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CONTENTS

Natural Farming Inputs (NFIs) as sustainable alternatives for enhancing the growth and development of Chickpea (*Cicer arietinum* L.)

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ABSTRACT: Natural farming is an ecologically sustainable production system that relies on locally available biological resources to improve soil health, crop growth and agro-ecosystem resilience while minimising dependence on chemical inputs. The present study evaluated the effectiveness of selected natural farming inputs (NFIs), namely Panchagavya, Jeevamruth and Amritpani on the growth and development of chickpea (*Cicer arietinum* L.) cultivar PG-186 under greenhouse conditions. Eleven treatments were assessed, and all NFI-based applications significantly enhanced plant growth compared to the control and farmyard manure (FYM). Among the evaluated inputs, Panchagavya proved most effective, resulting in superior biomass accumulation, nutrient uptake and biochemical attributes. Notably, Panchagavya application significantly increased plant height (54.51 ± 1.19 cm), fresh biomass (9.27 g) and dry biomass (3.05 g) over the control. Overall, the results highlight the potential of NFIs, particularly Panchagavya, as sustainable and efficient alternatives to conventional inputs for improving chickpea growth and productivity.

Keywords: Amritpani, Chickpea, Jeevaamruth, Panchagavya, Sustainable Yield

Natural farming is an ancient yet regenerative agricultural approach grounded in ecological interaction among soil, crops, livestock and microorganisms aimed at developing self-sustaining agro-ecosystems (Sharma *et al*., 2023). This system enhances soil fertility and overall soil health through the incorporation of beneficial microbial communities and organic resources, thereby reducing reliance on synthetic fertilisers. In recent years, natural farming has gained considerable attention and adoption in India as well as globally due to its sustainability and environmental benefits (Duddigan *et al*., 2022). The use of organic inputs such as farmyard manure, compost, neem cake, vermicompost and poultry manure has long been practiced as a viable alternative to chemical fertilisers, contributing to nutrient supply, soil organic carbon maintenance, and favourable soil physical conditions (Kumar *et al*., 2020; Islam *et al*., 2024). Recent advancements in natural farming emphasize the use of fermented liquid bio-inputs and effective microorganisms, particularly formulations derived from cow dung and urine, to increase nutrient availability, microbial activity and crop productivity (Sarma *et al*., 2024).

Natural farming inputs (NFIs) such as panchagavya, jeevamruth, and amritpani are widely used bovine-based fermented preparations that improve soil structure, microbial diversity and rhizospheric interactions. These inputs contain diverse microbial consortia, including nitrogen-fixing, phosphate-solubilising and plant growth–promoting microorganisms, which facilitate nutrient cycling, root development, plant vigour, and yield stability while reducing dependency on chemical agrochemicals (Gohil *et al*., 2023). Chickpea (*Cicer arietinum* L.), a major pulse crop of the Fabaceae family, is a vital source of plant-based protein, minerals, and micronutrients, particularly in semi-arid and temperate regions. Globally, chickpea ranks second in acreage and third in production among pulse crops, with India contributing the largest share of the estimated 11.5 million tonnes annual production (Merga and Haji, 2019). Given its nutritional and economic importance, the present study aimed to evaluate the individual effects of selected NFIs on the growth and development of chickpea under controlled conditions, with a focus on their microbial efficacy and potential as sustainable alternatives to conventional fertilisation practices.

MATERIALS AND METHODS

Experiment design

A pot experiment was conducted under controlled glasshouse conditions in the Department of Biological Sciences to evaluate the effects of natural farming inputs (NFIs), their microbial communities (MC), and microbial-free filtrates (MFF) on chickpea growth. The experiment was maintained at a temperature of 25–28°C with a 16/8 h light–dark photoperiod and approximately 60% relative humidity. Pots (2 kg capacity) were filled with a sterilised sand-soil mixture (3:1, w/w) having a pH of 7.15 and electrical conductivity of 65.1 µS. Four surface-sterilised seeds of chickpea (*Cicer arietinum* L.) cultivar PG-186 were sown per pot. At 15 days after sowing, seedlings were treated with the respective natural farming inputs (NFIs), microbial communities, and microbial-free filtrates through soil drenching, with 50 mL applied to each pot. Plants were harvested 45 days after treatment for physiological, biochemical, and nutrient analyses. The experiment comprised of eleven treatments: Control (T_1); Farm Yard manure(T_2); Panchagavya (T_3); Panchagavya microbial community (T_4); Panchagavya microbial-free filtrate (T_5); Jeevamruth (T_6); Jeevamruth microbial community (T_7); Jeevamruth microbial-free filtrate (T_8); Amritpani (T_9); Amritpani microbial community (T_{10}) and Amritpani microbial-free filtrate (T_{11}). Each treatment was replicated three times and arranged in a completely randomized block design.

Preparation of NFIs, MC and MFF

Panchagavya, Jeevamruth, and Amritpani were prepared following the methods described by Jain *et al*. (2014), Maity *et al*. (2020) and Shekh *et al*. (2018). For microbial communities (MC) preparation, 10 mL of each NFI was inoculated into 40 mL of N+P medium (nutrient broth and potato dextrose broth) and incubated at 27°C for 24 h, maintaining an optical density (OD) of 0.1. For microbial-free filtrate (MFF) preparation, each NFI was centrifuged at 12,000 rpm, the supernatant was filtered through Whatman No. 1 filter paper to remove debris, and subsequently passed through a 0.22 µm membrane filter under vacuum to eliminate associated microorganisms.

Plant Growth Characteristics

Plants were harvested 45 days after treatment and thoroughly washed with tap water to remove adhering soil particles. Root and shoot lengths, along with fresh biomass, were recorded. Dry matter accumulation was determined after oven-drying the samples at 65°C for 24 h.

Biochemical analysis

Estimation of Chlorophyll

Leaf chlorophyll content was estimated following Arnon (1949) by homogenising 0.1 g fresh leaf tissue in 10 mL of 80% acetone, incubating in the dark for 24 h, and recording absorbance at 663 nm (*Chl a*) and 645 nm (*Chlb*).

Estimation of Phosphorus and Potassium

Phosphorus content was estimated using the vanadomolybdate reagent method as described by Jackson (1973) and further detailed by Sharma and Sharma (2019). Potassium content was measured using a flame photometer Sharma and Sharma, (2019).

Statistical analysis

All data are expressed as mean ± standard error (SE), with three replicates per treatment (n = 3). Plant growth and biochemical parameters were analysed using one-way analysis of variance (ANOVA). Treatment means were separated using Tukey's honestly significant difference (HSD) test at a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

Effect of NFIs on vegetative characters

Shoot length, Shoot fresh and dry weight

The application of natural farming inputs (NFIs) significantly improved vegetative growth parameters of chickpea compared to the control and farmyard manure treatments. Among the evaluated NFIs, Panchagavya (T_3) produced the maximum shoot length (54.51 ± 1.19 cm), showing statistically significant results over all other treatments (Table 1). This was followed by Panchagavya microbial communities (T_4; 50.33 ± 0.57 cm) and Jeevamruth (T_6; 49.01 ± 0.71 cm), which were statistically comparable and markedly higher than the remaining treatments. The enhanced shoot elongation under Panchagavya application may be attributed to the presence of bioactive compounds, enzymes, and growth-promoting substances that stimulate cell division and elongation (Panchal *et al*., 2017). Similarly, Panchagavya application resulted in the highest shoot fresh weight (9.27 g) and dry weight (3.05 g), which were significantly superior to all other treatments (Table 1). The Panchagavya microbial community (T_4) ranked second, recording fresh and dry weights of 7.42 g and 2.08 g, respectively. The observed increase in biomass under Panchagavya and its microbial formulations can be ascribed to the availability of essential nutrients and growth-promoting metabolites that enhance biomass accumulation and overall plant vigour (Panda *et al*., 2020)

Root length, Root fresh and dry weight

Application of Panchagavya (T_3) resulted in maximum root length (30.97 cm), followed by Jeevamruth (T_6; 28.15 cm). The Panchagavya-derived microbial community (T_4) also significantly enhanced root elongation (27.47 cm), reflecting a strong stimulatory effect on root system development. The increased root extension observed across all NFI treatments (Table 1) suggests that these inputs act as nutrient-rich substrates that promote root proliferation. As reported by Hodge *et al*. (2004), plant roots respond to localised nutrient enrichment by increasing elongation and branching to optimise nutrient uptake. Panchagavya (T_3) also recorded the highest root fresh weight (4.35 g) and dry weight (0.95 g), followed by the Panchagavya microbial community (T_4), which yielded fresh and dry weights of 3.55 g and 0.84 g, respectively. Overall, Panchagavya and its associated microbial community were most effective in increasing root biomass, highlighting their potential to stimulate root growth and development. The improved root architecture observed under Panchagavya treatment likely facilitated greater water and nutrient uptake, contributing to enhanced plant vigour (Chaudhari *et al*., 2023). Furthermore, the balanced nutrient composition of these inputs ensures adequate

Table 1: Effect of NFIs on vegetative growth of chickpea cultivar PG-186

Treatment	Plant length (cm)	Plant fresh weight (g)	Plant dry weight (g)	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
T_1: Control	30.49±0.98a	3.14±0.09a	0.92±0.04a	16.66±0.33a	1.10±0.03a	0.37±0.02a
T_2: Farm Yard manure	36.00±0.60b	5.29±0.13b	1.09±0.04b	22.09±0.07b	1.37±0.02a	0.42±0.01a
T_3: Panchagvya	54.51±1.19f	9.27±0.04g	3.05±0.10h	30.97±0.49g	4.35±0.03f	0.95±0.01f
T_4: Panchagvya microbial Communities	50.33±0.57e	7.42 ±0.28f	2.08±0.03g	27.47±0.18f	3.55±0.19e	0.84±0.01d
T_5: Panchagvya microbial free filtrate	44.02±1.02cd	6.16±0.07ef	1.84±0.03f	25.36±0.22cde	2.99±0.03d	0.67±0.02c
T_6: Jeevamruth	49.01±0.71e	6.88±0.07ef	1.69±0.02e	28.15±0.62f	2.93±0.03d	0.82±0.004de
T_7: Jeevamruth microbial communities	46.53±0.84de	5.90±0.04cd	1.52±0.01ef	26.08±1.53def	2.82±0.08cd	0.74±0.03d
T_8: Jeevamruthmicrobial free filtrate	38.46±0.67b	5.87±0.06cd	1.36±0.03cd	24.70±0.64bc	2.56±0.03c	0.67±0.02c
T_9: Amritpani	47.40±0.56de	6.84±0.06ef	1.42±0.02cd	25.74±0.84de	2.90±0.01d	0.76±0.03de
T_{10}: Amritpani microbial communities	39.87±1.01bc	6.21±0.36d	1.25±0.02bc	23.40±0.36bcd	1.92±0.04b	0.68±0.02c
T_{11}: Amritpani microbial free filtrate	37.57±0.73b	5.41±0.11b	1.15±0.01b	22.25±0.12bcde	1.75±0.02b	0.54±0.01b
SD(m)	0.83	0.15	0.039	0.63	0.06	0.01
CD(5%)	2.45	0.45	0.11	1.87	0.20	0.053

All parameters are presented as mean ± standard error (n = 3). Different superscript letters indicate significant differences ($P < 0.05$) among treatments, while identical letters denote no significant difference availability of essential elements necessary for optimal plant growth, physiological processes and overall development (Singh *et al*., 2024).

Effect of NFIs on chlorophyll content in chickpea

Panchagavya (T_3) showed a pronounced positive effect on chlorophyll accumulation in chickpea (Table 2), leading to a significant increase in both chlorophyll *a* and chlorophyll *b* contents. The enhanced concentration of photosynthetic pigments under Panchagavya treatment may be associated with the presence of plant growth–promoting phytohormones, particularly kinetin, which plays a key role in chlorophyll synthesis and stability. The inclusion of coconut water during Panchagavya preparation, a known source of kinetin, likely contributed to the elevated chlorophyll content observed in this study (Khatua *et al*., 2025).

Effect of NFIs on phosphorus and potassium uptake in chickpea

Phosphorus and potassium uptake data are presented in Table 2. Among the evaluated natural farming inputs, Panchagavya (T_3) proved to be the most effective bio-nutrient source, resulting in the highest phosphorus (4.12±0.02%) accumulation in chickpea plants. Enhanced phosphorus content was also observed under the Panchagavya-derived microbial community (3.66%) and Jeevamruth (3.59%) treatments. Similarly, Panchagavya-treated plants recorded the maximum potassium content (5.25%), followed by Amritpani (4.57%) and the Panchagavya microbial community (4.51%), highlighting their strong influence on potassium uptake. These results align with earlier findings by Beaulah (2002), who reported that the integrated application of Panchagavya with organic amendments such as poultry manure and neem cake significantly improved nutrient concentrations in *Moringa oleifera* leaves and pods.

CONCLUSION

The present study demonstrates that natural farming inputs (NFIs) serve as effective and sustainable alternatives for improving the growth and development of chickpea under glasshouse. Application of NFIs, including their microbial communities and microbial-free filtrates, significantly enhanced shoot and root growth, biomass accumulation, and overall biochemical health compared to the control and farmyard manure. Among the treatments, Panchagavya and its associated microbial communities exhibited the greatest growth-promoting effects, followed by Jeevamruth. The superior performance of Panchagavya is attributed to its rich consortium of beneficial microorganisms and bioactive metabolites derived from cow-based components. Overall, the findings highlight the microbial- and metabolite-

Table 2: Effect of NFIs on chlorophyll content and phosphorus and potassium uptake

Treatments	Chl*a* (mg/g FW)	Chl*b* (mg/g FW)	Nutrients%	
			Phosphorus%	Potassium%
T_1: Control	0.49±0.009a	0.25±0.003a	1.38±0.02a	1.95±0.07a
T_2: Fram Yard manure	0.62±0.006b	0.30±0.005b	1.92±0.02b	3.04±0.02b
T_3: Panchagavya	1.11±0.01h	0.74±0.007g	4.12±0.02g	5.25±0.10i
T_4: Panchagavya microbial Communities	1.00±0.013gh	0.49±0.008ef	3.66±0.08f	4.51±0.06gh
T_5: Panchagavya microbial-free filtrate	0.89±0.019d	0.42±0.01cd	2.57±0.05d	4.04 ±0.10ef
T_6: Jeevamruth	1.06±0.006gh	0.52±0.004f	3.59±0.05f	4.07±0.07h
T_7: Jeevamruth microbial communities	0.97±0.003ef	0.48±0.002de	2.89±0.06e	3.61±0.10de
T_8: Jeevamruthmicrobial-free filtrate	0.88±0.006de	0.40±0.025cd	2.05±0.04c	3.14±0.06cd
T_9: Amritpani	1.00±0.021gh	0.44±0.009d	3.09±0.05e	4.57±0.08fg
T_{10}: Amritpani microbial communities	0.83±0.003d	0.42±0.015cd	2.18±0.03c	3.78±0.07def
T_{11}: Amritpani microbial-free filtrate	0.73±0.02c	0.36±0.009bc	2.17±0.03c	3.56±0.18bc
SD(m)	0.012	0.011	0.045	0.08
CD (5%)	0.03	0.03	0.13	0.26

All parameters are presented as mean ± standard error (n = 3). Different superscript letters indicate significant differences ($P < 0.05$) among treatments, while identical letters denote no significant difference mediated functionality of NFIs and confirm their potential to enhance chickpea productivity and resilience in sustainable agricultural systems.

Future perspectives

While the present study was conducted under controlled glasshouse conditions, future research should focus on multi-season field validation to assess the consistency and scalability of NFI-mediated benefits under diverse soil and climatic conditions. Molecular characterisation of the microbial communities associated with Panchagavya and Jeevamruth using metagenomics or amplicon sequencing would provide deeper insights into key functional taxa responsible for metabolite production and plant growth promotion. Additionally, metabolomic profiling of NFIs and rhizosphere soils could help identify specific bioactive compounds responsible for the observed physiological and biochemical improvements. Such integrated microbial and metabolite-based approaches will strengthen the scientific basis of natural farming inputs and support their wider adoption in sustainable and climate-resilient agricultural systems.

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