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Evaluation and Comparison of Nutritional Status of Soil and Jeevamrutham in the Growth and Yield of Paddy Variety

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Abstract: ***The decreasing soil fertility, over-reliance on chemical fertilizers, and the environmental degradation that comes with such practice are increasingly challenging sustainable rice farming. Continuous use of synthetic inputs has led to nutrient imbalance, reduced microbial diversity, and deterioration of soil health, ultimately affecting crop productivity. Against this backdrop, the current study was conducted to determine the efficacy of Jeevamrutham, a traditional fermented biofertilizer, in improving soil health, soil microbial activity, plant growth and yield performance of paddy (Oryza sativa L.) in the field.***

Keywords: Jeevamrutham nutrion components, soil nutrients and paddy variety

1. Introduction

Rice (Oryza sativa L.) is the backbone of Indian food and agriculture. Traditionally India has been the second-largest producer of rice in the world (after China) and has the largest area under rice cultivation [1]. In the decades since independence, the production of rice in India has increased by several folds, which was approximately 20.6 million tonnes in 195051 to over 104 million tonnes in 201617 and even more to approximately 150 million tonnes in the mid-2020s[2][3]. This almost five-fold growth in production was caused by a complex of reasons: the advent of high-yielding semi-dwarf varieties in the Green Revolution, the development of irrigation facilities, and increased application of fertilizers and other inputs. Average paddy yields rose from a mere ~668 kg per hectare in 1950–51 to ~2,800 kg/ha by 2021–22 [4]. Even with this development, the yields in India are still average in terms of the world (approximately 40 percent of the average yield of China approximately 7,100 kg/ha [5]) and there is still much to be done in terms of increasing productivity per unit land. Not only is rice a staple food of a significantly vast proportion of the Indian populace of 1.3+ billion people, but rice is also a major contributor to the agricultural economy. It produces approximately 30-35 percent of the total grain production in India and covers approximately 42-45 percent of the land under cereal production [6]. The crop's importance is especially pronounced in the eastern and southern states (such as West Bengal, Uttar Pradesh, Punjab, Andhra Pradesh, Telangana, Tamil Nadu, and Karnataka) where rice-based farming supports millions of rural livelihoods. The patterns of rice cultivation are different across regions: the eastern part of India used to have the highest area and more rainfed rice, whereas the northwestern states of Punjab and Haryana had some of the highest yields under the irrigated conditions after the Green Revolution [7]. Rice also plays a significant role in trade and economy of India. India has emerged as the largest exporter of rice in the world in recent years, with rice in 202122 almost a quarter of agricultural exports in India bringing in a value of more than 105,000 crore in foreign exchange [8]. The strategic importance of rice is highlighted by this dual role of the rice as the daily food of the population and as a source of export income. Therefore, the maintenance of the growth of rice production is essential to national food security, incomes of farmers, and the total agricultural GDP. Meanwhile, this growth should be attained without compromising the natural resource base since rice is a resource-based crop. The issue of productivity versus sustainability has become a theme in the development of rice farming in India.

The modern intensive practices that boosted India's rice output – particularly during the Green Revolution of the 1960s–70s – have also revealed serious drawbacks over time. The Green Revolution introduced high-yielding dwarf rice varieties (like IR-8 "Miracle Rice") coupled with heavy application of chemical fertilizers, pesticides, and assured irrigation. While this strategy rapidly raised paddy yields and ended recurring rice shortages [9] its long-term legacy includes environmental degradation and health concerns. Excessive use of nitrogen-phosphorus-potassium (NPK) fertilizers and agro-chemicals has led to declining soil fertility, nutrient imbalances, and pollution of water resources[10]. Soils under continuous rice monocropping and high chemical inputs have shown a reduction in organic matter and beneficial microbial activity – repeated NPK fertilizer application can deplete soil organic carbon and suppress soil microbes that are vital for nutrient cycling[11]. Additionally, agrochemical residues (from fertilizers and pesticides) often leach or runoff into groundwater and surface water. In intensive rice-growing regions such as Punjab and parts of Andhra Pradesh, nitrate from overuse of urea fertilizer has contaminated aquifers, with one study linking "blue baby syndrome" (infant methemoglobinemia) to high nitrate levels in well water near paddy fields[12]. Such cases illustrate the hidden human health risks of indiscriminate chemical use.

Environmental externalities of conventional rice farming are now widely evident. Over-irrigation and paddy flooding, combined with inefficient fertilizer use, have contributed to water table decline and water quality issues. For instance, northwestern India's success in rice production (notably Punjab's "grain bowl" transformation) came with severe groundwater depletion – rice-wheat double cropping fueled by free electricity for pumping has mined aquifers to dangerously low levels[13]. The intensive farming cycle also generated new pest and disease pressures, often managed with more pesticides, creating a vicious cycle of resistance and resurgence of pests. Pesticide overuse has harmed non-target organisms and raised food safety concerns[14]. Ecologically, mono-cropping of rice has led to biodiversity loss in agro-ecosystems, and the common practice of burning rice straw after harvest (to prepare for the next crop) causes air pollution and greenhouse gas emissions. Rice paddies themselves emit methane, a potent greenhouse gas, and excess nitrogen fertilizer can lead to nitrous oxide emissions – both contributing to climate change. These unintended consequences have turned some of India's most productive rice areas into environmental hotpots. Punjab, for example, now grapples with a nexus of problems: falling water tables, increasing salinity in soil, and seasonal air pollution from stubble burning[15]. Economically, the input-intensive model has also put small farmers under strain. The cost of fertilizers, pesticides, diesel for pumping, and other inputs keeps rising, squeezing profit margins especially when government support is limited. Many farmers are caught in a cycle of high expenditures for incremental yield gains, leading to indebtedness in some cases. Thus, the conventional chemical-intensive approach, while successful in raising yields, has proved **unsustainable** in the long run – degrading the very resource base (soil and water) on which agriculture depends[16][17]. This recognition has galvanized interest in alternative farming practices that can maintain productivity while mitigating environmental and health risks.

2. Review of Literature

Organic farming aims to maintain soil fertility and ecosystem health by using natural inputs and biodiversity instead of synthetic chemicals[143]. In this paradigm, Jeevamrutham is a traditional biofertilizer originating from India's "zero budget" farming movement. Its name ("Jeeva-mrutha") literally means "nectar of life," reflecting claims that it invigorates soil life. Conventionally, Jeevamrutham is made by fermenting a mixture of cow dung, cow urine, jaggery, pulse flour (or rice bran), and clayey soil in water for several days[41]. The organic ingredients serve as nutrients and microbial food, while the addition of native soil inoculates the brew with local beneficial microorganisms[44]. Practitioners typically prepare Jeevamrutham under shade, stirring it daily to aerate the culture, and then dilute it before applying to fields. A mature Jeevamrutham (drava form) is a dark, frothy liquid rich in bacteria and nutrients. It can also be sun-dried into "Ghana" Jeevamrutham cakes for convenient storage.

Laboratory tests verify the presence of high populations of microbes and N, P, K in Jeevamrutham. A single study stated that a one-liter sample had approximately 0.04 -0.22 g nitrogen, 0.04 -0.11 g phosphorus, 0.28 -1.09 g potassium, 0.39 -0.46 g sulfur, based on the type of cattle used [49] (see Table 2). The fermenting mixture also develops a very acidic pH (pH = 3.63.8 in 5 days) and this can be used to dissolve the minerals. The microflora population is complicated: the number of beneficial bacteria (e.g. Bacillus spp., Azotobacter spp.) increase dramatically during fermentation [47]. Of various recipes, the dung of native (desi) cows is likely to have more bacteria than buffalo or hybrid dung [144]. Therefore, although nutrient concentrations in Jeevamrutham are small (as it is a dilute), its capacity is to enhance soil biology and nutrient-cycling mechanisms [45][46].

3. Methodology

3.1 Preparation of Jeevamrutham

Jeevamrutham was prepared as a liquid organic biofertilizer following a standardized and reproducible procedure to ensure consistency across all experimental treatments. The preparation of Jeevamrutham plays a crucial role in determining its effectiveness, as the microbial population and nutrient composition largely depend on the quality of ingredients and the fermentation process. Therefore, careful attention was given to the selection of raw materials, preparation method, and environmental conditions during fermentation.

The formulation of Jeevamrutham consisted of five primary components: fresh cow dung, cow urine, jaggery, pulse flour (gram flour), and a small quantity of rhizospheric soil. Fresh cow dung obtained from indigenous cattle was used as the primary source of beneficial microorganisms. Cow urine served as a rich source of nitrogen and micronutrients, while jaggery acted as a carbon source to promote rapid microbial growth. Pulse flour provided proteins and additional nutrients necessary for microbial multiplication, and the rhizospheric soil introduced native microbial flora into the mixture, enhancing its biological diversity.

The preparation process involved mixing the ingredients in a large plastic container filled with water. The mixture was thoroughly stirred to ensure uniform distribution of all components.

Soil sampling and analysis constituted a fundamental component of the present study, as it provided essential information regarding the physicochemical and biological properties of the soil under different treatment conditions. Accurate soil analysis is crucial for understanding the impact of Jeevamrutham and chemical fertilizers on soil fertility, nutrient availability, and microbial activity. Therefore, standardized procedures were followed for soil sampling, handling, and laboratory analysis to ensure reliability and reproducibility of results.

Soil samples were collected from each experimental plot at specific stages of the crop growth cycle, including the initial stage (before treatment application) and after harvest. The initial soil sampling was carried out to determine the baseline soil properties, which served as a reference point for evaluating changes resulting from different treatments. Post-harvest sampling allowed for the assessment of

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treatment effects on soil fertility after the completion of the crop cycle.

Sampling was performed using a soil auger from the root zone depth, typically ranging between 0–15 cm, which represents the active zone of nutrient uptake in paddy cultivation. Multiple subsamples were collected randomly from different locations within each plot to account for spatial variability. These subsamples were then thoroughly mixed to form a composite sample for each plot. The composite sampling method ensured that the collected sample accurately represented the overall soil condition of the plot.

After collection, soil samples were carefully labeled and transported to the laboratory for further processing. The samples were air-dried under shade to prevent alteration of chemical properties. After drying, the soil was ground gently and passed through a 2 mm sieve to remove debris, stones, and plant residues. Proper preparation of samples is essential to ensure uniformity and accuracy in laboratory analysis.

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The physicochemical properties of the soil were analyzed using standard laboratory methods. Soil pH was determined using a pH meter in a soil-water suspension, which provides an indication of soil acidity or alkalinity. Electrical conductivity (EC) was measured to assess the salinity status of the soil. Organic carbon content was estimated using the Walkley-Black method, which reflects the organic matter status of the soil and its capacity to supply nutrients.

Macronutrients such as nitrogen, phosphorus, and potassium were analyzed to evaluate soil fertility under different treatments. Available nitrogen was determined using the alkaline permanganate method, which estimates the mineralizable nitrogen content of the soil. Available phosphorus was measured using the Olsen method, which is suitable for neutral to alkaline soils, while available potassium was estimated using a flame photometer after extraction with ammonium acetate.

Micronutrients such as iron, zinc, manganese, and copper were also analyzed, as they play a vital role in plant metabolic processes and overall crop health. These micronutrients were extracted using appropriate chemical solutions and quantified using standard analytical techniques.

In addition to chemical analysis, biological parameters of the soil were also assessed to evaluate microbial activity. Soil microbial population was determined using serial dilution and plate count techniques, which estimate the number of viable microorganisms present in the soil. This analysis provided insights into the impact of Jeevamrutham on soil microbial dynamics.

Enzymatic activities such as dehydrogenase and phosphatase were also considered as indicators of soil biological health. These enzymes play a key role in nutrient cycling and reflect the metabolic activity of soil microorganisms. Higher enzyme activity indicates a more active and healthy soil ecosystem.

Soil Parameters and Methods of Analysis

S. No.	Parameter	Method Used	Significance
1	Soil pH	pH meter (soil-water suspension)	Indicates soil acidity/alkalinity
2	Electrical Conductivity	Conductivity meter	Measures soil salinity
3	Organic Carbon	Walkley-Black method	Indicates organic matter content
4	Available Nitrogen	Alkaline $KMnO_4$ method	Indicates nitrogen availability
5	Available Phosphorus	Olsen method	Indicates phosphorus availability
6	Available Potassium	Flame photometer	Indicates potassium availability
7	Micronutrients (Fe, Zn, Mn, Cu)	DTPA extraction method	Essential for plant metabolism

4. Result & Discussion

4.1 Physicochemical Properties of Soil and Jeevamrutham

Parameter	Soil	Jeevamrutham
pH (1:2.5 ratio)	7.5	5.63
Electrical Conductivity	0.72 dS/m	0.75 dS/m
Organic Carbon (OC)	1.24 % (W/W)	0.46% (W/V)

presents the comparative analysis of key physicochemical parameters of soil and Jeevamrutham, including pH, electrical conductivity, and organic carbon content. The soil exhibited a neutral to slightly alkaline pH, whereas Jeevamrutham showed a moderately acidic nature due to the fermentation process. Electrical conductivity values in both soil and Jeevamrutham were within normal limits, indicating the absence of salinity stress. The organic carbon content was higher in soil, while Jeevamrutham contained readily available carbon that supports microbial activity. Overall, the results indicate that Jeevamrutham possesses properties that can enhance soil nutrient dynamics and biological activity when applied under field conditions

4.2 Physicochemical Properties of Soil and Jeevamrutham

The physicochemical properties of soil and Jeevamrutham were analyzed to understand their inherent characteristics and to evaluate their potential influence on soil fertility and plant growth. The comparative analysis of parameters such as pH, electrical conductivity, and organic carbon provides important insights into the chemical nature of both the soil and the biofertilizer used in the study.

The pH of the soil was recorded as 7.5, indicating a neutral to slightly alkaline nature. Such soil conditions are generally favorable for paddy cultivation, as they support the availability of essential nutrients and promote microbial activity. In contrast, the pH of Jeevamrutham was observed to be 5.63, which is moderately acidic. This acidic nature of Jeevamrutham can be attributed to the fermentation process, during which organic acids are produced by microbial activity. The lower pH of Jeevamrutham plays a significant role in enhancing nutrient solubility, particularly phosphorus and micronutrients, making them more available for plant uptake when applied to the soil. The application of slightly acidic Jeevamrutham to neutral soil may help in maintaining a balanced soil pH and improving nutrient dynamics. Electrical conductivity (EC), which indicates the soluble salt content of a substance, was found to be 0.72 dS/m in soil and 0.75 dS/m in Jeevamrutham. Both values fall within the normal range, suggesting that neither the soil nor the Jeevamrutham poses any salinity-related stress to plants. The slightly higher EC value in Jeevamrutham reflects the presence of dissolved nutrients and ions resulting from the fermentation of organic materials. This indicates that Jeevamrutham can contribute to the nutrient pool of the soil without causing excessive salt accumulation, thereby maintaining a favorable environment for plant growth.

Organic carbon content is a key indicator of soil fertility, as it reflects the presence of organic matter, which plays a vital role in nutrient retention, soil structure, and microbial activity. In the present study, the organic carbon content of soil was recorded as 1.24% (W/W), indicating a relatively good level of soil organic matter. On the other hand, Jeevamrutham showed an organic carbon content of 0.46% (W/V). Although lower in comparison to soil, the organic carbon present in Jeevamrutham is in a more labile and readily available form, which can be quickly utilized by soil microorganisms. This readily available carbon acts as an energy source for microbial proliferation, thereby enhancing biological activity in the soil.

The comparison of these physicochemical parameters clearly indicates that while the soil provides a stable medium for plant growth, Jeevamrutham acts as a dynamic input that enhances nutrient availability and microbial activity. The acidic nature, balanced electrical conductivity, and presence of readily available organic carbon in Jeevamrutham contribute to improving soil fertility and supporting plant growth processes.

In conclusion, the physicochemical analysis highlights the complementary relationship between soil and Jeevamrutham. While soil serves as the primary growth medium with inherent fertility, Jeevamrutham enhances its biological and chemical properties, thereby creating a more favorable environment for crop development.

Table 6: Physicochemical Properties of Soil and Jeevamrutham

Parameter	Soil	Jeevamrutham
pH (1:2.5 ratio)	7.5	5.63
Electrical Conductivity	0.72 dS/m	0.75 dS/m
Organic Carbon (OC)	1.24 % (W/W)	0.46% (W/V)

Table 6 presents the comparative analysis of key physicochemical parameters of soil and Jeevamrutham, including pH, electrical conductivity, and organic carbon content. The soil exhibited a neutral to slightly alkaline pH, whereas Jeevamrutham showed a moderately acidic nature due to the fermentation process. Electrical conductivity values in both soil and Jeevamrutham were within normal limits, indicating the absence of salinity stress. The organic carbon content was higher in soil, while Jeevamrutham contained readily available carbon that supports microbial activity. Overall, the results indicate that Jeevamrutham possesses properties that can enhance soil nutrient dynamics and biological activity when applied under field conditions.

4.3 Physicochemical Properties of Soil and Jeevamrutham

1) Soil pH (7.5) vs Jeevamrutham pH (5.63)

The figure clearly shows that the soil has a pH of 7.5, which indicates a neutral to slightly alkaline condition. This range is generally considered suitable for paddy cultivation as it allows optimal availability of most essential nutrients. In contrast, Jeevamrutham exhibits a lower pH of 5.63, indicating its acidic nature. This acidity is a result of microbial fermentation, during which organic acids are produced. When applied to soil, this acidic nature helps in solubilizing nutrients such as phosphorus and micronutrients, thereby enhancing their availability to plants. Thus, Jeevamrutham acts as a modifying agent that can improve nutrient dynamics in slightly alkaline soils.

2) Electrical Conductivity (Soil: 0.72 dS/m vs Jeevamrutham: 0.75 dS/m)

The electrical conductivity values of both soil and Jeevamrutham are shown to be very close, with soil at 0.72 dS/m and Jeevamrutham at 0.75 dS/m. These values fall within the safe range, indicating that there is no risk of salinity stress for plants. The slightly higher EC in Jeevamrutham reflects the presence of dissolved salts and nutrients generated during fermentation. However, since the difference is minimal, it suggests that Jeevamrutham can enrich the soil nutrient pool without adversely affecting soil salinity levels.

3) Organic Carbon Content (Soil: 1.24% vs Jeevamrutham: 0.46%)

The figure indicates that soil has a higher organic carbon content (1.24%) compared to Jeevamrutham (0.46%). This suggests that the soil already possesses a good level of organic matter, which is beneficial for maintaining soil fertility and structure. However, the organic carbon present in Jeevamrutham is in a more active and easily decomposable form. This labile carbon serves as an immediate energy source for soil microorganisms, thereby enhancing microbial activity. As a result, even though Jeevamrutham has lower total carbon, its contribution to biological activity is significant.

4) Overall Comparative Trend

The figure highlights a clear complementary relationship between soil and Jeevamrutham. While soil provides a stable and nutrient-rich base, Jeevamrutham contributes dynamic properties such as acidity and readily available carbon, which enhance nutrient solubility and microbial processes. This combination supports improved soil health and plant growth.

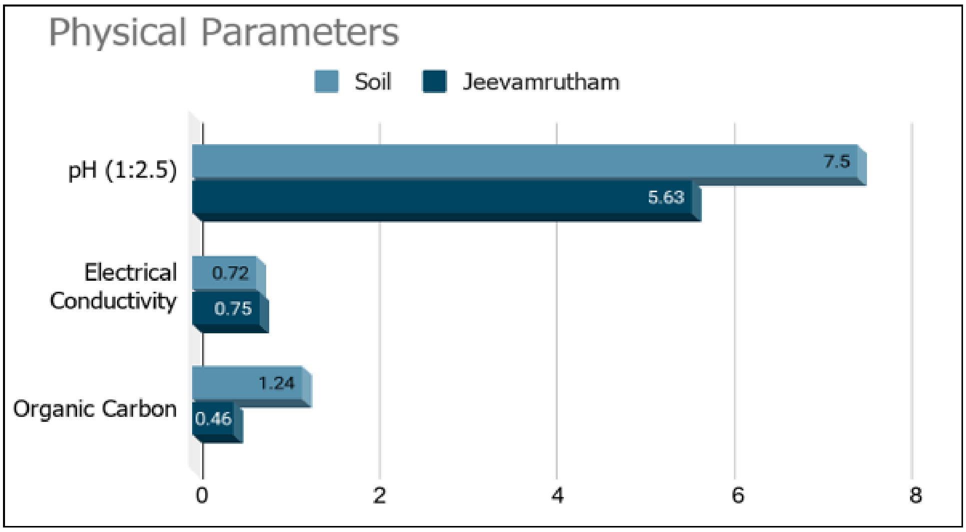

Figure 4: Comparative Analysis of Physicochemical Properties of Soil and Jeevamrutham

The data presented in Figure 4 illustrate the comparative physicochemical characteristics of soil and Jeevamrutham used in the study. The soil exhibited a neutral to slightly alkaline pH, which is favorable for crop growth, whereas Jeevamrutham showed an acidic pH due to fermentation processes. Electrical conductivity values of both soil and Jeevamrutham were within safe limits, indicating the absence of salinity-related constraints. Although the soil had higher organic carbon content, the carbon present in Jeevamrutham is more labile and readily available for microbial utilization. This combination of stable soil properties and dynamic biofertilizer characteristics suggests that Jeevamrutham plays a significant role in enhancing nutrient availability and microbial activity, thereby improving overall soil fertility and supporting plant growth.

4.4 Macronutrient Composition of Soil and Jeevamrutham

1) **Nitrogen (Soil: 0.31 gm/100gm vs Jeevamrutham: 1.96 gm/l)**

The nitrogen content in Jeevamrutham (1.96 gm/l) is significantly higher than that of soil (0.31 gm/100gm). This clearly indicates that Jeevamrutham acts as a rich source of nitrogen, which is one of the most essential nutrients required for plant growth. Nitrogen plays a crucial role in chlorophyll formation, protein synthesis, and vegetative development. The higher nitrogen content in Jeevamrutham can be attributed to the presence of cow urine and microbial activity during fermentation. When applied to soil, this nitrogen becomes available in a more dynamic form, enhancing plant growth and promoting greener and healthier foliage.

2) **Phosphorus (Soil: 0.35 gm/100gm vs Jeevamrutham: 0.18 gm/l)**

In contrast to nitrogen, the phosphorus content is higher in soil (0.35 gm/100gm) compared to Jeevamrutham (0.18 gm/l). This indicates that soil serves as a primary reservoir of phosphorus. However, the phosphorus present in soil is often in insoluble form and not readily available to plants. Jeevamrutham, despite having lower phosphorus content, plays an important role in solubilizing this nutrient through microbial activity and organic acid production, thereby improving its availability to plants.

3) **Potassium (Soil: 0.15 gm/100gm vs Jeevamrutham: 0.28 gm/l)**

The potassium content in Jeevamrutham (0.28 gm/l) is higher than in soil (0.15 gm/100gm), indicating its contribution as a potassium source. Potassium is essential for enzyme activation, water regulation, and stress tolerance in plants. The presence of higher potassium in Jeevamrutham suggests that its application can improve plant resistance to environmental stress and enhance overall plant vigor.

4) **Magnesium (Soil: 0.08 gm/100gm vs Jeevamrutham: 0.024 gm/l)**

Magnesium content is higher in soil compared to Jeevamrutham. Magnesium is a central component of chlorophyll and plays a vital role in photosynthesis. Although Jeevamrutham contains lower magnesium, its role in enhancing microbial activity may indirectly improve the availability of magnesium present in soil, thus supporting plant metabolic functions.

5) **Calcium (Soil: 0.07 gm/100gm vs Jeevamrutham: 0.189 gm/l)**

The calcium content in Jeevamrutham (0.189 gm/l) is significantly higher than in soil (0.07 gm/100gm). Calcium is essential for cell wall formation, root development, and overall structural stability of plants. The higher calcium content in Jeevamrutham indicates its role in strengthening plant tissues and improving root growth when applied to soil.

6) **Sulfur (Soil: 0.003 gm/100gm vs Jeevamrutham: 0.564 gm/l)**

A very significant difference is observed in sulfur content, where Jeevamrutham (0.564 gm/l) contains substantially higher sulfur compared to soil (0.003 gm/100gm). Sulfur is important for protein synthesis and enzyme function. The high sulfur content in Jeevamrutham enhances nutrient metabolism and supports overall plant growth and development.

7) Overall Nutrient Trend

The comparative analysis clearly shows that Jeevamrutham is particularly rich in nitrogen, potassium, calcium, and sulfur, whereas soil contains relatively higher phosphorus and magnesium. This indicates a complementary relationship where Jeevamrutham supplements key nutrients and enhances the availability of those already present in soil through biological processes.

Table 8: Macronutrient Composition of Soil and Jeevamrutham

Parameter	Soil (gm/100gm)	Jeevamrutham (gm/l)
N	0.31	1.96
P	0.35	0.18
K	0.15	0.28
Mg	0.08	0.024
Ca	0.07	0.189
S	0.003	0.564

The data presented in Table 4.2 highlight the comparative macronutrient composition of soil and Jeevamrutham. Jeevamrutham was found to be particularly rich in nitrogen, potassium, calcium, and sulfur, indicating its potential as a nutrient-enriching biofertilizer. Although soil exhibited higher phosphorus and magnesium content, these nutrients are often present in less available forms. The application of Jeevamrutham enhances the availability of such nutrients through microbial activity and organic acid production. Overall, the results demonstrate that Jeevamrutham not only supplies essential nutrients but also improves nutrient availability in soil, thereby contributing to enhanced plant growth and productivity.

4.5 Macronutrient Composition of Soil and Jeevamrutham

1) Nitrogen (N): Jeevamrutham (1.96 gm/l) vs Soil (0.31 gm/100gm)

The figure clearly shows a significantly higher proportion of nitrogen in Jeevamrutham compared to soil. This indicates that Jeevamrutham serves as a rich nitrogen source. Nitrogen is essential for vegetative growth, chlorophyll formation, and protein synthesis. The elevated nitrogen content in Jeevamrutham enhances plant growth by improving leaf development and photosynthetic efficiency. This also explains better chlorophyll values and biomass observed in higher treatment groups.

2) Phosphorus (P): Soil (0.35 gm/100gm) vs Jeevamrutham (0.18 gm/l)

The soil shows a higher phosphorus content compared to Jeevamrutham. However, the phosphorus in soil is often present in fixed or insoluble forms. The figure highlights that even though Jeevamrutham contains lower phosphorus, its application helps in solubilizing soil-bound phosphorus through microbial activity and organic acid production. Thus, Jeevamrutham indirectly enhances phosphorus availability.

3) Potassium (K): Jeevamrutham (0.28 gm/l) vs Soil (0.15 gm/100gm)

The potassium content is higher in Jeevamrutham as compared to soil. Potassium plays a vital role in enzyme activation, stomatal regulation, and stress resistance. The higher potassium levels in Jeevamrutham contribute to improved plant vigor, better water regulation, and enhanced resistance against environmental stress conditions.

4) Magnesium (Mg): Soil (0.08 gm/100gm) vs Jeevamrutham (0.024 gm/l)

The figure shows that magnesium content is higher in soil than in Jeevamrutham. Magnesium is a key component of chlorophyll and is directly involved in photosynthesis. Although Jeevamrutham contains lower magnesium, its role in improving microbial activity helps in making soil magnesium more available to plants.

5) Calcium (Ca): Jeevamrutham (0.189 gm/l) vs Soil (0.07 gm/100gm)

A significantly higher calcium content is observed in Jeevamrutham. Calcium is essential for cell wall development, root growth, and structural stability of plants. The higher calcium levels in Jeevamrutham indicate its role in strengthening plant tissues and improving root development, which ultimately supports better nutrient uptake.

6) Sulfur (S): Jeevamrutham (0.564 gm/l) vs Soil (0.003 gm/100gm)

The most prominent difference is observed in sulfur content, where Jeevamrutham shows a very high value compared to negligible levels in soil. Sulfur is important for protein synthesis and enzyme function. The high sulfur content in Jeevamrutham enhances metabolic activities and contributes to improved plant growth and yield.

7) Overall Trend from Figure

The figure clearly demonstrates that Jeevamrutham is particularly rich in nitrogen, potassium, calcium, and sulfur, while soil contributes relatively more phosphorus and magnesium. This indicates a complementary interaction, where Jeevamrutham not only supplies nutrients but also enhances the availability of nutrients already present in soil.

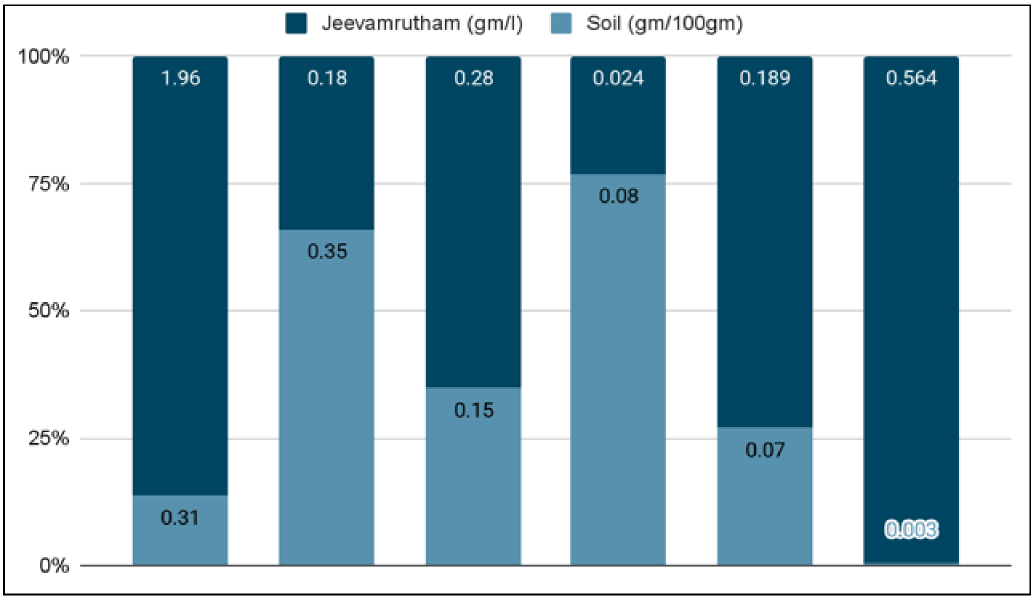

Figure 5: Comparative Macronutrient Composition of Soil and Jeevamrutham

The results presented in Figure 4.2 and Table 4.2 reveal significant variations in macronutrient composition between soil and Jeevamrutham. Jeevamrutham was found to be particularly enriched with nitrogen, potassium, calcium, and sulfur, indicating its strong potential as a nutrient-supplying biofertilizer. Although soil contained relatively higher phosphorus and magnesium, these nutrients are often present in less available forms. The application of Jeevamrutham enhances their availability through microbial activity and biochemical processes. The overall findings suggest that Jeevamrutham not only supplements essential nutrients but also improves nutrient use efficiency by facilitating their transformation into plant-available forms, thereby supporting enhanced crop growth and productivity.

4.6 Micronutrient Composition of Soil and Jeevamrutham

1) Iron (Fe): Jeevamrutham (42.4 mg/l) vs Soil (10 mg/100g)

The data clearly show that iron concentration is significantly higher in Jeevamrutham compared to soil. Iron is a critical micronutrient involved in chlorophyll synthesis and enzymatic activities. The higher iron content in Jeevamrutham indicates its strong potential to correct iron deficiency in plants, leading to improved chlorophyll formation and enhanced photosynthetic efficiency. This may directly contribute to higher SPAD values and better plant growth observed in treated groups.

2) Copper (Cu): Soil (2.45 mg/100g) vs Jeevamrutham (1.58 mg/l)

Copper content is relatively higher in soil compared to Jeevamrutham. Copper plays an essential role in enzymatic reactions and plant metabolism. Although Jeevamrutham contains slightly lower copper, its application can enhance the availability of soil copper through microbial processes, thereby ensuring adequate supply to plants.

3) Cobalt (Co): Soil (0.35 mg/100g) vs Jeevamrutham (Absent)

Cobalt is present in soil but absent in Jeevamrutham. This indicates that Jeevamrutham does not directly contribute cobalt to the soil. However, cobalt is required in very small quantities and is mainly important for nitrogen-fixing microorganisms. Since Jeevamrutham enhances microbial activity, it may indirectly support cobalt utilization already present in soil.

4) Manganese (Mn): Soil (3.8 mg/100g) vs Jeevamrutham (0.56 mg/l)

Manganese content is higher in soil compared to Jeevamrutham. Manganese plays a vital role in photosynthesis and enzyme activation. Although Jeevamrutham has lower manganese content, its role in improving microbial activity and soil conditions may increase the availability of manganese from soil reserves.

5) Zinc (Zn): Jeevamrutham (1.56 mg/l) vs Soil (0.5 mg/100g)

Zinc content is significantly higher in Jeevamrutham compared to soil. Zinc is essential for enzyme activation, protein synthesis, and growth regulation. The higher zinc concentration in Jeevamrutham suggests that its application can effectively improve zinc availability, which is often deficient in agricultural soils, thereby enhancing plant growth and development.

6) Molybdenum (Mo): Soil (0.1 mg/100g) vs Jeevamrutham (Absent)

Molybdenum is present in soil but not detected in Jeevamrutham. This indicates that Jeevamrutham does not contribute directly to molybdenum supply. However, molybdenum is required in trace amounts and is mainly involved in nitrogen metabolism. The enhanced microbial activity due to Jeevamrutham may indirectly support efficient utilization of soil molybdenum.

7) Overall Micronutrient Trend

The analysis indicates that Jeevamrutham is particularly rich in iron and zinc, while soil serves as a source of copper, manganese, cobalt, and molybdenum. This again highlights a complementary interaction where Jeevamrutham enhances the availability and utilization of micronutrients present in soil rather than acting as a complete replacement.

Table 8: Micronutrient Composition of Soil and Jeevamrutham

Parameter	Soil (mg/100g)	Jeevamrutham (mg/l)
Fe	10	42.4
Cu	2.45	1.58
Co	0.35	–
Mn	3.8	0.56
Zn	0.5	1.56
Mo	0.1	–

The data presented in Table 4.3 demonstrate significant variations in micronutrient composition between soil and Jeevamrutham. Jeevamrutham was found to be particularly rich in iron and zinc, which are essential for chlorophyll synthesis and enzyme activation, respectively. In contrast, soil contained higher levels of copper, manganese, cobalt, and molybdenum. Although Jeevamrutham lacks certain micronutrients, its application enhances microbial activity and improves the availability of these nutrients from soil. The results indicate that Jeevamrutham functions not only as a source of specific micronutrients but also as a catalyst that enhances the overall micronutrient dynamics in the soil, thereby supporting improved plant growth and productivity.

4.7 Composition of Jeevamrutham

1) Water (87.2%) – Major Component

The figure clearly shows that water constitutes the largest proportion (87.2%) of Jeevamrutham. This highlights its role as a medium for microbial suspension and fermentation. Water provides a suitable environment for microbial growth, allowing nutrients and microorganisms to remain in an active and mobile state. It also facilitates easy application in the field, especially during soil drenching and irrigation. The high water content ensures uniform distribution of nutrients and microbes in the soil.

2) Cow Urine (5.0%) – Nitrogen Source

Cow urine accounts for approximately 5.0% of the composition. It serves as a rich source of nitrogen and other micronutrients, along with growth-promoting substances. Cow urine also contains urea and other compounds that support microbial activity during fermentation. Its presence significantly contributes to the high nitrogen content observed in Jeevamrutham, making it an important component for enhancing plant growth.

3) Fresh Cow Dung (4.8%) – Microbial Inoculum

Fresh cow dung contributes about 4.8% to the total composition and acts as the primary source of beneficial microorganisms. It contains a diverse population of bacteria, fungi, and actinomycetes that play a crucial role in nutrient cycling and soil health improvement. The microorganisms introduced through cow dung multiply during fermentation and enhance soil biological activity when applied.

4) Jaggery (1.3%)- Carbon Source

Jaggery constitutes around 1.3% of the composition and serves as a readily available carbon source for microorganisms. It provides energy required for rapid microbial multiplication during the fermentation process. The presence of jaggery ensures active microbial growth, leading to the production of organic acids and other beneficial metabolites.

5) Minor Components (Pulse Flour & Soil – Not Highlighted in Figure)

Although not prominently visible in the figure, pulse flour and rhizospheric soil are also important components of Jeevamrutham. Pulse flour provides proteins and nutrients that support microbial growth, while soil introduces native microorganisms, enhancing microbial diversity. These components play a supporting role in strengthening the overall biological activity of the formulation.

6) Overall Functional Interpretation

The composition clearly indicates that Jeevamrutham is not just a nutrient solution but a biologically active formulation. The combination of water as a medium, cow dung as a microbial source, cow urine as a nutrient provider, and jaggery as an energy source creates an ideal environment for microbial proliferation. This synergistic interaction results in a highly effective biofertilizer that enhances soil fertility and plant growth.

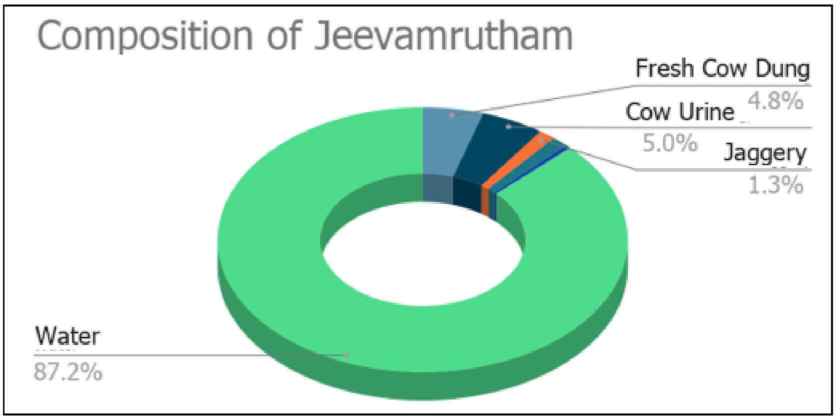

Figure 6: Composition of Jeevamrutham

Table 9: Composition and Functional Role of Jeevamrutham Components

Component	Percentage (%)	Functional Role
Water	87.2	Medium for microbial activity and application
Cow Urine	5	Nitrogen source and growth promoters
Fresh Cow Dung	4.8	Source of beneficial microorganisms
Jaggery	1.3	Carbon source for microbial growth
Pulse Flour	Trace	Protein source for microbial proliferation
Rhizospheric Soil	Trace	Introduces native beneficial microbes

The composition of Jeevamrutham, as illustrated in Figure 4.3 and Table 4.4, reflects its nature as a biologically active organic formulation. The predominance of water facilitates microbial activity and uniform application, while components such as cow dung and cow urine provide essential microorganisms and nutrients. Jaggery acts as a carbon source, promoting rapid microbial multiplication during fermentation. Although present in smaller quantities, pulse flour and rhizospheric soil contribute significantly to microbial diversity and activity. The synergistic interaction of these components results in a nutrient-rich and microbially active solution that enhances soil fertility, nutrient availability, and plant growth. This composition explains the improved performance observed in treatments involving Jeevamrutham.

4.8 Ingredients and Functional Role of Jeevamrutham

1) Fresh Cow Dung (10 kg) – Primary Microbial Inoculum

Fresh cow dung acts as the core component of Jeevamrutham, serving as a rich source of beneficial microorganisms such as bacteria, fungi, and actinomycetes. These microorganisms play a vital role in decomposition, nutrient cycling, and soil fertility enhancement. The fibrous nature of cow dung also supports microbial attachment and growth, making it a strong biological base for fermentation.

2) Cow Urine (10 L) – Nitrogen Source and Growth Promoter

Cow urine provides a readily available source of nitrogen, along with micronutrients and growth-promoting substances. It enhances microbial activity during fermentation and contributes to the high nitrogen content observed in Jeevamrutham. Additionally, compounds present in cow urine help in stimulating plant growth and improving metabolic activities.

3) Jaggery (2 kg) – Carbon and Energy Source

Jaggery serves as a rapidly fermentable carbon source that provides energy for microbial proliferation. It plays a crucial role in accelerating the fermentation process by supporting rapid multiplication of microorganisms. The presence of simple sugars in jaggery ensures quick activation of microbial metabolism, leading to the production of beneficial organic acids.

4) Pulse Flour (2 kg) – Protein Source for Microbial Growth

Pulse flour acts as a protein-rich substrate that supplies essential nutrients required for microbial growth and multiplication. It enhances microbial diversity and supports the development of a stable microbial community within Jeevamrutham. This leads to improved biological activity when applied to soil.

5) Rhizosphere Soil (Handful) – Source of Native Microorganisms

Rhizosphere soil introduces indigenous microorganisms that are naturally adapted to local environmental conditions. These microbes play a crucial role in enhancing nutrient availability and establishing a balanced microbial ecosystem. Their presence increases the effectiveness of Jeevamrutham by improving its adaptability to field conditions.

6) Water (200 L) – Medium for Fermentation and Application

Water forms the major component of Jeevamrutham and acts as a medium for microbial suspension and nutrient distribution. It facilitates fermentation by providing a suitable environment for microbial growth and ensures uniform application in the field. The high water content allows easy transport of nutrients and microorganisms into the soil.

7) Overall Functional Synergy

The combination of these ingredients creates a synergistic system where carbon, nitrogen, proteins, and microbial inoculum interact to produce a highly active biofertilizer. Each component plays a specific role, and together they enhance microbial proliferation, nutrient transformation, and soil biological activity. This integrated composition explains the effectiveness of Jeevamrutham in improving soil fertility and plant growth.

Table 10: Ingredients and Functional Role of Jeevamrutham

Ingredient	Quantity	Role in Fermentation
Fresh Cow Dung	10 kg	Primary microbial inoculum & fiber source
Cow Urine	10 L	Nitrogen source & growth promoters
Jaggery	2 kg	Rapidly fermentable carbon (Energy source)
Pulse Flour	2 kg	Protein source for microbial proliferation
Rhizosphere Soil	Handful	Inoculum for native beneficial local microbes
Water	200 L	Medium for microbial suspension & fermentation

Table 10 presents the composition of Jeevamrutham along with the functional role of each ingredient involved in its preparation. The formulation is designed to create a biologically active system where cow dung provides microbial inoculum, cow urine supplies nitrogen and growth-promoting substances, and jaggery acts as a carbon source for microbial energy. Pulse flour contributes proteins necessary for microbial proliferation, while rhizosphere soil introduces native microorganisms that enhance adaptability and efficiency. Water serves as a medium for fermentation

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and ensures uniform distribution during application. The synergistic interaction of these components results in a nutrient-rich and microbially active formulation, which plays a significant role in enhancing soil fertility, nutrient availability, and crop productivity.

Comparative Performance of Treatments
The figure clearly demonstrates that:
G1 (Control) shows the lowest performance in all parameters
G2 (Chemical) improves yield but lacks biological enhancement
G3 (Jeevamrutham) improves root and physiological parameters
G4 (Integrated) shows the best overall performance

Overall Trend
The overall trend across all parameters is:
G4 > G2 > G3 > G1 (for yield)
G4 > G3 > G2 > G1 (for physiological traits)

This indicates that while chemical fertilizers enhance yield, Jeevamrutham improves plant health, and their combination produces the best results.

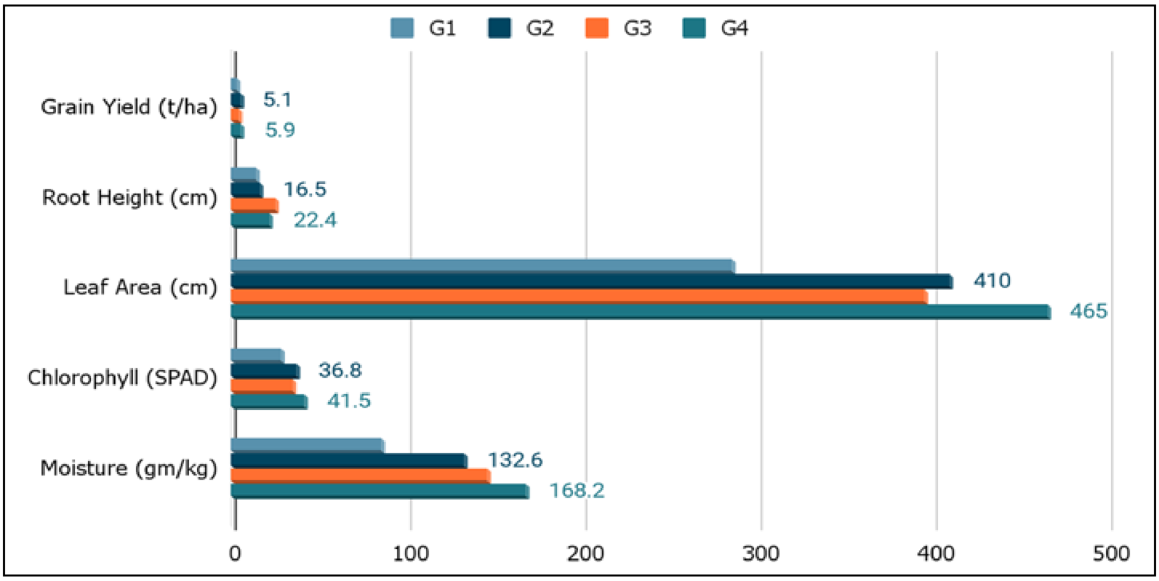

Figure 12: Effect of Different Treatments (G1–G4) on Yield and Physiological Parameters of Paddy

Figure 12 illustrates the effect of different treatments on yield and physiological parameters of paddy. The integrated treatment (G4) consistently recorded the highest values for grain yield, leaf area, chlorophyll content, and moisture content, indicating superior crop performance. While chemical fertilizer treatment (G2) resulted in higher yield compared to Jeevamrutham alone (G3), the combined application in G4 produced a synergistic effect, leading to maximum productivity. Jeevamrutham contributed significantly to improved root growth, chlorophyll content, and water retention, which are essential for plant development. The results clearly demonstrate that integrated nutrient management enhances both yield and plant health, making it the most effective approach for sustainable paddy cultivation

5. Discussion

One of the key areas of discussion in this presentation is how the soil, which is a relatively inert medium of growth in untreated situations, becomes biologically active, functionally dynamic, under the treatment of Jeevamrutham. These findings clearly indicated a gradual increase in microbial population, enzymatic activity and nutrient availability between G1 and G4 treatments. Such a change can be attributed to the idea of soil as a living system in which the microorganisms are central to the process of nutrient cycling and plant development. Food and Agriculture Organization (FAO) states that maintenance of biological activity is a critical factor in sustainable soil management since soil microorganisms are the ones that decompose organic matter and release nutrients to plants.

The tendency of the increase in microbial diversity and activity in the Jeevamrutham-treated soils is in line with the concepts of microbial ecology, where the presence of organic food sources and energy sources promotes the growth of a wide range of microbial communities. Jeevamrutham is abundant in organic carbon, nitrogen, and other beneficial microorganisms thus providing a perfect environment in which microbes thrive. Similar results have been documented in studies of organic farming systems, with the use of organic inputs greatly increasing microbial biomass and enzyme activity, thus improving soil fertility and productivity (e.g., published by the Indian Council of Agricultural Research).

The other issue that is covered in this chapter is the nutrient transforming role of Jeevamrutham as opposed to the direct nutrient supply. In contrast to chemical fertilizers that present nutrients in easily digestible forms, Jeevamrutham is a catalyst, which triggers biological reactions in soil. The results of the experiment revealed that despite the fact that some of the nutrients were more abundant in soil or chemical treatments, the availability of Jeevamrutham had a positive effect on their availability and efficiency of utilization. Microbial processes that can explain this phenomenon include nitrogen fixation, phosphorus solubilization and organic matter mineralization. Soil microbiology has well documented these processes which are critical towards ensuring long term soil fertility.

The relative effectiveness of treatments also emphasizes the significance of combined nutrient management. Though chemical fertilizers (G2) led to increased short-term productivity than Jeevamrutham (G3) alone, they did not significantly improve the microbial diversity.

Besides biological factors, the effects of Jeevamrutham on soil physicochemical properties are also discussed. The acidic properties of Jeevamrutham as observed in the results are what help in solubilizing nutrients, especially phosphorus and micronutrients. This enhances availability of nutrients in neutral to slightly alkaline soils which is prevalent in most agricultural areas. In addition, labile organic carbon in Jeevamrutham gives an instant power source to microorganisms, thus boosting their activity and efficiency.

These findings have implications beyond the experimental conditions to the real practice in agriculture. Jeevamrutham is a substitute that is cost efficient and environmental friendly to overdependence on chemical fertilizers. The practices based on Jeevamrutham can play a significant role in sustainable agriculture by enhancing the health of soil, decreasing the expenditures of inputs, and increasing the crop yields. This is especially applicable in light of the growing worries on soil erosion, decreasing productivity, and environmental contamination with intensive chemical cultivation.

Simultaneously, limitations of the study should be identified. The experiment was carried out under certain environmental and soil conditions and the results can be different under various agro-climatic conditions. The sustainability and consistency of practices based on Jeevamrutham in various cropping cycles should be evaluated through long-term studies. Moreover, more studies should be conducted to standardize the preparation techniques and maximize the application rates of various crops and soils.

Finally, this chapter offers a detailed explanation of the experimental results, their connection with scientific concepts and practical farming activities. The findings are a solid indication that Jeevamrutham can stimulate the biological activity of soil and boost the performance of crops especially when applied together with chemical fertilizers. The discussion preconditions the following sections, where particular parameters are discussed more specifically to give more information about the mechanisms that underlie the observed effects.

The conversion of soil as a rather passive medium of growing crops to a biologically active and functionally dynamic system under Jeevamrutham-based treatments is a major focus of this chapter. The experimental findings revealed a definite and progressive increase in microbial population, enzymatic activity and nutrient availability between G1 and G4. This can be explained by the idea of soil as a living system in which the microorganisms serve as essential regulators of nutrient cycling and plant growth. The Food and Agriculture Organization pointed out that the key to sustainable soil management is the preservation of the biological activity of the soil since soil microorganisms are the ones that carry out the process of decomposition, mineralization, and the transformation of nutrients that have direct impact on crop yield.

Principles of microbial ecology can be used to further explain the increase in microbial diversity and activity observed in Jeevamrutham-treated soils. Jeevamrutham is a good source of organic carbon, nitrogen, and good microorganisms that in combination forms an optimal environment in which microorganisms could proliferate. The presence of readily degradable organic materials promotes microbial processes and the growth of a rich microbial community. Research carried out by the Indian Council of Agricultural Research has also shown similar observations whereby the use of organic inputs greatly improved microbial biomass and enzyme activities resulting in improved soil fertility and crop performances.

The other significant point that is brought out in this chapter is the functional role of Jeevamrutham in the transformation of nutrients and not the direct provision of nutrients. As opposed to chemical fertilizers, which supply nutrients in readily accessible forms, Jeevamrutham is a biological catalyst that triggers the soil processes. The outcomes of the experiment suggested that though some of the nutrients were found in greater levels in soil or chemical treatments, their availability and their utilization were greatly increased in the presence of Jeevamrutham. This is owed to microbial-mediated activities like fixation of nitrogen, solubilization of phosphorus, and degradation of organic matter, which are core in sustainable management of soil fertility.

Jeevamrutham has a significant role in enhancing crop performance due to its effects on soil physicochemical properties. Jeevamrutham has a slightly acidic character which is seen in the results to enable the solubilization of nutrients, especially phosphorus and micronutrients, which are more readily absorbed by the plants. Also, the availability of labile organic carbon is an instant source of energy to the microorganisms, increasing their activity and efficiency in nutrient transformation.

Practically, the results of this study have profound implications on sustainable agriculture. Application of Jeevamrutham is a cheaper and less harmful substitute to the high use of chemicals as fertilizers. Jeevamrutham-based practices can help make agriculture more sustainable in the long term by enhancing microbial health and reducing input costs, improving soil health. This especially applies in the scenario where there are rising concerns with regard to soil degradation, reduced fertility and environmental pollution that is a result of intensive farming activities.

However, it is important to acknowledge the limitations of the study. The experiment was carried out under certain conditions of soil and climatic conditions and the results can differ in various agro-ecological conditions. The sustainability and stability of the practices based on Jeevamrutham need to be assessed through long-term studies throughout the various cropping cycles. More studies should be conducted as well to be able to standardize the preparation procedures and maximize the application rates of various crops and soils.

Finally, the section helps to develop a broad framework of the interpretation of the experimental results in the preceding chapter. Connecting the findings to scientific principles and practical applications, it offers a solid ground to the discussion of specific parameters in the following parts. The results obtained are a clear indication that the hypothesis that Jeevamrutham improves soil biological activity and improves crop performance is true, especially when used alongside chemical fertilizers.

Physicochemical properties of soil are essential in defining whether the soil is fertile, whether it contains nutrients or not and whether it is suitable to grow crops. The parameters that showed considerable differences due to various treatments in the current study included pH, electrical conductivity, organic carbon, and nutrient composition. Such differences could be attributed to the interaction of Jeevamrutham, soil constituents, and microbial activities.

One of the most notable observations was the difference in pH between soil (7.5) and Jeevamrutham (5.63). The nature of the soil is slightly alkaline, which is common in most agricultural soils and is usually conducive to paddy farming. Nonetheless, the acidic character of Jeevamrutham, which is caused by the synthesis of organic acids in the process of fermentation is important in altering the soil chemistry. This acidic input when used on soil assists in dissolving the nutrient like phosphorus, iron and zinc that are usually not soluble in alkaline soils. The phenomenon is highly justified by the principles of soil chemistry according to which the lower pH increases the availability of micronutrients and phosphorus.

Electrical conductivity (EC) values observed in the study (0.72 dS/m in soil and 0.75 dS/m in Jeevamrutham) were within the optimal range, indicating that there was no salinity stress imposed on plants. The minimal rise in EC in Jeevamrutham is explained by the existence of dissolved salts and nutrients that are formed in the course of fermentation.

The major distinction, however, is the nature of carbon present. The carbon in soil is fairly stable but the carbon in Jeevamrutham is labile and can be easily utilized by microbes. This conveniently available carbon is a source of energy to the microorganisms that causes higher microbial activity and further cycling of nutrients. The observation is in line with the findings made by the Indian Council of Agricultural Research which state the significance of labile carbon in the initiation of soil biological processes.

The macronutrient analysis showed that the nitrogen, potassium, calcium, and sulfur concentration is high in Jeevamrutham and phosphorus and magnesium are found in relatively high amounts in soil. This complementary balance of nutrients implies that Jeevamrutham does not substitute soil nutrients, but increases their presence and usage. This high nitrogen content in Jeevamrutham is due to the presence of cow urine and microbial activity that enhances better vegetative growth and chlorophyll production. On the same note, potassium and calcium are present and aid in enzyme activation, water balance, and stability of plants.

The fact that phosphorus is relatively less in Jeevamrutham than in soil is not a constraint since Jeevamrutham increases phosphorus availability by solubilizing it through microbes. Microorganisms found in Jeevamrutham are phosphate-solubilizing, which means that they can change insoluble phosphorus into forms that can easily be absorbed by plants. This is a transformation mediated by microorganisms, which are a major mechanism used in the organic farming system and helps in enhancing the efficiency of nutrient use.

Micronutrient analysis also contributes to the role of Jeevamrutham in enhancing soil fertility. The increased content of iron and zinc in Jeevamrutham implies that it may be used in correcting micronutrient deficiencies, a common problem in most agricultural soils. These micronutrients are vital in enzymatic processes, chlorophyll formation as well as general plant metabolism. These nutrients are present in bioavailable forms which improve growth and productivity of plants.

The findings also indicate the dynamic aspect of nutrient availability in the treatment of Jeevamrutham. In contrast to the chemical fertilizers, which offer nutrients in fixed amounts, Jeevamrutham offers nutrients in continuous amounts, which is due to microbial processes. This is to guarantee constant and prolonged discharge of nutrients, lowering the chances of losing nutrients through leaching or volatilization.

The other factor is the relationship between the physicochemical characteristics of the soil and the activity of the microbes. Increased nutrient availability in the treatment with Jeevamrutham is directly correlated with the increased activity of microbes. Microorganisms are very important in the decomposition of organic matter, release nutrients, and the fertility of soil. Labile carbon and conducive PH in Jeevamrutham-treated soils provide the right environment in which microbes thrive thereby increasing nutrient cycling.

To sum up, the results of the current research obviously indicate that Jeevamrutham has a great impact on the physicochemical characteristics of soil and nutrient dynamics. Jeevamrutham helps to increase soil fertility and crop performance by increasing nutrient availability, enhancing microbial activity and ensuring optimal soil conditions. The findings affirm the notion that sustainable soil management involves a balance between chemical and biological strategies with Jeevamrutham being instrumental in closing the divide between the two.

The current chapter critically and analytically explains the findings of the experimental research done to assess the impact of Jeevamrutham on soil health, microbial activity, plant growth and yield performance of paddy (Oryza sativa L.). Although the last chapter has presented the observed data in a systematic manner, the current chapter attempts to transcend the descriptive analysis, and form a scientific interpretation of the mechanisms behind the observed trends. The discussion combines both experimental results and known theories and empirical evidence related to the disciplines of soil science, agricultural microbiology, and plant physiology, thus offering a comprehensive explanation of the findings.

The conversion of soil as a rather passive medium of growing crops to a biologically active and functionally dynamic system under Jeevamrutham-based treatments is a major focus of this chapter. The experimental findings revealed a definite and progressive increase in microbial population, enzymatic activity and nutrient availability between G1 and G4. This can be explained by the idea of soil as a living system in which the microorganisms serve as essential regulators of nutrient cycling and plant growth. The Food and Agriculture Organization pointed out that the key to sustainable soil management is the preservation of the biological activity of the soil since soil microorganisms are the ones that carry out the process of decomposition, mineralization, and the transformation of nutrients that have direct impact on crop yield.

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The relative comparison of treatments (G1 to G4) also gives a deeper understanding of the effectiveness of various nutrient management strategies. Treatment with chemical fertilizers (G2) led to increased immediate yield than Jeevamrutham alone (G3), as a result of quick availability of nutrients. But it did not have a significant effect on microbial diversity or soil biological health. On the contrary, Jeevamrutham treatment increased microbial activity and soil fertility but with relatively moderate yield increase when applied as a standalone treatment. The combined treatment (G4), which is a combination of Jeevamrutham and chemical fertilizers, had the best overall results, which shows a synergistic effect between organic and inorganic inputs. This observation supports the idea of integrated nutrient management as a sustainable practice of agriculture.

6. Conclusion

To conclude, the current research is a detailed scientifically based assessment of the use of Jeevamrutham in improving the soil health, Among the valuable lessons learned during the study is the understanding that soil is a biologically active ecosystem and not a lifeless substrate. The gradual increase in microbial population, diversity and enzymatic activity evident in the various treatments, clearly shows that the fertility of soil is not determined by the mere presence of nutrients, but also the biological processes that govern their conversion and availability. Jeevamrutham application enhanced microbial proliferation and produced greater numbers of beneficial microorganisms including plant growth-promoting rhizobacteria, nitrogen- fixing and phosphate-solubilizing microbes. These microorganisms are important in the cycling of nutrients, transforming inaccessible forms of nutrients into accessible forms in plants, enhancing efficiency in the utilization of nutrients and lowering reliance on external inputs.

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