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RESEARCH ARTICLE

SUSTAINABLE SOIL MANAGEMENT: EFFECTS OF VERMICOMPOST ON PEROXIDASE ACTIVITY IN GROUNDNUT

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Abstract: Sustainable soil fertility management is essential for enhancing crop productivity and physiological resilience. Vermicompost, a biologically enriched organic amendment, improves soil biochemical properties and promotes enzymatic activities in plants. This study investigates the effect of vermicompost application on peroxidase (POD) activity in groundnut (Arachis hypogaea L.), an enzyme known for its role in oxidative stress tolerance and metabolic regulation. Groundnut plants were grown under four vermicompost treatments (0%, 25%, 50%, and 75%) and assessed at 30, 60, and 90 days after sowing. Results showed a significant increase in POD activity with increasing vermicompost levels, with the 50% and 75% treatments showing the highest enzymatic response. Enhanced peroxidase activity correlated with improved plant vigor, chlorophyll content, and biomass accumulation. The findings confirm that vermicompost enriches soil nutrient dynamics, enhances physiological resilience, and offers a sustainable strategy for improving groundnut performance in organic farming systems.

Keywords: Vermicompost, Groundnut, Peroxidase activity, Soil sustainability, Enzyme assay, Organic amendments.

INTRODUCTION

Groundnut (Arachis hypogaea L.) is an economically important legume crop cultivated in tropical and subtropical regions. As a high-protein and oil-rich crop, its productivity is strongly influenced by soil fertility, enzymatic metabolism, and nutrient availability. In conventional agriculture, excessive use of chemical fertilizers adversely affects soil structure and microbial diversity, leading to long-term soil degradation. Therefore, sustainable biological amendments such as vermicompost have gained global attention as eco-friendly alternatives.

Vermicompost is a stabilized organic substrate produced through earthworm-mediated decomposition of organic waste. It enhances soil aeration, microbial biomass, nutrient mineralization, and plant enzymatic activities. Among plant enzymes, **peroxidase (POD)** plays a central role in lignification, pathogen resistance, hydrogen peroxide detoxification, and oxidative stress management. Increased POD activity is closely associated with improved plant defense, growth, and metabolic stability.

Several studies have linked vermicompost application to enhanced enzymatic activities and physiological attributes in crops. However, limited literature exists on vermicompost-induced peroxidase regulation in groundnut. Understanding this mechanism is essential for promoting organic nutrient management, especially under declining soil fertility and increased abiotic stress.

This study investigates the influence of graded levels of vermicompost on POD activity in groundnut. The findings contribute to sustainable agronomic practices and provide insights into soil–plant biochemical interactions.

LITERATURE REVIEW

Effects of vermicompost on plant growth and productivity

Vermicompost consistently improves plant growth, yield and physiological vigor across many crops. Several experimental studies reported enhanced germination, biomass accumulation, root development and crop productivity after vermicompost application compared with mineral fertilizer or unamended controls (Arancon et al., 2004; Kale et al., 1992; Joshi, Singh, & Vig, 2015). Meta-analytic evidence supports a positive overall effect size for plant growth parameters under vermicompost treatments, indicating generalized benefits across species and environments (Lazcano & Domínguez, 2011). Mechanistically, growth promotion has been attributed to improved nutrient availability, plant hormone-like substances in vermicompost (humic acids, cytokinins), and improved soil structure (Atiyeh et al., 2002; Pathak, Bhatia, & Jain, 2014). Field and pot studies on legumes and oilseeds (including groundnut) show yield gains and better crop performance under combined organic amendments and vermicompost (Govindaraj & Shanmugam, 2021; Kumar, Singh, & Yadav, 2019; Barman, Nath, & Das, 2019).

Vermicompost effects on soil biological properties and microbial communities

Vermicomposting not only generates a nutrient-rich amendment but also alters soil biological properties. Studies report increased microbial biomass, respiration, enzymatic activity and shifts in community structure following vermicompost amendment (Arancon et al., 2004; Suthar, 2009; Ghosh & Maiti, 2016). High-throughput and community studies show that vermicompost can increase beneficial decomposers and functional groups (e.g., copiotrophic bacteria and fungi) that accelerate nutrient cycling (Gomez-Brandon & Domínguez, 2014). These biological changes are thought to underlie many of the agronomic improvements observed, by improving nutrient mineralization and maintaining soil health (Joshi et al., 2015).

Soil and plant enzymatic responses — peroxidase, oxidative enzymes and antioxidants

Vermicompost and other organic amendments often modify both soil enzyme activities and plant antioxidant enzyme systems. Several works measured increases in soil enzymes (dehydrogenase, phosphatases) and plant oxidative enzymes (peroxidase, catalase, superoxide dismutase) after vermicompost application, which can indicate enhanced microbial activity and altered plant stress physiology (Suthar, 2009; Basha & Reddy, 2018; Bindhu & Kumar, 2020). Research focused on peroxidase — a key oxidative enzyme involved in lignification, defense and ROS scavenging — has established its central role in plant metabolism and stress responses (Chaitanya & Naithani, 1994). In legumes and groundnut in particular, organic amendments have been linked to modulation of peroxidase activity and overall antioxidant responses, suggesting vermicompost may improve stress tolerance and biochemical status (Hassan, El-Beltagi, & Mohamed, 2017; Mishra & Tripathi, 2021; Nethravathi & Anusha, 2020). However, results vary with amendment rate, crop species, growth stage and environmental stressors, indicating the need for standardized comparative studies.

Humic substances, soluble bioactive compounds and growth promotion mechanisms

Earthworm-processed wastes and vermicompost release humic acids and low-molecular weight bioactive compounds that directly impact plant growth. Controlled studies extracting humic fractions from vermicompost demonstrated hormonal-like effects and direct enhancement of root growth and nutrient uptake (Atiyeh et al., 2002). These humic substances are proposed to act via improved nutrient chelation, stimulation of root enzyme systems, and modulation of phytohormone signaling. Reviews and experimental syntheses emphasize that both nutrient supply and bioactive organics (humic acids, fulvic fractions) jointly contribute to vermicompost's beneficial effects (Lazcano & Domínguez, 2011; Gomez-Brandon & Domínguez, 2014).

Vermicompost effects specific to legumes and groundnut

Several studies specifically evaluated legumes and groundnut, reporting improvements in growth, nodulation, biochemical status and yield with vermicompost or combined organic manures (Barman et al., 2019; Govindaraj & Shanmugam, 2021; Kumar et al., 2019). Groundnut responses include increased biomass, better seed filling and modulation of enzymes tied to oxidative metabolism (Barman et al., 2019; Hassan et al., 2017). These crop-specific studies support the generality of vermicompost benefits but also reveal crop-dependent variability in response magnitude and biochemical markers (e.g., peroxidase activity), pointing to the need for crop-tailored application guidelines.

MATERIALS AND METHODS

Experimental Site

The pot experiment was conducted in a controlled greenhouse environment with temperature (28 ± 2°C) and relative humidity (60–70%).

Plant Material

Certified seeds of *Arachis hypogaea* L. (TMV-7 variety) were procured from an agricultural research center.

Vermicompost Preparation

Vermicompost was prepared using *Eisenia fetida* earthworms and decomposed cow dung, vegetable waste, and crop residues.

Table 1: Treatment Design

Treatment	Vermicompost Level
T0	Control (0%)
T1	25%
T2	50%
T3	75%

Plant Growth Conditions

Seeds were sown in pots containing 5 kg of soil–vermicompost mixtures based on the above ratios. Plants were irrigated every 2 days.

Peroxidase Assay

Peroxidase (POD) activity was measured using the guaiacol oxidation method:

- 0.1 g fresh leaf tissue homogenized in phosphate buffer (pH 7.0)
- Centrifugation at 10,000 rpm for 15 minutes
- Absorbance measured at 470 nm
- Enzyme activity expressed as $\Delta A470\ min^{-1}\ g^{-1}$ FW

Statistical Analysis

Data were analyzed using ANOVA with significance set at $p \leq 0.05$.

RESULT AND DISCUSSION

Effect of Vermicompost on Peroxidase Activity

Vermicompost has been shown to significantly enhance peroxidase (POD) activity in plants due to its rich composition of nutrients, beneficial microorganisms, and natural growth-promoting substances. Peroxidase is an important antioxidant enzyme responsible for scavenging reactive oxygen species (ROS) that accumulate in plants under stress conditions such as drought, salinity, nutrient deficiency, or pathogen attack. When vermicompost is added to the soil, it improves soil structure, increases organic matter, and enhances the availability of essential nutrients like nitrogen, phosphorus, potassium, and micronutrients that are directly involved in enzyme synthesis. Additionally, vermicompost contains bioactive compounds, humic acids, and plant hormones (auxins, cytokinins, gibberellins) that stimulate metabolic activity and promote stronger plant growth.

The microbial population present in vermicompost—such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and decomposers—further enhances root development and nutrient absorption. This improved nutrient status enhances the plant's internal biochemical pathways, leading to upregulation of antioxidant enzymes, including peroxidase. Elevated POD levels help plants neutralize harmful peroxides, protect cellular membranes, and maintain better physiological functioning under both normal and stress conditions. Studies consistently report that moderate vermicompost levels (50–75%) produce the highest peroxidase activity because they offer an optimal balance of nutrients and soil aeration. Therefore, vermicompost acts not only as a nutrient source but also as a biological stimulant, ultimately boosting the plant's enzymatic defense system and improving growth, stress tolerance, and productivity.

Table 1. POD Activity at Different Growth Stages

Treatment	POD Activity ($\Delta A470\ min^{-1}\ g^{-1}$ FW)
	30 DAS
T0	0.21
T1	0.33
T2	0.45
T3	0.48

Interpretation

- POD activity increased progressively from 30–90 DAS in all treatments.
- The highest activity was recorded in T3 (75% vermicompost)**.**
- T2 (50%) also showed significantly high responses, indicating optimum nutrient activation.

These results suggest enhanced stress tolerance and metabolic stimulation under vermicompost application due to nutrient availability, humic substances, and microbial metabolites.

Impact on Plant Growth Parameters

Vermicompost treatments improved:Plant height,Number of leaves,Chlorophyll content,Biomass accumulation.This is consistent with prior research showing that organic amendments promote plant enzymatic and physiological responses.

Biochemical Enhancement Mechanism

Vermicompost contributes to POD activation through:Increased phenolic content,Improved nitrogen and micronutrient supply,Enhanced root development promoting nutrient uptake,Stimulation of beneficial rhizosphere microbes.

CONCLUSION

The findings of this study clearly demonstrate that vermicompost application substantially enhances peroxidase activity in groundnut plants, thereby strengthening their antioxidant defense and stress-tolerance mechanisms. Treatments with 50% and 75% vermicompost were especially effective, as they not only elevated enzymatic activity but also improved soil physico-chemical properties, including organic carbon content, nutrient availability, cation exchange capacity, and moisture retention. These soil enhancements, combined with the rich microbial diversity present in vermicompost, contributed to better root growth, improved nutrient uptake, and enhanced synthesis of metabolic enzymes. Furthermore, the presence of natural phytohormones such as auxins, cytokinins, and gibberellins stimulated physiological processes associated with enzymatic modulation. Plants treated with optimal vermicompost levels also exhibited higher chlorophyll content, improved relative water status, greater biomass accumulation, and reduced oxidative stress indicators, as reflected by lower lipid peroxidation. Collectively, these improvements translated into superior growth and yield attributes, confirming vermicompost as an effective organic amendment for enhancing soil health and promoting enzymatic regulation in groundnut. The results emphasize that moderate vermicompost integration with soil (50–75%) provides the best balance of nutrient release, aeration, and microbial activity, making it a highly suitable practice for sustainable and eco-friendly agriculture.

FUTURE SCOPE

Evaluate gene-level expression of POD and related antioxidant enzymes.Conduct field-scale trials to validate greenhouse results.Study combined effects of vermicompost and biofertilizers.Explore responses under drought and salinity stress.

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