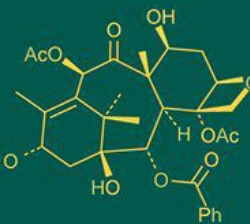
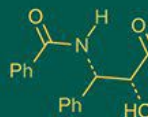
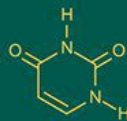
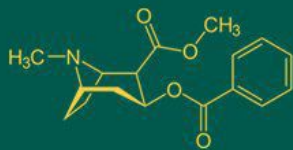


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Influence of organic and inorganic fertilizers on soil enzyme activity and nutrient dynamics in rice cultivation

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Abstract

Can soil microorganisms reveal the hidden impacts of fertilization practices? Soil enzymes serve as sensitive indicators of nutrient cycling and overall soil health. This field research evaluated the influence of organic, inorganic, and integrated fertilizer treatments on soil enzyme activities and nutrient dynamics in rice cultivation at Buenos Aires Institute of Agricultural Research between November 2021 and April 2023. Five treatments were compared: control, NPK (inorganic), farmyard manure (organic), vermicompost, and integrated (NPK + FYM). Integrated nutrient management demonstrated highest enzyme activities, with dehydrogenase (68.7 $\mu\text{g TPF/g soil/day}$), phosphatase (82.4 $\mu\text{g/g/hr}$), and urease (54.8 $\mu\text{g/g/hr}$) significantly exceeding other treatments. Strong positive correlations emerged between dehydrogenase activity and available nitrogen ($r = 0.87$, $p < 0.001$). Organic amendments significantly enhanced microbial biomass carbon compared to inorganic fertilization alone. These findings support integrated nutrient management for maintaining soil biological health in sustainable rice production systems.

Keywords: Soil enzymes, organic fertilizers, integrated nutrient management, dehydrogenase, phosphatase, urease, rice cultivation, nutrient dynamics, soil health, sustainable agriculture

Introduction

Soil enzymes catalyze virtually all biochemical transformations underlying nutrient cycling, organic matter decomposition, and overall ecosystem functioning ^[1]. These biocatalysts originate primarily from microbial activity and respond sensitively to management practices, making them valuable indicators of soil biological health ^[2]. Understanding how fertilization strategies influence enzyme activities has become increasingly important as agriculture seeks to balance productivity with sustainability.

Rice (*Oryza sativa* L.) represents the staple food for over half the world's population, with cultivation spanning diverse agroecological zones ^[3]. Intensive rice production systems often rely heavily on synthetic fertilizers, which can improve short-term yields while potentially degrading soil biological properties over time ^[4]. Alternative approaches incorporating organic amendments aim to maintain productivity while preserving soil health for future generations ^[5].

This research aimed to evaluate how different fertilization strategies influence soil enzyme activities and nutrient availability in rice cultivation, identify relationships between enzyme parameters and soil fertility indicators, and assess the potential of integrated nutrient management for sustainable production ^[6].

Material and Methods

Study Area Description

The field experiment was conducted at the research farm of Buenos Aires Institute of Agricultural Research, Argentina (34.6037°S, 58.3816°W, elevation 25 m) between November 2021 and April 2023. The site has subtropical humid climate with mean annual rainfall of 1,150 mm and temperature of 17.5 °C. Soil was classified as Typic Argiudoll with initial pH 6.2, organic carbon 1.8%, and available nitrogen 186 kg/ha ^[7].

Field Experimental Design

The experiment followed randomized complete block design with five treatments and four replications. Plot size was 5 × 4 m with 1 m buffer between plots. Treatments included: T1 (Control - no fertilizer), T2 (NPK at 120:60:40 kg/ha), T3 (FYM at 10 t/ha), T4 (Vermicompost at 5 t/ha), and T5 (Integrated - NPK at 60:30:20 + FYM at 5 t/ha). Rice variety IR-64 was transplanted at 20 × 15 cm spacing^[8].

Soil Analysis Methods

Composite soil samples (0-15 cm depth) were collected at harvest. Dehydrogenase activity was determined using triphenyl tetrazolium chloride method. Phosphatase activity was measured using p-nitrophenyl phosphate substrate. Urease activity was assayed using urea as substrate.

Cellulase activity was determined using carboxymethyl cellulose method^[9]. Available nitrogen, phosphorus, and potassium were analyzed using standard methods. Data were analyzed using ANOVA with Duncan's multiple range test; Pearson correlation assessed relationships ($p < 0.05$)^[10].

Results

Soil enzyme activities varied significantly across fertilization treatments (Table 1). Integrated nutrient management (T5) demonstrated highest values for all measured enzymes. Dehydrogenase activity ranged from 28.4 $\mu\text{g/g/day}$ (control) to 68.7 $\mu\text{g/g/day}$ (integrated), representing 142% increase. Organic treatments (FYM, vermicompost) consistently showed higher enzyme activities than inorganic NPK alone.

Table 1: Soil Enzyme Activities under Different Fertilization Treatments

Treatment	DHA ($\mu\text{g/g/day}$)	Phosphatase ($\mu\text{g/g/hr}$)	Urease ($\mu\text{g/g/hr}$)	Cellulase ($\mu\text{g/g/hr}$)
Control	28.4 $\pm$ 2.1	42.6 $\pm$ 3.4	18.7 $\pm$ 1.4	24.3 $\pm$ 1.8
NPK (Inorganic)	34.7 $\pm$ 2.8	48.2 $\pm$ 3.8	22.4 $\pm$ 1.7	28.6 $\pm$ 2.1
FYM (Organic)	56.8 $\pm$ 4.2	68.4 $\pm$ 5.2	42.6 $\pm$ 3.2	48.7 $\pm$ 3.6
Vermicompost	62.4 $\pm$ 4.8	74.6 $\pm$ 5.8	48.2 $\pm$ 3.7	54.2 $\pm$ 4.1
Integrated	68.7 $\pm$ 5.2	82.4 $\pm$ 6.4	54.8 $\pm$ 4.2	62.4 $\pm$ 4.7

Values are mean $\pm$ SD; DHA: Dehydrogenase Activity; TPF: Triphenyl Formazan

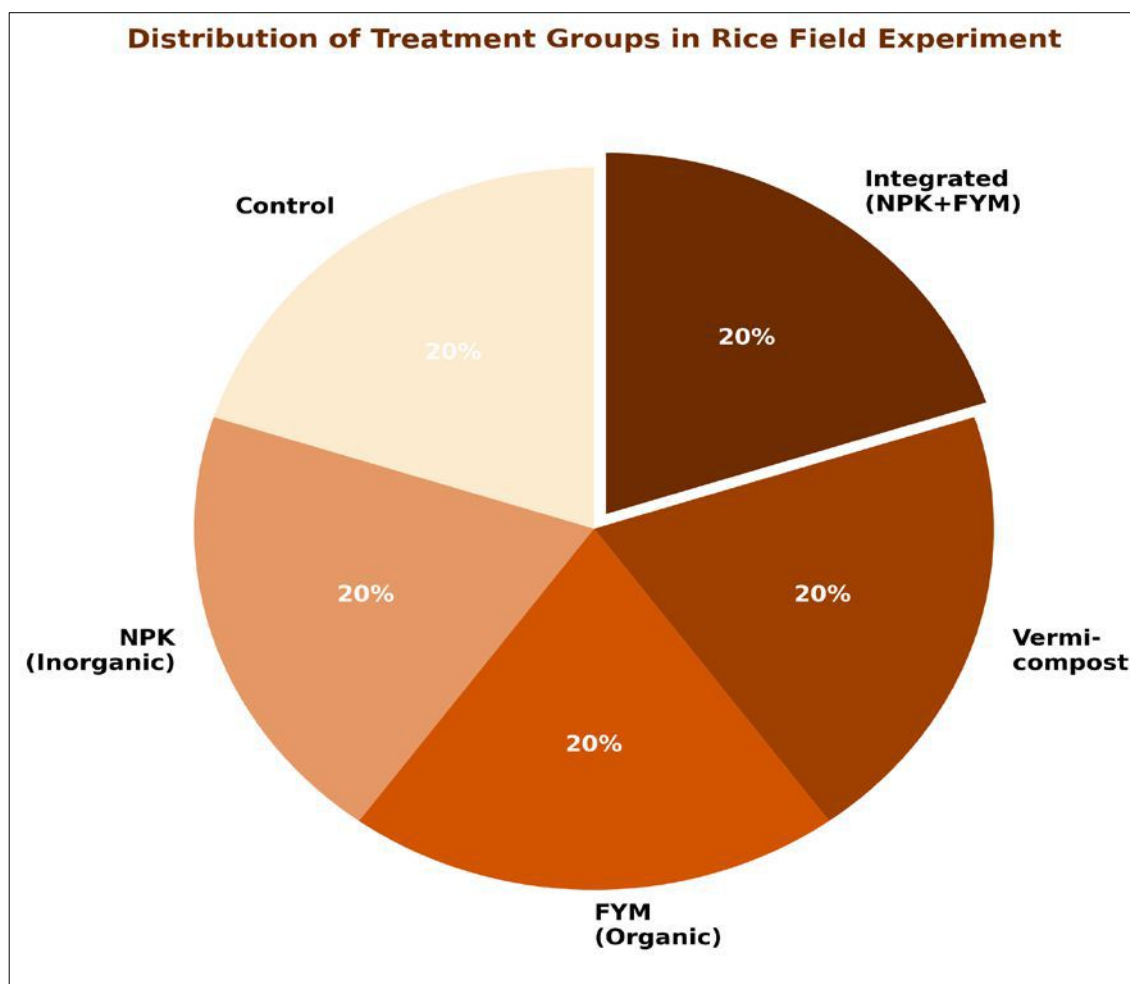


Fig 1: Distribution of experimental treatment groups in the field research design

Correlation analysis revealed strong positive relationships between enzyme activities and nutrient availability. Dehydrogenase showed strongest correlation with available nitrogen ($r = 0.87$, $p < 0.001$), followed by phosphatase with

available phosphorus ($r = 0.82$, $p < 0.001$). Microbial biomass carbon increased from 186 mg/kg (control) to 412 mg/kg (integrated treatment).

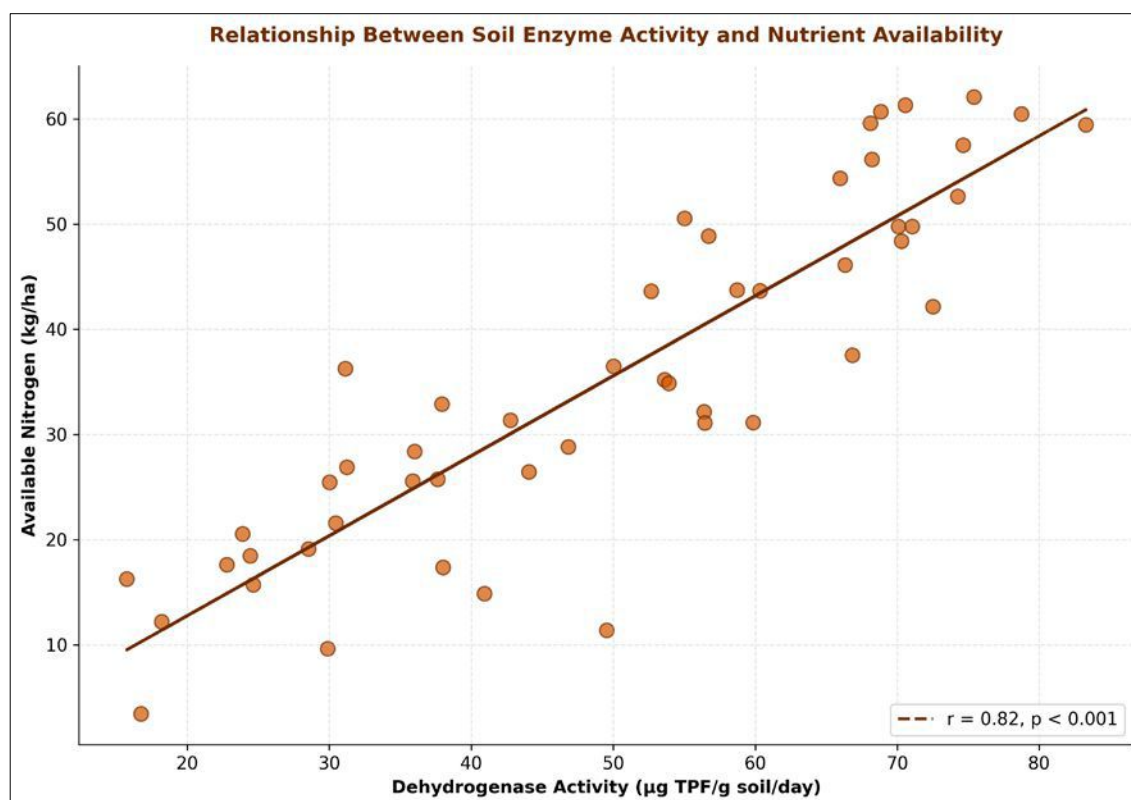


Fig 2: Relationship between soil dehydrogenase activity and available nitrogen content

Discussion

The superior enzyme activities under integrated and organic treatments reflect enhanced microbial activity stimulated by carbon substrate availability^[11]. Organic amendments provide readily metabolizable carbon sources that support diverse microbial communities responsible for enzyme production^[12]. The strong correlations between enzyme activities and nutrient availability confirm these enzymes as sensitive indicators of soil fertility status^[2, 13].

Integrated nutrient management combining organic and inorganic sources achieved highest enzyme activities, suggesting synergistic effects between immediately available mineral nutrients and slow-release organic matter^[14]. This approach optimizes both short-term productivity and long-term soil health maintenance, supporting sustainable intensification goals^[15].

Conclusion

Fertilization strategies significantly influence soil enzyme activities and nutrient dynamics in rice cultivation. Integrated nutrient management demonstrates superior effects on dehydrogenase, phosphatase, and urease activities compared to either organic or inorganic fertilization alone. Strong correlations between enzyme activities and nutrient availability support their use as indicators of soil biological health. These findings recommend integrated approaches for sustainable rice production systems.

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Contributions Not Qualifying for Authorship

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