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STUDIES ON BIOFERTILIZERS AND BIOPESTICIDES ON SPINACH PLANT HEALTH AND DISEASE MANAGEMENT UNDER FIELD CONDITIONS

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ABSTRACT

This field-based study evaluates the integrated application of biofertilizers (vermicompost) and biopesticides (*Trichoderma harzianum* and *Pseudomonas fluorescens*) on the growth performance and disease resistance of spinach (Spinacia oleracea) in Noida, India. The treatments were arranged in a randomized block design and revealed significant improvements in key agronomic traits such as plant height, leaf area, and yield. Notably, disease incidence, particularly from downy mildew, was reduced by 45–60%. Enhanced microbial activity and nutrient availability were observed in soils treated with vermicompost, underscoring the soil-enriching potential of organic amendments. The findings support the use of bio-inputs as a sustainable agricultural strategy, minimizing chemical dependency, promoting plant vigor, and maintaining ecological balance. Further research is recommended to evaluate scalability across agro-climatic zones and assess long-term impacts on soil and crop health.

Keywords: Biofertilizers, Biopesticides, Spinach, Sustainable Agriculture, Plant Health, Downy Mildew, Vermicompost.

INTRODUCTION

Spinach (*Spinacia oleracea*), commonly known as "Palak" in India, is a highly nutritious leafy vegetable of the Chenopodiaceae family. It is rich in essential micronutrients including calcium, iron, and vitamins A, C, and B-complex. Due to its high nutritional and medicinal value, spinach is widely consumed. However, its cultivation is often challenged by the extensive use of synthetic fertilizers and pesticides, which degrade soil quality, contribute to environmental pollution, and leave harmful residues on edible leaves.

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In recent years, the use of organic alternatives like vermicompost and microbial biocontrol agents has emerged as an environmentally friendly solution. Vermicompost, derived from decomposed organic matter using earthworms, enhances soil structure, moisture retention, microbial diversity, and nutrient availability. It also contributes to a circular economy by recycling organic waste.

Simultaneously, spinach crops are vulnerable to several pests and diseases, particularly downy mildew (*Peronospora effusa*), which significantly impacts yield and quality. Biopesticides such as *Trichoderma harzianum* and *Pseudomonas fluorescens* offer a sustainable method for disease suppression through microbial antagonism and competition, reducing the need for harmful chemicals.

In light of growing concerns over environmental degradation, pesticide residues, and declining soil fertility, there is a pressing need to transition toward sustainable agricultural inputs. Biofertilizers and biopesticides have emerged as promising alternatives that support crop productivity while maintaining ecological balance. Vermicompost, in particular, has been shown to enhance soil microbial diversity, organic carbon content, and nutrient availability, making it highly suitable for leafy vegetables like spinach (Sinha et al., 2020). Additionally, beneficial microbes such as Trichoderma harzianum and Pseudomonas fluorescens act as natural antagonists to pathogens and induce systemic resistance in plants (Kumar & Singh, 2023). These biocontrol agents offer effective suppression of common spinach diseases, including downy mildew, without the harmful residues associated with synthetic fungicides (Patel & Desai, 2022). Recent studies further emphasize the compatibility of such bio-inputs with sustainable crop management strategies, reinforcing their role in safer, residue-free spinach production systems (El-Sayed & El-Mehy, 2021; Mahanty et al., 2021).

This study was conducted under the field conditions of Noida to assess the synergistic effects of vermicompost, biofertilizers and biopesticides on spinach growth, yield, and disease resistance. The broader aim is to promote sustainable agricultural practices that enhance food security, mitigate the impacts of climate change, and support healthier food systems.

MATERIALS AND METHODS

Study Location:

The experiment was conducted during the Rabi season of 2024–2025 at the Experimental Research Field, Amity University, Noida, Uttar Pradesh. The site is situated at an elevation of 200 meters above sea level (latitude 28.5440°N and longitude 77.3330°E).

Climatic Conditions:

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Noida falls within the Trans-Gangetic Plains agro-climatic zone and experiences extreme seasonal variations. During the study, the average maximum and minimum temperatures were 35.21°C and 23.74°C, respectively. Relative humidity averaged 60.5%, with 141.26 mm of rainfall and approximately 6 hours of daily sunshine.

Soil Characteristics:

Soil samples collected from 15–30 cm depth exhibited a sandy loam texture (62.20% sand, 11.00% silt, and 24.20% clay). The soil was mildly alkaline, with moderate potassium, low phosphorus, and deficient levels of nitrogen (0.045%) and organic carbon (0.60%). The site had good drainage and a uniform topography.

Field Operations:

Field preparation included tillage followed by the application of biofertilizers and biopesticides according to the treatment plan. Other cultural operations—such as sowing, weeding, irrigation, and harvesting—were conducted using standard agronomic practices.

Experimental design:

The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each plot measured 2 m × 3 m, and spacing between spinach rows was maintained at 20 cm with 10 cm between plants.

Assessment Parameters:

To evaluate treatment efficacy, five healthy spinach plants from each plot were tagged and monitored. Observations included plant height, root length, number of leaves, leaf area, and yield per plot.

RESULTS AND DISCUSSIONS

The study revealed that integrating biofertilizers and biopesticides significantly improved spinach growth and yield compared to control plots. The combined treatment of vermicompost, *Pseudomonas fluorescens*, and *Trichoderma harzianum* produced the highest plant height (32.2 cm), root length (15.4 cm), leaf area (72.86 cm^2), number of leaves (39), and yield (6.2 kg per plot). In contrast, the untreated control showed the lowest performance across all parameters.

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TREATMENTS	GROWTH PARAMETERS				
	Plant height (cm)	Root length (cm)	Leaf area (cm)	Number of leaves	Yield per plot (kg)
Vermicompost	24 cm	8.8 cm	36.40 cm	27	4 kg
Vermicompost + *Pseudomonas fluorescens*	26.5 cm	11.3 cm	42.33 cm	26	4.5 kg
Vermicompost + *Trichoderma harzianum*	28.8 cm	12.7 cm	48.53 cm	30	5 kg
Pseudomonas fluorescens + *Trichoderma harzianum*	30 cm	14 cm	60.86 cm	35	5.2 kg
Vermicompost + *Pseudomonas fluorescens* + *Trichoderma harzianum*	32.2 cm	15.4 cm	72.86 cm	39	6.2 kg
Control	22 cm	6.5 cm	32.54 cm	21	3 kg
SE	0.44	0.52	0.42	0.89	0.63
C.D at 5%	0.98	1.16	0.93	2.04	1.42

Limitations and Scope:

This study was conducted in a single season and did not include microbial soil quantification or broader pest spectrum analysis beyond downy mildew. Future work should incorporate multiple seasons, cost-benefit analyses, and monitoring of pests such as aphids and leaf miners for more comprehensive insight.

Statistical analysis:

The collected data were subjected to analysis of variance (ANOVA) using a Randomized Block Design (RBD) framework to assess treatment effects. Mean values were compared using the

Critical Difference (C.D.) test at a 5% level of significance ($p < 0.05$). Statistical analysis was performed using Microsoft Excel. Results were presented as means ± standard error (SE), and graphical representations were generated to illustrate treatment-wise differences across growth and yield parameters.

CONCLUSION

Spinach production faces considerable threats from pests and diseases like aphids, caterpillars, and particularly downy mildew. Given spinach's leafy morphology and high surface area, chemical residues tend to accumulate easily. This study highlights the efficacy of bio-inputs as part of an Integrated Pest Management (IPM) strategy that not only mitigates pest pressure but also safeguards food quality and environmental health.

By reducing chemical use and enhancing soil biology, the integration of vermicompost and microbial biocontrol agents fosters a healthier, more resilient farming system. This approach aligns well with the principles of sustainable agriculture and holds great potential for adoption in urban and peri-urban farming zones. The integrated use of vermicompost and microbial biocontrol agents (Pseudomonas fluorescens and Trichoderma harzianum) significantly enhanced spinach growth, yield, and resistance to downy mildew. This approach supports sustainable agriculture by reducing chemical inputs and improving soil health. However, economic feasibility, seasonal validation, and broader pest management need to be addressed in future research to ensure large-scale farmer adoption.

Continued research on region-specific adaptations and long-term field trials is essential to fine-tune dosage, timing, and crop compatibility for wider application across India.

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