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Physico-Chemical Characteristics of Soil as Affected by Organic Amendments in Coloured Capsicum under Greenhouse Conditions

Shahnaz Mufti [a*], Danishta Yousuf [a], Rakshanda Anayat [b], Ajaz Malik [a], Faheema Mushtaq [a], Baseerat Afroza [a], Rehana Rasool [c], Ummayiah Masoodi [a], Nida Manzoor [a], Ambreena Sultan [a] and Marifa Gulzar [a]

[a] *Division of Vegetable Sciences, Faculty of Horticulture (FoH), SKUAST- Kashmir, India.*
[b] *Division of Horticulture, Faculty of Agriculture (FoA), SKUAST-Kashmir, India.*
[c] *Division of Soil Science, Faculty of Agriculture (FoA), SKUAST-Kashmir, India.*

Authors' contributions

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

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ABSTRACT

Organic manures and bio-fertilizers are one of the alternative renewable sources of nutrient supply. Bio-fertilizers combined with organic manure influences the plant growth by enhancing root biomass; total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. In this experiment, various types of organic sources of nutrients (FYM, Poultry manure, Vermicompost and Sheep manure) and biofertilizers

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

(*Azotobacter*, PSB and KSB) were evaluated in coloured capsicum under greenhouse conditions and their impact was studied on various physico-chemical properties of soil. Observations were recorded on various physical parameters like pH, soil EC, soil OC, soil bulk density, chemical parameters like available N, P, K and uptake of nutrient N, P and K. Data on various soil parameters revealed that T_5 (75% vermicompost+ Azotobacter+ PSB+ KSB) significantly enhanced available soil nutrients and resulted in maximizing the nutrient status of the soil after the crop harvest. Highest available N (220.13kg/ ha), P (30.24kg/ ha), K (222.16kg/ ha) was recorded in treatment T_5 and was found maximum as compared to all other treatments under study. However, the uptake of nutrients was observed maximum in treatment T_9 (RFD). Treatment T_5 (75% vermicompost + azotobacter +PSB +KSB) also contributed in improving the physical parameters of soil like electrical conductivity (0.114 dsm^{-1}) and soil organic carbon content (1.37%) than initial status of soil, recording EC of 0.102 dsm^{-1} and organic carbon content of 1.19%. Additionally, the organic manures also brought the pH of soil to a desired level and pH was declined from 7.02(initial status) to 6.81 by treatment T_5 (75% vermicompost + azotobacter +PSB +KSB). But treatment T_2 (100% Poultry manure) improved the bulk density of soil and was reduced to 1.22 g/cm^3 as compared to initial soil status recording bulk density of 1.38 g/cm^3.

Keywords: Capsicum; cultivation; biofertilizers; greenhouse conditions.

1. INTRODUCTION

Capsicum (Capsicum annuum L.) also known as Bell pepper, sweet pepper, green pepper and Shimla mirch is one of the popular Solanaceous vegetable crop grown throughout India in open as well as protected environments. Capsicum attained a status of high value low volume crop in India in recent years and occupies a place of pride among vegetables in Indian cuisine. Also, coloured capsicum ensures a lucrative revenue return owing to its high-value vegetable. This crop is having good storability and can be stored in the cold storage facility even up to one month. Capsicum can be grown throughout the year under the protected structure and if grown organically, can fetch a high profit. Basically, these are the perfect items for selling from shopping malls, supermarkets, and online marketplaces.

Bell peppers come with enormous health benefits like it contains plenty of vitamin C. However, the highest amount of Vitamin C is in red variety. Additionally, Red bell peppers help in activating thermogenesis and increase the metabolic rate. Hence, it supports weight loss. Coloured capsicums also contain several phytochemicals and carotenoids, particularly beta-carotene. These are also a good source of vitamin E, vitamin B6 as well [1].

Cultivation of capsicum under protected structures is gaining momentum due to increased demand for the produce throughout the year. Cultivation of capsicum in the cost effective naturally ventilated polyhouses is proving to be a very remunerative venture. A naturally ventilated greenhouse works effectively in temperature range of 15-35 ^{0}C. The cultivation of capsicum in net house can play a better role in improving quality, advancing maturity as well as increasing fruiting span and productivity. Keyhaninejad et al., [2] reported that greenhouse and shade house reduced light intensity that resulted in a two- to three-fold increase in carotenoid content in pepper fruit (Capsicum annuum) as compared to open-field conditions. Moreover, production of capsicum under controlled environment has high production per unit area of land and extended harvest period. Higher yields are reported when capsicum is grown under protected structures. Sweet pepper grown in greenhouse can produce yield up to 100 t/ha [3].

Among the various factors responsible for low production of coloured capsicum, nutrition is of prime importance. Many investigators reported that the supply of balanced nutrition had a major effect on plant growth [4,5,6] and quality of sweet pepper [7]. But, application of chemical fertilizers alone supplies only major nutrient elements to the crop. The chemical fertilizers are known to degrade soil and water resources. However, the modern day's agriculture is focused not only for production but also accounts for the sustainability of all the resources including soil for the generations to come. So, the alternative farming system which is sustainable and self-sufficient is the organic farming. Organic farming is an agricultural production system, involving locally and naturally available organic materials or agro inputs, without endangering our precious natural resources. Organic manures and bio-fertilizers are one of the alternative renewable sources of nutrient supply. Organic manure not only supply macro, micro, and secondary nutrient, but also improve physical, chemical and biological properties of soil. Organic manures are slow releasing fertilizers and loss of nutrients is less than inorganic fertilizers resulting in reduction of soil, water and air pollution. It can supply practically all the elements of soil fertility that the crops require when applied in right proportions. Additionally, organic manures contain enzymes like amylase, lipase, cellulase and chitinase which continues to break down organic matter in the soil (to release the nutrients and make it available to the plant roots). These also contain several plant growth promoters, enzymes rich in plant nutrients, beneficial bacteria and mycorrhizae. In contrast, Bio-fertilizers are the preparations containing living or latent cells of efficient strains of microorganisms capable of fixing atmospheric nitrogen, solubilizing phosphorous and potassium, mobilizing nutrients and absorption of water, decomposing cellulolytic and alginolytic water materials. These are low cost, eco-friendly input and not only improve the crop growth and yield but also improve fertilizer use efficiency. These also produces growth promoting substances (IAA and GA) which greatly influences the seed germination, root growth and proliferation. According to Fawzy *et al.* [8] application of bio-fertilizer increased ascorbic acid in sweet pepper fruits. Also, Bashan and Leavanany [9] obtained higher fruit yield of bell pepper with *Azospirillum* inoculation of seedlings under greenhouse condition.

We hypothesized that the physio-chemical characteristics of soil were significantly affected by the use of various organic manures and biofertilizers in the study due to the positive benefits it offers towards successive crop growth and development. Hence, the focus of this research was to see how different organic amendments affected the overall soil health in coloured capsicum grown under protected conditions in temperate conditions.

2. METHODOLOGY

The present investigation was carried out at Experimental Farm, Division of vegetable science, SKUAST-Kashmir Shalimar campus, during kharif 2020, which is 15km away from Srinagar city that lies between 34.1o North latitude and 74.89o East longitude at an altitude of 1587 meters above mean sea level. The F1 Hybrid used in this experiment was Ayesha. Three types of bio-fertilizers viz., Azotobacter, PSB, KSB and four types of organic manures viz., vermicompost, sheep manure, farmyard manure and poultry manure were used as nutrient sources in different combinations. The experiment comprised of 9 treatments viz, T1= 100% Vermicompost, T2= 100% poultry manure, T3= 100% FYM, 100% sheep manure, T4=75% vermicompost + Azotobacter + PSB + KSB, T5=75% Poultry manure + Azotobacter + PSB + KSB, T6= 75% FYM + Azotobacter + PSB + KSB, T7=75% FYM + Azotobacter + PSB + KSB, T8=75% Sheep manure + Azotobacter + PSB + KSB, T9 = Control (Recommended fertilizer dose). The organic manures were applied on N equivalent basis as per the recommended dose of fertilizers and biofertilizers were applied @ 2.5 litre/ ha.

The experiment had 3 replications which were laid out in Randomized Complete Block Design (RCBD). Each block accommodated nine (09) treatments and the treatments were randomized in three replications. Plot size for each treatment was kept at 3m x 2.5m accommodating 25 plants per plot, spaced 60 x 45cm apart.

Well-decomposed organic manures were incorporated in the experimental field at least 10-15 days prior to transplanting and the dosage was calculated on the basis of nutrient status of the manures. Biofertilizers were applied as seedling dip. For giving seedling dip, liquid Biofertilizer were mixed with some jaggery and the solution was prepared. Jaggery acts as a sticking agent and makes biofertilizers to stick on the seedling roots. Seedlings were dipped in the solution for 30 minutes before transplanting.

Representative soil samples of the experimental site before the start of experiment as well as after the harvest of crop from each treatment were taken from a depth of 0-15 cm and analysed for physico-chemical properties viz., Electrical Conductivity, pH, Organic Carbon, Bulk Density and Available Nitrogen, Phosphorus, Potassium (kg/ha).

The initial status of experimental site with respect to above characteristics is given as:

The Organic manures were also analysed for the nutrient status given as under:

Transplanting was done in well prepared field and all standard practices were followed for raising the crop. The data pertaining to growth, yield, quality and soil health was recorded and was subjected to statistical analysis using standard procedures.

2.1 Procedures Followed for Soil Analysis

pH: The pH of soil samples was determined by digital pH meter in ratio of 1:2.5 soil water suspension (Jackson, 1973).

Organic carbon (%): The organic carbon content was calculated by Walkley and Black's method, 1934.

Electrical Conductivity (ds/m): Electrical conductivity was estimated by solubridge conductivity meter (Jackson, 1973).

Bulk density (g/cm^3): Bulk density was estimated by taking soil sample from undisturbed soil core, adapting excavation method, as outlined by Jaiswal, 2003.

Available N (kg/ha): Available nitrogen was determined by alkaline permanganate method as described by Subbaih and Asija (1956).

Available P (kg/ha): Available P was determined by Olsen method (1954) as described by Jackson (1973).

Available K (kg/ha): In NH_4OH was used as extractant and the available K content was determined by feeding the extract to flame photometer (Jackson, 1973).

Plant Uptake: Samples from five randomly selected observational plants were taken at final harvest stage to serve as substrate for nutrient analysis. The selected samples were cleaned with 0.2% liquid detergent, HCL solution 98 ml/l water and distilled water. The cleaned plant material was cut into pieces, air dried and finally subjected to oven drying at 65^{o}C till the material exhibited a constant weight. The dried material was ground to fine powder.

Nitrogen uptake (kg/ha): For estimating N concentration the powdered sample (1g) was digested in 10 ml concentrated H_2SO_4 + digestion mixture (10 parts of K_2SO_4 +3 parts of $FeSO_4$ +1 part of $CuSO_4$ +1 part of selenium powder). The digestion was continued until all samples were clear with blue/green solution. After completion of digestion the digest was cooled and diluted with distilled water and volume was made up to 100 ml.

10 ml of aliquot was taken in digestion tube and placed in distillation unit for N estimation. Also 10 ml of 4% boric acid indicator solution was taken in conical flask and placed in distillation unit and 30 ml of 40% NaOH was dispensed into the tube and fit in the set. The contents were distilled till pinkish colour turned to green. After completion of distillation boric acid was titrated against N/50 H_2SO_4. The colour change at end point was from green to faint pink. Blank was also run to same end point as that of sample. Then nitrogen uptake was calculated by following formula:

Nitrogen uptake (kg/ha) = Nitrogen concentration in plant (%) × Dry matter yield (kg/ha)

Table 1. Physico-chemical properties of soil of experimental site

Particulars	Initial status
Soil pH	7.02
Electrical Conductivity (ds/m)	0.102
Organic Carbon (%)	1.19
Bulk Density (g/cm^3)	1.38
Available N (kg/ha)	210.50
Available P (kg/ha)	22.75
Available K (kg/ha)	205.20

Table 2. Chemical composition of organic manures used in the experiment

Organic manure	Per cent N	Per cent P	Per cent K
Vermicompost	2.0	1.2	0.6
Farmyard manure	0.6	0.4	0.5
Poultry manure	1.8	1.6	0.8
Sheep manure	0.7	0.3	0.9

Phosphorus uptake (kg/ha): For estimating the concentration of P the powdered sample (1g) was digested in di acid mixture *viz.*, nitric acid and perchloric acid in ratio 3:1. The digestion was continued till samples were clear. Plant digest was transferred to 100 ml volumetric flask then volume was made up to mark with distilled water. From 100 ml plant digest volume 5 ml aliquot was taken in 25 ml volumetric flask and add 10 ml of vanadomolybdate reagent to it and volume was made up to mark with distilled water. The absorbance was then read on spectrophotometer at 420 nm and P concentration was obtained with the help of standard curve. Then, phosphorus uptake was calculated by the following formula:

Phosphorus uptake (kg/ha) = Phosphorus conc. in plant (%) × Dry matter yield (kg/ha)

Potassium uptake (kg/ha): For estimating the concentration of K, (1 g) powdered sample was digested in diacid mixture, nitric acid and per chloric acid in the ratio 3:1. The digestion was continued till samples were clear. Plant digest was then transferred to 100 ml volumetric flask and volume was made up to mark with distilled water. From 100 ml plant digest volume, 5 ml aliquot was taken in 25 ml volumetric flask and volume made up to mark. The samples were then read on flame photometer for determining K concentration. The K uptake was then calculated by following formula:

Potassium uptake (kg/ha) = Potassium concentration in plant (%) × Dry matter yield (kg/ha)

3. RESULTS

3.1 Effect of Different Organic Amendments on Physico-Chemical Properties of Soil

Among the different organic amendments, treatment T_5 (75% VC+ Azotobacter+ PSB+ KSB) recorded a soil pH of 6.81, EC (0.114 ds/m) and Organic carbon (1.37 %), depicting a significant difference as compared to the initial status of soil with pH (7.02), EC (0.102 ds/m) and organic carbon (1.19 %) as presented in Table 3. The data pertaining to bulk density presented in Table 3 reveal a significant variation in bulk density of soil after harvesting of crop. Among all the treatments, sole organic treatments resulted in more improvement in bulk density as compared to integrated organic treatments. Among sole treatments, treatment T_2 (100% poultry manure) recorded a bulk density of 1.22 g/cm^3 followed by T_4 (100% SM) having bulk density of 1.23 g/cm^3. Whereas, among integrated organic amendments T_6 (75% poultry manure @ 6.24 t ha^{-1} + Azotobacter + PSB + KSB) recorded a bulk density of 1.26 g/cm^3 and was followed by T_8 (75% SM+ Azotobacter+ PSB+ KSB) with density of 1.27 g/cm^3. Moreover, T_9 (RFD) which did not receive any organic manures, recorded a least improvement in physico-chemical properties of soil.

The experimental results in Table 4 gives us a full overview of the effect of various organic treatments on chemical properties of soil. According to the study, various organic amendments have significantly influenced the soil parameters and the availability of various nutrients has improved after application of different organic treatments except the treatment that didn’t receive any organic input. The data revealed that treatment T_5 (75% VC+ Azotobacter+ PSB+ KSB) resulted in highest available N (220.13 kg/ha), P (30.24 kg/ha) and K (222.16 kg/ha), respectively. This was followed by treatment T_7 (75% FYM+ Azotobacter+ PSB+ KSB) with available N (219.41 kg/ha), P (29.52 kg/ha) and K (216.24 kg/ha), respectively. Likewise, among sole organic manures T_1 (100% vermicompost) recorded maximum available N (213.13 kg/ha), P (26.15 kg/ha) and K (209.93 kg/ha), respectively. Among sole organic manures, T_1 (100% vermicompost) was followed by T_3 (100% farmyard manure) with available N (212.96 kg/ha), P (25.94 kg/ha) and K (208.75 kg/ha), respectively. Significantly lowest available N (198.52 kg/ha), P (21.12 kg/ha) and K (202.15 kg/ha) was recorded in treatment T_9 (RFD).

The data pertaining to uptake presented in Table 5 revealed significant influence of various applied treatments. Among different treatments, treatment T_9 (RFD) has recorded maximum uptake of N (82.85 kg/ha), P (18.86.12 kg/ha) and K (87.96 kg/ha) which was significantly superior to all other treatments followed by treatment T_5 (75% VC+ Azotobacter+ PSB+ KSB) with N, P and K uptake of 79.17 kg/ha, 17.52 kg/ha and 85.94 kg/ha, respectively. However, treatment T_2 (100% PM) recorded minimum nitrogen uptake of N (70.04 kg/ha), P (12.08 kg/ha) and K (79.35 kg/ha). In case of sole application of organic manures maximum uptake of N (72.94 kg/ha), P (14.73 kg/ha) and K (81.74 kg/ha) was recorded in treatment T_1 (100% VC).

Table 3. Effect of different organic amendments on physico-chemical properties of soil

S.No	Treatment details	pH	EC (dS/m)	Bulk density (g/cm^3)	Organic carbon (%)
T_1	100%vermicompost @ 7.5t ha^{-1}	6.88±0.01^{cd}	0.110±0.00^{bcde}	1.25±0.01^{abcd}	1.29±0.01^{de}
T_2	100% poultry manure @ 8.3t ha^{-1}	6.95±0.03^{fg}	0.106±0.00^{ab}	1.22±0.01^{a}	1.23±0.01^{ab}
T_3	100% farmyard manure @ 24.9t ha^{-1}	6.93±0.03^{ef}	0.108±0.00^{abcd}	1.24±0.02^{abc}	1.26±0.01^{cd}
T_4	100% sheep manure @ 21.43 t ha^{-1}	6.90±10.02^{de}	0.107±0.00^{abc}	1.23±0.02^{ab}	1.25±0.02^{bc}
T_5	75% vermicompost @ 5.62 t ha^{-1} + Azotobacter+ PSB+KSB	6.81±0.01^{a}	0.114±0.00^{f}	1.30±0.01^{ef}	1.37±0.01^{h}
T_6	75% poultry manure @ 6.24 t ha^{-1} + Azotobacter+PSB+ KSB	6.85±0.01^{bc}	0.111±0.00^{cdef}	1.26±0.03^{bcde}	1.31±0.01^{ef}
T_7	75% farmyard manure @ 18.7 t ha^{-1} + Azotobacter+ PSB+KSB	6.87±0.02^{bcd}	0.113±0.00^{ef}	1.28±0.02^{de}	1.35±0.02^{gh}
T_8	75% sheep manure @ 16.07 t ha^{-1} + Azotobacter+PSB+ KSB	6.83±0.02^{ab}	0.112±0.00^{def}	1.27±0.02^{cde}	1.33±0.01^{fg}
T_9	RFD@ (150 kg N, 120 kg P, 90 kg K/ ha) (Control)	6.98±0.05^{g}	0.105±0.00^{a}	1.32±0.02^{f}	1.21±0.01^{a}
	Initial status	7.02	0.102	1.38	1.19

**Values with different superscripts differ significantly*

Table 4. Effect of different organic amendments on nutrient availability of soil

S.No	Treatment details	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1	100%vermicompost @ 7.5t ha^{-1}	213.13±0.03^{e}	26.15±0.03^{e}	209.93±0.01^{e}
T_2	100% poultry manure @ 8.3t ha^{-1}	211.35±0.03^{b}	23.44±0.02^{b}	206.14±0.04^{b}
T_3	100% farmyard manure @ 24.9t ha^{-1}	212.96±0.01^{d}	25.94±0.03^{d}	208.75±0.02^{d}
T_4	100% sheep manure @ 21.43 t ha^{-1}	212.05±0.02^{c}	24.81±0.01^{c}	207.82±0.01^{c}
T_5	75% vermicompost @ 5.62 t ha^{-1} + Azotobacter+ PSB+KSB	220.13±0.02^{i}	30.24±0.03^{i}	222.16±0.02^{i}
T_6	75% poultry manure @ 6.24 t ha^{-1} + Azotobacter+PSB+ KSB	215.56±0.02^{f}	27.15±0.03^{f}	216.24±0.03^{f}
T_7	75% farmyard manure @ 18.7 t ha^{-1} + Azotobacter+ PSB+KSB	219.41±0.01^{h}	29.52±0.02^{h}	220.34±0.02^{h}
T_8	75% sheep manure @ 16.07 t ha^{-1} + Azotobacter+PSB+ KSB	217.65±0.03^{g}	28.44±0.02^{g}	219.45±0.02^{g}
T_9	RFD@ (150 kg N, 120 kg P, 90 kg K/ ha) (Control)	198.52±0.02^{a}	21.12±0.02^{a}	202.15±0.03^{a}
	Initial status	210.50	22.75	205.20

**Values with different superscripts differ significantly*

4. DISCUSSION

For nutrients like nitrogen and phosphorus to be available for plants in the soil, soil pH should be between 6.0 and 7.0 for pepper crop. At lower pH, Phosphorus forms insoluble compounds with Fe and Al making it unavailable for plant uptake. Vermicompost has a near-neutral pH, making it an excellent soil conditioner for both acidic and alkaline soils. It can help balance soil pH, creating a more favorable environment for plant growth. The decrease in soil pH in the treatment T_5 (75% VC+ Azotobacter+ PSB+ KSB) is due to release of various organic acids, especially carbonic acid during the decomposition process which might have resulted in lowering of pH. These results are in close conformity with [10,11]. Further the increase in electrical conductivity in treatment T_5 (75% vermicompost+ Azotobacter + PSB + KSB) is because of the fact that the decomposition of organic manures induces an acidic condition in soil which results in more solubility of salts. Thus, the salts present in soil become more mobile and conducts more electric current which results in increase in electrical conductivity. These results corroborate with Nisar et al. [11] and Mufti et al. [12]. Further, the addition of organic manure in treatment T_5 (75% vermicompost + Azotobacter + PSB + KSB) which recorded maximum OC results in modification of soil texture and the biological activity of the soil also got enhanced. Vermicompost also introduces beneficial microorganisms into the soil. These microorganisms break down organic materials further and improve soil microbial diversity, which is essential for nutrient cycling and overall soil health. The increase of organic carbon content may be due to improved microbial activities in the root zone which decomposed organic manures and also fixed unavailable form of mineral nutrients into available forms in soil thereby substantiated crop requirements and improved organic carbon level and stabilized soil pH. These results are in close conformity with Choudhary et al. [13] and Mufti et al. [12].

Reduced bulk density indicates better aeration and drainage besides good soil physical condition that would help in better root penetration and proliferation necessary for vigorous growth and subsequent high yield of crops. The reduction in bulk density by treatment T_2 (100% poultry manure) which recorded minimum bulk density of 1.22 g/cm^3 may be due to the improvement of aggregation and structure which has direct influence on the bulk density of the soil. Similar findings were reported by Adeleye et al. [14].

The treatment T_5 (75% VC+ Azotobacter+ PSB+ KSB) recorded more available N, P and K may be due to better and efficient decomposition, mineralization, solubilization of phosphorus and potassium compounds found in complexes, fixed and unavailable form in soil brought by action of phosphorus and potassium solubilizing bacteria. During, mineralization, earthworms convert organic nutrients into inorganic forms that plants can readily take up. Earthworms' digestive system and microbial activity in their guts contribute to this conversion, making nutrients more available for plant uptake. These results are in conformity with findings of Parthasarathi *et al.* (2007), Zakara (2009) and Jaipual *et al.* (2011). Further, the data pertaining to N, P and K uptake revealed significant influence of various treatments on uptake of nitrogen, phosphorus and potassium. Among different treatments, treatment T_9 (RDF) has recorded maximum uptake of N, P, and K may be attributed to the more availability of nutrients, since the nutrients are applied in chemical form only. These results are in conformity with the findings of Shilpa [15]. Unlike chemical fertilizers that provide a quick nutrient boost but can leach away or become unavailable to plants, vermicompost releases nutrients gradually over an extended period. This sustained release of nutrients ensures a consistent and stable supply for plant growth.

Table 5. Effect of different organic amendments on plant nutrient uptake in coloured capsicum

S.No	Treatment details	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
T_1	100%vermicompost @ 7.5t ha^{-1}	72.94±0.02^d	14.73±0.03^d	81.74±0.02^d
T_2	100% poultry manure @ 8.3t ha^{-1}	70.04±0.02^a	12.08±0.01^a	79.35±0.02^a
T_3	100% farmyard manure @ 24.9t ha^{-1}	71.55±0.03^c	13.93±0.01^c	81.08±0.01^c
T_4	100% sheep manure @ 21.43 t ha^{-1}	70.87±0.02^b	13.10±0.01^b	80.55±0.02^b
T_5	75% vermicompost @ 5.62 t ha^{-1} + Azotobacter+ PSB+KSB	79.17±0.03^h	17.52±0.02^h	85.94±0.02^h
T_6	75% poultry manure @ 6.24 t ha^{-1} + Azotobacter+PSB+ KSB	73.51±0.01^e	15.45±0.02^e	82.11±0.02^e
T_7	75% farmyard manure @ 18.7 t ha^{-1} + Azotobacter+ PSB+KSB	75.63±0.02^g	16.93±0.02^g	84.14±0.04^g
T_8	75% sheep manure @ 16.07 t ha^{-1} + Azotobacter+PSB+ KSB	74.12±0.02^f	16.07±0.02^f	83.14±0.02^f
T_9	RFD@ (150 kg N, 120 kg P, 90 kg K/ ha) (Control)	82.85±0.02^i	18.86±0.03^i	87.96±0.01^i

**Values with different superscripts differ significantly*

5. CONCLUSION

Use of vermicompost and biofertilizers in bell peppers proved to be beneficial for improving the soil health as it offers numerous benefits like improving the soil structure, soil texture, water retention capacity, and nutrient status. It proved to be a sustainable farming practice as it sequesters carbon in the soil, reducing the carbon footprint of agricultural practices, protecting environment as well. It provides an eco-friendly way to recycle organic waste, enhance soil fertility, and improve crop productivity while reducing the need for chemical inputs. By incorporating vermicomposting into agricultural systems, farmers can contribute to long-term soil sustainability and more resilient farming practices [16,17].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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