International Journal of Plant & Soil Science

Volume 38, Issue 8, Page 489-498, 2026; Article no.IJPSS.162948
ISSN: 2320-7035

Comparative Study on the Effect of Organic and Inorganic Fertilizers on Soil Health

Arti Rana [a], Simran [a*], Madhu [a] and Abhishek [a]

[a] *Department of Zoology, Sri Sai University, Palampur 176081, Kangra, Himachal Pradesh, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2026/v38i86235

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/162948

Original Research Article

Received: 31/05/2026
Accepted: 20/07/2026
Published: 30/07/2026

Abstract

Fertiliser source can influence crop growth and soil properties, but comparative information for pea cultivation under the mid-hill agro-climatic conditions of Himachal Pradesh remains limited. A field experiment was conducted at Panjiala Village, Kangra District, Himachal Pradesh, India, during the rabi season from December 2025 to March 2026 to evaluate the effects of organic and inorganic fertilisers on soil health and the growth performance of pea *(Pisum sativum L.)* cv. PB-89. The experiment was laid out in a randomised block design (RBD) with three treatments and three replications: T_1 (vermicompost applied at 5 t ha^{-1}, equivalent to 3.0 kg per gross plot), T_2 (seaweed-fortified granules applied at 416.7 kg ha^{-1}, equivalent to 250 g per gross plot), and T_3 (unfertilised control). The fertilisers were thoroughly incorporated into the soil before sowing, and observations were recorded from the net plot area (2.4 m × 1.8 m). Soil samples collected before sowing and after harvest were analysed for pH, electrical conductivity (EC), organic carbon, available phosphorus, potassium, sulphur, calcium, magnesium, soil texture, and soil colour. Plant height and number of leaves were recorded at weekly intervals from December to March. The organic treatment produced the greatest plant height (76.0 ± 8.25 cm) and number of leaves (79.0 ± 8.40) and increased soil

*Corresponding author: E-mail: simranmungyal@gmail.com;

***Cite as:** Rana, A., Simran, Madhu, & Abhishek. (2026). Comparative Study on the Effect of Organic and Inorganic Fertilizers on Soil Health. International Journal of Plant & Soil Science, 38(8), 489–498. https://doi.org/10.9734/ijpss/2026/v38i86235*

organic carbon from 0.80% before sowing to 1.10% after harvest. In contrast, the inorganic treatment recorded the highest available phosphorus (32.8 kg ha^{-1}) and potassium (385.6 kg ha^{-1}) after harvest. Soil pH remained slightly to moderately acidic, while EC remained within the normal range under all treatments. These results suggest that vermicompost was more effective in improving vegetative growth and soil organic carbon, whereas seaweed-fortified granules enhanced the availability of phosphorus and potassium under the agro-climatic conditions of Himachal Pradesh.

Keywords: Electrical conductivity; fertiliser management; pea; plant growth; seaweed-fortified granules; soil health; soil nutrients; soil organic carbon; sustainable nutrient management; vermicompost.

1. Introduction

Soil is one of the most valuable natural resources, providing physical support, water, nutrients, and a suitable environment for plant growth and thereby forming the foundation of agricultural production. It also contributes to carbon sequestration, nutrient cycling, and ecosystem stability. Soil fertility and its physical, chemical, and biological characteristics are critical determinants of agricultural productivity (Weil & Brady, 2017; Kumar et al., 2016; Lal, 2020). However, continuous cultivation, excessive use of chemical fertilisers, and poor soil management have contributed to declining soil fertility, nutrient imbalances, loss of soil organic matter, and deterioration of soil quality in many parts of the world (Food and Agriculture Organization [FAO], 2022). Fertilisers are essential for maintaining soil fertility and increasing crop yields. Organic fertilisers, such as farmyard manure, cow dung, and vermicompost, can improve soil structure, microbial activity, water-holding capacity, and organic carbon content while providing nutrients gradually over time (Allam et al., 2022; Shu et al., 2022). Inorganic fertilisers provide readily available nutrients that promote rapid plant growth and increased yields. However, continuous and excessive use of chemical fertilisers without adequate organic inputs can reduce microbial diversity, acidify the soil, and cause nutrient imbalances (Kakar et al., 2018). Therefore, integrated nutrient management has been widely promoted to sustain soil fertility and crop production (Jadoon et al., 2015). Pea *(Pisum sativum L.)* is a major cool-season legume crop grown worldwide and is valuable both nutritionally and economically. It is a rich source of dietary fibre, protein, carbohydrates, vitamins, and minerals. As a leguminous crop, pea forms a symbiotic association with rhizobial bacteria that fix atmospheric nitrogen and contribute nutrients to the soil. Pea is therefore commonly included in crop-rotation systems to reduce dependence on synthetic nitrogen fertilisers (Bünemann et al., 2018). The effects of organic and inorganic fertilisers on crop growth and soil health have been reported in several studies. Inorganic fertilisers ensure rapid nutrient availability and an immediate crop response, whereas organic nutrient sources improve soil physical properties, increase soil organic carbon, and stimulate microbial activity (Mia et al., 2025; Sharma et al., 2023). Combining organic and inorganic nutrient sources has been reported to improve nutrient-use efficiency, crop productivity, and soil fertility more effectively than either source alone (Allam et al., 2022). Recent comparative evidence in tomato showed that organic manures and inorganic NPK produced different patterns of vegetative and physiological responses, indicating that fertiliser effects should be interpreted according to the crop and measured trait (Adinkwu et al., 2026). A field study on radish similarly reported that combinations of inorganic fertilisers, organic nutrient sources, and phosphate-solubilising bacteria improved several growth and yield attributes under the study conditions (Prajapati et al., 2026). At a broader scale, a meta-analysis found that the effects of organic and mineral fertilisers on soil organic carbon and crop productivity varied with tillage, soil texture, climate, crop species, and irrigation management (Allam et al., 2022). Soil microbial communities are also central to organic-matter turnover and nutrient cycling, supporting the inclusion of soil-health indicators when fertiliser practices are evaluated (Bhattacharyya et al., 2022). Seaweed-extract application has been associated with changes in plant growth, productivity, available soil nitrogen, and rhizosphere bacterial communities; these findings support crop- and site-specific evaluation of seaweed-based inputs (Hussain et al., 2021).

However, the relative effects of organic and inorganic fertilisers on soil health and the growth performance of pea remain insufficiently understood under the agro-climatic conditions of Himachal Pradesh. The present study therefore evaluated selected soil-health parameters, including soil pH, electrical conductivity, organic carbon, available phosphorus, potassium, sulphur, calcium, magnesium, soil texture, and soil colour, together with the growth performance of pea *(Pisum sativum L.)* cv. PB-89. The findings are expected to inform sustainable nutrient-management strategies for improving soil fertility and pea productivity under the study conditions.

1.1 Research Gap

A specific evidence gap remains regarding the comparative effects of vermicompost and seaweed-fortified granules on selected soil properties and pea growth under the mid-hill agro-climatic conditions of Himachal Pradesh.

1.2 Objective

The objective of this study was to compare the effects of vermicompost and seaweed-fortified granules on selected soil-health parameters and the growth performance of pea *(Pisum sativum L.)* cv. PB-89 under the agro-climatic conditions of Himachal Pradesh.

2. Methods and Materials

2.1 Study Area

The field experiment was conducted at Panjiala Village in Baijnath Tehsil, Kangra District, Himachal Pradesh, India. The study area lies in the mid-hill zone of the subtropical north-western Himalayas. The experiment was conducted during the rabi season, from December 2025 to March 2026. Pea *(Pisum sativum L.)* cv. PB-89 was used as the experimental crop, and the seeds were procured from the local market in Baijnath. The location of the study area is shown in Fig. 1.

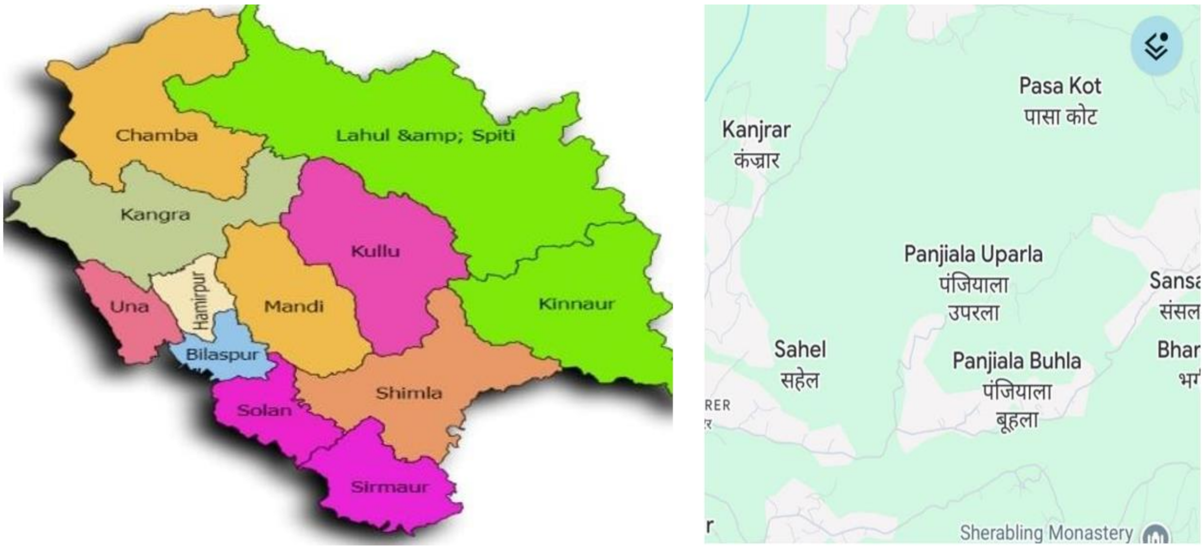

Fig. 1. Location map of Kangra district and Panjiala village

2.2 Design of Experiments

The experiment was arranged in a randomised block design (RBD) with three treatments and three replications.

The treatments were as follows:

T_1: Organic treatment. Vermicompost was applied at the recommended rate of 5 t ha^{-1} (equivalent to 3.0 kg per gross plot of 3.0 m × 2.0 m) and was thoroughly incorporated into the soil before sowing. Observations were recorded from the net plot area (2.4 m × 1.8 m).

T_2: Inorganic treatment. Seaweed-fortified granules were applied at 416.7 kg ha^{-1} (equivalent to 250 g per gross plot of 3.0 m × 2.0 m) and were thoroughly incorporated into the soil before sowing.

T_3: Unfertilised control

Table 1. Pre - experimental soil analysis

Parameter	Sample 1 organic	Rating	Sample2 Inorganic	Rating	Sample3 control	rating
ph	5.7	Moderately acidic	5.9	Moderately acidic	5.8	Moderately acidic
EC (ds m^{-1})	0.05	Normal	0.04	Normal	0.05	Normal
Organic carbon (%)	0.8	Medium	0.9	Medium	0.85	Medium
Phosphorus (kg ha^{-1})	16.28	Medium	26.00	High	21.5	Medium
Potassium (kg ha^{-1})	158.6	Medium	358.4	High	255.0	Medium
sulphur (kg ha^{-1})	16.28	Sufficient	175.6	Sufficient	95.0	Sufficient
Boron (mg kg^{-1})	8.3	Sufficient	6.5	Sufficient	7.4	Sufficient
calcium (meq100 g^{-1})	ND	Deficient	19.67	Sufficient	18.20	Sufficient
Magnesium(meq100g^{-1})	ND	Deficient	ND	Deficient	1.20	Sufficient
soil texture	Sandy loam soil	Good	Sandy loam soil	Good	Sandy loam soil	Good
soil color	Brown	Good	Brown	Good	Brown	Good

Pea seeds were sown at a depth of 2.5–3.0 cm with a spacing of 30 cm × 10 cm. Standard agronomic practices were followed throughout the crop-growth period.

2.3 Sample Preparation and Soil Sampling

Composite soil sampling: Before sowing (pre-sowing) and after crop harvest (post-harvest), composite soil samples were collected separately from each treatment plot. Soil was collected from 5–6 random locations within each plot at a depth of 0–15 cm using a soil auger. The samples from each plot were thoroughly mixed to form one composite sample, air-dried, ground, passed through a 2 mm sieve, and analysed for pH, EC, organic carbon, available phosphorus, potassium, sulphur, boron, calcium, magnesium, soil texture, and soil colour.

2.4 Analysis of Soil

The soil samples were analysed at the Soil Testing Laboratory in Holta, Palampur, Himachal Pradesh. The following parameters were determined:

2.4.1 Estimation of Soil pH

Soil pH was measured using a PUSA STFR digital soil-testing meter. A soil–water suspension was prepared according to the standard procedure, and the pH was recorded after calibration of the instrument (Jackson, 1973).

2.4.2 Estimation of Electrical Conductivity (EC)

Soil EC was measured using a digital EC meter to determine the soluble-salt content of the soil (Richards, 1954).

2.4.3 Estimation of Organic Carbon

Soil organic carbon was determined using the Walkley–Black wet-oxidation method and was expressed as a percentage (Walkley & Black, 1934).

2.4.4 Estimation of Available Nitrogen

Available soil nitrogen was determined using the Kjeldahl method and was expressed in kg ha^{-1} (Bremner & Mulvaney, 1982).

2.4.5 Estimation of Available Phosphorus

Available phosphorus was determined using the Olsen method and a spectrophotometer and was expressed in kg ha^{-1} (Olsen et al., 1954).

2.4.6 Estimation of Available Potassium

Available potassium was extracted with neutral ammonium acetate, measured using a flame photometer, and expressed in kg ha^{-1} (Pratt, 1965).

2.4.7 Estimation of Sulphur

Available sulphur was estimated using the turbidimetric method after extraction of the soil sample. The sulphur concentration was determined using a spectrophotometer.

2.4.8 Calcium Determination

Exchangeable calcium was determined using the conventional ammonium acetate extraction procedure to assess the nutrient status of the soil.

2.4.9 Magnesium Determination

Exchangeable magnesium was extracted with ammonium acetate and determined by titration with EDTA. The magnesium content was expressed in mg kg^{-1} (Schwarzenbach & Biedermann, 1948).

2.4.10 Soil Colour (Munsell Soil Colour Chart)

The soil colour was determined under daylight conditions using the Munsell Soil Colour Chart and was recorded in terms of hue, value, and chroma.

2.4.11 Soil Texture

Soil texture was determined by the feel method and classified according to the relative proportions of sand, silt, and clay. The appropriate textural class was then assigned.

The recommended analytical procedures for standard soil-testing methods were followed.

Table 1 presents the physico-chemical properties of the experimental soil collected from the organic, inorganic, and control plots before sowing and fertiliser application. Soil pH ranged from 5.7 to 5.9, indicating moderately acidic conditions. Electrical conductivity was within the normal range (0.04–0.05 dS m^{-1}), and organic carbon content was rated as medium in all plots. Available phosphorus and potassium varied among the samples, with comparatively higher values in the inorganic plot. Sulphur and boron were present at sufficient levels; however, calcium and magnesium were deficient in some samples. The soil was brown and had a sandy-loam texture in each plot. These baseline conditions were suitable for evaluating the effects of organic and inorganic fertilisers on soil health and pea growth.

2.5 Observations on Growth

From December to March, plant height (cm) and the number of leaves were recorded weekly. Five plants were randomly selected from each plot, and the mean values were used in the analysis.

2.6 Statistical Analysis

The experiment was conducted in a randomised block design with three replications. Data from the different treatments were analysed statistically at the 5% level of significance.

3. Result and Discussion

3.1 Effect of Different Fertilizer Treatments on Plant Height

Plant height increased gradually under all fertiliser treatments from December to March. Organically fertilised plants showed the greatest increase in March, from 65 cm in the first week to 86 cm in the fifth week. The control treatment showed the smallest increase (53–72 cm), while plant height under the inorganic treatment increased from 63 to 82 cm. In March, the organic treatment recorded the highest monthly mean plant height (76.0 ± 8.25 cm), followed by the inorganic treatment (72.6 ± 7.60 cm) and the control (62.4 ± 7.44 cm). The superior performance of the organic treatment may be attributable to gradual nutrient release, improved soil structure, greater microbial activity, and increased nutrient availability throughout the growing season. Organic amendments can improve root growth and water-retention capacity, resulting in enhanced vegetative development and nutrient uptake. Similar improvements in crop growth under organic amendments have been reported by Shu et al. (2022).

Table 2. Monthly growth performance of pea under different fertilizer treatment

Months	Organic		Inorganic		Control	
	No. of Leaves	Height in cm	No. of Leaves	Height in cm	No. of Leaves	Height in cm
December	9.25±2.49	8.25±2.39	7.75±2.28	8.25±2.68	6.5±2.39	8.2±2.17
January	29.6±3.12	26.8±3.2	29.2±3.0	25.8±2.8	24.2±2.6	21.8±2.4
February	53.5±4.29	48.7±4.38	51.2±3.19	49.2±4.23	45.0±3.69	41.5±3.66
March	79.0±8.40	76.0±8.25	74.0±9.03	72.6±7.60	67.2±6.34	62.4±7.44

Table 3. Post - experimental soil analysis

Parameter	Organic	Rating	Inorganic	Rating	Control	Rating
pH	6.2	Slightly acidic	5.7	Moderately acidic	5.8	Moderately acidic
EC (dS m^{-1})	0.08	Normal	0.07	Normal	0.05	Normal
Organic Carbon (%)	1.10	High	0.85	Medium	0.82	Medium
Phosphorus (kg ha^{-1})	24.5	High	32.8	High	22.0	High
Potassium (kg ha^{-1})	220.5	Medium	385.6	High	258.0	High
Calcium (meq 100 g^{-1} soil)	15.8	Sufficient	21.5	Sufficient	18.8	Sufficient
Magnesium (meq 100 g^{-1} soil)	1.8	Sufficient	0.9	Deficient	1.3	Sufficient
Sulphur (kg ha^{-1})	28.5	Sufficient	185.0	Sufficient	98.0	Sufficient
Soil texture	Sandy soil	Good	Sandy soil	Good	Sandy soil	Good
Soil color	Dark Brown	Good	Dark Brown	Good	Dark Brown	Good

3.2 Effect of Fertilizer Treatments on Number of Leaves

The number of leaves increased steadily under all treatments throughout the experiment. The organic treatment produced the greatest number of leaves in March, increasing from 69 in the first week to 90 in the fifth week. The control treatment produced the fewest leaves (59–75), whereas the inorganic treatment increased from 62 to 85 leaves. The monthly mean number of leaves was highest under the organic treatment (79.0 ± 8.40), followed by the inorganic treatment (74.0 ± 9.03) and the control (67.2 ± 6.34). Leaf production is an important indicator of vegetative growth because increased leaf area enhances photosynthetic activity. Improved nutrient cycling and greater microbial activity in organically amended soil may have contributed to the higher number of leaves observed under the organic treatment (Chivenge et al., 2011). Similar observations were reported by Kakar et al. (2018), who found that organic fertilisers improved soil fertility and promoted vigorous vegetative growth.

3.3 Overall Growth Performance

The organic treatment increased pea growth relative to both the control and inorganic treatments. Plant height and leaf number increased steadily under all treatments from December to March, but the organic treatment consistently recorded the highest values during the observation period. The poorest growth under the control indicated that the native soil nutrient supply was inadequate for optimal plant development. Organic fertiliser can provide a continuous nutrient supply while improving the physical, chemical, and biological properties of the soil (Shu et al., 2022). In contrast, inorganic fertiliser supplied readily available nutrients and promoted growth but did not substantially improve soil quality. Sharma et al. (2023) reported similar results and concluded that the addition of organic nutrient sources improved soil health and crop yields. The monthly growth data are presented in Table 2.

3.4 Effect of Fertilizer Treatments on Post-Harvest Soil Properties

Table 3 presents the differences observed in post-harvest soil properties among the fertiliser treatments. Electrical conductivity remained within the normal range (0.05–0.08 dS m^{-1}) under all treatments. Soil pH ranged from 5.7 to 6.2, indicating slightly to moderately acidic conditions. The inorganic treatment recorded the highest available phosphorus (32.8 kg ha^{-1}) and potassium (385.6 kg ha^{-1}), whereas the organic treatment (vermicompost) recorded the highest organic carbon content (1.10%). Calcium and sulphur levels were sufficient under all treatments, while magnesium was deficient only under the inorganic treatment. Soil texture remained sandy, and soil colour remained dark brown under all treatments.

The increase in soil organic carbon under the organic treatment may be attributed to the addition of vermicompost, which may have improved soil structure, moisture retention, microbial activity, and nutrient retention. These findings are consistent with Lal (2020) and Mader et al. (2002), who reported that regular application of organic amendments improves soil quality and supports sustainable agricultural production. Although the inorganic treatment increased the availability of phosphorus and potassium, it contributed less to the improvement of overall soil quality. The magnesium deficiency observed under the inorganic treatment suggests that continuous use of inorganic fertilisers without balanced nutrient management may lead to nutrient imbalances, as reported by Weil and Brady (2017). Similar findings were reported by Kumari et al. (2024), who observed improved residual soil fertility under organic nutrient sources in pea; Verma et al. (2024), who reported that vermicompost enhanced soil fertility and post-harvest soil quality; and Jadhav et al. (2025), who found that vermicompost-based nutrient management improved soil properties and pea productivity.

4. Conclusion

The study showed that the fertiliser treatments produced different responses in pea growth and selected soil properties under the experimental conditions. Vermicompost recorded the highest mean plant height (76.0 ± 8.25 cm) and leaf number (79.0 ± 8.40) during the final month of observation, compared with 72.6 ± 7.60 cm and 74.0 ± 9.03 leaves under seaweed-fortified granules and 62.4 ± 7.44 cm and 67.2 ± 6.34 leaves in the unfertilised control. Vermicompost also increased post-harvest soil organic carbon to 1.10%, indicating a more favourable response for soil carbon status. In contrast, seaweed-fortified granules produced the highest available phosphorus (32.8 kg ha^{-1}) and potassium (385.6 kg ha^{-1}), demonstrating their contribution to the availability of these nutrients. Soil pH remained slightly to moderately acidic, and electrical conductivity remained within the normal range across treatments. Overall, vermicompost performed better for vegetative growth and soil organic carbon, whereas seaweed-fortified granules were more effective in increasing available phosphorus and potassium during the single-season experiment.

5. Limitation of the Study

The study was conducted during a single rabi season at one location and included a limited number of experimental plots. Consequently, seasonal and site-related variability in crop response, soil health, and nutrient dynamics could not be assessed. The long-term effects of repeated organic and inorganic fertiliser application were also outside the scope of the experiment. Multi-season and multi-location trials are therefore required to determine whether the observed differences in pea growth and post-harvest soil properties remain consistent over time and under other agro-climatic conditions.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

References

Adinkwu, O. M., Isodje, U. O., & Oniko, A. J. (2026). Comparative effect of organic (cow dung and poultry manure) and inorganic fertilizer (NPK 20:10:10) on growth response and physiological performance of *Solanum lycoperscum* (tomato). *Asian Journal of Soil Science and Plant Nutrition, 12*(3), 85–95. https://doi.org/10.9734/ajsspn/2026/v12i3706

Allam, M., Radicetti, E., Quintarelli, V., Petroselli, V., Marinari, S., & Mancinelli, R. (2022). Influence of organic and mineral fertilizers on soil organic carbon and crop productivity under different tillage systems: A meta-analysis. *Agriculture, 12*(4), Article 464. https://doi.org/10.3390/agriculture12040464

Bhattacharyya, S. S., Ros, G. H., Furtak, K., Iqbal, H. M. N., & Parra-Saldívar, R. (2022). Soil carbon sequestration—An interplay between soil microbial community and soil organic matter dynamics. *Science of the Total Environment, 815*, Article 152928. https://doi.org/10.1016/j.scitotenv.2022.152928

Bremner, J. M., & Mulvaney, C. S. (1982). Nitrogen—Total. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of soil analysis: Part 2. Chemical and microbiological properties* (2nd ed., pp. 595–624). American Society of Agronomy and Soil Science Society of America. https://doi.org/10.2134/agronmonogr9.2.2ed.c31

Bünemann, E. K., Bongiorno, G., Bai, Z., Creamer, R. E., De Deyn, G., de Goede, R., Fleskens, L., Geissen, V., Kuyper, T. W., Mäder, P., Pulleman, M., Sukkel, W., van Groenigen, J. W., & Brussaard, L. (2018). Soil quality—A critical review. *Soil Biology and Biochemistry, 120*, 105–125. https://doi.org/10.1016/j.soilbio.2018.01.030

Chivenge, P., Vanlauwe, B., & Six, J. (2011). Does the combined application of organic and mineral nutrient sources influence maize productivity? A meta-analysis. *Plant and Soil, 342*(1–2), 1–30. https://doi.org/10.1007/s11104-010-0626-5

Food and Agriculture Organization of the United Nations. (2022). *The state of the world's land and water resources for food and agriculture 2021: Systems at breaking point*. https://doi.org/10.4060/cb9910en

Hussain, H. I., Kasinadhuni, N., & Arioli, T. (2021). The effect of seaweed extract on tomato plant growth, productivity and soil. *Journal of Applied Phycology, 33*(2), 1305–1314. https://doi.org/10.1007/s10811-021-02387-2

Jackson, M. L. (1973). *Soil chemical analysis*. Prentice Hall of India.

Jadhav, B. D., Gaikwad, B. V., & Dangade, K. S. (2025). Effect of organic manures on yield of pea (*Pisum sativum* L.). *International Journal of Research in Agronomy, 8*(12), 321–324.

Jadoon, S., Aljaff, H. K., Hamawandy, J. K., Pashdary, S. S., & Zakhoy, A. S. (2015). Assessment of the available potassium in the soil of Baharka District, Kurdistan-Iraq. *Der Pharma Chemica, 7*(12), 1–8.

Kakar, R., Sultanpuri, A., Sheoran, H. S., & Tripathi, D. (2018). Assessing the various soil properties affecting soil fertility in the northwestern Himalayas of India. *Chemical Science Review and Letters, 7*(25), 83–87.

Kumar, V., Bhatti, S. S., & Nagpal, A. K. (2016). Seasonal analysis of physicochemical parameters of agricultural soil samples collected from the banks of the Beas and Sutlej Rivers, Punjab, India. *Journal of Chemical and Pharmaceutical Research, 8*(8), 439–449.

Kumari, S., Dogra, B. S., & Dhiman, S. (2024). Effect of organic nutrient sources on soil nutrient level in pea (*Pisum sativum* L.). *Journal of Advances in Biology & Biotechnology, 27*(11), 1086–1093.

Lal, R. (2020). Soil organic matter and global food security. *Journal of Soil and Water Conservation, 75*(5), 123A–124A. https://doi.org/10.2489/jswc.2020.75.5.123A

Mäder, P., Fließbach, A., Dubois, D., Gunst, L., Fried, P., & Niggli, U. (2002). Soil fertility and biodiversity in organic farming. *Science, 296*(5573), 1694–1697. https://doi.org/10.1126/science.1071148

Mia, S., Howlader, N. C., Bulbul, M. T. A., & Roky, R. H. (2025). Comparative impacts of organic and inorganic fertilizers on the emergence and early growth of BARI Tomato-7 (*Solanum lycopersicum* L.). *Plant Physiology and Soil Chemistry, 5*(1), 1–3.

Olsen, S. R., Cole, C. V., Watanabe, F. S., & Dean, L. A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (USDA Circular No. 939). U.S. Government Printing Office.

Prajapati, R., Kumar, V., Trivedi, H., Panday, S., & Tiwari, A. (2026). Study of organic and inorganic fertilizers on growth, yield and quality parameters of radish (*Raphanus sativus* L.) cv. Pusa Desi. *Plant Cell Biotechnology and Molecular Biology, 27*(7–8), 280–290. https://doi.org/10.56557/pcbmb/2026/v27i7-810795

Pratt, P. F. (1965). Potassium. In C. A. Black (Ed.), *Methods of soil analysis: Part 2. Chemical and microbiological properties* (pp. 1022–1030). American Society of Agronomy. https://doi.org/10.2134/agronmonogr9.2.c20

Richards, L. A. (Ed.). (1954). *Diagnosis and improvement of saline and alkali soils* (Agriculture Handbook No. 60). U.S. Department of Agriculture. https://www.ars.usda.gov/ARSUserFiles/20360500/hb60_pdf/hb60complete.pdf

Schwarzenbach, G., & Biedermann, W. (1948). Komplexone X: Erdalkalikomplexe von o,o′-Dioxyazofarbstoffen. *Helvetica Chimica Acta, 31*(3), 678–687. https://doi.org/10.1002/hlca.19480310303

Sharma, A. K., Chauhan, M., Bijalwan, P., & Shilpa. (2023). Plant growth-promoting rhizobacteria, organic manures, and chemical fertilizers: Impact on crop productivity and soil health of capsicum (*Capsicum annum* L.) in the northwestern Himalayan region. *Journal of Plant Nutrition, 47*, 448–467.

Shu, X., He, J., Zhou, Z., Xia, L., Hu, Y., Zhang, Y., Zhang, Y., Luo, Y., Chu, H., et al. (2022). Organic amendments enhance soil microbial diversity, microbial functionality and crop yields: A meta-analysis. *Science of the Total Environment, 829*, Article 154627. https://doi.org/10.1016/j.scitotenv.2022.154627

Verma, A., Aravindakshan, K., Tippannavar, A., Rathore, P., Pandwala, N., & Kumari, N. (2024). Impact of vermicompost and pea (*Pisum sativum* L.)-based intercropping system on soil fertility and quality attributes of pea and garlic. *International Journal of Advanced Biochemistry Research, 8*(8), 852–857.

Walkley, A., & 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 Science, 37*(1), 29–38. https://doi.org/10.1097/00010694-193401000-00003

Weil, R. R., & Brady, N. C. (2017). *The nature and properties of soils* (15th ed.). Pearson.

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/162948