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Challenges Confronting Plant Disease Management in Nigeria

Jonathan SG[1]*, Okunola TT[1], Nwaokolo VM[2], Omeonu FC[3], Adegoke BA[1] and Salaam SM[1]

[1]*Myco-Pathology & Applied Microbiology Group, Department of Botany, University of Ibadan, Nigeria*

[2]*Federal College of Forestry, Jericho, Ibadan, Oyo State, Nigeria*

[3]*Department of Microbiology, Chrisland University, Abeokuta, Ogun State, Nigeria*

***Corresponding Author:** Jonathan SG, Myco-Pathology & Applied Microbiology Group, Department of Botany, University of Ibadan, Nigeria

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Abstract

The damage done by phytopathogens like fungi, viruses, bacteria, and nematodes have inflicted negative impact on Nigeria's agricultural products. Nigeria is a country where agriculture produce have greatly contributed substantially to the national economy. This article reviews the major challenges confronting plant disease management in Nigeria, including the increasing impact of pathogens like fungi, bacteria, and viruses on yield and production. The knowledge gap among small-scale farmers, have prevented adequate access to diagnostic facilities and underfunding of research centres. The misuse and over-reliance on chemical control methods, and the growing impacts of climate change has greatly influenced disease management in Nigeria.. Before the advent of civilisation, the manifestation of plant diseases was seen as retribution or vengeance for wrong acts from the gods among farmers. This belief made it uncommon to take proactive steps to control plant diseases, to early farmers depended on their ability to diagnose plant diseases using obvious disease symptoms. However, the advents of the chemical control methods have also led to pathogen resistance and damage to non-target organisms. Small holder farmers, who constitute the majority of the farming population and form the backbone of Nigeria's agriculture, often lack the technical knowledge and resources to effectively manage plant diseases confronting modern agriculture. To address these challenges, this study proposes strengthening the capacities of plant diagnostic and research centres, expanding access to extension services to improve farmers' knowledge and adopting sustainable agricultural practices. This article also underscores the importance of integrating modern techniques like polymerase chain reaction (PCR) and next-generation sequencing (NGS), and implementing climate-smart agricultural (CSA) practices and, investing in improved agricultural technology by the government and other stakeholders.

Keywords: *Disease management; Phyto-pathogens; Production; Chemical control; Nigeria*

Introduction

Nigeria's several agro-ecological zones enable the production of a broad range of crops, including commercial crops like oil palm, cocoa, and cotton and staple foods like rice, cassava, yam, and maize. Agriculture plays a significant role in national growth and development, contributing between 30% and 42% to Nigeria's economy (Emeka, 2007; Sobowale *et. al*., 2010a). However, the damage done by phytopathogens like fungi, viruses, bacteria and nematodes has

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greatly impacted the country's agricultural potential. Oyelakin et al. (2014) noted that the metabolic activities of these microorganisms are the primary reason for the deterioration of food. The country suffers from reduced agricultural yields and post-harvest losses due to the activities of these disease-causing organisms. In addition to compromising quality, plant diseases also threaten safe food use by introducing contamination and causing foodborne diseases (Sobowale et. al., 2010b; Wang et al., 2024). It has been empirically shown that plant pathogens and pests induce yield reductions of up to 40% in major commercially grown crops like rice maize, and wheat in the areas where these crops are cultivated. (Jonathan, 2019; Savary et al., 2019).

Similarly, it has been observed that edible mushrooms are a host for anthropod pests, who then complete their life cycles in these mushrooms, thereby causing economic loss, and reducing yield and quantity (Oyebamiji et al., 2018). According to Olowe (2018), fungal plant diseases are widely recognized as the primary microbial pathogen responsible for significant agricultural losses yearly. A plant develops a disease when it is persistently agitated by a causative factor, which causes an irregular physiological process that interferes with its regular development, structure, activities, or other processes. According to Sarvary et al. (2019), there are annual worldwide economic losses of approximately US$220 billion due to plant diseases.

Based on the type of causal agent (biotic or abiotic factors), plant diseases fall under either infectious or non-infectious categories. Infectious diseases have the potential to transmit from one susceptible host to another, as the infectious agent is capable of reproducing within the plant or on its surface (Nazarov et al., 2020; Udur et al, 2020, Agbaje et al, 2024). In contrast, non-infectious diseases are not transmitted from one plant to another. They usually arise from unfriendly growth conditions, including unfavourable environmental conditions and excess or insufficient nutrients. Before the manifestation of symptoms, the plant first reacts to the agent causing the disease.

Before the advent of civilisation, the manifestation of plant diseases was seen as retribution or vengeance for wrong acts from the gods among farmers. This belief made it uncommon to take proactive steps to control plant diseases, so early farmers depended on their ability to diagnose plant diseases using obvious disease symptoms. The arrival of before the advent of civilisation, the manifestation of plant diseases was seen as retribution or vengeance for wrong acts from the gods among farmers. This belief made it uncommon to take proactive steps to control plant diseases, pesticides in the mid-20th century was a significant breakthrough since it gave farmers a powerful tool for controlling a broad spectrum of diseases. (Kansotia et al., 2023). However, its continued use has been discouraged by pathogen resistance, ecological niche disruption, and environmental contamination from overuse and inadequate application of chemicals (Olowe, 2018). As a result of the unrestricted and unchecked use of these pesticides, non-target organisms have been affected and new resistant strains of pathogens have emerged (Kansotia et al., 2023). With this, continuous reliance on synthetic pesticides is not entirely favourable (Gulzar, 2023).

Despite many attempts by all stakeholders in the agricultural sector, the nation's ability to effectively manage plant diseases is impeded by several challenges. Numerous challenges in plant disease management are emerging due to rising temperatures, resistance to fungicides, biodiversity loss caused by pesticide residues, difficulties in identifying plant diseases, and the creation of new plant protection compounds (Senthilraja et al., 2024). This review discusses these challenges and proposes actionable solutions.

Some of the Challenges Confronting Plant Disease Management in Nigeria

Knowledge Gap among Small-scale Farmers

One major challenge confronting plant disease management in Nigeria is the inadequate knowledge among small-scale farmers. Agricultural production in Nigeria heavily relies on the dedicated efforts of small-scale farmers, primarily based in rural areas. These farmers rely on old-fashioned ways of managing plant diseases, which are not effective in combating modern pathogens. According to Agrios (2005), most farmers need formal training in plant pathology and depend on traditional knowledge, which is often insufficient for diagnosing and treating diseases in modern crop varieties. Even in cases where diseases are accurately diagnosed, the availability of cost-effective and efficient disease management strategies is still a significant problem. What is even more worrisome is that these small-scale farmers primarily drive the nation's agricultural sector and form the backbone of our food production. This knowledge gap contributes to a widespread unawareness of modern farming technologies, which can enhance productivity and sustainability. Consequently, this creates obstacles not only for the farmers themselves but also for the overall economic growth and food security of the nation.

Limited Access to Diagnostic Facilities and Extension Services

Small-scale farmers rely heavily on indigenous methods, and while these traditional methods have been handed over through the years and are often effective in specific contexts, they may not be adequate for tackling diseases in modern, high-yield crop varieties. The traditional approach involves in-person consultations between farmers and professionals, where the professionals assess plant symptoms, carry out necessary analyses, and provide recommendations (Siddiqui et al., 2022). Traditional approaches to the management of plant diseases are often limited by the inability to detect infections with no visible symptoms or at low pathogen levels. As noted by Mamo (2024), this leads to an underestimation of disease occurrence due to a lack of precision in disease detection. Contemporary diagnostic tools and molecular methods are therefore important for detecting diseases even before they spread to epidemic levels.

Although some government research organizations have laboratories for diagnostics, these facilities frequently suffer from inadequate funding and a paucity of the sophisticated technology necessary for in-depth analysis. For instance, molecular diagnostics, high-throughput sequencing, and advanced imaging techniques (Mamo, 2024), which are integral for identifying pathogens at the molecular level, are not widely available. This situation is particularly challenging for peasant farmers in rural areas, where there is often a need for knowledge regarding the identification of pests and diseases, effective crop protection strategies, and restricted availability of the services of extension officers (Akinyemi et al., 2023). High-throughput sequencing (HTS) technologies allow for faster and more precise screening of plants compared to conventional diagnostic methods. Modern techniques like polymerase chain reaction (PCR) and next-generation sequencing (NGS) allow for the quick and specific identification of pathogens, enhancing early intervention and the containment of disease outbreaks. However, despite the availability of agronomists and plant pathologists, the nation is faced with shortage of experts with specialized training in molecular diagnostics and advanced technologies, limiting the widespread use of HTS in plant disease management.

Misuse of Chemical Control Measures

In Nigeria, farmers are dealing with the challenges of controlling the increasing number of pest species that damage and destroy their crops while it is in the field and when it is being stored. The results of these insect pests on crops and livestock is that they diminish yields to a level where agricultural activities become unprofitable for farmers (Maton et al., 2016). Most farmers have found it necessary to use fungicides and herbicides to eliminate and control these pests. While these chemicals are effective, excessive use can negatively impact the ecosystem and lead to resistance in targeted species. In a study conducted by Jonathan et al. (2012) examining the effectiveness of Jatropha curcas as a fungicide against Ceratocystis paradoxa, it was revealed that using fungicides for extended periods of time for disease management can have harmful consequences on soil and water. They further asserted that continuous usage may pose a risk to non-target species and may cause the pathogen to develop resistance. Biodiversity is also lost due to residues of pesticides. Furthermore, the strive for higher crop yield has made farmers to cut corners in plant disease management, with Integrated Pest Management (IPM) measures being ignored. Practices such as proper crop rotation patterns, using biological control methods, eliminating alternate hosts, and clearing plant debris where pathogen spores could overwinter (Mwangi et al., 2023) are important yet commonly disregarded. Effective disease management necessitates a balance between achieving higher productivity and maintaining sound agricultural practices that safeguard both crops and the environment.

Climate Change and Environmental Factors

Climate change is the most serious menace to earthling existence, costing the world more than $1.2 trillion yearly and killing almost 0.4 million people worldwide (Mwangi et al., 2023). A study by the World Bank (2019) highlights Nigeria as one of the ten countries most at risk from global warming, with approximately 6% of its land projected to face extreme weather conditions. Projections indicate that by 2050, crop yields in Africa could decline by 10-20%, with some estimates suggesting losses as high as 50% due to the outcomes of climate change (Jones & Thornton, 2002). This is because a significant chunk of Africa's agricultural population heavily relies on rain-fed farming systems, with fewer farmers using technological advancements. Most Nigerian farmers operate on a small-scale or subsistence level, lacking the financial means, access to infrastructure, and reliable information networks that would enable them to respond to changing climate conditions. Natural disasters, such as droughts, floods, and forest fires (Zoellick, 2009), are creating more favourable environments for the proliferation of diseases. As temperature and moisture conditions shift, pathogens may move into previously unaffected regions, exposing new crop populations to disease risks. As asserted by Devi et al. (2022), increased temperatures promote the growth and distribution of plant pathogens, mainly fungi and bacteria, while at the same time weakening the natural defence systems of the host. Increased rainfall usually

encourages the growth and transmission of plant diseases, particularly those caused by fungi and oomycetes, while also reducing the efficiency of chemical and biological control methods (Lim et al., 2023). Climate change can impact plant internal processes and immune responses, including producing volatile organic compounds, and phytohormones. As noted by Singh et al. (2023), these changes can affect the ability of the plant to attract and develop beneficial genomes of microorganisms, which could result in microbial imbalances thereby increasing the likelihood of pathogen attack on the plant. These changes also bring about the introduction of new diseases in crops. Thus, making existing diseases difficult to predict and manage.

High Cost of Improved Seeds

The high cost of improved seeds poses a significant challenge to effective crop disease management in Nigeria. Many farmers, particularly those in rural areas, rely heavily on recycled seeds from previous harvests. Unfortunately, these recycled seeds often have lower resistance to pests and diseases, resulting in diminished yields (Okpani et al., 2023). This dependence on subpar seeds not only reduces the productivity of the farms but also threatens food security. The situation is exacerbated by the fact that improved seeds, especially for vegetables, carry a high price tag primarily due to the costs associated with importation. As a result, many small-scale farmers find themselves unable to afford these improved seed varieties, which could otherwise bolster their crop resilience and overall yield. The financial burden of acquiring improved seeds limits their ability to invest in better farming practices, perpetuating a cycle where low-quality seeds lead to lower productivity and vulnerability to agricultural threats.

Lack of Data-driven Approaches in Plant Disease Management

Effective plant disease management in Nigeria faces significant challenges, partly due to traditional farming practices that lack data-driven precision. Limited by inefficiencies and climate unpredictability, traditional methods often fail to optimize resource allocation and adequately address the rapid spread of plant diseases (Jonathan, 2019). Integrating data-driven approaches into disease management can transform this challenge by allowing for the development of mathematical models that quantify disease dynamics, identify optimal planting dates, and recommend crop varieties resistant to specific pathogens. These analytical models are important for tailoring management practices to local conditions, which are needed for adapting to shifting environmental factors and reducing disease incidence. Climate-based models, for example, integrate climatic data with crop growth parameters, giving farmers predictive insights into disease outbreaks driven by weather changes. This allows for strategic timing of planting, disease control measures, and crop selection to minimize pathogen susceptibility (Ajani et al., 2019). A data-centric approach also enables the sharing of disease incidence data across farming communities, ensuring the development of targeted, region-specific interventions. Models incorporating pest and pathogen dynamics can predict outbreak patterns and guide preventative treatments. Studies reveal that integrating real-time data with disease prediction models can greatly reduce reliance on fungicides and pesticides, minimizing disease impacts on crop yields while promoting eco-friendly farming practices (Kalu et al., 2021; Kirk et al., 2019).

The Way Forward

When dealing with the challenges of plant disease management in Nigeria, one of the best approaches is to expand and increase funding for existing diagnostic centres and establish more regional diagnostic centres equipped with modern technologies, such as molecular diagnostics and high-throughput sequencing. To decentralize research funding and lessen the concentration at the federal level, these diagnostic centres should be strategically located in rural areas for smallholder farmers to access. In remote places, mobile diagnostic units can be set up as well. The government can do this through its various ministries of Agriculture. Another critical factor in improving plant disease management is building the capacity of agricultural extension agents by training them in advanced diagnostic techniques and modern methods of controlling disease to guide farmers on timely interventions to prevent disease outbreaks effectively.

Introducing digital platforms such as mobile apps can improve the dissemination of disease management information to farmers. Many mobile applications for crops are now available, with features such as disease identification, detection, and user recommendations (Siddiqua et al., 2022). As reported by GSMA (2022), smartphone usage is experiencing rapid growth in Africa, with its usage to rise from 49% in 2021 to 61% (613 million subscribers) by 2025, with a substantial share of new users expected to come from Nigeria and Ethiopia. A study by Akinyemi et al. (2023) evaluated the reliability of the mobile application Plantix for diagnosing common pests and diseases affecting common crops in Nigeria. The result showed a 90-100% accuracy rate in identifying significant pests and diseases, including flea beetle, black sigatoka, cassava mosaic virus, and the invasive fall armyworm. This shows

the potential of mobile technology to support farmers in managing crop diseases effectively.

Establishing and strengthening agricultural research and education programs is vital to bridging the knowledge gap among smallholder farmers. Although the provision of extension services is an arduous task in Africa, and historically, it has had little success (Smith et al., 2009), strengthening our agricultural extension services will improve the knowledge of rural farmers about plant disease management and Integrated Pest Management (IPM). Efforts must be made by all stakeholders to ensure that farmers understand the pathogenesis, epidemic principles of plant pathogens, the genetic, biological, and physiological mechanisms of host plant defences and interactions between pathogens and their ecological environments (He et al., 2016). More than ever, agriculture must be professionalized through educational training programs. A better informed and knowledgeable farmer would be better equipped to employ effective disease management strategies.

Over time, the repeated use of synthetic pesticides selects for resistant strains of pathogens, making disease management increasingly difficult. This has been observed in various crops in Nigeria, where resistance to fungicides and pesticides (in general) has reduced the efficacy of traditional control methods. Implementing effective pest management practices is essential for ensuring the health and productivity of crops. One key strategy is the introduction of natural predators, which can help control pest populations without the need for chemical pesticides. Additionally, crop rotation in pest management prevents the buildup of specific pests and diseases that thrive on certain crops. Furthermore, emphasises should be placed on the use of resistant varieties of staple crops, especially crops like maize and rice. As asserted by Aregbesola et al. (2020), In order to combat diseases like B. maydis, which drastically reduce maize yields, it is important to find ways to identify resistance quickly. Biological control agents, due to their diverse modes of action, provide a solution to this problem by lowering the chances of resistance development. Biological control and biopesticides represent sustainable alternatives to chemical pesticides in modern plant pathology. The use of natural control agents such as parasitoids, predators, and pathogens offers an eco-friendly method for managing plant diseases, reducing the need for chemicals, minimizing harm to non-target organisms, and lowering chemical residues in crops (Mamo, 2024).

Addressing the impacts of climate change on plant diseases requires implementing climate-smart agricultural (CSA) practices and investing in improved agricultural technology by the government and other stakeholders. These include integrating data analytics and machine learning algorithms in climate prediction models to enable proactive management strategies and using disease-resistant and drought-tolerant crop varieties. Furthermore, incorporating large-scale climatic datasets will empower stakeholders to implement timely interventions and enhance our understanding of global warming and its effects.

Conclusion

This article has identified major challenges confronting plant disease management in Nigeria such as inadequate access to diagnostic tools, growing impact of climate change, knowledge gap among rural farmers and over-reliance on chemical control methods. There is however, a need for collaborative effort by all stakeholders in agriculture to adopt a multi-directional approach that includes investment in climate-smart agricultural practices, equipping diagnostic centres with modern plant disease detection technologies, improving farmer education and promoting eco-friendly pest and disease control strategies. This collaborative effort is important in building a more resilient agricultural sector that is equipped to face future challenges.

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