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Review

Combating yam anthracnose in Nigeria: A Review

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Abstract

Yam is an important tuber food crop in Nigeria and in most parts of tropical Africa. However, a major cause of low yield yam is the use of low yielding local varieties with little or no use of fertilizers. Other major constraints to yam production in the tropics are foliar diseases. One important foliar disease of yam of great economic importance is Yam Anthracnose caused by *Colletotrichum gloeosporioides.* Yam anthracnose disease is the most devastating disease of yam in all areas where yam is produced at commercial level due to low yielding varieties, poor agronomic package and lack of quality seed. Anthracnose can depress yield by 67% and 'Appollo' may result in total loss of planting seed. Anthracnose might cause yield production of up to 80% in Nigeria especially in some areas where yam is produced in substantial quantity. Cultural practices such as early planting and close spacing have been used to control the disease by small scale farmers. These control measures are usually limited and host plant resistance provides a more viable option, especially with small scale resource poor farmers in eastern Africa. However, the availability of resistant variety in most parts of the tropics is very limited. This paper reviews the epidemiology, economic importance and the various strategies of combating yam anthracnose diseases In Nigeria.

Keywords: yam anthracnose, *Colletotrichum gloeosporioides,* epidemiology, control, Nigeria

INTRODUCTION

Yam (*Dioscorea* spp) constitutes an economically important staple food for millions of people in the tropics and sub tropics. West Africa account for about 95% of world production and 93% of the total yam production area (FAO, 2012). Out of the world production of over 30 million metric tons per annum, Nigeria alone produces 22 million tons annually. Despite this, the demand for yam tubers in Nigeria has always exceeded its supply. However, it was estimated that an average of over 25% of the yield is lost annually to diseases and pests (Amusa, 2001). The two most important cultivated edible yams are white Guinea yam (*D . rotundata* poir) and water yam (*D. alata*). *D. rotundata* is indigenous to West Africa and represents the most important species in terms of volume of production while *D. alata*, which was introduced to Africa from Asia in the 16th century, is the most widely cultivated species globally. In comparison with *D. rotundata, D. alata* has superior characteristics for sustainable production, including high yield potential (especially under low to average soil fertility), ease of propagation, early vigour for weed suppression and storability of most cultivars to anthracnose disease that exerts a devastating impact on productivity. The deployment of durable host plant resistance in *D. alata* against yam anthracnose disease will contribute significantly to a high-level stability of field performance. Anthracnose (*Colletotrichum gloeosporioides*) causes leaf necrosis and dieback of yam vines, leading to a reduction in the effective photosynthetic surface area of the crop with a concomitant reduction in ability of the yam tuber to store food reserve (FAO, 2012). Epidemics that commence prior to or during tuber formation can have a tremendous effect on tuber yield. Successful control of anthracnose would encourage greater wide spread cultivation and significant increase in overall production to meet the high local and overseas demand for yam (FAO, 2002).

National Agricultural Research Systems (NARS) in Nigeria conducted most of the early research on anthracnose in the 1960s and 1970s. More recently, the International Institute of Tropical Agriculture (IITA, Ibadan Nigeria) has been of the forefront of yam anthracnose research in collaboration with National Agricultural Research Systems and advanced research laboratories. Following severe anthracnose epidemics in Nigeria in 1993 and the demise of the popular susceptible *D. alata* cultivars white libson and pacala is deemed necessary. Yam is very costly especially in far north where the climate does not favour its cultivation. And the major reasons for this are that of transport and diseases that yam suffers in the field and in storage. This paper reviews on the different ways of combating yam anthracnose in Nigeria, a disease that has been militating against profitable yam production in the country.

Biology and ecology of yam Anthracnose

The pathogen causing yam anthracnose was first described as *Gloeosporium pestis* Massee from yam in Fiji. It was later reported from *D. alata* in India and subsequently classified as *C. gloeosporioides*. *Colletotrium* is described in two - four forms associated with foliar anthracnose of yam in Nigeria. The Slow Growing Grey (SGG), the Fast-Growing Salmon (FGS), the Fast Growing Grey (FGG) and the Fast-Growing Olive (FGO) forms. Isolates of the four forms were identified as *C. gloeosporioides* based on morphology. Variation in growth rate, conidial and appressorial morphology were important criteria for differentiating between different species and or strains of *Colletotrium.*

The unambiguous identification of *Colletotrichum* species and the definition of sub-populations responsible for epidemics are vital for developing and implementing effective disease control strategies for instance, *C. gloeosporioides* and *C. acutatum* differ in their sensitivity to fungicides such as benomyl. Implementing a spray program where a mixed population exists without accounting for their differential sensitivity result in a shift in population ratio. *C. gloeosporioides* is widely accepted as the causal agent of yam anthracnose based on morphological criteria but such criteria have often proved inadequate for differentiating *Collectotrichum* species. The current inaccuracies in identifying *C. gloeosporioides* and defining sub-specific groupings within the pathogen solely by using morphological criteria have been largely overcome by the use of molecular methods for species and sub-specific differentiation within *Collectrichum* (Mignouna *et al.*, 2002).

Multiple morphologically indistinguishable *Colletotrichum* species are commonly associated with a single host, due to this complicated situation, *Colletotrichum* species-host combination involved in a given anthracnose incidence alone is often insufficient as a diagnostic indicator of disease aetiology. Although *C. gloeosporioides* can infect different yam plant parts (Abang *et al.*, 2001).

In view of the high morphological similarities between *C. gloeosporioides* and several other *Colletotricum* species, a biochemical and molecular approach was used to resolve the taxonomic status of the yam anthracnose pathogen (Abang *et al.,* 2004). The clarification of the systematic of colletotrichum strains infecting yam is a necessary precondition for studies on the population structure of the yam anthracnose pathogen. The reaction of monoconidial cultures a Casein Hydrolysis Medium (CHM), fungicide sensitivity, DNA polymorphism and sequence analysis of the internal transcribed spacer region of the ribosomal DNA were used to ascertain the identity of the yam anthracnose pathogen. All *Colletotrichum* isolates from yam could be distinguished from *C. acutatum* by the absence of protease activity on CHM (Abang *et al.,* 2002).

Forty one percent of all isolates produced abundant perithecia in culture, suggesting that these isolates may be able to reproduce via telemorph, *Glomerella cingulata*, in yam fields. The SGG isolates did not produce the telemorph in culture; however, failure to observe the sexual state does not necessarily imply the inability to produce it but may simply reflect the absence of conditions optimal for the production of the teleomorph by certain strains. Thus, while traditional methods for species delineation within *Colletotrichum* and for discrimination of sub-populations within species rely primarily on morphological characteristics, the strong influence of the environment on these traits has made their use unsatisfactory. Isolates thought to belong to *C. gloeosporioides* were found to br highly variable in morphology and virulence (Abang *et al*, 2001).

The presence of several pathogenic fungi on the yam phylloplane led Amusa (2001) to suggest that yam anthracnose is a disease complex, requiring the concerted action of a number of fungal pathogens for significant symptom development. Advances in understanding the molecular events in the early infection processes involved in the interaction between *C. gloeosporioides* and its hosts (KolaHukudy *et al.,* 2000). Penetration through natural opening such as stomata and wounds is possible; however, wounding did not increase symptom severity on *D. alata* (Abang *et al.*, 2001).

Epidemiology of yam Anthracnose

Yam anthracnose is characterized with dark, usually sunken lesions. the term anthracnose is from the greek word for coal or charcoal. These are typically diseases of leaves, stems or fruits. The anthracnose fungal organism attacks trees early in the spring causing a rapid wilt of newly imaging leaves. These rapid wilting is frequently misidentified as frost damage. Larger, more mature leaves develop a brown growth along the main veins, infected leaves often littering the ground (Singh, 1998). Yam dieback or anthracnose is incited by the fungus *Colletotrichum gloeosporioides.* It is probably present in all the countries of the region and is often a major problem where yams (*Dioscorea* spp) are grown intensively. However, water yam (*D. alata*) is thought to be more susceptible to anthracnose than other yams (Mehrotra and Aggarwal, 2003; Milgroom, 2003).

In some countries, yam dieback is thought to be caused by high lighting. This is because after heavy rain, the disease on some varieties increases rapidly from occasional leaf spots to extensive blackening of leaves and stems, and plant may die (Milgroom and Peever, 2003).

Although the pathogen is not able to survive in soil for more than a few weeks, it is able to survive between growing seasons on crop debris. Therefore, survival from one season to the next may occur, but is unlikely to be important where growers practice crop rotation and plough-in crop debris. The fungus, *Colletotrichum gloeosporioides*, infects many crops and weeds. It is possible that spores from these plants also affect that of yam crop. If tuber rots occur in the pacific as they do in the Caribbean, then infected planting materials is likely to be the most important way that new crops become diseased. Small immature tubers derived from early shoot death, may be a major sources of infection of the shoots as they develop ((Abang *et al.*, 2001; 2002; 2004).

Once infection is established in a crop, subsequent development of yam anthracnose depends on rainfall and host variety. Severe out breaks develop on susceptible varieties following rainstorms or cyclones as was the case in Nigeria in 1993. Spores are found in large numbers on the leaf spots and are splashed in rain and or carried by dripping dew to adjacent and lower leaves and stems (Okigbo, 2005).

Other pathogens associated with Anthracnose disease complex

The causal agent of anthracnose, *Colletotrichum gloeosporioides*, was isolated from yam leaves with foliar lesions (anthracnose and other leaf spots) in over 96% of all locations. The pathogen was also isolated from asymptomatic tissue. This suggests that the pathogen, as well as being the primary cause of anthracnose, might exist as an endophyte in yam tissue. The pathogens, *Colletotrichum capsici*, *Phoma* sp., *Curvularia* spp. *Cercospora apii* and *Fusarium* spp., were found in over 50% of yam lesions. These pathogens, along with *C. gloeosporioides*, are generally regarded as pathogens associated with the anthracnose complex. However, *Curvularia* spp., *Phoma* sp. and *Cercospora apii* were also associated with leaf symptoms that were distinct from anthracnose, yam pest and diseases posters. However, the non-anthracnose-type lesions accounted for an extremely small proportion of the lesions found on yams throughout Ghana and were not considered by the author to be the cause of significant yield loss. Also, die-back, associated with the anthracnose complex of pathogens, was regarded as anthracnose for the purpose of the disease survey. Other forms of die-back were present in the survey area. These were found to be associated with *Fusarium* spp. and *Rhizoctonia solani*. Typically, infected plants become necrotic from the base upwards (in contrast to the anthracnose-type where plants become necrotic from the shoot tips downwards). Affected tissues have a light brown, necrotic appearance. Infection usually results in the complete death of the plant. However, the incidence of the non-anthracnose type of die-back was low and was not recorded at any of the survey fields.

Economic importance of yam Anthracnose disease

Anthracnose disease causes serious yield loss on *D. alata* cultivated in any yam growing regions of the world especially where monocultures with a single popular susceptible variety are common. In Nigeria, susceptibility to anthracnose has made it virtually possible to grow the popular varieties pacala and white Lisbon, and anthracnose is considered the single most important factor responsible for the decline of yam production. Anthracnose might cause yield production of up to 80% in Nigeria (Okigbo, 2005).

Farmers in most yam growing areas of the world no longer rely on the effectiveness of benzimidazole and related fungicides for the control of yam anthracnose due to the development of fungicide resistant *C. gloesporioides* strains (McDonald and Linde, 2002). The pathogen is believed to play a role in tuber bio-deterioration in Nigeria. However, ‘dead skin’ symptoms have not been reported yet in Nigerian infested yam. Anthracnose occurs wherever yam is grown but extreme temperatures in parts of northern Nigeria appear in favour of disease development (McDonald and Linde, 2002). In areas where anthracnose is not currently considered a constraint, there is a risk of higher yield losses in the future, as new hybrids replace a wide spectrum of local landraces and that the fungus is becoming resistant to even the so called systemic fungicide plus the fact that few resistant yam varieties are available in Nigeria.

SYMPTOMS OF INFECTION

Above ground symptoms

Symptom varies according to the age of the leaf, amount of rain and the variety of yam. Mild infection leads to very small brown spots on young leaves. These small brown spots become larger as the leaves approach full size, and they may leaf spots run together to form large irregular blotches, the centre of which may fall out giving a ‘short hole’ effect. Infected leaves unusually fall off. In some varieties, the veins on the undersides of the leaf become black where they have been infected. If this occurs as the leaves are expanding, they may become cup-shaped and twisted. The ‘wings’ on the stems may also become infected.

Long periods of rain favour epidemics of the disease because the fungal spores (conidia) are spread by rain splash. Young foliage is more susceptible to anthracnose. Therefore, if periods of high rainfall coincided with the stage of crop development, that is where a lot of young leaves are present, the disease can quickly spread throughout the crop. In this case, rapidly expanding black lesions occur on the leaves and stems and the shoot die. This is particularly common when veins have reached the tops of their supporting poles, and the new growth droops near to other infected parts of the plant. Mature leaves, by contrast, develop numerous, brown pin-point spots which do not usually expand nor penetrate to the other side of the leaf.

Below ground symptoms

When dieback occurs on young plants, a few of the lower leaves may survive, but usually the whole vine dies resulting in no, or poor yield. New shoots sometime grow from the planting piece and plants become multi-stemmed in contrast to uninfected plants which usually only have one or two stems. Because each stem produces a tuber, affected plants may have several small tubers instead of the normal one or two (Milgroom, 2003).

Management of yam anthracnose disease

Anthracnose and other Yam diseases control have been extensively studied and several management strategies as well as measures have been recommended. These include;

CULTURAL METHODS

Cultural control measures such as the removal of weeds that may be alternative hosts, planting barrier crops of maize, avoiding damage to tubers at harvest, early, early staking, crop rotation, ploughing in plant residues immediately after harvest are likely to reduce disease development.

Earlier planting dates led to a marked delay in the development of anthracnose on *D*. *alata,* compared with intermediate and later planting dates. This result concurred with previous reports from West Africa (Odu *et al.,* 2006). The impact of anthracnose on early emerging yams was lower because the plants had had time to establish a canopy before the onset of weather conducive to disease development (continuous rains). Mature leaves of 'White Lisbon' are known to be more resistant to anthracnose than intermediate or juvenile ones. The beneficial effect of earlier planting was not, however, sufficient for commercial roots to develop, presumably because disease severity was already high at the onset of root bulking. Clearly, for a control measure to be economically effective, it must impede the development of anthracnose until the phase of root bulking is complete (Green, 2008).

None of the intercropping treatments had any effect on either the incidence or severity of yam anthracnose or subsequent yields. Failure of the intercrops to reduce the spread of anthracnose on *D*. *alata* cv. White Lisbon could have occurred for two reasons: The intercrops emerged at about the same time as White Lisbon and were probably ineffective in obstructing the splash dispersal of conidia of *C*. *gloeosporioides* across ridges. An alternative explanation is that multiple points of primary infection (resulting from root-borne inoculum) were present, facilitating the rapid spread of the disease within the rows of White Lisbon. Despite the apparent failure of intercropping as a control measure for anthracnose in this experiment, results from other studies suggest that the practice warrants further investigation (Odu *et al.,* 2006).

In the field experiments, the effect of each cultural practice on the development of anthracnose was considered in isolation. Findings from the survey indicated that also relevant would be to test the efficacy of combining different cropping practices to control anthracnose. In the Proceedings of the Tenth Symposium of the International Society for Tropical Root Crops, held in Salvador, Bahia, Brazil, October 23-29, 1994, it was shown that no individual cropping practice or control measure was effective in eliminating yam anthracnose disease during the growing season, but particular combinations of cultural practices and environmental conditions helped reduce disease development on certain farms. Low rainfall (1400 mm/y) and use of healthy planting material, for example, were factors of critical importance in controlling anthracnose. In addition, mixed cultivation, in small areas, of anthracnose-susceptible yams with tolerant cultivars and occasional intercropping with maize may help limit the spread of anthracnose on smallholdings by physically preventing the dispersal of *C*. *gloeosporioides* and by increasing genetic diversity.

Chemical control

Chemical control is difficult and costs are high. Weekly benomyl treatments alternating with applications of coper, dithiocarbonates or daconi have been tested. Resistance to benomyl is reported. Fungicides can delay the onset of epidemics, but cannot prevent them developing during the rainy season. If foliar sprays are used they should be applied before symptoms of anthracnose appear in the crop, and weekly during the growing season.

The use of chemical fungicides to control anthracnose on the foliage of *D*. *Alata* White Lisbon during the growing season, compared with 94% of plantation growers. About half the plantation growers used tractors with boom sprayers rather than knapsack sprayers but, irrespective of the mode of chemical application, fungicides usually became ineffective in controlling the disease during the heavy rains. Explanations for the failure of chemical control include infrequent or poorly timed applications (because of costs of chemicals, labour, and machinery), heavy rain washing fungicides off leaf surfaces, and the possible existence of fungicide-resistant strains of *C. gloeosporioides*. Even so, 29% of the plantations could maintain reasonable control until the end of the growing season. These growers began spray programmes before the first symptoms of anthracnose were visible and continued to spray on a weekly basis throughout the growing season. In Nigeria, some fungicides are banned from market and the available ones could be expensive or unavailable to farmers (Kutama *et al*., 2011). This has consequently led to the growth of the disease, sometime reaching epiphytotic stage.

Epidemiological studies have subsequently confirmed that high yields can be obtained if this type of spray programme is used to delay the onset of anthracnose until after root bulking (Sweetmore *et al*., 2002). Where effective and affordable (e.g., on commercial farms and research stations), fungicides can therefore be used as an interim measure for controlling foliar anthracnose, but, in isolation, they are unlikely to provide a sustainable solution probably because of some reasons earlier mentioned.

Selection of planting setts

Tubers should be selected from uninfected plants and stored in a cool dry place during dormancy. Setts should be carefully inspected and any showing areas of rot rejected. The setts should be treated should be treated with a broad-spectrum fungicide to eliminate surface-borne fungi and cutting knives should be treated frequently with bleach (Amusa, 2001).

Use of resistant varieties

Varieties differ in their resistance to anthracnose disease. Some are highly resistant at all stages of growth. Others show good resistant only when leaves are mature and a full leaf canopy have formed. In some resistant varieties, infection does not occur until late in the life of the crop. In this case, there may be dieback of young shoots, leaf curling with or without discoloration of veins on lower surfaces and infections of leaf stalks causing otherwise healthy mature leaves to fall off.

Growers should be encouraged to select tubers from plants showing resistance and to use only these for showing resistance and to use only these for propagation and increase of stock (McDonald and Linde, 2002).

Tracking pathogen populations

Yam is vegetatively propagated and planting materials (yam tuber), which is an important source of *C. gloeosporioides* inoculums, is frequently exchanged within and across national borders in West and Central Africa. Only SGG form has been observed to cause defoliation and premature death of inoculated plants (Mignouna *et al.*, 2002). The threat of the spread of the aggressive SGG stain in this region must be urgently addressed not only on account of the virulence of this strain, which appears to be linked to its ability to produce highly toxic metabolites (Abang *et al.,* 2004) but because of its epidemiological significance. Molecular differentiation of SGG and FGS populations using genetic markers will facilitate epidemiological studies (e.g. genotype tracking) as well as assist breeders develop improved strategies for resistance breeding against both pathogens populations (Mignouna *et al*, 2002).

Various viruses, bacterial and fungal diseases of yam have been reported in Nigeria since 1956. Pre- harvest and post -harvest tuber rot may result in storage loss of 25%. Pre-harvest rot is induced by the bacteria, *Corymebacterium* sp, *Erwinia* sp and the fungus *Botryodiplodia* sp. While the post harvest rot is caused by *Fusarium* sp, *Aspergillus sp*. amongst the foliar diseases described anthracnose can depress yield by 67% and ‘Appollo’ may result in total loss of planting seed. Storage losses have been controlled by carefully handling of the tubers and selections for resistant cultivars may help to control the other diseases.

CONCLUSION

Based on the write up, attempt to show how integrating traditional and molecular approaches to understanding the systematic, epidemiology and population genetics of *C. gloeosporioides* can lead to yam anthracnose disease, and thus to the development of effective and sustainable control measures.

The ability to use pathogenesis-related pathotoxins in the selection of anthracnose-resistant genotypes is expected to have a profound impact on breeding schemes for crops with long growth cycles such as yam.

Finally, all aspects of yam anthracnose research will benefit immensely from close collaboration between IITA, which has the global mandate for yam in the Consultative Group on International Agricultural Research (CGIAR) and advance research institutes in the industrialized countries.

References

Abang MM, Green KR, Wanyera NW, Iloba C(2001). Characterization of Colletotrichum gloeosporioides penz, from yam (Sioscorea spp) in Nigeria, Proceedings of the International Society for Tropical Root Crops Africa Branch, Cotonu, Benin. Pp. 613 – 615.
Abang MM, Hoffmann P, Winter S, Gree KR, Wolf GA(2004). Vegetative compatibility among isolates of Colletotrichium gloeosporioides from yam (Discorea spp) in Nig. J. phytopalm. Pp. 134-138
Abang MM, Winter S, Green KR, Hoffman P, Mignouna HD, Wolf GA(2002). Molecular identification of Colletotrichum gloeosporioides causing Anthracnose of yam in Nigeria Plant pathol. Pp. 63 – 71.
Amusa NA(2001). Screening yam cultivars for resistance to anthracnose using toxic metabolites of Colletotrichum species, Mycopathologia. Pp. 13 – 142.
FAO (2002). FAOSTAT Agriculture data Food and Agriculture Organisation of the United Nations http://apps.fao.org/collections.
FAO (2012). Food and Agricultural Organization Statistics Food data and Agriculture Organisation of the United Nations http://apps.fao.org/collections.
Green KR(2008). Studies on the epidemiology and control of yam Anthracnose. Ph.D. dissertation. University of Reading, UK.
KolaHukudy P, Kim E, Rogers L(2000). Early molecular communication between Colletotrichum gloeosporioides and its host. Minnesola, USA. Pp. 78 – 98.
Kutama AS, Emechebe AM, Aliyu BS (2011). Evaluating the efficacy of seed treatment fungicides in the control of sorghum head smut caused by Sporisorium reilianum, in the Sudan savanna region of Nigeria. J.Phytopathology and Plant Health. 1:93-98
McDonald BA, Linde C(2002). Pathogen population genetics, evolutionary potential and research advances in disease management Trop. Agric. Pp. 53 – 57.
Mehrotra RS, Aggarwal A(2003). Plant pathology, Second edition. Tata McGraw-Hill Publishing Company Limited. Pp. 411-423
Mignouna HD, Abang MM, Peleman J(2002). A genetic linkage map of water yam (Discoreaalata) based on AFLP markers and QTL analysis for anthracnose resistance. Pp. 726 – 735.
Milgroom MG, Peever TL(2003). Population biology of plant pathogens: The synthesis of plant disease epidemiology and population genetics. Plant disease. Pp. 608 – 616.
Odu BO, Asiedu R, Shoyinka SA, Hughes JA(2006). Reaction of white guinea yam (Dioscorea rotundata Poir.) genotypes to virus diseases in four agroecological zones in Nigeria. J. Phytopathology.154: 688–693.
Okigbo RN(2005). Biological control of post-harvest fungal rot of yams Dioscorea spp.) with Bacillus subtilis. Mycopathologia, 159: 307-314.
Singh RS(1998). Plant Diseases. Seventh edition. Oxford and IBH Publishing Co.PVT. LTD. Pp. 335-34
Sweetmore A, Simons SA, Kenward M(2002). Comparison of disease progress curves for yam anthracnose (Colletotrichum gloeosporioides). Plant Path. Pp. 43:206-215.