rhizopus* soft rot, a post-harvest disease caused by one of the principal sweet potato pathogens.

Antagonistic microorganisms

The use of microorganisms as biological control agents as a component of an integrated disease or pest management or used separately (Stathers *et al.*, 2018). A genetically stable organism that can be effective at low concentrations and operates against a wide spectrum of infections on diverse food commodities has been characterized as a suitable antagonist. The antagonist should have minimal nutritional needs, be able to survive under adverse environmental conditions and be able to establish itself in fermenters on inexpensive substrates. Furthermore, an ideal antagonist should not be pathogenic to the host crop and should not create metabolites that are hazardous to human beings as well as plants. Aside from that, it is also necessary that it can withstand common pesticides and complement other chemical and physical therapies effectively. The aforementioned traits enable harmful microbes to combat pathogenic organisms by producing antibiotics, through competition, parasitism, direct contact, or by developing resistance. "Biosave" (*Pseudomonas syringae* Van Hall) and Shemer" (*Metschnikowia fructicola*), are registered in both the United States and Israel to control sweet potato, potato, and carrot diseases, are a couple of examples of commercially available antagonistic products (Eshel *et al.*, 2009).

Secondary compounds of plants

Plant bioactive compounds have received attention recently as a potential new postharvest disease control strategy. The secondary metabolites that plants create are diverse and, in many cases, physiologically active. These compounds also having antioxident, antibacterial, bioregulatory, and allelopathic capabilities (Moomin *et al.*, 2023). This collection of substances includes; phenols, flavones, phenolic acids, quinones, flavonoids, coumarins, tannins, and flavanols as significant subclasses. These chemical classes have antibacterial properties and act as defense mechanisms for plants over harmful microbes. The site(s) and quantity of hydroxyl groups that are present in the phenolic compound are what cause it to be hazardous to microorganisms. Plants produce flavones, flavonoids, and flavonols, which are phenolic compounds containing a single carbonyl group. These compounds are frequently reported to be effective in vitro as antimicrobials against a variety of pathogens. Environmental factors, the time the plant part was gathered, how it was dried, storage conditions, and isolation techniques, among others, all affect the yielding ability of the biological properties at a given moment.

Botanical treatment

Plant extracts are generally preferred over synthetic chemicals when managing diseases due to the unsafe health conditions they pose. Chemicals of plant origin have lately received significant interest worldwide (Endersby and Morgan, 1991; Ware and Whitacre, 2000) due to their antifungal, antibacterial properties and environmentally friendly exposure. Botanical pesticides are a significant class of naturally occurring, frequently weak crop protectants that, relative to traditional pesticides, typically do less harm to people and the environment and have fewer long-term side effects (Pavela, 2009). According to Ivbijaro (2012), using botanicals to protect plants from pests offers several clear benefits. The use of botanicals as insecticides has long been considered an attractive alternative to synthetic insecticides, as they have little or no impact on the overall ecosystem and are also much safer for humans to use (Isman, 2006; Okpara *et al.*, 2021). Many researchers have expressed interest in exploring plant derivatives as a possible substitute for synthetic pesticides to avoid harmful or unfavourable side effects (Yang *et* *al.*, 2010). Due to the limitations associated with conventional chemical-based control methods, the focus has recently shifted toward the use of plant extracts as innovative fungicides (Okigbo and Ogbonnaya, 2006). The extraction of important bioactive plant tissue fractions from plants using select appropriate technologies has been a key focus of research into biopesticide extraction methods. When extracting compounds from plant tissue, it's important to consider the polarity of the solvent being used. The effectiveness of the plant extract will depend on a variety of factors, such as the type of plant material being used, the solvent of choice, and the extraction method. It's also worth noting that the type of solvent used can greatly impact the analysis of biologically active compounds in the plant material. With this in perspective, Alam *et al.* (2016) reported that low toxicity, preservation action, ability to trigger the resulting compound to dissociate, and ease of ease of evaporation are the appropriate properties of an ideal solvent extraction from plants. The extraction solvent should not be harmful and should not affect the bioassay because the finished product will still include residues of the extraction solvent. The chemicals that need to be eliminated will also have an impact on the choice. For the first examination of plants for possible antimicrobial activities, crude or alcohol extractions are typically performed, and different organic solvent extraction procedures can be used as a follow-up. Many plant species have been exploited in the search for distinct properties which could act against microbes. Nwaneri *et al.* (2020) reported that *R. stolonifer* causing sweet potato soft rot in Northern Nigeria can be greatly managed by the use of *Azadirachta indica* and *Moringa oleifera* extracts. Similar studies were conducted in Southern Nigeria also, by Amienyo and Ataga, (2007) by using three extracts namely; *Zingiber officinalis*, *Alchomia cordifolia,* and *Garcinia kola* to control rot on tubers caused by *Botryodiplodia theobromae*.

Again, (Linus, 2014b), used neem, ginger, and onion to inhibit the growth of *R. stolonifer* and *Aspergillus flavus* causing rots on three different sweet potato varieties in Ghana. The neem extracts inhibited *R. stolonifer* and *A. flavus* at 62.5 % and 56.2 % respectively while ginger and onion inhibited *A. flavus* at 42.7 % and 35.3 % respectively. Linus, (2014b) reported that a combination of three or four related chemicals and more than 20 minor compounds helps neem (*Azadirachta indica*) defend itself against pests. Triterpenes, such as limonoids, which have been found to inhibit insect development and have an impact on a variety of pests, are the most prevalent substances. Among these substances, azadirachtin, solanine, meliantriol, and nimbin are the most well-known and important.

Conclusion

The tuberous root of sweet potato contains many important nutrients and considering its importance to food security in Sub-Saharan Africa, it is imperative to find existing and current management as well as control strategies in the control of sweet potato root rot diseases caused by fungal pathogens. It is difficult for root rot disease management to control root rot disease due to high environmental influence, host diversity, hidden symptoms underground, and overwintering structures. Some root rots can only be prevented through chemical treatment or the green bridge between crops can be killed with chemical treatment.

Therefore, the adoption for an alternative approach to synthetic chemicals could be integrated disease management (IDM) as it will provide an unabated multidisciplinary approach with synergic action on several sweet potato fungal root rot-causing pathogens in the tropics.

References

Akinbo OK, Opara EU, Ikoro AI. 2016. Isolation and Characterization of Soft Rot pathogen of Yam (*Dioscorea* spp) in Nigeria - A Review. Journal of Agriculture and Sustainability **9**(2).

Alam MK, Rana ZH, Islam SN. 2016. Comparison of the proximate composition, total carotenoids and total polyphenol content of nine orange-fleshed sweet potato varieties grown in Bangladesh. Foods **5**(3), 64.

Alam MK. 2021. A comprehensive review of sweet potato (*Ipomoea batatas* [L.] Lam): Revisiting the associated health benefits. Trends in Food Science and Technology **115**, 512–529.

Alehegne T. 2007. Evaluation of planting time and selected insecticides against sweet potato weevil, *Cylas puncticollis* (Boh.)(Coleoptera: Brentidae) in Wolaita zone, Southern Ethiopia. Hawassa, Ethiopia: Hawassa University, Hawassa College of Agriculture, 67.

Amienyo CA, Ataga AE. 2007. Use of indigenous plant extracts for the protection of mechanically injured sweet potato [*Ipomoea batatas* (L.) Lam] tubers.

Bautista OK. 1990. Postharvest technology for Southeast Asian perishable crops [vegetables, fruits, plantation crops, ornamental crops, other crops].

Bodah ET. 2017. Root rot diseases in plants: a review of common causal agents and management strategies. Agric. Res. Technol. Open Access Journal **5**, 555661.

Bojanowski A, Avis TJ, Pelletier S, Tweddell RJ. 2013. Management of potato dry rot. Postharvest Biology and Technology **84**, 99–109.

Chen C-T, Setter TL. 2021. Role of tuber developmental processes in response of potato to high temperature and elevated CO_2. Plants **10**(5), 871.

Chojnacka K, Moustakas K, Witek-Krowiak A. 2020. Bio-based fertilizers: A practical approach towards circular economy. Bioresource Technology **295**, 122223.

Clark CA, da Silva WL, Arancibia RA, Main JL, Schultheis JR, van-Esbroeck ZP, Jiang C, Smith J. 2013. Incidence of end rots and internal necrosis in sweet potato is affected by cultivar, curing, and ethephon defoliation. HortTechnology **23**(6), 886–897.

Clark CA, Moyer JW. 1988. Compendium of sweet potato diseases. American Phytopathological Society.

Clark CA. 1980. End rot, surface rot, and stem lesions caused on sweet potato by *Fusarium solani*. Phytopathology **70**(2), 109–112.

Clark CA. 1988. Principal bacterial and fungal diseases of sweet potato and their control. 1. Planning Conference of Exploration, Maintenance and Utilization of Sweet Potato Genetic Resources, Lima (Peru), 23–27 Feb 1987.

Coates L, Johnson G. 1997. Postharvest diseases of fruit and vegetables. Plant Pathogens and Plant Diseases, 533–548.

Cullen DW, Toth IK, Pitkin Y, Boonham N, Walsh K, Barker I, Lees AK. 2005. Use of quantitative molecular diagnostic assays to investigate *Fusarium* dry rot in potato stocks and soil. Phytopathology **95**(12), 1462–1471.

Daniel CK. 2014. The effect of garlic extracts on the control of postharvest pathogens and postharvest decay of apples. Stellenbosch: Stellenbosch University.

Demeaux M, Vivier P. 1984. Méthodes modernes de conservation des ignames. L'agronomie Tropicale **39**(2), 186–191.

Dongzhen F, Xilin L, Xiaorong C, Wenwu Y, Yunlu H, Yi C, Jia C, Zhimin L, Litao G, Tuhong W. 2020. *Fusarium* species and *Fusarium oxysporum* species Complex Genotypes Associated With Yam Wilt in South-Central China. Frontiers in Microbiology **11**, 1964.

Du M, Ren X, Sun Q, Wang Y, Zhang R. 2012. Characterization of *Fusarium* spp. causing potato dry rot in China and susceptibility evaluation of Chinese potato germplasm to the pathogen. Potato Research **55**, 175–184.

Elsherbiny EA, Amin BH, Baka ZA. 2016. Efficiency of pomegranate (*Punica granatum* L.) peels extract as a high potential natural tool towards *Fusarium* dry rot on potato tubers. Postharvest Biology and Technology **111**, 256–263.

Endersby NM, Morgan WC. 1991. Alternatives to synthetic chemical insecticides for use in crucifer crops. Biological Agriculture & Horticulture **8**(1), 33–52.

Escobar-Puentes AA, Palomo I, Rodríguez L, Fuentes E, Villegas-Ochoa MA, González-Aguilar GA, Olivas-Aguirre FJ, Wall-Medrano A. 2022. Sweet potato (*Ipomoea batatas* L.) phenotypes: From agroindustry to health effects. Foods **11**(7), 1058.

Eshel D, Regev R, Orenstein J, Droby S, Gan-Mor S. 2009. Combining physical, chemical and biological methods for synergistic control of postharvest diseases: A case study of Black Root Rot of carrot. Postharvest Biology and Technology **54**(1), 48–52.

Fadel-Sartori F, Floriano-Pimpinato R, Tornisielo VL, Dieminger-Engroff T, de Souza Jaccoud-Filho D, Menten JO, Dorrance AE, Dourado-Neto D. 2020. Soybean seed treatment: how do fungicides translocate in plants? Pest Management Science **76**(7), 2355–2359.

Gachango E, Hanson LE, Rojas A, Hao JJ, Kirk WW. 2012. *Fusarium* spp. causing dry rot of seed potato tubers in Michigan and their sensitivity to fungicides. Plant Disease **96**(12), 1767–1774.

Gambari UOB, Okinedo JI. 2020. Aetiology of fungal diseases of sweet potato. Journal of Agriculture and Veterinary Sciences **12**(2).

Ghimire R, Norton U, Bista P, Obour AK, Norton JB. 2017. Soil organic matter, greenhouse gases and net global warming potential of irrigated conventional, reduced-tillage and organic cropping systems. Nutrient Cycling in Agroecosystems **107**, 49–62.

Gildemacher P, Maina P, Nyongesa M, Kinyae P, Woldegiorgis G, Lema Y, Damene B, Tafesse S, Kakuhenzire R, Kashaija I. 2009. Participatory analysis of the potato knowledge and information system in Ethiopia, Kenya and Uganda. Innovation Africa: Enriching Farmers' Livelihoods, 153–165.

Giri K, Gurung S, Pokharel S, Karn R, Subedi AP. 2020. Effect of different plant extracts on sprouting, storability and post-harvest loss of potato in Baglung district, Nepal. Malaysian Journal of Sustainable Agriculture **4**(1), 16–21.

Hedge V, Misra RS, Jeeva ML. 2012. Sweetpotato Diseases: Diagnosis and Management. Fruits Veget. Cereal Sci. Biotechnology **6**, 65–78.

Holmes GJ, Stange RR. 2002. Influence of wound type and storage duration on susceptibility of sweet potatoes to *Rhizopus* soft rot. Plant Disease **86**(4), 345–348.

Hue S-M, Low M-Y. 2015. An insight into sweet potato weevils management: A review. Psyche: A Journal of Entomology, 2015.

Isman MB. 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol. **51**, 45–66.

Ivbijaro MFA. 2012. Natural pesticides from Nigeria in: poverty alleviation from biodiversity management. Book Builders Editions of Africa. Ibadan, Nigeria 431p.

Jarvis A, Ramirez-Villegas J, Herrera-Campo BV, Navarro-Racines C. 2012. Is cassava the answer to African climate change adaptation? Tropical Plant Biology **5**, 9–29.

Junaid JM, Dar NA, Bhat TA, Bhat AH, Bhat MA. 2013. Commercial biocontrol agents and their mechanism of action in the management of plant pathogens. International Journal of Modern Plant & Animal Sciences **1**(2), 39–57.

Karavidas I, Ntatsi G, Vougeleka V, Karkanis A, Ntanasi T, Saitanis C, Agathokleous E, Ropokis A, Sabatino L, Tran F. 2022. Agronomic practices to increase the yield and quality of common bean (*Phaseolus vulgaris* L.): a systematic review. Agronomy **12**(2), 271.

Krochmal-Marczak B, Sawicka B, Krzysztofik B, Danilčenko H, Jariene E. 2020. The effects of temperature on the quality and storage stability of sweet potato (*Ipomoea batatas* L.) grown in Central Europe. Agronomy **10**(11), 1665.

Linus B. 2014. Evaluation of the efficacy of three Organic Extracts in controlling storage rot in Sweet Potato. Kwame Nkrumah University of Science and Technology, Kumasi Ghana 93p.

Low JW, Ortiz R, Vandamme E, Andrade M, Biazin B, Grüneberg WJ. 2020. Nutrient-dense orange-fleshed sweet potato: advances in drought-tolerance breeding and understanding of management practices for sustainable next-generation cropping systems in sub-Saharan Africa. Frontiers in Sustainable Food Systems **4**, 50.

Mohsin SM, Hasanuzzaman M, Parvin K, Morokuma M, Fujita M. 2021. Effect of tebuconazole and trifloxystrobin on Ceratocystis fimbriata to control black rot of sweet potato: processes of reactive oxygen species generation and antioxidant defense responses. World Journal of Microbiology and Biotechnology **37**(9), 148.

Moomin A, Russell WR, Knott RM, Scobbie L, Mensah KB, Adu-Gyamfi PKT, Duthie SJ. 2023. Season, storage and extraction method impact on the phytochemical profile of *Terminalia ivorensis*. BMC Plant Biology **23**(1), 1–18.

Morugán-Coronado A, Linares C, Gómez-López MD, Faz Á, Zornoza R. 2020. The impact of intercropping, tillage and fertilizer type on soil and crop yield in fruit orchards under Mediterranean conditions: A meta-analysis of field studies. Agricultural Systems **178**, 102736.

Murigi WW, Nyankanga RO, Shibairo SI. 2021. Effect of storage temperature and postharvest tuber treatment with chemical and biorational inhibitors on suppression of sprouts during potato storage. Journal of Horticultural Research **29**(1), 83–94.

Musa AK, Mustapha S, Lawal MT. 2022. Pesticidal evaluation of teak and almond ethanol leaf extracts against two insect pests of sweet potato (*Ipomea batatas* L.). Tropical Agriculture **99**(2), 10.

Ndanyi V, Ooko AG, Okoth MW, Odhiambo EG. 2021. Postharvest Handling Practices of Sweetpotato in Kenya: A case of Bungoma and Homabay Counties. East African Journal of Science, Technology and Innovation **2**(5), 1–32. https://doi.org/10.37425/eajsti.v2i.350

Nwaneri JA, Enyiukwu DN, Cyprain UEC, Nicholas JC. 2020. Response of Fungal Rot Pathogens of Sweet Potato (*Ipomoea batatas* (L) Lam. in Storage to Aqueous Extracts of Some Tropical Plant Materials and Benomyl.

Okigbo RN, Ogbonnaya UO. 2006. Antifungal effects of two tropical plant leaf extracts (*Ocimum gratissimum* and *Aframomum melegueta*) on postharvest yam (*Dioscorea* spp.) rot. African Journal of Biotechnology **5**(9).

Okpara UG, Emeasor KC, Asawalam EF. 2021. Study on the management of sweet potato weevil (*Cylas puncticollis* (Boheman)) in Umuahia, Abia State. Nigerian Journal of Plant Protection **35**(1), 12–21.

Pan C, Yang K, Erhunmwunsee F, Li Y-X, Liu M, Pan S, Yang D, Lu G, Ma D, Tian J. 2023. Inhibitory effect of cinnamaldehyde on *Fusarium solani* and its application in postharvest preservation of sweet potato. Food Chemistry **408**, 135213.

Pang L-J, Adeel M, Shakoor N, Guo K-R, Ma D-F, Ahmad MA, Lu G-Q, Zhao M-H, Li S-E, Rui Y-K. 2021. Engineered nanomaterials suppress the soft rot disease (*Rhizopus stolonifer*) and slow down the loss of nutrient in sweet potato. Nanomaterials **11**(10), 2572.

Paul NC, Park S, Liu H, Lee JG, Han GH, Kim H, Sang H. 2021. Fungi associated with postharvest diseases of sweet potato storage roots and in vitro antagonistic assay of *Trichoderma harzianum* against the diseases. Journal of Fungi **7**(11), 927.

Paul NC, Park W, Lee S, Chung MN, Lee H-U, Yang J-W. 2020. Occurrence of sweet potato (*Ipomoea batatas*) wilt and surface rot disease and determining resistance of selected varieties to the pathogen in Korea. Plants **9**(4), 497.

Paul V, Ezekiel R, Pandey R. 2016. Sprout suppression on potato: need to look beyond CIPC for more effective and safer alternatives. Journal of Food Science and Technology **53**, 1–18.

PaVela R. 2009. Effectiveness of some botanical insecticides against *Spodoptera littoralis* Boisduvala (Lepidoptera: Noctudiae), *Myzus persicae* Sulzer (Hemiptera: Aphididae) and *Tetranychus urticae* Koch (Acari: Tetranychidae). Plant Protection Science **45**(4), 161–167.

Penyimpanan K, Lady VK, Di Bawah PR, Suhu R, Kashif F, Abbasi S, Masud T, Qayyum A, Khan SU, Abbas S, Jenks MA. 2016. Storage stability of potato variety Lady Rosetta under comparative temperature regimes. Sains Malaysiana **45**(5), 677–688.

Ray RC, Edison S. 2005. Microbial spoilage of stored sweet potato (*Ipomoea batatas*) roots in the tropics and control measures. Journal of Mycopathological Research **43**(2), 147–158.

Ray RC, Ravi V. 2005. Postharvest spoilage of sweet potato in tropics and control measures. Critical Reviews in Food Science and Nutrition **45**(7–8), 623–644.

Ray RC, Tomlins KI. 2010. Sweet potato: post-harvest aspects in food, feed and industry. Nova Science Publishers, Incorporated.

Reddy GVP, Wu S, Mendi RC, Miller RH. 2014. Efficacy of pheromone trapping of the sweet potato weevil (Coleoptera: Brentidae): based on dose, septum age, attractive radius, and mass trapping. Environmental Entomology **43**(3), 767–773.

Sagar V, Sharma S, Jeevalatha A, Chakrabarti SK, Singh BP. 2011. First report of *Fusarium sambucinum* causing dry rot of potato in India. New Dis Rep **24**(5), 588–2044.

Scruggs AC, Quesada-Ocampo LM. 2016. Cultural, chemical, and alternative control strategies for *Rhizopus* soft rot of sweet potato. Plant Disease **100**(8), 1532–1540.

Sowley ENK, Oduro KA. 2002. Effectiveness of curing in controlling fungal-induced storage rot in sweet potato in Ghana. Tropical Science **42**(1), 6–10.

Sowley ENK. 1999. Etiology of storage root of sweet potato (*Ipomoea batatas* (L) Lam) and its control by curing. An MPhil Thesis Presented to the Department of Crop Science, University of Ghana, Legon, 120.

Stahr M. 2021. Black Rot of Sweet potato: Epidemiology, Dispersal, and Detection of *Ceratocystis fimbriata*. North Carolina State University.

Stahr MN, Quesada-Ocampo LM. 2019. Black rot of sweet potato: A comprehensive diagnostic guide. Plant Health Progress **20**(4), 255–260.

Stathers T, McEwan M, Gibson R, Mwanga ROM, Carey EE, Namanda S, Low JW, Ogero K, Rajendran S, Abidin PE. 2018. Everything you ever wanted to know about sweet potato, Topic 5: Sweet potato seed systems.

Tartoura EAA, El-Gamily EI, EL-Shall ZA, El-Sharqawy MMS. 2015. Effect of some medicinal and aromatic plants extracts on storability of potato at the ambient temperature: 1-sprouting behavior, weight loss and damage percentage. Journal of Plant Production **6**(6), 977–993.

Tiwari I, Shah KK, Tripathi S, Modi B, Subedi S, Shrestha J. 2021. Late blight of potato and its management through the application of different fungicides and organic amendments: a review. Journal of Agriculture and Natural Resources **4**(1), 301–320.

Tiwari RK, Bashyal BM, Shanmugam V, Lal MK, Kumar R, Sharma S, Gaikwad K, Singh B, Aggarwal R. 2021. Impact of Fusarium dry rot on physicochemical attributes of potato tubers during postharvest storage. Postharvest Biology and Technology **181**, 111638.

Tomlins KI, Ndunguru GT, Rwiza E, Westby A. 2000. Postharvest handling, transport and quality of sweet potato in Tanzania. The Journal of Horticultural Science and Biotechnology **75**(5), 586–590.

Tortoe C, Dowuona S, Dziedzoave NT, Rees D. 2014. Effect of curing treatments on seven key farmers' yams (*Dioscorea* spp.) in Ghana. Agricultural Science **5**(12), 1–119.

Vithu P, Dash SK, Rayaguru K, Pal US. 2020. Study on optimization of mechanical peeling for sweet potato. Agricultural Engineering Today **44**(1), 1–7.

Ware GW, Whitacre D. 2000. The pesticide book 5th edn. Thomson Publications, Fresno, CA, USA.

Yang F-L, Zhu F, Lei C-L. 2010. Garlic essential oil and its major component as fumigants for controlling *Tribolium castaneum* (Herbst) in chambers filled with stored grain. Journal of Pest Science **83**, 311–317.