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Minireview

Yam diseases and its management in Nigeria

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This review presents different diseases associated with yam and the management strategies employed in combating its menace in Nigeria. The field and storage diseases are presented, anthracnose is regarded as the most widely spread of all the field diseases, while yam mosaic virus disease is considered to cause the most severe losses in yams. Dry rot is considered as the most devastating of all the storage diseases of yam. Dry rot of yams alone causes a marked reduction in the quantity, marketable value and edible portions of tubers and those reductions are more severe in stored yams. The management strategies adopted and advocated for combating the field diseases includes the use of crop rotation, fallowing, planting of healthy material, the destruction of infected crop cultivars and the use of resistant cultivars. With regards to the storage diseases, the use of Tecto (Thiabendazole), locally made dry gins or wood ash before storage has been found to protect yam tubers against fungal infection in storage. Finally, processing of yam tubers into chips or cubes increases its shelf live for a period of between 6 months and one year.

Key words: Yam, field and storage diseases, resistant varieties, yam nematodes, disease management, fungicides, Nigeria.

BACKGROUND

Cultivated yams belong to the family Dioscoreceae and to the genus *Dioscorea* (Coursey, 1967). The most cultivated species in Nigeria are the *D. rotundata* (white yam), *D. cayenesis*, (yellow or guinea yam) and *D. alata* (water yam). There are also species of wild yam growing in Nigeria whose tubers are collected for eating in times of food shortage. Yam are a valuable source of carbohydrate to the people of the tropical and subtropical Africa, Central and South America, parts of Asia, the Caribbean and Pacific Islands (Coursey, 1967; Adelusi and Lawanson, 1987). *Dioscorea* spp constitutes a staple food in the tropics (Han et al., 1987). Yams after peeling the tuber can be cooked in various ways by boiling and mashing, but roasting and frying are also widely used. Yam in Nigeria, is also processed into various staple, intermediate and end product forms (Okaka et al., 1991; Okaka and Anajekwu, 1990), which are used for direct consumption by animals, used as the basic ingredient for snacks or made into flour used for making instant puree (Coursey, 1983; Okaka and Okechukwu, 1987).

Out of the World production of over 30 million tonne per annum, Nigeria alone produces 22 million tonne (FAO, 1998). Despite this, the demand for yam tubers in Nigeria has always exceeded its supply. However, it has been estimated that an average of over 25% of the yield is lost annually to diseases and pests (Arene, 1987; Ezeh, 1998; FAO, 1998). Onayemi (1983) also reported that over 50% of the yam tubers produced and harvested in Nigeria are lost in storage.

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Table 1. Fungi associated with disease complex of yam *Dioscorea* spp in southwestern Nigeria.

Fungi	Isolation Site	% Frequency of Isolation		
		D. cayenensis	*D. alata*	*D. rotundata*
Colletotrichum gloeosporioides	Leaves and Stems	90	93	98
Curvularia pallescens	Leaves	10	8	12
Curvularia eragrostides	Leaves	12	14	13
Pestalotia sp	Leaves	18	14	12
Rhizoctonia solani	Leaves and Stems	40	44	36

Source: Amusa (1997).

The disease causing agents not only reduce the quantity of yam produced, but also reduce the quality by making them unappealing to the consumers.

Yam is prone to infection right from the seedling stage through to harvesting and even after harvesting, in storage. For the purpose of this write up, yam diseases will be classified into 2 categories, which are field and storage diseases.

FIELD DISEASES

The field diseases are those diseases that cause economic damage to yam in the field from the seedling stage to the point of harvest.

Yam anthracnose disease

Anthracnose disease of yam has had a considerable impact on yam production world-wide (Nwakiti and Arene, 1978; Simon, 1983). This is caused mostly by the fungus *Colletotrichum gloeosporioides* Jackson and Nwhoof (Nwakiti and Arene, 1978; Nwakiti et al., 1980). IITA (1993) reported that *Glomerela cingulata* (isolate number IMI W3725) was the yam anthracnose inducing pathogen in Southwestern Nigeria. *G. cingulata* is the perfect state of *C. gloeosporioides*, the form that is usually found causing field anthracnose disease.

On susceptible yam cultivars, symptoms appeared at first as small dark brown or black lesion on the leaves, petioles and stems. The lesion is often surrounded by a chlorotic halo enlarged and coalesces, resulting in extensive necrosis of the leaves and die-back of the stem (Amusa, 1991, 1997). The withered leaves and stem die-back gave the plant a scorched appearance hence the name 'scorch' disease (IITA, 1993).

Previous work (Amusa, 1997) indicates that yam anthracnose is a disease complex, which has however been associated with the activities of *Colletotrichum gloeosporioides*, *Curvularia pallescens*, *Curvularia eragrostides, Pestalotia* sp and *Rhizoctonia solani.* (Table 1). These associated fungi were also found to induce necrotic lesion of varying sizes on the leaves of *D. alata*. PANS (1984) have reported that *Pestalotia* spp mainly affects *D. esculenta* but appear to act as a secondary invader after infection by *C. gloeosporioides* on *D. alata* and *D. cayenensis*. Simon (1993) had reported that many of the symptoms attributed to yam anthracnose in Nigeria are probably caused by *R. solani* often in the absence of *C. gloeosporioides.* However, Winch (1981) had reported that interaction existed between *C. gloeosporioides* and *R. solani* in anthracnose disease complex of yam. Although the presence and the activities of the other pathogens, which are likely responsible for the complexity of the disease, might be playing a significant role in the development and the severity of anthracnose disease of yam. However, the activities of the other pathogens are probably enhanced by the death of plant cells caused by toxic metabolites produced by *C. gloeosporioides* (Amusa et al., 1993). The phytotoxic metabolite extracted from the culture of the *C. gloeosporioides* and even from the *C. gloeosporioides* infected leaves were able in the absence of the pathogen to induce similar necrotic lesion on yam leaves and stems (Amusa, 1991).

The anthracnose inducing pathogen is an ubiquitous pathogen infecting several crops. *C. gloeosporioides* overwinters in leaves, stems, seeds and in infected soil (Amusa and Alabi, 1996).

Yam Mosaic Virus Disease

This disease is caused by an aphid-transmitted potyvirus that infects several species of Dioscorea, particularly *D. alata*, *D. cayenensis*, *D. rotundata* and *D. trifida*. The symptoms observed in each host can be vein banding, curling, mottling, green-spotting, flecking etc (Mantell, 1980; IITA, 1993). Yam mosaic virus (YMV) is considered to cause the most severe losses in yams. It is known that the most economically important virus diseases of yam so far characterized are caused by members of the potyvirus group, but there is inadequate information on the number and variability of these viruses.

Table 2. Microorganisms found associated with the stored and marketed yam tubers obtained from the tropical forest region of South-western Nigeria and their pathogenicity on yam.

Pathogens	Symptoms of infection	Pathogenicity
Botryodiplodia Theobromae	Dry rot	+++
Aspergillus. Tamari	,,	++
Penicillium oxalicum	,,	+++
P. cyclopium	,,	+++
P.italicum	,,	+++
Fusarium oxysporium	,,	++
F. solani	,,	++
Rhizopus nigricans	Soft rot	++
Sclerotium rolfsii	,,	+++
Muccor circinelloides	,,	+++
Trichoderma. viridae	,,	++
Erwinia carotovora	Wet rot	+++

++: Mildly pathogenic (> 10< 50mm in diameter. +++ Highly pathogenic (>_50mm in diameter).
Source: (Amusa and Baiyewu, 1999).

Water yam virus disease (*Dioscorea alata* virus)

The disease is more commonly found on *D. alata*. Symptoms included chlorosis vein banding, flecking and leaf puckering. The organism has not been characterized. (IITA, 1993). Concentric leaf spot disease: Concentric leaf spot disease of yam has been reported to be the second commonly encountered fungal folial disease on yam in south western Nigeria (Amusa, 2000). The causal agent has been identified as *Sclerotium rolfsii* (Amusa, 2000). Okpala and Eziakor (1989) first reported the wilting of yam vine caused by *S. rolfsii* in the eastern Nigeria. Symptoms of the disease include circular leaf spots of varying sizes that form concentric rings. At maturity, the center of the leaf spots contained sclerotia of the fungus. The lesion may merge, together with the center eventually falling out due to necrosis. These circular leaf spots were observable both in the field and at nurseries causing not only spot but complete blight of sprouting yam. Sclerotia are also produced at the base of the infected yam vine. Soil, plant debris and several weeds such *as Aclipha ciliata, Chromolaena odoranta, Euphobia heterophilla, Ipomea triloba, Commelina erecta* were found to harbour the pathogen (Amusa, 2000). The effect of this disease on yield has not been investigated, but we have observed that under severe attack yield loss of more than 50% could be obtained.

Other foliage diseases

Other foliage diseases occasionally encountered on the yam field include zonate leaf spot induced by *Curvularia eragroistides,* and *Pestalotia macro trichia (*Emua and Fajola, 1980; PANS, 1984; Amusa et al., 1996). Foliar symptoms of nematode infections on food yams are occasionally observed. Early yellowing, and leaf fall termination of vine growth have been seen on *D. rotundata* infected with *M. incognita,* but infections only rarely reduces total tuber yield of these yams (Adesiyan and Odihirin, 1978; Nwauzer and Fawole, 1981)

STORAGE DISEASES

Yam tubers are harvested in Nigeria mostly between June and September and most of which are stored in different storage facilities depending on the cultural and traditional values as well as the technological advancement of the people of such area (Amusa, 2000) until consumption or replanting.

During storage, the tubers are subject to losses of up to 50% of the fresh matter. Here, the losses due to microbial attack play a predominant role. The fungal pathogens penetrate through wounds in the tubers and infect the inner tuber tissue. Such wounds are caused by insects, nematodes and poor handling before, during and after harvest. Morse et al. (2000) reported that most of the yam rot induced by fungi in specialized barns near Idah, Kogi State, Nigeria were predisposed by insect attack by mainly storage beetles (*Coleoptera*), mealy bug (*Planococcus citri*) and sclae insect (*Aspidiella hartii*) during storage. Treatments of the yam tubers with insecticide dust (Actellic 2% Dust; ai=pirimiphos-methyl) significantly reduced fungal infections and also ameliorated physical damages acquired during harvest resulting in significantly fewer fungal lesions (Morse et al., 2000). The storage diseases of yam can be categorized into 3 based on the symptoms and the causal agents (Amusa and Baiyewu, 1999) (Table 2).

Dry rot

The symptoms though vary with varying coloration depending on the invading pathogen, the infected tissues become hard and dry. When tubers are infected with *Penicilium oxalicum* and *P. cyclopium*, the tubers turn brown, become hard and dry maintaining their integrity, except when the tissues were invaded by *S. marcescens* (IITA, 1993). Such invaded tissues become covered with the greenish mycelia of the fungus. When tubers were infected with *Aspergilus niger* and *A. tamari,* such tissues subsequently turn brown with yellowish margin. *Rosellinia bunodes,* and *Botryodiplodia theobromae,* has been reported to cause dry black rot. The infected tubers first turned grey and then black, such tubers become pulverulent, breaking into small dry particles (IITA, 1993).

Fusarium species were also reportedly associated with dry rot in yam tubers in Nigeria (Ogundana et al., 1970; Morse et al., 2000) inducing pinkish with yellowish border on the infected tissues (IITA, 1993). The species of *Fusarium* implicated in dry tuber yam rot includes *F. oxsporium, F. moniliforme and F. solani* (Amusa and Baiyewu, 1999). Tubers infected by *Sphaerostilbe repens* had reddish mycelia on the rotted part (IITA, 1993). Infected tissue was discolored brown and smelled fermented grains but maintained their integrity.

The yam nematode, *S. bradys*, has also been found to the cause of decay of yam tubers known as " dry rot disease." This type dry rot of yam occurs in the outer 1or 2 cm of tubers. The internal stage of the nematode dry rot consists of cream and light yellow lesions below the outer stem of the tuber. No external symptoms are found at the stage. As the disease progresses it spreads into the tuber, normally to a maximum depth of 2 cm but sometimes deeper. In these later stages of dry rot, infected tissues first became light brown and then turn chatle brown to black. External cracks appear in the skin of the tubers and parts can flake off exposing patches of dark brown, dry rot tissues. The most severe symptoms of dry rot are seen in mature tubers especially during storage when it is often associated with general decay of tubers. However, weight differences between healthy and diseased tubers harvested from the fields have been estimated to be 0 to 29% in Nigeria (Wood et al., 1980).

Water loss from tubers continues during storage and is significantly greater in tubers infected with *S. bradys* compared to healthy tubers (Adesiyan et al., 1975). Dry rot of yams alone causes a marked reduction in the quantity, marketable value and edible part ions of tubers. Those reductions are more severe in stored yams. Adesiyan and Odihirin (1975) have reported losses in a whole tuber can be as high as 80-100% in storage. The degree of pre-harvest damage to tubers by *S. bradys* varied from 0 to 40% in Nigeria (Wood et al., 1980). Bridge (1973) observed that nearly 47% of all tubers on sale in Nigeria markets were infested with *S. bradys*, and both dry rot and wet rot diseases of tubers have been observed in all Nigerian yam barns and markets sampled (Adesiyan and Odihirin, 1977).

Knotting or galling and internal rotting of yam tuber has been found associated with *Meloidogyne* spp. In certain yam species sprouting in galled tubers are often reduced or suppressed and root proliferation from galls on tubers can occur (Bridge, 1973; Adesiyan and Odihirin, 1978; Nwauzer and Fawole, 1981). It is estimated that there is a reduction of 34 to 52% in the price of galled tubers compared to healthy ones (Nwauzer and Fawole, 1981). Other diseases caused by *M. incognita* and *M. javanica* in stored tubers are reduction in the edible portion (more peel has to be removed), a weight loss, and an increase in the number of rotted tubers in both *D. alata* and *D. rotundata* (Nwauzer and Fawole, 1981).

Soft rot

Infected tissues become soft ramified by the fungal mycelium. The causal fungi quickly ramified the tissue which turn brown and become soft and at times wet due to a rapid collapse of the cell walls. Fungi associated with this type of rot are *Rhizopus* spp, *Mucor circinelloides, S. rolsii*, and *Rhizoctonia solani* and *Armillariella mellea* (Ikotun, 1983, 1989; Green et al., 1995; Amusa and Baiyewu, 1999).

Wet rot

Wet rot is characterized by the oozing of whitish fluid out of the tissue when pressed. This symptom is usually associated with a bacterium, *Erwinia carotovora pv carotovora* (IITA, 1993; Amusa and Baiyewu, 1999).

YAM DISEASE MANAGEMENT

Yam diseases control has been extensively studied, and several measures has been recommended. These include the use of crop rotation, fallowing and planting of healthy materials and the destruction of infected crop cultivars (Nwakiti, 1982; Nwakiti and Arene, 1976; Ogundana. et al, 1970).

For soil borne diseases such as nematodes and sclerotium diseases, the site on which yam plants are to be cultivated are often recommended for soil testing for the presence of the pathogen (Arene, 1987; Amusa, 2000). Nematode can be controlled by the use of crop rotation and the use of nematicides such as carbofuran granular at the planting. Dipping of seed pieces in Nemacuron before planting also eliminate the inoculum of the pathogen from the planting materials. Early plowing and thorough disking which exposes the sclerotia to early germination and exhaustion before planting has also been recommended (Arene, 1980). Planting of yam setts with disease-free material as been found very effective in reducing nematode problems. Yam setts are often treated with a suspension of *Fernasan D* or two handfuls of wood ash in 4 litres of water (Osai, 1993), after which the yam setts are spread under shade for the cut surface to dry before planting. Use of virus-free planting materials and meristem culture has been recommended in the case of controlling viral diseases (Mantell, 1980)

For post harvest losses, minimizing physical damage of tubers during post-harvest operations has been recommended and is being practiced. Treatment of yam tubers with fungicides such as Benlate and Captan has been found to be effective in reducing fungal yam rot (Ogundana, 1971, 1981). Due to toxicity of many chemicals, the use of Tecto (Thiabendazole) (Ogundana, 1971, 1981; PANS, 1984; Amusa and Ayinla, 1997) locally made dry gins (Akinnusi et al., 1987; Ogali et al., 1991) or wood ash before storage (Osai, 1993) which are known to have little or no mammalian toxicity have also been recommended. Fungal infected yam tuber treated with Tecto at the concentration of between 0.6 and 1.0 kg /500 kg of yam tubers had significant reductions in weight loss compared with the control. Thiabendazole application have been reported to stimulate sprouting of yam minisetts (Amusa and Ayinla, 1997).

The boring beetle attack on shoot and tubers can be controlled by granular application of diazinon and carbofuran. While treatments of the yam tubers with insecticide dust (Actellic 2% Dust; ai=pirimiphos-methyl) will reduced fungal infections and also ameliorate physical damages acquired during harvest resulting in significantly fewer fungal lesions (Morse et al., 2000).

Moreover, yam farmers in south western Nigeria have been processing over 1/3rd of the harvested yam tubers into chips or cubes which can be stored between 6 months and one year (Amusa, 2001; Okaka and Okechukwu, 1987; Okaka and Anajekwu, 1990) as a means of reducing post harvest losses associated with yam storage.

It has been reported that the most effective and desirable means of controlling field yam diseases is by the selection and planting of resistant cultivars (Nwakiti et al., 1987). The use of anthracnose-resistant cultivars (e.g. TDA 291, TDA 297) bred and released by the international Institute of tropical Agriculture (IITA) has been advocated (IITA, 1993). Yam like any other crop is often evaluated for disease incidence and severity in field and green house using artificial or natural inoculation of the pathogen. However these screening procedures are very cumbersome and time consuming. Screening for resistance varieties with the use of toxic metabolite of *Colletotrichum* spp has been found effective, reliable and comparable to the conventional screening methods (Amusa, 2000; Amusa et al., 1994).

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