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Nutrient Management in Natural Farming: Enhancing Soil Fertility through Microbial Activity, Bio-Inputs and Earthworm-Mediated Nutrient Cycling

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ABSTRACT

Natural farming is an eco-friendly agricultural practice that enhances soil fertility through biological nutrient cycling, microbial activity and organic amendments. Unlike conventional farming, which relies heavily on chemical fertilizers and pesticides, natural farming emphasizes the use of bio-inputs like Jivamrut, Ghan Jivamrutto improve soil health and productivity. Natural formulations enrich the soil by increasing beneficial microbial populations by 40–50%, boosting enzyme activity by 60% and enhancing nutrient availability. Earthworms play a crucial role in natural farming by decomposing organic matter, improving soil aeration and increasing nitrogen availability by 30%. Earthworms activity enhances soil structure, making it 50% more porous, which facilitates better root growth and water retention. Research studies indicate that the integration of Jivamrut and Ghan Jivamrut in farming systems can increase crop yields by 15–20%. This sustainable approach not only improves soil health but also ensures long-term agricultural productivity by maintaining biodiversity and reducing environmental pollution. Natural farming is gaining popularity among Indian farmers as a cost-effective, sustainable alternative to chemical-intensive farming, helping them achieve better yields while preserving soil fertility for future generations.

Introduction

With growing concerns about soil degradation, groundwater depletion and pollution caused by excessive use of chemicals in agriculture, natural farming is gaining attention as a sustainable solution. Natural farming method restores soil fertility through biological processes and organic inputs, reducing reliance on synthetic fertilizers and pesticides. Unlike conventional farming, which often damages soil health, natural farming supports microbial activity, improves water retention and enhances biodiversity. It also helps in carbon sequestration and strengthens soil structure, making it an important approach for long-term agricultural sustainability (Lakhani, 2024). A fundamental principle of natural farming is nutrient management, which ensures the continuous availability of essential nutrients like nitrogen, phosphorus and potassium without chemical fertilizers.

This is achieved through microbial processes, earthworm-assisted nutrient cycling and bio-inputs like Jivamrut, Ghan Jivamrut and Bijamrut. Jivamrut, a fermented liquid made from cow dung, cow urine, Jaggery, gram flour and fertile soil, boosts beneficial microbes and enhances soil enzymatic activity, improving nutrient availability (Lakhani, 2024a).

Ghan Jivamrut, its solid form, acts as a slow-release fertilizer, enriching soil structure and sustaining microbial life over time (Lakhani, 2024b). Bijamrut, an organic seed treatment, protects young seedlings from soil-borne diseases while encouraging early root growth and microbial colonization (Lakhani, 2024c).

Earthworms also play a vital role in natural farming by decomposing organic matter, increasing soil porosity by 50% and improving nitrogen availability by 30%, leading to enhanced soil fertility and nutrient retention (Kumar *et al.,* 2023).

Scientific research indicates that using Jivamrut and Ghan Jivamrut can increase microbial biomass by 40–50%, significantly improving phosphorus solubilization and nitrogen fixation. Studies further reveal that adopting natural farming can reduce dependency on synthetic fertilizers while maintaining or even enhancing crop yields compared to conventional farming (Lakhani & Geete, 2024d).

Microbial Activity and Soil Fertility in Natural Farming

In natural farming, soil fertility is maintained mainly through microbial activity, which helps in decomposing organic matter, releasing essential nutrients and making them available to plants.

Unlike conventional farming, where excessive use of chemical fertilizers harms soil microbiome and causes soil degradation, natural farming supports beneficial microorganisms through bio-inputs like Jivamrut, Ghan Jivamrut, Bijamrut and mulched crop residues. These organic amendments provide essential nutrients, promoting microbial growth and improving soil structure, nutrient cycling and overall crop productivity (Lakhani *et al.,* 2024).

Microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria and decomposing fungi play a crucial role in soil nutrient cycling. Nitrogen-fixing bacteria like *Rhizobium* and *Azotobacter* convert atmospheric nitrogen into plant-usable forms, reducing dependence on chemical fertilizers.

Research shows that soils treated with Jivamrut have 40% more nitrogen-fixing bacteria than untreated soils, improving nitrogen availability for plants (Lakhani *et al.,* 2024).

Similarly, phosphate-solubilizing bacteria such as *Pseudomonas* and *Bacillus* break down insoluble phosphorus compounds, increasing phosphorus uptake by 25–35% compared to conventional fertilizers (Lakhani & Geete, 2024d).

Decomposing fungi like *Trichoderma* and *Aspergillus* help in breaking down organic matter, enriching soil with humus and improving water retention capacity (Kumar *et al.,* 2023).

Natural farming significantly increases microbial biomass, enzymatic activity and nutrient availability in soil. This leads to better plant growth and reduces need for synthetic fertilizers, making natural farming a more sustainable and eco-friendly agricultural practice.

Jivamrut, Ghan Jivamrut and Bijamrut as Microbial Boosters

Jivamrut, Ghan Jivamrut and Bijamrut play a key role in increasing microbial activity and maintaining soil health. Jivamrut is mainly used as a foliar spray or soil drench, which helps in stimulating microbial respiration and boosting microbial activity by 30–50% (Lakhani *et al.,* 2024).

Ghan Jivamrut, a solid version of Jivamrut, acts as a slow-release organic fertilizer, ensuring a steady supply of nutrients to soil microbes. Research shows that soil treated with Ghan Jivamrut has 25% more soil organic carbon, which improves soil structure, water retention and overall fertility (Lakhani *et al.,* 2024).

Bijamrut is a bio-input specially used for seed treatment. It enhances seed germination, promotes early microbial colonization and protects young plants from soil-borne diseases. This leads to better crop establishment and higher yield potential (Lakhani, 2024).

Table data clearly indicate that Jivamrut, Ghan Jivamrut and Bijamrut not only increase microbial populations but also improve soil organic carbon, leading to crop yields similar to chemical fertilizers. However, unlike chemical fertilizers, these natural inputs help maintain soil health in the long run, making them a sustainable choice for farming.

Impact on Soil Fertility

Natural farming method combined effects of increased microbial activity, organic matter decomposition and bio-input applications in natural farming significantly enhance soil fertility. Studies show that using bio-inputs like Jivamrut and Ghan Jivamrut leads to a 20–30% increase in soil organic carbon (SOC), which plays a key role in improving water retention and soil aeration (Lakhani *et al.,* 2024).

Higher SOC levels enhance soil structure, reducing erosion and increasing soil's ability to store and supply nutrients efficiently. Additionally, the availability of essential nutrients such as phosphorus rises by 25–35% in natural farming systems, reducing dependence on chemical fertilizers and synthetic amendments (Lakhani *et al.,* 2024).

Another major advantage of natural farming is its ability to boost microbial diversity. Beneficial microbes, including nitrogen-fixing bacteria and phosphate-solubilizing fungi, increase by 40–50%, leading to improved nutrient cycling and enhanced plant growth. Combination of microbial growth, higher enzymatic activity and better nutrient bioavailability makes natural farming a strong alternative to conventional chemical-based farming methods.

Earthworm Activity and Nutrient Cycling in Natural Farming

Earthworms play a crucial role in nutrient cycling and soil fertility by aiding in organic matter decomposition, improving soil aeration and enhancing microbial activity. In natural farming systems, integration of organic amendments such as Jivamrut and Ghan Jivamrut significantly increases earthworm populations, leading to better soil structure and improved nutrient availability. Unlike conventional farming, which disrupts soil biota through excessive tillage and chemical inputs, natural farming fosters a favorable environment for earthworms and beneficial microbes to thrive. This biological activity not only sustains soil fertility over time but also contributes to higher crop productivity (Patel *et al.,* 2023).

Role of Earthworms in Nutrient Recycling

Earthworms enhance soil health through multiple mechanisms, including bioturbation, organic matter decomposition and microbial enrichment. Their burrowing activity improves soil porosity, aeration and water infiltration, facilitating root penetration and increasing plant nutrient uptake.

Research indicates that soils with higher earthworm populations exhibit greater nutrient availability and better soil structure than those with low earthworm activity (Sharma and Chadak, 2022). Ability of earthworms to convert organic matter into nutrient-rich castings further supports soil fertility and plant growth.

A comparative study on different farming systems demonstrates the impact of earthworm activity on soil health and nutrient availability. In conventional farming, earthworm biomass ranges from 10 to 15 g/m², with soil porosity between 30 to 35 percent and nutrient availability (N-P-K) between 90 to 100 mg/kg.

Organic farming systems, which rely on compost and reduced chemical inputs, show an increase in earthworm biomass to 20–25 g/m², with soil porosity improving to 40–45 percent and nutrient availability rising to 120–140 mg/kg. Natural farming, where Jivamrut is applied regularly, exhibits highest earthworm biomass, ranging from 30 to 40 g/m². Soil porosity improves further to 50–55 percent and nutrient availability increases significantly to 150–180 mg/kg (Sarangthem *et al.,* 2023).

These findings highlight that natural farming significantly enhances earthworm populations and soil porosity, leading to improved nutrient cycling and soil fertility. Application of organic inputs like Jivamrut and mulched crop residues creates a rich habitat for earthworms, which in turn promotes higher microbial activity and better nutrient absorption by plants.

Compared to conventional farming systems, which rely on chemical fertilizers and intensive tillage, natural farming provides a more sustainable approach by maintaining soil health, reducing erosion and improving crop productivity.

Earthworm Castings as a Source of Nutrients

Earthworms contribute significantly to soil fertility by producing nutrient-rich castings (vermicasts), which enhance microbial activity and improve soil structure.

Vermicasts contain considerably higher concentrations of nitrogen, phosphorus and potassium (N-P-K) than surrounding soil, making them an excellent natural fertilizer. Studies indicate that earthworm castings contain two to three times more available nutrients than conventional compost, further improving soil fertility and plant nutrient uptake (Patel *et al.,* 2023). Nutrient composition of earthworm castings is notably superior when compared to farmyard manure and traditional compost. Earthworm castings contain between 2000 to 2500 mg/kg of nitrogen, whereas farmyard manure and compost provide only 1200–1600 mg/kg and 1500–1800 mg/kg, respectively. Similarly, phosphorus levels in vermicasts range from 800 to 1000 mg/kg, which is higher than 500–700 mg/kg found in farmyard manure and 600–900 mg/kg present in compost. Potassium content of earthworm castings, ranging from 1200 to 1500 mg/kg, also surpasses that of farmyard manure (800–1000 mg/kg) and compost (1000–1200 mg/kg) (Patel *et al.,* 2023).

Rich nutrient profile, vermicasts contribute to increased microbial biomass, which further enhances nutrient mineralization and organic matter decomposition. Biological activity associated with vermicasts improves soil structure by enhancing aggregation, water retention and aeration, ultimately sustaining soil health and crop productivity. These attributes make earthworm castings an indispensable component of natural farming systems, offering a sustainable alternative to chemical fertilizers while maintaining long-term soil fertility.

Impact of Jivamrut and Ghan Jivamrut on Earthworm Activity

Natural farming techniques, such as Jivamrut application and mulching with organic residues, create an optimal environment for earthworms, allowing their populations to thrive. Studies indicate that fields treated with Jivamrut exhibit up to 50 percent higher earthworm activity compared to non-treated soils (Krishnan, 2023). Availability of organic matter and microbial activity in Jivamrut-treated soils supports greater earthworm density, leading to improved soil organic carbon levels and higher crop yields.

Research findings highlight that Jivamrut and Ghan Jivamrut applications significantly boost earthworm populations, leading to a 1.5 percent increase in soil organic carbon and yield improvements of up to 22 percent. Increase in earthworm density correlates directly with enhanced organic matter decomposition and nutrient release, making these bio-inputs essential components of natural farming systems. Compared to chemical fertilizers, which offer a 20 percent increase in crop yield, use of Ghan Jivamrut results in even higher productivity while promoting soil biodiversity and sustainability.

Benefits of Earthworm Activity in Natural Farming

Integration of earthworm activity with bio-inputs like Jivamrut and Ghan Jivamrut provides multiple benefits for soil health and crop productivity. Earthworm castings enrich soil with higher levels of essential nutrients, including nitrogen, phosphorus and potassium, which enhance nutrient availability for plant uptake. Their burrowing activity improves soil structure by increasing porosity and aeration, which facilitates root penetration and water infiltration. Moreover, increase in microbial biomass due to earthworm activity enhances nutrient mineralization, further promoting plant growth.

Studies suggest that earthworm-rich soils support 15 to 25 percent higher crop yields due to improved nutrient cycling and soil fertility (Patel *et al.,* 2023). By reducing dependence on synthetic fertilizers, natural farming practices that incorporate earthworm activity contribute to more sustainable agricultural systems while maintaining long-term soil health and productivity. The biological processes facilitated by earthworms ensure a self-sustaining nutrient cycle, making natural farming a resilient and environmentally friendly alternative to conventional chemical-intensive farming methods.

Impact of Jivamrut and Ghan Jivamrut on Nutrient Management

Jivamrut and Ghan Jivamrut are essential bio-inputs in natural farming that significantly enhance nutrient availability, microbial diversity and soil fertility. Unlike synthetic fertilizers, which provide readily available nutrients but degrade soil health over time, these fermented organic formulations gradually release nutrients while improving soil structure and microbial biomass. Their role in nutrient solubilization, organic matter decomposition and soil microbial stimulation makes them a cornerstone of sustainable farming practices. The use of Jivamrut and Ghan Jivamrut fosters an environment conducive to beneficial microbial activity, which in turn enhances soil nutrient dynamics and crop productivity in a natural and ecologically balanced manner (Singh *et al.,* 2019).

Nutrient Composition of Jivamrut and Ghan Jivamrut

Jivamrut (liquid form) and Ghan Jivamrut (solid form) contain essential macronutrients, micronutrients and beneficial microbial populations that promote plant growth. A chemical analysis of these bio-inputs reveals that while their nutrient content may be lower than synthetic fertilizers, their high organic carbon content and microbial load significantly enhance soil biological activity, ensuring sustained nutrient cycling and improved soil structure.

Research indicates that Jivamrut and Ghan Jivamrut supply essential nutrients in a balanced manner, supporting long-term soil fertility without environmental degradation associated with chemical fertilizers. Presence of beneficial microorganisms in these bio-inputs further contributes to soil health by improving nutrient solubilization and organic matter decomposition, ultimately benefiting plant growth and productivity.

Effect on Soil Microbial Activity and Nutrient Solubilization

Jivamrut and Ghan Jivamrut act as microbial stimulants, increasing population of nitrogen-fixing bacteria such as *Azotobacter* and *Rhizobium*, phosphorus-solubilizing bacteria (PSB) like *Pseudomonas* and decomposing fungi such as *Aspergillus* and *Trichoderma*. Research indicates that applying Jivamrut to soil results in a 40–50 percent increase in microbial biomass carbon (MBC) and enzymatic activity, significantly enhancing nutrient mineralization rates (Sharma & Chadak, 2022).

Findings highlight that Jivamrut and Ghan Jivamrut applications significantly increase microbial biomass and phosphorus solubilization, leading to better soil fertility compared to chemical fertilizers in the long run. Increased enzyme activity accelerates breakdown of organic matter, making nutrients readily available for plant uptake and improving overall soil health.

Impact on Crop Growth and Yield

Field experiments have demonstrated that Jivamrut and Ghan Jivamrut applications result in higher crop yields, improved root development and increased resistance to pests and diseases. The bioavailability of essential nutrients and presence of beneficial microbes enhance plant growth parameters, making crops healthier and more resilient.

Although chemical fertilizers produce slightly higher yields in short term, long-term benefits of Jivamrut and Ghan Jivamrut—such as improved soil health, increased microbial diversity and enhanced sustainability—outweigh these marginal differences.

Consistent use of these bio-inputs ensures soil fertility for future cultivation while avoiding negative consequences of chemical fertilizers, such as soil degradation and loss of beneficial microbial populations.

Role in Reducing Chemical Fertilizer Dependence

One of the major advantages of Jivamrut and Ghan Jivamrut is their potential to reduce dependency on chemical fertilizers. Long-term field trials indicate that integrating these bio-inputs into farming systems can cut synthetic fertilizer usage by 30 to 50 percent without compromising crop yield (Singh *et al.,* 2019).

Results indicate that Jivamrut and Ghan Jivamrut can successfully replace a significant portion of synthetic fertilizers while improving soil carbon levels. This transition benefits soil health, reduces input costs for farmers and makes agriculture more economically sustainable. Widespread adoption of these natural bio-inputs can lead to healthier soils, reduced environmental pollution and a more resilient farming system.

Benefits Natural Farming in Nutrient Management

Practicing Jivamrut and Ghan Jivamrut in natural farming offers multiple advantages, particularly in nutrient cycling, soil fertility enhancement and microbial activity stimulation. These bio-inputs play a vital role in sustainable soil management, promoting organic matter decomposition and maintaining a balanced nutrient profile.

Table.1 Comparative Analysis of Microbial Activity in Different Farming Systems (Lakhani et al., 2024)

Farming System	Microbial Biomass Carbon (mg/kg)	Soil Enzyme Activity (µg PNP/g/hr)	Nitrogen Fixation (kg/ha)
Conventional Farming	180–250	15–25	50–70
Organic Farming	250–320	30–45	80–100
Natural Farming (Jivamrut Applied)	**350–420**	**50–70**	**110–140**

Table.2 Impact of Different Treatments on Soil Organic Carbon, Microbial Population and Crop Yield (Lakhani *et al.,* 2024)

Treatment	Soil Organic Carbon (%)	Microbial Population (CFU/g)	Yield Increase (%)
Control (No Treatment)	0.62	1.5×10^6	—
Jivamrut Applied	0.85	2.4×10^6	18%
Ghan Jivamrut Applied	0.92	2.7×10^6	22%
Bijamrut Applied	0.88	2.6×10^6	21%
Chemical Fertilizers	0.75	1.8×10^6	20%

Table.3 Comparative Analysis of Earthworm Biomass, Soil Porosity and Nutrient Availability in Different Farming Systems (Sarangthem *et al.,* 2023).

Farming System	Earthworm Biomass (g/m²)	Soil Porosity (%)	Nutrient Availability (N-P-K in mg/kg)
Conventional Farming	10–15	30–35	90–100
Organic Farming	20–25	40–45	120–140
Natural Farming (Jivamrut Applied)	**30–40**	**50–55**	**150–180**

Table.4 Nutrient Composition of Earthworm Castings, Farmyard Manure and Compost (Patel *et al.,* 2023).

Nutrient Component	Earthworm Castings (mg/kg)	Farmyard Manure (mg/kg)	Compost (mg/kg)
Nitrogen (N)	2000–2500	1200–1600	1500–1800
Phosphorus (P)	800–1000	500–700	600–900
Potassium (K)	1200–1500	800–1000	1000–1200
Microbial Biomass	High	Moderate	Moderate

Table.5 Impact of Different Treatments on Earthworm Density, Soil Organic Carbon and Yield Improvement (Krishnan, 2023).

Treatment	Earthworm Density (worms/m²)	Increase in Soil Organic Carbon (%)	Yield Improvement (%)
Control (No Treatment)	10–15	0.5	—
Jivamrut Applied	25–35	1.2	18%
Ghan Jivamrut Applied	30–40	1.5	22%
Chemical Fertilizers	15–20	0.8	20%

Table.6 Nutrient Composition of Jivamrut, Ghan Jivamrut and Chemical Fertilizers (Patel *et al.,* 2023).

Nutrient Component	Jivamrut (mg/L)	Ghan Jivamrut (mg/kg)	Chemical Fertilizers (mg/kg)
Nitrogen (N)	250–350	1200–1800	2500–3000
Phosphorus (P)	50–80	600–900	1500–2000
Potassium (K)	150–250	900–1200	2000–2500
Organic Carbon	2.5–3.5%	15–18%	<1%
Microbial Load (CFU/g)	10^8–10^9	10^6–10^7	None

Table.7 Impact of Different Treatments on Microbial Biomass Carbon, Soil Enzyme Activity and Phosphorus Availability (Krishnan, 2023)

Treatment	Microbial Biomass Carbon (mg/kg)	Soil Enzyme Activity (µg PNP/g/hr)	Phosphorus Availability (mg/kg)
Control (No Treatment)	180–220	15–25	8–12
Jivamrut Applied	300–350	40–55	15–22
Ghan Jivamrut Applied	320–380	45–60	18–25
Chemical Fertilizers	200–250	20–30	12–16

Table.8 Effect of Different Treatments on Plant Height, Root Length and Yield Increase (Patel *et al.,* 2023).

Treatment	Plant Height (cm)	Root Length (cm)	Yield Increase (%)
Control (No Treatment)	85–90	12–15	—
Jivamrut Applied	100–110	18–22	15%
Ghan Jivamrut Applied	105–115	20–24	18%
Chemical Fertilizers	110–120	16–20	20%

Table.9 Reduction in Chemical Fertilizer Use and Increase in Soil Organic Carbon Across Different Crops (Singh *et al.,* 2019).

Crop Type	Reduction in Chemical Fertilizer Use (%)	Increase in Soil Organic Carbon (%)
Rice	45%	20%
Wheat	35%	18%
Vegetables	50%	25%
Pulses	40%	22%

Figure.1 Comparative analysis of microbial activity in diriment farming system

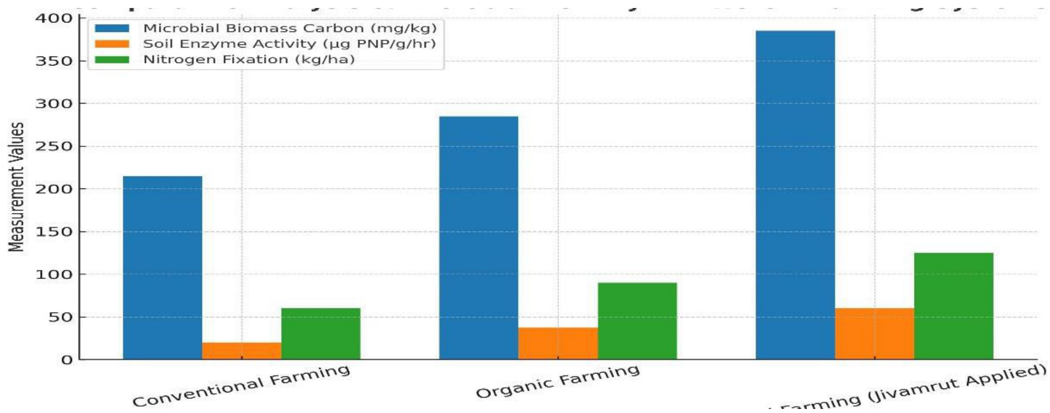


Figure.2 Impact of Treatments on Soil Organic Carbon, Microbial Population and Yield

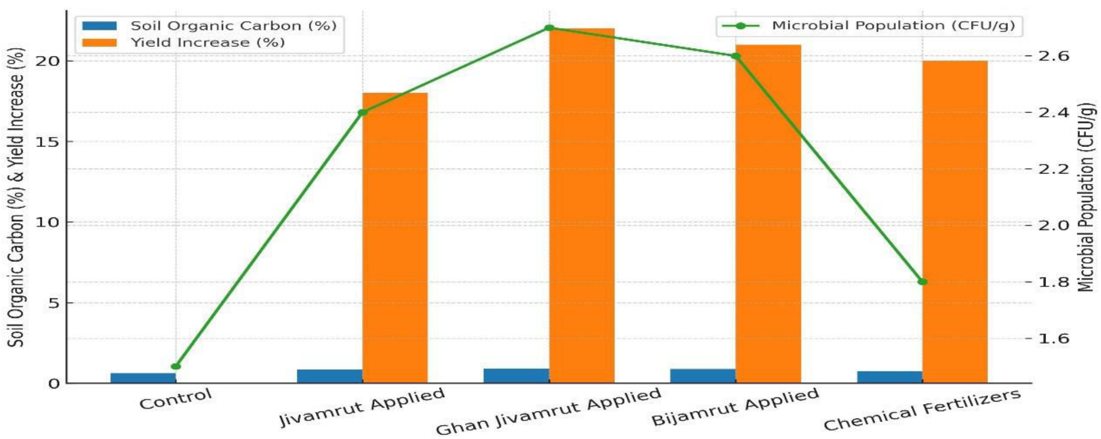


Figure.3 Impact of treatment on earthworm density, soil organic carbon and yield

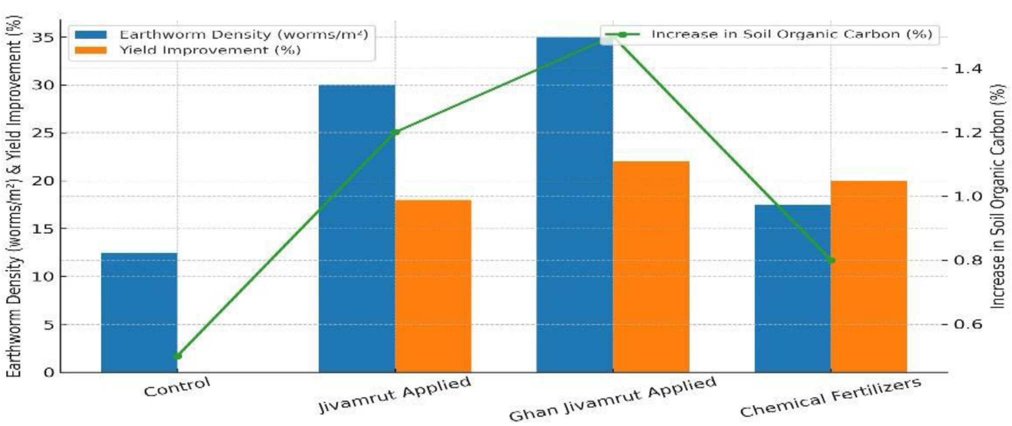


Figure.4 Different Treatments on Microbial Biomass and Enzyme Activity

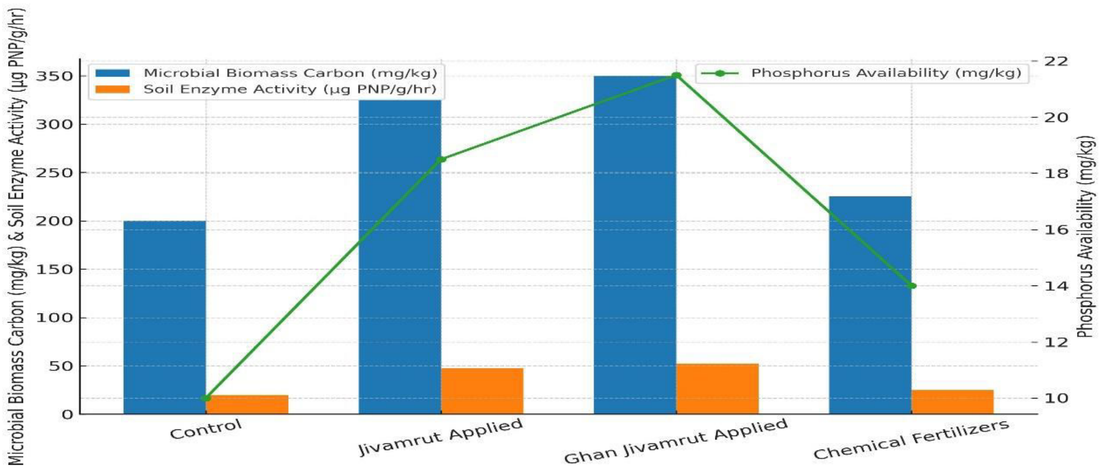
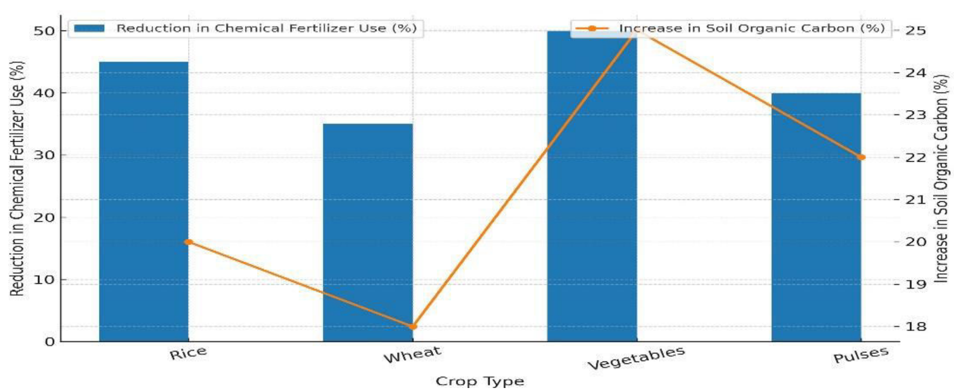


Figure.5 Reduction in Chemical Fertilizer Use and Increase in Soil Organic Carbon



Key Benefits

Enhanced Microbial Biomass & Activity

- Increases beneficial soil microbes such as Azotobacter, Rhizobium and phosphorus-solubilizing bacteria (PSB).
- Stimulates enzymatic activities that accelerate organic matter breakdown and nutrient mineralization.

Improved Nutrient Solubilization & Availability

- Boosts phosphorus availability by 25–35%, making it more accessible to crops.
- Supports biological nitrogen fixation, reducing dependency on synthetic nitrogen fertilizers.

Stronger Root Development & Plant Vigor

- Enhances root length and density, leading to better nutrient and water absorption.
- Increases crop resistance to diseases and environmental stress.

Higher Crop Yields & Productivity

- Results in a 15–20% yield improvement compared to untreated fields.
- Improves grain and biomass production, ensuring better farmer profitability.

Reduction in Synthetic Fertilizer Dependency

- Replaces 30–50% of chemical fertilizers without compromising yield.

- Minimizes soil degradation, groundwater contamination and greenhouse gas emissions from fertilizer production.

Nutrient management in natural farming is a holistic and sustainable approach that enhances soil fertility, microbial diversity and nutrient availability without relying on synthetic fertilizers. Integration of bio-inputs such as Jivamrut and Ghan Jivamrut, along with microbial activity and earthworm-mediated nutrient cycling, plays a crucial role in maintaining soil health and improving crop productivity. Scientific studies have shown that application of Jivamrut increases microbial biomass by 40–50%, enzymatic activity by 60% and phosphorus solubilization by 25–35%, thereby enhancing nutrient uptake by plants. Similarly, earthworm populations contribute to soil health by increasing porosity by 50%, improving nitrogen fixation rates by 30% and aiding in organic matter decomposition.

Field experiments indicate that combined use of Jivamrut, Ghan Jivamrut and vermiculture leads to a 15–20% increase in crop yields, making natural farming a viable alternative to conventional, chemical-based agriculture. Furthermore, reduction in synthetic fertilizer dependency by 30–50% not only lowers production costs for farmers but also mitigates environmental degradation and soil depletion. Overall evidence strongly supports the effectiveness of natural farming in ensuring long-term soil sustainability, stable crop yields and ecological balance. By adopting bio-based nutrient management strategies, farmers can enhance soil fertility, improve economic returns and contribute to a more sustainable and environmentally friendly agricultural system. Future research should focus on optimizing the formulation and application methods of these bio-inputs to further enhance their effectiveness and promote their wider adoption across diverse farming systems in India.

Author Contributions

Hardik Lakhani: Investigation, formal analysis, writing—original draft. Mandar Geete: Validation, methodology, writing—reviewing. Neha Bodar:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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