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Original Research

Occurrence and Distribution of Fungal Species Associated with Maize in Selected Farms in Plateau State, Nigeria

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ABSTRACT: Maize is an important staple crop worldwide, but fungal diseases are a major cause of yield losses for farmers. This study aimed at identifying the fungal species associated with maize from selected farms in Plateau State, Nigeria. Maize seeds were collected from infected plants, surface-sterilized, and plated on potato dextrose agar amended with gentamicin and streptomycin. After incubation, fungal colonies were identified based on macroscopic and microscopic characteristics. Four fungal species were identified: *Aspergillus niger,* Aspergillus flavus, *Fusarium sp.,* and *Penicilliumsp*. The occurrence of each species was recorded for each farm, *Fusarium sp.* was present in three farms, with the highest frequency in F3 farm (2 colonies), having a total occurrence of 22.22% across all farms. *Penicillium sp.* was the lowest frequency present in any of the farms; this fungal isolate was present in two farms and having a total occurrence of 14.81% across all farms. The percentages in the table help to compare the relative occurrence of each fungal isolate within and across the farms. Data were analyzed using chi square test to identify any patterns or trends in the occurrence of the fungal species across the farms. This information can be valuable for understanding the prevalence and distribution of fungal species associated with maize in the selected farms in Plateau State, Nigeria.

Keywords: Maize, fungal species, Plateau State

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INTRODUCTION

Maize is a vital crop for food security and economic development in many countries, including Nigeria. Successful maize production depends on the correct application of productions inputs that will sustain the environment as well as agricultural production. These inputs are, inter alia, adapted cultivars, plant population, soil tillage, fertilization, weed, insect and disease control, harvesting, marketing and financial resources (Plessis, 2003). Zea mays also referred to as corn in some parts of the world particularly America, Europe and Asia respectively, is a cereal plant of the Gramineae family of grasses that today constitutes the most widely distributed food plant in the world and it is a cereal crop that has been domesticated. Maize cultivation and processing are driven by the production of food and livestock feed, fermentation and raw materials for industry. In 2016, Nigeria produced 10.4 million tonnes of maize worth millions in the US dollar market (FAOSTAT, 2017). The specifics of maize production, reproduction, cultivation, processing and consumption, its resiliency, mutability, as well as the intractability of cultural and botanical constraints, continue to provide science with insights into the past and possible future of the species. Despite the importance of maize in Nigeria, its safety is often compromised by the presence of toxic chemicals of Fungal origin, e.g. aflatoxins (Adetunji et a., 2017).

This could be attributed to poor farming and storage practices that encourage frequent contamination by fungi (Bankole et a., 2006). The history of maize in existence for a very long period and no wonder it is associated with a number of diseases ranging from fungi, bacteria, virus, etc.(many of these diseases have been identified and known). List of fungal associated Diseases of Maize are as Rust, Corn Smut, Northern and Southern Corn Leaf Blight, Maize downy mildew, Maize Dwarf mosaic Virus, Maize Streak Virus, Stewart's wilt, etc (Marra et al., 2012). Fungal diseases are a major challenge for farmers, causing significant yield losses annually.

Fungi causes a number of plant and animal diseases in humans, ringworm, athletes foot, and several more serious diseases are caused by fungi. Fungi are more chemically and genetically similar to animals than other organisms, this makes fungal diseases very difficult to treat. Plant diseases caused by fungal are more chemically and genetically similar to animals than other organisms. Plant diseases caused by fungal include rusts, smuts and leaf, root and stem rots, and may cause severe damage to crops. However, a number of fungi, in particular the yeast are important “model organism” for studying problems in genetics and molecular biology. The fungi *Neurospora* spp. And *Physarum polycephalum* have been found to be excellent experimental organisms for the study of the laws of heredity and DNA synthesis respectively (Paul et al., 2012)

Downy Mildew disease of maize was first reported in Nigeria in 1969 in Samara near Zaira Kaduna State. However, in 1995 over 7500 square kilometers was affected within the forest and transitional forest zones of Nigeria (Adenola and Akinwumi 1995). A Maize Parasitic weed called striga caused economic loss in Northern Guinea Savanna and some parts of derived southern Guinea (Ogunbodede and Olakojo, 2001).

According to MacDonald and R. Chapman (1997) research study, where samples of maize were collected from different locations including Central American, Africa and Asia, the resulting fungal Genus with the highest occurrence was *Fusarium* and the highest species was *Fusarium moniliforme*. The research study at different field and stores at Abakpa, Enugu State, sampled maize of two different types which are the red corn and white corn and cultured on Agar Plate using Potato Dextrose Agar (PDA) medium and isolated different species of fungal and stated *Fusarium* spp. the predominant fungus due to its highest frequency (Onyeze, et al., 2013).

According to Atehnkeng et al., (2008), maize samples were collected during a survey in three agro-ecological zones in Nigeria, Aspergillus was the most predominant fungal genera identified followed by Fusarium with mean incidences of 70 and 24%, respectively. This study aimed to identify the fungal species associated with maize in selected farms in Plateau State, Nigeria.

The information generated from this study will aid in the development of effective control strategies for fungal diseases of maize.

MATERIALS AND METHODS

Field study was carried out during the rainy season to the early harmattan period of 2019, at five sites in plateau state, Nigeria: Farin Gada, Jos North L.G.A, Du, Jos South L.G.A, Sabon Barki, Jos South L.G.A, and Mushere, Bokkos L.G.A. The criteria for the the maize was: infected maize cob been selected due to the presence of either white or black dotted spores on the maize cob. Maize seeds were harvested from the infected maize are washed in 1 ml sterile water three times at room temperature for 10 minutes shaking and centrifuged at 1300rpm for 1 minute. Seeds are then disinfected with chlorphenamine at room temperature for 15 minutes shaking and centrifuged at 13000rpm for 1 minutes two times. Then again, the seeds are washed three times sterile water and centrifuged with 13000rpm for 1 minute and at the end the seeds are suspended in 1 ml sterile water. The disinfected seeds are plated on Potato Dextrose Agar amended with gentamicin and streptomycin of 10 and 90 µg/ml, respectively. Plates are incubated at 28℃ and after few days single colonies are picked with a sterile inoculating needle and transferred into a new PD Agar without any antibiotics. At least 24 single colonies are picked and re-streaked three times to get pure single colonies.

Subculture of fungi isolates

The culture plates were sub cultured into a new Potato Dextrose Agar without any antibiotics to obtain culture of the isolates. Each distinct colony observed was transferred aseptically into a solidified prepared medium using a sterile inoculating needle and was incubated at room temperature.

Identification and characterization of fungal

Identification and characterization of the various isolates were based on macroscopic and microscopic examination with reference to De Hoog et al. (2000) and Sarah *et al.,* (2016).

Microscopic examination

For each examination, a streak of fungal mycelium was placed on a glass slide. One drop Lactophenol in cotton blue was added and the cover slip placed. The slide was mounted on the microscope and observed at magnification of x10, x40 and x100. Morphological characteristics of fungi isolated were determined and

Table 1: Count of frequency occurrence of the different farm with the percentage of occurrence of the different fungi isolated.

Fungal isolates	F1	%	F2	%	F3	%	F4	%	F5	%	Total
A. Niger	2	50	3	37.5	1	16.7	1	25	2	40	33.33%
A. Flavus	1	25	2	25	2	33.3	1	25	2	40	29.63%
Fusarium spp.	1	25	-	0	2	33.3	2	50	1	20	22.22%
Penecillium spp.	-	0	3	37.5	1	16.7	-	0	-	0	14.81%

Table 2: Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.594	12	0.652
Likelihood Ratio	12.107	12	0.437
N of Valid Cases	27		???

identified using method described by (kirk at el.., 2008). Lengths of the hyphae were determined with eyepiece graticule by using colonial and morphological characteristics.

RESULTS

Four fungal species were identified in the maize samples: *Aspergillus niger, Aspergillus flavus, Fusarium sp.,* and *Penicillium sp.* The occurrence of each species varied across the farms. *Aspergillus niger* was present in all farms, but its frequency varied from 2 colonies in F1 to 3 colonies in F2. *Aspergillus flavus* was present in all farms but had the highest frequency in F2 (2 colonies) and F5 (2 colonies) (Table 1). *Fusarium sp*. was present in three farms (F1, F3, and F5), with the highest frequency in F3 (2 colonies). *Penicillium sp*. was the lowest frequency present in any of the farms. Table 1 shows the total number of colony for each farm on the Petri dish isolated after 14 days on inoculation. This table provides a breakdown of the fungal isolates and their occurrence in each of the five farms (F1, F2, F3, F4, and F5). It also includes the percentage of occurrence for each fungal isolate in each farm.

Aspergillus niger

This fungal isolate was present in all five farms. In Farm 1 (F1), it accounted for 2 out of the total isolates, representing 50% of the occurrence in that farm. In Farm 2 (F2), it accounted for 3 isolates, which is 37.5% of the occurrence. Similarly, for Farms 3, 4, and 5, the percentage occurrence was 16.7%, 25%, and 40% respectively. Overall, A. Niger had a total occurrence of 33.33% across all farms
(Figures 2 and 3).

Aspergillus flavus

This fungal isolate was also present in all five farms. In Farm 1 (F1), it accounted for 1 out of the total isolates, representing 25% of the occurrence in that farm. In Farm 2 (F2), it accounted for 2 isolates, which is 25% of the occurrence. Similarly, for Farms 3, 4, and 5, the percentage occurrence was 33.3%, 25%, and 40% respectively. Overall, A. Flavus had a total occurrence of 29.63% across all farms. 3. *Fusarium spp.*: This fungal isolate was present in three farms: F1, F3, and F5. In Farm 1 (F1), it accounted for 1 out of the total isolates, representing 25% of the occurrence in that farm. In Farms 3 and 5, it accounted for 2 isolates each, which is 33.3% and 50% of the occurrence respectively (Figures 5 and 6). Overall, Fusarium spp. had a total occurrence of 22.22% across all farms.

4 Penecillium spp.: This fungal isolate was present in two farms: F2 and F3. In Farm 2 (F2), it accounted for 3 out of the total isolates, representing 37.5% of the occurrence in that farm. In Farm 3 (F3), it accounted for 1 isolate, which is 16.7% of the occurrence (Figures 7 and 8). Overall, Penecillium spp. had a total occurrence of 14.81% across all farms.

The percentages in the table help to compare the relative occurrence of each fungal isolate within and across the farms. This information can be valuable for understanding the prevalence and distribution of fungal species associated with maize in the selected farms in Plateau State, Nigeria. There is no significant association between farm and fungi isolates. χ^2 (12) = 9.594, $p > 0.05$. χ^2 (12 this is the degree of freedom) = 9.594 chi square value, $p > 0.05$ (0.652 p value) (Table 2).

DISCUSSION

A total of seven (4) species belonging to six (3) genera were collected frm the maize grains. *Asperigillus* was the most common genera of which A. niger spp was the most prevalent. Onyeze et al (2013) found that Fusarium spp and penicillium spp were th common fungi in the sample maize grains on farms and in storage collected from Abakpa, Enugu state, Nigeria. Also Binyam, (2016) recorded Asperigillus spp, Fusarium spp and Penicillium

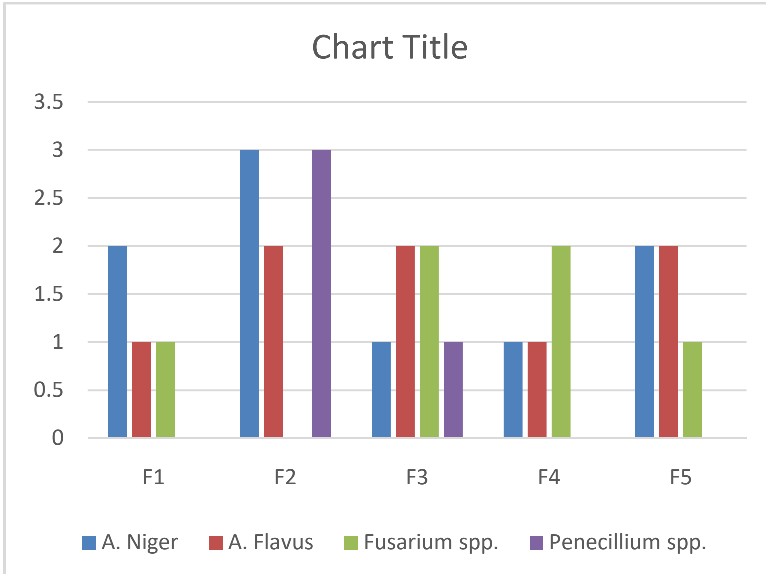

Figure 1: Graphical chart on the fungal occurrence on the different fungal species in the different farms.

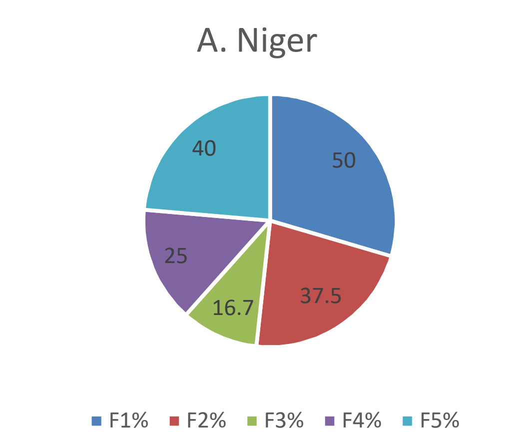

Figure 2: Graphical presentation of A. Niger with occurrence percentage in the different farms.

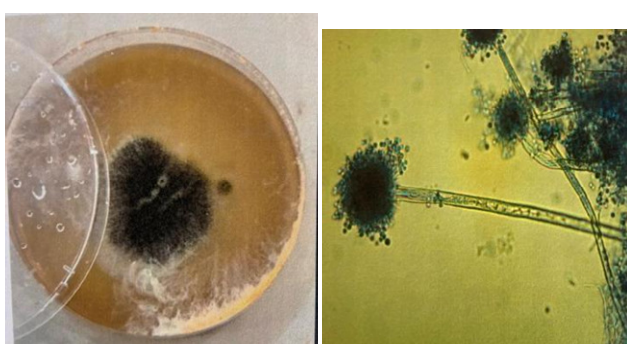

Figure 3: Images of A.Niger on Pd Adar and Microscopic view.

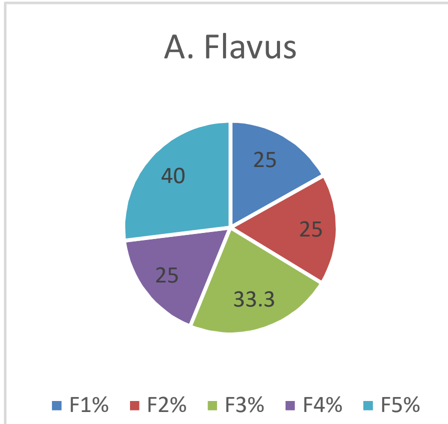

Figure 4: Graphical presentation of A. Flavus with occurrence percentage in the different farms.

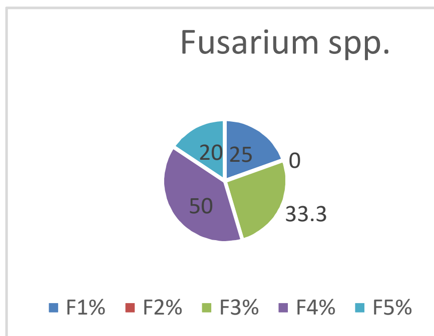

Figure 5: Chart showing the fungal occurrence of *Fusarium spp.* In the different farms.

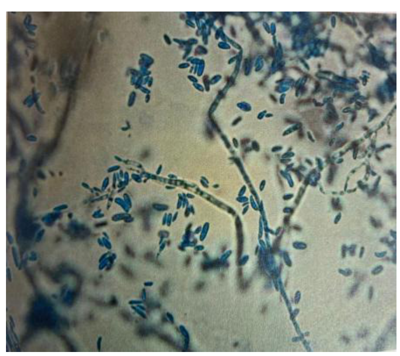

Figure 6: Microscopic views of *Fusarium spp*

spp as the highest diversity of fungi in maize grains of Ethiopia. Most fungi isolated in the current study e.g Aspergillus, mucor, Fusarium, penicillium and Rhizopus agree with the results from Latvia, Egypt and Pakistan (Kaspars et al 2016, Abdel-Sater et al., 2017; Niaz and Dawar, 2009). The presence of Aspergillus niger and Aspergillus flavus were the most frequently occurring fungi. These fungi are known to cause aflatoxin contamination in maize, which can pose health risks to both humans and animals. The presence of Fusarium sp. in three of the farms is also of concern, as this fungus can cause Fusarium ear rot, reducing maize yield and

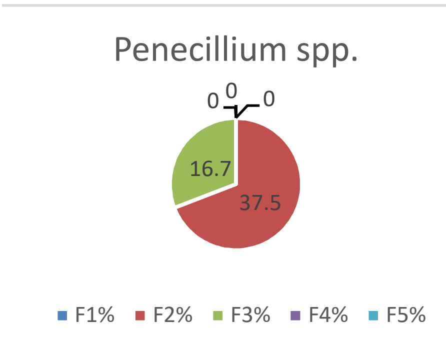

Figure 7: Graphical representation of *Penicillium spp*

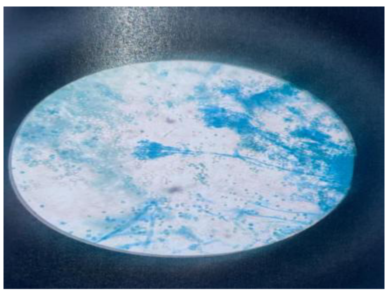

Figure 8: Microscpic view of Penicillium spp

quality. The low presence of Penicillium sp. in all the farms studied may be due to the geographical location or farming practices.

Conclusion

This study identified the fungal species associated with maize in selected farms in Plateau State, Nigeria. The results showed that Aspergillus niger, Aspergillus flavus, and Fusarium sp. were present in the maize samples. The occurrence of these fungi varied across the farms, indicating a need for targeted control strategies. The information generated from this study is useful for developing effective management practices for fungal diseases of maize in Plateau State, Nigeria.

Future research directions

In addition to the findings of this study, there are several areas that warrant further investigation to address the challenges faced by maize farmers in managing fungal diseases. The following research directions are proposed to enhance the practical applicability of the study's results and develop effective solutions:

1. Efficacy of Different Fungicides: Further research should be conducted to evaluate the effectiveness of various fungicides in controlling the identified fungal species. This should include studies on optimal application methods, dosages, and timing of fungicide treatments to maximize their efficacy in reducing fungal infections and minimizing yield losses. The outcomes of such studies would provide valuable insights for farmers and extension services in selecting the most suitable fungicides for managing fungal diseases in maize.

2. Biocontrol Agents: Investigating the potential of biocontrol agents, such as beneficial microorganisms or natural antagonists, holds promise for sustainable disease management. Future research should focus on assessing the efficacy and practicality of using biocontrol agents to suppress the growth and activity of pathogenic fungi while promoting plant health. Understanding the mechanisms by which these agents interact with fungal pathogens and maize plants would contribute to the development of effective biocontrol strategies.

3. Influence of Climate and Soil Conditions: Climate and soil conditions play a significant role in the occurrence and distribution of fungal diseases. Therefore, studies should be conducted to explore the influence of specific climatic factors, such as temperature, humidity, and rainfall patterns, on the development and spread of fungal species associated with maize. Additionally, investigating the impact of soil characteristics, including pH, organic matter content, and nutrient availability, on fungal populations and disease severity would provide valuable insights for disease management strategies tailored to local environmental conditions.

4. Development of Resistant Maize Varieties: Breeding programs aimed at developing maize varieties with enhanced resistance to the identified fungal species should be prioritized. By identifying genetic traits and mechanisms that confer resistance, researchers can contribute to the development of commercially viable maize cultivars that are less susceptible to fungal diseases. Field trials should be conducted to evaluate the resistance levels and agronomic performance of these varieties under different environmental conditions.

5. Integrated Disease Management Strategies: Integrating multiple disease management approaches, such as cultural practices, resistant varieties, fungicides, and biocontrol agents, is essential for effective disease control. Further research should focus on developing and evaluating integrated disease management strategies that consider local conditions, practical implementation, and long-term sustainability. Economic analyses should also be conducted to assess the cost-effectiveness and financial viability of different management strategies, providing farmers with valuable information for decision-making.

6. Farmer Education and Awareness: Enhancing farmer education and awareness regarding fungal disease management in maize is crucial for successful implementation of control measures. Future studies should evaluate the effectiveness of educational programs and extension services in improving farmers' knowledge and practices. Innovative approaches, such as farmer field schools or participatory learning platforms, should be explored to enhance farmer capacity and engagement in disease management.

7. Economic Analysis: Conducting economic analyses to evaluate the cost-effectiveness and potential economic benefits of disease management strategies is essential. Assessing the impact of disease control measures on yield increases, reduction in input costs, and market value of disease-free produce will provide a comprehensive understanding of the economic implications. This information can guide policy decisions and resource allocation for disease management programs.

By pursuing these research directions, we can contribute to the development of practical and sustainable solutions for managing fungal diseases in maize. This will ultimately benefit farmers in Plateau State, Nigeria, and other regions facing similar challenges.

Future studies could investigate the factors influencing the occurrence and distribution of these fungal species in maize farms.

Future directions

Further studies could investigate the impact of environmental factors on the occurrence and distribution of fungal species associated with maize seeds in Plateau State, Nigeria. The effectiveness of management strategies developed based on the knowledge gained from this study could be evaluated.

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