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Exploring Fungal Diversity: A Comprehensive Study of Fungi Species in Ondo Agro-Ecological Zone

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Abstract

This study explores the prevalence and diversity of fungal species in soil samples collected from all local government areas in Ondo State, Southwest Nigeria. The research provides critical insights into fungal distribution across the region and serves as a basis for developing strategies to manage soil resources and conserve fungal biodiversity. Soil samples were collected from three locations in five selected farmlands within each local government area and processed on Potato Dextrose Agar (PDA) for fungal isolation and identification under laboratory conditions. The study determined the relative abundance of various fungi, including Aspergillus spp., Fusarium spp., Trichoderma spp., *yeast, and* Rhizopus spp. *Results revealed that* Aspergillus spp. *exhibited the highest prevalence (64.5%), followed by* Fusarium spp. *(16%),* Trichoderma spp. *(14.5%), yeast (3%), and* Rhizopus spp. *(2%). The findings highlight the abundance of both pathogenic and beneficial fungi in the soils, with potential applications in enhancing soil fertility and sustainable agriculture. Notably, the presence of* Trichoderma spp. *offers promising prospects for its use as a biocontrol agent to mitigate the prevalence of pathogenic organisms, contributing to agricultural sustainability.*

Key Words: *Aspergillus* spp, *Trichoderma* spp, *Fusarium* spp, *Rhizopus* spp, Yeast.

Introduction: Fungi are a diverse group of eukaryotic organisms, are fundamental to the functioning of ecosystems. They are ubiquitous and inhabit a wide range of environments, including soil, water, air, and living organisms. As primary decomposers, fungi break down organic matter, recycling nutrients and enhancing soil health. They also form mutualistic associations with plants, such as mycorrhizal relationships, which enhance nutrient uptake and promote plant growth contributing to the nutrient cycle and soil health (Avery, S. V., Singleton, I., Magan, N., & Goldman, G. H., 2019). They also form mutualistic relationships with plants, enhancing nutrient uptake and promoting plant growth. Soil fungi, in particular, play a vital role in maintaining soil fertility and structure. Their abundance and diversity are influenced by environmental factors such as soil type, organic matter content, climatic conditions, and anthropogenic activities. For instance, the presence and activity of soil fungi can significantly impact crop production and ecosystem stability (van der Heijden, M. G. A., Bardgett, R. D., & van Straalen, N. M. (2015). Moreover, fungi produce a wide range of secondary metabolites, including antibiotics, enzymes, and food additives, with significant applications in medicine and biotechnology (Makun, H. A., Dutton, M. F., Njobeh, P. B., Phoku, J. Z., & Yah, C. 2011).

Ondo State, located in Southwestern Nigeria, has a diverse range of climates and soil types, making it an ideal place to investigate the prevalence and diversity of fungi species in soil. The soil types, are influenced by various factors such as geological formations, agricultural activities, and environmental contamination. The geoelectric properties and localized geology have been identified as indicators affecting cocoa yield in southwestern Nigeria, including Ondo State (Osotuyi, A., Mohammed, M., Ajayi, I., & Salako, A. (2021). Additionally, the measurement of natural radioactivity and radiological hazard evaluation in soil samples collected from Owo, Ondo State, provides insights into the composition and properties of the soil in the region (Aladeniyi, K., Olowookere, C., & Blessing, O. 2019). The relationship between fungi diversity, prevalence, distribution, and type of soil is a complex interplay influenced by various environmental factors. The occurrence and diversity of root-associated fungi are influenced by soil environmental conditions and the presence of preferred plant hosts (Aaron, J Hogan, Michelle, A. J, Mattew, E. Smith, Adriana C. Xiaoyang S., Yue-hua Hu, Jie Yang, Min cao, Oscar, J. Valverde-Berrantes, Christopher Baraloto, 2023). The observed diversity of soil fungi largely depends on the method used and the numbers of isolates obtained (van der Heijden, M. G. A., Bardgett, R. D., & van Straalen, N. M. 2015). Soil fungal community composition and diversity change with different plot types, indicating a relationship between soil fungi and the surrounding environment (Long, Y., Yang, X., Cao, Y., Lv, G., Li, Y., Pan, Y., & Liu, Y., 2021). The distribution and abundance of keratinophilic fungi are well studied in relation to the presence of organic materials in soil and different soil factors (Shadzi, S., Chadeganipour, M., & Alimoradi, M., 2002). This study aims to isolate and identify fungi species from soil samples collected from selected local government areas in Ondo State, determine their abundance and distribution, and generate data on the occurrence of fungi species in the region. The study's findings could potentially contribute to the development of new methods for improving soil fertility,

controlling pests and diseases, and raising awareness of the importance of soil fungi for environmental conservation and agricultural sustainability. Despite the rich ecological diversity in the Ondo agroecological zone, there is insufficient and outdated information on the diversity of fungi species, underutilization of beneficial fungi, human activities such as deforestation, land-use changes and overuse of chemical pesticides also pose a serious threat to the survival and diversity of the fungi species in this region. Correspondingly, the changing climate is altering the ecosystem and there is little understanding of how these climatic changes are affecting fungi population in the Ondo agroecological Zone.

Materials and Methods: Description of the Study Area: Ondo state is a south-western Nigerian state situated in the savannah agro-ecological zone. The rainfall pattern is a bimodal distribution averaging between 1000 and1300 mm per year and the temperature varies from 26 to 38 °C (Aruwa, C. E., & Ogundare, O., 2017). Soil samples were collected from all the local governments in Ondo State Southwestern Nigeria, namely Ondo East, Ondo West, Idanre, Igbokoda, Irele, Igbotu, Okitipupa, Odigbo, Ile-Oluji, Akure South, Akure North, Ifedore, Akoko North East (Ikare), Akoko North West (Oke- Agbe), Akoko South west, Akoko South East, Ose, and Owo Local Governments Areas. Food crops, such as maize and cassava are grown mostly by subsistent farmers in the state. Soil from (5) five selected agricultural farms in each local government area were collected and mixed thoroughly for equal representation of the environment and tagged according to the location, thereby taken to the Soil lab at the Olusegun Agagu University of Science and Technology, Okitipupa, Ondo Nigeria for further isolation procedures.

Sample Preparation and Fungal Isolation: Soil samples were sieved to remove large particles and homogenized with sterile distilled water to prepare a suspension. For each sampling location, a one-gram portion of sieved soil was mixed with 90 mL of sterile distilled water in a 150 mL conical flask. The mixture was agitated on an orbital shaker at 240 rpm for 15 minutes. Serial dilutions of the soil suspension were then prepared to achieve concentrations ranging from 10^{-1} to 10^{-7} mL. A 0.1 mL aliquot of the 10^{-4} dilution was spread onto potato dextrose agar (PDA) plates under aseptic conditions and incubated at 28 ± 2°C for 3–7 days. All soil samples were processed within 24–48 hours of collection to ensure the isolation of viable fungal species.

Fungal Identification: Fungal colonies were differentiated and identified based on morphological characteristics observed in five-day-old cultures under a light microscope. The fungal counts ranged from $1.00 \times 10^4 \pm 0.02$ CFU/g to $6.33 \times 10^4 \pm 0.11$ CFU/g of soil.

Statistical Analysis: Data on colony-forming units were subjected to analysis of variance (ANOVA) using the Minitab statistical package. Mean values were separated using Tukey's test at a 5% significance level ($p \leq 0.05$).

Results and Discussion: The most prevalent fungal species across the North Senatorial District of Ondo State is *Aspergillus* species, with no significant differences observed among Akoko South West, Akoko South East, and Akoko North West local government areas (Fig. 1). However, this region recorded the highest mean fungal population, which differed significantly from the mean value in Akoko North East. In contrast, Owo and Ose local government areas showed no significant difference in fungal populations. These findings align with the work by Ekpakpale, D. O., Kraak, B., Meijer, M., Ayeni, K. I., Houbraken, J., & Ezekiel, C. N. (2021), which identified *Aspergillus* spp. as an increasingly dominant fungal group in tropical regions. Figure two (2) further supports the prevalence of *Aspergillus* species across all local governments in the Central Senatorial District, which corresponds to the trends observed in Figure 1. However, unlike Figure 1, Ondo East and Idanre Local Government Areas recorded the highest mean values for *Fusarium* species, though the differences in their mean values were not statistically significant.The diversity, prevalence, and distribution of fungal species are influenced by complex interactions involving soil properties such as pH, nutrient content, soil type, and geographical factors. Studies by Yokoya *et al.* (2021) and Chen *et al*. (2022) have demonstrated that these factors are critical in shaping the composition of soil fungal communities. In this study, the prevalence of *Aspergillus* species was found to be 23.5%, 29.5%, and 31.5% in Ondo South, Central, and North Senatorial Districts, respectively. The abundance of *Aspergillus* species across all 18 local governments in Ondo State suggests a strong correlation with the region's weather, climatic conditions, and agricultural practices.

Ekpakpale *et al*. (2021) reported similar findings in their study of fungal diversity in maize, cassava-based flour (pupuru), and rice in Ondo State, where *Aspergillus* species accounted for 80.9% of the fungal isolates among 26 fungal families. The high prevalence of *Aspergillus* species in Ondo State is likely associated with the cultivation of maize and cassava, staple crops that serve as primary hosts for this fungal group. This observation aligns with the report by Reflinaldon, R., Trizelia, T., Hasmiandy, H., & Ganeshi, J. (2014), which highlighted that the occurrence and diversity of pathogenic fungi are influenced by geographical location, soil type, altitude, environmental conditions, and cultivation practices. However, the predominance of *Aspergillus* species in Ondo State raises concerns due to its association with aflatoxin contamination in food and animal feeds. *Aspergillus flavus*, is a notable producer of aflatoxins, which are carcinogenic and pose significant health risks to humans and animals (Ayeni, K. I., Akinyemi, O. M., Kovač, T., & Ezekiel, C. N. (2020).

Interestingly, Ose Local Government Area recorded the highest significant mean value for yeast species, while *Fusarium* species showed no significant differences across the district. The rhizosphere-beneficial *Trichoderma* species was significantly present in Akoko South West. The significant presence of beneficial rhizosphere microorganisms, particularly *Trichoderma* species, across the state presents an opportunity for exploration as biocontrol agents. Studies by Asaduzzaman, M., Alam M. J., Islam M. M (2013), suggest that certain *Trichoderma* strains not only increase germination rates and vigor indices but also contribute to the suppression of seed-borne pathogens. These microorganisms have the potential to manage crop diseases, enhance plant growth, and reduce the incidence and

severity of plant diseases, thereby improving agricultural productivity sustainably. Studies by Carvalho *et al.* (2011) highlighted the effectiveness of T. *harzianum* in reducing the occurrence of seed-borne pathogens such as *Aspergillus spp. Cladosporium* spp and *Sclerotinia sclerotiorum* in bean seedlings, Seed treatment with *T. harzianum* reduces the occurrence of *Aspergillus*, *Cladosporium* and *S. sclerotiorum* in common bean seeds "Jalo Precoce".

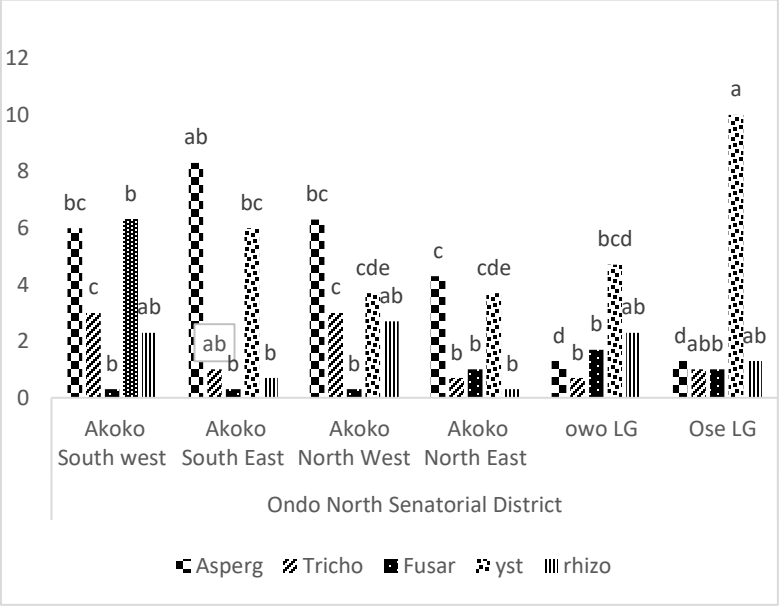

Figure 1: Fungi diversity across Ondo North Senatorial District, means with the same letter are not significantly different.

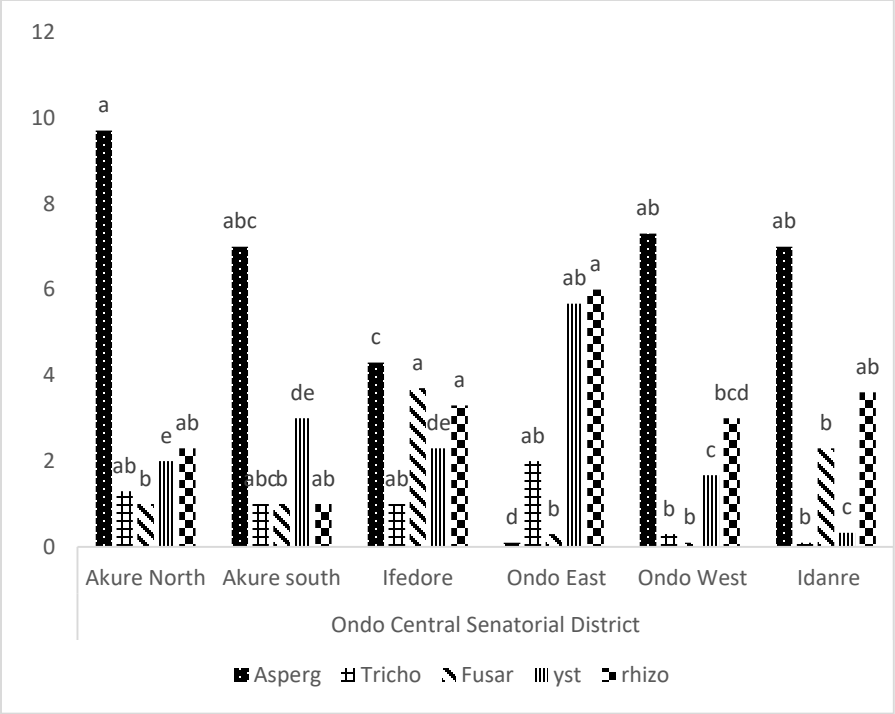

Figure 2: Fungi diversity across Ondo Central Senatorial District, means with the same letter are not significantly different.

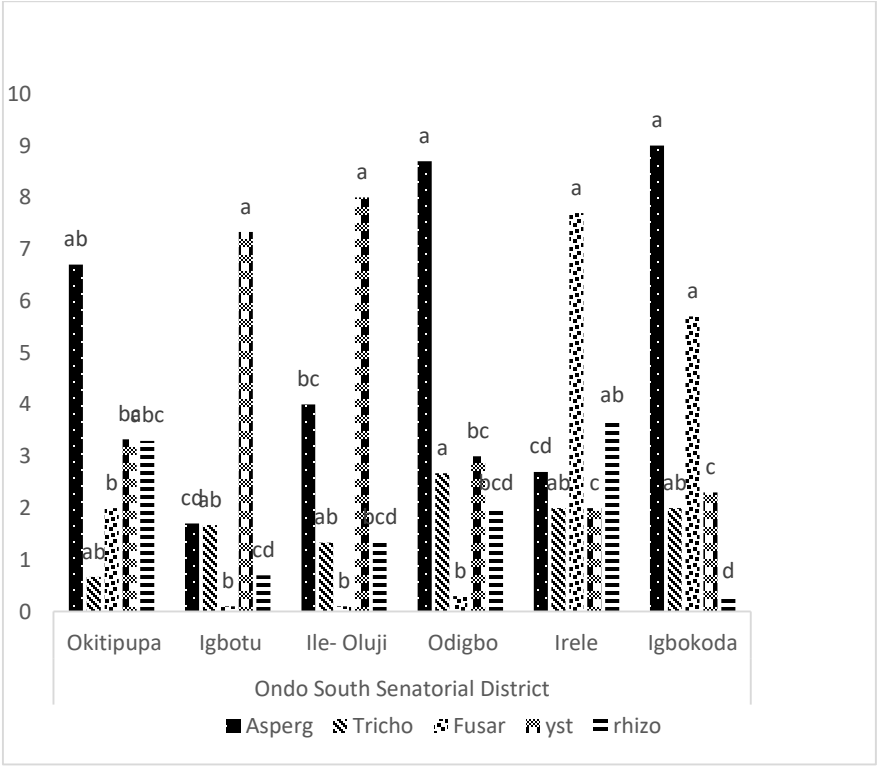

Figure 3: Fungi diversity across Ondo South Senatorial District, means with the same letter are not significantly different.

The result from figure 3 below correlate with other finding reported in Figure 1 & 2 respectively, all the local government in the South Senatorial district recorded *Aspergillus* species as the most dominant fungi species with significant differences followed by *Yeast* species, while *Trichoderma* species was equally represented across all the local government with no significant difference.

Conclusion: This study provides snapshot data on the fungal diversity in Ondo state southwestern Nigeria and can be concluded that different areas, is prone to different diseases and the crop susceptibility is in relation to the abundance of fungi found therein.

Recommendations: It is recommended that further study should be carried out to identify the toxigenic and atoxigenic strain of *Aspergillus* fungi and explore its biotechnological application, such as enzymes production, biodegradation or bioremediation potential to boost environmental sustainability and economic value of the region. Correspondingly, recommend molecular characterization of the fungi species to understand their genetic diversity and potential application in agriculture. Also, advocate more on the awareness and application of the beneficial fungi such as *Trichoderma* and mycorrhiza species for biocontrol, improve nutrient uptake and enhance crop productivity.

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