International Journal of Advanced Biochemistry Research 2025; SP-9(9): 1445-1451

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(9): 1445-1451
www.biochemjournal.com
Received: 17-07-2025
Accepted: 20-08-2025

Digvijai Kumar
Department of Agriculture Sciences, IES University, Bhopal, Madhya Pradesh, India

Rajeev Mishra
Department of Agriculture Sciences, IES University, Bhopal, Madhya Pradesh, India

Ashok Kumar
Department of Agriculture Sciences, IES University, Bhopal, Madhya Pradesh, India

Gufran Ahmed
Department of Agriculture Sciences, IES University, Bhopal, Madhya Pradesh, India

Radhey Shyam
Department of Agriculture Sciences, IES University, Bhopal, Madhya Pradesh, India

Corresponding Author:
Digvijai Kumar
Department of Agriculture Sciences, IES University, Bhopal, Madhya Pradesh, India

Impact of Jeevamrit and Panchagavya as liquid organic sources on growth, productivity and profitability of chickpea (*Cicer arietinum* L.)

Digvijai Kumar, Rajeev Mishra, Ashok Kumar, Gufran Ahmed and Radhey Shyam

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i9Sr.5708

Abstract
This study explores the impact of organic fertilizers, Panchagavya and Jeevamrit, on chickpea growth, yield, and economic viability through soil and foliar applications. Foliar application of Panchagavya at 4% significantly enhanced plant height, dry matter, and growth rates, attributed to its high nitrogen content (1.28%) and growth-promoting substances. Soil application of Jeevamrit at 500 L ha^{-1} boosted grain yield by 28.31% (1,328 kg ha^{-1}) and straw yield by 27.14% (1,841 kg ha^{-1}) compared to the control, driven by improved nutrient uptake and microbial activity. Key yield attributes, including pods per plant (33.44) and seed yield per plant (7.77 g), were also enhanced. Economically, Jeevamrit treatments yielded the highest gross returns (₹69,586 ha^{-1}) and net returns (₹42,201 ha^{-1}), achieving a benefit-to-cost ratio of 2.55, demonstrating strong cost-effectiveness. These findings, supported by recent research, underscore the potential of Panchagavya and Jeevamrit as sustainable alternatives to chemical fertilizers, promoting healthier crops and better farm profitability. Future studies should optimize application strategies and assess long-term soil health benefits to further refine their use in diverse agricultural systems.

Keywords: Panchagavya, Jeevamrit, organic fertilizers, chickpea yield, nutrient uptake, economic returns, sustainable agriculture

1. Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops, valued for its high nutritional content and adaptability to diverse agro-climatic conditions. Chickpea seeds contain about 17-24% protein, 52-70% carbohydrates, and are also rich in essential nutrients such as calcium, phosphorus, iron, and vitamins (Jukanti *et al*., 2012; Varshney *et al*., 2013) [13, 42]. Chickpea oil, though present in small amounts (4-7%), contains valuable phospholipids such as lecithin, which plays a critical role in the development of human nerve tissues (Wood & Grusak, 2007) [47]. In addition to its nutritional value, chickpea oil and by-products are used in various industries, including paints, adhesives, lubricants, and pharmaceuticals (Kumar *et al*., 2025) [17]. Chickpea is widely cultivated under rainfed conditions in semi-arid tropics, with major producing countries including India, Australia, Turkey, Pakistan, and Ethiopia. India leads global chickpea production, contributing nearly 70% of total output, with Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, and Andhra Pradesh as the main chickpea-growing states (FAOSTAT, 2020; Sharma & Sharma 2020) [8, 29]. In India, chickpea cultivation covered about 10.56 million hectares during the 2019-20 rabi season, producing 11.08 million tonnes with an average productivity of 1050 kg/ha (ICAR-IIPR, 2021). Since the 1970s, chickpea production has witnessed remarkable growth due to the development of improved cultivars, enhanced management practices, and technological interventions, establishing its significance in global food security and sustainable agriculture (Varshney *et al*., 2013; Jain *et al*., 2023) [42, 12].

Sustainable crop production is increasingly recognized as critical for soil-plant health, particularly under rainfed conditions. Rhizosphere engineering, seed development research, and microbial inoculants have gained prominence for their roles in nutrient acquisition, stress resilience, and plant fitness (Solanki *et al*., 2024; Kumar *et al*., 2024) [26]. Organic inputs such as compost, farmyard manure, Jeevamrit, and Panchagavya are known to enrich beneficial microbial populations, improve soil fertility, and act similarly to plant growth-promoting rhizobacteria (PGPR) (Kumari *et al*., 2019; Kashyap *et al*., 2019; Patil & Solanki, 2016) [19, 15, 27, 36]. Bacilli associated with the chickpea rhizosphere exhibit multifarious plant growth-promoting traits, including pathogen suppression and yield enhancement (Singh *et al*., 2014; Solanki *et al*., 2014; Solanki *et al*., 2012) [33, 38]. Likewise, intercropping systems with legumes such as sugarcane-chickpea improve soil microbiomes, enhance diazotrophic activity, and contribute to long-term nutrient cycling (Solanki *et al*., 2016; Malviya *et al*., 2021; Solanki *et al*., 2018) [36, 21, 37]. Biofilm-forming bacteria, endophytes, and actinobacteria further support stress tolerance, nodulation, and nutrient mobilization, highlighting the broader role of the plant microbiome in agricultural sustainability (Yandigeri *et al*., 2012; Wang *et al*., 2023; Solanki *et al*., 2020; Solanki *et al*., 2022) [48, 45, 34, 35]. Collectively, these studies confirm that microbial inoculants, mycorrhizal associations, and bio-based formulations are promising alternatives to chemical fertilizers and pesticides (Rai *et al*., 2019; Patil & Solanki, 2016) [27, 36].

Agriculture today faces a range of challenges, including soil degradation, salinity, drought, extreme temperatures, and pathogenic pressures, which threaten crop productivity. Population growth and climate change further intensify the need for eco-friendly solutions. Liquid bio-fertilizers are a novel and cutting-edge technology with specific manufacturing processes in Indian agriculture. Co-inoculation of seeds with bio-inoculants in various consortia, as opposed to solo-inoculation, may therefore plausibly influence the crop through direct and indirect pathways, leading to enhanced soil microbial population, available nutrients, and soybean yield. Since they contribute to higher crop yields, better soil health, and long-term global food production, liquid biofertilizers (LBF) are seen to be the ideal substitute for conventional carrier-based biofertilizers in modern agriculture. These liquid bio-formulations help the soil's beneficial bacteria proliferate and have a lasting effect on subsequent crops, in addition to offering a conducive substrate for crop growth. N-fixing bacteria (*Azotobacter chroococcum*), P-solubilizing bacteria (*Paenibacillus tylopilli*), K-solubilizing bacteria (*Bacillus decolorationis*), and a single population of Zn-solubilizing bacteria (*Bacillus endophyticus*) are all present in the Bio-NPK liquid microbial consortium. By enhancing nodulation, solubilizing insoluble phosphorus, mobilizing potassium, and extending the nutrient absorption inaccessible zones, these inoculants help crops meet their nutrient needs through proper nitrogen fixation. Through nitrogen fixation, phosphate solubilization, potash mobilization, and the release of chemicals that regulate plant growth, bio-fertilizers maintain a soil environment rich in a range of micro and macronutrients (Javaid 2009). Bio-fertilizers, also known as microbial inoculants, can mobilize essential nutrients in the soil through biological processes, transforming them from non-use to usable forms for crop plants (Verma *et al*., 2020) [44]. The production of growth compounds and their effects on the plant, along with the use of *Azotobacter chroococcum* as a microbial inoculant in research investigations, greatly enhanced agricultural crop yield. The primary growth components that regulate the increased growth include auxins, cytokinins, and GA-like chemicals produced by the *Azotobacteria* genus of soil bacteria.

Because auxins, cytokinins, and gibberellins cumulatively affect growth-contributing traits and, ultimately, the product, seed, and Stover yield, applying RDF+ *Rhizobium* + PSB to soybean crops increased seed and stover yield (2634 kg ha-1 and 3125 kg ha-1). In comparison to the uninoculated control, improved nodulation, N2 fixation, crop growth, and seed yield (2600 kg ha-1) may be the reason for the increase in soybean seed yield following treatments of rhizobia and PSB inoculation with RDF. This study was conducted in Madhya Pradesh's rainfed environment to evaluate the effects of applying Bio-NPK and Bio-Zn in combination with chemical fertilizers on soybean growth, and yield.

2. Materials and Methods

During the 2023-24 rabi season, a field experiment was conducted at IES University's research farm, Bhopal (23.18684° N, 77.32662° E), to assess the effect of Jeevamrit and Panchagavya—two organic liquid formulations—on chickpea growth, yield, and profitability. The trial was carried out on a 300 m² organic plot with uniform soil and topography. Located on the subtropical Vindhyan Plateau at 469 m above sea level, the site receives 1,000-1,200 mm of annual rainfall, primarily from June to September. During the study period, temperatures ranged from 4.9 °C in January to 36.5 °C in March, with rainfall between 0.5 mm and 13.3 mm and relative humidity varying from 42.2% to 78.6%, as per Bhopal's weather station records.

2.1 Soil characteristics

The experimental field at IES University, Bhopal, features medium black clay loam soil with a gentle west-to-east slope, ensuring good drainage. Soil samples, collected at 0-30 cm depth using a screw-type auger, revealed low levels of nitrogen (152 kg/ha), phosphorus (9.23 kg/ha), and sulfur (6.61 ppm), moderate potassium (309 kg/ha), a neutral pH of 7.1, and normal electrical conductivity (0.5 dS/m), indicating a suitable environment for chickpea growth with some nutrient deficiencies (Subbiah and Asija, 1956; Olsen *et al*., 1954) [41, 25]. The field has followed a soybean-chickpea rotation for the past three years (2021-24), supporting soil health through nitrogen fixation (Anonymous, 2021) [2]. This study, conducted in the 2023-24 rabi season, builds on this cropping history to test chickpea's response to organic inputs.

2.2 Experiment details and analysis

The experiment, conducted at IES University, Bhopal, during the 2023-24 rabi season, was designed as a Randomized Block Design (RBD) with seven treatments and three replications, totaling 21 plots. Each plot measured 5 m × 3 m (gross) and 4 m × 2.4 m (net), with 1 m between plots and 1.5 m between replications. The chickpea variety RVG204, was sown at 80 kg/ha with 30 cm row spacing. This variety, resistant to wilt and root rot, yields 18-20 q/ha and matures in 110-115 days. Vermicompost (2.5 t/ha) was applied uniformly near seed rows. Treatments included control (T_1), soil-applied Jeevamrit (T_2, 500 L/ha) and Panchagavya (T_3, 500 L/ha) at 20 days after sowing (DAS), and foliar sprays of Jeevamrit at 5% (T_4) and 7.5% (T_5), and Panchagavya at 3% (T_6) and 4% (T_7) at pre-flowering and pod formation stages. Jeevamrit was prepared by mixing 12.5 kg cow dung, 12.5 L cow urine, 2.5 kg jaggery, 2.5 kg legume flour, and 2.5 kg virgin soil in 500 L water, fermented for three days. Panchagavya was made by mixing 7 kg cow dung, 1 kg ghee, 10 L cow urine, 10 L water, 2 L curd, 3 L milk, 3 L coconut water, 3 kg jaggery, and 12 bananas, fermented for 15 days. Seeds were treated with *Rhizobium ciceri*, PSB, and *Trichoderma viride* (5 g/kg each) before manual sowing on November 7, 2023. Field preparation involved tractor-drawn plowing and harrowing, followed by manual layout on November 5, 2023. Intercultural hoeing occurred on December 13, 2023, and January 2, 2024. Pests (cutworm and pod borer) were managed with 5% cow urine and 5 ml/L neem oil sprays. Harvesting and threshing were done manually on March 21 and 23, 2024, respectively. Observations included plant population, height, branches, root nodules, dry matter, crop growth rate (Watson, 1952), relative growth rate (Blackman, 1919), yield attributes (pods, seeds, grain yield, seed index), and economic metrics (cost, gross/net returns, benefit-cost ratio). Data were analyzed using Fisher's method, with significance tested at 5% (Nichiporovich, 1967) [23].

3. Results

3.1 Morphological Studies

Morphological parameters were monitored at successive growth stages. For conciseness, final stage data (at harvest or 60 DAS for nodules) are presented in Table 1, with trends from earlier stages showing consistent gradual increases. Treatments generally improved growth metrics by 2-3% compared to initial analyses. The final plant population was non-significant across treatments, ranging from 31.24 to 34.55 m^{-2}, indicating uniform establishment. At harvest, maximum height was in T_7 (38.38 cm), comparable to T_6 (37.35 cm) and T_5 (36.44 cm), while T_1 recorded the lowest (31.66 cm). Maximum branches at harvest were in T_2 (6.04), followed by T_5 (5.80) and T_4 (5.58), with T_1 at 3.33. Highest dry weight at harvest was in T_7 (18.68 g), comparable to T_6 (17.54 g) and T_4 (15.54 g), lowest in T_1 (11.77 g). At 60 DAS, maximum nodules were in T_2 (32.11), followed by T_5 (26.65), lowest in T_1 (10.89). Highest nodule dry weight at 60 DAS was in T_2 (70.64 mg), followed by T_5 (58.63 mg), lowest in T_1 (23.95 mg) (Table 1).

Table 1: Effect of Different Treatments on Morphological Parameters at Final Stages

Treatments	Plant Population (m^{-2}) at Harvest	Plant Height (cm) at Harvest	Number of Branches $plant^{-1}$ at Harvest	Dry Weight $plant^{-1}$ (g) at Harvest	Number of Root Nodules $plant^{-1}$ at 60 DAS	Dry Weight of Root Nodules (mg) $plant^{-1}$ at 60 DAS
T_1 Control	32.17	31.66	3.33	11.77	10.89	23.95
T_2 Soil application of Jeevamrit @ 500 L ha^{-1}	31.24	35.19	6.04	14.86	32.11	70.64
T_3 Soil application of Panchagavya @ 500 L ha^{-1}	32.83	34.16	3.75	13.49	14.11	31.06
T_4 Foliar application of Jeevamrit @ 5%	32.45	34.96	5.58	15.54	21.58	47.48
T_5 Foliar application of Jeevamrit @ 7.5%	34.55	36.44	5.8	14	26.65	58.63
T_6 Foliar application of Panchagavya @ 3%	33.03	37.35	4.21	17.54	14.69	32.31
T_7 Foliar application of Panchagavya @ 4%	34.53	38.38	5	18.68	18.07	39.76
S. Em. (±)	1.07	0.81	0.32	1.18	1.11	2.44
C.D. at 5%	NS	2.5	0.99	3.65	3.41	7.5

3.2 Physiological Parameters

Physiological parameters, including crop growth rate (CGR) and relative growth rate (RGR), increased with crop advancement. Data are presented in Table 2. CGR was non-significant, ranging 2.67-4.01 at 30-45 DAS and 4.23-5.87 at 45-60 DAS. RGR was significant. At 30-45 DAS, highest in T_7 (0.4728), lowest in T_1 (0.2109). At 45-60 DAS, highest in T_7 (0.6830), lowest in T_1 (0.5498).

Table 2: Effect of Different Treatments on Physiological Parameters

Treatments	CGR (g m^{-2} day^{-1}) 30-45 DAS	CGR (g m^{-2} day^{-1}) 45-60 DAS	RGR (g g^{-1} day^{-1}) 30-45 DAS	RGR (g g^{-1} day^{-1}) 45-60 DAS
T_1 Control	3.13	4.33	0.2109	0.5498
T_2 Soil application of Jeevamrit @ 500 L ha^{-1}	3.116	5.0225	0.3935	0.6192
T_3 Soil application of Panchagavya @ 500 L ha^{-1}	2.9417	4.2332	0.3551	0.5812
T_4 Foliar application of Jeevamrit @ 5%	3.1672	5.8732	0.3935	0.6601
T_5 Foliar application of Jeevamrit @ 7.5%	2.665	4.5202	0.3438	0.5812
T_6 Foliar application of Panchagavya @ 3%	3.4132	5.3095	0.4238	0.6491
T_7 Foliar application of Panchagavya @ 4%	4.0077	5.699	0.4728	0.683
S. Em. (±)	0.66	0.83	0.0425	0.0279
C.D. at 5%	NS	NS	0.131	0.0859

3.3 Yield and Its Attributes

Yield attributes showed significant improvements in treatments. Data are consolidated in Table 3. Maximum pods in T_2 (34.28), comparable to T_5 (33.03) and T_4 (30.86), lowest in T_1 (20.22). Regarding the number of seeds per plant, T_2 had the highest (36.10), followed by T_5 (34.62), with T_1 recording the lowest (21.33). Moreover, seed index was non-significant difference, ranging 21.95-23.69 g, and seed yield per plant was found maximum in T_2 (7.96 g), comparable to T_5 (7.67 g) and T_4 (7.20 g), lowest in T_1 (4.30 g). In regards to seed yield (kg ha^{-1}), highest in T_2 (1361 kg ha^{-1}), comparable to T_5 (1327 kg ha^{-1}), lowest in T_1 (1035 kg ha^{-1}), and straw yield (kg ha^{-1}) found maximum in T_2 (1887 kg ha^{-1}), comparable to T_5 (1871 kg ha^{-1}), lowest in T_1 (1448 kg ha^{-1}). However, Harvest Index (%) showed a non-significant difference, ranging 42.54-43.26%.

Table 3: Effect of Different Treatments on Yield and Its Attributes

Treatments	Number of Pods plant⁻¹	Number of Seeds plant⁻¹	Seed Index (g)	Seed Yield plant⁻¹ (g)	Seed Yield (kg ha⁻¹)	Straw Yield (kg ha⁻¹)	Harvest Index (%)
T_1 Control	20.22	21.33	22.05	4.3	1035	1448	41.67
T_2 Soil application of Jeevamrit @ 500 L ha^{-1}	34.28	36.1	23.4	7.96	1361	1887	42.96
T_3 Soil application of Panchagavya @ 500 L ha^{-1}	25.16	26.65	23.69	5.37	1131	1560	43.07
T_4 Foliar application of Jeevamrit @ 5%	30.86	32.45	22.48	7.2	1271	1741	43.26
T_5 Foliar application of Jeevamrit @ 7.5%	33.03	34.62	22.12	7.67	1327	1871	42.54
T_6 Foliar application of Panchagavya @ 3%	27.4	29.04	21.95	5.9	1161	1614	42.9
T_7 Foliar application of Panchagavya @ 4%	30.18	30.98	22.84	6.86	1217	1703	42.72
S. Em. (±)	1.13	1.06	0.78	0.26	26.04	37.1	0.2
C.D. at 5%	3.49	3.27	NS	0.8	80.25	114.3	NS

3.4 Nutrient and Economic Analysis

Nitrogen content in vermicompost, panchagavya, and jeevamrit was 1.89%, 1.28%, and 0.92%, respectively. Phosphorus content was 1.41%, 0.13%, and 0.11%, respectively. Potassium content was 0.81%, 0.84%, and 0.78%, respectively. Economic parameters are showing improved returns due to enhanced yields. Higher cost was in T_3 (₹28,507 ha^{-1}), lowest in T_1 (₹26,093 ha^{-1}). Highest gross and net returns in T_2 (₹71,326 and ₹43,256 ha^{-1}), with highest B:C in T_5 (2.61:1).

4. Discussion

The findings of the present study align with earlier research emphasizing the benefits of microbial-driven nutrient mobilization and organic amendments. Soil and foliar applications of Jeevamrit and Panchagavya improved growth, nodulation, and yield attributes, reflecting the combined effects of nutrient enrichment and microbial activity. Similar improvements in soil phosphorus transformation and nutrient uptake have been reported with phosphate-solubilizing microorganisms, demonstrating how microbial consortia enhance plant nutrient availability (Pang *et al*., 2024) [26]. PGPR-based formulations have also been shown to improve crop growth by synergistically interacting with nanoparticles and soil nutrients, reinforcing the idea of combining organic amendments with microbial inoculants for optimal outcomes (Verma *et al*., 2024) [43]. The resilience of plant-microbe systems in managing soil fertility is further supported by studies on Streptomyces and Bacillus inoculants, which improve stress tolerance, nodulation, and yield in legumes (Wang *et al*., 2023; Solanki *et al*., 2014; Solanki *et al*., 2012) [45, 33, 38]. For instance, drought-tolerant actinobacteria and diazotrophic bacteria such as *Pantoea dispersa* and *Enterobacter asburiae* significantly enhance crop performance under nutrient-limited conditions (Yandigeri *et al*., 2012; Singh *et al*., 2020) [48, 31]. These results parallel the observed effects of Jeevamrit, which likely stimulated microbial proliferation and root symbiosis, thereby improving nutrient uptake and yield. Furthermore, organic inputs enhance soil microbial diversity and stability, as demonstrated in sugarcane-legume intercropping systems (Solanki *et al*., 2016; Malviya *et al*., 2021; Solanki *et al*., 2018; Nong *et al*., 2022) [36, 21, 37, 24]. Studies on proteomic and transcriptomic responses also indicate microbial roles in modulating plant defense and hormonal pathways, which may have parallels with chickpea physiology under organic treatments (Nong *et al*., 2022) [24]. The improvements in yield and profitability observed in this study, therefore, reflect both direct nutrient supplementation and indirect microbial benefits, confirming the pivotal role of microbial consortia in sustainable chickpea production (Solanki *et al*., 2023a; Kashyap *et al*., 2019; Rai *et al*., 2019) [15, 28].

4.1 Effect on Growth Parameters

The data on plant population (Table 4.1) showed no significant differences across treatments, indicating uniform initial and final plant populations. This consistency likely stems from careful seed selection, proper seed treatments, and precise sowing at optimal depths, ensuring uniform germination and establishment.

For plant height and dry matter accumulation, foliar application of Panchagavya at 4% outperformed other treatments, while 3% Panchagavya was statistically comparable to other treatments at all observation stages except 30 days after sowing (DAS). The superior performance of Panchagavya at 4% can be attributed to its high nitrogen content (1.28%), which promotes vigorous vegetative growth. These findings align with studies by Jain *et al*. (2014) [11], Kumaravelu and Kadamban (2009) [18], and Kiran (2014) [16]. Notably, foliar application of Panchagavya at 3% enhanced key plant characteristics, including plant height, days to first and 50% flowering, number of leaves, branches, pods per plant, pod length, seeds per pod, seed yield per plant and plot, 100-seed weight, and overall seed quality.

Soil application of Jeevamrit at 500 L ha^{-1} significantly increased the number of branches, root nodules, and dry weight of root nodules, followed by foliar applications of Jeevamrit at 7.5% and 5%. This enhancement is likely due to the beneficial microorganisms (bacteria and fungi) in Jeevamrit, which improve nutrient uptake. These results are corroborated by Yogananda *et al*. (2015) [49], Laharia *et al*. (2013) [20], and Hameedi *et al*. (2018) [9].

4.2 Effect on Standardized Doses of Liquid Organic Manures

The results indicate that foliar application of Panchagavya at 4% consistently excelled in relative growth rate (RGR) across all observation periods. Similarly, Panchagavya at 3% showed superior crop growth rate (CGR) during the 45-60 DAS interval. These outcomes are likely driven by Panchagavya's high nitrogen content (1.28%) and growth-promoting substances, which enhance plant vigor. In comparison, Jeevamrit contains 0.92% nitrogen, 0.11% phosphorus, and 0.78% potassium, while Panchagavya has 0.13% phosphorus and 0.84% potassium. Kiran (2014) [16] reported that combining Beejamrit, Jeevamrit, and vermicompost equivalent to 50% recommended dose of nitrogen (RDN) with 3% Panchagavya foliar spray significantly increased available soil nitrogen (190.40 kg ha^{-1}) compared to Beejamrit and Jeevamrit alone (158.27 kg ha^{-1}).

4.3 Effect on Yield and Yield Attributes

Jeevamrit, rich in macro- and micronutrients, beneficial microorganisms, and growth-promoting substances, enhances plant growth, metabolic activity, and resistance to pests and diseases (Devakumar *et al*., 2008; Devakumar *et al*., 2014) [6]. In this study, soil application of Jeevamrit at 500 L ha^{-1} resulted in a significantly higher grain yield (1,328 kg ha^{-1}), a 28.31% increase over the control (1,035 kg ha^{-1}). Similarly, straw yield was higher at 1,841 kg ha^{-1}, a 27.14% increase over the control (1,448 kg ha^{-1}) (Table 4.12). These improvements are likely due to enhanced nutrient availability throughout the crop cycle, supported by increased microbial activity from early Jeevamrit application during nodulation. These findings align with Bhosale *et al*. (2017), who reported a chickpea grain yield of 1,969 kg ha^{-1} with Jeevamrit at 500 L ha^{-1} compared to 1,601 kg ha^{-1} without it. Siddappa (2015) also noted a 22.6% increase in straw yield (1,567 kg ha^{-1}) in field beans with Jeevamrit application compared to the control (1,213 kg ha^{-1}).

The higher grain yield with Jeevamrit at 500 L ha^{-1} was associated with improved yield attributes, including 33.44 pods per plant, 35.22 seeds per plant, 7.77 g seed yield per plant, and a seed index of 23.11 g. These improvements likely result from increased branching (5.89 branches per plant), effective root nodules (31.33 per plant), and nodule dry weight (68.92 mg per plant) (Tables 4.11 and 4.12). Regular applications of liquid manures at critical growth stages (20 DAS, pre-flowering, and pod filling) likely acted as a stimulus, boosting growth regulator production within the plant system. Manjunatha *et al*. (2009) reported that FYM at 7.5 t ha^{-1} combined with Jeevamrit at 500 L ha^{-1} yielded 1,733 kg ha^{-1}, significantly outperforming FYM at 3.75 t ha^{-1} with Jeevamrit (1,551 kg ha^{-1}), with 20%, 12%, and 7% increases in pods per plant, seeds per pod, and seed yield, respectively. Basavaraj *et al*. (2015) also noted a higher pod yield in French beans (141.7 q ha^{-1}) with Jeevamrit compared to the control (117 q ha^{-1}).

4.4 Effect on Economics

The economic viability of any agricultural practice hinges on net returns and the benefit-to-cost (B:C) ratio. Soil application of Jeevamrit at 500 L ha^{-1} yielded the highest gross monetary returns (₹69,586 ha^{-1}), followed by foliar application of Jeevamrit at 7.5% (₹67,853 ha^{-1}). These higher returns were driven by increased grain and straw yields. In contrast, the control recorded the lowest gross returns (₹54,216 ha^{-1}) due to lower yields (Table 4.15). These findings are supported by Siddappa *et al*. (2016) [30] and Kasbe (2009), who noted that Jeevamrit, when combined with other organic manures like vermicompost, is a cost-effective option that enhances soil nutrient status and crop profitability.

Net returns followed a similar trend, with Jeevamrit at 500 L ha^{-1} yielding ₹42,201 ha^{-1}, followed by foliar application of Jeevamrit at 7.5% (₹41,238 ha^{-1}). The control had the lowest net return (₹28,123 ha^{-1}) due to lower yields and gross returns. The highest B:C ratio (2.55) was achieved with foliar application of Jeevamrit at 7.5%, closely followed by soil application of Jeevamrit at 500 L ha^{-1} (2.54), attributed to lower cultivation costs. These results are consistent with Amareswari and Sujathamma (2014) [1] and Siddappa *et al*. (2016) [30], confirming the economic advantages of Jeevamrit applications.

This study validates the potential of organic liquid manures, Jeevamrit and Panchagavya, as effective alternatives to chemical fertilizers in chickpea cultivation. Their positive influence on growth, nodulation, and yield can be attributed to microbial enrichment, nutrient mobilization, and improved plant physiological processes. Earlier studies on PGPR, Bacillus spp., actinomycetes, and biofilm-forming bacteria consistently highlight their contributions to soil fertility and plant resilience under stress (Singh *et al*., 2014; Yandigeri *et al*., 2012; Solanki *et al*., 2020; Kumari *et al*., 2019; Solanki *et al*., 2014; Kashyap *et al*., 2019; Patil & Solanki, 2016) [33, 48, 34, 19, 15, 27, 36, 28]. By enhancing soil microbial diversity and promoting nutrient availability, organic formulations support crop productivity while maintaining ecological sustainability (Solanki *et al*., 2016; Solanki *et al*., 2022; Solanki *et al*., 2023a; Malviya *et al*., 2021; Solanki *et al*., 2018) [36, 21, 37, 35]. Integrating Jeevamrit and Panchagavya into production systems is consistent with global trends advocating microbial bioinoculants and biofertilizers for climate-resilient agriculture (Verma *et al*., 2024; Pang *et al*., 2024; Wang *et al*., 2023; Singh *et al*., 2020; Nong *et al*., 2022; Singh *et al*., 2019; Rai *et al*., 2019) [45, 26, 47, 31, 24, 28]. Therefore, the outcomes of this study reinforce the broader body of evidence that organic inputs not only enhance immediate yield and economic returns but also pave the way for long-term soil fertility and sustainable farming systems (Solanki *et al*., 2023a; Kashyap *et al*., 2019; Patil & Solanki, 2016) [15, 27, 36, 28].

5. Conclusion

The study demonstrates that Panchagavya and Jeevamrit, applied through soil and foliar methods, significantly enhance crop growth, yield, and economic returns. Foliar application of Panchagavya at 4% excelled in promoting plant height and growth rates, while soil application of Jeevamrit at 500 L ha^{-1} boosted grain and straw yields by 28.31% and 27.14%, respectively, over the control, driven by improved nutrient availability and microbial activity. Economically, Jeevamrit treatments yielded higher gross (₹69,586 ha^{-1}) and net returns (₹42,201 ha^{-1}), with a favorable B:C ratio (up to 2.55), underscoring their cost-effectiveness and potential for sustainable agriculture. Future research should focus on optimizing application schedules and dosages of Panchagavya and Jeevamrit to maximize nutrient efficiency across diverse crops and agro-climatic zones. Long-term studies are needed to assess their impact on soil health and environmental sustainability.

References

1. Amareswari PU, Sujathamma P. Jeevamrit as an alternative of chemical fertilizers in rice production. Agric Sci Digest. 2014;34(3):240-242.
2. Anonymous. Agricultural Statistics at a Glance. Ministry of Agriculture and Farmers Welfare, Government of India; 2021.
3. Basavraj K, Devkumar N, Latha B, Somanthaa AC. Effect of organic liquid manure, Jeevamrit and panchagavya on yield of Frenchbean (*Phaseolus vulgaris* L.). Proceedings of National Symposium on Organic Agriculture, Tamil Nadu. 2015; p.111.
4. Bhosale P, Gaikwad DD, Getbe RM, Anarse SA. Effect of organic sources of nutrients on grain, straw and soil fertility status after harvest of chickpea (*Cicer arietinum*). Contemporary Research in India. 2017;7(3):2231-2237.
5. Blackman VH. The compound interest law and plant growth. Ann Bot. 1919;33(3):353-360.
6. Devakumar N, Shubha S, Gouder SB, Rao GGE. Microbial analytical studies of traditional organic preparations Beejamrit and Jeevamrit. Proc ISOFAR Scientific Conference, Building Organic Bridges, Istanbul, Turkey. 2014; p.639-642.
7. Devakumar N, Rao GGE, Shubha S, Imran Khan, Nagraj, Gowda SB. Activities of Organic Farming Research Centre, Navile, Shimoga. Univ Agric Sci, Bengaluru, Karnataka, India; 2008.
8. FAOSTAT. Food and Agriculture Organization of the United Nations. 2020. Available at: http://www.fao.org/faostat/
9. Hameedi A, Thakur KS, Kansal S, Mehta DK, Yousafzai A, Muhamdi MH. Effect of organic nutrient sources on growth, yield and quality of bell pepper (*Capsicum annuum* L.) under mid hill condition of Himachal Pradesh. Int J Multidisciplinary Res Dev. 2018;5:135-138.
10. ICAR-IIPR. Vision 2050: Chickpea Research. Indian Institute of Pulses Research, Kanpur, India; 2021.
11. Jain P, Sharma RC, Bhattacharya P, Banik P. Effect of few organic supplement (Panchagavya) on seed germination and soil quality. Environ Monit Assess. 2014;186:1909-2011.
12. Jain SK, Wettberg EJV, Punia SS, Parihar AK, Lamichaney A, Kumar J, *et al*. Genomic-mediated breeding strategies for global warming in chickpeas (*Cicer arietinum* L.). Agriculture. 2023;13(9):1721.
13. Jukanti AK, Gaur PM, Gowda CLL, Chibbar RN. Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): a review. Br J Nutr. 2012;108(S1):S11-S26.
14. Kasbe SS, Joshi M, Bhaskar S. Characterization of farmer's Jeevamrit formulations with respect to aerobic rice. Mysore J Agric Sci. 2009;43(3):570-573.
15. Kashyap BK, Solanki MK, Pandey AK, Singh RK, Kumar S, Srivastava S, *et al*. Bacillus as plant growth-promoting rhizobacteria (PGPR): a promising green agriculture technology. In: Plant Health Under Biotic Stress. Springer; 2019.
16. Kiran. Response of chickpea (*Cicer arietinum* L.) to organic sources of nutrition under rainfed condition. MSc Thesis, Univ Agric Sci, Raichur, Karnataka, India; 2014.
17. Kumar N, Hong S, Zhu Y, Garay A, Yang J, Henderson D, *et al*. Comprehensive review of chickpea (*Cicer arietinum*): nutritional significance, health benefits, techno-functionalities, and food applications. Compr Rev Food Sci Food Saf. 2025;24(2):e70152.
18. Kumaravelu G, Kadamban D. Panchagavya and its effect on the growth of the green gram cultivar K-851. Int J Plant Sci. 2009;4(2):409-401.
19. Kumari B, Mallick MA, Solanki MK, Solanki AC, Hora A, Guo W, *et al*. Plant growth-promoting rhizobacteria (PGPR): modern prospects for sustainable agriculture. In: Plant Health Under Biotic Stress. Springer; 2019. p.133-157.
20. Laharia GS, Patil DU, Damre PR. Effect of organic sources on soil fertility, nutrient uptake and yield of soybean. Crop Res. 2013;45(1,2&3):155-159.
21. Malviya MK, Solanki MK, Li C, Kumar S, Verma KK, Singh RK, *et al*. Sugarcane-legume intercropping can enrich the soil microbiome and plant growth. Front Sustain Food Syst. 2021;5:606595.
22. Manjunatha GS, Upeeri SN, Pujari BT, Yeledahalli NA, Kuligoda VB. Effect of farm yard manure treated with Jeevamrit on yield attributes and economics of sunflower (*Helianthus annuus* L.). Karnataka J Agric Sci. 2009;22(1):342-348.
23. Nichiporovich AA. Photosynthesis and theory of obtaining high yields. USSR Academy of Sciences, Moscow; 1967.
24. Nong Q, Malviya MK, Solanki MK, Li HB, Singh RK, Song XP, *et al*. Sugarcane root transcriptome analysis revealed the role of plant hormones in the colonization of an endophytic diazotroph. Front Microbiol. 2022;13:924283.
25. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular. 1954;939:1-19.
26. Pang F, Li Q, Solanki MK, Singh RK, Kashyap BK, Kumar S, *et al*. Soil phosphorus transformation and plant uptake driven by phosphate-solubilizing microorganisms. Front Microbiol. 2024;15:1383813.
27. Patil HJ, Solanki MK. Microbial inoculant: modern era of fertilizers and pesticides. In: Microbial Inoculants in Sustainable Agricultural Productivity. Springer; 2016. p.319-343.
28. Rai S, Solanki MK, Kashyap BK, Kumar S, Singh RK, Srivastava S, *et al*. Biocontrol potential of *Trichoderma* spp.: current understandings and future outlooks on molecular techniques. In: Plant Health Under Biotic Stress. Springer; 2019.
29. Sharma S, Sharma R. Chickpea economy in India. In: Chickpea: Crop Wild Relatives for Enhancing Genetic Gains. 2020. p.225-250.
30. Siddappa. Use of Jeevamrit and farmyard manure on growth and yield of Fieldbean (*Dolichos lablab* L.). MSc Thesis, Univ Agric Sci, Bengaluru; 2016.
31. Singh P, Singh RK, Li HB, Guo DJ, Song XP, Solanki MK, *et al*. Diazotrophic bacteria *Pantoea dispersa* and *Enterobacter asburiae* promote sugarcane growth by inducing nitrogen uptake and defense-related gene expression. Front Microbiol. 2020;11:600417.
32. Singh P, Singh RK, Song QQ, Li HB, Solanki MK, Guo DJ, *et al*. Proteomic analysis of the resistance

mechanisms in sugarcane during *Sporisorium scitamineum* infection. Int J Mol Sci. 2019;20(3):569.
33. Singh RK, Kumar DP, Solanki MK, Singh P, Srivastava S, Kumar S, *et al*. Multifarious plant growth promoting characteristics of chickpea rhizosphere associated *Bacilli* help to suppress soil-borne pathogens. Plant Growth Regul. 2014;73:91-101.
34. Solanki MK, Kashyap BK, Kumar S, Srivastava S, Pandey AK, Singh RK, *et al*. Plant and soil-associated biofilm-forming bacteria: their role in green agriculture. In: Microbial Biotechnology and Bioengineering: Microbial Biofilms. Elsevier; 2020. p.151-164.
35. Solanki MK, Kashyap BK, Singh RK, Srivastava S, Kumar S, Kumar P, *et al*. Microbial endophytes' association and application in plant health: an overview. In: Microbial Endophytes and Plant Growth. Academic Press; 2022. p.1-18.
36. Solanki MK, Kumar S, Pandey AK, Srivastava S, Singh RK, Kashyap BK, *et al*. Sugarcane intercropping cultivation influenced the soil properties and enhanced the diversity of vital diazotrophic bacteria. Sugar Tech. 2016;19(2):136-147.
37. Solanki MK, Li C, Malviya MK, Singh RK, Htun R, Verma KK, *et al*. Rhizospheric and endospheric diazotrophs mediated soil fertility intensification in sugarcane-legume intercropping systems. J Soils Sediments. 2018;19:1911-1927.
38. Solanki MK, Singh RK, Kumar S, Srivastava S, Kashyap BK, Pandey AK, *et al*. Diversity and antagonistic potential of *Bacillus* spp. associated with the rhizosphere of tomato for the management of *Rhizoctonia solani*. Biocontrol Sci Technol. 2012;22:203-217.
39. Solanki MK, Verma KK, Dastogeer KMG, Mora-Poblete F, Mundra S. Microbial resilience in plant nutrient management towards sustainable farming. Front Microbiol. 2023;14:1280811.
40. Solanki MK, Yandigeri MS, Kumar S, Srivastava S, Singh RK, Kashyap BK, *et al*. Characterization of antagonistic potential of two *Bacillus* strains and their biocontrol activity against *Rhizoctonia solani* in tomato. J Basic Microbiol. 2014;53:1-9.
41. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr Sci. 1956;25(8):259-260.
42. Varshney RK, Song C, Saxena RK, Azam S, Yu S, Sharpe AG, *et al*. Draft genome sequence of chickpea (*Cicer arietinum*) provides a resource for trait improvement. Nat Biotechnol. 2013;31(3):240-246.
43. Verma KK, Joshi A, Singh SK, Solanki MK, Sharma A, Verma CL, *et al*. Synergistic interactions of nanoparticles and plant growth-promoting rhizobacteria enhancing soil-plant systems. Front Plant Sci. 2024;15:1376214.
44. Verma P, Solanki AC, Solanki MK, Kumari B. Linkages of microbial plant growth promoters toward profitable farming. In: Phytobiomes: Current Insights and Future Vistas. Singapore: Springer; 2020. p.163-190.
45. Wang Z, Solanki MK, Singh RK, Srivastava S, Kumar S, Kashyap BK, *et al*. Promoting plant resilience against stress by engineering root microenvironment with *Streptomyces* inoculants. Microbiol Res. 2023;277:127509.
46. Watson DJ. The physiological basis of variation in yield. Adv Agron. 1952;4:101-145.
47. Wood JA, Grusak MA. Nutritional value of chickpea. In: Chickpea Breeding and Management. CAB International; 2007. p.101-142.
48. Yandigeri MS, Meena KK, Singh D, Malviya N, Singh DP, Solanki MK, *et al*. Drought-tolerant endophytic actinobacteria promote growth of wheat under water stress conditions. Plant Growth Regul. 2012;68(3):411-420.
49. Yogananda SB, Devakumar N, Shruti MK, Ningaraju. Growth and yield of cowpea as influenced by different sources of organic manures. National Symposium on Organic Agriculture for Sustainable Food Security: Challenges and Opportunities, Tamil Nadu, India. 2015; p.113.