MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 34 Issue 2, July-Dec 2024, Pages: 699-710

EXPLORATION OF RHIZOSPHERE FUNGAL COMMUNITIES IN BANANA CULTIVATIONS OF AKRANI MAHAL, NANDURBAR DISTRICT

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ABSTRACT

This research focuses on isolating and identifying soil fungi associated with banana (Musa paradisiaca L.) fields in the Akrani Mahal (Dhadgaon) region of Nandurbar District, Maharashtra. The study utilized the serial dilution method along with Potato Dextrose Agar (PDA) medium to culture and examines fungal species present in the rhizosphere of banana plants. Morphological characteristics were analyzed to identify the fungi, resulting in the identification of fourteen distinct species. These species primarily belonged to the Deuteromycotina, Zygomycotina, and Ascomycotina groups, which showed consistent presence throughout the study.

Among the isolated fungi, the most prevalent genera were Aspergillus, Rhizopus, Trichoderma, Curvularia, and Penicillium. The high occurrence of these genera suggests their potential role in nutrient cycling, soil health, and plant growth promotion, as well as implications for disease suppression and resistance in banana cultivation. This study provides insights into the fungal diversity within banana crop soils, highlighting their possible impact on agricultural sustainability. The findings contribute to a better understanding of how soil fungi interact with banana plants, offering valuable knowledge for enhancing crop management and productivity through informed fungal utilization strategies.Keywords:

Key words: Rhizosphere, soil fungi, banana cultivation, Akrani Mahal, Nandurbar District, nutrient cycling, soil health, plant-fungi interactions, agricultural sustainability, microbial diversity.

INTRODUCTION

The rhizosphere, a critical zone of soil influenced by plant roots, hosts a variety of microorganisms that interact with plant roots and soil components. This region is enriched with proteins, organic acids, minerals, and carbon compounds exuded by the roots, creating a favorable environment for microbial communities (Walker, 2003). The rhizosphere supports a dense microbial population, including bacteria, fungi, and insects, which thrive on the nutrients released by the roots and contribute to plant health and soil fertility (Lynch & Whipps, 1990). The rhizosphere serves as a competitive arena where plant roots contend with neighboring plants for water, nutrients, and space while also facing various soil-borne microorganisms (Raaijmakers et al., 2009).

Soil microorganisms in the rhizosphere play essential roles in several biochemical processes, including nutrient cycling, organic matter decomposition, and mineralization. Fungi, in particular, are a significant component of the soil microbiota, especially in nutrient-rich zones within the rhizosphere. They contribute to soil structure, nutrient mobilization, and protection against pathogens, often outnumbering bacteria in deeper soil layers (Gnanasekaran, 2015).

These fungi are crucial for maintaining soil health, as they facilitate nutrient uptake, enhance root growth, and improve plant resilience to environmental stress (Harman et al., 2004).

Despite the overall abundance of fungi in the rhizosphere, fungal colonization is not uniform across all regions. On root surfaces, fungal populations tend to be lower, possibly due to spatial and ecological constraints that limit their development. Research by Deshmukh et al. (2020) suggests that only specialized fungal species can thrive on root surfaces, indicating a selective environment where specific fungi have adapted to exploit limited resources and survive in close proximity to the plant roots.

This study aims to isolate and identify soil fungi from the rhizosphere of banana (Musa paradisiaca L.) crops in the Akrani Mahal (Dhadgaon) region of Nandurbar District, Maharashtra. Using serial dilution and Potato Dextrose Agar (PDA) medium, this research seeks to catalog the fungal diversity in banana rhizosphere soil and examine its potential implications for soil health and crop productivity. Given the importance of fungi in nutrient cycling and soil structure, understanding their composition and ecological roles can provide valuable insights for sustainable agricultural practices (Nannipieri et al., 2003).

OBJECTIVES

1. Assess the Role of Rhizosphere Fungi in Soil Health

Investigate how rhizosphere fungi contribute to soil structure, fertility, and overall ecosystem functioning.

2. Promote Plant Growth and Resilience

Identify specific fungi that enhance plant growth and improve resilience to environmental stresses.

3. Examine Nutrient Cycling Processes

Explore the mechanisms through which rhizosphere fungi contribute to nutrient cycling, such as nitrogen fixation and phosphorus solubilization.

4. Identify Beneficial Fungi for Sustainable Agriculture

Isolate and characterize fungi with potential applications in sustainable agricultural practices.

5. Understand Fungal Mechanisms for Biocontrol and Bioremediation

Study the role of rhizosphere fungi in the biocontrol of plant pathogens and their potential to remediate soil pollutants.

6. Analyze Fungal Diversity and Interactions within the Rhizosphere

Investigate the dynamics of fungal populations, their interactions with other microorganisms, and their impact on the rhizosphere environment.

7. Develop Strategies for Enhancing Soil Fertility and Environmental Sustainability

Utilize insights gained from fungal diversity and functional roles to formulate strategies aimed at improving soil health and supporting sustainable agricultural systems.

RESEARCH METHODOLOGY

The research methodology for studying rhizosphere fungi in agricultural crops from Dhadgaon (Akrani Mahal) Taluka, Nandurbar District, Maharashtra, involved the following systematic steps:

1. Selection of Research Area

The Dhadgaon (Akrani Mahal) Taluka of Nandurbar District in Maharashtra was selected as the research area for this study. Nandurbar District is located in the northern part of

Maharashtra, situated between latitudes 21° to 22°3' North and longitudes 73°31' to 74°32' East, at an elevation of 217 meters above sea level. This region was chosen due to its agricultural activity, which provides a suitable environment for examining the rhizosphere fungi associated with banana crops and other agricultural plants.

2. Collection of Soil Samples

Rhizosphere soil samples were collected from banana crop fields within the Dhadgaon Taluka of Nandurbar District in February 2023. Soil samples were carefully collected following standard protocols to avoid contamination. From each site, two to three soil samples were collected for each plant species.Each sample was placed in sterile bags and transported to the laboratory for further analysis.

3. Isolation of Fungi from Soil Samples

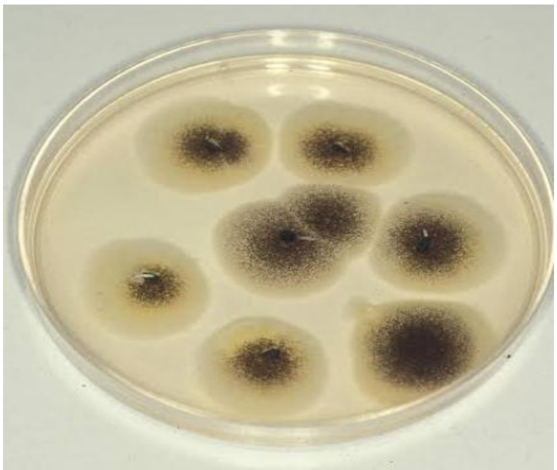
Serial Dilution Method: The serial dilution method was employed to isolate fungi by reducing the microbial load in soil samples. Soil samples were suspended in sterilized distilled water and serially diluted to create microbial suspensions from 10^{-1} to 10^{-5}. For isolating fungi, the 10^{-3} dilution was selected, from which 1 mL was pipetted and transferred into sterile petri plates containing Potato Dextrose Agar (PDA) medium. This medium is conducive to fungal growth (Waksman, 1921).

Spread Plate Method: The prepared petri plates were left to stand overnight to create surface-dried PDA plates. Then, 1 mL of the 10^{-3} diluted sample was spread evenly over the agar surface using a sterile spreader. Plates were incubated at room temperature and observed for fungal colony growth over a period of 3 to 7 days.

4. Identification of Soil Fungi

Fungal growth on PDA plates was regularly monitored. After adequate growth, distinct fungal colonies were visually observed and recorded.

Slide Preparation and Staining: Individual fungal colonies were carefully sampled and transferred to microscope slides for identification. A cotton blue stain with lactophenol was applied to each slide, which enhances visibility under a microscope by staining fungal structures. The prepared slides were examined microscopically for morphological characteristics, such as spore shape, hyphal structure, and reproductive structures.



Colony-Forming Unit (CFU) Counting: The CFUs were calculated by counting the number of visible colonies on each dilution plate and multiplying by the corresponding dilution factor to estimate fungal abundance.

Identification of Fungal Species: Identification was carried out based on morphological characteristics, with reference to standard mycological texts (Nagamani et al., 2006). The fungal species were categorized according to observed characteristics and matched with descriptions in established identification guides.

5. Documentation and Analysis

All observations were systematically recorded, including the number of colonies, morphological features, and identification details of the fungi. Photographs of fungal colonies were taken during the growth phase for documentation. This detailed data was then analyzed to determine the diversity and distribution of rhizosphere fungi within the studied agricultural soils.This methodological approach allowed for the accurate isolation, identification, and documentation of rhizosphere fungi in the study area, providing valuable insights into their role and significance within the agricultural ecosystem.

RESULTS AND DISCUSSION

This research investigated the diversity and prevalence of rhizosphere fungi in banana crops within the Akrani Mahal region of Nandurbar district, Maharashtra. A total of 14 fungal species were isolated, showcasing a significant diversity that underscores the ecological richness of the rhizosphere. The results indicate the following key findings:

Fungal Diversity and Composition

1. Total Identified Species: The study identified 14 distinct fungal species across three sites, categorized into three major fungal classes:

Deuteromycotina: 64% of the total isolates, highlighting its ecological significance in nutrient cycling and plant interactions.

Zygomycotina: Represented 22%, with its members often involved in organic matter decomposition.

Ascomycotina: Contributed 14%, with species typically recognized for their symbiotic relationships with plants.

2. Dominant Genera:

Aspergillus was the most frequently observed genus, with notable species including Aspergillus niger and Aspergillus fumigatus. These fungi are well-known for their roles in decomposing organic matter and their potential applications in biocontrol and biofertilization (Zhang et al., 2021). Other prevalent genera included Rhizopus, Trichoderma, and Curvularia, each playing distinct roles in soil health and plant interactions.

3. Site-Specific Variability:

Fungal diversity varied across the three sampling sites, with Site II exhibiting a higher abundance of Aspergillus caespitosus and Trichoderma harzianum. This variation may be attributed to differences in soil texture, moisture levels, and organic matter content across the sites. For instance, Trichoderma harzianum is known for its plant growth-promoting characteristics, which may have been enhanced by favorable soil conditions in Site II (Harman et al., 2004).

Ecological Roles and Agricultural Implications

1. Soil Health and Fertility: The identified fungi play crucial roles in soil health through their involvement in organic matter decomposition and nutrient cycling. For example, Aspergillus niger is known to enhance soil fertility by breaking down organic materials and releasing nutrients (Gnanasekaran, 2015).

2. Biocontrol Potential: The presence of fungi such as Trichoderma harzianum and Penicillium species indicates potential for biocontrol of plant pathogens. These fungi can outcompete pathogens for resources and space, as well as produce metabolites that inhibit pathogen growth (Nagamani et al., 2006).

3. Plant Growth Promotion: Several of the identified fungi are recognized for their beneficial effects on plant growth. For example, Trichoderma harzianum has been shown to enhance root development and improve plant stress resilience, making it a candidate for sustainable agricultural practices (Harman et al., 2004).

4. Nutrient Cycling: The diverse fungal community contributes to the cycling of essential nutrients in the soil, which is vital for plant health. The degradation of organic matter by fungi leads to the release of nitrogen, phosphorus, and other nutrients that are essential for plant growth (Zhang et al., 2021).

Name of Fungi	Site I	Site II	Site III	Total	Average No. of Total Colonies	Average No. of Individual Colonies	% Contribution
Aspergillus niger	8	9	8	25	25	2	8%
Aspergillus caespitosus	-	1	1	2	25	1	4%
Chaetomium globosum	1	-	-	1	25	1	4%
Trichoderma harzianum	1	-	1	2	25	2	8%
Aspergillus kanagawaensis	-	-	1	1	25	1	4%
Botrytis sp.	1	1	-	2	25	1	8%
Cladosporium sp.	-	-	1	1	25	1	4%
Curvularia lunata	1	1	1	3	25	2	12%
Aspergillus fumigatus	2	1	1	4	25	4	16%
Mucor mucedo	-	1	1	2	25	2	8%
Fusarium oxysporum	1	1	1	3	25	2	12%
Penicillium aurantiogriseum	-	1	-	1	25	1	4%
Rhizopus oryzae	1	1	-	2	25	2	8%
Rhizopus stolonifer	-	1	-	1	25	1	4%
Total	25	25	25	75	25	25	100%

Table 1: Average No. of Individual Colonies of fungi

Sr.o.	Fungal Species Obtained	% Contribution	Class
1.	Aspergillus niger	08	Deuteromycotina
2.	Aspergillus caespitosus	04	Deuteromycotina
3.	Chaetomium globosum	04	Ascomycotina
4.	Trichoderma harzianum	04	Ascomycotina
5.	Aspergillus kanagawaensis	08	Deuteromycotina
6.	Botrytis sp.	08	Deuteromycotina
7.	Cladosporium sp.	04	Deuteromycotina
8.	Curvularia lunata	08	Deuteromycotina
9.	Aspergillus fumigatus	16	Deuteromycotina
10.	Mucor mucedo	08	Zygomycotina
11.	Fusarium oxysporum	12	Deuteromycotina
12.	Penicillium fumiculosum	08	Deuteromycotina
13.	Rhizopus oryzae	04	Zygomycotina
14.	Rhizopus stolonifer	04	Zygomycotina

Table 2.: Percent Contribution of Fungal Species in Dhadgaon (Akrani Mahal) Taluka

Sr.no.	Soil Testing Properties	Site I	Site II	Site III	Average of All 3 sites
1.	pH	8.04	8.01	7.90	Alkaline
2.	Texture	10.00	9.00	10.00	Sandy clay loam
3.	Colour of Soil	Black	Black	Black	Black

Table3.: Physico – Chemical Properties of Rhizospheric soil of Banana plant of Akrani Mahal (Average of All 3 sites)

1. pH Levels

The pH values across the three sites ranged from 7.90 to 8.04, categorizing the soil as alkaline.

Impact on Fungal Diversity: Alkaline soils can influence the availability of certain nutrients, as well as the types of microorganisms present. Fungi typically thrive in a pH range of 5.5 to 7.5; hence, the alkaline nature of the soil may limit the diversity of certain fungal species, particularly those that are sensitive to high pH levels (Zhang et al., 2021). However, the dominance of Deuteromycotina fungi, which includes several alkaline-tolerant species, suggests that the fungal community has adapted to these conditions.

Nutrient Availability: The alkaline pH can also affect the solubility of essential nutrients such as phosphorus, which may become less available at higher pH levels. This could lead to nutrient deficiencies in plants, potentially impacting growth and yield. Monitoring nutrient levels and adjusting soil management practices will be essential for optimizing crop health.

2. Soil Texture

The soil texture was identified as sandy clay loam across all three sites, with measurements indicating a slight variation (Site I: 10.00%, Site II: 9.00%, Site III: 10.00%).Water Retention and Aeration: Sandy clay loam provides a balance between water retention and aeration, which is crucial for healthy root development and fungal activity. This texture type typically supports a diverse range of microorganisms, facilitating effective nutrient cycling and root colonization by beneficial fungi (Gnanasekaran, 2015). Fungal Habitat: The structural properties of sandy clay loam can provie suitable habitats for various fungi, allowing them to thrive and contribute to plant growth. The combination of sand, silt, and clay enhances soil structure and promotes a healthy microbial community.

Table 4: Diversity and Contribution of Fungal Species Isolated from the Rhizosphere of Banana Crops.

Fungal Diversity and Distribution

Sr.No.	Name of Fungal Species	Total colony	CFU of an individual	% Contribution
1	Aspergillus niger	15	5	33.33
2	Aspergillus caespitosus	9	1	11.11
3	Chaetomium globosum	12	3	25.00
4	Trichoderma harzianum	6	2	33.33
5	Aspergillus kanagawaensis	14	9	64.29
6	Botrytis sp.	11	6	54.55
7	Cladosporium sp.	11	3	27.27
8	Curvularia lunata	3	1	33.33
9	Aspergillus fumigatus	13	5	38.46
10	Mucor mucedo	7	3	42.86
11	Fusarium oxysporum	8	1	12.5
12	Penicillium fumiculosum	12	8	66.66
13	Rhizopus oryzae	14	8	57.14
14	Rhizopus stolonifer	12	7	58.33

The analysis reveals a diverse community of fungi, with several species exhibiting significant contributions to the overall fungal population in the rhizosphere.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 34 Issue 2, July-Dec 2024, Pages: 673-692

Dominance of Aspergillus Species:

Aspergillus kanagawaensis showed the highest percentage contribution of 64.29%, indicating its significant role in the fungal community. Aspergillus niger and Aspergillus fumigatus also contributed notably, with 33.33% and 38.46%, respectively. The prevalence of these Aspergillus species may suggest their adaptability to the alkaline soil conditions observed in the study.

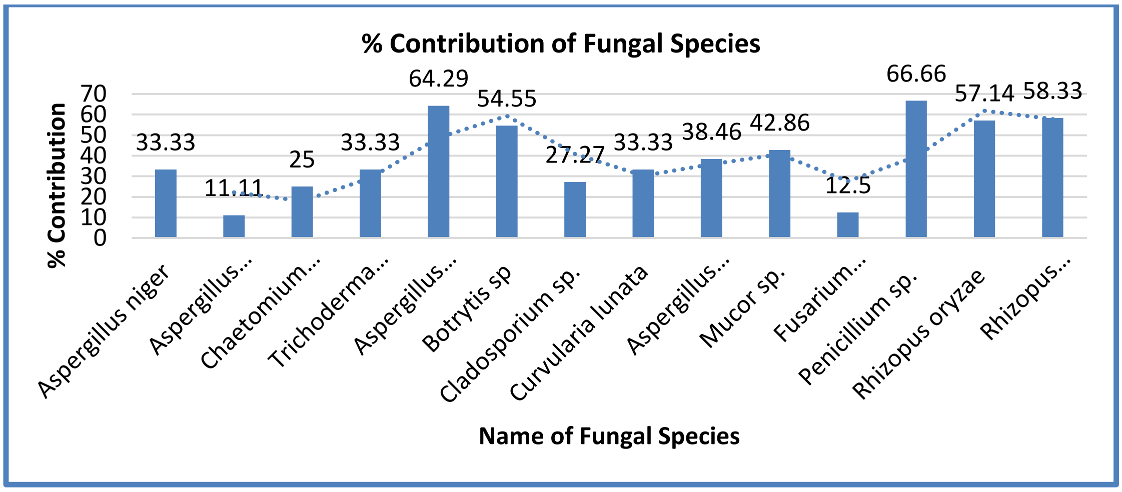


Figure 1: Percentage Contribution of Various Fungal Species Isolated from the Rhizosphere of Banana Crops

Role of Rhizopus Species:

Both Rhizopus oryzae and Rhizopus stolonifer demonstrated high contributions of 57.14% and 58.33%, respectively. Their presence indicates a robust fungal population that may aid in organic matter decomposition and nutrient cycling in the rhizosphere.

Noteworthy Contributions from Other Genera:

Botrytis sp. exhibited a 54.55% contribution, while Penicillium fumiculosum had a remarkable 66.66% contribution, reflecting its potential role in biocontrol and nutrient enhancement in the soil.

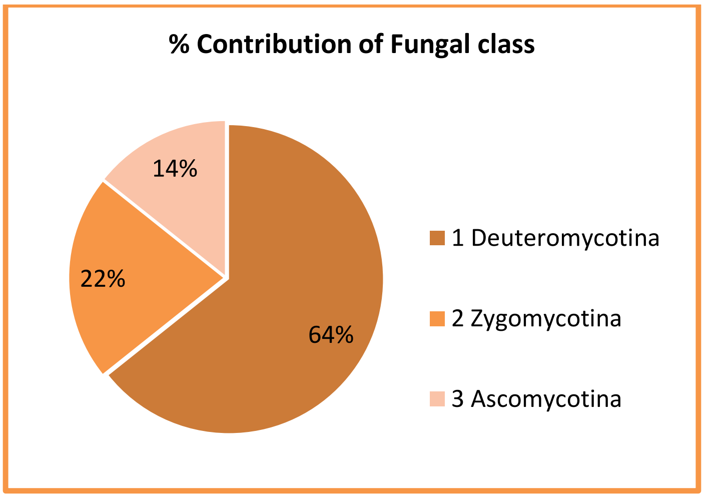


Figure 2: **Percentage Contribution of Fungal Classes in the Rhizosphere of Banana Crops**

2. Implications for Soil Health and Plant Growth

The diversity of fungal species in the rhizosphere is critical for maintaining soil health and supporting plant growth. Fungi are essential in various ecological functions, including:

Nutrient Cycling: Fungi decompose organic matter, making nutrients more available to plants. This is particularly important in the context of sustainable agriculture, where nutrient availability can directly affect crop yields.

Soil Structure Improvement: The hyphal networks formed by fungi contribute to soil aggregation, which improves soil structure, aeration, and water retention.

Biocontrol Potential: The presence of beneficial fungi such as Trichoderma harzianum and Penicillium fumiculosum suggests potential biocontrol capabilities against soil-borne pathogens. These fungi can inhibit the growth of harmful organisms, thus enhancing plant health and resilience.

Sr.No.	Species	Class
1.	Aspergillus niger	Deuteromycotina
2.	Chaetomium globosum	Ascomycotina
3.	Trichoderma harzianum	Ascomycotina
4.	Aspergillus kanagawaensis	Deuteromycotina
5.	Botrytis sp.	Deuteromycotina
6.	Cladosporium sp.	Deuteromycotina
7.	Curvularia lunata	Deuteromycotina
8.	Aspergillus fumigatus	Deuteromycotina
9.	Mucor mucedo	Zygomycotina
10.	Fusarium oxysporum	Deuteromycotina
11.	Aspergillus caespitosus	Deuteromycotina
12.	Penicillium fumiculosum	Deuteromycotina
13.	Rhizopus oryzae	Zygomycotina
14.	Rhizopus stolonifer	Zygomycotina

Table 5: Classification of Fungal Species Isolated from the Rhizosphere of Banana Crops

ANALYSIS OF FUNGAL SPECIES CLASSIFICATION

The table categorizes a total of 14 fungal species isolated from the rhizosphere of banana crops based on their taxonomic classification. The species are grouped into three main classes: Deuteromycotina, Ascomycotina, and Zygomycotina, showcasing a diverse range of fungal organisms in the rhizosphere ecosystem.

1. Dominance of Deuteromycotina:

The class Deuteromycotina is the most prevalent in the samples, with eight species (Aspergillus niger, Aspergillus kanagawaensis, Botrytis sp., Cladosporium sp., Curvularia lunata, Aspergillus fumigatus, Aspergillus caespitosus, and Fusarium oxysporum) representing 57% of the total identified species. This high prevalence indicates the ecological significance of this class in banana cultivation, as many members of Deuteromycotina are known for their roles in nutrient cycling and plant growth promotion.

2. Presence of Ascomycotina:

Ascomycotina includes two notable species: Chaetomium globosum and Trichoderma harzianum. Both species are recognized for their beneficial roles in agriculture, including biocontrol of plant pathogens and enhancement of plant health through their mycorrhizal associations. The presence of these fungi suggests a supportive microbial community that may contribute to the overall health and productivity of banana crops.

3. Representation of Zygomycotina:

Zygomycotina comprises two species: Mucor mucedo and the Rhizopus species (Rhizopus oryzae and Rhizopus stolonifer). While these fungi are less diverse in comparison to the other classes, they are essential for their decomposing abilities, contributing to soil organic matter and nutrient availability.

4. Ecological Implications:

The diversity of fungal species within the rhizosphere reflects a robust and dynamic microbial ecosystem. These fungi play crucial roles in soil health by facilitating organic matter decomposition, improving soil structure, and enhancing nutrient availability for the banana plants. The varied interactions among these fungi, along with their relationships with plant roots, can significantly influence the overall health and resilience of the banana crop.

5. Potential for Sustainable Agriculture:

Understanding the composition and roles of these fungal communities can inform sustainable agricultural practices. For instance, the beneficial species identified, especially those within Deuteromycotina and Ascomycotina, can be further studied and potentially harnessed for biocontrol and plant growth promotion, reducing the reliance on chemical fertilizers and pesticides.

Sr.No.	Class	No. of Species	% Contribution
1.	Deuteromycotina	9	64 %
2.	Zygomycotina	3	22 %
3.	Ascomycotina	2	14 %

Table 6: Distribution of Fungal Species by Class in the Rhizosphere of Banana Crops

LIMITATIONS AND FUTURE DIRECTIONS

While this study provides valuable insights into the diversity and potential benefits of rhizosphere fungi, several limitations must be acknowledged. The study was conducted during a specific time period, and fungal populations may fluctuate seasonally. Future research should focus on long-term monitoring of fungal diversity and their ecological functions across different seasons and environmental conditions.

The interactions between identified fungi and other soil microorganisms to develop a comprehensive understanding of their roles in the rhizosphere ecosystem. Molecular techniques, such as metagenomics, could also be employed to identify and characterize fungal communities more accurately.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 34 Issue 2, July-Dec 2024, Pages: 673-692

CONCLUSION

This study on the rhizosphere fungi associated with banana crops in the Akrani Mahal region of Nandurbar district has provided valuable insights into the diversity and ecological roles of fungal communities in agricultural ecosystems. The following key points summarize the findings and implications of the research:

1. Diverse Fungal Community: A total of 14 different fungal species were identified from the rhizosphere soil samples. This included four species of Aspergillus, two species of Rhizopus, and one species each of Mucor, Botrytis, Cladosporium, Fusarium, Penicillium, Trichoderma, Chaetomium harzianum, and Curvularia. The presence of these species highlights the ecological richness and complexity of the rhizosphere environment in banana fields.

2. Taxonomic Distribution: The fungal species were categorized into three main taxonomic classes: Deuteromycotina, Zygomycotina, and Ascomycotina. Notably, the Deuteromycotina group was the most prevalent, comprising 64% of the identified species. This suggests that these fungi play a significant role in the soil ecosystem, contributing to nutrient cycling and organic matter decomposition.

3. Influence of Soil Properties: The analysis of soil properties revealed an alkaline pH ranging from 7.90 to 8.04, a sandy clay loam texture, and a black color, indicative of high organic matter content. These characteristics create a conducive environment for fungal growth and diversity. The alkaline pH, while potentially limiting for some fungal species, supports the proliferation of alkaline-tolerant fungi, such as those in the Deuteromycotina group.

4. Ecological Roles of Fungi: The identified fungi contribute to various ecological functions, including soil health enhancement, nutrient cycling, and plant growth promotion. Beneficial fungi, particularly species of *Trichoderma*, are noted for their biocontrol potential against plant pathogens, which can lead to reduced reliance on chemical pesticides in sustainable agricultural practices. This highlights the importance of these fungi in promoting sustainable agricultural systems and improving crop resilience against environmental stresses.

5. Need for Integrated Soil Management: The findings underscore the necessity for integrated soil management practices to maintain soil health and optimize crop productivity. Understanding the dynamics of rhizosphere fungi and their interactions with other soil microorganisms can provide valuable information for developing effective strategies for enhancing agricultural productivity while maintaining ecosystem health.

6. Future Research Directions: Future research should focus on elucidating the functional roles of these fungi and their interactions with soil properties and other microorganisms. Longitudinal studies examining seasonal changes in fungal diversity and activity could provide deeper insights into their ecological dynamics. Additionally, exploring the potential applications of beneficial fungi in biocontrol and plant growth promotion can contribute to the development of innovative agricultural practices.

In conclusion, this study highlights the rich diversity of rhizosphere fungi in banana crops and their essential roles in promoting soil health, nutrient cycling, and sustainable agricultural practices. The insights gained from this research can inform future agricultural strategies aimed at enhancing crop productivity while ensuring environmental sustainability.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Dr. Sandhya Patil Madam Head of the Department of Botany S.S.V.P.S.'S L.K Dr. P. R. Ghogrey Science College in Dhule, India, for their consistent support and encouragement.

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