

## RESEARCH ARTICLE

# Assessing the Influence of Bioinputs on the Performance of Pea (*Pisum sativum* L.) under Natural Farming Practices

Nibedita Patra, Dwipendra Thakuria\*, Mahasweta Chakraborty<sup>1</sup>, Pranab Dutta<sup>2</sup>, L. Momo Singh, Dhara Hareesh, Anindita Das<sup>3</sup>, Sabyasachi Majumdar<sup>4</sup>

### Abstract

Natural farming practices, inclusive of inputs like *biocultures* (*Beejamrutha*, *Jeevamrutha*, etc.), native biofertilizers and biopesticides, organic manures, and crop residues, are gaining attention as an alternative for conventional inputs for addressing modern agricultural challenges of chemical pollution, soil degradation, loss of soil biodiversity and impaired biological interactions in agroecosystems. The effect of these biological inputs on crop growth and soil fertility is likely to be influenced by soil type and other local environmental conditions, especially in acidic soils under hilly agroecosystems. This study evaluated the different combinations of biocultures, native biofertilizer, organic manure and crop residue on growth and yield of pea crop and soil fertility in a strongly acid *Inceptisol* in mid hills of Meghalaya. A pot experiment was laid out during the *rabi* season, 2023-24, in the Factorial Completely Randomized Design with two different factors, viz., soil management (M) and seed treatments (S). The soil management factor consisted of treatments: M1, organic manure (OM); M2, OM + Crop Residue mulch (CR); M3, OM + *Jeevamrutha* (JM); M4, OM + CR + JM; and the Seed treatment factor included treatments: S1: No seed treatment (SO); S2: *Beejamrutha* (BJ); S3: *Biofertilizer* (BIO). Results showed that the M4 treatment (Organic Manure + Crop Residue mulch + *Jeevamrutha*) had the most significant effect on soil chemical parameters, particularly with respect to availability of nitrogen, phosphorus, potassium and also significantly increased the growth, yield and uptake of these nutrients in pea crop. Although seed treatments could not influence the soil parameters, pea crop growth and yield were significantly influenced by the seed treatments, especially with the biofertilizer treatment. Therefore, a biofertilizer consortium may be included along with natural farming soil management components as a potential option for improved performance of the pea crop in acid soil.

**Keywords:** *Beejamrutha*, *Jeevamrutha*, *Biofertilizer*, *Crop residue mulch*, *Soil fertility*

### Introduction

Global food security is increasingly at risk due to rapid population growth, climate change, and shrinking arable land availability (Kumar *et al.*, 2022). While modern agricultural practices and extensive use of chemical fertilizers have boosted production, they have also led to habitat loss and soil degradation. Widespread application of chemical inputs has disrupted soil microbial diversity, reduced soil organic matter, and impaired overall soil health and fertility, shrinking arable land availability (Kumar *et al.*, 2022). While modern agricultural practices and extensive use of chemical fertilizers have boosted production, they have also led to habitat loss and soil degradation. Widespread application of chemical inputs has disrupted soil microbial diversity, reduced soil organic matter, and impaired overall soil health and fertility (Pahalvi *et al.*, 2021). In India, agriculture has shifted based on the demand for food from traditional systems to intensive chemical-based practices, particularly after the Green Revolution of the 1960s. However, there have been growing concerns over sustainability, soil health deterioration, and declining crop productivity under heavy usage of chemical inputs

in agriculture in recent times. Natural farming practices emphasize the synergistic effects of plant and animal products in supporting crop establishment and enhancing soil fertility and microorganisms (Smith *et al.*, 2020). In nature, each element plays a role within the interconnected web of life. Recently, natural farming has emerged as a promising solution to address India's agricultural challenges, utilizing bio-cultures such as *Beejamrutha*, *Jeevamrutha*, *Ghanajeevamrutha*, *Panchagavya*, etc., plant residues, and a wealth of traditional cultivation knowledge (Suganthi *et al.*, 2023). These methods help maintain soil health, reduce farmers' reliance on costly chemicals, and increase their income by reducing external inputs and relying on local resources. India leads globally in pulse production and consumption, with 25% of production and 27% of consumption attributed to the country (Tyagi and Kumar, 2019). Among pulses, pea (*Pisum sativum* L.) is a significant *rabi* season crop known for its nitrogen-fixing ability through symbiosis with rhizobium, which promotes nutrient cycling and soil nutrient balance (Shiri *et al.*, 2020). Due to its nitrogen-fixing properties and agricultural value, optimizing nutrient management is crucial. Although natural farming

<sup>1</sup>School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya, India

<sup>1</sup>Division of System Research and Engineering, ICAR Research Complex for NEH Region, Umiam, Meghalaya

<sup>2</sup>School of Crop Protection, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya, India

<sup>3</sup>Krishi Vigyan Kendra, Assam Agricultural University, Silchar, Assam, India

<sup>4</sup>College of Agriculture, Central Agricultural University (Imphal), Kyrdemkulai, Ribhoi, Meghalaya, India

**\*Corresponding Author:** Dwipendra Thakuria School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya, India, E-Mail: thakuria.dwipendra@yahoo.co.in

**How to cite this article:** Patra, N., Thakuria, D., Chakraborty, M., Dutta, P., Singh, L.M., Hareesh, D., Das, A., Majumdar, S. 2025. Assessing the Influence of Bioinputs on the Performance of Pea (*Pisum sativum* L.) under Natural Farming Practices. *Indian J. Hill Farm.*, **38**(2):33-38.

**Source of support:** Nil

**Conflict of interest:** None.

**Received:** 18/04/2025 **Revised:** 05/05/2025 **Accepted:** 16/05/2025

components such as *Jeevamrutha*, *Beejamrutha*, and crop residue mulch are advised to be taken up for their benefits on soil health, scientific data to support their effectiveness on soil nutrient availability and crop performance is still limited. Understanding how these components influence soil fertility and plant growth in highly acidic environments is crucial for optimizing their application in sustainable farming systems. This study was taken up to evaluate the impact of different bioinputs combination under natural farming practices involving *Jeevamrutha*, *Beejamrutha*, and crop residue mulch, along with a native biofertilizer source, on soil fertility and performance of pea crop in an acid soil of Meghalaya.

## Materials And Methods

### Experimental location and description of soil

The present pot experiment was carried out at the Soil Science Research Farm of ICAR Research Complex for NEH Region, Umiam (Meghalaya), during the *Rabi* season of 2023-2024. During that period, the site received 8.3 mm of maximum rainfall, and maximum and minimum temperatures ranged from 21 to 27°C and 7 to 14.5°C, respectively. The soil used for the experiment was collected from the research farm and classified as an Inceptisol (USDA Soil Taxonomic Classification). The texture of the soil was sandy loam with an acidic pH. To determine the initial biochemical and chemical properties of the experimental



**Figure 1:** An overview of the pot experiment at 60 days after sowing (DAS) of pea crop as influenced by soil management (M) and seed treatment (S) factors. The soil management factor consisted of treatments: M1: Organic Manure; M2: M1 + Crop residue mulch; M3: M1 + *Jeevamrutha*; M4: M2 + *Jeevamrutha*. Seed treatment factors were: S1: No seed treatment; S2: *Beejamrutha*; S3: *Jeevamrutha*.

soil, a composite soil sample was collected from the top 0–15 cm layer following standard soil sampling protocols. The collected sample was then air-dried, sieved (2 mm), and divided into two portions—one for baseline soil analysis and the other for use in the pot experiment. The initial soil properties, including pH, organic carbon, and available nutrients, were analyzed and are presented in Table 1.

### Pot experiment

This experiment included two factors, i.e., soil management (M) and seed treatment (S). The soil management factor consisted of treatments viz., M1: Organic Manure; M2: M1 + Crop Residue mulch; M3: M1 + *Jeevamrutha*; M4: M2 + *Jeevamrutha*; and the Seed treatment factor included treatments viz., S1: No seed treatment; S2: *Beejamrutha*; S3: *Jeevamrutha* treatments, making a total of twelve (12) treatments. Each treatment was replicated thrice, making 36 pots. The variety of pea used in this study was 'Arkel', a widely cultivated variety with good adaptability to acidic soils. Four (4) seeds were sown per pot containing 8 kg of soil, and thinning was done after one week of germination, leaving two (2) healthy plants per pot. Since this experiment focused on natural farming approaches, organic inputs like *Jeevamrutha*, *Beejamrutha*, crop residues and biofertilizer were added as per the treatments in the individual pots. Neem-based extracts were applied as a preventive plant protection measure. Weeding was performed manually to prevent competition for nutrients and to maintain plant health. No synthetic pesticides or chemicals were

**Table 1:** Initial chemical attributes of soil used in the pot experiment

Attributes	Values	Range
pH (1:2.5 soil: water suspension)	4.88 ± 0.02	Acidic
Soil organic carbon (% w w <sup>-1</sup> )	1.55 ± 0.02	High
Soil available nitrogen (kg ha <sup>-1</sup> )	332 ± 1.49	Medium
Soil available phosphorous (kg ha <sup>-1</sup> )	26.7 ± 1.52	Low
Soil available potassium (kg ha <sup>-1</sup> )	142 ± 1.77	Medium

**Table 2:** Effect of soil management practices and seed treatments on soil chemical properties

Soil Management (M)	pH	OC (%)	Avl-N (kg ha <sup>-1</sup> )	Avl-P (kg ha <sup>-1</sup> )	Avl-K (kg ha <sup>-1</sup> )
M1 (OM)	4.86 ± 0.010a	1.55 ± 0.003a	340 ± 0.88a	26.5 ± 0.46a	144 ± 0.88a
M2 (OM+CR)	4.87 ± 0.009a	1.57 ± 0.003ab	352 ± 1.73b	29.6 ± 0.40b	170 ± 1.45b
M3 (OM+JV)	4.89 ± 0.006ab	1.57 ± 0.003ab	356 ± 0.88b	31.2 ± 0.72b	190 ± 0.88c
M4 (OM+CR+JV)	4.91 ± 0.009b	1.58 ± 0.003b	364 ± 0.33c	35.4 ± 1.22c	209 ± 2.19d
Seed Treatment (S)					
S1 (NS)	4.87 ± 0.012a	1.57 ± 0.004a	354 ± 4.97a	29.5 ± 1.51a	176 ± 13.58a
S2 (BJ)	4.88 ± 0.013a	1.57 ± 0.008a	352 ± 5.33a	30.8 ± 1.94a	178 ± 13.55a
S3 (BIO)	4.90 ± 0.011a	1.57 ± 0.006a	354 ± 4.91a	31.8 ± 2.12a	180 ± 14.23a
Seed Treatment (S)	NS	NS	NS	NS	NS
Soil Management (M)	**	*	**	**	**

Values are means ± standard error, \*, \*\* represent significant level at  $P < 0.05$ ,  $0.01$ , respectively. Note: OM: Organic Manure; CR: Crop Residue mulch; JV: Jeevamrutha; BJ: Beejamrutha; NS: No Seed Treatment; BIO: Biofertilizer, OC: Organic carbon, Avl-N: available nitrogen, Avl-P: available phosphorus, Avl-K: available potassium

used during the entire growing season of the crop in this experiment. An overview of the pot experiment at 60 days after sowing (DAS) is presented (Figure 1).

### Soil and Plant analysis

Post-harvest soil samples were collected from each pot to analyze changes in soil chemical properties. The soil pH readings were recorded using a standard pH meter with a combined glass electrode, following the procedure given by Jackson (1973). The soil organic carbon was determined using the rapid dichromate wet digestion method given by Walkley and Black (1934). Soil Available nitrogen was determined by the alkaline permanganate method as given by Subbiah and Asija (1956). Available potassium content was determined via flame photometry following the method outlined by Hanway and Heidel (1952). The available potassium (Avl-K) was expressed in kg ha<sup>-1</sup>. After the harvest of the pea crop, plant samples were collected for nutrient content analysis. These samples were dried in an oven at 65°C until they reached a stable weight. Subsequently, the dried samples of stover and seeds were analyzed to determine the levels of nitrogen, phosphorus, and potassium. The total nitrogen content in stover and seed was measured using a modified micro Kjeldahl method as described by Jackson (1973). Phosphorus content in stover and seed was determined using the vanadomolybdo-phosphoric yellow color method (Jackson, 1973). The potassium content in the stover and seed was analyzed using the potassium acetate method with a flame photometer, as outlined by Jackson (1973). The clear solution obtained from the tri-acid digest was used to determine total potassium content in the same manner as described for measuring available potassium in soil samples. The results were expressed in mg g<sup>-1</sup> stover and mg g<sup>-1</sup> seed.

### Statistical analysis

Statistical analyses were performed for the pot experiment using SPSS v.23 (Statistical Packages for Social Science Inc., Chicago, IL, USA). For each parameter, the effect of soil management and seed treatment was determined by performing two-factorial ANOVA (Soil management and Seed treatment), incorporating the multiple pair-wise comparison using SNK post-hoc test (IBM SPSS, 2023).

### Results

#### Soil chemical properties at harvest of pea crop as influenced by application of bioinputs

The study evaluated the impact of different soil management approaches (M1: OM, M2: OM + Crop Residue mulch, M3: OM + *Jeevamrutha*, and M4: OM + Crop Residue mulch + *Jeevamrutha*) and seed treatments (S1: No seed treatment, S2: *Beejamrutha*, and S3: Biofertilizer) on soil chemical properties at harvest of pea crop such as soil pH, soil organic carbon (SOC), and available nutrients (N, P, K) (Table 2). Findings showed that soil pH values remained within a narrow range across the various treatments- M4 had the highest soil pH (4.91), followed by M<sub>3</sub> (4.89), M<sub>2</sub> (4.87) and M<sub>1</sub> (4.86), indicating that soil management practices had minimal impact on pH. While a slight significant increase in pH ( $p < 0.01$ ) was observed in treatments that included *Jeevamrutha* and crop residue mulch, the overall variation was small. Seed treatments showed no significant effects ( $p > 0.05$ ) on soil pH. In the case of soil organic carbon (SOC), M4 had the highest SOC value (1.58%), followed by M<sub>3</sub>, M<sub>2</sub>, and M<sub>1</sub>, with significant differences noted among soil management treatments ( $p < 0.05$ ). Seed treatments had no significant impact on SOC levels. M4 also consistently yielded the highest available nitrogen (364 kg ha<sup>-1</sup>), phosphorus (35.4 kg ha<sup>-1</sup>),

**Table 3:** Effect of soil management practices and seed treatments on growth and yield attributes of pea crop

Soil Management (M)	Plant height		Harvest cm	No. of pods plant <sup>-1</sup> nos. plant <sup>-1</sup>	No. of seeds pod <sup>-1</sup> nos. plant <sup>-1</sup>	Stover yield g plant <sup>-1</sup>	Dry pod yield g plant <sup>-1</sup>	Dry seed yield g plant <sup>-1</sup>
	30 DAS	60 DAS						
	cm	cm						
M1 (OM)	21.8 ± 0.89a	37.4 ± 0.48a	50.7 ± 0.61a	7 ± 0.49a	6 ± 0.40a	8.50 ± 0.57a	2.57 ± 0.25a	2.18 ± 0.08a
M2 (OM+CR)	22.4 ± 0.88ab	38.6 ± 0.45b	52.1 ± 0.79b	7 ± 0.36b	7 ± 0.44b	9.52 ± 0.25b	3.02 ± 0.54b	2.62 ± 0.38b
M3 (OM+JV)	22.9 ± 0.79b	37.6 ± 0.99a	52.6 ± 0.47b	8 ± 0.29c	7 ± 0.36bc	9.92 ± 0.33b	3.88 ± 0.46c	2.84 ± 0.36b
M4 (OM+CR+JV)	24.4 ± 0.40c	39.2 ± 0.69b	54.2 ± 1.13b	8 ± 0.19c	8 ± 0.36c	11.2 ± 0.60b	4.41 ± 0.19d	3.33 ± 0.25c
Seed Treatment (S)								
S1 (NS)	21.9 ± 0.76a	37.6 ± 0.47a	51.2 ± 0.59a	7 ± 0.39a	6 ± 0.44a	9.15 ± 0.68a	3.02 ± 0.48a	2.41 ± 0.24a
S2 (BJ)	22.4 ± 0.55a	37.6 ± 0.54a	52.4 ± 0.69b	7 ± 0.40a	7 ± 0.39a	9.66 ± 0.35a	3.22 ± 0.41a	2.55 ± 0.20a
S3 (BIO)	24.3 ± 0.36b	39.4 ± 0.51b	53.7 ± 0.90c	8 ± 0.39b	8 ± 0.39b	10.5 ± 0.67b	4.18 ± 0.41b	3.26 ± 0.33b
Seed Treatment (S)	**	**	**	**	**	**	**	**
Soil Management (M)	**	**	**	**	**	**	**	**

Values are means ± standard error, \*, \*\* represent significant level at  $P < 0.05$ ,  $0.01$  respectively.

Note: OM: Organic Manure; CR: Crop Residue mulch; JV: Jeevamrutha; BJ: Beejamrutha; NS: No Seed Treatment; BIO: Biofertilizer

and potassium ( $209 \text{ kg ha}^{-1}$ ), with significant differences among soil management practices for each nutrient ( $p < 0.01$ ). However, seed treatments did not significantly influence nitrogen, phosphorus and potassium availability ( $p > 0.05$ ) in soils.

#### Effect of bioinputs on plant growth parameters and yield attributes of pea crop

The impact of different seed treatments and soil managements on plant height at 30, 60 days after sowing (DAS) and at harvest, number of pods plant<sup>-1</sup>, number of seeds pod<sup>-1</sup>, stover yield, dry pod yield and dry seed yield were tested in this study (Table 3). At 30 DAS, among the seed treatments, the tallest plants (24.3 cm) were observed in S3 (Biofertilizer), followed by S2 (*Beejamrutha*) and S1 (Control); among the soil management treatments, M4 (OM + CR + JV) yielded the tallest plants (24.4 cm), followed by M3, M2, and M1. By 60 DAS, S3 again led with the tallest plants (39.4 cm) among the seed treatments, followed by S2, while among the soil managements, M4 continued to show the maximum height (39.2 cm), with M2, M3, and M1 trailing. At harvest, the tallest plants were again from S3 53.7 cm and M4 54.2 cm, respectively, among seed treatments and soil management treatments. The number of pods per plant and seeds per pod were also highest under S3 (Biofertilizer) among seed treatments and M4 (OM + CR + JV) treatment among the soil managements, although M3 and M4 did not differ significantly with respect to the number of pods per plant (~ 8 nos per plant). Seed treatment with biofertilizer (S3) produced the highest dry pod yield at  $4.18 \text{ g plant}^{-1}$ , followed by S2 at  $3.22 \text{ g plant}^{-1}$  and S1 at  $3.02 \text{ g plant}^{-1}$ , with S1 and S2 showing no significant difference ( $p < 0.01$ ). Dry seed yield was also found to be highest in S3 ( $3.26 \text{ g plant}^{-1}$ ) followed by S2 ( $2.55 \text{ g plant}^{-1}$ ) and S1 ( $2.41 \text{ g plant}^{-1}$ ), with S3 significantly superior to S1 and S2 ( $p < 0.01$ ). S3 showed the highest stover yield ( $10.5 \text{ g per plant}$ ), followed by S2 ( $9.66 \text{ g per plant}$ ) and S1 ( $9.15 \text{ g per plant}$ ), with S1 (no seed treatment) and S2 (*Beejamrutha* seed treatment) showing no significant difference ( $p < 0.01$ ). Among soil management treatments, M4 showed the highest stover yield ( $11.2 \text{ g per plant}$ ), followed by M3 ( $9.92 \text{ g per plant}$ ), M2 ( $9.52 \text{ g per plant}$ ), and M1 ( $8.50 \text{ g per plant}$ ), with M2 and M3 not differing significantly ( $p < 0.01$ ). The highest dry pod yield was also recorded in M4 ( $4.41 \text{ g plant}^{-1}$ ) followed by M3 ( $3.88 \text{ g plant}^{-1}$ ), M2 ( $3.02 \text{ g plant}^{-1}$ ), and M1 ( $2.57 \text{ g plant}^{-1}$ ), all of which were statistically different from each other ( $p < 0.01$ ). M4 again showed the significantly ( $p < 0.01$ ) highest dry seed yield ( $3.33 \text{ g plant}^{-1}$ ) followed by M3 ( $2.84 \text{ g plant}^{-1}$ ), M2 ( $2.62 \text{ g plant}^{-1}$ ), and M1 ( $2.18 \text{ g plant}^{-1}$ ).

#### N, P, K content in stover and seed of pea as influenced by bioinputs

The nitrogen (N) content in pea crop stover and seed was analyzed under various soil management and seed treatment combinations (Table 4). In the stover, N content significantly varied among the soil management

**Table 4:** Effect of soil management practices and seed treatments on nutrient content of stover and seed of pea crop

Soil Management (M)	N content stover (mg g <sup>-1</sup> stover)	N content seed (mg g <sup>-1</sup> seed)	P content stover (mg g <sup>-1</sup> stover)	P content seed (mg g <sup>-1</sup> seed)	K content stover (mg g <sup>-1</sup> stover)	K content seed (mg g <sup>-1</sup> seed)
M1 (OM)	13.4 ± 0.49a	29.3 ± 1.02a	3.47 ± 0.15a	3.37 ± 0.19a	12.0 ± 0.19a	10.4 ± 0.18a
M2 (OM+CR)	14.2 ± 0.43b	31.9 ± 0.26b	3.85 ± 0.14a	4.24 ± 0.12b	13.0 ± 0.18b	11.1 ± 0.18b
M3 (OM+JV)	14.9 ± 0.34c	32.6 ± 0.30c	3.72 ± 0.13a	4.89 ± 0.10c	13.8 ± 0.21c	12.0 ± 0.20c
M4 (OM+CR+JV)	15.9 ± 0.47d	33.2 ± 0.32d	4.31 ± 0.21b	4.58 ± 0.30bc	14.6 ± 0.15d	12.4 ± 0.18c
<i>Seed Treatment (S)</i>						
S1 (NS)	13.8 ± 0.58a	31.2 ± 1.01a	3.58 ± 0.17a	4.00 ± 0.35a	13.1 ± 0.54a	11.2 ± 0.45a
S2 (BJ)	14.7 ± 0.41b	31.5 ± 1.08a	3.82 ± 0.15ab	4.20 ± 0.33ab	13.3 ± 0.58a	11.5 ± 0.46ab
S3 (BIO)	15.2 ± 0.57c	32.7 ± 0.54b	4.11 ± 0.21b	4.60 ± 0.33b	13.7 ± 0.53b	11.8 ± 0.46c
Seed Treatment (S)	**	**	*	*	*	*
Soil Management (M)	**	**	**	**	**	**

Values are means ± standard error, \*, \*\* represent significant level at P < 0.05, 0.01, respectively.

Note: OM: Organic Manure; CR: Crop Residue mulch; JV: Jeevamrutha; BJ: Beejamrutha; NS: No Seed Treatment; BIO: Biofertilizer

treatments from 13.4 to 15.9 mg g<sup>-1</sup>, with the highest level recorded in the M4 treatment (15.9 mg g<sup>-1</sup>), followed by M3 (14.9 mg g<sup>-1</sup>), M2 (14.2 mg g<sup>-1</sup>), and M1 (13.4 mg g<sup>-1</sup>). Among the seed treatments, S3 exhibited the highest N content in stover (15.2 mg g<sup>-1</sup>) followed by S2 (14.7 mg g<sup>-1</sup>) and S1 (13.8 mg g<sup>-1</sup>), with all three treatments differing significantly. Seed N content ranged from 29.3 to 33.2 mg g<sup>-1</sup> under the different soil management treatments, with M4 showing the highest content (33.2 mg g<sup>-1</sup>) followed by M3, M2, and M1, with the differences among treatments being statistically significant. Among the seed treatments, S3 recorded the highest seed N content of 32.7 mg g<sup>-1</sup>, followed by S2 (31.5 mg g<sup>-1</sup>) and S1 (31.2 mg g<sup>-1</sup>). Phosphorus (P) content in pea crop stover varied under different soil management practices, ranging from 3.47 to 4.31 mg g<sup>-1</sup>; M4 had the highest P content of 4.31 mg g<sup>-1</sup>, followed by M2 (3.85 mg g<sup>-1</sup>), M3 (3.72 mg g<sup>-1</sup>), and M1 (3.47 mg g<sup>-1</sup>), with M1, M2, and M3 showing no significant differences. However, seed P content was the highest in M3 treatment (4.89 mg g<sup>-1</sup>) followed by M4, M2, and M1 (Table 4). Among seed treatments, S3 recorded the highest P content in stover (4.11 mg g<sup>-1</sup>) followed by S2 (3.82 mg g<sup>-1</sup>) and S1 (3.58 mg g<sup>-1</sup>). S3 also showed the significantly highest seed P content of 4.60 mg g<sup>-1</sup>, followed by S2 (4.20 mg g<sup>-1</sup>) and S1 (4.00 mg g<sup>-1</sup>). Potassium (K) content in pea crop stover varied significantly (P < 0.01; Table 4) under different soil management practices; M4 had the highest content (14.6 mg g<sup>-1</sup>) followed by M3 (13.8 mg g<sup>-1</sup>), M2 (13.0 mg g<sup>-1</sup>), and M1 (12.0 mg g<sup>-1</sup>). A similar trend of significant differences was observed for K content in seeds with M<sub>4</sub> treatment recording the highest (12.4 mg g<sup>-1</sup>). Among the seed treatments, S3 reported the highest K content in stover of 13.7 mg g<sup>-1</sup>, followed by S2 (13.3 mg g<sup>-1</sup>) and S1 (13.1 mg g<sup>-1</sup>), with S1 and S2 being statistically non-significant. Seed treatments showed K content in seed ranging from 11.2 to 11.8 mg g<sup>-1</sup>, with S3 recording the highest (11.8 mg g<sup>-1</sup>).

## Discussion

The application of different bioinputs influenced soil nutrient availability, plant growth, and yield attributes in the pea crop. Soil pH and soil organic carbon (SOC) exhibited a narrow range from 4.86 to 4.91 and 1.55 to 1.58% across different soil management practices, with the highest pH and SOC recorded in the M4 treatment (Organic Manure+ Crop Residue mulch + *Jeevamrutha*). While the increase in pH and SOC in the treatment that included *Jeevamrutha* and crop residue mulch was significant (P < 0.01), the overall variation was small. This slight increase in soil pH may be attributed to the combined effects of these organic components, along with *Jeevamrutha*, which may increase the activity of soil microorganisms and enhance the organic matter decomposition with the release of alkaline substances (Ceglie and Abdelrahman, 2014). Increase in SOC in treatments involving crop residue mulch and *Jeevamrutha* may indicate slower buildup of organic carbon linked to microbial diversity and activity (Chen *et al.*, 2024), however, the effect was limited in single growing season considered in this study. Similarly, M4 treatment involving combined application of Organic Manure+ Crop Residue mulch + *Jeevamrutha* recorded significantly (P < 0.01) higher levels of available nitrogen, phosphorus, and potassium, i.e., 364, 35.4, and 209 kg ha<sup>-1</sup>, respectively, as compared to M1, M2, and M3 treatments involving individual applications of these bioinputs. Seed treatments, however, did not significantly enhance soil pH, oxidizable organic carbon (SOC) content, and nutrient availability in the soil. These results align closely with findings of Oyege *et al.* (2023), who reported that incorporating vermicompost with *Jeevamrutha* promotes mineralization by increasing microbial and enzymatic activity in soil. This microbial activity supports the release of higher amounts of available nitrogen (N), phosphorus (P), and potassium (K). Additionally, the observed increase in available phosphorus may be

due to native phosphate solubilization via organic acids produced during the microbial breakdown of organic material. The use of bioinputs also led to notable differences in plant growth, yield attributes and nutrient content. Although seed treatments had no significant effect on soil chemical properties, they played a significant role in plant growth and yield improvement. Among seed treatments, S3 (biofertilizer) achieved the greatest plant height (24.33, 39.45, and 53.77 cm at 30, 60 days after sowing (DAS) and at harvest, respectively), the highest pod count per plant (8.29), seeds per pod (7.66), and stover yield (10.54 g per plant) compared to the other treatments. These results align with earlier findings by Sharma *et al.* (2023), which reported a significant improvement in plant growth attributes with the application of FYM and biofertilizers (RZB + PSB), suggesting that the biofertilizer treatment's increase in growth attributes may be largely due to enhanced plant growth promoters. Soil management treatment M4 (Organic Manure+ Crop Residue mulch + *Jeevamrutha*) resulted in the highest plant height (24.39, 39.28 and 54.19 cm at 30, 60 DAS and at harvest, respectively), pods per plant (8.33), seeds per pod (7.77), and stover yield (11.22 g per plant) compared to the other treatments. These results are consistent with findings by Thakur *et al.* (2024), where a significant variation in growth attributes was noted with the combined use of Organic Manure, Crop Residue, and *Jeevamrutha*, indicating that the improvement in plant height, pod number, and seed count may be due to the balanced supply of nutrients. Organic manure, together with *Jeevamrutha* was important for sustaining soil fertility, thus maximizing crop yield potential, as reported by Rabade *et al.* (2022). Seed treatment with biofertilizer (S3) exhibited significant influence on nitrogen, phosphorus and potassium content in stover (15.2 mg g<sup>-1</sup> stover, 4.11 mg g<sup>-1</sup> stover, 13.7 mg g<sup>-1</sup> stover, respectively) and also in seed (32.7 mg g<sup>-1</sup> seed, 4.60 mg g<sup>-1</sup> seed, and 11.8 mg g<sup>-1</sup> seed, respectively). Soil management treatment M4 (Organic Manure+ Crop Residue mulch + *Jeevamrutha*) recorded the significantly highest nitrogen content (15.9 mg g<sup>-1</sup> stover), phosphorus content (4.31 mg g<sup>-1</sup> stover), and potassium content (14.6 mg g<sup>-1</sup> stover) in stover, surpassing all other treatments. Likewise, the soil management M4 (Organic Manure+ Crop Residue mulch + *Jeevamrutha*) also exhibited significantly the highest nitrogen, phosphorus and potassium content (33.2, 4.58, 12.4 mg g<sup>-1</sup> seed, respectively) in seed of the pea crop, which might be attributed to enhanced nutrient mineralization in the soil and more efficient absorption by plants. The increased yield and nutrient uptake under the combined application of bioinputs may likely be due to the synergistic effects of these inputs, ensuring better nutrient supply throughout crop growth (Bhadu *et al.*, 2023; Gopal *et al.*, 2022).

## Conclusion

Overall, this study demonstrated that soil management practices involving organic manure, crop residue mulch and *Jeevamrutha* increased soil nutrient availability, pea crop growth and yield. At the same time, seed treatment with biofertilizers could enhance the crop performance. However, it did not show much influence on soil available nutrient pools in the harvest soil in the single-season pot experiment. Integration of natural farming soil management components with native biofertilizer consortium may therefore be considered as a potential option for higher productivity of pea crop in acid soil. However, further research should focus on field-scale trials in diverse cropping systems to evaluate the effects of bioinputs on soil health and crop productivity.

## Acknowledgment

The authors acknowledge the College of PG Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya, for laboratory infrastructures and the Department of Biotechnology, Ministry of Science and Technology, Govt. of India for funding (No.BT/PR45218/NER/95/1903/2022 dtd.12/03/2022). We also acknowledge the ICAR Research Complex for NEH Region, Umiam, for providing the necessary facilities for the experimental setup and laboratory.

## References

- Bhadu K, Rathore RS, Shekhawat PS (2023). *Jeevamrut* and panchagavya's consequences on growth, quality and productivity of organically grown crops: A review. *Agric. Rev.*, 44(4): 451-459.
- Ceglie, F.G., & Abdelrahman, H. M. (2014). Ecological intensification through nutrients recycling and composting in organic farming. In *Composting for sustainable agriculture* (pp. 1-22). Cham: Springer International Publishing.
- Chen L, Zhou S, Zhang Q, Zou M, Yin Q, Qiu Y, Qin W (2024). Effect of organic material addition on active soil organic carbon and microbial diversity: A meta-analysis. *Soil Tillage Res.*, 241: 106128.
- Gopal V, Gurusiddappa LH (2022). Influence of *Jeevamrutha* (fermented liquid manure) on growth and yield parameters of tomato (*Solanum lycopersicum* L.). *World J Environ Biosci* 11(3): 1-7.
- Hanway JJ, Heidel H (1952). Soil analysis methods as used in Iowa State College Soil Testing Laboratory. *Iowa Agric* 57:1-31.
- Jackson ML (1973) Soil Chemical Analysis. Prentice Hall of India Pvt Ltd, New Delhi, pp 186-192.
- Kumar S, Bamboriya SD, Rani K, Meena RS, Sheoran S, Loyal A (2022) Grain legumes: a diversified diet for sustainable livelihood, food, and nutritional security. In: Meena RS and Kumar S (eds) *Advances in Legumes for Sustainable Intensification*, 1<sup>st</sup> edn. Academic Press, New York, pp. 157-178.
- Oyege I, Balaji Bhaskar MS (2023). Effects of vermicompost on soil and plant health and promoting sustainable agriculture. *Soil Syst* 7(4): 101.
- Pahalvi, H.N., Rafiya, L., Rashid, S., Nisar, B., Kamili, A.N. (2021).

- Chemical Fertilizers and Their Impact on Soil Health. In: Dar, G.H., Bhat, R.A., Mehmood, M.A., Hakeem, K.R. (eds) *Microbiota and Biofertilizers*, Vol 2. Springer, Cham. [https://doi.org/10.1007/978-3-030-61010-4\\_1](https://doi.org/10.1007/978-3-030-61010-4_1)
- Rabade M, Singh R, Indu T (2022). Response of biofertilizer and foliar spray of organic amendments on economics and yield attributes of cowpea (*Vigna unguiculata* L.). *Int J Environ Clim Chan* 12(11):397-402.
- Sharma S, Sharma N, Gupta N, Angmo P, Siddiqui MH, Rahman MA (2023). Impact of chemically diverse organic residue amendment on soil enzymatic activities in a sandy loam soil. *Agronomy* 13(7): 1719.
- Shiri T, Kumar A, Priyta V, Kumar A, Singh G, Saifi N (2020). Stimulus of panchgavya bio-manure (PGBM) on developmental growth as well as harvest of *Pisum sativum*. *J Pharmacogn Phytochem* 9(3):905-910.
- Smith J, Yeluripati J, Smith P, Nayak DR (2020) Potential yield challenges to scale-up of zero budget natural farming. *Nat Sustain* 3(3):247-252.
- Subbiah BV, Asija GL (1956). A rapid procedure for the determination of available nitrogen in soil. *Curr Sci* 25: 259-260.
- Thakur V, Sharma P, Kumar P, Sharma P, Bhat SA, Sharma S, Thakur S (2024). Quantifying the impact of fermented liquid bio formulations, biofertilizers and organic amendments on horticultural and soil nutrient traits of garden pea (*Pisum sativum* L.). *Int J Recycl Org Waste Agric* 13(3): 1-17.
- Suganthy M, Janaki P, Parameswari E, Krishnan, R, Kavitha P, Ramasubramanian M, Kalarani M (2023). Natural farming: present status and future prospects. Tamil Nadu Agricultural University, pp 481.
- Tyagi S, Kumar P. (2019) Integrated weed management strategies in pulse crops. In: Nigam R, Singh J, Singh R, Kumar A, Aggarwal YK, editors. *Modern approaches in pest and disease management*. 1st Ed. London: Rubicon Press.;70-80.
- Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sc.*, 37: 29-38.282